PLANKTON

Lesson Plans

A CURRICULUM IN MARINE SCIENCES

CAN BE MODIFIED FOR GRADES 4 - 12

UNIVERSITY OF CALIFORNIA, LOS ANGELES
MARINE SCIENCE CENTER

revised for UCLA OceanGLOBE, 4/03

PLANKTON LESSONS

Note: Activities in this lesson package are enhanced by using the UCLA OceanGLOBE Plankton Guide Booklet. Download from:

http://www.msc.ucla.edu/oceanglobe/pdf/guide_plankton1.pdf

Introduction to Plankton

Plankton is a word derived from Greek for “drifters”. It refers to all the plants and animals that drift with the ocean currents as inhabitants of the open waters of the sea (and also fresh waters; but our concern here is with marine environments). Zooplankton, the planktonic animals, are all weak swimmers, whereas phytoplankton, planktonic plants, do not swim at all. Plankton have traditionally been distinguished from nekton, those animals which swim rapidly and migrate where they choose, irrespective of the directions of the currents, e.g. fish, squid, marine mammals, and sea turtles. In the open sea everything must float, swim, or sink. The only physical objects that can remain near the surface without floating are living organisms. For living plants and animals, there are only a few ways to remain near the surface in safety. This is because in open water there is no cover, no trees or rocks behind which they can hide.

Phytoplankton always live near the surface of the sea because, like all plants, they require light for photosynthesis, the transformation of water and carbon dioxide into short chain sugars. Unlike terrestrial plants that must counteract gravity to reach toward the sun, with strong trunks, branching stems and large leaves, the plants in the pelagic zone are exceptionally small, microscopic, and single-celled, buoyantly supported by the density of the surrounding water. Plants, of course, do not have muscle tissues, and so they cannot swim like oceanic animals. But without special adaptations of some type, these tiny plants would necessarily eventually either sink to the bottom and die. Plants can remain near the surface only if they are almost neutrally buoyant. Small objects weight less than large ones. Small objects have a large surface area in relation to their volume. And since phytoplankton are very small objects indeed, often only 1/1000th of a millimeter in diameter, they don’t weigh very much and they have a very large surface area/volume ratio. Small objects and phytoplankton, therefore, sink slowly because they don’t weigh very much and because they have a large surface area in contact with water, which is far stickier than air. Interestingly, some of the very smallest plants, the dinoflagellates, have tiny motile, tail-like appendages, called flagella, that propel the single-celled plant slowly through the water. Because the cells sink very slowly, equally slow swimming speeds can maintain these plants near the surface. Other types of cells change their buoyancy by manufacturing light-weight oils when they sink too deep. Since oil floats, the positively buoyant cell now floats slowly back toward the surface.

Phytoplankton also remain near the surface because the surface waters of the open sea and large lakes are regularly mixed each day by the wind. The sun brings light for photosynthesis to the water surface but it also brings heat, and the warm surface waters float above the denser and colder deeper water mass. The transition between these two bodies of water, where the temperature changes abruptly, is called the thermocline. When the wind blows, it mixes the surface waters but only down to the thermocline. There the density difference is sufficiently strong to resist further mixing, and so the heat accumulates mostly near the surface. The waters above the thermocline mix completely each day, from the surface to depths of 10 to 100 meters. But single celled plants sink at rates of only a few meters each day, and so even though some kinds of phytoplankton, such as diatoms, sink inexorably toward the bottom, they are mixed at greater distances and more rapid speeds throughout the upper water column by the wind each day, far faster than they can ever sink.

Miniature, almost invisible planktonic animals, the zooplankton, eat these tiny plant cells. We can not see most zooplankton without a microscope. At sea or in a large lake at the surface during the day, when we look down into the water from shore or from a small boat, we generally do not see anything at all in the clear, blue surface waters. Yet when we drag a fine plankton net through the water behind the boat and carefully examine the catch in a clear glass jar we see thousands of tiny animals darting about within the jar.

