LABORATORY INVESTIGATIONS

Black-line Masters

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 1

Making Ocean Water

INTRODUCTION

Natural ocean water is water with salt dissolved in it. You can make ocean water from sea salts. The percentage of salt dissolved in seawater is 3.5, which means there are about 3.5 grams of salt dissolved in every 100 milliliters (mL) of ocean water. Sea salts consist of a mixture of different salt compounds, which are manufactured and sold commercially. The purpose of this lab is to make ocean water for your classroom aquarium.

PROBLEM: How can we make seawater for an aquarium?

SKILLS: Using a graduated cylinder; using a triple-beam balance.

MATERIALS: 1000-mL graduated cylinder, large beaker, triple-beam balance, sea salts, spatula, labels, stirrer.

PROCEDURE

1. Fill the graduated cylinder to the 1000-mL mark with tap water.
2. Pour the tap water from the graduated cylinder into a 1000-mL beaker or large container.
3. Set up your triple-beam balance to measure out the sea salts. Use the diagram in Figure 1-10 as a guide. Begin by moving all three riders on the three scales to the notches at the far left.

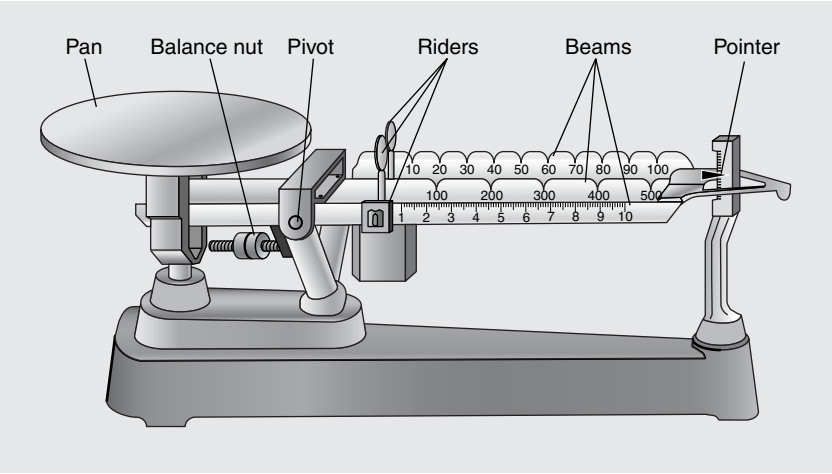


Figure 1-10 A triple-beam balance.

4. Check that the scale is balanced. The pointer should be at the zero mark. If the pointer is off-center, turn the counterweight screw located under the pan until it comes into balance.

5. Place a piece of paper on the pan to hold the salts. Since the paper has weight (mass), you need to bring the scale back into balance by moving the smallest rider until it balances.

6. Weigh out 35 grams of salt. Move the middle rider to the 30-gram mark and then move the lowest rider up to 5 grams.

7. Use the spatula to put sea salts on the paper. Keep adding the sea salts until the scale comes into balance at the zero mark.

8. Carefully transfer the sea salts from the pan into the jar containing the 1000 mL of tap water. Stir. Label the jar Artificial Seawater 3.5%, and put your name and the date on it.

9. Tap water contains chlorine, which may be harmful to living things in your aquarium. Let the container of seawater stand uncovered overnight. This will de-chlorinate the water (the chlorine gas leaves the water) before it is poured into your tank.

OBSERVATIONS AND ANALYSES

1. A student measured out 350 grams of salt. How much tap water would have to be added to make ocean water containing 3.5% salt?

_____

_____

_____

2. Why should artificial seawater sit overnight before being poured into an aquarium tank?

_____

_____

_____

3. Why is it important to balance the scale before using it?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 2

Measuring Snail Speed

INTRODUCTION

Marine animals exhibit a variety of life functions that can be observed. Locomotion, the ability to move from one place to another, is a life function that can be measured. Knowing the average speed of an animal under normal conditions can help us understand its behavior. The marine snail is an excellent subject for the study of locomotion because it moves slowly. As a result, its movement can be easily observed, timed, and measured. The purpose of this lab is to determine the average speed of a marine snail.

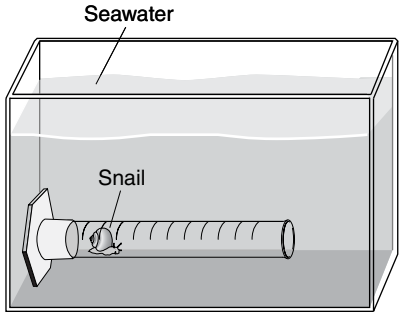
PROBLEM: How fast (or slow!) is a marine snail?

SKILLS: Measuring distance; calculating rate of movement.

MATERIALS: Graduated cylinder (or jar), seawater, metric ruler, marine snail, clock or watch.

PROCEDURE

1. Fill a graduated cylinder (or jar) with seawater. Use a metric ruler to measure the height of the water column in millimeters, so you have an idea of the distance the snail may travel in each trial.
2. Place a small snail at the bottom of the cylinder or jar of water. Start timing the snail when it begins to move from the bottom. Continue timing the snail as it moves up the side of the container. If the snail moves too slowly to record for the whole length of the cylinder, record it for a shorter distance.
3. Try to run six trials in the allotted time. Enter the distance and time for each trial in a copy of Table 2-5 in your notebook. (See figure below.)



4. Compute the speed for each trial "run" of the snail by using the following formula: Speed = Distance (mm)/Time (min). Enter your results for each trial in the Speed column of the table. Total these figures and divide by the number of trials to get an average rate of speed for the marine snail.

TABLE 2-5 MEASURING THE SPEED OF A MARINE SNAIL

Trial	Distance *(mm)*	Time *(min)*	Speed *(mm/min)*
1			
2			
3			
4			
5			
6			
Total			
Av. Speed			

OBSERVATIONS AND ANALYSES

1. Why do you think different groups doing this experiment may show different average speeds for their snails?

_____

_____

_____

2. Why is it preferable to run six trials rather than just one trial in this type of experiment?

_____

_____

_____

3. As you have observed, the snail is a slow-moving animal. Name one adaptive feature that helps the snail compensate for its slowness.

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 3

Examining Beach Sand

INTRODUCTION

Many shores are composed of sandy beaches. Beach sand consists of tiny shell fragments and, mostly, fine particles of rock that have been eroded from the land and carried to the shore by rivers and streams. The sand grains in beach sand are composed of different minerals, which are the chemical components of rock. The minerals give the sand various physical characteristics, or properties. The purpose of this lab is to learn more about beach sand by observing its physical properties.

PROBLEM: What are the physical properties of beach sand?

SKILLS: Using a dissecting microscope; measuring tiny sand grains.

MATERIALS: Transparent metric ruler, dissecting microscope (or compound microscope), sand samples, dissecting needle, petri dish, magnet.

PROCEDURE

1. Place the transparent metric ruler on the stage of the microscope.
2. Sprinkle some sand in the petri dish and put the dish on top of the ruler.
3. Observe the sand grains under the microscope. In your notebook, record the size of a single grain, in mm, on a copy of Table 3-1. If the grains vary widely in size, measure several and record the average size. Notice if there are any tiny shells or fragments that may be the remains of foraminifers.
4. Observe the physical properties of color, texture, luster, and shape in the grains. Use a dissecting needle to separate the grains into different piles, each representing a different property. Record your observations in the table. Make a sketch of a sand grain from each sample pile.

TABLE 3-1 PHYSICAL PROPERTIES OF SAND SAMPLES

Sample	Size	Color	Texture	Luster	Shape	Minerals
A						
B						
C						
D						
E						

Name _____ Class _____ Date _____

TABLE 3-2 MINERALS AND THEIR PHYSICAL PROPERTIES

Mineral	Physical Properties
Quartz	Clear, glassy, resembles salt crystals, eroded from granite
Feldspar	Clear, tan or gray, usually square, eroded from granite
Hornblende	Dark gray to black, glassy
Mica	Thin shiny flakes, silver gray to black
Magnetite	Dark shiny triangles, clings to magnet, contains iron
Garnet	Purple to red, angular, abrasive, used in sandpaper
Olivine	Olive-green, glassy
Basalt	Gray to black, resembles lumps of coal
Pyrite	Pale orange to yellow, metallic luster (like gold)
Calcite	Opaque, glassy, composed of calcium carbonate, reacts with dilute HCl to produce bubbles of CO_2

5. Place a small magnet in contact with the sand. Do the sand grains cling to the magnet? If the sand clings, iron is present. Identify the mineral in Table 3-2 that contains the element iron. Use this table to identify the minerals that match the physical properties of the samples you observed. Record the information in your copy of Table 3-1.

