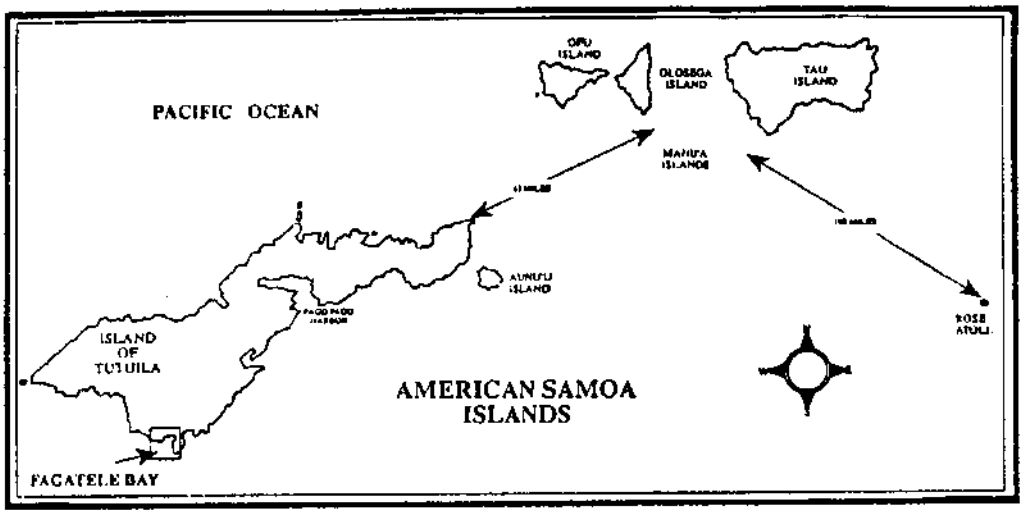
Fagatele Bay National Marine Sanctuary
Summer Program

Course Activities



by

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Sponsored by

Fagatele Bay National Marine Sanctuary Program

Economic Development Planning Office

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Pacific Island Network

University of Hawaii Sea Grant-Extension Service

School of Ocean and Earth Science and Technology

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The Marine Science Summer Camp

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and the

Department of Education

Fagatele Bay National Marine Sanctuary Program

Prepared by

University of Hawaii Sea Grant College Program

Preface

The Fagatele Bay National Marine Sanctuary Summer Program began in 1990 and consists of three sessions, each two weeks long. The program has been very popular among eighth grade students in American Samoa. The program consist of integrated hands-on lab and field experiences. The goals of the program include 1) to increase the Samoan students' awareness about the local marine environment; 2) to foster an appreciation of the traditional uses of the local marine environment with a modern understanding of the need for proper management of marine resources; 3) to increase the awareness about the value of protected areas; 4) to increase the swimming abilities of the students; 5) to teach the students first aid and CPR; and 6) to let the students have fun.

The activities in this laboratory manual represent the written portion of the program the students are required to complete. This summer will be the first time these activities will be combined into a laboratory manual, and each student will receive a copy.

We would like to thank Elizabeth Kumabe of the Pacific Island Network (PIN) for her assistance in the production of this manual. Her encouragement and effort to find the funds to support this project are greatly appreciated. We would also like to acknowledge Sea Grant College Program for providing the funds to make this manual a reality. We are also grateful to Sharon Ziegler, coordinator of PIN, for her support and suggestions to improve this manual. Thanks also goes to Don Hoffman and Brandon Avegalio for their help on the diagrams.

L.M. and D.F.

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*Tentative schedule – activities may vary or be replaced depending on weather and tidal conditions.

Orientation Questions

Please answer the following questions as completely as possible.

1. Explain briefly why corals are important to the people of Samoa.

2. Name 10 different animals that live in the ocean waters that surround Samoa.

3. Name five different animals that live in the ocean waters surrounding Samoa that the Samoans like to eat.

4. Name two reasons why it is against the law to fish using chlorine bleach, dynamite, or ava niukini on the reef.

5. Give one possible reason which causes the water in Pago Pago harbor to have a different color than the water of other villages.

6. What does the word extinction mean?

7. Can you name one organism that used to be plentiful in the waters surrounding Samoa that is now hard to find?

8. Do you know where Fagatele Bay is located?

9. What is the main difference between Fagatele Bay and other bays surrounding Tutuila?

Name_____

Date_____

Lab I. Protected Areas In Samoa

Purpose: To learn about the protected areas in American Samoa and what the differences are between them.

Introduction

Fagatele Bay National Marine Sanctuary is located in the village of Futiga, on the southwest shore of Tutuila Island (Figure 1). Designated as a marine sanctuary in 1986 by the United States Congress, it is the smallest (0.25 sq. mi.) sanctuary in the National Marine Sanctuary (NMS) program (Daschbach 1992). The NMS program selects special areas in the United States and its territories for protection. The goal of the program is to protect these areas because of their special ecological, historical, research, or educational value (Snider 1992). Fagatele Bay was chosen because of its unique tropical rain forest and coral reef system. In the late 1970s, the crown-of-thorns starfish killed most of the corals in American Samoa, as well as in Fagatele Bay (Daschbach 1992). The recovery of the reef at Fagatele Bay after this disaster is being studied. With the long-term protection provided by the NMS program, scientists will learn how long it takes corals and other inhabitants of a coral reef to repopulate an area after a crown-of-thorns infestation.

Fagatele Bay is open to the public for recreational purposes. Activities allowed include swimming, snorkeling, SCUBA diving, reef walking, traditional fishing methods in the inner bay, and line fishing in the outer portion of the bay. Activities not allowed include the removal of any invertebrates; corals, fishing with poles, handlines or trawls; or commercial fishing (National Oceanic and Atmospheric Administration, no date). If the public obeys these regulations, Fagatele Bay will provide a habitat that future generations of Samoans can enjoy.

Rose Atoll National Wildlife Refuge is remotely situated approximately 150 miles east-southeast of Tutuila Island (Figure 1). As a National Wildlife Refuge, it protects all wildlife and resources within the refuge from human activities. Rose Atoll is not open to the public, and an authorized permit to enter the refuge is required. To acquire a permit, you must submit reasons for visiting the atoll, which must be

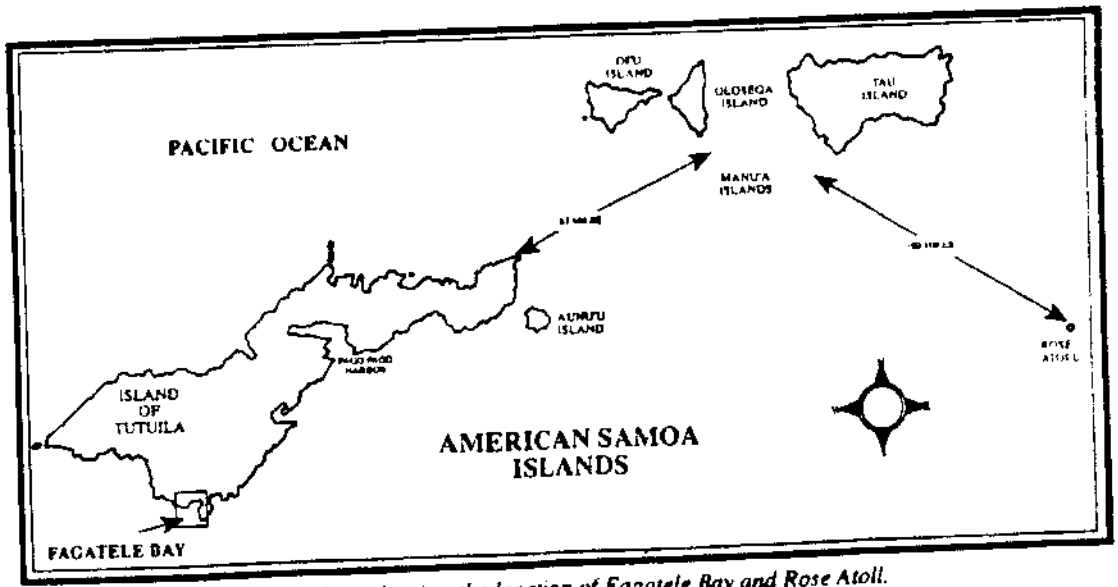

Figure 1. The Samoan Archipelago showing the location of Fagatele Bay and Rose Atoll.

approved by the U.S. Fish and Wildlife Service in Hawaii. As a result of the permit system, the atoll is rarely visited by anyone except research scientists and their assistants and educators. Nevertheless, research on the atoll is limited to studies that are not damaging to the area. Due to the limited amount of access and activities on Rose Atoll, it remains one of the pristine marine ecosystems in Samoa.

Methods and Materials

Materials

1. Television
2. Video player
3. Video of Rose Atoll and Fagatele Bay

Methods

1. Watch the videos about Rose Atoll and Fagatele Bay.

Results

1. How are Fagatele Bay and Rose Atoll similar?

2. How are Fagatele Bay and Rose Atoll different?

3. Why is it necessary to protect certain areas in American Samoa?

Conclusion

In your conclusion try to answer the following questions:

1. What can individuals do in other areas in American Samoa that would help preserve these areas?
2. How do the activities of people harm the environment?
3. Can human activities be beneficial to an environment? In what ways?

References

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National Oceanic and Atmospheric Administration (no date) *Fagatele Bay National Marine Sanctuary*. Pamphlet.

Snider, J.A. 1992. The National Marine Sanctuary Program. *Current* 11:2:3.

Name_____

Date_____

Lab II. How to Build and Maintain An Aquarium

Purpose: To build a five-gallon aquarium and teach students how to maintain the aquarium.

Introduction

An aquarium is a water-tight container that is used to keep aquatic animals and plants. Aquariums can be set up for either freshwater or saltwater organisms.

To keep fish healthy in your aquarium, three conditions must be monitored. The first is to make sure enough oxygen is in the water for the fish to survive. Most oxygen enters the aquarium at the air-water interface (Spotte 1973). If bottom waters in the aquarium are not circulated and brought to the surface where they can obtain oxygen, the animals would not have enough oxygen in the water and would eventually die. The air pump insures that the water is circulated and exposed to the atmosphere so that enough oxygen is present for the fish and other organisms in the aquarium (Figure 1).

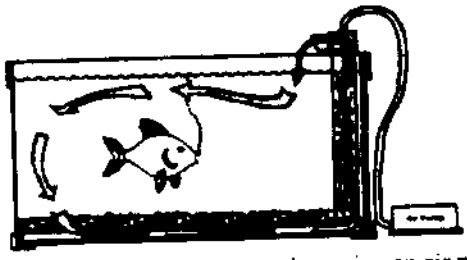


Figure 1. Circulation of water in an aquarium using an air pump.

The filtration of unwanted substances from the water is the second important condition that must be monitored. The three most common substances to remove are biological waste products, suspended particles, and dissolved organics. For most organisms in the marine environment the principal biological waste product is ammonia. Suspended particles are any substances that make the water look cloudy or muddy. Dissolved organics are chemicals in the water that come from living organisms. These substances can be removed by biological, mechanical, or chemical filtration. Biological filtration is the removal of ammonia from the water by bacteria, which convert the harmful ammonia to non-harmful gases (Figure 2). This process is called ammonification. Mechanical filtration is accomplished when the water circulating through the aquarium carries the suspended particles to the gravel at the bottom of the aquarium.

Chemical filtration of dissolved organics is the removal by adsorption, airstripping, or direct oxidation (Spotte 1973). Activated carbon or charcoal is used to remove the organics by adsorption. This means the organics stick to the charcoal, removing them from the water. Oxidation is the breakdown of substances by the addition of oxygen. Airstripping occurs when organics attach themselves to the thin surface layer of gas bubbles (Spotte 1973).

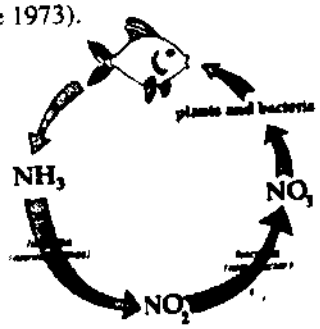


Figure 2. Biological filtration.

The third condition to consider when building and maintaining the aquarium is food for the fish. Depending on the type of fish, a variety of foods can be used. These include but are not limited to the following: a) dried food; b) brine shrimp; c) worms; d) shrimp and fish eggs; and e) insects (Ward 1978). The most important point about feeding the fish is not to overfeed. In general, do not feed fish more than they can completely eat within five minutes of introduction into the aquarium.

Materials and Methods

Materials

1. Gloves
2. Eye protection
3. Glass
4. Silicone glue/sealant
5. Rubbing alcohol
6. Emery cloth
7. Paper towels
8. Masking tape
9. Half-inch PVC pipe
10. Four PVC elbows
11. Fiberglass mosquito screen
12. super glue

Methods

1. Cut glass to desired dimensions. (Glass is precut for this activity: 2 sides 10 x 15 in.; 2 sides 7.25 x 10 in.; 1 bottom 7.5 x 15 in.)
2. Sand glass edges with emery cloth until edges are not sharp.
3. Clean glass with paper towel and alcohol.
4. Place the bottom piece (7.5 x 15 in.) flat on a book to raise it off the table. Attach two or three pieces of masking tape about 3 inches long, near each of the four edges of glass. Leave about 1.5 inches of the tape hanging over each edge.
5. Flip the bottom piece of glass over so the tape hanging over the edges is sticking upwards.
6. Take one 10 x 15 in. side and one 7.25 x 10 in. side and align them onto the bottom piece. Pull the pieces of tape from the bottom glass taut to hold the two sides in place.
7. Use one or two pieces of tape to hold these sides together.
8. Repeat steps 6 and 7.
9. Make sure each side is not loose to the touch. Add extra tape if necessary.
10. Glue all joints of glass on the interior of the aquarium with silicone glue. Let the glue dry for 24 hours.
11. Check for leaks. If leaks occur, then reglue.
12. Cut PVC pipe to fit dimensions of the aquarium and attach elbows.
13. Glue fiberglass screen to PVC frame with super glue.
14. Add gravel, water, and organisms.