Most of these animals are less than about a millimeter long, less than 1/16 th of an inch, and most are quite transparent. They are called “net zooplankton” because we can only investigate them by the use of plankton nets. Individually these animals are difficult to see in the sea or in the lake because our eyes cannot easily resolve individual spots smaller than about one millimeter, yet when crowded together in the collecting jar of the plankton net these planktonic animals are collectively visible as a cloudy, milling mix of tiny creatures. Small size is an important survival strategy in the open sea because many pelagic predators are visual predators with eyes much like our own. If we can not see these tiny animals, then predatory fish probably can not see them either!

We examine our catch of net plankton carefully under the lens of a microscope or magnifying glass, and we see now that not only are there thousands of tiny animals but also there are many different types of animals, with strange shapes and appendages. Some of the most common are clearly tiny crustaceans, darting copepods with long antennae but with shrimp-like legs. Other recognizable animals are tiny jellyfish, rapidly beating their transparent bells. Tiny clams lie quietly on the bottom of the dish but then they suddenly open their valves and dart off into the water. Other animals are unlike anything that we have ever seen before, strange creatures that live only in the plankton, like arrow worms and radiolarians, and we are amazed and yet perplexed by the diversity of so many different types of such tiny animals all living in such clear water, apparently devoid of living things.

Other kinds of zooplankton also occur at the surface of the sea during the day…the gelatinous zooplankton. This is an assemblage of much larger animals than we captured in our nets, consisting of large jellyfish, planktonic, transparent snails, comb jellies, large arrow worms, and pelagic tunicates, like salps and appendicularians. All of these animals are transparent, soft bodied, and delicate, with the consistency of jello. Many scientists refer to this group of animals as “jello-plankton”. Gelatinous zooplankton are fairly large animals, from centimeters to even meters in diameter (1/2 inch to 6 feet) for the largest jellyfish. They do not swim rapidly but remain buoyant despite large size because the mixture of salts in their gelatinous tissue is lighter than the weight of the salt in the seawater within which they swim. Gelatinous zooplankton almost never occur in freshwater habitats because in the absence of salts they cannot regulate their buoyancy to remain up in the water column. At sea gelatinous zooplankton are both important predators (jellyfish and comb jellies) and filter-feeding herbivores (pelagic tunicates), and they can have an enormous impact on the food webs of the sea. Historically these animals were difficult to study because their delicate tissues were invariably damaged by nets. During the past 20 years, however, gelatinous zooplankton have been investigated extensively by scuba divers who hand-collect animal at sea, capturing perfect, undamaged specimens one at a time in individual jars that are then transported back to the laboratory aquarium for study. Gelatinous zooplankton are also difficult to study because they are hard to see within the sunlit waters of the open sea because of their transparency, which provides important protection from visual predators in the open sea.

At night larger herbivores and carnivores migrate up to the surface to feed. In the dark they cannot be seen by their even much larger predators, so they can feed in relative safety near the surface at night. Ultimately all of the food in the sea comes from the surface waters where the planktonic plants live, and it makes sense to come to the surface because that is where the food is located. But at dawn, light once again penetrates the surface, the migratory animals become visible, so they migrate swiftly down into the permanent dark of the deep during daylight hours for protection. This periodic vertical swimming behavior therefore occurs twice a day. The behavior pattern is called *vertical diurnal migration*, and it one of the most pervasive behavior patterns on earth. In the exceptionally clear waters of the open sea, sunlight can penetrate to depths of several thousand feet during the day, so vertical migrators often have to swim several thousands of feet twice a day. This can be accomplished only by relatively large animals with good swimming ability.

Consequently most of the vertical migrators are 1 to 10 centimeters long (1/2 to 4 inches), much larger than net zooplankton. Shrimp-like krill, small squids and many species of small fishes make up the vertical diurnal assemblage. At night, when one fishes the surface waters with a plankton net, the catch is much different than it was during the day because at night the net captures tiny net zooplankton, larger vertical diurnal migrators, and, of course, gelatinous animals, which are usually damaged and squished by the net.

