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Preface

The thirteen projects within this manual are designed mainly for 4-H leaders and members. Each project is a unique study because a simple procedure is all that is needed to fulfill its objective.

The projects are not new to many of those who have been in the 4-H organization for the past year or so. The manual, though, is relatively new because it not only encompasses some of the earlier Special Interest projects in marine science but also some brand new projects developed by other authoritative sources.

This manual by no means fulfills the requirements of the 4-H Marine Program as a whole, but is definitely a beginning in helping to develop it. The projects herewith will help fill a void in the many new marine science programs that are being developed in the 4-H clubs throughout Florida by putting a project package in the hands of the leaders and members.

Included within this manual are both biotic and abiotic projects. Biotic projects are those which deal with the living things and the abiotic are those that are not living such as sand and tides. The biotic factors are arranged phylogenetically (from the lowest form of marine organism to the highest form) while the abiotic factors (Exploring Beach Sand, Florida’s Sandy Beaches and What Makes The Tides) are placed in their respective order so that the learning from one project will help in working with the next.

It is important today for the people of the United States as well as the entire world to understand the complete ecosystem process of our earth. Hopefully this first 4-H Marine Program Manual will help to do just that with respect to the marine world.

Resources provided by the National Oceanic and Atmospheric Administration and the Florida Sea Grant College, aided by Dr. Hugh Poponoe and Dr. William Seaman, Jr., have facilitated the development of this manual.

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OCEAN-GOING PLANTS

seaweeds

Have you ever eaten seaweed?
Most of you would probably answer this with a most emphatic "no!" Seaweed is slimy, smelly stuff.
Let's ask it this way, then. Have you ever eaten ice cream? If you can answer "yes" to this question, then you have, indirectly, eaten seaweed.

A little about seaweeds
Seaweeds are plants that live in the ocean. Each seaweed captures a little energy from the sun, and turns it into part of the plant itself. This is a complicated process carried on by structures in the plant that contain the green coloring, or pigment, that makes plants green. This green pigment is called chlorophyll. Although all seaweeds contain chlorophyll, not all of them are green. Some seaweeds contain pigments other than chlorophyll so that they are golden brown, dark brown, or even red in color.
The proper name for seaweeds is algae. Not all algae are seaweeds; some algae also live on land and in fresh water. Not even all algae that live in the sea are called seaweeds. Only the marine (sea-dwelling) algae that are large enough to pick up can be properly called seaweeds.

Green seaweeds
Scientists call this group the Chlorophyta. Some of them are up to several feet long and are of various shapes: soft and leathery, long and ribbon-like, mushroom shaped. One kind, sea lettuce, looks somewhat like a leaf of lettuce.

Brown seaweeds
Scientists call this group Phaeophyta. They grow much bigger than other algae. The giant kelp may grow to several hundred feet long. Another brown algae, gulfweed (Sargassum), washes up on Florida beaches regularly. If you go to the beach and see piles of seaweed on the sand, it is probably gulfweed.

Red seaweeds
Scientists call this group Rhodophyta. The color of these seaweeds may be red, reddish-purple, or reddish-brown. Red seaweeds do not get as big as brown seaweeds.
Seaweeds do not have roots and stems and leaves like green plants do. Seaweeds that are attached have a thickened root-like or foot-like extension called a holdfast. If seaweeds are cut off or broken off above this holdfast, some of them may die, but many will keep on growing.
Instead of stems and leaves, some seaweeds have a stem-like area called the stipe, and a leaf-like area called the blade. Most seaweeds have a stipe, a holdfast, and a blade, but you may have trouble telling where they are on some kinds.
Green plants reproduce by forming flowers, which in turn produce seeds, but seaweeds do not produce either one. Instead, they produce spores on the tips of their branches, which are very tiny, and float away to start new plants.
Seaweeds are a home for many small creatures. Some small fishes and crabs look very much like the seaweed they live on so they can hide from animals that eat them.
Seaweeds can be found on the shore of any beach. Some grow attached to rocks and piers. Some even grow on sea-grasses, which are a few kinds of true grasses that live in shallow salt water. Others, like gulfweed, float free in the ocean and sometimes wash up on shore. If you wanted to see the giant kelp, however, you would have to go diving on the coast of one of our northern states, because it grows in deep, cold water.