Results

1. Measure the length, height, and width of your aquarium in inches.

   l = _____ in. w = _____ in. ht. = _____ in.

2. Determine the volume of your aquarium in cubic inches by multiplying your length x width x height.

   l x w x ht = volume (in^3)

   _____ x _____ x _____ = _____ $in.^3$

3. Determine the exact volume of your aquarium using the following equation:

   $$\text{Volume in gallons} = \frac{\text{volume from equation (2)}}{231\ in.^3}$$

   $$\text{Volume in gallons} = \frac{\qquad}{231\ in.^3}$$

   Volume in gallons = _____

4. Draw a picture of your aquarium and label the dimensions.

5. Using the gallons containers supplied, fill your aquarium to test for leaks and determine the volume of your aquarium using this direct method.

Conclusion

In your conclusion try to an · the following questions:

1. What was the calculate lume you calculated for your aquarium?
2. How did your calculated volume compare to the volume when you used the direct method? Is there a difference between the two volumes? Can you explain why?
3. Did your aquarium leak? If it leaked can you explain why?
4. What steps in building the aquarium are important to ensure it does not leak?
5. Name two important things that must be done to maintain organisms in the aquarium.
6. Why must you not overfeed the fish?
7. What is the function of the air pump?

References

Spotte, S. 1973. *Marine Aquarium Keeping: The Science, Animals and Art.* New York: John Wiley & Sons.

Ward, B. 1978. *Tropical Fish.* London: Macdonald Educational Ltd.

Name_____

Date_____

Lab III. Corals and Coral Reefs

Purpose: To observe some general characteristics of corals and develop an understanding of how coral reefs are formed.

Introduction

A coral reef is one of the world's most complex communities of organisms. The most important members of the community are the coral polyps, which are responsible for making the skeletal material of calcium carbonate that accumulates into the structure called a coral reef. Worldwide, there are several thousand species of corals. Not all species of corals contribute to the building of coral reefs, and some corals do not produce a skeleton of calcium carbonate. Some organisms closely related to corals also secrete a skeleton of calcium carbonate and contribute to the reef structure. The growth of massive mound shaped corals and strong branching corals, together with many less robust species, produces the framework of the reef. When the polyps die, the skeletal remains are cemented together by special algae called coralline algae. These algae also produce calcium carbonate. The coral skeleton covered with coralline algae then provides a hard surface for a new coral polyp to grow. Only the top layer of the reef consists of living corals. Under the top layer are the remains of centuries of coral growth and death. This sequence gives rise to the upward and outward accumulation of coral skeletons that produce the reef.

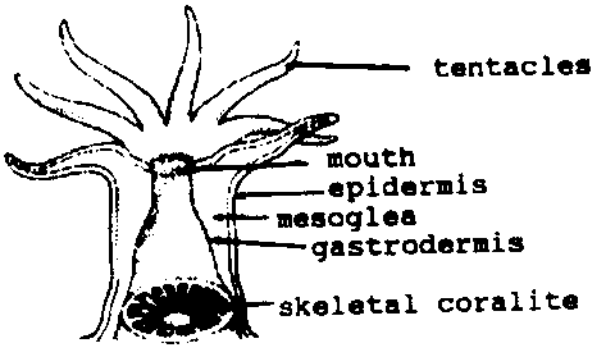


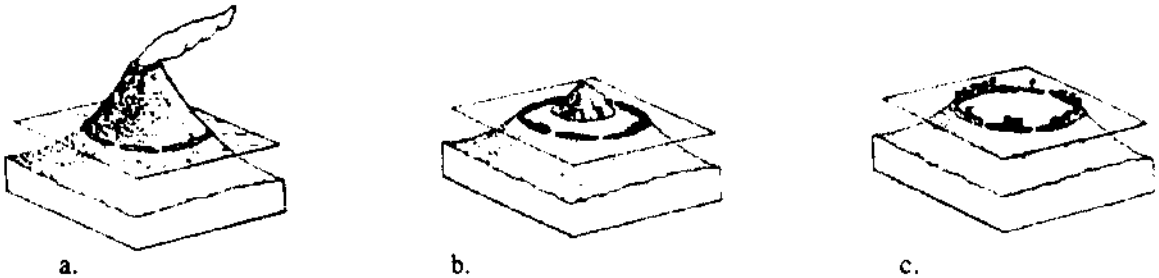
Figure 1. The basic structure of a coral polyp (King 1988; reprinted with permission).

The polyp is a simple animal. A ring of tentacles surrounds a mouth that leads to a single body cavity for digestion. The tentacles have special cells called nematocyst, which have little harpoons that can deliver a small dose of toxin for capturing prey. The tentacles extend from the skeletal cup called a corallite when the polyp is feeding and retract when danger is present. The polyp has three body layers: an outer layer of epidermis, an inner layer of gastrodermis lining the body cavity, and, between these, a layer of jelly-like material called mesoglea (Barnes 1980) (Figure 1). Living in the gastrodermis of reef building corals are minute algae called zooxanthellae (Muscatine 1969). The zooxanthellae help the polyps in the production of their skeleton and also provide some nutrients for the polyps. Without the zooxanthellae the corals would not be able to produce the massive quantities of calcium carbonate that form the reef. Some coral polyps live solitary lives and can grow to 25 cm. in size. Most, however, live in colonies and are no more than 1 to 3 cm in size (Goreau et. al. 1979) (Figure 2). The variety of growth forms in reef building corals leads to many different shapes of the colonies. Some coral colonies can grow to be enormous as a result of asexual reproduction (Goreau et. al. 1979). Polyps can also reproduce sexually, producing a free swimming larva that will settle and form a new coral colony (Randall and Myers 1983).

a. b.

Figure 2. a) solitary polyp and b) colony of polyps (King 1988; reprinted with permission).

Reef building corals need shallow, clear, warm, and sunlit sea waters (Goreau et. al. 1979). Therefore, coral reefs are found only in the tropical and subtropical regions away from the influence of continental sediments and cool nutrient-rich upwellings. The movement of oceanic plates, which causes islands to sink, produces three major types of reefs. These are called fringing, barrier, and atoll (Figure 3). A fringing reef grows up to the land mass. A barrier reef is separated from the land mass by a lagoon. An atoll is formed when the island has sunk below the ocean's surface, leaving a reef surrounding a central lagoon. A small reef that grows up from the lagoon floor of an atoll or barrier reef is called a patch reef.



a. b. c.

Figure 3. Evolution of a coral reef: a) fringing, b) barrier, and c) atoll (King 1988; reprinted with permission).

A healthy coral reef has always been a valuable resource in local economies. If coral reefs are to continue providing these natural resources to native populations, human activities such as dynamiting and bleaching to capture fish, and urbanization, which causes sedimentation will have to be eliminated or reduced.

Materials and Methods

Materials

1. Two samples of coral skeletons
2. One or two samples of living corals
3. Small centimeter ruler
4. Hand lens
5. Dissecting microscope

Methods

1. Draw a picture of two samples of coral skeletons.
2. Without the use of a hand lens, observe the two samples of coral skeletons given to you. List at least four general similarities and four differences between the two samples.
3. Using a hand lens, observe the finer details of the samples. List any new observations.
4. Measure the diameter of the corallites with the ruler.

5. With the ruler and a pencil, mark approximately one square centimeter on one of the coral skeletons. Count how many corallites are in this area. Estimate how many corallites are in your colony of coral.
6. Observe at least one sample of living coral. Record differences between the coral skeletons and the live specimen. See if you can identify the tentacles and mouth (you may need to use the dissecting microscope for this). Note any differences in color between the living coral and coral skeleton. List any other differences.

Results

1. Draw the pictures of your two coral skeletons.

2. List four general similarities and four differences between your two samples of coral skeletons.

Similarities	Differences
1.	
2.	
3.	
4.	

3. After using the hand lens, list your observations.

Similarities	Differences
1.	
2.	
3.	
4.	

4. How big are the corallites on your samples?

   Sample A = _____ Sample B = _____

5. How many corallites did you count in one square centimeter of one sample? What is your estimate of the number of polyps in your colony?

   Number of corallites in one square centimeter = _____

   Estimate of the number of polyps in the colony = _____

6. What were the main differences you noticed between the living coral sample and the dead coral skeletons?

Conclusion

In your conclusion try to answer these questions:

1. Based on your observations, can you predict any generalizations about other coral species?
2. What was your estimate of the number of polyps in the colony of your coral sample? Can you imagine how many polyps must be living on a coral reef?
3. Based on the shapes of the coral samples, do you think these corals live in areas where the water is calm or rough? Explain your answer.
4. Why do you think so many other organisms live where the corals grow and why do you think corals are important to these other organisms?
5. Can you explain why corals are so important to the people of island countries?

References

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Name_____

Date_____

Lab IV. Fish

Purpose: To identify some general characteristics of fish and to learn, on the basis of these characteristics, about their habitat.

Introduction

Fish are the most common vertebrate found in the world's oceans and fresh water systems (Moyle and Cech 1982). Of the approximately 22,000 living species of fish, 58% are found in the marine environment (Moyle and Cech 1982). In the marine environment, 45% are found along continental margins in waters shallower than 200 meters; 1% are found in the surface layers of the oceans; 5% are found in the unlighted sections of the water column, and 7% are found on the bottom surfaces (Moyle and Cech 1982). Despite the large diversity and adaptations of fish, only three main groups of fish exist: jawless, bony, and cartilaginous fish. Jawless fish have no vertebrae but a bony head and other characteristics to classify them as vertebrates (Hickman et. al. 1993). Bony fish have a bony skeleton and an outer covering of scales. Cartilaginous fish, which lack a bony skeleton, have instead a skeleton of cartilage. Jawless fish are the hagfishes and lampreys. Cartilaginous fish include the sharks and rays. All others are bony fish that include most of the fish found on the coral reefs.

Fish are well adapted for life in the water; their gills are extremely efficient at removing oxygen from the water and they have an excellent sense of smell. The lateral line system allows them to detect vibrations and water currents. Fins give them propulsion and stability, and the variety of numerous body shapes and lifestyles has allowed fish to live in almost all aquatic habitats. By observing a fish closely, it is possible to determine some of the adaptations an individual species has developed in order to survive in a particular environment. Clues such as body shape, coloring, mouth and teeth shape, and shape of fins can be aids in learning about the lifestyle of individual fish (Figure 1).

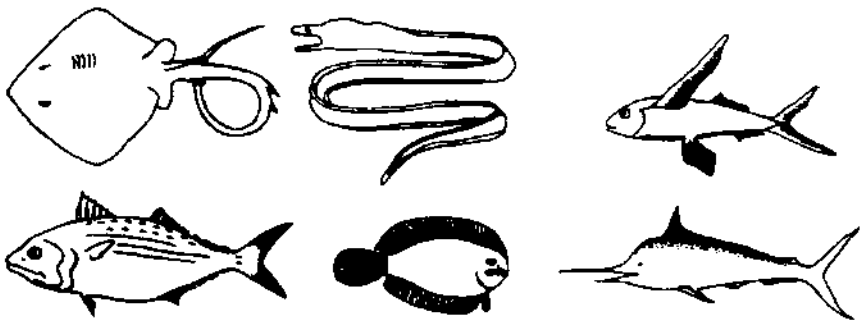

Figure 1. Examples of different body shapes in fish (not to scale).

The barracuda, swordfish, and tunas are streamlined fishes with pointed heads that enable them to be fast and efficient swimmers. This body shape is typical of predatory fish. A flatfish, like a flounder, is flattened with both eyes on one side of the body and a mouth that faces upward. This is because it lives on bottom surfaces. Eels have long, slender bodies for entering small holes and crevices in the reef in search for food and for protection.

Coloring helps some fish avoid predators. For other fish, color is a signal to be aware of poisonous spines. Some fish have special pigments to change their color to match their surroundings. Many reef fish have bright colors but use the safety of the reef for their protection.

Clues to a fish's diet and method of feeding can be determined by examining a fish's teeth, body shape, and digestive system. Sharp teeth indicate a predatory life style; short, comb-like bristles indicate a life around hard substrates where algae grow. On the reef many fish have small mouths at the end of long snouts for eating coral polyps (Alexander 1974). Parrotfish have fused teeth that form a powerful beak allowing them to bite off pieces of hard coral. Pufferfish also have a fused beak for crushing the shells of mollusks (Alexander 1974).

The basic fins found on fish are the dorsal, caudal, pectoral, pelvic, and anal (Figure 2). The many different body designs that exist in fish lead to variations and modifications in the size and shape of the different fins. Nevertheless, the pelvic, dorsal and anal fins are important as stabilizers (Moyle and Cech 1982). The pectoral fins are used for maneuverability and the caudal fin is used for increasing the swimming speed of the fish (Moyle and Cech 1982).

