Everblue Education

Swimming Salps

In this lesson, students will be getting physically and mentally active! As weather starts warming and clearing up, feel free to take this lesson outdoors. If there is not a safe outdoor space for you to run around in, this activity is fully functional inside. This lesson provides students with opportunities to think critically, explore different ways of modeling information, and develop the math skills that professional ocean scientists use in their research. Anytime you use these methods to ask and answer questions, 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 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.

Grade Level:	Timing:
K-8	43 - 75 minutes

Materials:

- Many (30-50) small, round objects (e.g. cotton balls)
- A few (3-5) medium, round objects (e.g. tennis balls)
- Something to write down numbers or write out math problems

Research Papers

Comparative jet wake structure and swimming performance of salps. *Kelly R. Sutherland and Laurence P. Madin. 2010.*
A comparison of filtration rates among pelagic tunicates using kinematic measurements. *Kelly R. Sutherland and Laurence P. Madin. 2009.*
Filtration of submicrometer particles by pelagic tunicates. *Kelly R. Sutherland et al. 2010.*

Common Core State Standards

Math:
Analyzing & interpreting data
Measurement & data
Operations & algebraic thinking

Next Generation Science Standards

Science & Engineering Practices:	Crosscutting Concepts:	Disciplinary Core Ideas:
Analyzing & interpreting data Using mathematics & computational thinking Using models	Cause & effect Patterns Structure & function	Organization for matter & energy flow in organisms

Lesson Overview

Title of Activity	Learning Cycle Stage	Time
Warm-up	Invitation, Exploration	5 minutes
Meet the Salps	Concept Invention	5 minutes
Swimming like a salp	Concept Invention, Application	15-30 minutes
Eating like a salp	Concept Invention, Application	15-30 minutes
Reflection	Reflection	3-5 minutes

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Swimming Salps Lesson

Warm-up

For this activity, students will explore different ways that their bodies can expand and contract to prepare them to get moving and learning about salps!

1. First, have your students stand in an area where they can freely move without fear of knocking things down. If the weather is nice, take them outside for a little time in the sun!
2. You can either read the following to your students, or do the actions along with them:
    a. Put your hands on your ribs and feel the bones of your ribs underneath your hands. Keep your hands there as you take a few deep breaths, noticing how your body moves.
    b. Try placing your hands in different places each time you take a breath and notice if different parts of your ribs move more than others when you breathe.
    c. Now, wrap your arms around your ribs and give yourself a big hug. With your arms around your ribs, take a big breath in, and a big breath out. Do you feel anything similar to your first deep breaths? Anything different?
    d. Did you feel your ribs expand, or get larger, when you inhaled? Try it again.
    e. Did you feel your ribs contract, or get smaller, when you exhaled? Try it again.
    f. Now, imagine that you are an ocean creature. With every inhale, you are sucking water into your body and spitting that water back into the ocean with every exhale. This is how the sea creature we are learning about in this lesson both moves and eats - today we are going to be learning about salps!

Meet the Salps

It's time to meet the salps! Read the following to your students as you both look at the images of your new friends. The definitions of the blue vocabulary words can be found in Appendix I.

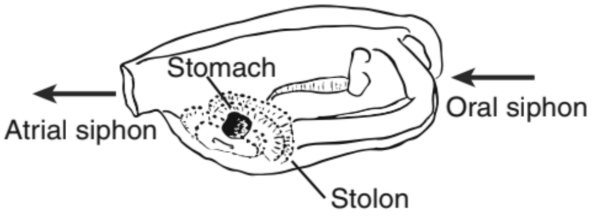
Image 1: A solitary salp. *Sutherland & Madin, 2009.*

A salp is a squishy animal that lives in the open ocean. Scientists call the open ocean the "pelagic zone." Salps have two stages: the solitary stage (Image 1), where the salp floats alone, and the colony stage (Image 2), where the salps stick together forming a salp chain.

Even though salps look squishy like jellyfish, they are actually one of our closest invertebrate relatives! (Remember that we learned that invertebrates are animals without backbones in Everblue's "Tropical Reef Communities" lesson.) This is because salps have a spinal cord as babies, but lose it when they become adults. Because of their baby spinal cords, salps are called chordates.

