Everblue Education

Adaptation in Action: Jumping Copepods

This week's lesson takes students into the microscopic world of tiny planktonic crustaceans called copepods. They will learn about how they move and how they've adapted to their environment, as well as how their environment is shaped by temperature. This lesson is based on a 2014 paper studying three different species of copepods living in the eastern tropical north Pacific Ocean, west of Central America. The researchers looked at the metabolic responses of these copepods to different temperatures and dissolved oxygen levels. Similarly, students will be thinking critically about how temperature might affect how these organisms behave. Anytime you ask questions to better understand how the natural world works, you are doing science! It doesn't take a special kind of person to be a scientist, just exploration and curiosity.

Everblue is a 501(c)(3) nonprofit dedicated to encouraging ocean-conscious living by increasing scientific literacy. Our online education resources connect current science to daily life, allowing you to learn about the ocean at your fingertips! Stay in touch by following @oceanoeverblue on your prefered social media platform or by visiting our website at www.oceaneverblue.org.

To help us keep the ocean ever blue, please share this program with the teachers and parents you know so we can spread ocean science far and wide. Partnering with marine scientists from around the world who study all parts of the ocean, we've created simple and engaging activities based on recently published papers! These activities connect you and your students to current research while fulfilling education standards for reading, math, science, and writing. Even though the activities are created for grade school, they're fun and informative for parents and siblings, as well! More activities will be available to download for FREE off of our website, with a new activity added every Friday until the end of quarantine.

Research Paper: Eucalanoid copepod metabolic rates in the oxygen minimum zone of the eastern tropical north Pacific: Effects of oxygen and temperature. *Christine J. Cass and Kendra L. Daly. 2014.*

Grade Level:	Timing:
Elementary School, Grades 1-5	40 minutes

Materials

- Writing utensils (colors would be fun, but are not essential)
- Two identical clear cups
- One piece of stiff, flat plastic that covers the mouth of your chosen cup (see above)
- Food coloring in two different colors that if mixed would produce a distinctly different third color (Ex - yellow & blue instead of yellow & orange)
- Access to cold and warm water

Next Generation Science Standards

Science & Engineering Practices:	Crosscutting Concepts:	Disciplinary Core Ideas:
Developing & using models Constructing explanations	Cause & effect Patterns	Structure & properties of matter Variation of traits

Activity Overview

Title of Activity	Learning Cycle Stage	Time
Jumping Copepods	Invitation, Exploration	5 minutes
Copepod Adaptations	Concept Invention, Application	10 minutes
Layers in the Ocean	Concept Invention, Application	15 minutes
Reflection	Reflection	5 minutes

Appendix Contents

Appendix I Instructor Support	Appendix II Attached Lesson Materials
Ocean Vocabulary Common Questions	Modeling Differences in Behavior

Activity

Jumping Copepods

This activity is best done outside, and can be done in a backyard or on a quiet street! If neither of these are available to you, go ahead and clear out a space in a room in your home where your students can get active. Then, read the following to your students.

1. Today, we're going to be learning about one of the fastest jumping animals in the *world!* What are some examples of animals you know that like to jump?
    a. *Allow students time to list animals that jump - answers will most likely include land species like frogs, kangaroos, grasshoppers, rabbits, etc.*
2. Let's pretend we are the jumping animals we just named!
    a. *Have students jump around the room impersonating the animals they just named in #1. Allow them a minute or so to play before asking them the next question.*
3. But, all of the animals you just named live on the land. Our jumping animal today actually lives in the ocean! Do you have any guesses for what this animal is?
    a. *Allow students a few moments to guess what kinds of animals in the ocean might move by jumping.*
4. The animal we're learning about today is called a copepod! Let's say that together: CO-pah-pod.
    a. *If your students are familiar with the show "Spongebob Squarepants," read #5. If not, move on to reading #6.*
5. In fact, you already know a copepod! The show "Spongebob Squarepants" was actually created by a marine biologist, and the evil Plankton is drawn to look like a copepod!
6. Copepods are teeny tiny plankton animals that live in the ocean. There are so many of them in the sea that they make up a very important part of the bottom of the food chain!
7. Now, let's learn to jump like copepods! Copepods jump by moving their appendages, or arms, through the water and propelling themselves forward! First, let's practice moving our arms. Bring your arms all the way up in the air above your head, and then on the count of three, lower them in front of your body as fast as you can and back down to your sides! 1… 2… 3!
    a. *Have students practice raising and lowering their arms in front of their bodies (**not** out to their sides like a flying bird) a few times, then move on.*