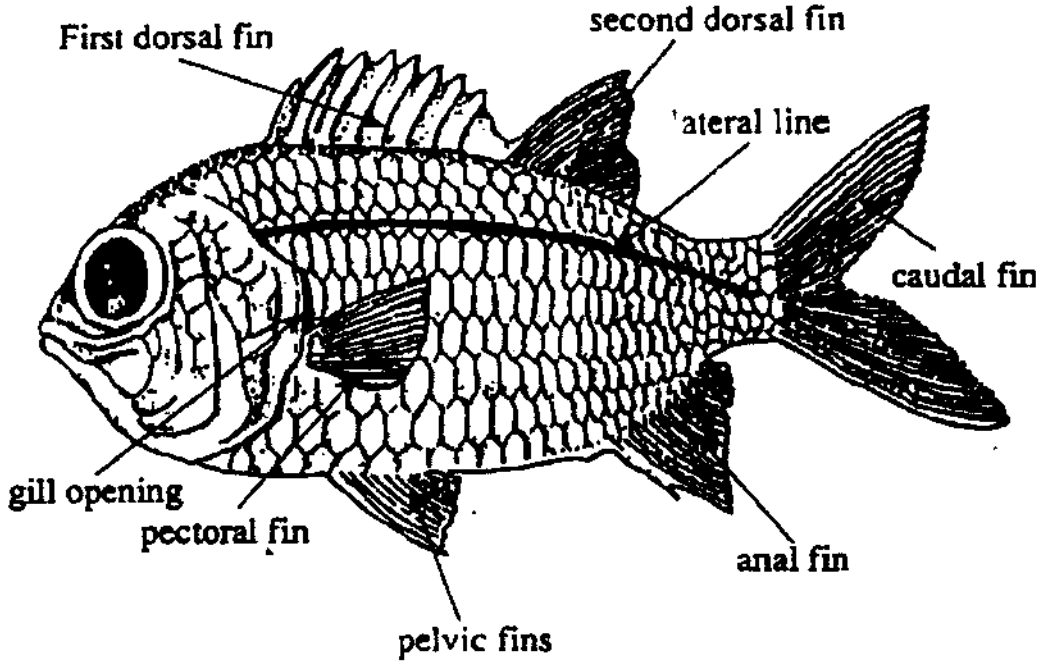

Figure 2. Basic external characteristics of a fish (Source: High School Marine Science Studies: Living Ocean).

Methods and Materials

Materials

1. One fresh fish
2. A copy of *Micronesian Reef Fishes* by Robert Meyers
3. Dissecting pan
4. Paint
5. One scalpel

Methods

1. Place your fish in a dissecting pan.
2. Using *Micronesian Reef Fishes* by Robert Meyers, identify your fish and write down the scientific name of your fish.
3. Write down the local Samoan name of your fish.
4. Observe the distinguishing characteristics of your fish (for example, shape of body, mouth, fins, teeth, and coloration).

5. Try to determine what habitat your fish lives in (for example, open water, bottom surface, or within the reef). Look for clues such as body shape, mouth, teeth, fins, and coloration.
6. Based on the shape of the mouth and teeth, or lack of teeth, try to determine what your fish eats.
7. Using the ancient Japanese technique of gyotaku, make a print of your fish.
8. Make a cut with the scalpel and extract the stomach. Look through the contents of the stomach and determine what the fish eats.

Results

1. The scientific name of your fish is _____.
2. The Samoan name for your fish is _____.
3. List the distinguishing characteristics of your fish.

4. Based on the distinguishing characteristics, what habitat do you think your fish live in?

5. Based on the characteristics of the mouth, what did you think your fish eats?

6. What did you find in your observations of the stomach contents?

7. Was your prediction of what your fish ate correct or not?

Conclusion

In your conclusion try to answer these questions:

1. Do you think your fish lives in the open water or on the reef? Explain your answer based on the characteristics of your fish.
2. What do you think your fish feeds on? Explain your reasons for this conclusion.
3. Based on stomach analysis, did your findings agree with your predictions based on the characteristics of the mouth? Can you make any generalizations about the characteristics of a fish's mouth and the diet of a fish?

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Name_____

Date_____

Lab V. Observation of Interstitial Fauna

Purpose: To observe some of the general characteristics of the interstitial community and estimate the population density of interstitial fauna at a given site.

Introduction

Interstitial fauna are very small organisms living in the limited space found between sand grains. Interstitial fauna can be found in almost all marine sediments. There are, however, not as many in saturated sediments or nearly dry sediments (Pollock 1971). Sand grain size and shape determine the pore size between grains, which affects the number and mobility of these organisms. A pore size of 150–200 microns (a micron is a millionth of a meter) is necessary for interstitial fauna to be present (Pollock 1971). The pore size also affects water permeability, which means the ability of water to pass through the sand. The amount of oxygen available to these organisms is dependent on the water permeability (Pollock 1971). Thus, sediments such as clay, silt, or very fine sand, have low permeability of water and limit the distribution of the interstitial fauna to the very top of the sediment. Intertidal areas that have medium to large sized sand grains and good water permeability provide ideal conditions for many species of interstitial fauna. In sandy tidal beaches, interstitial organisms occupy an area from low to high tide and from the sand surface to depths of several meters. As the coarseness and size of sand grains decrease, however, so does the diversity of organisms. In addition, the maximum density of interstitial fauna is restricted to the top few centimeters of the beach (Pollock 1971).

Almost every phylum of invertebrates is represented within the interstitial community (Farris 1983). Interstitial fauna tend to be worm-like in shape and are without major organs or eyes (Figure 1). They have adhesive structures that keep them attached to the sand grains. Some species are unicellular while others are multicellular. Nevertheless, they range in size from microscopic to small macroscopic specimens. Most are tolerant of broad temperature changes, but are able to detect pore size, water permeability, and chemical stimuli (Jansson 1971). Algae, organic detritus (disintegrated plant and animal material), bacteria, and other interstitial organisms provide the necessary food to sustain the interstitial community (Pollock 1971).

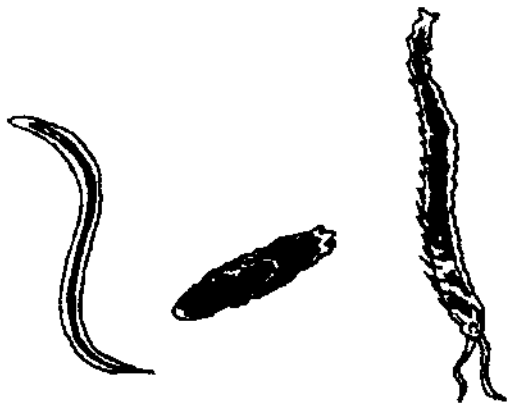

Figure 1. Some examples of interstitial organisms.

Materials and Methods

Materials

1. Magnesium chloride (MgCl)
2. Scoop or spoon
3. Large graduated cylinder (500 or 1,000 mL)
4. Hydrometer
5. Funnel
6. Sieve (see special instructions on how to make one)
7. Petri dish
8. Eye dropper
9. Two 500 ml erlenmeyer flasks
10. Dissecting microscope
11. Compound microscope

Methods

1. Collect 200 milliliters of wet sand near the water's edge. Low to medium tide is better than high tide line. (The organisms can survive several weeks if the sand sample is placed in a erlenmeyer with a volume of seawater one inch above the sand surface and sealed to avoid evaporation).
2. Using a hydrometer, measure the specific gravity of the water where the sand was collected.
3. Mix a solution of distilled water with enough MgCl to equal the specific gravity of the seawater collected.
4. Place the wet sand sample in a 500 ml erlenmeyer flask. Pour off any excess water from the sand.
5. Fill the erlenmeyer flask containing the sand sample with the MgCl solution.
6. Place a large cork stopper into the flask making sure no air bubbles are in the flask.
7. Invert the flask slowly in a figure eight motion several times to make sure all the sand is mixed well with the MgCl.
8. Let the erlenmeyer flask sit for 3 to 5 minutes (more than 10 minutes will kill the organisms).
9. Wet the sieve (see section on how to make sieve) with clean seawater and place it in a funnel, then place the funnel over an erlenmeyer or large beaker.
10. Invert the erlenmeyer with the sand sample several more times, and when the lightest sand demarcation appears, decant the MgCl solution through the sieve. (The MgCl solution can be saved and reused.)
11. Pour the MgCl solution back into the erlenmeyer containing the sand sample and repeat steps 5 through 7 and then step 10.
12. Cover the bottom of a petri dish with a little seawater.
13. Put the sieve in the petri dish with seawater by placing one edge of the sieve into the water like you would with a cover slip on a wet-mount slide so not to catch any air.
14. Examine the organisms on the sieve with a dissecting microscope.
15. For a closer inspection, organisms can be removed from the sieve with an eye dropper and placed on a slide for viewing with a compound microscope.

How to make a sieve

1. Cut a half-inch length of a PVC pipe that has the diameter to fit into a petri dish.
2. Cut 64 micron mesh or silkscreen to fit amply over the half-inch ring cut in step one.

3. Lay the screen tightly over the ring. Where the screen is flush on the ring, place drops of glue at regular intervals. (Superglue works well or you can make glue of 90% glacial acetic acid, 10% chloroform, and a pinch of PVC shavings.
4. After dried, use angular file carefully to remove fringe of mesh screen.

Results

1. Record the total number of interstitial fauna you observed in your 200 milliliter sample.

   Total # = _____

2. Estimate the population density of interstitial fauna for the area sampled using the following equation:

   $$\text{Density} = \frac{\text{(Total \# observed)}}{200\ \text{ml}}$$

   = _____

3. How many different types of interstitial fauna did you observe? _____
4. What general characteristics did you observe?

5. Draw several different pictures of interstitial fauna you observed.

Conclusion

In your conclusions try to answer the following questions:

1. Was there a general body shape of the interstitial fauna you observed and what was it?
2. How many different types of interstitial fauna did you observe at this beach?
3. Why do you think most interstitial fauna are found near the surface?
4. Do you think all beaches would have the same density and kinds of interstitial fauna as the ones you observed? Explain why or why not?
5. Explain why you think we sampled near the water's edge and not from sand that was submerged underwater?

References

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Name_____

Date_____

Lab VI. Observation of Plankton

Purpose: To observe examples of plankton and gain a better understanding of the planktonic community.

Introduction

Plankton are a variety of small plants and animals that drift with ocean currents. Plankton can be grouped or classified by one of following methods: a) trophic level, b) size, or c) life history. Trophic level refers to the order or sequence in which organisms get their food. It can be considered a food chain of plants, herbivores, carnivores, and decomposers. Within the trophic level the plant plankton are called phytoplankton. Life in the oceans is dependent on the phytoplankton because they are the primary producers. Without the phytoplankton capturing energy from the sun and converting it to plant material, there would be no food and life could not exist in the oceans. The consumers are the animal plankton called zooplankton and the decomposers are the bacterioplankton. Phytoplankton such as diatoms and dinoflagellates are eaten by zooplankton such as copepods, as well as by other filter feeders of the marine environment. The zooplankton become food for larger zooplankton and other planktonic carnivores such as fish and whales. Bacterioplankton are the decomposers of the plankton and are the final link in the food chain.

Classification by size has five divisions: 1) the ultraplankton are less than 5 microns (a micron is one-millionth of a meter), this includes bacterioplankton and some phytoplankton; 2) the nannoplankton range in size from 5–50 microns which are primarily phytoplankton; 3) the microplankton range from 50–500 microns and include phytoplankton, zooplankton and protozoans; 4) the macroplankton range in size from 500–2000 microns and include zooplankton and fish larvae; and 5) the megaplankton are greater than 2000 microns and include jellyfish and krill (Barnes and Mann 1980).

Zooplankton exhibit a variety of life cycles but two general classifications exist. Zooplankton that spend all phases of their life in the plankton are called holoplankton. Examples include jellyfish, krill, and copepods. Zooplankton that spend only part of their life in the plankton are called meroplankton. Examples include crabs, starfish, sea urchins, clams, corals, and many others.

Life in the oceans is dependent on the primary producers, phytoplankton. Without the phytoplankton capturing energy from the sun and converting it to plant material, there would be no food and life could not exist in the oceans.

Zooplankton swim primarily in a vertical direction (Wickstead 1965). The vertical movement coincides with a 24 hour cycle, moving upward at night and downward during the day. Nevertheless, these movements do not enable them to move against the currents. Plankton lacking swimming abilities have developed very good buoyancy capabilities. One example is the development of a very small body size. Organisms with a very small body size sink very slowly, because compared to their size, the ocean water is more dense. This produces sinking rates in the range of only 10 to 100 centimeters per day. Other things plankton do to avoid sinking include the development of spines or extensions of their body, accumulation of oil and fat cells, having a high (97–99%) water content, loss of hard parts and having gas floats (A. Alldredge pers. comm.; Wickstead 1965). Some examples can be seen in Figure 1.

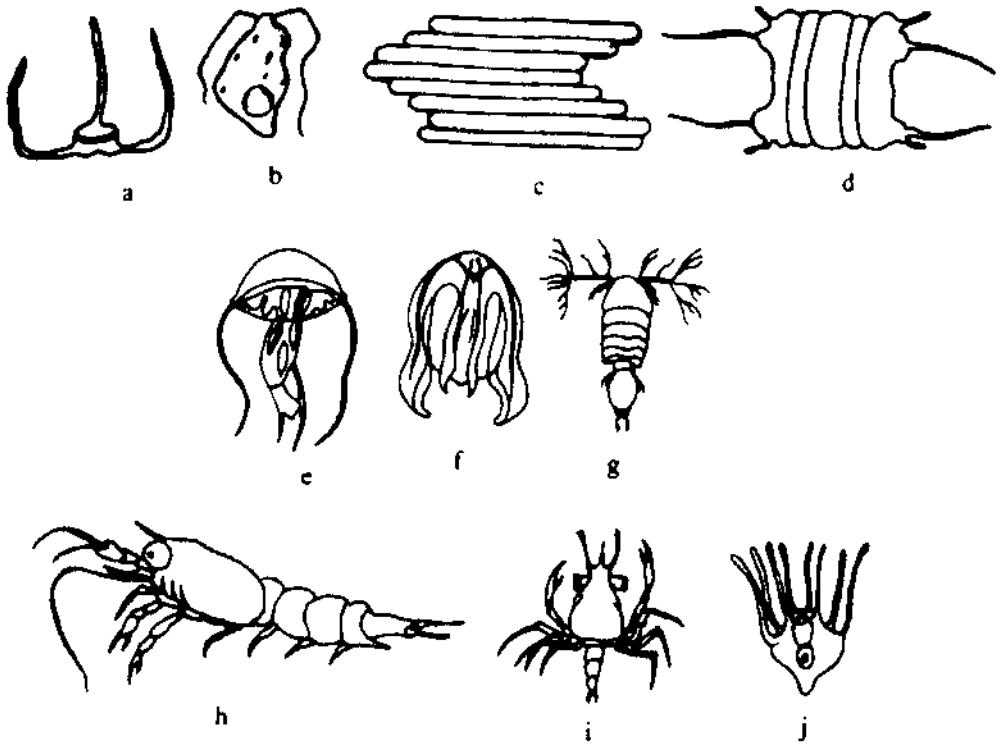

Figure 1. Examples of plankton (not to scale): a-d are phytoplankton of which a and b are dinoflagellates and c and d are diatoms; e-g are holoplanktonic zooplankton; and h-j are meroplanktonic zooplankton.