Now, about eating seaweed:
In ice cream, as well as in some commercially prepared cakes, you will find an ingredient called agar-agar. This is extracted from seaweeds. It helps to keep the ice cream smooth and to keep the cakes moist.
In the Orient, though, people really do eat seaweed. There, seaweed is grown as a crop. Instead of being called agriculture (farming on the land) it is called mariculture (farming under the sea). If you are interested in knowing more about preparing seaweed for food, your leader has a list of cookbooks in which you can find recipes.
Other agar-agar compounds are used in making medicines and cosmetics. Your dentist may prepare impressions of your teeth with agar-agar.

Where you can look for seaweeds
Any time you go to the beach you can look for seaweed. As you walk along above the edge of the water, you may find piles of brown seaweed heaped up on the sand. This is probably gulfweed (see the drawing of a branch of gulfweed on the next page).

If you arrive at the beach just as the tide is starting to go out, you can watch the attached seaweeds become visible as the water no longer covers rocks and sand. Notice that as the water recedes, different kinds of seaweeds appear. The kind that appears first is able to withstand a long period of exposure to the air, while the kind that is still within reach of the waves at low tides will not tolerate dryness very long. Seaweeds grow in bands, or zones, both above and below the low tide mark according to the amount of air, water, and sunlight they need. If you follow the tide down, you can observe this zonation of the different kinds of seaweeds.

Here are drawings of some seaweeds you might see on a Florida beach.

**SARGASSUM - Gulfweed**
(A brown alga)

**ULVA - Sea-lettuce**
(A green alga)

**PADINA**
(A brown alga)

**GRACILARIA**
(A red alga)

A Crossword Puzzle

On the next page is a crossword puzzle. Many of you have probably seen or worked one of these; in case you haven't, here's how you do it: You are given a set of clues. Each clue describes a word you learned in this project. Figure out what each word is and write it in the row of boxes that begins with the same number that the clue is. An example is given for you: Clue number 12 across is “Sea-dwelling”. You need a word that has the same number of letters as there are boxes; six. The word is “marine”. It has been filled in for you. If you have trouble going on, your leader will help you.
**Across**
3. What seaweeds reproduce by, instead of seeds.
4. Chlorophyta (2 words).
6. The group of plants that seaweeds belong to.
8. Farming under the sea.
13. The arrangement of seaweeds in zones on the seashore.

**Down**
1. Coloring.
2. “Root” of a seaweed.
5. “Leaf” of a seaweed.
7. A brown seaweed that commonly washes ashore on Florida beaches.
9. Used commercially.
10. Red seaweeds
11. “Stem” of a seaweed.
PLANKTON
the basis of life

Look outside. See all the green plants? What if they all suddenly came uprooted and flew up into the air to grow there instead of on the ground? Then cows and horses and all the other animals that eat plants would have to chase the plants around in the air to get anything to eat.

Sounds silly, doesn't it? But there is one place on Earth that is very much like this. Plants and animals float about and are not confined to the Earth's surface. That place is the ocean.

The Sea-Garden

In the ocean, some plants are fastened to a rock or the sand, and look much like land plants. Many more of them are too tiny to see without a microscope, and float freely in the water. Organisms that are small sometimes have only one cell, and are called microscopic. This great mass of microscopic plants floating in the water, is the garden of the sea. It is the place where all marine (ocean-dwelling) life, either directly or indirectly, get its food.

These tiny plants do not swim around in the ocean, but are carried by the water. Organisms that just float along with the water in this way are called plankton.

Two different kinds of plankton float in the water. One kind is phytoplankton, the plants. The other kinds is zooplankton, the animals. When someone says just "plankton" it means both the phytoplankton and the zooplankton, or all the floating plants and animals.

As we discuss plankton, we will for the most part be talking about microscopic plankton. You should be aware, however, that some planktonic jellyfish may be as large as three feet across. And one kind of planktonic plant, called gulfweed (Sargassum), grows in great patches that float near the surface of the water.