OBSERVATIONS AND ANALYSES

1. Which type of sand would be a good source for magnetite—coral sand or volcanic sand? Explain.

_____

_____

_____

2. What are the four physical properties of beach sand that are important for identification?

_____

_____

_____

3. In what ways do you think the texture and shape of a sand grain are related to its source (where the sand is from; wave action; activities of organisms)?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 4

How Diatoms Perform Their Life Functions

INTRODUCTION

Diatoms are microscopic organisms that float and drift on or near the water's surface. Diatoms make their own food by photosynthesis, and during that process they give off oxygen. As part of the phytoplankton population, diatoms are an important food source for many organisms; they are often called the "grasses of the sea." The purpose of this lab is to observe the structure of a diatom in order to understand how diatoms carry out some of their life functions. As you observe the diatoms, you will notice they have various colors from pigments. Importantly, all of the pigments are associated with the process of nutrition.

PROBLEM: How are diatoms adapted for carrying out their life functions?

SKILL: Using a microscope to observe unicellular organisms.

MATERIALS: Slides, medicine droppers, live diatoms, microscope, coverslips.

PROCEDURE

1. Place a drop of water that contains diatoms on a clean slide. Cover the sample with a clean coverslip. (*Note*: If fresh diatoms are not available, use a prepared slide of diatoms.)
2. Place the slide on your microscope stage. Move the low-power objective into position. Focus the lens. Move the slide until you observe cells that contain green, yellow, or orange pigments. These cells are diatoms.
3. Move the high-power objective into position. Focus on a single diatom. Notice the pigment color in the diatom you are viewing. The green pigment is chlorophyll, the yellow pigment is xanthophyll, and the orange pigment is carotene. All are involved in nutrition.
4. Make a sketch of the diatom you are observing. If possible, color it in appropriately and label any parts you can identify. Check to see if you recognize any of the diatoms shown in Figure 4-4 or in Figure 4-7.
5. Move the slide to locate other types of diatoms. Sketch each one you observe.

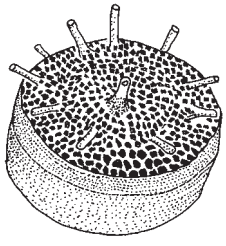


Figure 4-7 A diatom.

Name _____ Class _____ Date _____

OBSERVATIONS AND ANALYSES

1. Why are the pigments in the diatom visible?

_____

_____

_____

2. Identify two life functions carried out by diatoms.

_____

_____

_____

3. How are diatoms adapted for making their food?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 5

Adaptations of a Marine Alga

INTRODUCTION

Marine algae vary in size from the microscopic unicellular organisms to large multicellular seaweeds. Seaweeds are often attached to substrates in the intertidal and subtidal zones. One of the most common seaweeds is the brown alga *Fucus,* or rockweed. The purpose of this investigation is to observe the structure of *Fucus* in order to understand the ways in which this brown alga is adapted to survive in a marine environment.

PROBLEM: How is a marine alga adapted to live in the ocean?

SKILL: Observing the external structure of a seaweed.

MATERIALS: *Fucus,* pan, seawater, scissors.

PROCEDURE

1. Put a piece of *Fucus* in a pan of seawater. Notice the alga's brown-green color, which results from the mixture of green and yellow pigments in its cells.
2. Observe the flattened shape of the seaweed. More specifically, look at the shape of its stem. (Refer also to Figure 5-11.)

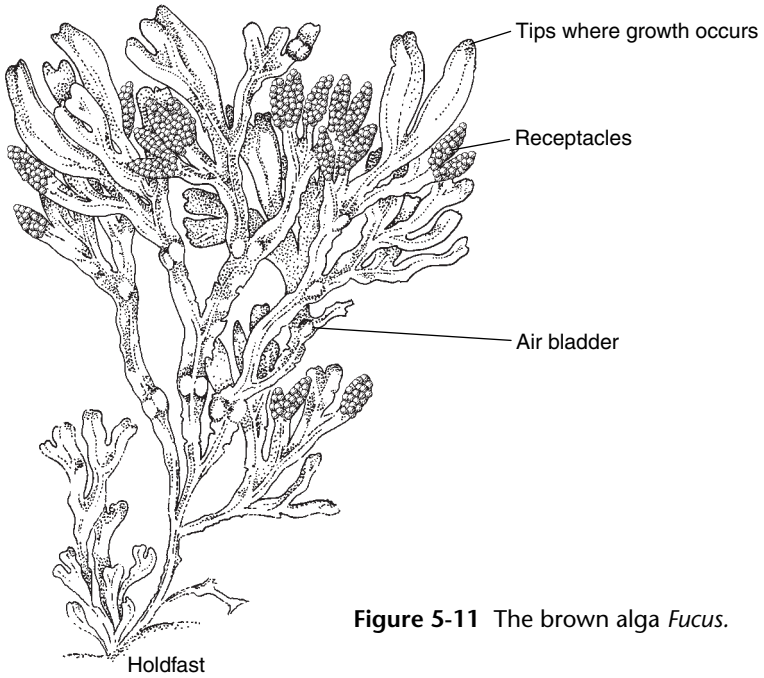


Figure 5-11 The brown alga *Fucus.*

3. In your notebook, make a drawing of the whole specimen that you are examining.
4. Use your fingers to locate a small sac along one of the stems. Cut open the sac with your scissors. Make a drawing of what you observe.
5. Growth occurs from the tips of the alga. Find some forked stem tips that are flat. Draw what you observe.
6. You may also find some tips that are swollen. The swollen tips are the receptacles. These are the reproductive organs that contain the sperm cells and egg cells.

OBSERVATIONS AND ANALYSES

1. What are three adaptations *Fucus* shows for carrying out photosynthesis?

_____

_____

_____

2. What structure prevents *Fucus* from being washed away?

_____

_____

_____

3. Why do you think *Fucus* lives close to shore and not out in the open sea?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION *6*

Observing Diverse Zooplankton

INTRODUCTION

The organisms referred to as zooplankton include tiny invertebrates that float and drift on or near the surface of the ocean. Zooplankton are an important food source for life in the sea. A plankton net is used to strain zooplankton from the water. There are many different species of zooplankton. In this investigation, students will observe various species of zooplankton under the microscope.

PROBLEM: What kinds of zooplankton can be found in seawater?

SKILL: Observing tiny organisms under the microscope.

MATERIALS: Compound microscope, zooplankton samples, medicine droppers, slides, coverslips.

PROCEDURE

1. Prepare a wet mount slide of plankton. Use a medicine dropper to put 1 or 2 drops of your plankton sample on a glass slide. Place a coverslip over the slide. Make sure the bottom of your slide is dry.
2. Place the slide on the stage of a microscope and observe under low power.
3. Focus with the coarse adjustment. Move the slide around until you see something that moves.
4. In your notebook, make sketches of each of the zooplankton you observe. Locate and sketch as many zooplankton as you can in the allotted time. You may want to ask your teacher to help you try to identify them.

OBSERVATIONS AND ANALYSES

1. Why might you have difficulty in finding zooplankton in a bucket of seawater?

_____

_____

_____

2. How would you know that the organism you observed is a type of zooplankton or phytoplankton?

_____

_____

_____

3. Why is it more difficult to find zooplankton under high power than under low power?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 7

Observing Stinging Tentacles

INTRODUCTION

Cnidarians use their tentacles to stun and capture prey. Numerous cells in the tentacles contain stinging nematocysts, which consist of a microscopic thread with a barb at the end. Nematocysts can be discharged in response to an appropriate stimulus. The purpose of this lab is to observe nematocysts discharging in response to a chemical stimulus. (You may find small anemones for your lab attached to mussels and other encrusting organisms at the beach.)

PROBLEM: How can you observe the discharging nematocysts of a stinging tentacle?

SKILL: Using the compound microscope to observe tiny cell structures in action.

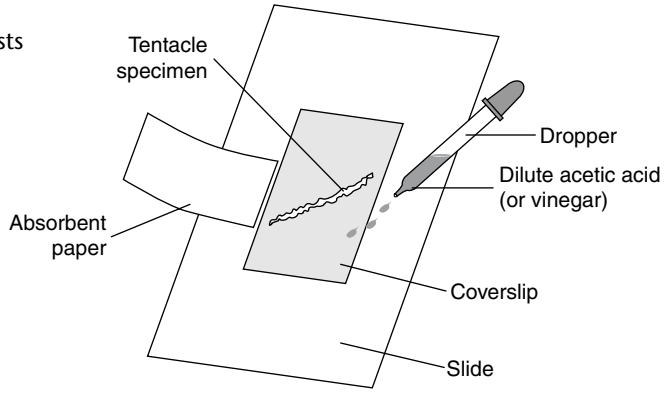
MATERIALS: Tiny sea anemone or jellyfish tentacles, forceps, slides, coverslip, compound microscope, absorbent paper, medicine dropper, dilute acetic acid (or clear vinegar).