Materials and Methods

Materials

1. Monofilament rubber-coated wire
2. One nylon stocking
3. Plastic collecting bottle or medicine bottle
4. Sewing needle
5. Tongue depressor
6. Fishing line
7. Rubber bands

Methods

1. Bend the wire into a loop with a diameter of approximately three inches.
2. Cut an 18-inch length of nylon stocking and sew one end to the loop using the needle and fishing line.
3. Slide the plastic bottle into the other end of the nylon. Then place two or three rubber bands around the bottle making sure the nylon is snug on the bottle. Test for snugness by pulling the nylon to see if it comes off the bottle. If the nylon comes off then make your rubber bands tighter.
4. Cut three lengths of fishing line approximately 15 inches long. Tie each end of the fishing line to the wire loop. When you tie these lines to the wire, space the points where you tie the lines so that the attachment points would be the points of a triangle (Figure 2).
5. Hold the plankton net up by the three lengths of fishing line. Level the wire loop and then tie the loose ends of fishing line together making sure the wire loop remains level.

Figure 2. A standard plankton net.

6. Cut a 10-foot length of fishing line and tie it to the point where the three lines were tied together in step 5.
7. Tie the other end of the 10-foot line to a popsicle stick and wind up the remaining line.
8. At the docks, mark out a 20-foot interval. Starting with an empty net, trawl for 20 feet. After this trawling, place all of the net's contents in a separate bucket or container. Take this container back to the class. DO NOT PLACE ANY ADDITIONAL PLANKTON IN THIS CONTAINER.
9. Continue trawling for the remainder of the time allowed. Save your catch for observing with a microscope in the classroom.

Results

1. Measure the diameter of your net in inches. D = _____ in.
2. Determine the area of your net opening using the following equation:

   $$\text{Area} = 3.14\ (D/2)^2$$

   Area = _____ in^2
3. Assume all of the water in the net's path actually passes through the net. (Note this assumption is incorrect, but it does permit the calculation of a maximum possible water volume.) Calculate the number of gallons that passed through the net using the following formula:

   Given: a) 20 ft. = 240 in.

   b) 1 gallon = 231 $in.^3$

   Volume sampled ($in.^3$) = (area of net opening) x 240 in. = _____ $in.^3$

   $$\text{Volume in gallons} = \frac{\text{(volume from above equation)}}{231\ in.^3}$$

   Volume in gallons = _____
4. Determine the number of plankton caught in the 20 foot trawl.

   Total number of plankton = _____
5. Determine the density of plankton using the following equa-tion:

   $$\text{Plankton Density} = \frac{\text{total number of plankton}}{\text{volume filtered}}$$

   = _____
6. Draw several different plankton you observed.

Conclusion

In your conclusion try to answer the following questions:

1. Describe the plankton you observed. List any general characteristics you observed.
2. Do you think you would find the same types of plankton if you sampled at night? Why or why not?
3. Do you think you would find the same densities of plankton if you sampled at different locations around the island? Explain your answer.
4. Would sampling at different times of the day affect the density measurements? Explain your answer.
5. Why do you think there are so many plankton in Pago Pago Harbor?
6. What factors do you think affect the size of plankton populations?

References

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Name_____

Date_____

Lab VII. Tides

Purpose: To understand what causes the tides and learn how to read the local tide calendar.

Introduction

The gravitational forces of the moon and sun, combined with the rotational forces of the earth, produces a regular motion in the oceans called tides. This motion causes a continuous rise and fall of the seawater level. The rise and fall of the water level is most noticeable along coastlines. When the waters fall, exposing portions of the coastline, this is called low tide. When the water rises, covering the same portions of coastline, this is called high tide. The motion of the tides is mostly caused by the gravitational attraction of the moon on the earth. Although the moon is much smaller than the sun, its attractive force is greater because it is much closer to the earth. This does not mean the sun does not have an attractive force affecting the tides, but the moon's force is greater.

The gravitational force of the moon causes the water on the surface of the earth to bulge. The side of the earth nearest to the moon has a stronger force than the opposite side of the earth, thus the bulge of water is bigger on one side. Centrifugal force is a spinning force which pushes outwards. (A good example of centrifugal force is when you swing a bucket of water around in a circle. The water does not fall out because the force is pushing the water outwards or into the bucket). Combining the gravitational forces with the centrifugal force of the earth enlarges the bulges of water on the surface of the earth.

The sun's gravitational force, which is less than one-half the force of the moon's, produces a smaller water bulge (Hewitt 1985). Nevertheless, the bulge produced by the sun can increase or decrease the bulge of water caused by the moon. Twice a month, during a new and full moon, the sun and moon are in line with one another. As a result, the gravitational forces of the moon and sun coincide, producing a larger than normal bulge on both sides of the earth (Figure 1). The tides associated with this event are called spring tides. When the moon is halfway between new moon and full moon, forming a right angle to the line causing spring tides, the gravitational forces partially cancel each other, producing a smaller bulge of water (Figure 1). These tides are referred to as neap tides. As the moon orbits around the earth, the cycle of large bulge to small bulge produces the daily changes we observe in the heights of the tides.

As the earth rotates, it passes through a bulge of water (high tide), then to a lower surface level (low tide), then again through a bulge (high tide), then another low surface level (low tide). This cycle takes 24 hours and 50 minutes (Hewitt 1985). Therefore, on each succeeding day, the time of the low or high tide will be 50 minutes later.

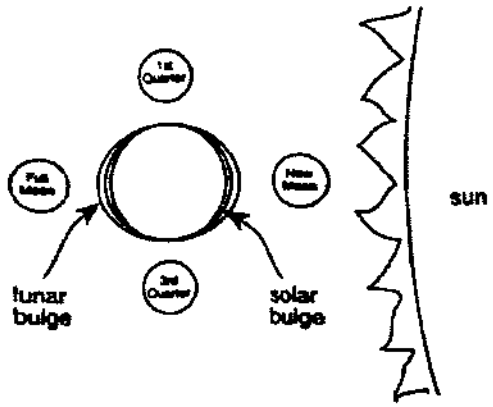

Figure 1. Diagram showing the earth's bulges of water caused by the gravitational forces of the moon and sun. When new or full moon occurs, spring tides are produced. When first or third quarter occurs, neap tides are produced.

Three types of tidal fluctuations exist. When an area has two high tides and two low tides per day, and the height of each high and each low are approximately equal, these are called semidaily tides (Gross 1977). Semidaily tides are mostly found along the North Atlantic coast (Gross 1977). When an area has two high and two low tides per day but the height of each high and each low is different, these are called mixed tides (Gross 1977). Mixed tides are common in the Pacific region (Gross 1977). When an area has only one high tide and one low tide each day, these tides are called daily tides (Gross 1977). Certain areas of the Gulf of Mexico exhibit daily tides (Gross 1977). Many variables influence the type of tides an area will have. The shape of the ocean basin, slope of the bottom, and geographical location all play a role in the type of tides an area will have. With the aid of computers the effect of all the variables can be calculated to accurately predict the height and time of each tide for a given area.

Methods and Materials

Materials

1. Copy of an art and tide calendar

Methods

1. Look at the tide calendar for the month of July 1995. The numbers on the left hand side which correspond to the horizontal lines represent the height of the water in feet. The vertical lines represent the time of day in three-hour intervals.
2. Identify the day of the month that has the lowest and highest tide.
3. Determine the height of the highest tide on this day.
4. Determine the height of the lowest tide.
5. Determine the time of day for these tides.
6. Determine which week has the greatest fluctuation in the height of the tides.
7. Determine which week has the least fluctuation in the height of the tides.
8. Identify the days of the new, first quarter, full, and third quarter moon.
9. Determine which days represent spring tides.
10. Determine which days represent neap tides.
11. Record the height of the high and low tides on the day of the new and full moon.
12. Record the approximate time of either a high tide or low tide for any day. Then record the time of the same tide for the next six days.

Results

1. _____ had the highest and lowest tides.
2. The height of the highest tide was _____.
3. The height of the lowest tide was _____.
4. The time of the highest tide was _____ and the time of the lowest tide was _____.
5. The week that had the greatest fluctuations in the heights of the tides was _____.
6. The week that had the least fluctuations in the heights of the tides was _____.
7. The day of the new moon is _____.
   The day of the full moon is _____.
   The day of the first quarter is _____.
   The day of the third quarter is _____.
8. On _____ and _____ spring tides occurred.
9. On _____ and _____ neap tides occurred.

10. On the day of the new moon, the height of the highest tide was _____ and the height of the lowest was _____.
11. On the day of the full moon, the height of the highest tide was _____ and the height of the lowest was _____.
12. Pick any week during the month, record the time of the high tide _____ for Sunday. Then record the time of the high tide for the remaining days of the week. Do you notice a pattern?

_____ had a high tide at _____.
_____ had a high tide at _____.
_____ had a high tide at _____.
_____ had a high tide at _____.
_____ had a high tide at _____.
_____ had a high tide at _____.

Conclusion

In your conclusion try to answer the following questions:

1. What type of tides (semi-daily, mixed, or daily) occur in Samoa? Explain your reasoning.
2. According to the tide calendar, which days of the month were spring tides?
3. According to the tide calendar, which days of the month were neap tides?
4. According to the tide calendar, which days had the highest and lowest tides?
5. Can you explain why the day with the highest tides also had the lowest tides?
6. Was there a difference in the height of the tides for new moon and full moon? Can you explain this?
7. What was the difference in time from day to day for the tide you chose? Can you explain why?
8. Can you think of any reasons why it is important to keep track of the tides?
9. Do you think your ancestors were able to predict the tides? How do you think they were able to do this?

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Name_____

Date_____

Lab VIII. The Scientific Method

Purpose: To exercise the steps of one version of the scientific method.

Introduction

Make observations. State the problem. Form a hypothesis. Perform an experiment. Interpret the data. Draw a conclusion. Any graduate of a science class probably recognizes these steps as part of the scientific method. This sequence, or some variation of it, can be found in most introductory science books. The presentation of the method in some texts suggests it is a timeless natural law. This is not the case. The "modern" scientific method is only about 500 years old (Oldroyd 1986). When compared to the crossing of the Bering Straits by humans (at least 8,000 years before present) and the entrance of the first Polynesians into the South Pacific (about 3,200 years before present), the scientific method is rather new.

Why do we use the scientific method? The scientific method is a procedure for gaining knowledge. It is not the first or only way to gain knowledge and likely will not be the last. However, the technical advances over the last 500 years are evidence of its power. The differences between the technology of A.D. 100 and A.D. 600 were relatively few. The differences between the technology of 1500 and the present are astonishing. The scientific method has played a major role in these advances.

The following is an exercise in the use of the scientific method. The problem is a simple one, but the objective of this lab is not to make a big discovery. The objective is to try a new way of thinking... a way that may require some practice.

Materials and Methods

Materials

1. One egg per student.
2. One problem: Is the egg hard boiled or raw?
3. Guidelines for solving the problem:
   Only one...Assume raw eggs are fertile and are to be hatched. Therefore, any test that might injure the chick is forbidden. Cracking the eggshell is not an option.
4. Access to one known raw egg.
5. Access to one known hard boiled egg. (The eggs of known conditions will act as controls.)

Methods

The method used will be the scientific method. The method's steps will be presented here as a sequence, but it must be remembered that the method on the whole is a thought process. "Scientists find it difficult to tell in what order they actually use the scientific method. The human mind probably does not actually solve problems in a systematic fashion (World Book Encyclopedia 1975). However, presenting the method as a specific sequence of steps does help explain the problem and should permit anyone to repeat the solution. Repeatability is a fundamental characteristic of modern science.

1. In the results section, state the problem.
2. If you think you can predict (=guess) the condition of your egg by performing a test, state the prediction and describe the test. The prediction is called a hypothesis, and should be based on some prior knowledge. Some sample hypotheses might be "based on ..., I predict that boiled eggs weigh more than raw eggs," or "raw eggs are less dense than boiled eggs, therefore, I predict..." Though most versions of the scientific method include hypothesis formation, you should not feel that you have to state a hypothesis. The hypothesis is supposed to be an educated guess. Even some of the greatest scientists have on occasion solved problems by performing a test based on a hunch or feeling. New students of the scientific method sometimes make

hypotheses that have absolutely no basis. If you cannot think of a reason for your prediction, do not feel obligated to state an hypothesis.

3. Record any observations you make concerning your attempts to determine your egg type. One approach to solving the problem might be to compare properties of your unknown egg to those of the known eggs. Do the eggs have the same mass? Do they all roll at the same rate? Do they all sound the same when gently tapped? Do they smell the same? Can light be shown through any/all of them? Anything goes in this step; you should record the results of your hypothesis, as well as everything you measure. The information gathered in this step is called data. The process by which the data is gathered is called an experiment.
4. Examine your data. Look for patterns. Do all of the hard boiled eggs have a specific density? Do they all sink in water? The act of looking for some pattern or meaning in the data is called interpretation. Write down anything you feel might allow you to predict your egg type.
5. After interpreting your data, try to arrive at a conclusion. Your conclusion should be a summary of your interpretation. As an example, you might have noticed that the boiled eggs always rolled faster than the raw eggs. If your unknown egg was a fast roller, you might conclude that it too was a hard boiled egg. Your conclusion for this activity must include a response to your stated problem. It will be some variation to the following:

   a. I believe I have a hard boiled egg because...

   b. I believe I have a raw egg because...

   c. I do not have enough data to make a decision...