Image 2: A colony of salp forming a salp chain. *Sutherland & Madin, 2009.*

Image 3: Labeled diagram of a salp. *Sutherland & Madin, 2009.*



Salps eat by filter feeding. This means they suck water into the middle of their barrel-shaped bodies, filter out the yummy bacteria and plankton through a sticky mucous net, and spit out the rest of the water! When you did your breathing in our warm-up, your breath came in and out of your body through one opening: your mouth or nose.

Salps have two openings called siphons. One siphon is at the front of their body and one is at the back. In Image 3, the oral siphon is the front siphon and the atrial siphon is the back siphon. Remember when you felt how your body expands and contracts when you breathed deeply? The movement of getting bigger sucks in water through the front siphon and the movement of getting smaller spits out the water through the back siphon. Because they eat mostly plant-like phytoplankton, they are known as grazers of the open sea, just like a cow is a grazer of an open field.

Swimming like a salp

In this activity, students will model how salps swim and why some salps swim faster than others!

Swimming Model 1

In this model, students will explore how salps swim. To model how salps swim using student hands, read your students the following and have them do the corresponding motions. Feel free to do the motions too.

1. First, make the shape of an "O" with your hands in front of you by overlapping your thumbs at the bottom and other fingers at the top. Imagine that this "O" is your very own salp, with its front siphon pointing away from you, and its back siphon pointing towards you.
2. Salps swim by taking water in and out through their siphons, just like our inhales and exhales that we did in our earlier breathing exercises! Each time they bring water into their bodies, they open their siphon wide. So, open your "O"! Whenever you open your "O," breathe in and stay standing in the same place to suck in the imaginary water and filter out your food.
3. Whenever you close your "O," breathe out and take one step forward! This is because you create a little water jet that pushes you forward as you spit out the extra water. This type of movement is called jet propulsion, and it is how salps swim!
4. Practice walking around the room by taking one step at a time every time you close your "O" and breathe out. Remember that you have to stay still when your "O" is open to take in water and filter feed!

Swimming Model 2

In this model, students will learn why some salps swim faster than others! To start, clear a large area for students to run in. (This activity works best outside, but can work indoors if the weather is poor.) Scatter small "food" items (e.g. cotton balls) all over the ground, so that the entire space is filled with food. Once your activity space is ready, read the following information to your students:

1. Have the students line up on one side of the yard or room and run in a straight line to the other side. They are going to model how the thickness of a salp's body affects how fast it can swim.
2. First, you will be a salp with a thick body. Your muscle bands are very strong! (Have the students strike a pose to show off their strong salp muscles.) Since you have such strong muscle bands, you can pump water very quickly, so you are a fast swimmer. Let's swim like salps with thick bodies - run in a straight line to the other side of your activity space!
    a. Note - You do not need to pause every breath or use your hand-salp. Just run!

3. Wow, you are fast! However, since you are a fast swimmer, you need a *lot* of food to give you energy. This time, as you run straight across the activity space, you have to gather food from the ground as you go!
4. Have the students count their food after running across the room. They should have quite a lot, but they shouldn't have been able to pick up all the food on the ground. Have your students set the food that they collected in a pile off to the side, and leave the remaining food on the ground.
    a. Note - If most of the food was eaten by this salp with a thick body, write down the number of food items before redistributing them in the activity space.
5. Next, you will be a salp with a thin body. Your muscle bands aren't quite so strong, so you're a much slower swimmer. Since you swim slower than the first salp, it is harder for you to move through the water. This is called "drag".
6. To demonstrate drag as the students run as salps with thin bodies, pair them up. (If there are not enough students, pair them with a sibling or a parent.) Have one person hold onto the shirt or back of the runner, and then have them run straight across the room again.
7. That was a little different than the first salp, wasn't it? The good news is, since you're not as strong of a swimmer, you don't need as much energy from food. This time, as you run straight across the room with your drag slowing you down, pick up whatever food you can, but don't let it slow you down from reaching the other side.
8. Have the students count their food after running across the room with their drag in tow. They should have much less than the first time, when they were running without drag. Put this food in a separate pile next to the pile collected by the faster, thicker salp.
9. Compare the number of food items collected by the two different salps. Students can move the collected food items to help them visualize their math.
    a. Which salp ate more food? You can compare numbers with subtraction. This math compares two similar types of things, like the amount of food eaten by each type of salp.
        i. Subtract the number of items collected by the salp with a thin body from the number of items collected by the salp with a thick body.
            1. Hint -
                a. Recount the number of items in the second pile, the food items collected by the salp with a thin body. Remember this number or write it down.
                b. Move this number of items from the first pile, the food items collected by the salp with a thick body, into a smaller pile next to it.
                c. Now count how many items are left in the original pile of food items collected by the salp with a thick body.