PROCEDURE

1. Cut a small piece of a fresh jellyfish tentacle or, using your forceps, remove a tentacle from a sea anemone. (*CAUTION:* Do not touch the tentacles with your hands!)
2. Place the tentacle on a glass slide. Put 1 or 2 drops of seawater on the tentacle. Carefully apply the coverslip.
3. Place the wet mount slide on the microscope stage under the low-power objective.
4. Look for the tentacle under low power. Focus along the edge of the tentacle. In your notebook, draw a section of the tentacle.
5. Now place a piece of absorbent paper on the glass slide to the left of the coverslip. Fill the medicine dropper with clear vinegar or dilute acetic acid.
6. While looking through the microscope at the edge of the tentacle, squeeze 2 or 3 drops of acid on the slide so that the acid makes contact with the right side of the coverslip. Then place the absorbent paper in contact with the left side of the

Name _____ Class _____ Date _____

Figure 7-12 Acetic acid will make the nematocysts in a tentacle discharge.



coverslip. (See Figure 7-12.) The paper will absorb the seawater and draw the acid into contact with the tentacle.

7. Look for many fine threads shooting out from the tentacle. These threads are the discharging nematocysts. Sketch your observation. (Refer to Figure 7-3.)

8. Examine the nematocyst under high power. Draw and label the structure.

OBSERVATIONS AND ANALYSES

1. What is the adaptive value of stinging tentacles?

_____

_____

_____

2. Why do you think the nematocysts reacted to the acetic acid?

_____

_____

_____

3. Why do some fish avoid swimming near sea anemones?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 8

Adaptations of the Sandworm

INTRODUCTION

The sandworm is a segmented worm that lives in the sediments in the intertidal zones of bays and inlets. Sandworms feed on tiny invertebrates and scavenge on organic debris. You can dig for sandworms at low tide. Be careful when handling live sandworms; the mouth contains two sharp hooks that can inflict a painful bite.

It is often helpful to observe the structures of an animal's body in order to understand how it carries out its life functions. The purpose of this dissection lab is to observe the internal and external structures that make the sandworm well-adapted to its environment.

PROBLEM: How is the sandworm adapted for carrying out life functions?

SKILL: Observing features of the sandworm by means of dissection.

MATERIALS: Preserved sandworm, dissecting pan, water, hand lens, forceps, scissors, pins.

PROCEDURE

1. Place a sandworm in a dissecting pan and cover it with water so that you can see the tissues more clearly. Notice that the body is divided into segments. Count the number of segments and record the number.
2. Which end of the sandworm is the front, or anterior, end? Use your hand lens to locate the mouth, which is located in the first two segments at the anterior end. With the forceps, gently squeeze the area. Two sharp hooks (jaws) should stick out from the mouth, showing that this is the worm's front.
3. Which side of the sandworm is the upper surface and which is the lower? Notice that the lower surface is lighter in color than the upper surface. The lower surface is the ventral side, and the upper surface is the dorsal side.
4. Notice the many tiny fiberlike appendages projecting from each segment. Examine one of the appendages with your hand lens. The appendage, called a parapodium, has a fleshy paddle shape. The parapodia contain bristles called setae. These appendages are used for swimming and for burrowing.
5. Sandworms breathe through the thin, moist skin of the parapodia. Use your hand lens to examine the parapodia.
6. Now place the sandworm in a dry dissecting pan with its dorsal surface up. Pin the sandworm to the tray at the worm's anterior and posterior ends. Beginning

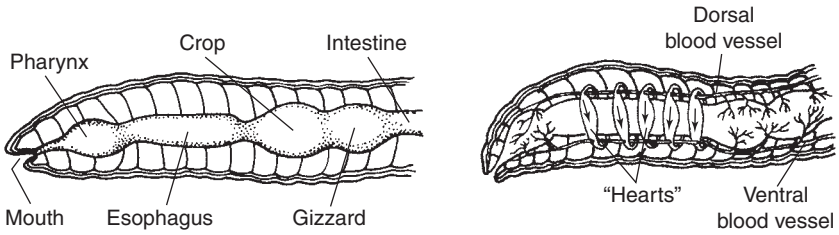


Figure 8-11 The internal anatomy of a sandworm.

at the posterior end, cut through the skin with the scissors. Make the cut just slightly to the right of the midline (center of worm, lengthwise). Carefully cut the skin without cutting the underlying tissues. As you cut, pin the skin on both sides to the tray. Cut all the way up to the anterior end.

7. To see the internal structures more clearly, pour just enough water over the sandworm to cover it. (See Figure 8-11.) Look at the inside body wall. The wall is composed of longitudinal and circular muscles for movement.

8. Use your hand lens to locate the "brain," or cerebral ganglia, at the anterior end near the dorsal surface. The brain is a white structure with two lobes. Locate the connection of the brain to a double ventral nerve cord. Trace the ventral cord and notice that it extends the entire length of the sandworm. Locate the tiny lateral nerve branches going to the muscles in each segment. The ventral nerve cord relays messages to and from the brain.

9. Food enters the worm's mouth; then it is digested in a food tube, the digestive tract. The mouth is connected to a wider part of the digestive tract called the pharynx.

10. The pharynx connects with a narrow esophagus, located in segments 6 through 14. Food moves from the esophagus into the crop. The crop, in segments 15 and 16, temporarily stores the food. Then the food passes into the gizzard, where it is ground up with sand that is ingested with it.

11. Next, the food passes into the intestine, where it is further digested and then absorbed into the blood. Finally, solid wastes are eliminated through the anus, located in the last two segments. Note that the digestive tract is separated from the skin by the fluid-filled space called the coelom.

12. Nutrients and oxygen are transported in the blood. Use your hand lens to locate the aortic arches ("hearts") and the dorsal blood vessel (on top of the food tube), which connects with the arteries, veins, and capillaries.

13. Locate the ventral blood vessel under the digestive tract. The smaller blood vessels connect the dorsal and ventral blood vessels. The blood vessels are the circulatory system of the sandworm. Blood flows only inside this network of blood vessels; thus the sandworm has a closed circulatory system.

14. Wastes are removed by paired, coiled tubes called nephridia, located in most segments. Use your hand lens to look for tiny white tubes attached to the inside body wall. (You may have to push the digestive tract aside.)

15. Two sandworms are required for sexual reproduction to occur; the sexes are separate. With your hand lens, locate a pair of testes in segments 10 and 11, or the ovaries in segments 12 and 13. Both fertilization and development are external; the larvae are planktonic.

OBSERVATIONS AND ANALYSES

1. What adaptations does the sandworm have for breathing?

_____

_____

_____

2. Describe the structures of the sandworm that enable locomotion.

_____

_____

_____

3. How is the sandworm adapted for carrying out ingestion and digestion?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 9

Feeding in a Bivalve

INTRODUCTION

Mussels, clams, oysters, and scallops are bivalves that strain food from the water by a process known as filter feeding. During filter feeding, currents of food-containing water enter the bivalve through its siphon. Specialized cells inside the mollusk are responsible for creating those currents of water. The purpose of this investigation is to observe the cells that enable filter feeding.

PROBLEM: How does a bivalve filter feed?

SKILL: Observing the action of ciliated cells under a microscope.

MATERIALS: Live clams or blue mussels, shallow bowls, seawater, medicine dropper, food coloring, hand lens, dissecting trays, newspapers, small rock, forceps, carmine powder, slides, coverslips, dissecting needles, microscope.

PROCEDURE

1. Put a live clam or mussel in a bowl and cover it with seawater. Using a medicine dropper, squeeze out a few drops of food coloring near the edge of its shell. Notice what happens. Enter your observations in your notebook. If the bivalve is alive (and it should be!), the dye should enter through the siphon. Observe the siphon with your hand lens. Make a sketch of the bivalve; draw and label its siphon. (See Figure 9-17.)
2. Remove the bivalve from the bowl and place it on a tray lined with newspapers or hold it in the palm of your hand. Open the bivalve by gently tapping

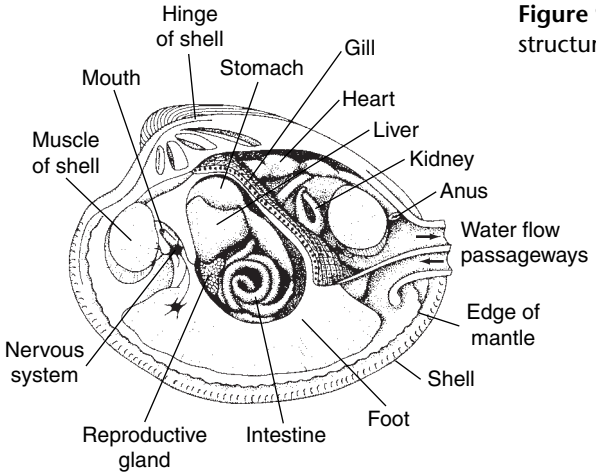


Figure 9-17 Internal structures of a clam.

one shell with a small rock until it cracks. Remove the pieces of shell with forceps. Try not to pull away the underlying tissues. (*Note:* It may work best to hold the bivalve in your hand, so that both shells do not crack.)

3. Put the bivalve back in a bowl and cover it with seawater. The top layer of tissue is a thin membrane called the mantle. Parts of the mantle may be stuck to the shell fragments. Glands in the mantle secrete the shell.

4. Under the mantle lie several overlapping membranes coated with a thick fluid or mucus. These membranes are the gills. Sprinkle a few particles of carmine powder on the gills. Wait and see what happens. The particles are moved along by the action of special cells on the surface of the gills.