There are interesting and predictable seasonal changes in plankton communities. There is little phytoplankton growth during the winter, but winter storms mix the open waters of the sea to great depths, bringing nutrients to the surface. In spring, the days begin to lengthen, the surface of the sea begins to warm, and a shallow, seasonal thermocline is formed anew. Now is the optimal time for phytoplankton growth, and these rapidly growing tiny plants experience population explosions, "blooms", and "red tides", utilizing the nutrients upwelled in winter. Later in the spring, zooplankton populations begin to rapidly expand, grazing upon the phytoplankton, and then top carnivores, the pelagic fish, spawn, producing vast shoals of larval fish, that feed in turn on zooplankton. In summer, marine mammals calve and produce pups, just as the larval fish have turned into bite sized juveniles. And then summer passes, predators migrate toward the tropics, the winds of fall and winter begin to blow and the annual cycle repeats.

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Plankton Investigation Concepts
Related to the California State Science Standards

Standards for the Life Sciences

Grade 4 -
Science Standard #2. All organisms need energy and matter to live and grow. As a basis for understanding this concept: b. Students know producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.

Grade 6 –
Science Standard #5. Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept: a. Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs. c. Students know populations of organisms can be categorized by the functions they serve in an ecosystem.

Grade 8 -
Science Standard #8. Density and Buoyancy: All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept: d. Students know how to predict whether an object will float or sink.

Standards for Investigation and Experimentation

Grade 4 –
Science Standard #6. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will: f. Follow a set of written instructions for a scientific investigation.

Grade 5 –
Science Standard #6. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will: a. Classify objects (e.g., rocks, plants, leaves) in accordance with appropriate criteria.

Grade 6-
Science Standard #7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will: b. select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

Grade 7-
Science Standard #7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will: e. Communicate the steps and results from an investigation in written reports and oral presentations.

Grades 9 – 12
Science Standard #l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

ref: http://www.cde.ca.gov/standards/science/

Plankton Concepts Related to the National Science Standards

Grades K-4
THE CHARACTERISTICS OF ORGANISMS
Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking.

LIFE CYCLES OF ORGANISMS
Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms.

Grades 5 - 8
POPULATIONS AND ECOSYSTEMS
For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.

DIVERSITY AND ADAPTATIONS OF ORGANISMS
Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.

STRUCTURE OF THE EARTH SYSTEM
Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere

Grades 9 - 12
THE INTERDEPENDENCE OF ORGANISMS
Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.

Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.

MATTER, ENERGY, AND ORGANIZATION IN LIVING SYSTEMS
The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules.

ref: http://www.nap.edu/readingroom/books/nses/html/

Plankton Vocabulary

diatoms
a group of phytoplankton that are green and have a shell of silicon. They make the water green in color.

dinoflagellates
a group of phytoplankton that are are reddish-brown and have armored plates of cellulose. They can act like both animals and plants, and can move through the water. Most are bioluminescent and toxic.

larva
a developmental stage of an animal (after hatching from an egg) that appears different than the adult.

holoplankton
permanent plankton; any plankton that spends its whole life drifting or floating with the currents.

macroplankton
large plankton; plankton from 2 cm to 20 cm.

megaplankton
huge plankton; jellyfish, salps and others with sizes greater than 20 cm.

meroplankton
temporary plankton; zooplankton in the egg or larva stage, that will live on the sea floor or become a powerful swimmer as an adult.

microplankton
plankton from .020 mm to 0.2 mm (20 mm to 200 mm) in size.

nannoplankton
plankton from .002 mm to .020 mm (or 2 mm to 20 mm) in size.

photosynthesis
the process of plants converting water and carbon dioxide into food using sunlight as energy.

phytoplankton
microscopic photosynthetic organisms that drift in the surface waters of the ocean. The beginning of most food chains in the ocean.

plankton
living organisms that cannot swim strongly and and are carried around inside the ocean currents.

red tide
a patch of the ocean surface which has turned reddish-brown by a bloom or population explosion of dinoflagellates.

zooplankton
animals that drift in the ocean currents; different types are found at all depths from the surface down to the deepest depths.

Activity #1 - Phyto- v. Zoo- Plankton

Objective:
Students will be able to identify two broad groups of plankton: phytoplankton and zooplankton. They will describe the general body adaptations which characterize each group.