2. Note - Put the thicker salp pile back together before your next comparison.

b. How much did the salps eat while swimming across the activity space? You can compare with division, too. This math makes numbers smaller so we can compare the numbers in groups, like how much food is eaten in a certain amount of space.
    i. NOTE - If you have a student who is learning how to divide, they can make equal piles by alternating which pile they are adding items to. Students can also make a prediction of what the number will be before sorting their items into their piles and checking their guess.
    ii. Make sure your piles of food items collected by the salps with different bodies are put back together after your subtraction so you only have the two piles.
    iii. Measure your activity space by having you or your students walk across the space in a straight line, counting every step. These can be big steps or small steps! Write down the number of steps you counted.
    iv. Recount how many food items are in each pile and write down your numbers if you haven't already. These numbers are how many food items each salp ate while swimming across your activity space.
    v. Divide the number of food items collected by each salp by two and write down your numbers. These numbers are an estimation (a guess) of how many food items each animal ate in half of the activity space. How many steps would that be?
        1. Hint -
            a. For each pile of food items (thicker salp and thinner salp), create two smaller piles with the same number of items in them.
                i. Example: If the original pile had six items, the two smaller piles would each have three.
            b. Count how many items are in one of the two smaller piles of food items collected by the salp with a thick body. Remember this number or write it down.
            c. Count how many items are in one of the two smaller piles of food items collected by the salp with a thin body. Remember this number or write it down.
    vi. If your students are enjoying comparing their numbers with division, continue to explore this skill by dividing the piles of food items collected by the two salps by other numbers. Remember to divide your step measurement to know the amount of space the food was collected in.

10. Activity review:
    a. Did you gather more food as a fast swimming salp or a slower swimming salp? Why do you think so?
    b. Why would a faster swimming salp need more food? (can make a comparison to how hungry they feel when they spend a day running and playing vs a day when they're inside not doing much).
11. Take home message (if students are struggling to answer the review questions, read the following information):

As a slower swimming salp, you couldn't filter as much food, but you didn't need as much food as the faster swimming salp that uses more energy! This is how the salps have come up with a way to make sure they have enough food energy for their body plan; faster swimming salps can filter feed more than slower swimming salps.

Eating like a salp

In this activity, students will learn more about how salps eat by filter feeding and where they get their main source of energy. They will model how salps move and eat, why salps eat what they do, and compare salps to other sea creatures who also filter feed.

Filter Feeding Model 1

Our first model helps students visualize how salps move and eat, using their hand-salps from earlier. To model how salps filter feed with their hands, read your students the following and have them do the corresponding motions. Feel free to do the motions too.

1. Salps are pretty special, because the same movement that allows them to swim allows them to eat, as well! Create your hand-salp by making the shape of an "O" with your hands in front of you, overlapping your thumbs at the bottom and other fingers at the top. Remember that the front siphon is pointing away from you, and its back siphon is pointing towards you.
2. Salps filter feed by taking water in and out through their siphons, just like our inhales and exhales that we did in our earlier breathing exercises! Each time they bring water into their bodies, they open their siphon wide. So, open your "O"!
3. Imagine that when you open your "O," the water that you suck in is filled with yummy plankton. Using your salp mucous net, you capture all this yummy food, but then you need to spit out the extra water. To get rid of the water, close your "O" by pinching your fingers together!
4. Practice "eating" with your hand-salp by opening and closing your "O."

