PHASE THREE: CONTROL
MINI MOTORS

Mission: How do chemical forces control how tiny things move?

Age: 5+
Materials: $4

Time: 20 min
(Set-up: 5 min   Activity: 10 min   Clean-up: 5 min)

What you need:

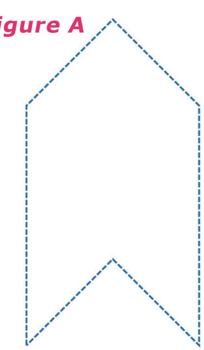
Materials:
- Dishwashing liquid
- Paper
- Tap water

Equipment:
- Large cake pan or baking sheet with raised edges
- Scissors

What to do:

1. Fill the large pan or baking sheet with about 1/2 inch of tap water.
2. Make your “boat” by cutting out a piece of paper about 1 inch wide and 2 inches long, then cut the top and bottom edges into points as shown – *see Figure A.*
3. Dip the tips of the two points on the back end of the boat in dish-washing liquid.
4. Predict: what do you think will happen when you place the boat on the water?
5. Carefully drop the boat onto the water so that it lands flat upon the surface. What happens to the boat? What direction does it move?
6. Repeat the experiment with fresh water and fresh boats. Try different boat shapes or dip the dish-washing liquid onto other parts of the boat and notice how the boat moves each time.

Figure A



Clean-up:

All disposable materials can be thrown away in the regular trash.

What’s Happening?

The water and dish-washing liquid have an interesting chemical interaction that can be used to power motion and make small objects move. The two liquids have different levels of a property called surface tension. Water has high surface tension because water molecules stick together very strongly—that’s why we see water droplets beading up on a leaf. Dish-washing liquid, on the other hand, has low surface tension. When you put your boat on the water, the molecules of dish-washing liquid quickly spread out across the water surface, moving to areas of higher surface tension. Since you put the dish-washing liquid on the back of the boat, the force of the molecules moving away pushes the boat forward in the opposite direction.

So What?

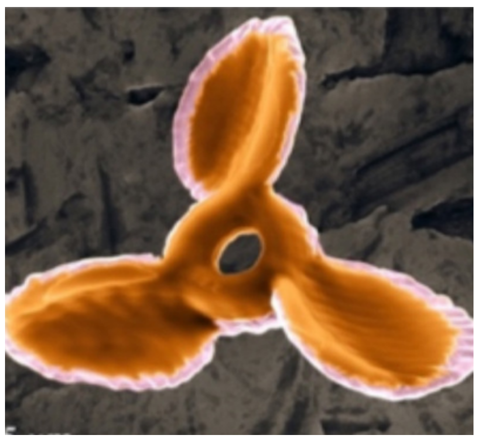


Image credit: Remmi Baker/Penn State

In nature, chemical forces control the motion of tiny living and non-living particles. These examples inspire scientists to design materials that can move in similar ways. For instance, based on how bacteria move, scientists have created motors that are a thousand times smaller than a grain of sand – much smaller than your boat! These materials are called nanomotors and can be powered by different methods, including chemical forces, as well as magnets, light, and sound waves.

Because the motors are so small, they could be put into the body and used to carry medicine through the bloodstream and to individual cells. This is an exciting possibility for cancer research because current cancer medicines have one big problem: they often kill healthy cells along with tumor cells. Scientists hope to solve this problem by using nanomotors to carry the medicine directly to the tumor cells and limit the effects on healthy cells. Before they can do that, however, scientists need to find ways to make nanomotors cheaper to produce and safer to use in living organisms. Because the motors are usually made up of expensive metals that are bad for cells in the body, current medicines are still cheaper and safer to use.

NGSS Alignment of Mini Motors Activity

The information below may not include every area that this activity can be linked to NGSS concepts

Disciplinary Core Ideas

PS2.A: Forces and Motion

- Grade 3
  - ◇ Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.
  - ◇ The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.
- Middle School
  - ◇ The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
  - ◇ All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

Performance Expectations

3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Crosscutting Concepts

Cause and Effect: Mechanism and Prediction

- Grade 3-5
  - ◇ Cause and effect relationships are routinely identified, tested, and used to explain change.
- Middle School
  - ◇ Cause and effect relationships may be used to predict phenomena in natural or designed systems.
  - ◇ Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Engineering and Science Practices

Planning and Carrying Out Investigations

- Grade 3-5
  - ◇ Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
  - ◇ Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.
  - ◇ Make predictions about what would happen if a variable changes.
- Middle School
  - ◇ Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data is needed to support a claim.
  - ◇ Collect data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.