Where it all begins

Phytoplankton may be accurately called the "grass of the sea". It serves much the same purpose that grass and other green plants do on land.

Land plants trap and store energy contained in sunlight. Then when animals eat the green plants, they use the energy that the plants have stored. Because plants store energy and produce food for other creatures in this way, they are called producers.

In the ocean, the situation is very similar. Phytoplankton store energy contained in sunlight, and thus produce food for other creatures. So, they are the producers in the ocean community. Since phytoplankton need sunlight, they are found only near the surface of the ocean where the sunlight can reach them.

Where it goes

On land, many creatures eat the green plants. Cows, horses, many insects, and many other small animals feed on the food the producers have stored. Because these animals consume this stored food, they are called consumers. But what about other animals (such as man) that eat the consumers (such as cows)? Aren't they consumers also?

To put this a little more clearly, we can draw what is known as a food chain:

- man (consumer)
- cow (consumer)
- green plants (producers)

This is a very simple food chain. What it says is that the man ate the cow that ate the green plants. The arrows show which way the energy that the plants stored is moving.

But sometimes we need to be able to tell whether the consumer we are talking about was one who ate the producer, or one who ate another consumer. So, we call a consumer who eats green plants a 1st order consumer. Then, we call a consumer who eats a 1st order consumer a 2nd order consumer. Now, our food chain looks like this:

- 2nd order consumer (man)
- 1st order consumer (cow)
- producers (green plants)

Wait a minute! People sometimes eat green plants! OK, when they do, they are 1st order consumers. Draw the food chain this way:

- 2nd order and 1st order consumer (man)
- 1st order consumer (cow)
- producer (green plants)

Now our food chain is a food web. There are many such food chains and food webs, both on land and in the sea. Sometimes they become very complicated.

We have already said that phytoplankton are the producers in the ocean. What are the 1st order consumers?
Well, zooplankton are. So, we can begin an ocean food chain this way:

1st order consumers (zooplankton) → producers (phytoplankton)

Some whales feed on only plankton, both phytoplankton and zooplankton. So, let's add whales and some fishes and we can draw a food web that begins to get complicated. (To make it easier to read, we will write just the names of the organisms).

If we wanted to, we could keep adding to this, until it became much more complicated.

Now let's isolate one food chain out of this food web and see how much plankton it takes to feed, for instance, a large fish.

4th order consumer—large fish 1 pound
(an example of a large fish is a tuna)

3rd order consumer—medium fish 10 pounds

2nd order consumer—small fish 100 pounds

1st order consumer—zooplankton 1,000 pounds

producer—phytoplankton 10,000 pounds

As a general rule, it takes 10 pounds of producer for the 1st order consumer to gain one pound. It takes 10 pounds of 1st order consumer for the 2nd order consumer to gain one pound, and so on.

The drawing shows the amount, by weight, of plankton and small and medium fish that a large fish (tuna) must eat to gain one pound. Though the tuna does not eat plankton, it eats medium fish, that eat small fish, that eat zooplankton, that eat phytoplankton. Thus, the tuna is ultimately dependent on the phytoplankton.

You can see that it takes 10,000 pounds (that's 5 tons!) of phytoplankton for a tuna to gain one pound. Without phytoplankton, we would have no fish to eat. Not only must plankton be present, they must be present in enormous numbers. Plankton are the basis for all fish life in the ocean.

To demonstrate the effects of fertilizer on the growth of plankton, take two five gallon buckets of seawater or fresh lake water. Label one bucket "control", and the other "experimental", and place them in a sunny place. Each day add one or two drops or a pinch of household phosphate detergent, or fertilizer, to the experimental bucket. Record water temperature, turbidity and general appearance. Continue the experiment until water becomes very turbid and green, a plankton bloom. Answer the following questions: 1) Why is the water green? 2) Is there any difference between the two buckets? Explain the difference.