Materials:
- Phyto- and Zoo- student activity sheets
- scissors
- glue
- colored pencils (or felt pens, crayons, etc)

Student Procedures:
1. Arrange students into small teams. Have them cut out the plankton pictures on their student activity sheets.
2. Next ask each team to sort their pictures into two groups: producers and consumers.
3. Have volunteers share their sorted groupings and tell why they were sorted.
4. Ask students to share and to list the physical characteristics for each of their two groups.

Evaluation:
1. Ask the class to find a diatom among their cut out pictures. Tell them that this tiny producer is shaped like a Petri dish: a top half and a bottom half that fit together. The shell of a diatom is made of silicon, the same material as glass. Point out that diatoms use photosynthesis, and together with other kinds of phytoplankton are the producer organisms in the sea. Glass shells do not disolve easily in salt water so when diatoms die their tiny glass shells sink to the bottom of the deep ocean and pile up. Ask students to color the diatom pictures green.

2. Ask the class to find a dinoflagellate among their cut out pictures.. Tell them that dinoflagellates are also tiny producers, and these plants move by whipping their tail-like projections (flagella). The shell of a dinoflagellate is made of cellulose, like thick cardboard or wood. Point out that dinoflagellates also use photosynthesis, and together with diatoms and other kinds of phytoplankton are the producer organisms in the sea. Dinoflagellates are reddish-brown in color so when they "bloom" this is called a red tide. Dinoflagellates are also bioluminescent and many are toxic. Ask students to color the dinoflagellate picutres red.

3. Ask the class to find a copepod among their cut out pictures. Tell them that copepods are tiny animals related to shrimps, crabs and lobsters. They are the most abundant animal on Earth. Point out that copepods phytoplankton, and are the first level of consumer organisms in the ocean food chain. This is like being a rabbit or a cow in a land-based ecosystem.

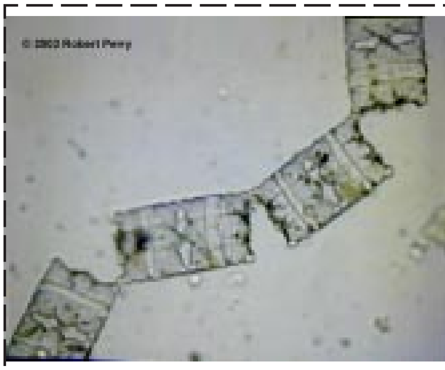
4. Ask the class to find the larvae among their cut out pictures. Tell them that larvae are the early developmental stages most animals in the ocean. Point out that larval stages are part of a life cycle that involves a metamorphosis...different appearances at different stages of a life. (As in a catterpillar/butterfly or a tadpole/ frog). Ask them if they can think of some animals in the ocean that do NOT have planktonic larval stages. [copepods, krill, mammals, reptiles, birds, and a few groups of fishes].

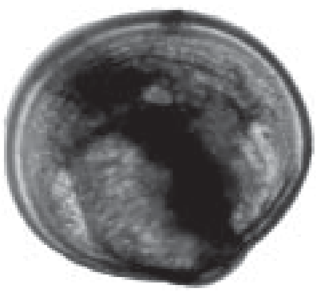
5. Ask the class to leave the zooplankton uncolored. This is to represent the fact that most zooplankton in the surface waters are naturally clear, without body pigments. Ask for ideas as to WHY zooplankton in the surface waters are transparent. [camouflage in the clear ocean water]. Can students think of any other ocean animals that are transparent or clear? [jellyfish, salps, sea gooseberries, and others]

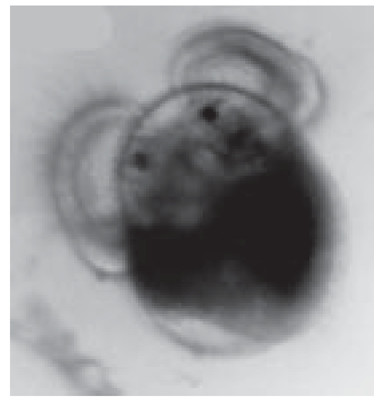
6. In summary, ask the student teams to discuss and write about the differences between phytoplankton and zooplankton. Suggest that they focus on the differences in appearance and differences in their ecological role.