Results

1. State the problem.

2. State any hypotheses you might have tested. If you did not state a hypothesis, simply write "no hypothesis stated."

3. Record all observations; record the results of all tests.

4. Interpret the data. Describe any patterns you might see in your data.

5. Write a conclusion. Be sure your conclusion includes a response to your problem.

Conclusion

Break the egg and then answer the following questions.

1. Was the conclusion correct? If it was not, what do you think caused you to come to the wrong conclusion?
2. The scientific method has roots in a way of thinking called empiricism. Empiricism suggests that people gain knowledge by experiencing things with their senses. Before the development of the scientific method, people were more willing than now to base their beliefs on the statements of others without actually seeing if the statements were supported by facts. Think of one superstition. How would you test it using the scientific method? (Sample superstition: You can catch a bird by putting salt on its tail.)

References

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Name_____

Date_____

Lab IX. How to Write a Research Paper

Purpose: To write a research paper presenting data/information gained through the scientific method.

Introduction

It has been said that an experiment is not finished until the results have been published (Day 1979). This may overstate the importance of the research paper, but not by much. One of the fundamental assumptions in modern science is the idea that the results of an experiment should be repeatable. Given the same equipment, two different people should be able to perform the same experiment and obtain the same results. This requires that both people know the experiment's procedure (i.e. how the experiment was conducted). One of the main functions of a research paper is to make known to the world the procedure used to obtain any given result. Two recent experiments illustrate the importance of this role. High temperature superconductors were first reported in 1987. Laboratories all over the world repeated the experiments and confirmed the results. Cold fusion was reported in 1989. Many labs throughout the world have been unable to repeat this experiment, causing most people to doubt the existence of this type of fusion.

Research papers serve another purpose. They establish who was first: first to discover, first to invent, first to find, first to think of, etc. Sometimes called establishing priority, this role of a research paper is very important to scientists. Awards have been given and careers have been dashed according to who published a paper first, sometimes without regard to who actually first performed the experiment.

The following is a recipe for writing a research paper. Different journals request that contributing authors follow different formats. The format presented comprises the following elements:

Title
Abstract
Introduction
Materials and Methods
Results
Conclusion
References

Research papers and the scientific method go hand in hand. The paper is a formal documentation of the method. Familiarize yourself with the different parts; with some practice you will be able to present the results of any experiment in a research paper.

Materials and Methods

Materials:

1. Pencil or pen
2. Results from the Scientific Method lab

Methods:

(Note: research papers are usually written after the research has been performed. There is no recognized order for writing the different sections, although the nature of each makes some approaches better than others, e.g., the results section might best be written before the conclusion, and the title and abstract are usually best written last).

1. In the materials section, list the materials used in the Scientific Method lab (Lab VIII).
2. In the methods, write down the sequence steps you used to decide whether the egg was raw or hard boiled.
3. In the results section, present any data you collected (measurements, observations, tables, charts) that caused you to say the egg was hard boiled or raw. You should not speculate as to what the results mean...save speculation for the conclusion.
4. In the conclusion section, state your conclusion. Your conclusion should be based on your interpretation of the results.
5. Write a brief introduction. Your introduction should explain the problem (e.g., include a statement that describes the significance and relevance of the problem), review what has been previously done, and briefly state what is about to be done.
6. After the above parts are complete, write an abstract. An abstract is a summary of the whole experiment. The abstract should briefly state the purpose and conclusion of the experiment.
7. It is not essential that the title be written last, but it is a good idea. S< times the focus of the paper changes as it is being written. The title should reflect as closely possible the content of your paper. Lack of time prevents people from reading many articles; . .ten they just scan through titles. Try to think of a title that will grab the readers attention and give the reader a good idea of what the paper is about.
8. In the references section, list your references. Include books, magazine articles, technical reports, etc. Book references should follow the following format:

   Author's last name, author's first two initials. Date of publication. Book title. City of publisher. Name of publisher.

   Example: Day, R.A. 1979. How to Write and Publish a Scientific Paper. Philadelphia, Pennsylvania. ISI Press, University City Science Center.

   Below is a format for a journal reference.

   Author's last name, author's first two initials. Date of publication. Title of journal artical. Title of journal (space) volume of journal: beginning page-ending page.

   Example: (three authors)

   Paladino, F.V., Standora, E.A., S.J. Morreale. 1992. Scientists use sonic, satellite, and radio telemetry to save sea turtles. Environmental Science and Technology News 26:424-426.

Results

Make an entry for each section. You may be brief. The purpose of the lab is to familiarize you with the different sections of a research paper.

Title _____

Abstract _____

_____

_____

Introduction _____

_____

_____

_____

_____

Materials and Methods

Materials

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Methods

1. _____
2. _____
3. _____
4. _____
5. _____

Results

Conclusion

References

Conclusion

Answer the following in a brief paragraph.

1. Which part of the practice research paper did you find easiest to write? What caused it to be easy?
2. Which part of this practice paper did you find most difficult to write? What caused it to be difficult?

References

Day, R.A 1979. *How to Write and Publish a Scientific Paper.* Philadelphia, Pennsylvania. ISI Press. University City Science Center.

Demanche, E. 1987. *Instructional Guidelines for the Student Sy.mposium on Marine Affairs.* Honolulu, Hawaii. Hawaiian Academy of Science.

Name_____

Date_____

Lab X. The Transect Procedure

Purpose: To use the transect procedure to estimate the diversity, density, and distribution of organisms in a given area.

Introduction

Few news events draw more attention to the environment than ecological disturbances. Oil spills, storms, discharge from industry, and other events make us pause and wonder if the affected animals and plants will recover. A photo of an oil covered bird or diseased seal may long focus the public's attention on the fate of individual organisms, but it is the effect on the overall ecological community that will determine the lasting impact of the disturbance.

A community is an interacting assemblage of different species that share a habitat. Ecologists often measure three properties within a community to determine its "state" or "health": 1) species diversity, 2) density of each species, and 3) the distribution of each species. A transect (Figure 1) is a tool used to estimate these properties.

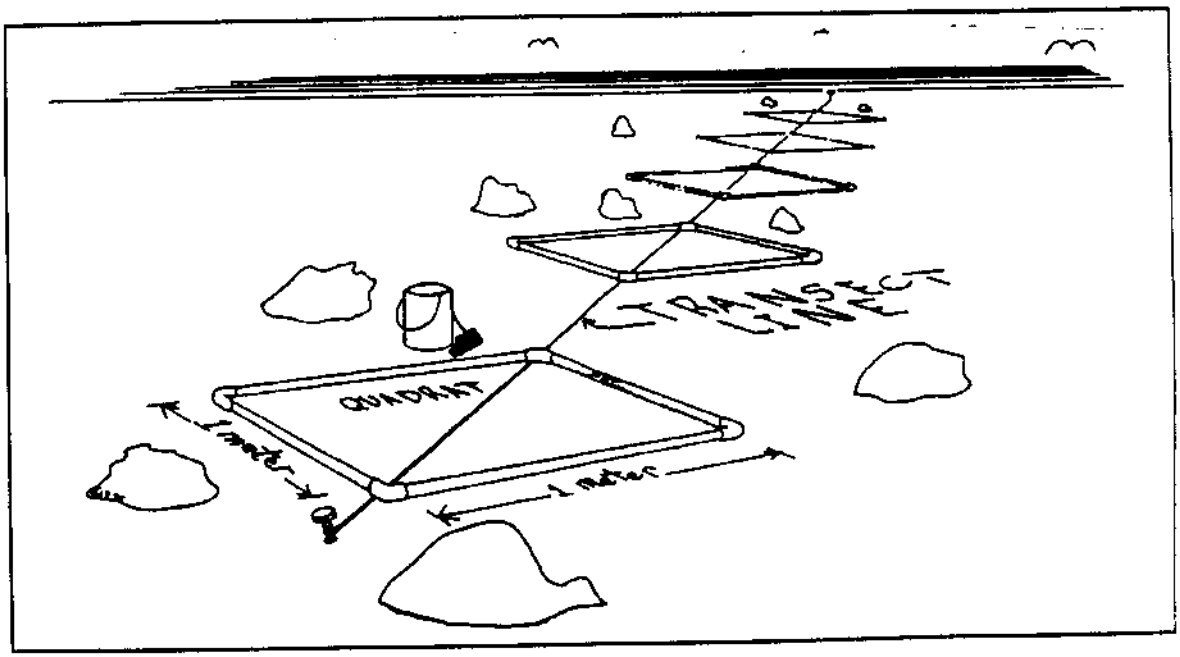


Figure 1. Five one square meter quadrats along a transect line.

The terms may be new, but the concept behind a transect procedure is familiar to anyone who has visited a doctor. In determining a patient's health, one property a doctor measures is temperature. The value of this common procedure rests entirely on the assumption that the doctor knows the temperature of a healthy human. The measured temperatures of many healthy people have shown the temperature of a healthy human to be about 98.7°F. This is a well established fact. However, imagine the problems that would arise if a doctor did not know the normal body temperature of a healthy human. Should a fever patient having a temperature of 102°F be warmed or cooled? Absurd as it may seem, this parallels an ecologist's dilemma following an ecological disturbance. That the community was changed may be obvious. However, the degree and the direction of the change may be hard to determine if there are no records of the community's health prior to the disturbance.

In this experiment each group will count the numbers and kinds of organisms in a measured area called a quadrat. These data will permit the calculation of the quadrat's species diversity and the density of each species within the quadrat. Each group will also observe how the members of one species are arranged and decide whether their distribution is random, uniform, or grouped (Figure 2). The quadrats will lie along an imaginary line called a transect. A rope called a transect line is often used to allow people to see the transect, just as pencil lead is used to "see" the imaginary line that lies between two points on a paper.

Recall that the transect procedure is used to make estimates. The measurements of density, diversity, and distribution are likely to be fairly accurate for each quadrat. However, values obtained from quadrats are often used to estimate these properties over larger areas. A branch of mathematics called statistics provides methods for calculating the accuracy of these estimates. These methods are widely used in the science of ecology.

Take care in making your counts. Your transect study may be the first to have been conducted in this area.

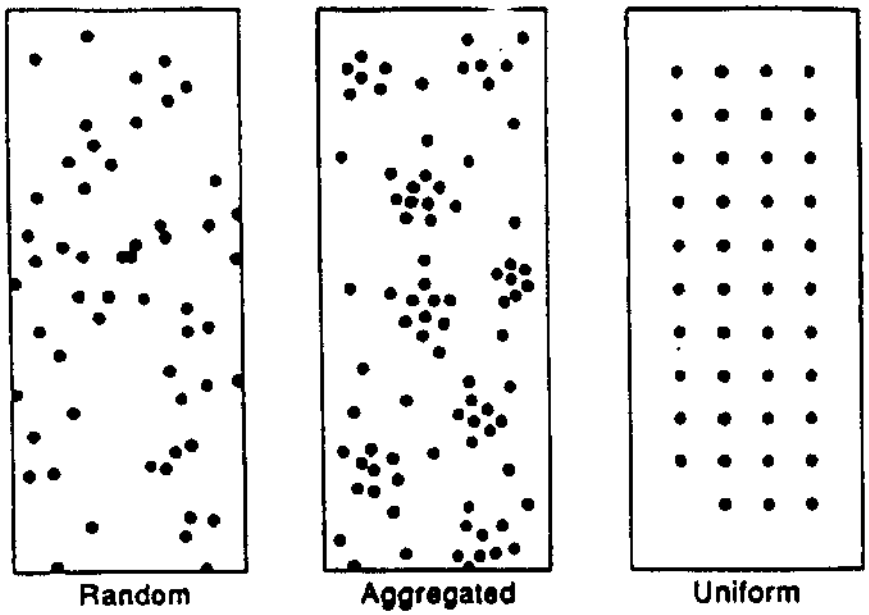


Figure 2. Three possible types of spatial patterning of individual animals and plants in a population. (Source: Krebbs 1989)

Materials and Methods

Materials

1. Five 1-m^2 quadrats constructed of four 1-m lengths of 3/4" PVC pipe and four 3/4" PVC right angle joints.
2. 50-meter line, marked at 1-meter intervals.
3. Grease pencil.
4. Data sheet.
5. Collecting buckets.
6. One to four nets.

Methods

1. Assemble the PVC quadrat markers.
2. Record the time and date on the data sheet.
3. Lay down the transect line along the desired transect. Secure both ends.
4. Record the location of both end points. This information will allow someone else to lay down a line along the same coordinates.
5. You will be assigned a point along the transect. Record the distance of this point from the origin. Place one corner of your quadrat at this point, and the opposite diagonal corner on the transect line.
6. Choose one group member to record on the data sheet the organisms seen by the other group members.
7. Take a minute to observe your quadrat. Choose ONE organism, and decide whether its distribution is random, aggregated, or uniform. (Record the organism and distribution type).
8. Start collecting organisms within the quadrat. Once recorded, the organism may be released outside the transect area or placed in a collecting bucket. For extremely abundant organisms, (e.g., algae covering large areas of the bottom) enter TNC (too numerous to count).

   CAUTION: Organisms kept in buckets can be harmed by some conditions:

   a. Too much handling.

   b. Anoxia (lack of oxygen).

   c. Hyperthermia (high body temperature, caused by sun-heated water).
9. Your group may be asked to evaluate another quadrat. If so, repeat steps 5, 6, 7, and 8.