From the experimental bucket pour some water into dishes and observe the plankton. Most of the plankton is transparent. Why do you think this would aid the plankton? Perhaps their enemies cannot see them as well. Watch the plankton's weak swimming motions. Can you see why plankton are referred to as drifters of the sea? Many of the animal plankton feed on tiny one-celled plants in the water. Use a magnifying glass to look for feeding structures on the plankton.
A Crossword Puzzle

Here is a crossword puzzle. Many of you have probably seen or worked one of these; in case you haven’t, here’s how you do it: You are given a set of clues. Each clue describes a word you learned in this project. Figure out what each word is and write it in the row of boxes that begins with the same number that the clue is. An example is given for you: Clue number 8 across is “Food”. You want a word that will go in the blank, and has as many letters as there are boxes (5). The word is “chain”. It has been filled in for you. If you have trouble going on, your leader can help you.

Across
3. What all green plants need so that they can store energy.
5. Animals that feed on other organisms. (1st order , for example)
8. Food
9. Organisms that float and drift with the movement of water.
10. Many food chains make this (two words).

Down
1. Green plants’ role in a food chain or food web.
2. Planktonic plants.
4. Planktonic animals.
6. Organisms that it takes a microscope to see.
7. A large, plankton-eating animal (not a fish).

8. CHAIN
PHYTOPLANKTON
the ocean's wandering plants

Have you ever thought about what it would be like if plants didn’t have roots? They wouldn't stay in the same place all the time. They’d wander around all over the place every time the wind blew.

But that’s the way it is in the ocean. Some plants are attached to things by a foot-like structure called a holdfast. But many ocean-going plants are not fastened to anything, and they wander about with the tides and the currents.

These wandering plants are called phytoplankton (“Phyto” means plant, and “plankton” means to wander or drift). Some of the phytoplankton float in great patches at the surface of the ocean. Most of them, however, are too small to see without a microscope. It is these microscopic phytoplankton we will learn about in this project.

The microscopic phytoplankton are of two major types, the Diatoms and the Dinoflagellates.

The Diatoms

A diatom is a lot like a miniature pill box. It has an outside shell or capsule called a frustule (frus-choo). This frustule has two halves that fit one inside the other like this:

The larger half, the epitheca (ep-i-the-ka), fits over the small half, the hypotheca (hy-po-the-ka). Where they overlap is called the girdle. On the drawing, label the epitheca, hypotheca, and girdle.

Diatoms are divided into two groups on the basis of the shape of their frustules. Centric diatoms are usually circular, cylindrical, or triangular. Pennate diatoms are usually elongated, oblong, or feather-shaped. In the following drawings, indicate whether the diatom is centric or pennate by writing a C or a P in each space.
The Dinoflagellates

I'm sure many of you have heard of the "red tide". If you live near the beach, you may even have seen the thousands of dead and dying fish, and smelled the irritating fumes produced by such a "red tide".

Or have you ever walked on the beach at night, just above where the waves were breaking? Did you see tiny lights twinkling around your feet in the sand each time you took a step?

Both the "red tide" and the little lights (called bioluminescence) are caused by members of this group of phytoplankton.

Dinoflagellates are able to move themselves around in the water a little by the use of flagella. This is why they are called flagellates. A flagellum is very much like a thin tail, and the plant uses its two flagella in much the same way as an alligator uses its tail. By wiggling them back and forth, the dinoflagellate can propell itself through the water.

Most dinoflagellates have a transverse flagellum that lies in a groove called a girdle that wraps around for sideways motion, and a longitudinal flagellum that lies in a groove called the sulcus and hangs behind for forward motion. Both flagella arise from flagellar pores. On the drawings, find and label the transverse and longitudinal flagella, girdle, sulcus, and flagellar pores.

Dinoflagellates are really somewhere between plants and animals. They can produce their own food with the aid of sunlight, like plants. They can also feed on tiny particles of food in the water, and are capable of a certain degree of motion, like animals.

There is one other group of microscopic phytoplankton we will mention, called the coccolithophores (kock-o-lith-o-fors). Some have two flagella, but both trail behind in the water like the dinoflagellates longitudinal flagellum. They are covered with armored plates called coccoliths (kock-o-liths).

On the drawing, put a D beside the dinoflagellates and a C beside the coccolithophores.
ZOPLANKTON
the ocean's wandering animals

Have you ever thought about what it would be like if animals were not confined to the earth's surface? Farmers would have to put their cows in cages instead of fences. You'd have to chase your dog all over the sky instead of the yard.

