THE GREAT PLANKTON RACE

FOR THE TEACHER

Discipline
Biological Science

Theme
Scale and Structure

Key Concept
Plankton have a variety of unique adaptations which help them avoid sinking below the photic zone.

Synopsis
Students construct plankton models from materials of various shapes and densities to simulate adaptations which slow sinking. They then "race" their models (slowest wins), and calculate and graph sinking rates.

Science Process Skills
relating, measuring, inferring, applying

MATERIALS

•large pictures, slides and/or video of various plankton species Note: Monterey Bay Aquarium's Video Collection has an excellent 6 minute plankton section and is available for purchase at the aquarium or by loan from the MARE library.
•large aquarium (20 gallons or more, and at least 25 cm deep, if possible)
•several gallon jars (eg. plastic mayonnaise)
•two stopwatches
•recycled styrofoam packing "peanuts" and or corks
•toothpicks, paper clips, metal washers, colored yarn, split-shot fishing sinkers

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INTRODUCTION

Dip a clear jar into the sea and examine your sample. At first glance, the contents may seem devoid of life; but, under a microscope, an incredible world teeming with life is revealed. These tiny plants and animals are critically important to the health of the ocean, for they form the base of the food chain. Called *plankton* (from the Greek word for wandering), they drift at the mercy of the currents. Although most plankton are tiny, any organism which can't swim against a current qualifies as plankton; some, like the jelly fish can be quite large. The plants in the plankton are called *phytoplankton* and the animals are called *zooplankton*. Scientists further classify plankton according to their life histories. Organisms which spend their whole lives drifting are called *holoplankton*; those spending only part of their lives as plankton are *meroplankton*. Most meroplankton are larvae of animals which spend their adult lives on the bottom (like mussels) or free swimming (like anchovies).

The one-celled plants of the phytoplankton form the pastures of the sea. The vast majority of marine organisms depend on phytoplankton-based food chains. In addition, phytoplankton produce much of our oxygen and are important absorbers of carbon dioxide (responsible for global warming). Diatoms and dinoflagellates are among the most important members of the phytoplankton. Diatoms are housed in beautifully decorated glass skeletons resembling petri dishes. Some diatom species form long chains which may help them float and avoid being eaten. Dinoflagellates share both animal and plant traits. Like plants, most photosynthesize, but some eat other organisms. They can also swim using tiny whip-like flagellae. Some dinoflagellates are bioluminescent and create light when disturbed by waves, boat wakes or predators. Other dinoflagellates produce toxins which they release into the water. During blooms they may become so abundant that the water turns red. These “red tides” can cause fish kills due to poisoning and oxygen depletion. During some months, mussels and other filter-feeding shellfish are unsafe to eat due to concentrated dinoflagellate toxins which cause Paralytic Shellfish Poisoning.

Most major animal groups have representatives in the zooplankton. Arthropods of the class Crustacea are the most numerous zooplankton. Some, like the copepods spend their entire lives in the plankton (holoplankton). Copepods graze on phytoplankton, and, as the most numerous animals on earth, are critically important to the ocean ecosystem. Some crustaceans, like crab larvae, are temporary members of the plankton community, and settle to the bottom to live their adult lives. Shrimp-like krill are among the most popularly known plankton because they are the major food source for some of the great whales. Other common zooplankton groups include the phyla Cnidaria (jelly fishes), Mollusca (larvae of snails, clams, etc., and holoplanktonic pteropods and heteropods), Chaetognatha (arrow worms), Ctenophora (comb jellies), and Chordata (e.g., fish larvae, salps, and larvaceans). With nowhere to hide in the

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open sea, many plankton species are transparent, and nearly invisible. In addition, many have long spines to help repel predators.

All plankton must avoid sinking. Phytoplankton need sunlight for photosynthesis, so they must stay within the photic zone, usually the top 100 meters. Zooplankton depend on phytoplankton and other zooplankton for food, so they must avoid sinking as well. Plankton avoid that sinking feeling by increasing their surface area and/or decreasing their density. Most plankton are quite small, providing larger surface to volume ratios than larger organisms. Flattened bodies and appendages, spines, and other body projections also slow sinking by adding surface area without increasing density. Some diatoms resist sinking by forming chains. Another way to resist sinking is to store low density substances like oil or fat which increase buoyancy and also serve as food reserves. In addition, water currents caused by convection and upwelling can stir the water and help keep plankton from sinking.