5. With your forceps, pull out a tiny piece of gill membrane and put it on a glass slide. Use dissecting needles to tease the piece of gill into even smaller pieces. Add a few drops of seawater to the teased pieces and put a coverslip over the slide.

6. Observe this wet mount under the low power of the microscope. Look for currents of moving water. Focus on the cells. Notice the tiny hairs beating back and forth. The hairs that are attached to the surface of these specialized cells are the cilia. The beating of the cilia causes the currents of water.

7. Turn to high power. Notice that each cell has a single hair, or cilium. Draw and label a row of ciliated cells.

OBSERVATIONS AND ANALYSES

1. How does a bivalve filter feed? What is the siphon's role?

_____

_____

_____

2. Describe the action of the cilia. Why are they so important?

_____

_____

_____

3. Why was food coloring used in this experiment?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 10

Adaptations of Crabs

INTRODUCTION

The crab has several external features that clearly identify it as an arthropod, e.g., an exoskeleton and jointed appendages. Crabs are active marine invertebrates. The purpose of this lab is to observe the external structures that help the crab carry out its life functions in the marine environment.

PROBLEM: How is the crab adapted for carrying out its life functions?

SKILL: Observing adaptive features of a crab's external anatomy.

MATERIALS: frozen crabs (thawed), trays, hand lens, probe.

PROCEDURE

1. Put a crab on a tray with the dorsal side facing up. Tap the shell with your pen. Notice the hardness of the shell. The shell is the crab's exoskeleton. Because the exoskeleton is rigid, the crab has to shed it, or molt, several times during its lifetime as its body size increases. (See Figure 10-12.)
2. The body of a crab is divided into segments: the cephalothorax and the abdomen. The cephalothorax is composed of two parts, the head and the chest. The shell that covers the cephalothorax is the carapace. The abdomen is located on the ventral side. Turn the crab over and look at the flat abdomen, located between the legs. In the male, the abdomen is narrow and V-shaped. In the female, it is wide and U-shaped.
3. How does the crab move? Crabs use their legs, or appendages, for crawling and swimming. Count the number of legs. There are five pairs (ten legs); hence

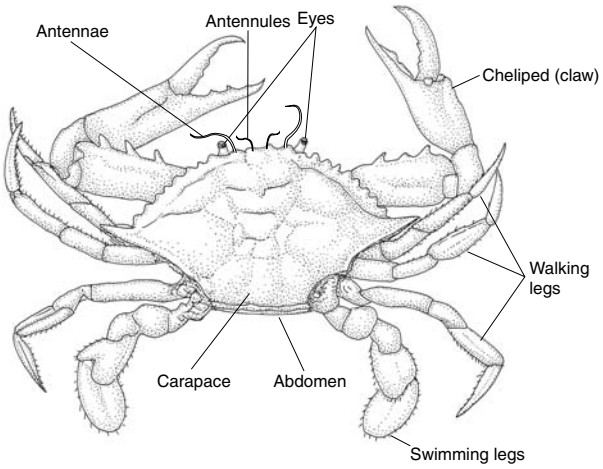


Figure 10-12 External anatomy of a crab.

the name of the order to which crabs and lobsters belong: Decapoda (*deca* meaning "ten"; *pod* meaning "foot"). Why are some of the legs pointed and others flat? The pointed ones are used for crawling, and the flat ones are used like paddles for swimming. Examine the first pair of legs, which are modified as claws, called chelipeds. The chelipeds catch and hold food and bring it to the mouth. Sketch the appendages in your notebook. Identify which ones are used for swimming, crawling, and feeding.

4. How does the crab ingest food? Food is brought to the mouth by the claws. Locate the mouth using your probe and hand lens. The mouth is surrounded by several pairs of mouthparts, which are used for tasting, moving, and shredding the food into smaller pieces.

5. How does the crab sense its environment? Use the hand lens to observe its eyes and its antennae in the head region. The two eyes are mounted on stalks. The two pairs of antennae are used to sense the environment. They function as receptors for touch, temperature, sound, and smell.

OBSERVATIONS AND ANALYSES

1. What are the advantages and disadvantages of an exoskeleton?

_____

_____

_____

2. What body parts does the crab use to ingest food?

_____

_____

_____

3. How is the crab adapted for locomotion?

_____

_____

_____

4. How does the crab sense its environment?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 11

Adaptations of Sea Stars

INTRODUCTION

The sea star is often called a starfish. However, the sea star is not a fish at all but an invertebrate, classified in phylum Echinodermata. The purpose of this investigation is to observe the sea star's external structures to better understand how it carries out its life functions.

PROBLEM: How is the sea star adapted for carrying out its life functions?

SKILL: Identifying relationships between body structures and life functions.

MATERIALS: Living sea star, pan of seawater, hand lens, fresh clam or mussel.

PROCEDURE

1. Put a sea star, dorsal side up, in a shallow pan and cover it with seawater. Use the sea star diagrams in Figures 11-3 and 11-4 as a guide. How many arms or appendages does the sea star have? Make a sketch of your sea star. Label one of the arms in your drawing.
2. Feel the skin of the sea star. Then examine the skin with a hand lens. Notice the short spines, which you were able to feel. The spines are connected to an endoskeleton, which is composed of calcium carbonate (like the shells of mollusks). Label the spines in your drawing.
3. How does the sea star breathe? Examine the skin with your hand lens. Look for tiny fingerlike projections, called skin gills. Oxygen diffuses from the water through the thin membrane of the skin gills and into the coelom.
4. Locate the sieve plate, or madreporite, which is a white or orange spot on the dorsal surface. Water enters through the sieve plate, then passes through a network of canals that ends in the tube feet.
5. Locate the tube feet by turning the sea star over. The many tube feet are in grooves that run down the center of each arm. Touch the tube feet; you will notice that they cling to your finger. Each tube foot looks like a tiny plunger. Put the sea star back in the pan of water, with the tube feet facing down. Notice the clinging and pulling action of the tube feet used in locomotion. Make a sketch of a tube foot and describe its function.
6. Now place the sea star ventral side up in the pan of seawater. Make a sketch of the sea star that shows its ventral side. Describe the motion of the tube feet.

Name _____ Class _____ Date _____

TABLE 11-1 SEA STAR STRUCTURES AND FUNCTIONS

Sea Star Observations	Structure	Function	Behavior
Dorsal Side			
Ventral Side			

Can the sea star turn itself over? Which arms does it use to turn over? Record your observations in a copy of Table 11-1 in your notebook.

7. How does the sea star feed? Look for the mouth in the center of the sea star on its ventral side. The mouth is too small to ingest a whole clam. Instead, the sea star pushes its thin, membranous stomach out through its mouth and into the clam's shell, where it digests the food externally. Open up a mussel or clam shell and put it in a pan of seawater. Place a sea star that has not been fed for a few days next to the clam. Record your observations.

8. How does a sea star open up a clam? Put your hand underwater and place a sea star on top of it. Gently try to pull the sea star off your hand. Notice how it clings to your skin. The tube feet, with their suction disks, generate a pulling force. When the arms of a sea star are draped over the two shells of a clam, hundreds of tube feet pull the shells in opposite directions. The adductor muscles in the clam become fatigued, causing the shells to open.

OBSERVATIONS AND ANALYSES

1. How does a sea star move?

_____

_____

_____

2. How does the sea star ingest and digest food?

_____

_____

_____

3. Compare the "skeleton" of a mollusk with that of an echinoderm.

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 12

Breathing and Transport in a Fish

INTRODUCTION

In multicellular animals such as the fish, blood circulates in pathways through the body to bring nutrients and oxygen to all the cells and to carry away cellular wastes. The purpose of this lab is to observe the processes of respiration and blood circulation (transport) in a fish. The caudal fin (tail) is the part of a fish's body in which the movement of blood cells can be easily observed.

PROBLEM: How does a fish carry out respiration and circulation?

SKILLS: Calculating a fish's breathing rate; observing circulation in a fish.

MATERIALS: Killifish *(Fundulus),* seawater, bowl, petri dish, cotton (or gauze), watch, microscope, medicine dropper, dip net.

PROCEDURE

1. Place a killifish in a small bowl filled with seawater. Notice the fish's operculum, which covers the gills on either side of the head. You can see that the fish is breathing because its operculum continually opens and closes.
2. The fish breathes by taking in water through its mouth. Notice that the fish's mouth opens and closes at regular intervals. The water passes over the gill membranes, where an exchange of gases occurs.
3. What is the breathing rate of the fish? You can measure the breathing rate by counting how many times the operculum moves per a unit of time. Have your lab partner count movements of the operculum while you time it for 15 seconds. Multiply the number by 4 to get the movements (rate) per minute. Do six trials; calculate the total and divide by 6 to get an average rate.
4. Now observe circulation in a fish. Thoroughly moisten two pieces of cotton or gauze by dipping them in seawater. Flatten out the two pieces and put them in a petri dish.
5. Use a dip net to remove a killifish from the aquarium. (See Figure 12-20.) Carefully place the fish on one piece of cotton, with its tail hanging over the edge of the cotton and lying flat against the petri dish. (*Note:* To protect its scales, wet your hands thoroughly before touching the fish.)
6. Cover the fish's head and gills with the other piece of wet cotton. Leave the mouth and tail exposed. Put a few drops of seawater on the fish's tail.