Results

1. Construct a histogram showing the abundance of the taxonomic groups.
2. State the diversity for your quadrat in the following units:

   Quadrat___ Diversity= $\frac{\text{\_\_\_\_ taxonomic groups}}{\text{m}^2}$
3. The distribution of _____ (taxonomic group) was most similar to a (random/ aggregated/ uniform) distribution.
4. The density of _____(choose one taxonomic group)= $\frac{\text{\_\_\_\_\_ individuals}}{\text{m}^2}$
5. As a class, select a taxonomic group, and construct a line graph showing how the density of organisms changes with distance from the origin.

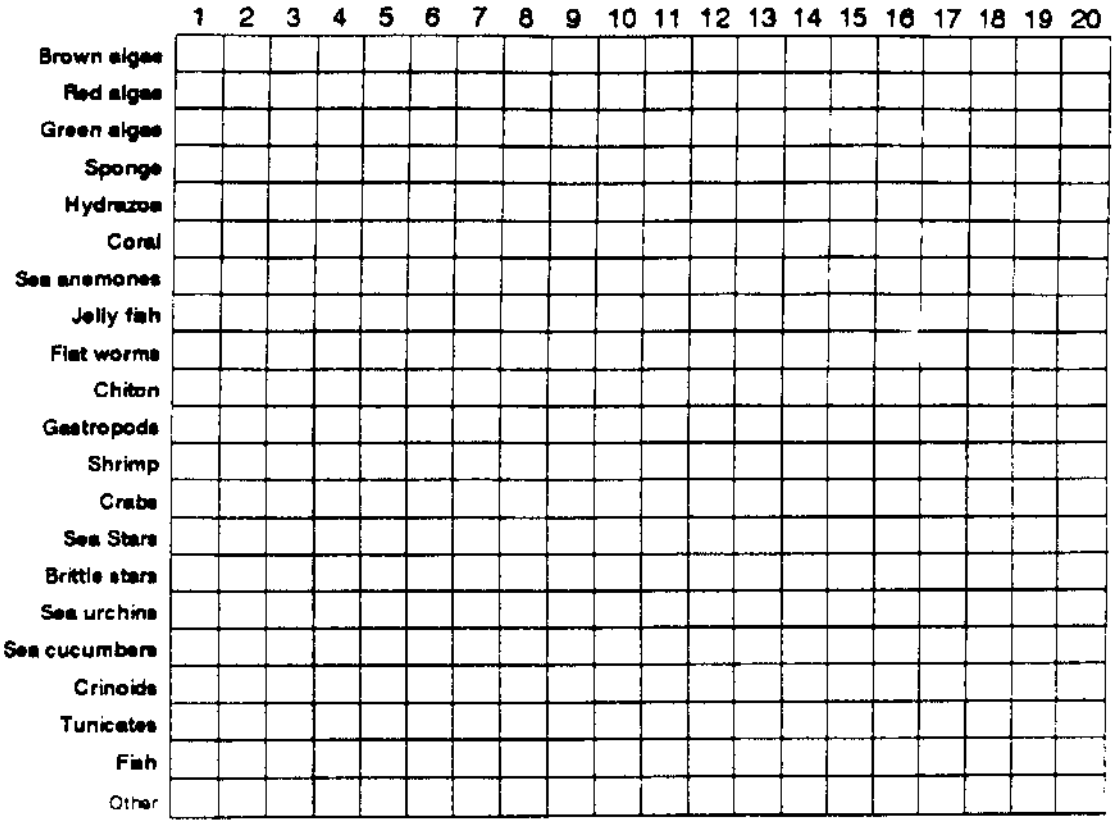
FAGATELE BAY SUMMER PROGRAM

Group #_____ Name _____

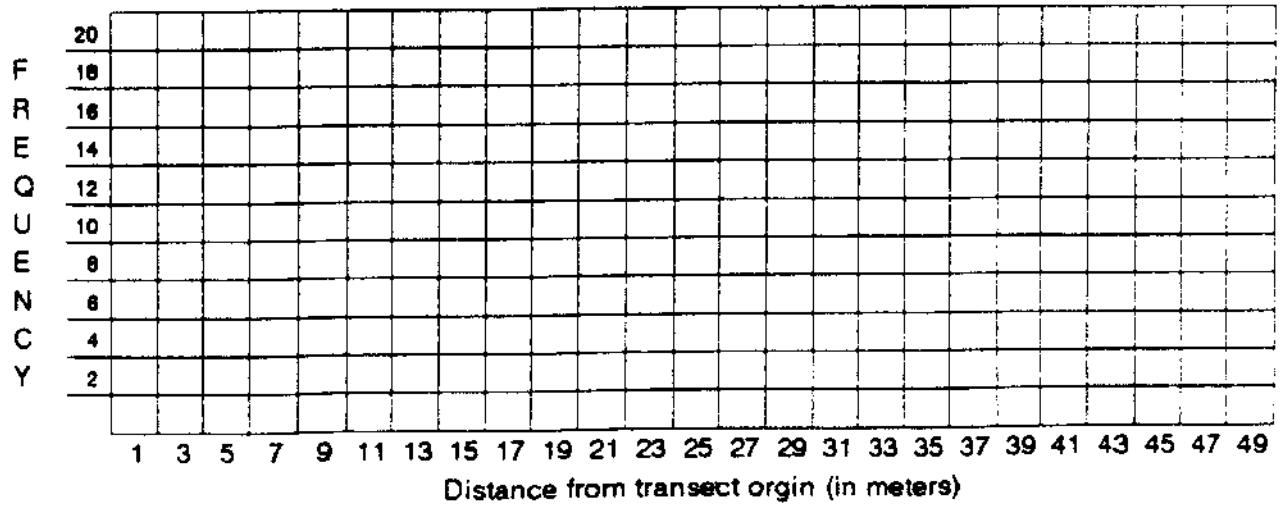
Meters from origin _____ Date _____

TRANSECT HISTOGRAM

Number of specimens observed



Graph of _____ vs. distance from transect orgin



Conclusion

Answer the following in a brief paragraph.

1. What problems did your group experience in trying to collect data? (e.g., water currents, glare, group members fooling around, lack of equipment, etc.)
2. What taxonomic groups were present in the greatest densities?
3. What taxonomic groups were present in the lowest densities?
4. a. Which quadrat(s) had the greatest diversity of taxonomic groups? Reason?

   b. Which quadrat(s) had the least diversity of taxonomic groups? Reason?
5. Examine your line graph. Try to explain any changes of density with distance. If there was no change, what might this suggest about the microenvironment of each quadrat?

References

Krebbs, J.K. 1989. *Ecological Methodology*. New York: Harper and Row.

Name_____

Date_____

Lab XI. Scientific Illustration

Purpose: To draw an organism using the dot stipple technique, observing the criteria given for a scientific illustration.

Introduction

Illustrations have played a key role in the development of scientific thought. The invention of the telescope and the microscope in the early 1600's (Clay and Court 1975) quite literally made visible worlds that had never before been seen. The scientists who made use of these tools used words and illustrations to record the things they saw. In the days before photography, illustrations were the only means of pictorially recording observations. Illustrations also allowed scientists to communicate ideas across language barriers.

The development of photography in the 1830s provided science with a revolutionary method for recording observations. Surprisingly, it did not diminish the importance of scientific illustrations. This can be attributed to at least two factors. First, most scientists communicate their ideas by publishing papers, and black and white illustrations are less expensive to print than photographs. Second, where photographs tend to show everything, illustrations show only enough to convey an idea. At times an illustration can be more effective in focussing a viewer's attention than a photo.

A scientific illustration can be defined as a picture used to explain a scientific fact. Good illustrations meet the following criteria: 1) they are accurate, 2) they are artistically pleasing, 3) they show only those things needed to "explain" a fact or communicate an idea, and 4) they are documented. In addition, most scientific illustrations are shaded in a way that suggests that the light is coming from the upper left hand corner.

Contemporary scientific illustrations can be placed into one of three broad categories: black and white, continuous tone, and color. Black and white illustrations cost least to print, and are the type most common in scientific journals. Continuous tone and color illustrations are the costliest to reproduce.

The following describes a dot stipple technique for producing a scientific illustration from a photograph. It is worth emphasizing that scientific illustrators use a variety of techniques to get the job done. You do not have to be an artist to produce a good scientific illustration.

Figure 1. Galileo's map of the moon. One of the first lunar maps to be made with the aid of a telescope. (Source: Clay and Court 1975)

Figure 2. Robert Hooke's observation of small compartments in cork bark was one of the first recorded observations of cells. (Source: Hooke, 1665)

Materials and Methods

Materials

1. Pencil
2. Felt tipped pen (#01 if available. BIC or Flair Ultrafine grade pens also perform well)
3. Straight edge or ruler
4. One sheet of tracing paper
5. One sheet of white drawing paper (Xerox will do)
6. Documentation paper
7. Photograph of an organism
8. Masking tape

Figure 3. The dot stipple shading technique. Rapidograph on velum. (The copepod Xinopsylla cheopsis*)*

Methods

1. Tape the photo to a drawing surface (table, desktop, etc.).
2. Tape tracing paper over the photograph.
3. Make a pencil line tracing of the organism on the tracing paper. Do not include anything (e.g., rocks, barnacles, etc.) that might shift the viewer's focus from your subject. If in doubt as to what to include, ask your instructor.
4. Untape the tracing paper and the photo. Return the photograph to a safe place.
5. Tape the tracing paper to a light table. If a light table is unavailable, place the tracing paper on top of a white piece of paper, and tape both pieces of paper to a drawing surface.
6. Tape a second sheet of white paper on top of the tracing paper. This sheet must be clean, as it will contain the final art work.
7. Transfer the line drawing from the tracing paper to a second sheet of white paper by pencil tracing.
8. After reading the following suggestions, ink in the final drawing.
   a. Use the ruler to draw a 1/2" margin on all sides of the paper.
   b. Make sure your hands are clean. When necessary, rest your hands on a piece of scratch paper instead of your art work.

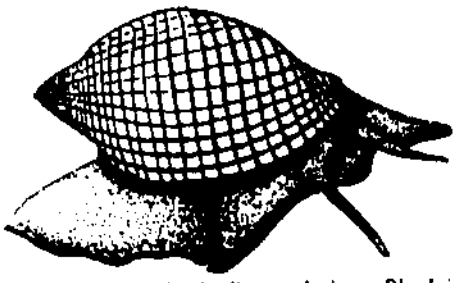


Figure 4. The dot stipple shading technique. Black ink on zerox paper. (The mollusc Tonna perdix*)*

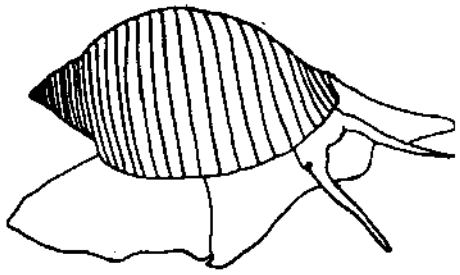


Figure 5. Black ink on white scratchboard.

   c. Using a pencil, lightly print the word "light" in the upper left hand corner of the paper to remind yourself of the origin of the imagined light source.
   d. Initially ink in lines nearest to the light source with an extremely fine, broken line.
   e. Initially ink in lines distant from the light source or in shadows with a heavier line.
   f. Use the dot stipple shading technique. Proceed slowly. At intervals, hold the art work up and view it from a distance. Sometimes viewing the illustration through squinted eyes helps define which areas should be shaded.
   g. Remember: ink is much easier to apply than remove. Do not rush.
9. After you have finished your illustration, complete the document paper. It must be done in ink.

10. Tape the documentation paper to the back of the illustration.

FAGATELE BAY MARINE SANCTUARY SUMMER CAMP '91 SCIENTIFIC ILLUSTRATION	
NAME	
DATE	
PROJECT	

Figure 6. Sample documentation sheet. (65 % original size)

Figure 7. Black ink on zerox paper. (The protist Vorticella *sp.)*

Results

Submit your illustration for evaluation.

Scientific Illustration Evaluation

Margins

Score Possible
_____ 1 1/2
_____ 1 ink
_____ 1 lines stop at the corners

Illustration

Score Possible
_____ 1 properly labeled
_____ 1 ink
_____ 2 correct shading (when applicable)
_____ 2 neatness
_____ 2 aesthetic value
_____ 2 accuracy

Documentation (must be in ink)

Score Possible
_____ 1 Name
_____ 1 Date
_____ 2 Subject
_____ 1 Project

Total Score= _____

Total Number possible = 20

Conclusion

Answer the following in a brief paragraph.

1. What is a scientific illustration?
2. Examine your illustration. Which corner does the light source appear to come from?
3. Name one advantage an illustration might have over a photograph.
4. Name one advantage a photograph might have over an illustration.
5. You have just completed a black and white illustration.
   a) How much would it cost to make a copy of your illustration?
   b) Had your illustration been in color, how much would it cost to reproduce it in color?

References

Clay, R.S., and T.H. Court. 1975. *The History of the Microscope.* London: The Holland Press.

Hooke, R. 1965. *Micrographia.* Facsimile edition, 1987. Lincolnwood: Science Heritage Ltd.

Moore, P. 1977. The Story of Astronomy. 5th Ed. New York: Grosset and Dunlap.

Wood, P. 1979. Scientific Illustration: A Guide to Biological, Zoological, and Medical Rendering Techniques. Design, Printing, and Display. New York: Van Nostrand Reinhold Co.

Name_____

Date_____

Lab XII. Island Biogeography

Purpose: To study the relationship between an island's distance from the mainland and the rate at which new species arrive.

Introduction

When a 26 year old naturalist named Charles Darwin reached the Galapagos Islands in 1835, it was known that different islands of the world (Figure 1) were home to different kinds of organisms. However, the question of how this came about was a profound puzzle. Attempts to solve the puzzle eventually led to the development of a science called biogeography.