While plankton are too weak to swim against a current, many do swim relatively huge distances *vertically* each day. Great numbers of zooplankton commute up to 1,300 feet toward the surface (at night) and back down each day. That's the equivalent of a person walking 25 miles to and from work each day! There are several possible reasons for this amazing daily vertical migration. Migrating plankton can take advantage of greater densities of food near the surface at night when they can't be as easily seen by predators, then move to deeper, darker waters at sunrise. Plankton can move faster and feed more efficiently in warmer surface waters, then conserve energy in deeper, cooler waters where they move more slowly. Another theory is that, since horizontal current directions vary with depth, plankton can catch rides to other areas by moving vertically.

Scientists measure productivity by the amount of phytoplankton produced in an area in a given amount of time. Plankton densities vary greatly for different ocean regions. 90% of the ocean is virtually a biological desert, with relatively few plankton or other marine life. Low densities of plankton in mid-oceanic areas result in extremely clear, deep blue waters. Most of the sea's productivity is in the polar regions, and coastal areas above the continental shelf where upwelling and input from rivers provide high nutrient levels. High densities of plankton in these areas result in green waters, and low visibility. As plankton die, nutrients constantly sink to depths below the photic zone, resulting in lower productivity. In upwelling areas, seasonal winds push surface waters offshore creating upwelling of deep nutrient rich waters from below. A ten thousand-fold increase in phytoplankton may occur at this time. 90% of the world's fisheries occur in these rich coastal areas thanks to the high densities of plankton.

INTO

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THE ACTIVITIES

Have each student observe photos, slides or video of various plankton species, then and record observations like colors, shapes, spines, motion (if video available). See if another student can pick out the described/sketched plankton (or have students play plankton charades).

Brainstorm possible advantages to observed adaptations (e.g. camouflage, predator avoidance, prey capture, floatation)

Brainstorm ways hypothesized advantages could be confirmed (library research, field or aquarium observations, modelling, etc.)

Discuss advantages of floatation adaptations to plankton and brainstorm ways plankton could reduce sinking rates (eg. flattened appendages, small bodies, long spines, gas or oil floats, chains, etc.).

THROUGH
THE ACTIVITIES

Have students design and build plankton model from materials of varying densities. Each model should be constructed to sink as slowly as possible, but must not float at the surface *(in nature some plankton species do live at or on the surface, but most drift beneath it).* Students may wish to add eyes and other features to their models.*Teacher: place a pile of available materials and a gallon jar of water (for pre-race testing) in the center of small groups of students.*

Have pairs of students take turns explaining the adaptations of their plankton.

Conduct a number of preliminary heats in the large aquarium at the front of the classroom. Two students at a time place their models just below the surface. Other students stand ready with stopwatches to record the time each takes to sink to the bottom of the aquarium (25 cm). At the "go" signal (consider using a toy cap pistol for effect) each contestant releases their plankter and the race is on. Record each student’s time on the board.

After all students have raced their plankters, select the four students with the slowest times for semi-final sink-offs. Winners of the two semi-final heats race off for the championship. Have the winners describe the adaptations that led to their plankton’s success. Award cardboard cut-out trophies to the slowest racers and participant ribbons to all.

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BEYOND THE ACTIVITIES

Have students graph their sinking times on a frequency histogram on the blackboard (or graph sinking rates in cm/sec)

As a class, determine the range (difference between the fastest and slowest) and average sinking time (or rate) for the class. Estimate the time it would take the slowest to sink below the photic zone (25 cm sinking time x 4 = sinking time per meter x 100 = sinking time through photic zone)

Review advantages to slow sinking rates.

Have students make detailed and labled design drawings of their models. Make a bulletin board for the plankton "blueprints."

Construct nylon stocking plankton nets and collect plankton for microscope observations. Sketch a plankter and describe its flotation adaptations.

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