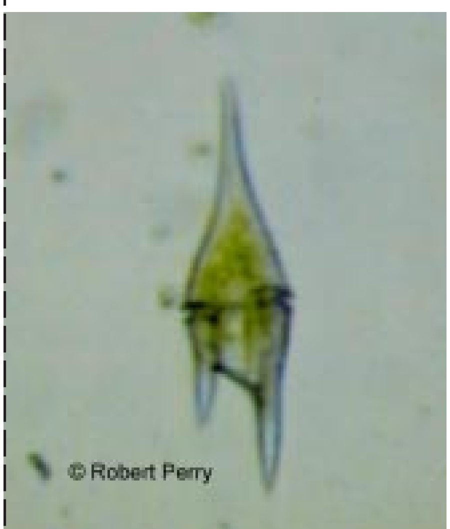
7. In summary, ask the student teams to discuss and write about what it would be like to be carried around by the ocean currents, unable to swim against them. List and describe some of the advantages of being planktonic as compared with powerfully swimming animals or bottom dwelling life.

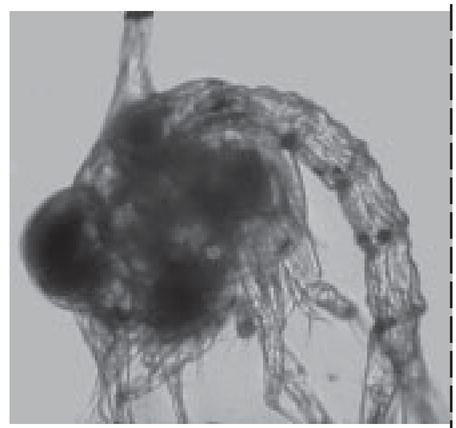
Activity #1 - Student Activity Sheet

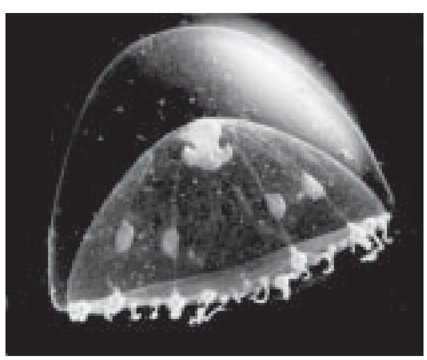


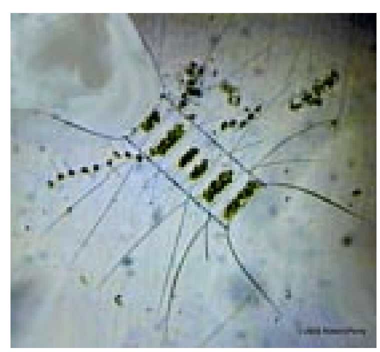




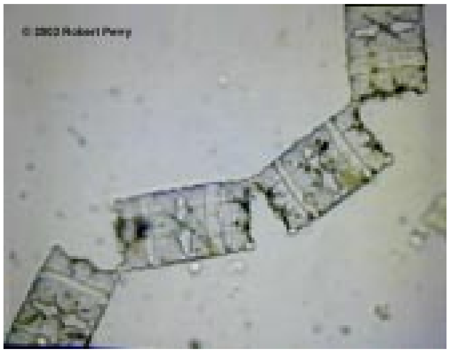






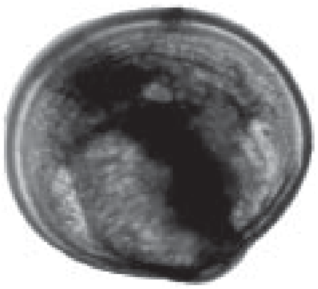


Activity #1 - Teacher Guide Sheet

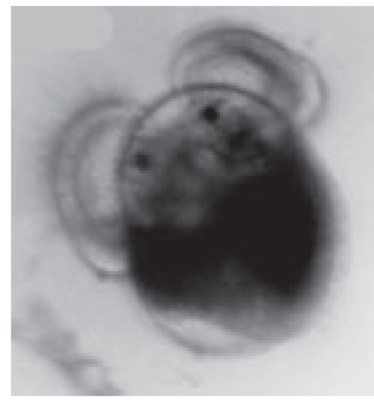

phyto - diatom chain (Biddulphia)


phyto - dinoflagellate (Ceratium)

zoo - nauplius larva (barnacle)