Name _____ Class _____ Date _____

7. Place the petri dish on the microscope stage under the low-power lens. Position the fish so that its tail is directly under the low-power lens. (You may want to place a slide carefully over the fish's tail to help keep it in position.)

8. Focus under low power. The fish may move its tail. Check the position of the tail and then refocus. Look for moving streams of blood. Notice the small red blood cells, which carry oxygen, moving in the bloodstream.

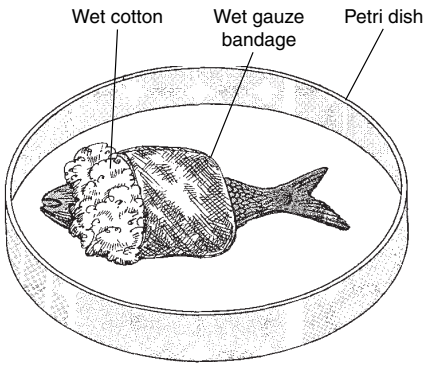


Figure 12-20 Observing circulation in a fish's tail.

9. Observe the blood vessels. The vessels in which the blood spurts are the arteries. The spurting of blood is a result of the pumping action of the heart. The vessels in which the blood moves more slowly are the veins. Look for very narrow blood vessels, the capillaries, which connect arteries to veins. Notice that red blood cells in the capillaries move very slowly in single file.

10. Observe your fish for only 5 minutes or so, then return it to the aquarium. If the fish is sluggish, gently prod it with your finger to help get it moving.

OBSERVATIONS AND ANALYSES

1. How does a fish breathe? What is the role of the gills in breathing?

_____

_____

_____

2. What are the three types of blood vessels in the fish's circulatory system?

_____

_____

_____

3. Why was it important to cover the fish's head and gills with wet cotton?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 13

Adaptive Features of Marine Reptiles and Birds

INTRODUCTION

Marine birds and marine reptiles have particular adaptations for living, and feeding, in and on the ocean. In this investigation, you will note some of the structures that enable reptiles and birds to adapt to the rigors of life nearby, and in, the sea.

PROBLEM: What are some features of birds and reptiles that show adaptations to the marine environment?

SKILLS: Observing and identifying adaptive features.

MATERIALS: Collection of photographs, illustrations, and/or plastic models of various marine birds and reptiles. You may also refer to the figures in this chapter.

PROCEDURE

1. Observe the features of various representative marine reptiles. In your notebook, make a copy of Table 13-1. Then list one or more features for each animal that you think may be specialized for its life in the water. What function does the particular feature serve? That is, how is it adaptive for an animal that spends more time in the water than on land? (You can note the same feature more than once.)

TABLE 13-1 ADAPTIVE FEATURES OF MARINE REPTILES

Reptile	Features/Structures	Purpose/Function
Crocodile		
Sea turtle		
Sea snake		
Marine iguana		

2. Observe the features of various representative marine (or aquatic) birds. In your notebook, make a copy of Table 13-2. Then list the features for each bird that you think enable it to function well in a marine environment (salt marsh or ocean), or list the particular function or purpose that the adaptive feature serves for the bird (depending on which space is left blank). You can add other features or functions that are not listed in the table but that are also important for survival in the bird's particular habitat.

Name _____ Class _____ Date _____

TABLE 13-2 ADAPTIVE FEATURES OF MARINE (AQUATIC) BIRDS

Bird	Features/Structures	Purpose/Function
Skimmer	Longer lower bill	
Osprey		Catching fish (in flight)
Penguin		Swimming underwater
Oystercatcher	Knifelike bill	
Sea duck	Webbed feet	
Sandpiper		Feeding along shore
Heron (egret)	Long legs and bill	
Albatross		Long-distance flight
Pelican	Large pouch	
Cormorant		Fishing underwater

OBSERVATIONS AND ANALYSES

1. Describe three features of marine reptiles that are adaptive for living in an aquatic environment.

_____

_____

_____

2. Describe five features of seabirds that are adaptive for feeding and/or living in a marine environment.

_____

_____

_____

_____

_____

3. What are some adaptive features that are similar in both marine reptiles and marine birds? List the particular birds and reptiles.

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 14

Diving Response in Humans

INTRODUCTION

Many marine mammals can make deep and prolonged dives. During their dives, these mammals undergo a diving response. Part of the diving response is bradycardia, a slowing of the heartbeat (pulse rate) as the animal dives beneath the surface. Bradycardia is an energy-conserving response made during the critical time of breath hold. The slowing of the heartbeat is a response to increasing water pressure. Bradycardia has been demonstrated in humans during actual dives. It is thought that bradycardia begins as soon as a person's face is submerged (underwater). The purpose of this lab is to determine if bradycardia can be shown during facial submersion.

PROBLEM: Can a diving response be demonstrated in humans?

SKILL: Measuring pulse rates.

MATERIALS: Basin or bucket of warm water (about 25 to 30°C), catch basin, stopwatch, ear plugs, towel, swim cap.

PROCEDURE

1. Work with a partner. Locate the pulse in your partner's wrist. (The pulse rate is the rate at which the heart beats.) Take your partner's pulse while he/she holds his/her breath for 15 seconds. (Either you or your partner can look at the stopwatch.) Multiply by 4 to get the pulse rate per minute. In your notebook, record the result in a copy of Table 14-2.
2. Switch roles and have your partner take your pulse for 15 seconds, while you hold your breath. Again, multiply by 4 to get the pulse rate per minute. Record the result in your table. If time permits, repeat this procedure for a total of six trials (three per partner). Calculate the average by adding the results for each trial and dividing by the number of trials. These data serve as the control group, since the experimental factor (water pressure) was not involved.
3. Fill a basin or bucket to the top with warm water and place it in a container large enough to catch the overflow. Put on a swim cap and ear plugs. Now submerge your face in the water for 15 seconds, while your partner takes your pulse. (In this case, your partner will watch the time!) Multiply by 4 to get the pulse rate per minute. (If 15 seconds feels too long, submerge and time the pulse for 10 seconds, then multiply by 6 to get the pulse rate per minute.) Record the result in your table.
4. Repeat for a total of six trials (with partners taking three turns each, alternating at submerging and timing) and calculate the average. These data represent the

Name _____ Class _____ Date _____

TABLE 14-2 COMPARING PULSE RATES OF NOT-SUBMERGED AND FACIALLY SUBMERGED PEOPLE

Trial	Not-Submerged Pulse Rate *(beats per minute)*	Facially Submerged Pulse Rate *(beats per minute)*
1		
2		
3		
4		
5		
6		
Total		
Average		

experimental group, with facial submersion in water (water pressure) being the experimental factor. Compare with above (control group) results to see if there is any difference.

5. Write all students' results on the chalkboard. Compute a class average to see if the overall results appear to be significant.

OBSERVATIONS AND ANALYSES

1. What was your average pulse rate for breath-hold in the air? In the water? What does your pulse rate actually represent?

_____

_____

_____

2. What differences, if any, did you observe in the two sets of trials? Why did you hold your breath for the control group trials?

_____

_____

_____

3. Based on your results, can bradycardia occur in humans? Does it begin with facial submersion? Explain.

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 15

Determining Seawater Salinity

INTRODUCTION

The amount of salt dissolved in seawater determines its salinity. The ocean has an average salinity of about 3.5 percent. Salinity is affected by a variety of factors, including rainfall, drought, evaporation, distance from the coast, and closeness to freshwater sources. The purpose of this lab is to measure the salinity of a saltwater sample taken from your locale or prepared in your class.

PROBLEM: How much salt is dissolved in ocean water?

SKILLS: Using a graduated cylinder and a triple-beam balance; calculating percentages.

MATERIALS: Triple-beam balance, 100-mL beakers, graduated cylinder, salt water, Bunsen burner or hot plate, beaker cover, tongs, cooling pad.

PROCEDURE

1. Balance your scale at the zero point. Determine the mass of an empty 100-mL beaker. In your notebook, record the amount in a copy of Table 15-2.
2. Measure out 20 mL of salt water into a graduated cylinder. Pour the 20 mL into the 100-mL beaker. Use the balance to find the mass of the beaker containing the water. Record the amount in the table.
3. Place the beaker of water over the burner or hot plate and heat it until all the water is boiled off. Place a cover on the beaker when most of the water is boiled off to prevent the salt from splattering out. (See Figure 15-11.)
4. Use the tongs to remove the beaker from the hot plate. Place the beaker on a cooling pad for a few minutes; then place it on the balance to find its mass. Record the mass of the beaker plus salt in your copy of Table 15-2.