Filter Feeding Model 2

Our second model will let students experience filter feeding and learn more about why salps eat what they do. To start, scatter a bunch of small items of two sizes (e.g. cotton balls and tennis balls) with many more (~10x more) cotton balls within a defined area, to represent the available food in the water. Then, read the following directions to your students:

1. In this model, you are a salp in the open ocean! All of the items on the ground are your food. The small items are phytoplankton, which make up the base of the food chain. The large items are zooplankton. You eat both of these items by filter feeding through your mucous net.
2. Hold up the bottom of your shirt like a fabric basket to make your mucous net! On the count of three, you have 20 seconds to collect as much food as you can (of both sizes), but you can *only* collect it in your net. Are you ready?
    a. If there is only one student, have them compete against the time limit.
    b. If there is more than one student, have them compete to see who can pick up the most "food."
3. When the time limit is up, compare how many small and large items they collected.
    a. Note - The students should have many more small items than large ones.
4. As a floating salp, the zooplankton might be bigger, and more nutritious to eat, but there are *many* more phytoplankton to be eaten! This is why scientists think you salps get your main source of energy from very tiny foods.

Filter Feeding Model 3

In this model, students will learn why salps are so important in the ocean food web: they are very efficient filter feeders! To start, re-scatter your small and large "food" items.

1. Get as many people involved in this activity as possible: students, parents, and siblings! Then, assign each person a role. Each role has a different maximum amount of food they can pick up at any given time. Alternatively, the students can play three rounds, each round spent as a different role.
    a. All of the students will be solitary salps. Salps can pick up **ten** pieces of food in their mucous net at a time.
    b. Any siblings participating will be krill. Krill are small filter-feeding relatives of shrimp. Krill can pick up **five** pieces of food at a time, but do not have a mucous net, so they must hold the food pieces in their hands.
    c. Any parents participating will be larvaceans. Larvaceans are filter-feeders that are closely related to salps, but are smaller than salps. They live in a 'house' made of mucous! Larvaceans can pick up **three** pieces of food in their mucous net at a time.

2. After assigning roles, have each person pick a “home base” well outside of the area where the “food” has been scattered. Home bases can be chairs, tables, etc.
3. Each person will start at their home base. On the count of three, we will have 20 seconds to collect as much food as possible, but remember the specific rules for your animals! Salps can pick up ten pieces in their shirt-net, krill can pick up five pieces but must hold the food in their hands, and larvaceans can pick up three pieces in their shirt-net. Once a person is holding as many pieces of “food” as their animal can hold, run back to your home base and deposit it before going to get more!
4. On the count of three, have students, siblings, and parents grab as many of the items (of both sizes) as they can within 20 seconds, running back and forth to their home base.
5. When the time limit is up, have them count how many items they collected, keeping the food items collected by each animal in their own specific pile or area.
    a. The students (salps) should have much more food than the others.
    b. The parents (larvaceans) and siblings (krill) should have much less food than the students.
6. Which animal ate more food? Compare the number of food items collected by each animal. Students can move the collected food items to help them visualize their math.
    a. Did salps eat more than the other creatures? You can compare numbers with subtraction. This math compares two similar types of things, like the amount of food eaten by each animal.
        i. Subtract the number of items collected by the krill from the number of items collected by the salps.
            1. Hint -
                a. Recount the number of items in the krill pile.
                b. Move that number of items from the salp pile into a smaller pile right next to the salp pile.
                c. Now count how many items are left in the original pile. Remember this number or write it down.
            2. Note - Put the salp pile back together before comparing the larvaceans to the salps.
        ii. Subtract the number of items collected by the larvaceans from the number of items collected by the salps.
            1. Hint -
                a. Recount the number of items in the larvacean pile.
                b. Move that number of items from the salp pile into a smaller pile right next to the salp pile.
                c. Now count how many items are left in the original pile. Remember this number or write it down.

iii. Ask your students some questions to help them think about what their math means:
    1. Which difference is bigger?
    2. If the difference between this animal and the salps is bigger than the other difference, did this animal eat the least amount of food or did the other animal eat the least?