Biogeography is the study of the geographical distribution of organisms. Island biogeography is a specialized topic within this science, focussing on the way organisms are distributed throughout islands. By 1835 the distribution of island life had a number of popular explanations. A man named Comte de Buffen suggested that all organisms originally came from the Old World (Europe, Asia, Africa). Buffen thought that organisms migrated or were placed by man in their present locations. Another man named Condolle thought distributions might be the result of unknown geological processes. Another explanation was that of Charles Lyell, who suggested that organisms had been in their present positions since the beginning of time (Nelson 1978).

Though the idea troubled him, Darwin, like others, suspected that some organisms reached islands by chance dispersal. Examples of chance dispersals on islands include the arrival of birds blown off course and seeds randomly washed ashore. However, an idea that was new was Darwin's suggestion that new species sometimes arose from old species via a process called evolution. This idea arose from Darwin's observations of life on the Galapagos.

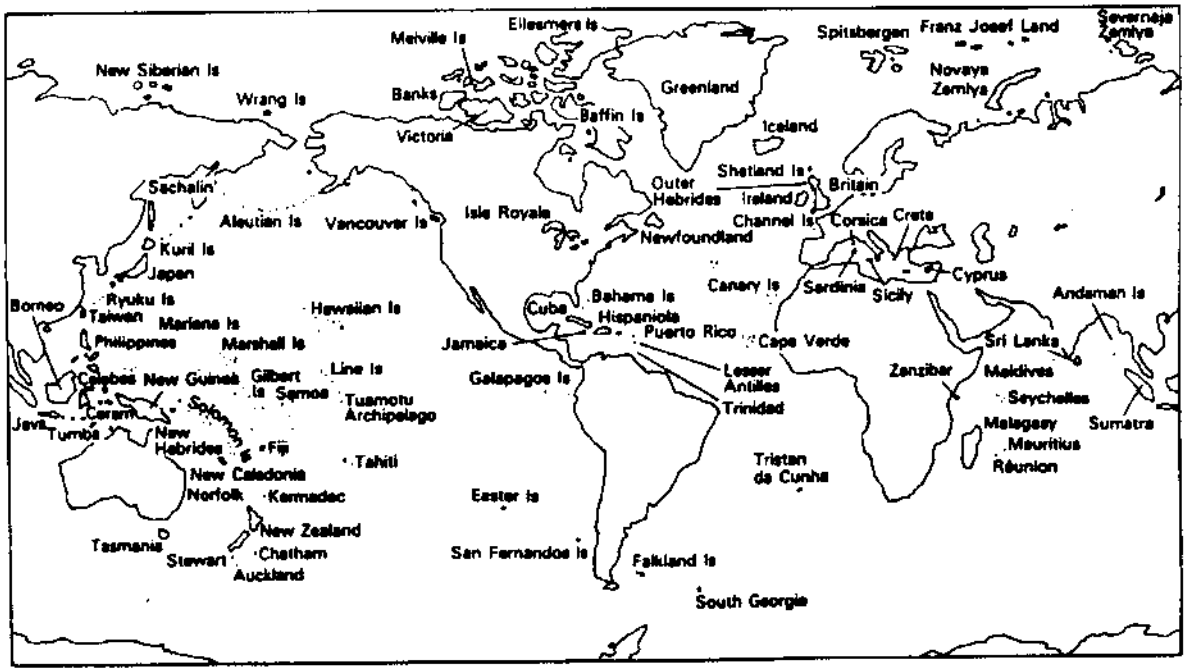


Figure 1. Some of the islands that have been the focus of scientific studies (Source: Milke 1989).

It is now known that an island's species diversity is largely determined by chance dispersal. The island's geologic history and species evolution may also play important roles, especially on remote islands.

After Darwin presented his theory of evolution, island study assumed for many years a minor role in the development of biogeographic theories. In the 1960s two important factors increased interest in island biogeography. In 1967 Robert MacArthur and Edward Wilson published a book titled *The Theory of Island Biogeography.* This theory suggested that the number of species on an island could be estimated if two things were known: 1) the immigration rate of new species (Figure 2) the extinction rate of old species (Figure 3). This part of the theory is summarized in Figure 4.

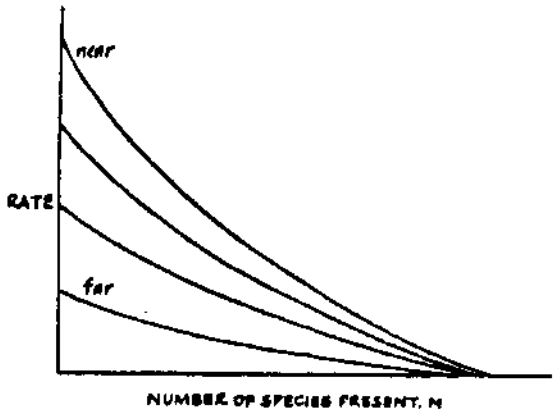


Figure 2. The initial immigration rates of new species for islands near to a mainland are greater than the immigration rates for islands far from the mainland (Source: Mac Arthur and Wilson 1967).

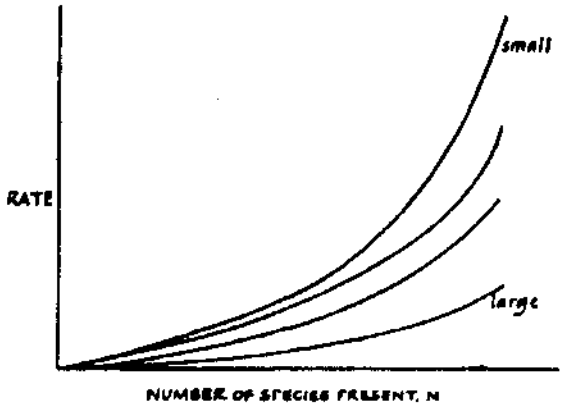


Figure 3. The extinction rates of species on small islands are greater than the extinction rates on large islands (Source: Mac Arthur and Wilson 1967).

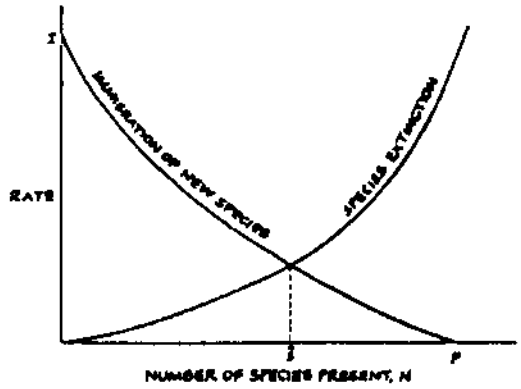


Figure 4. The number of species on an island declines when the immigration rate is less than the extinction rate (Source: Mac Arthur and Wilson 1967).

A second factor was an increased interest in the environment. People saw that the term "island" need not strictly apply to a landmass surrounded by water. A cool mountain top could act as an island for arctic plants, and an oasis was in a sense an island for a fish. Following the same line of thought, parks, sanctuaries, and refuges could be viewed as islands in a sea of human activities. For a given amount of land, which is best for preserving the health of the natural community, one large area or many small areas? At a time when natural habitats are becoming scarce, studies in island biogeography could provide answers (Game 1980).

The theory of island biogeography is not perfect; this is freely admitted by its authors. One shortcoming of the original model is its failure to address the process of evolution, which can profoundly affect species diversity on isolated islands. Despite its flaws, however, it has caused people to think about new explanations for the distribution of organisms. The following procedure investigates how an island's distance from a mainland source affects the rate of immigration of new species. The graph that will be constructed differs slightly from that presented by MacArthur and Wilson. Its interpretation, however, should yield a similar conclusion.

Materials and Methods

Materials

1. one pie pan (or any other circular container) per group
2. one data sheet per group
3. one stopwatch or watch
4. one bag of bird seed (or any assortment of seeds, eg., rice, popcorn, sunflower seeds)
5. three cups per group, to be labeled "Mainland Source."
6. one damp cloth cut to cover the bottom of the pan

Methods

1. Distribute the data sheets. All results will be shared, but each member must fill out a data sheet. Have each group select one group member to act as a recorder of immigration rates and timer. Select a second person to act as a species counter.
2. It is important that all of the "Mainland Source" cups for all groups contain roughly equivalent numbers of seeds in roughly equivalent proportions. If bird seed is to be used, assume the seed types are evenly mixed and simply fill all cups to the same level. Seed types not previously mixed may be added to each cup in equal volumes (e.g., three tablespoons of rice per), or equal numbers (e.g., fifty kernels of popcorn per cup).

3. Tape an example of each type of seed to be thrown under "Seed Type" of Table 1, and name the seed.
4. Place a moist paper towel at the bottom of each pie pan. The towel will reduce the number of seeds that bounce out of the pan.
5. Place the pie pans at varying distances in front of the throwing line (mainland). See the table below for suggested distances.

Group	Distance
1	1.0 meters
2	1.5 meters
3	2.0 meters
4	2.5 meters
5	3.0 meters

6. For two minutes the remaining group members should try throwing seeds from the "Mainland Source" cups into the pie pan. The timer will monitor the clock. (NOTE: Do not count seeds that bounce out of the pan. These will be considered unsuccessful immigrations.)
7. Stop all throws at the end of two minutes. The counter will count the number of types of seeds and divide by 2. This value represents the immigration rate in units of new species per minute.
8. Repeat steps 3 and 4 until Data Table 1 for your group's island is complete.
9. Complete Data Table 2. You will need data on other islands, so be sure to exchange data with other groups.

Results

Make entries on Table 1 and Table 2 and Figure 5.

Table 1.

SEED TYPE	SEEDS PRESENT ON ISLAND		
	Total # Present (0-2 mins)	Total # Present (2-4 mins)	Total # Present (4-6 mins)
	(0-2 minutes)	(2-4 minutes)	(4-6 minutes)
New Types During Interval			
Immigration Rate = New Types During Interval / 2 Minutes			

Table 2.

ISLAND	IMMIGRATION RATES		
	End of 2 minutes	End of 4 minutes	End of 8 minutes
Group 1			
Group 2			
Group 3			
Group 4			
Group 5			
Group 6			

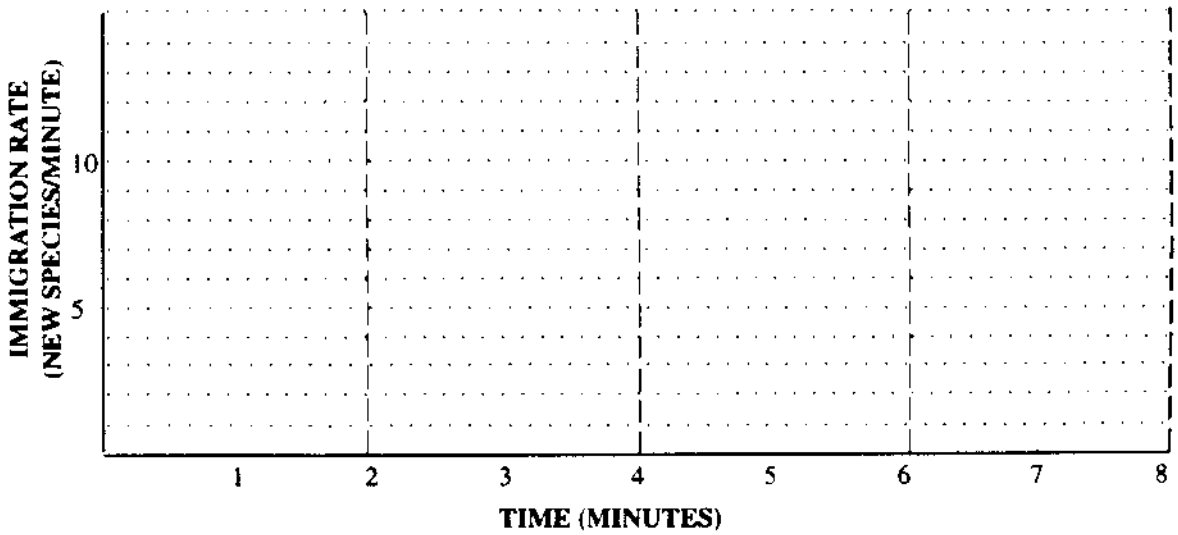


Figure 5.

Conclusion

In your conclusion, try to answer the following questions:

1. As time passed, what happened to the rate of species immigration to your pie pan islands?
2. Were the initial rates greatest on near or far islands?
3. Examine the immigrant seeds on the pie pan island farthest from the throwing line. Do these seeds have anything in common?
4. Suppose you had watered the seeds that landed in your pie pan and had given them time to germinate. Based on any previous experience you or a group member might have, would you suspect all of the seeds would sprout? Does a successful arrival guarantee a species will establish itself on an island?
5. Consider any organism on your island, and answer the following:

   a. Where might it have come from?

   b. How might it have travel l?
6. Suppose two pie pans are of equal distance from the throwing line. One pan is very large, one pan is very small. Which might have the greater initial immigration rate? Give one reason to support your answer.

References

Game, M. 1980. Best shape for nature reserves. *Nature* 289:630–632

McArthur, R.H., and E.O. Wilson. 1967. *The Theory of Island Biogeography*. Princeton: Princeton University Press.

Mielke, H.W. 1989. *Patterns of Life: Biogeography of a Changing World*. Boston: Unwin Hyman Inc.

Nelson, G. 1978. From Condolle to Croizat: Comments on the history of biogeography. *J. Hist. Biol.* 11:279–305

Name_____

Date_____

Lab XIII. Biotelemetry

Purpose: To construct a simple radio transmitter and use it to learn about an animal's home range.