TABLE 15-2 SALINITY DETERMINATION

1. Mass of empty beaker	_____ grams
2. Mass of beaker plus water	_____ grams
3. Mass of water (subtract #1 from #2)	_____ grams
4. Mass of beaker plus salt	_____ grams
5. Mass of salt (subtract #1 from #4)	_____ grams

Name _____ Class _____ Date _____

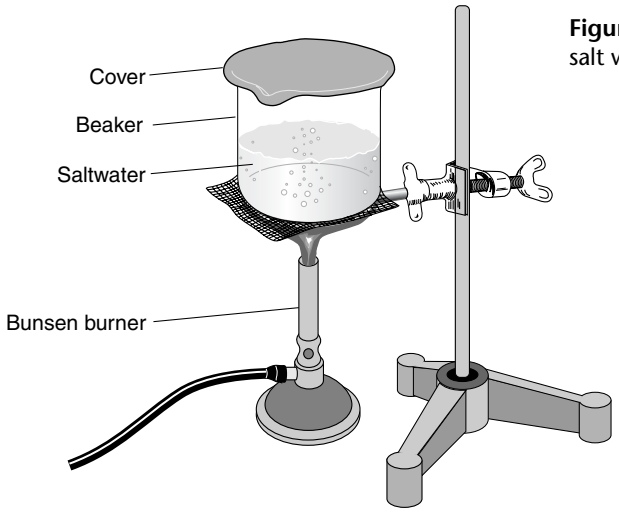


Figure 15-11 Heating a beaker of salt water to determine the salinity.

5. Calculate the mass of the salt and the mass of the water (subtract the mass of the empty beaker from that amount plus salt and that amount plus water, respectively) and write the amounts in the table. To calculate percent salt, divide the results for #3 into the results for #5 and multiply by 100.

OBSERVATIONS AND ANALYSES

1. What is meant by salinity? What is the salinity of your water sample?

_____

_____

_____

2. Give two reasons why students using the same water samples may determine different salinities.

_____

_____

_____

3. Which location would have a higher salinity, an estuary or the open ocean? Explain your answer.

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 16

Getting Water from a "Stone"

INTRODUCTION

Where did the ocean's water come from? One of the original sources of ocean water was Earth's crust. Water is still found in Earth's crust, bound chemically to compounds. Chemicals that contain water are called hydrated molecules, or hydrates. Copper sulfate, which has the formula $CuSO_4 \bullet 5\ H_2O$, is an example of a hydrate. Notice that water is part of the molecule. The purpose of this investigation is to extract water from a solid ("get water from a stone") and to calculate its percentage by weight.

PROBLEM: How can we show that Earth's crust contains water?

SKILLS: Heating and measuring a chemical compound; calculating weight (mass) and percentages.

MATERIALS: Safety glasses, Bunsen burner or hot plate, porcelain evaporating dish, hydrated copper sulfate, spatula, tongs, triple-beam balance, cooling pad.

PROCEDURE

1. Put on the safety glasses. Heat the evaporating dish over a Bunsen burner or on a hot plate for a minute to evaporate possible moisture from the dish.
2. Use tongs to transfer the dish to a cooling pad for a few minutes.
3. After it cools, transfer the dish to the balance to be weighed. In your notebook, record the weight (mass) in a copy of Table 16-1.
4. Use a spatula to measure out 2 grams of copper sulfate and put it into the evaporating dish. Record the weight (mass) of the dish plus the copper sulfate in the table.
5. Place the evaporating dish that contains the copper sulfate onto a hot plate or over the Bunsen burner. Heat gently for five minutes, until the blue color of the copper sulfate disappears.

TABLE 16-1 WEIGHTS (MASSES) OF COPPER SULFATE

Evaporating dish (empty):	_____ grams
Evaporating dish plus copper sulfate (before heating):	_____ grams
Evaporating dish plus copper sulfate (after heating):	_____ grams

6. Use tongs to transfer the dish to a cooling pad and wait a minute for it to cool. Place the dish on the balance and record the weight (mass) in the table.

CALCULATIONS

1. To find the weight (mass) of the copper sulfate, subtract the weight (mass) obtained in step 3 from that of step 4.
2. To find the weight (mass) of the water, subtract the weight (mass) obtained in step 6 from that of step 4 (line 3 from line 2 in the table).
3. To calculate the percentage of water in the hydrate, use the equation

   Percentage of water = weight of water ÷ weight of hydrate × 100.
4. You can calculate the number of water molecules in the hydrate by using the equation

   Number of water molecules = weight of hydrate ÷ weight of water.

OBSERVATIONS AND ANALYSES

1. Compare your answer for calculation 4 with those of the other students. Your answers may vary. How can you explain these differences? (The correct number of water molecules is five.)

_____

_____

_____

2. Describe what happened—physically and chemically—to the copper sulfate hydrate when it was heated.

_____

_____

_____

3. What is the important difference between the copper sulfate before it was heated and the copper sulfate after it was heated?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 17

Analyzing Ocean Temperatures

INTRODUCTION

Periodic climatic disturbances that affect much of the globe have been attributed to an unpredictable warm ocean current that originates in the western Pacific. Called El Niño, this current moves from west to east across the middle of the Pacific Ocean. In this lab, students will analyze two maps of surface ocean temperatures in order to determine which year the El Niño event took place.

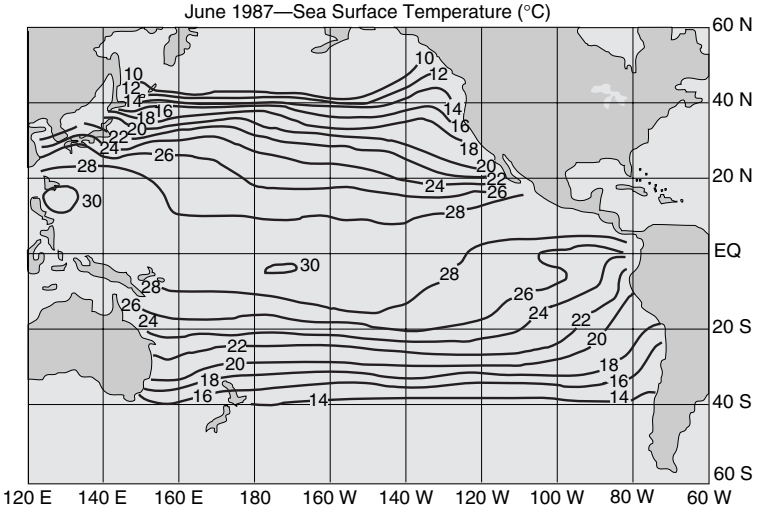
PROBLEM: How can we analyze temperature differences in ocean currents?

SKILLS: Map reading; comparing and analyzing scientific data.

MATERIALS: Colored pencils, copies of the two maps of the Pacific Ocean.

PROCEDURE

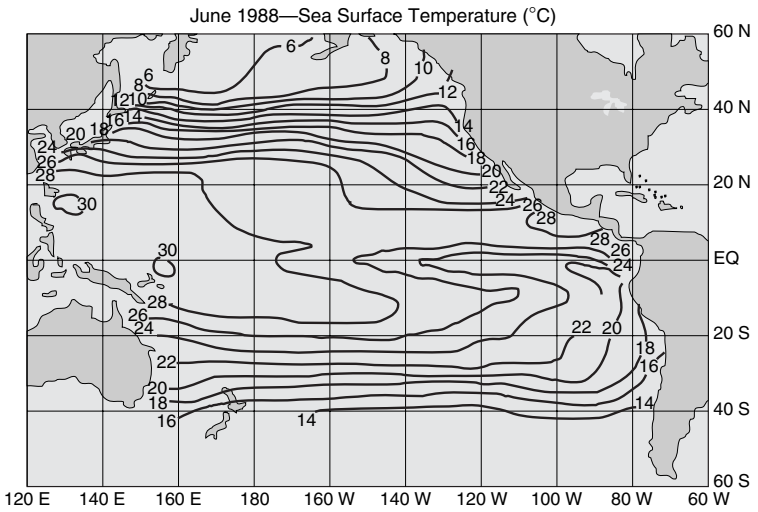
1. Examine the two maps of the Pacific Ocean. Notice the isotherms—lines that connect locations having the same temperature. Each isotherm represents a different surface temperature.
2. Use the colored pencils to highlight the temperature ranges indicated by the isotherms. Prepare a temperature key that shows the appropriate colors.



Temperature Color Key

28°C or >	26–28°C	24–26°C	22–24°C	20–22°C	20°C or <
(red)	(orange)	(yellow)	(blue)	(green)	(violet)

Name _____ Class _____ Date _____



Temperature Color Key

28°C or >	26–28°C	24–26°C	22–24°C	20–22°C	20°C or <
(red)	(orange)	(yellow)	(blue)	(green)	(violet)

3. Next, color in the temperature ranges of the isotherms on your copy of each map, using the color key as a guide.

4. Study both maps to see if any significant difference is observable.

OBSERVATIONS AND ANALYSES

1. Which year had a cooler mid-ocean temperature at the equator, 1987 or 1988?

_____

_____

_____

2. Compare the temperatures of mid-ocean water at 20°S and at 20°N for the two years. Is there a noticeable difference between them?