b. You can compare numbers with division. This math makes numbers smaller so we can compare the numbers in groups, like how much food is eaten in a certain amount of time.
    i. NOTE - If you have a student who is learning how to divide, they can make equal piles by alternating which pile they are adding items to. Students can also make a prediction of what the number will be before sorting their items into their piles and checking their guess.
    ii. Make sure your salp, krill, and larvacean piles are each put back together after your subtraction so you only have the three piles.
    iii. Recount how many food items are in each pile and write down your numbers. These numbers are how many food items each animal ate in twenty seconds.
    iv. Divide the number of food items collected by each animal by two and write down your numbers. These numbers are an estimation (a guess) of how many food items each animal ate in ten seconds, because twenty seconds divided by two is ten seconds.
        1. Hint -
            a. For each pile of food items (salp, krill, and larvacean), create two smaller piles with the same number of items in them.
                i. Example: If the original pile had six items, the two smaller piles would each have three.
            b. Count how many items are in one of the two smaller salp piles. Remember this number or write it down.
            c. Count how many items are in one of the two smaller krill piles. Remember this number or write it down.
            d. Count how many items are in one of the two smaller larvacean piles. Remember this number or write it down.
    v. If your students are enjoying comparing their numbers with division, continue to explore this skill by dividing piles by other numbers.

7. Activity review:
    a. How do the salps, krill, and larvaceans gather food differently?
    b. Why do salps eat more food than other filter feeders in the same amount of time?

8. Take home message (if students are struggling to answer the review questions, read the following information):
    a. The siphons in salps move a lot of water through their bodies and their mucus net captures most of the tiny food particles that are floating in the water. These structures allow the salps to eat much more food than other filter feeders can in the same amount of time. Krill move the ocean water with their legs to bring food closer to them, but they don't have a mucous net like salps to trap it all. Larvaceans do have a mucous net, but instead of using siphons like the salps, they live in a house made of mucous. Larvaceans use their tail to move the water and food towards them, like the krill's legs, and this moves much less water than the salp siphons. This is why scientists think salps are so important in the ocean food chain - they are very efficient eaters! They are able to eat more than other filter feeders, which gives more nutrients to the next organism in the food chain.

Reflection

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

- What was your favorite part from our activities today?
- What is something that you learned about these animals?
- Did you notice any patterns during our activities today?
- What are you wondering about after our different models of feeding and swimming?
- What surprised you the most during our activities today?
- How do you think our models were most like what really happens in the ocean?
- What do you think was the silliest model, and not like what really happens in the ocean?
- Why? (Follow up any answer you want them to think about more)

Appendix I - Instructor Support

Ocean vocabulary

- Chordate - Members of the phylum *Chordata,* these invertebrates have a notochord (similar to a spinal cord) at some time in their life cycle, but do not have a true backbone.
- Colony - An aggregation or group of connected individuals. Often colonies function as a single living being, feeding and moving together.
- Filter feeding - A special mechanism of feeding used by many marine animals to filter small food particles from the surrounding seawater.
- Grazer - An animal that feeds on plants and plant-like organisms at the bottom of the food chain.
- Invertebrate - Any animal that does not have a backbone, including corals, crabs, jellyfish, salps, and insects
- Mucous net - A sticky sieve, produced inside the salp, used to trap plankton and other food particles for the salp to eat.
- Pelagic zone - An area including the water column of the open ocean.
- Phytoplankton - Tiny plant-like plankton that photosynthesize just like land plants. This category of plankton makes up the base of the ocean food chain, and is a very important food source for the rest of the life in the sea.
- 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.
- Salp - A gelatinous, pelagic tunicate (see definition below) that swims by jet propulsion and eats using filter feeding with a mucous net.
- Salp chain - A colony of salp clones.
- Siphon - Openings in the tunicate body plan that allow water to enter and exit the body for filter feeding.
- Tunicate - A type of chordate, including the salps, larvaceans, and sea squirts. Tunicates are characterized by a soft outer body called a "tunic," and filter feed using siphons and a mucous net.
- Zooplankton - The prefix "zoo" refers to animals, so zooplankton are animal plankton. Zooplankton can be very tiny, like baby invertebrate larvae, or very large, like a lion's mane jellyfish. Unlike phytoplankton (plant-like plankton), zooplankton cannot photosynthesize, so they have to get their energy from eating smaller plants and animals. Salps are an example of zooplankton!

Common Questions

Are salps jellyfish?

The term "jellyfish" generally refers to the medusa stage of members of the phylum Cnidaria. These medusa jellyfish have a gelatinous bell and long, trailing tentacles covered in stinging cells used to immobilize their prey. Salps are also gelatinous, but do not have stinging cells. Instead, they use an internal mucous net to filter microscopic prey from the water. So, salps are not jellyfish, but are typically grouped into the same broad category of "gelatinous zooplankton" (gelatinous = made of jelly; zoo = animal; plankton = drifter).