8. Now, every time a copepod pushes its arms against the water, they move themselves forward. So, let's add a jump! We'll bring our arms up into the air again, but this time, when we lower our arms, we jump! On the count of three, 1… 2… 3!
    a. *Have students practice jumping around the room every time they lower their arms. Make sure they stay still when they are raising their arms, and only jumping when they lower their arms.*
9. But, this is the craziest thing about copepods - they are one of the world's *fastest jumpers!* In fact, if copepods were as big as humans, they could jump the entire length of a football field in a single jump. But, since they are so tiny, we don't see them jump quite as far.
10. Let's watch a short video to see real copepods in action from the Discovery Channel. "World's Fastest Jumper Identified"-https://www.youtube.com/watch?v=Mc4UEUXLov0

Copepod Adaptations

In this activity, students will explore how different types of copepods have adapted, or changed their behavior, to survive in their specific environment. Read the following to your students and guide them through their visualizations if they are unsure of what to draw. *You will need a writing utensil and "Modeling Differences in Behavior" from Appendix II for this activity. If you have multiple participants, you may want to have separate copies of this page for each student.*

1. We just learned that copepods are excellent jumpers like the animals you brainstormed in the very beginning of our first activity. Let's think about those animals a little bit more to help us learn about our copepods.
    a. Did you think of a kangaroo? These animals are great jumpers that live in Australia. Most kangaroos look and act very similarly. This is because wild kangaroos are only found in Australia, so these animals haven't had to change to survive in different habitats.
    b. Was another jumping example a rabbit, bunny, or hare? These fuzzy jumpers live all around the world and can look and behave very differently from each other. Some are very small to hide from predators and some have really large and strong legs that allow them to jump away from predators.
        i. Jackrabbits can "run" up to 40 miles per hour, with each jump moving them ten feet at a time - this is faster than the speed limit in your neighborhood!

        ii. Snowshoe hares have a very unique adaptation that allows their fur to change between white and brown with the seasons - this allows them to blend in with the white snow during the winter and the brown dirt and rocks in their habitat during the warmer months.
    c. Copepods not only have jumping in common with rabbits, bunnies, and hares, but depending on where the different copepods live, they have different adaptations, too!
2. The ocean is very large and very deep. Ocean water is warmer near the surface because it is warmed up by the sun - although it may still feel very cold to us! - and gets colder the deeper the water gets. These warmer and colder temperatures are one reason copepods that live at different depths act differently from each other.
    a. *On your Modeling Differences in Behavior sheet, have your students circle "warmer" next to the shallow ocean water title and circle "colder" next to the deeper ocean water title*
3. When copepods live in warmer water, they are able to be more active than copepods that live in colder water. Let's visualize this difference by drawing on the Modeling Differences in Behavior sheet.
    a. *Have your students draw their representation of the different activity levels in each water temperature, making sure to stay within the boundaries of each box. Students might draw continuous lines showing the animals swimming, or dots, or anything else that makes sense to THEM. Remind the students that the drawings should look different. Students may also choose to use different colors.*
4. When we make models, explaining what they mean to others is an important practice in science.
    a. *Ask your students to explain their drawings. Some sentence frames that might be helpful to guide your student's explanations are:*
        i. I chose to draw ______ because ______. *(If students say "because I wanted to" ask them to explain why they wanted to draw what they did.)*
        ii. A difference between my two drawings is ______. This shows ______ because ______.
        iii. My model is connected to what we are learning because ______.
5. Now, which copepods do you think would need to eat more food to keep up their energy? The copepods in the warmer water, or the colder water?
    a. *Allow the students time here to hypothesize, or make guesses, based on what they know about energy and food.*