_____

_____

_____

3. Based on the ocean temperature differences between the two maps, which year probably shows an El Niño? Explain.

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 18

Effects of Temperature and Salinity on Water Density

INTRODUCTION

Floating in the ocean is easier than floating in a lake because ocean water is more dense than lake water. Density is defined as mass per unit volume and is measured in grams per cubic centimeter (g/cm^3). Two factors that affect the density of water are salinity and temperature. Salinity, the amount of salt dissolved in water, is measured in parts per thousand (ppt). Temperature, a measure of the average kinetic energy of a substance, is measured in degrees Celsius. In this lab, students will see how temperature and salinity determine water density.

PROBLEM: How do temperature and salinity affect the density of ocean water?

SKILL: Graphing scientific data.

MATERIALS: Temperature-Salinity Diagram (Figure 18-9), ruler, pencil.

PROCEDURE

1. Two seawater samples, labeled A and B, were taken and tested for temperature and salinity. The results were plotted as two dots, A and B, on the Temperature-Salinity Diagram (Figure 18-9). Find the temperature and salinity values

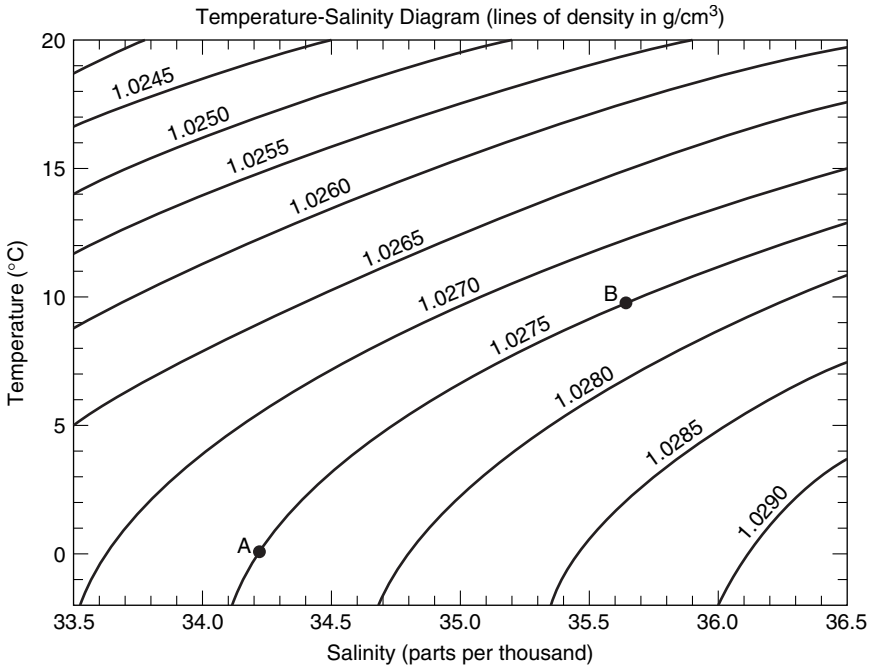


Figure 18-9 Both temperature and salinity have an effect on water density.

Name _____ Class _____ Date _____

TABLE 18-3 TEMPERATURE/SALINITY/DENSITY OF WATER SAMPLES

Sample	Temperature *(°C)*	Salinity *(parts per thousand)*	Density *(g/cm^3)*
A			
B			
C			

for A and B and record them in a copy of Table 18-3 in your notebook. Next, record the density for each sample in your table.

2. Record in the water sample table the temperature and salinity of water sample C that would result if equal volumes of samples A and B were mixed together. (*Hint:* Mixing one liter of 10°C water with one liter of 30°C water results in two liters of water at 20°C.)

3. Plot the new sample C by placing a dot on the Temperature-Salinity Diagram. Next, record in the water sample table the density of sample C.

4. On the Temperature-Salinity Diagram, draw a straight line between the points representing samples A and B. The point representing any possible mixture of these seawater samples, including sample C, would fall somewhere on this straight line.

OBSERVATIONS AND ANALYSES

1. How does an increase or decrease in temperature affect density?

_____

_____

_____

2. How does an increase or decrease in salinity affect density?

_____

_____

_____

3. Does sample C have a density that is equal to, less than, or greater than the densities of sample A and sample B prior to mixing?

_____

_____

_____

4. Which water samples would sink and which would float above the others?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 19

Identifying Pigments in Algae

INTRODUCTION

Food-making in algae takes place inside light-absorbing structures called chloroplasts. The chloroplasts contain different colored chemicals called pigments, which are the food factories of the cells. Pigments found in marine algae include chlorophyll (green), carotene (orange-red), xanthophyll (yellow), phycoerythrin (red), and phycocyanin (blue).

The pigments can be identified by color stains left on a piece of filter paper, following migration of a pigment extract through the paper. This process is called filter-paper chromatography. Each pigment separates into a colored band based on its rate of migration through the paper (a result of its molecular size and structure). In this lab, students will use chromatography to analyze pigments found in (chlorophyll extract from) the marine alga *Ulva.*

PROBLEM: How can the pigments in marine algae be identified?

SKILL: Using filter-paper chromatography technique.

MATERIALS: Test tube, test tube rack or holder, solvent, filter paper, pin, cork stopper, chlorophyll extract (from *Ulva*), dissecting needle.

PROCEDURE

1. Pour about 10 mL of solvent into a test tube. Cut a piece of filter paper. Use a pin to attach the top end of it to a cork stopper. (See Figure 19-9.)
2. Dip the tip of a dissecting needle into the chlorophyll extract. Apply the extract to the filter paper at its bottom end. Wait one minute for it to dry; then repeat twice.
3. After the chlorophyll spot dries, insert the filter paper (with cork) into the test tube so that the bottom end just touches the solvent. Within 10 minutes you should see bands of different colors appearing on the paper, as the solvent migrates to the top of it.
4. Remove the filter paper and observe the colored bands. Carotene (the fastest-moving pigment molecule) should be at the top. What are the positions

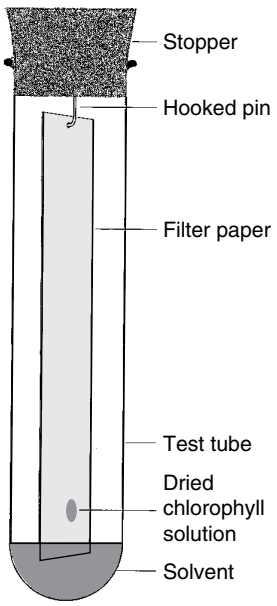


Figure 19-9.

of the other bands? Write a report indicating your findings; attach the filter paper to your report.

OBSERVATIONS AND ANALYSES

1. Identify the pigments you found in your extract from *Ulva.*

_____

_____

_____

2. Why do the pigments separate into different colored bands?

_____

_____

_____

3. Which pigment had the fastest migration through the paper? Which had the slowest?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 20

Measuring Ocean Waves

INTRODUCTION

Waves are up-and-down movements of the ocean's surface. Natural disturbances such as winds, earthquakes, tides, and icebergs (falling in the water from glaciers) can all cause waves. Even activities such as rowing a boat or swimming can produce waves. Waves have the following characteristics: wave height, wave period, wavelength, and speed. In this investigation, students will learn how to measure the characteristics of a wave.

PROBLEM: How are ocean waves measured?

SKILLS: Interpreting diagrams; making calculations.

MATERIALS: A copy of Table 20-2 (below).

PROCEDURE

1. Examine the Wave Characteristics diagram (Figure 20-22). One of the characteristics of a wave is wave height. Wave height (C) is the vertical distance from the crest (A) to the trough (B). Copy Table 20-2 and Figure 20-22 into your notebook, and label parts A, B, C, and D in the figure.
2. Wavelength (D) is the horizontal distance between two successive wave crests or wave troughs. Use the scale in Figure 20-22 to measure the wavelength in the diagram. Record your answer in the table.
3. The wave period is the time required for two successive crests to pass a fixed point. If it takes 100 seconds for 10 waves to pass a given point, what is the period? Record your answer in the table.
4. The wave speed is the distance a wave travels divided by the time it takes to travel that distance, or speed = wavelength/wave period. Calculate the wave speed and record your answer in the table. Fill in the correct "generating factor" under the *Wind* column in the table.

TABLE 20-2 WAVE CHARACTERISTICS AND WAVE TYPES

Wave Characteristic	Wind	Tide	Tsunami
Wavelength	_____ (m)	_____ (km)	_____ (km)
Wave period	_____ (sec)	_____ (hr)	_____ (hr)
Wave speed	_____ (m/sec)	_____ (km/hr)	_____ (km/hr)
Generating factor (wind, earthquake, gravitation)	_____	_____	_____

Name _____ Class _____ Date _____

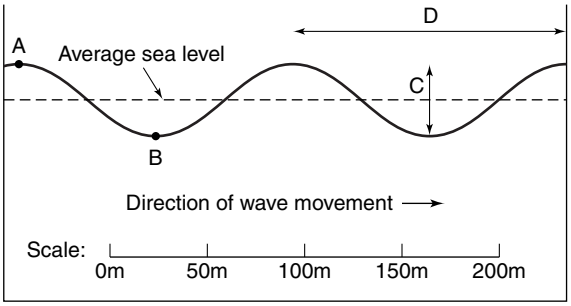


Figure 20-22 Wave characteristics.