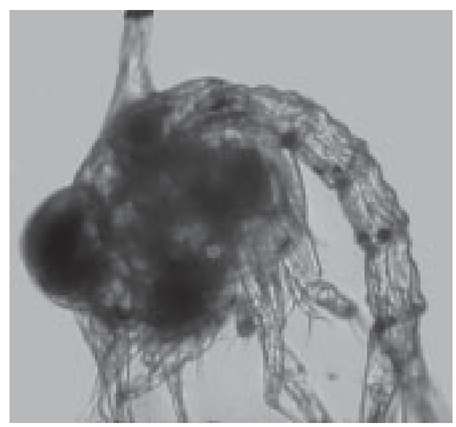

zoo - bivalve veliger larva (clam)


zoo - copepod (Calanus)

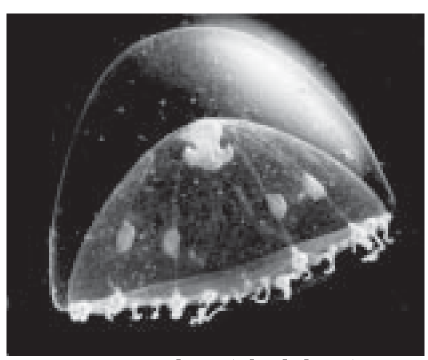

zoo - early veliger larva (snail)

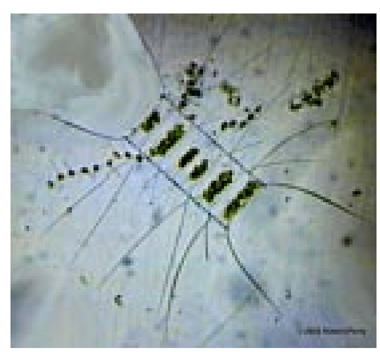
phyto - dinoflagellate (Ceratium)

zoo - echinopluteus larva (sand dollar)


zoo - zoea larva (crab)


phyto - diatom (Coscinodiscus)


zoo - medusa (Phialidium)


phyto - diatom chain (Chaetoceros)

Activity #2 - Make and Use a Plankton Net

Objective:

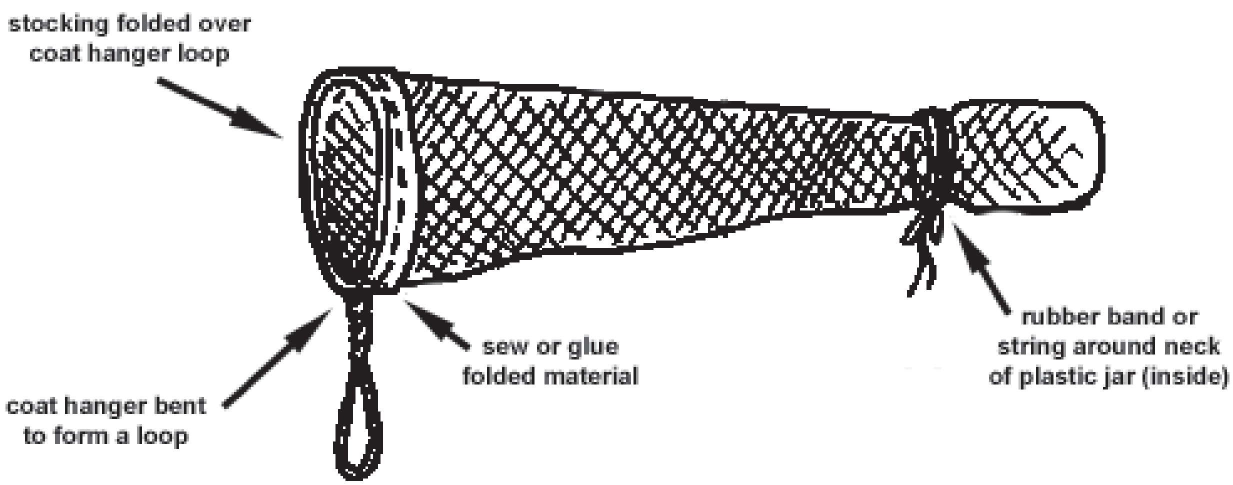
Students will make a simple plankton net and use it to collect and identify common forms of plankton.