6. More active copepods that live in the warm water need a lot of food to give them energy! This food comes in the form of *protein* from eating other planktonic matter. On the other hand, less active copepods that live in cold water don't need a lot of food, and rely instead on reserves of lipids, or fats, in their body for energy. Let's visualize this difference by adding to the Modeling Differences in Behavior sheet. What kinds of foods do you think have a lot of protein in them? What kinds of foods have a lot of fat? But, when drawing, remember - the copepods in the cold environment don't need to eat as much food to sustain their low energy lifestyle, so you don't need to draw as much food for them as you draw for the copepods in the warm environment!
    a. *Have students brainstorm foods high in protein (i.e. meats, fish, beans) and high in fats (i.e. butter, avocado, cheese) and then draw them next to the copepods in the corresponding water temperature. High protein foods should be drawn in the warmer water, while high fat foods should be drawn in the colder water.*
7. Copepods not only have cool adaptations for water temperature - they can also adapt to the amount of oxygen in the water! We get oxygen by breathing air to survive, and copepods get oxygen from the water to survive, too. There are some areas in the ocean called oxygen minimum zones, or OMZs, where the oxygen content of the water is very low. This can happen naturally, by lots of animals using it up, or unnaturally, by climate change. *(See the "Common Questions" section of Appendix I if you are curious how this happens.)*
8. Copepods that are slower and only need a little bit of fat to eat are very well adapted to living in places with low oxygen! Let's hypothesize - of the colder water and warmer water copepods, which do you think could survive in low oxygen environments?
    a. *Hopefully, the students will use their knowledge from the previous drawing to come to the conclusion that the colder water copepods could do well in low oxygen environments. If not, gently help lead them to that conclusion.*
9. The copepods in colder water could probably live in low oxygen! Now, let's visualize this difference by adding to our Modeling Differences in Behavior sheet. The sign for oxygen is "O2," so write some "O2s" in the warm water box. Now, your copepods are happy in their ocean zones!

Layers in the Ocean

In this activity, students will explore some of the physical properties of water which affect the copepods' habitat. For this activity, you will need two identical clear glasses, hot and cold water, a piece of stiff, clear plastic large enough to cover the tops of your glasses, and food dye in two different colors (the colors you choose don't really matter, as long as they are distinct, i.e. yellow and blue would be better choices than yellow and orange). Read the following to your students as you go through the activity. Students can help with parts of this activity, however some parts may be too challenging for younger students; these steps are **highlighted in bold**. Notes to you, the teacher, are *written in italics*. As this activity can be a little messy, it is best done either over a rimmed cookie sheet or in a sink or bathtub.

1. As we learned in our last activity, copepods that live at different depths in the ocean have different adaptations. Now let's take a closer look at these different areas of the ocean and how temperature plays a big role in creating different habitat types. We also learned that the top part of the ocean is warmer because it is warmed by the sun while the deeper parts are colder because less sunlight can get down deep through the water to warm it up. Now we're going to model what that looks like in the ocean!
    a. Fill one glass with hot water *(not boiling or hot enough to burn, but still very warm)* and another with very cold water, so that both glasses are overfull and there is a dome of water extending above the surface.
    b. Add a different color of food dye to each glass and carefully mix *(if water spills out, top off the glasses with the appropriate temperature of water).*
    c. Place the piece of plastic on top of the WARM glass of water *(some water will spill out; that's ok)*.
    d. Keeping one hand on the piece of plastic, flip the cup of warm water upside down. Gently remove your hand (the air pressure from the room will keep the plastic in place!) and set the warm glass on top of the cold glass. Carefully align the rims of the two glasses and slowly slide the piece of plastic out from between them.
2. Ask your student the following discussion questions:
    a. What do you observe?
    (Note - There should be a small amount of mixing where the two liquids meet at first, but it should quickly become an obvious line between the two.)
    b. The food dye lets us see that the warm water is not mixing in with the cold water below. Why do you think the water does not mix?
3. Warm water is lighter than cold water so it stays near the top and won't mix with the denser cold water, just like we see here! But what if a storm came along and cooled the surface of the water so that it was colder than the deeper water underneath?
    a. Repeat steps 1a. & 1b.

   b. Place the piece of plastic on top of the COLD glass of water.
   c. **Keeping one hand on the piece of plastic, flip the cup of cold water upside down. Gently remove your hand and set the cold glass on top of the warm glass. Carefully align the rims of the two glasses and slowly slide the piece of plastic out from between them.**
4. Discuss the following with your students:
   a. What do you observe?
   (This time, the two liquids should quickly mix completely, becoming purple throughout.)
   b. Why do you think we see the cold water mixing with the warm water this time when we didn't before? *Encourage students to try to give their own explanations before reading on.*

Because the colder, denser, heavier water was on top this time, it sank into the warmer, lighter water below it. As the cold water mixes with the warm water, they make lukewarm water, so we don't see the cold water settle under the warm water. This is important in the ocean! The differences in temperature and density create different kinds of habitats for animals to adapt to fit. For teeny tiny animals like our friends the copepods, the temperature outside their bodies can make a big difference in what happens inside their bodies.

