Squid to System

Model jet propulsion to design and test a fluid device

ZOO.3.8 "Enrichment: Use an engineering design process to model the jet propulsion utilized by cephalopods in mechanical design of fluid systems (e.g., improving hydraulic systems).*"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the squid's actions, circle the device parts that copy them, and number the steps used to test and improve the device. Use your marks to trace how a biological system becomes an engineering model.

A Squid-Inspired Water Jet

1. A squid can dart away from a threat without pushing against a solid surface. Its muscular mantle expands, creating room in the mantle cavity for water to enter around the mantle's edge. The mantle then contracts, squeezing water from the cavity through a funnel. As water shoots backward, the squid moves forward. Turning the funnel changes the direction of the thrust. The cavity stores water briefly, but it does not perform the muscular squeeze. This cycle offers engineers a model of how a flexible chamber can take in fluid and send it out in a controlled direction.

2. Imagine a hand-powered device that sends water through a tube to rinse a clogged screen. An engineer could use a flexible chamber as a stand-in for the mantle and its cavity, with a squeeze acting like mantle contraction. An inlet check valve would let water enter during release but block it during a squeeze. An outlet check valve would let water leave during a squeeze but limit its return during release. A nozzle could aim the exiting stream, like a squid's funnel. Unlike the squid, this device needs added valves to enforce one-way flow through separate paths.

3. To improve this prototype, the engineer first sets a goal: clear more debris from the screen using the same volume of water. The engineer builds two nozzles with different opening sizes, then tests each at the same distance from the screen with equal water volumes and equal squeeze rates. The mass of debris removed provides a measure of success. A smaller opening might create a faster jet, but it can also resist flow, so the result must be measured rather than assumed. If the device clears little debris, the engineer revises its nozzle and repeats the controlled test.

2 ANSWER WITH EVIDENCE

Use the passage

1. When the squid's mantle expands and contracts, what happens to the water in the mantle cavity? How could the flexible chamber copy these actions?

2. Why does the device use an inlet check valve and an outlet check valve?

3. When comparing nozzle sizes, name two conditions the engineer keeps the same and the measurement used to judge success.

4. Why should the engineer test a smaller nozzle instead of assuming it works better? What happens after a poor result?

3 YOUR TURN

Your own words

Design a hand-powered device that lifts pond water into a sample bottle without pulling it back down. In five sentences, explain how squid motion inspires your chamber, describe the water path and a way to prevent backflow, propose a controlled comparison with a measurable outcome, and state how you would revise a design that performs poorly.

Squid to System

PART 1 · READ AND MARK

Underline the squid's actions, circle the device parts that copy them, and number the steps used to test and improve the device. Use your marks to trace how a biological system becomes an engineering model. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	When the squid's mantle expands and contracts, what happens to the water in the mantle cavity? How could the flexible chamber copy these actions?	**Mantle expansion lets water enter the cavity; mantle contraction forces water out through the funnel. Releasing and squeezing the flexible chamber can copy those actions.**
2	Why does the device use an inlet check valve and an outlet check valve?	**The inlet valve admits water during release but blocks its escape during a squeeze. The outlet valve lets water leave during a squeeze but limits its return during release.**
3	When comparing nozzle sizes, name two conditions the engineer keeps the same and the measurement used to judge success.	**The engineer keeps the distance from the screen, water volume, and squeeze rate the same. The mass of debris removed measures success.**
4	Why should the engineer test a smaller nozzle instead of assuming it works better? What happens after a poor result?	**A smaller opening might speed the jet but also resist flow. After a poor result, the engineer revises the nozzle and repeats the controlled test.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would use a flexible chamber that fills when released and pushes pond water out when squeezed, like a squid's expanding and contracting mantle. An inlet tube would carry water from the pond into the chamber, and an outlet tube would carry it to the sample bottle. Check valves in both tubes would prevent water from flowing backward. I would compare two chamber sizes using the same number of squeezes and measure the volume collected in the bottle. If the first chamber delivers too little water, I would try a larger chamber and repeat the test.

Accept designs that accurately connect mantle movement to chamber filling and emptying, prevent backflow, and propose a measurable, controlled test followed by a revision. The mantle moves; the mantle cavity is the space that fills and empties.