Materials:

- UCLA OceanGLOBE Plankton Guide booklets
- plankton samples (best if refrigerated)
- microscopes or one microscope with projector attached
- petri dishes or microscope slides
- eyedroppers
- coat hangers
- string or strong rubber band
- nylon stockings or pantyhose
- plastic jars with lids
- needle and thread (or fabric glue)
- pliers

Procedures: Part A - Making a Plankton Net

1. Bend the coat hanger into a 5” circle and make a looped “handle.”
2. Take one nylon stocking (or pantyhose leg) and place it over the wire circle, folding the nylon down about 5”. Sew or glue the folded over section securely.
3. Tie a knot at the toe end of the stocking.
4. Place an open jar inside the stocking, bottom against the knot.
5. Tie a string or secure a rubber band around the stocking and top of the jar.
6. Collect your plankton samples by scooping the net through the ocean water. [The easiest place to do this is a place where the waters are calm and within easy reach of the students. A public boat dock or launch ramp is an ideal place. Alternatively, a thin piece of rope or strong string can be tied to the open mouth of the net so it can be towed from an ocean pier or even a boat.]
7. Remove the plastic jar from the nylon stocking. Cover it tightly, place in refrigerator or ice chest until ready for observation.



Modified from "Marine Explorations CD-ROM," FOR SEA, 2001. J.Kolb.

Procedures: Part B - Observing Plankton

8. Place a few drops of your plankton sample in half of a Petri dish or on a clean microscope slide.
9. Watch the plankton under a microscope.
10. Draw the plankton you see, large and with detail.
11. Label each picture. Use the identification guide to assist you.
12. List a few observable characteristics of your planktonic organisms in general.

Evaluation:

1. Were there more zooplankton or phytoplankton? Think about the variety of factors that could cause this and list them. [Most phytoplankton will be too small for the mesh of a nylon stocking, hence you should expect to see more zooplankton even though phytoplankton are approximiately 10 times more abundant.]
2. Which kinds of producer and consumer organisms were the most numerous in your sample?
3. Were there any temporary plankton (meroplankton) in your sample? LIst them.
4. Were there any permanent zooplankton (holoplankton) in the sample? List them.
5. What could possibly cause a significant change in the number of plankton in the ocean?

Extension:

Refer to the the last two pages of the UCLA OceanGLOBE Plankton Guide for instructions and mathematical formulas needed to calculate the abundance of each species of plankton. If you plan to do these calculations you should read this BEFORE you collect your samples.

Activity #3 - How Plankton Prevent Sinking

Objective:

Students construct a model of a plankton to slowly sink to the bottom of a tank.

Materials:

- buckets of water
- aquarium with water
- stopwatch or watch with second hand
- modeling clay
- toothpicks
- foil
- straws
- styrofoam

Procedures:

1. Discuss with students what plankton look like and what adaptations help them stay near the surface in the ocean.
2. Students use the materials provided to design a plankton that will remain neutrally buoyant for the longest period of time. Note: the object here is to make a model that does not remain on the surface floating, and does not sink quickly to the bottom.
3. Students are given time to experiment with their models in buckets of water.
4. Ask students to write down each modification they make to their model and give the reasons why.
5. Students take their best models and compete against the clock for the best time.

Evaluation:

Students draw a picture of their plankton model and describe its features and how well it slowly sank.
Award a prize to the plankton which took the longest time sinking

Extension:

Students record the total time it takes for each model plankton to sink. The rate of sinking is calculated by dividing the distance from the surface to the bottom of the test aquarium by the elapsed time. A simple bar graph of the results from each student or team of students can be made and discussed.