Can plankton swim?

The term "plankton" refers to a broad range of organisms (plants, animals, protists, and bacteria) that cannot swim strongly enough to overcome ocean currents, and so drift around wherever the current takes them. However, just because they are weak swimmers doesn't mean that they can't swim at all! These organisms **do** have the ability to move themselves around in the water, but if there is a current they are not able to swim against it.

Appendix II - Supplemental Materials

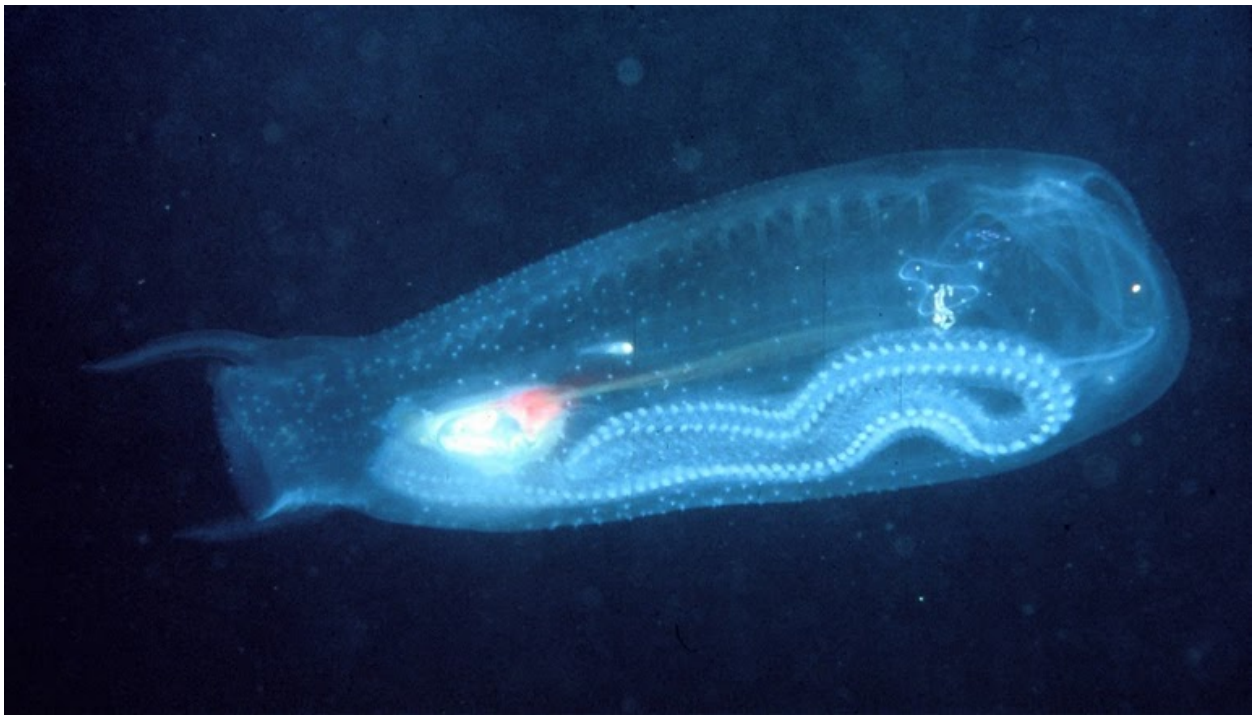
Salp videos:

1. Watch members of a salp chain swim together! Each salp contracts to squirt out water and propel the colony forward. This is jet propulsion in action! The green stuff is a fluorescent dye used to see fluid motion https://youtu.be/BYE2uZoSrCw (Video by Dr. Kelly Sutherland and Daniel Weihs)

2. See how a solitary salp swims: https://figshare.com/articles/W_cylinidrca_solitary_from_Hydrodynamic_advantages_of_swimming_by_salp_chains/5212687 (Video by Dr. Kelly Sutherland)

Salp photograph:

1. The twin sailed salp - *Thetys vagina*



(Lovell and Libby Langstroth © California Academy of Sciences)