Note: if the experiment didn't work out as planned, check out this short video from BeardedScienceGuy! Even if your experiment did work as planned, we would still suggest watching the video to see a thermal camera's view of the water interactions.

"Hot vs. Cold Water Experiment" - https://www.youtube.com/watch?v=H0xB15fNzHc

Reflection

As you and your student are cleaning up, talk to your student about what you just did together. Here are some guiding questions to help shape your conversation.

- ➢ What was your favorite part of our activity today?
- ➢ What is something that you learned about the ocean?
- ➢ Did you notice any patterns during our activity today?
- ➢ What is something you wonder about copepods or the layers in the ocean?
- ➢ What surprised you the most during our activity today?

Appendix I - Instructor Support

Ocean Vocabulary

- `Adaptation` - the process by which a species becomes fitted to its environment; it is the result of natural selection's acting upon heritable variation over several generations.
- `Appendage` - an external body part, that protrudes from an organism's body, such as arms and legs
- `Copepod` - Very small crustaceans (related to crabs and lobsters) that live in freshwater and saltwater environments. They are very common and important food for other marine animals!
- `Density` - the amount of matter in a given volume. If an object is heavy but only takes up little space, it has a high density.
- `Habitat` - place where an organism or a community of organisms lives, including all living and nonliving factors or conditions of the surrounding environment
- `Metabolic` - Relating to an organism's metabolism, or the rate at which an organism uses energy
- `Molecule` - A group of atoms bonded together, representing the smallest fundamental unit of a chemical compound that can take part in a chemical reaction. For example, a molecule of water is composed of one atom of oxygen bonded to two atoms of hydrogen
- `Oxygen minimum zone` - Zones in the ocean defined by very low levels of oxygen in the water.
- `Plankton` - Any organism that cannot swim against the current. This includes both phytoplankton and zooplankton. The important part is that plankton are "drifters" since they cannot swim against a current like fish.

Common Questions

Why is warm water lighter than cold water?

It has to do with something called density. Density means how close together or far apart things are in a given volume. For example, if there are two balloons of the same volume and one is filled with air while the other is filled with water, the water balloon will obviously be much heavier than the air balloon. That is because there are many more water molecules than air molecules in their respective balloons. In fact, water is almost 800 times more dense than air! This is why an air balloon floats in water. The same phenomenon can be observed with water of different temperatures, as we saw in the

"Layers in the Ocean" activity. When water is cold, it's molecules are very close together, but as it gets warmer those molecules gain energy and start to vibrate more, causing them to spread out from each other, making warm water less dense than cold water. Because the molecules are further apart, warm water is lighter than cold water so it stays near the top and won't mix with the denser cold water.

If warm water is lighter than cold water, why does ice float?

Usually solids are heavier than liquids (which are heavier than gases). However, water is an exception! When water (a liquid) freezes into ice (a solid), the ice is even lighter than warm water. The water particles, called molecules, are spaced and secured in a crystal structure. This means that the water molecules in ice are further apart than the water molecules in a liquid form. This difference in molecule spacing is called density.

Are there only two layers in the ocean?

No! There are many, many different layers in the ocean that are constantly moving. The water on the west coast of the United States was near Greenland hundreds of years ago before it sank and traveled all around the world at different depths, moving kind of like a conveyor belt. Lots of factors contribute to the layers in the ocean. We explored temperature in this activity, but salinity (the amount of salt dissolved in water) also has a big effect on water density. In places with lots of rain, a thin layer of fresh water forms on the ocean's surface.

What causes oxygen minimum zones (OMZs)?

Oxygen minimum zones are regions in the ocean where levels of oxygen are very low. Almost all life uses oxygen to convert food into fuel, so OMZs are harsh places to live. Oxygen in the ocean is produced by plant-like algae and phytoplankton through photosynthesis (a process that uses CO_2 and sunlight). This oxygen is used by other living things and gets depleted in deep waters far from the sun (where photosynthesis is impossible). One way that humans can cause OMZs is through agriculture. When fertilizers used on crops get into streams, they eventually reach the ocean where the nutrients cause a large phytoplankton bloom. When they die and decompose, oxygen is depleted rapidly, causing a dead zone. OMZs can also be exacerbated through global warming, because as the temperature of the surface waters warm, there is less mixing of ocean water, since the warm layers stay on top. This creates a greater stratification of already-existing layers like the OMZs.

Appendix II - Attached Lesson Materials

Modeling Differences in Behavior

Shallow ocean water	Circle: warmer or colder
Deeper ocean water	Circle: warmer or colder