5. The crest of a global ocean wave represents high tide and the trough is low tide. Where two high tides occur each day, the wave period is about 12.5 hours. If the wavelength is about 20,000 km, calculate the wave speed and record your answer in the table. Fill in the correct "generating factor" under the *Tide* column in the table.

6. If a tsunami has a period of 0.5 hour and a wavelength of about 200 km, calculate its speed. Record your answer in the table. Fill in the correct "generating factor" under the *Tsunami* column in the table.

OBSERVATIONS AND ANALYSES

1. Suppose an earthquake occurred off Alaska. Using the wave speed from Table 20-2, calculate how long it would take a tsunami to travel to Hawaii, a distance of about 4000 km.

_____

_____

_____

2. Explain, based on your data, why the term *tidal wave* is not an accurate description of a tsunami.

_____

_____

_____

3. Why do waves produced by tides have longer wave periods than those of tsunamis?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 21

Observing How a Barnacle Filter Feeds

INTRODUCTION

All living things depend on other living things and their environment. The food chain is a type of relationship in which one organism serves as food for another organism. The barnacle—a small crustacean—is one of many organisms that are part of the marine food chain. Because it lives attached to hard substrates, the barnacle cannot move to find its food. Instead, it obtains nutrients by filter feeding on food in the surrounding water. In this lab, students will observe the filter-feeding technique of the barnacle.

PROBLEM: How does the barnacle obtain its food?

SKILLS: Conducting an experiment; observing the behavior of organisms.

MATERIALS: Live barnacles attached to substrates, bowls or shallow containers, seawater, hand lens, watch or clock, fish food (dried plankton).

PROCEDURE

1. Put a barnacle with its attached substrate in an empty bowl or container. Notice the overlapping shells that surround and protect the barnacle. Make a sketch of the barnacle in your notebook. Observe the barnacle closely and note if it moves or responds to the environment in any way.
2. Cover the barnacle with seawater. Wait a minute for the barnacle to respond. Notice the appendages, called *cirri*, as they extend outward and then retract into the barnacle's shells. This movement is an automatic response by the barnacle to its seawater environment.
3. Count the cirri and record the number in your notebook. Notice the hairlike bristles attached to the cirri. Use your hand lens for a close-up look. Food particles get trapped in the bristles as the cirri sweep the water. The movement of the cirri in and out of the shells is the barnacle's method of filter feeding. Make a sketch of a filter-feeding barnacle; label all parts.
4. You can measure the automatic feeding response of the barnacle by calculating the number of times the cirri beat per minute. Count the number of times the cirri move in 15 seconds and multiply by 4 to get the number of movements per minute. Record this number in the *Automatic Response* column in your copy of Table 21-1. Try to perform six trials to obtain an average number of cirri movements per minute. (This is the control group.)

Name _____ Class _____ Date _____

TABLE 21-1 COMPARING FEEDING RESPONSES OF THE BARNACLE (MOVEMENTS/MINUTE)

Trials	Automatic Response	Response to Food
1		
2		
3		
4		
5		
6		
Total		
Average		

5. Now sprinkle some fish food in the water, near the barnacle. Again, count the movements for 15 seconds and then calculate the number per minute. Record the number in the *Response to Food* column in your copy of Table 21-1. Try to perform six trials to obtain an average number of cirri movements per minute. (This is the experimental group.) Compare the results from both sets of trials to see if there are any significant (measurable) differences.

OBSERVATIONS AND ANALYSES

1. Does the barnacle show any feeding response when it is *not* covered with seawater (that is, when it is exposed to the air)?

_____

_____

_____

2. Compare the feeding responses of the barnacle in the presence and in the absence of food. Is there a measurable difference?

_____

_____

_____

3. Explain how the barnacle is adapted for filter-feeding. What special structures and functions did you observe that help the barnacle survive?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 22

Determining the pH of Water Samples

INTRODUCTION

The health of a body of water depends, in part, on its maintenance of an appropriate pH level. The pH of a liquid is a measure of the acidity or alkalinity of that substance; pH levels are classified as either acidic, basic, or neutral, depending on their concentrations of hydrogen and hydroxyl ions. Chemical substances called indicators are used to determine pH. A substance's pH is measured on a scale that ranges from 0 to 14. In this lab, students will measure the pH of different water samples, and they will determine where the pH of ocean water falls within this range. (Ocean water is normally slightly basic, or alkaline.)

PROBLEM: How can the pH of various water samples be determined? What is the pH of ocean water?

SKILL: Using chemical indicators to measure pH levels.

MATERIALS: Tray, loose-leaf paper, red litmus paper, blue litmus paper, pH hydrion paper (wide range), medicine dropper, ocean water, rainwater, tap water, pond water.

PROCEDURE

1. Place a piece of loose-leaf paper on your tray. Open the vials containing red litmus paper and blue litmus paper. Remove four strips of red litmus paper and four strips of blue litmus paper. Place them on the loose-leaf paper, in four sets of one blue and one red each. Label each set with the type of water being tested: ocean, rain, tap, and pond water.
2. Use the medicine dropper to place one drop of each water sample on the red litmus paper and one drop on the blue litmus paper. Do one water sample at a time. Observe if there is a color change. Write the color in your copy of Table 22-1. Repeat for each of the samples.

TABLE 22-1 TESTING THE pH OF WATER SAMPLES

Sample	Red Litmus	Blue Litmus	Acidic, Basic, or Neutral	pH level
Ocean water				
Rainwater				
Tap water				
Pond water				

3. To determine if the water sample is acidic, basic, or neutral, you can use the following scheme: Red litmus paper stays red in acid, but turns blue in base; blue litmus paper stays blue in base, but turns red in acid.

4. Litmus paper is useful only for determining whether your water sample is acidic, basic, or neutral. To find the pH level, you need to use pH hydrion paper, which comes in a container with a color scale that indicates pH values.

5. Remove four strips of pH paper from the container. Put a drop of water from the first sample on one strip of pH paper. Compare the color on the strip with the color scale on the container. Note the pH and record it in Table 22-1. Repeat for the other water samples.

6. Check your results by referring to the following pH scale: 0 to 6 ranges from very to slightly acidic; 7 is neutral; 8 to 14 ranges from slightly to very basic (alkaline).

OBSERVATIONS AND ANALYSES

1. What is the pH of ocean water? Find its location on the pH scale.

_____

_____

_____

2. Briefly describe how you would determine the pH of ocean water.

_____

_____

_____

3. What is the advantage of using pH hydrion paper instead of, or in addition to, litmus paper?

_____

_____

_____

Name _____ Class _____ Date _____

LABORATORY INVESTIGATION 23

Analyzing Fishery Data

INTRODUCTION

The economy of New England, like that of many other coastal regions, is linked in large part to the success of its fishing industry. Bottom-dwelling food fish, such as cod, haddock, and flounder, are the backbone of the commercial fishing economy in the Gulf of Maine and Georges Bank. These groundfish are caught by use of a bottom-trawling net. The average catch per trawl (in kilograms) in this region over the past three decades is shown in Table 23-4. The purpose of this lab is to have students interpret the data in the table, construct a line graph, and draw conclusions based on the data.

PROBLEM: How can we determine the status of the New England fishery?

SKILLS: Analyzing data from a table; constructing a graph.

MATERIALS: Graph paper, pencil, ruler.

PROCEDURE

1. Examine the data in Table 23-4, which show the average fish catch per trawl (in kilograms) in New England waters for select years from 1963 to 1993.
2. Use the information in the table to construct a line graph on your piece of graph paper. (You may also want to construct a bar graph for further comparison.)
3. Mark an appropriate scale for the horizontal and vertical axes based on data in the table. Plot the data on the graph (you should have seven points.) Surround each point with a small circle and draw lines connecting the points.

TABLE 23-4 AVERAGE CATCH PER TRAWL (KG)

Year	Fish Catch
1963	63.6
1968	35.0
1973	27.2
1978	36.4
1983	18.1
1988	13.6
1993	14.5

Name _____ Class _____ Date _____

OBSERVATIONS AND ANALYSES

1. How would you describe the status of the fishing industry in the New England region in 1963 versus the status in 1993?

_____

_____

_____

2. Congress passed the Magnuson Act in 1976 to prevent foreign fishing boats from working our coastal waters (out to 333 km). Based on the data in the graph, how effective was this conservation measure in the short term? How effective was it in the long term?

_____

_____

_____

3. After 1978, the U.S. fishing fleet grew rapidly. According to the graph, what effect did a larger and more modernized fishing fleet have on the local fish stocks?

_____

_____

_____