Introduction

A home range can be defined as the area over which an animal travels during its lifetime. Knowledge of home ranges and migration patterns was essential to ancient hunters, whose survival often depended upon tracking the location of the herds.

Knowledge of home ranges is today a key part of efforts to save endangered species. Loss of habitat, not hunting, now for many species poses the greatest extinction threat. When parks, sanctuaries, and refuges are established to protect endangered species, it is important that these areas include portions of the organism's home range. Biotelemetry through tracking provides a way of determining the home ranges of animals.

Biotelemetry has been defined as the measurement of biological processes from afar (Kimmich 1980). Tracking is probably the best known application, but a host of other biological processes have also been measured. Biotelemetry is used by National Aeronautics and Space Administration (NASA) to monitor the heartbeat and other body functions of astronauts in space (NASA Educational Topics ET 78-1).

Various types of waves have been used to transmit measurements. Radio waves and light waves are very effective for transmitting information through air and space. Ultrasound waves have proven effective for transmitting information through water. Recent advances in satellite navigation have made available microwaves for tracking far ranging animals such as sea turtles (Paladino et al. 1992).

Three simple circuits that will transmit radio pulses to an AM transistor radio are shown below. The methods section will detail the steps for building one, version II of the MacKay oscillator, but the procedure can be applied with only slight modification to either of the other two circuits. The transmitter will be attached to the shells of land hermit crabs in an attempt to determine foraging patterns. The crabs will be released at the point of capture and tracked the following day.

The list of animals that have been tracked is long and includes insects, bears, bats, and whales. The paucity of commercial radio stations in the Pacific presents a unique opportunity; the AM and FM bands in some areas are signal free. A transistor radio and one of the circuits below are all that one needs to try their hand at biotelemety. Once mastering the method, perhaps you can be the first to monitor the movement of a local animal.

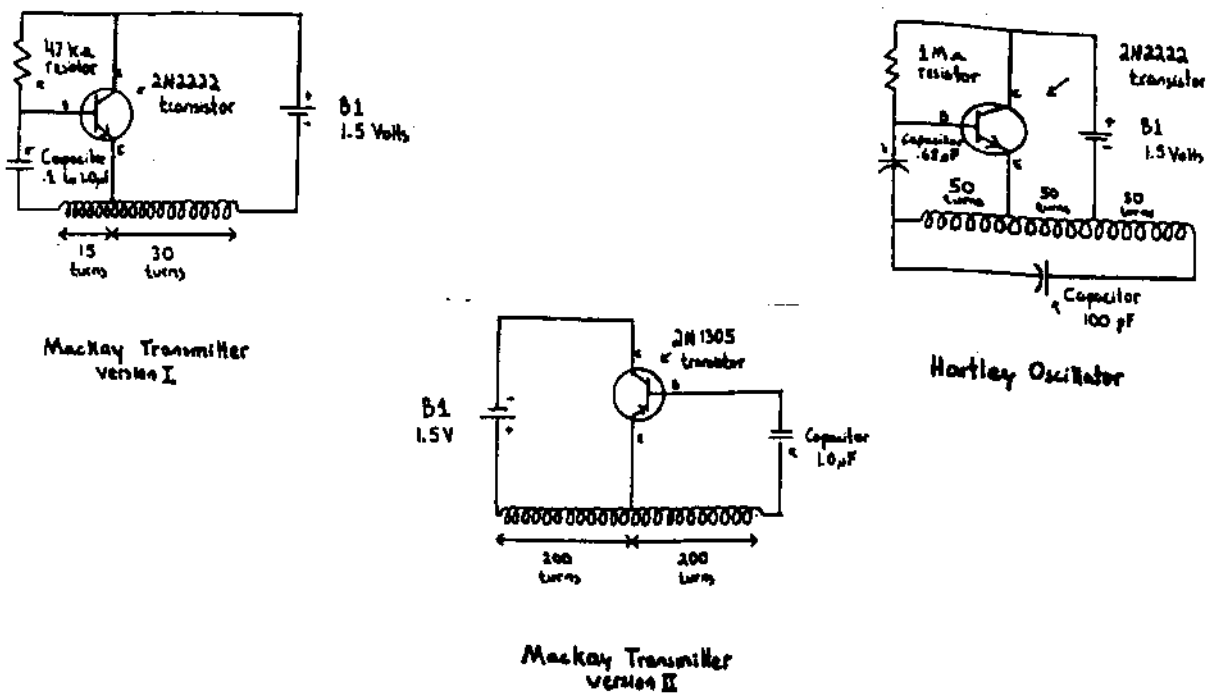


Figure1. Three simple transmitters: a) Mackay transmitter, version I; b) Mackay transmitter, version II; and c) Hartley oscillator

Materials and Methods

Materials

Circuit #1: Mackay Transmitter, version I (Mimms 1987)
Approximately 15 cm of # 30 magnet wire
1- 2N2222 transistor
1- 50 kohm resistor (1/4 or 1/8 watt)
1- ceramic capacitor, value anywhere between .1uF and 1.0 uF
1- 1.5V button cell battery
1- tube of Krazy Glue
1- tube of Liquid Solder
1- plastic soda straw
Varnish
Epoxy
Circuit # 2: Mackay Transmitter, version II (NASA Educational Topics, ET 78-1)
11 meters of #38 magnet wire
1- 1.0 uF ceramic capacitor
1- 2N1305 transistor
1- 1.5V button cell battery
1- plastic straw
1- tube of Krazy Glue
1- tube of liquid solder
Varnish
Epoxy
Circuit # 3 Hartley Oscillator (Ford and Van Scheik 1988)
8 meters of #40 gauge magnet wire
1- 2N2222 transistor

1- 100 uF capacitor
1- .68 uF capacitor
1- 1 M resistor
1- 1.5 hearing aid battery
1- plastic soda straw
Varnish
Epoxy

Methods

1. Cut off a 3 cm length of plastic straw.
2. Krazy Glue the end of the wire to one end of the straw. Leave a short length of wire (about 1 cm) extending beyond the end of the straw.
3. With a marking pen, place a mark at the middle of the straw segment.
4. Wind 200 turns of wire on half of the straw. Periodically apply Krazy Glue to the coils to prevent them from slipping off of the straw.
5. Construct a small loop after the 200th turn, and then wind 200 more turns around the second half of the straw.
6. Leave a 1 cm length of wire extending beyond the second half of the straw, and then cut the wire.
7. The coil should have 3 leads: a lead at each end and a lead in the middle.
8. The leads will be soldered to other components, which requires that varnish that insulates the wire be removed. This can be done by flaming the wire leads with a match or lighter.
9. Solder one end lead to the 1.0 uF capacitor.
10. Solder the middle lead to the emitter of the transistor. (Note: Check with your instructor or the data sheet that accompanies the transistor to determine where the base, emitter, and collector leads are on the transistor).
11. Tape the remaining coil lead to the positive side of the button cell.
12. Solder the free lead of the capacitor to the base of the transistor.
13. Tape the base of the transistor to the negative end of the battery.
14. After the circuit has been assembled, test it by placing it near an AM radio. A clicking pulse should be heard over the radio. If no clicking is heard:
    a. Check that the battery has a full charge.
    b. Check all soldered electrical connections.
    c. Check all taped connections.
    d. Make sure the radio is working.
15. Once the transmitter is operating, it can be water proofed with a dip in some resin (eg. Bondo, etc.).
16. Krazy Glue the transmitter to a hermit crab shell.
17. Record the date and time the hermit crab is released.
18. On the following day attempt to track the crab with an AM transistor radio.
19. Record the date and time for any successful re-captures.

Results

1. Record the number of clicks for 1 minute. The click frequency =_____
2. Set the transmitter on a table and carry the transistor away until the clicking ceases. The transmitting range =_____.
3. Record the date and capture site of your hermit crab.

   Capture site:_____ Date:_____ Time:_____
4. Record the date and release site of your hermit crab.

   Release site:_____ Date:_____ Time:_____
5. Return the next day. Try to find your crab. If you are successful, record recovery site, date, and time.

   Recovery site:_____ Date:_____ Time:_____

Conclusion

Answer the following in a l[illegible]f paragraph.

1. How is biotelemetry defined, and for what purpose are you using biotelemetry in this lab?
2. Were you able to find your crab?
3. If so, how far was the recovery site from the release site?
4. Does the distance between the recovery and release sites give the minimum or maximum distance travelled?
5. What, if any, kinds of problems did you experience in trying to attach the transmitter to the hermit crab's shell?

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Name_____

Date_____

Lab XIV. Classification and Patterns of Shared Characteristics

Purpose: To identify some patterns of shared characteristics present throughout the five kingdoms of living things.

Introduction

Man's desire to organize his environment has given rise to many different classification systems. An informal system that was to dominate the sciences was that of dividing the environment into living and non-living things. As time passed, the living environment became the focus of the biological sciences (botany, zoology, mycology, bacteriology, protistology, etc.), and the non-living environment became the focus of the physical sciences (physics, chemistry, geology, astronomy, etc.). Biologists who worked on ways to further classify living things are now called taxonomists; the science of classifying living things came to be known as taxonomy.

The limits of the human senses have played a fundamental role in the way people classify living things. Early taxonomists grouped organisms according to characteristics that could be easily seen. As a result, life was categorized as being either animal or plant (Margulis and Schwartz 1988) The invention of the microscope changed this way of thinking. The discovery of single-celled organisms was for two reasons a milestone in the history of taxonomy. First, it added to the list of known living things a completely unexpected group of organisms. Second, it showed how devices capable of extending the senses could radically change the way life was classified.

Armed with a microscope and a keen eye, the Swedish botanist Carolus Linnaeus in the 1700s laid the groundwork for today's classification system. Linnaeus gave all organisms a two-part Latin name, a practice called binomial nomenclature. The first name is called the genus name, the second name is called the species name. According to this system, humans are called *Homo sapiens*, where *Homo* is the genus name and *sapiens* is the species name. In scientific writing these names are by convention underlined or italicized.

Linnaeus's system helped create a great interest in taxonomy. The person who first named an organism was recognized as its discoverer, even though the organism may have long been known by a common name. Consequently, people rushed to name organisms according to the new system. The crush of newly named organisms reinforced a need for a refined classification system. The one that eventually arose has the following seven levels of classification:

Kingdom
Phylum (= Division in plant taxonomy)
Class
Order
Family
Genus
Species

Of these seven, the only level having any real meaning in nature is the species. A species is defined as a group of interbreeding organisms capable of producing fertile offspring that are viable in nature. A mating is, in a sense, the species test. Fertile offspring indicate both organisms are members of the same species. Sterile or no offspring indicate the organisms are of different species. There are no equivalent tests for the other levels of classification. These levels are human creations, designed to help people organize their view of living things.

Taxonomists now recognize five kingdoms, at least 90 phyla (Margulis and Schwartz 1988), and about 1.5 million species (Crisci, et.al. 1993). Estimates for the number of species yet to be described range from 3.5 to over 20 million; anyone intent on describing a new species still has many opportunities to do so.

Homo sapiens **Homo sapiens**

(a) (b)

Figure 1. The accepted convention for printing scientific names: a) in italics or b) underlined.

Humans tend to flourish in those environments they understand best. An understanding of the living environment starts with a description of the organisms it is composed of. Today's taxonomists are using biochemical and electron microscope studies to inspect organisms and modify classification systems. These studies have revealed shared characteristics that are not obvious to the naked eye. It is likely that Deoxyribonucleic acid (DNA) will play an important role in future taxonomy systems. This lab examines the occurrence of the following characteristics throughout the five kingdoms:

molecules composed of carbon (called organic molecules)
life
non-life
mostly single celled
cell nucleus absent
cell nucleus present
organelles
mostly many celled
energy obtained from sunlight (autotrophic)
energy obtained from eating other things (heterotrophic)
energy obtained by absorbing food from the outside (saprozoic)
sexual reproduction
asexual reproduction
mostly stationary throughout life cycle
ability to move
contains DNA

Materials and Methods

Materials

1. Pencil or pen
2. Sheet of Life handout

Methods

1. As a class, look over the Sheet of Life handout. Start at the bottom and work up. The sheet is a summary of different levels of biological complexity, as well as a summary of one version of the five kingdom taxonomy system. Try to think of examples for different taxonomic terms. For the following steps, you will need to work as a class.
2. In box #1 of the results section:
   a. Draw a "U" that contains those molecules having carbon.
   b. Draw an upside down "U" that includes those molecules lacking carbon.
3. In box #2 of the results section:
   a. Draw a line separating living from non-living. Show which is which.
   b. Circle and label the organelles.

4. In box #3 of the results section:

   a. Circle and label those groups that are mostly single celled.

   b. Draw a line separating those organisms having a nucleus from those organisms lacking a nucleus. Show which is which.

5. In box #4 of the results section:

   a. Circle those groups in which reproduction is usually asexual.

   b. Circle those groups in which reproduction is usually sexual.

6. In box #5 of the results section:

   a. Circle those organisms that get their energy by eating other things (heterotrophs).

   b. Circle and label those organisms that get their energy from sunlight (autotrophs).

   c. Circle and label those organisms that get their energy by absorbing food (saprobes).

7. In box #6 of the results section:

   a. Circle and label those organisms that move at some time in their life.

   b. Circle and label those organisms that are mostly stationary throughout their life.

8. In box #7 of the results section, circle all of the groups having DNA in their cells.

9. In box #8 YOU choose one characteristic (for example, ability to swim) and circle any group having a member with that ability.

Results

Perform steps 2 through 9 on the illustration on the following pages.

Conclusion

In your conclusion, try to answer the following questions:

1. Are there any elements found throughout all five kingdoms?
2. Are there any molecules found throughout all five kingdoms?
3. Name all of the kingdoms having cells with nuclei.
4. Future taxonomy systems may be based largely on chromosome comparisons. Can you think of a reason chromosomes were not compared 100 years ago?

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