Fins and Flow

A hands-on activity for students, families, and adults
Duration: About 30 minutes

Nature is great at solving problems. This is why scientists and engineers often use biology to inspire their research and solutions in a field called biomimicry. In this activity, you will explore how the study of fish can help us create more energy-efficient boats and underwater vehicles.

Background:

- Traditional methods of propelling boats, such as propellers, turbines, and jets, are very inefficient. Most of the energy produced by burning fuel does not move the boat forward, but instead goes into producing heat and pushing against the drag of the water.
- Fish such as bluefin tuna are very efficient. They have evolved to use the energy from what they eat to propel them at speeds up to 46 miles (74 km) per hour!

MIT Connection:

To explore how fish swim so efficiently, researchers David Barrett and Michael Triantafyllou in MIT's Department of Mechanical Engineering built RoboTuna, a flexible robot that they could program with various swimming patterns to test in the MIT Towing Tank. They studied how the water moved around the robot to learn how a fish's shape and movements affect its efficiency. Their research could help boats save fuel and help battery-powered autonomous vehicles explore the deep ocean for months at a time! RoboTuna is now on display at the MIT Museum. Newer biomimetic swimming robots from MIT include RoboPike, Octobot, and others (see links under *Explore More*).

Goal:

After learning about swimming animals for inspiration, design and test a series of fins that could be used in place of propellers on boats. The goal is to make the fin as efficient as possible, which means:

- The fin pushes as much water as possible behind the fish, not to the sides or forward.
- The fin does not need to flap very quickly.

MIT Museum Activity: Fins and Flow

Materials:

- Laminated card stock. Postcards and junk mail advertisements work well.
- Sink
- Water
- Scissors
- Food coloring

Directions:

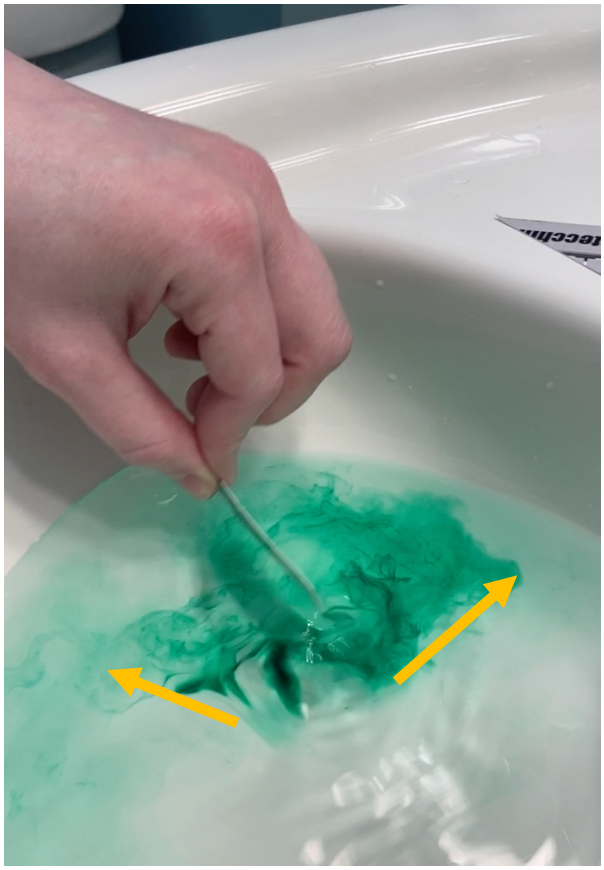
1. Explore the different fin shapes that fish have. Be sure to think about how each fish moves—for example, do they move fast or slow, in straight lines or zigzags, in shallow or deep water?
2. Use the scissors to cut out several fin shapes from the cardstock. You can copy fish you have seen or combine different features to make unique fins. Try different sizes of fins. The only limitation is that the fin should fit in your sink and not hit the sides.
3. Fill the sink with water.
4. Hold one of your fins by the end that would be attached to the fish's body. Hold the fin in the water at one end of the sink.
5. Place a single drop of food coloring right behind the fin, on the opposite end from where you are holding it.
6. Wave the fin back and forth and make some observations. An observation template sheet is included below.
7. Repeat the experiment by changing the fin shape or changing how you hold or move the fin. Since you are adding only one drop of food coloring for each trial, you should be able to do multiple trials before needing to drain and refill the sink.

What to Look For:

- An efficient fish will push water directly backwards in order to propel itself forward. Water that is pushed sideways does not help a fish move forward. The motion of the food coloring should help you determine where the water is pushed by the fin.
- How much splashing do you see? Does splashing make the fin more or less efficient?
- Does changing the speed of the fin make a difference?
- Does changing how you hold the fin make a difference?
- Does it make a difference if you hold the fin at different depths in the water?
- What other questions can you think of?

Efficient

Not Efficient



Iterate:

- Once you have tested your first set of fins, look at your observations. What worked well and what did not?
- Use what you have learned to create a new set of fins, modifying them to be more efficient.
- Repeat the experiments and record your data.
- Based on your new observations, continue iterating (repeating the pattern of building, testing, and improving) until you have a fin is very efficient.

Explore More:

- Get to know the RoboTuna project: Read this article showing how the robot is inspired by natural fish swimming. https://instruction2.mtsac.edu/jkido/Biology%2020/Handouts%20&%20Articles/Exam%203/An%20Efficient%20Swimming%20Machine.pdf
- The MIT Penguin Boat: https://techtv.mit.edu/videos/650-proteus-the-penguinboat
- Aquatic Biomimicry Research at MIT: http://web.mit.edu/towtank/www/index.html
- Finegan the RoboTurtle: https://www.youtube.com/watch?v=3XXJGRGRp64
- MIT Squishy Fish: http://news.mit.edu/2018/soft-robotic-fish-swims-alongside-real-ones-coral-reefs-0321

Observations

Fin Shape #___ Drawing of fin: --- Experiment Observations:	Fin Shape #___ Drawing of fin: --- Experiment Observations:
Fin Shape #___ Drawing of fin: --- Experiment Observations:	Fin Shape #___ Drawing of fin: --- Experiment Observations: