Title: Jet Propulsion in the Natural and Modern World

Topics: jet propulsion, animal anatomy, adaptation

Related Disciplines: biology, physics

Objectives:

A. Understand the mechanism behind jet propulsion.
B. Identify examples of jet propulsion in nature and the man-made world.
C. Explain how biomimicry is seen in jet propulsion.
D. Construct a 3D art project that utilizes jet propulsion.

Lesson:

A. Introduction (20 minutes)

Man has a way of mimicking nature. One very popular case of this is the use of jet propulsion for motion. Jet propulsion is the act of moving a body in the forward direction from the discharge of a fluid from the rear side. This fluid is most commonly water or air. Humans have used this concept and adapted it in a way to power engines used in planes, spacecraft, rockets, and vehicles. We have been able to magnify the force created from jet propulsion to produce the fastest speeds recorded by man-made machines.

Jet propulsion in nature operates under the same general mechanism as man-made re-creations. The most well-known example of natural jet propulsion is seen in the locomotion of cephalopods, especially the squid. The squid uses jet propulsion when in need of high-speed, linear movement. Examples of such times include hunting, escaping predators, and dancing with fellow squid. The squid can reach up to 25 miles per hour using jet propulsion, and even send itself out of the water to evade predators if necessary.

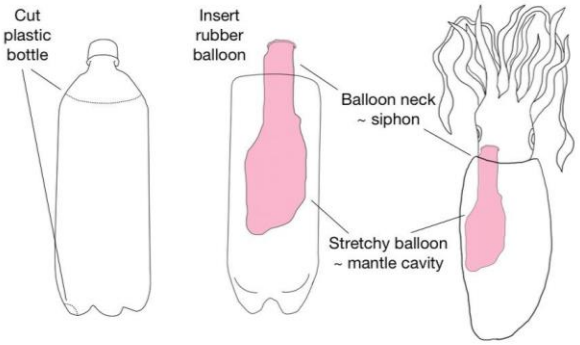
The squid is able to achieve such feats because it is built for quick acceleration. The body of the squid, called the mantle, is a hollow organ with walls made of muscles. One end of the mantle has a head with eyes and the other has tentacles. To begin the process of moving by jet propulsion, the squid uses specific muscles to draw water into the mantle through an opening on the cranial end. Next, the squid contracts a different set of muscles which expels the water out of the caudal end, while simultaneously closing the opening at the cranial end. The water is squeezed through a thin funnel called the siphon. The siphon is extremely mobile and can point in any direction. It is responsible for controlling the direction in which the squid travels. Additionally, the squid may control its path of travel by flipping its body to whichever direction it wants to travel in. The squid is not the only cephalopod to use jet propulsion; other examples include the octopus, pufferfish, and nautilus. However, jet propulsion is an energy-demanding process so many cephalopods do not use it unless necessary.

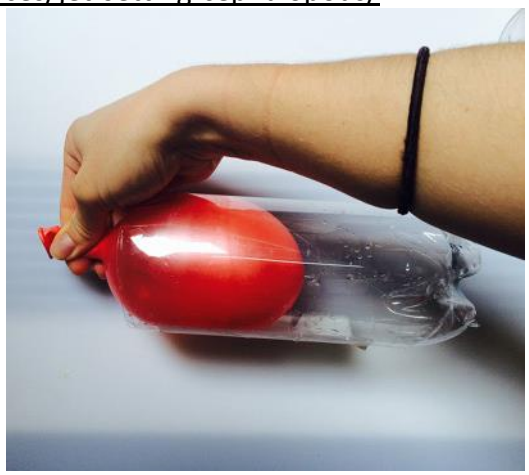
Marine salps, organisms that resemble jellyfish, also use jet propulsion to move. Similar to the squid, the marine salp draws water into itself from one body part, and forces it out of another. These actions are controlled by the contraction of certain muscle groups within the organism. Unlike the squid, the marine salp uses jet propulsion for more than just locomotion;

as the water is forced out of the marine salp's body it is also filtered for algae, a food source for the organism. Jet propulsion appears to be essential to the viability of the marine salp. The *Notarchus indicus*, a particular type of sea hare, also uses the flow of water from its body to move. This organism has a body that is essentially a closed sac. It moves by sucking water into this sac and expelling it out. Lastly, scallops use a mechanism very similar to jet propulsion. Scallops swim by opening and closing their shells. This process forces water into and out of the organism, resulting in movement. As you can see, there is a general trend of jet propulsion causing the movement of a body.

While jet propulsion is mainly used for locomotion, there is a similar mechanism that occurs with the release of venom from cobra snakes. A common misconception about cobras is that they have the ability to 'spit' venom at prey; in reality, the cobra contracts muscles, squeezing the venom gland and forcing venom out of the fangs. This process is similar to jet propulsion because it involves the discharge of a fluid resulting from muscle contraction, but it does not involve the original intake of fluid.

Jet propulsion can be modeled using everyday materials. Ariel Zych describes a project on *Science Friday* that can model the jet propulsion of the squid from a balloon and plastic soda bottle. For more details on how to construct this model, visit http://www.sciencefriday.com/educational-resources/jet-setting-cephalopods/.





B. Class Project (60 minutes)

Please see attached PowerPoint presentation for description of class project.

C. Conclusion (10 minutes)

Discussion Questions:

- Explain the mechanism of jet propulsion.
- What are advantages and disadvantages to this type of locomotion?
- How have humans used the concept of jet propulsion for their own benefit?
- What worked well with the art project? How could it have been improved or made to be more realistic?

Homework:

- Create another way to represent jet propulsion using common household items.
- Explain the concept of jet propulsion to a family member or friend. Together, come up with a list of man-made machines that use jet propulsion.
- What are other techniques of locomotion that humans have mimicked? Explain what technique was mimicked and how.
- What did you like about this lesson on jet propulsion? How does it connect to other lessons we've had in class?
- In your own words, explain biomimicry and the potential it has for technological innovation.

Further Reading:

Live Science Staff. "How Cobras Spit with Perfect Accuracy." *Live Science,* 23 Jan 2009. http://www.livescience.com/7646-cobras-spit-perfect-accuracy.html. Accessed 15 Feb 2017.

Rudman, W.B. "Aplysioidea-swimming." *Sea Slug Forum,* 22 Dec 2004. http://www.seaslugforum.net/find/aplyswim. Accessed 13 Feb 2017.

Simmons, Adam. *Encyclopedia of Adaptations in the Natural World.* ABC-CLIO, LLC, 2010, Santa Barbara, California (68-70).

Zych, Ariel. "Jet-setting Cephalopods." *Science Friday,* 19 June, 2015. http://www.sciencefriday.com/educational-resources/jet-setting-cephalopods/. Accessed 13 Feb 2017.