But that's the way it is in the ocean. Fish swim all over the place, and go wherever they want to.

There is another group of animals that moves around in the water. These animals are called zooplankton (zo-plank-ton). They don't swim around like fish, but they are carried by the currents and tides. Their name comes from two words—"zoo," which means "animal," and "plankton," which means to "wander or drift." All the plants and animals that float on the currents in this way are collectively called "plankton."

Since there are many, many different kinds of zooplankton, we will discuss only the kinds that are more common.

The zooplankton can be divided into two major groups: those animals that spend their whole life as plankton (holoplankton), and those that spend only part of their lives as plankton (meroplankton).

The Holoplankton

The most important members of the holoplankton are the copepods. These are little animals that look like shrimp, but may be smaller than the head of a pin. Copepods are one of the most common kinds of the zooplankton. Since many fish depend on the zooplankton for their food, the copepods are an important source of food.

A copepod has two long antennae which it uses to position itself in the water. It also has six pairs of legs, and a tail. The tail is divided into two lobes, each of which has five feathery bristles on it. On the adult copepod, below, locate and label an antenna, a leg, and the two tail-lobes.

When copepod eggs hatch, the young copepod is called nauplius. The nauplius does not look very much like the full-grown copepod. Both a nauplius and an adult copepod are shown below.

A member of the zooplankton that is only a little less common than the copepods is the arrowworms. Arrow-worms are transparent, with three general body areas: the head, a long-middle section, or trunk, and a short tail-piece with fins. Only the two small black eyes are easy to see.

Arrow-worms eat copepods and anything else they can find that is a little smaller than they are, including baby fish. They catch their prey with the grasping spines on their heads.

On the drawing of the arrow-worm below, locate and label the eyes and the grasping spines.
There are also one-celled zooplankton. The most familiar of these are the Radiolaria and the Foraminifera. These microscopic creatures have tiny hard capsules that protect them much like seashells protect the animals that live in them.

Radiolarians have many spines or spikes, and their capsules have only one chamber.

Foraminifers have one to many chambers. Sometimes they have spines, but these are usually broken off when the animal is collected.

Label the drawings, below, of a Radiolarian, (R), and a Foraminiferan, (F).

Maybe the most well-known holoplankter is the jellyfish. Jellyfish are often seen floating in the water or stranded on the beach. A jellyfish has a mouth on its underside. The mouth is surrounded by a ring of stinging tentacles with which the jellyfish captures prey. The dome-shaped part of its body is called the umbrella.

Below are drawings of two jellyfish you might commonly see in Florida waters. Locate and label a mouth, tentacles, and an umbrella.

Two more members of the holoplankton we will look at are two creatures that look much alike, and are related to, jellyfish. One is the comb-jelly or sea-gooseberry. This is not a true jellyfish, but it is clear and jelly-like, much like many jellyfish. Comb-jellies have a mouth at one end. They move about by beating the water with the rows of combs on their bodies.

In the waters around Florida, you might see what looks like a light blue Baggie floating on the surface of the water. This is the float of the Portuguese Man-of-War. Below the float hang tentacles that may be up to 30 feet long, much longer than those of most true jellyfish. These tentacles can sting you very badly, so if you see this creature, stay away from it!
On the drawing of the comb-jelly below, locate and label the mouth and the combs. On the drawing of the Portuguese Man-of-War below, locate and label the float and the tentacles.

The Meroplankton

The meroplankton spend only part of their lives as plankton. For the rest of their lives they either crawl about on the sea floor, or are attached to something under the water.

Crabs are planktonic for a short time after they hatch from eggs. At first, a crab larva is called a zoea. Before it can become an adult crab, it must develop into another larval stage called a megalops, which is also planktonic, and resembles an adult crab. The megalops will then develop into an adult.

Shrimp are also planktonic when they first hatch from eggs. A shrimp larva is called a mysis, and looks very much like an adult shrimp.

Below are drawings of an adult crab with its zoea and megalops, and an adult shrimp with its mysis. See if you can label each one correctly.
SPONGES - apartment houses
and water pumps of the sea

Why Study Sponges?
Sponges serve two important purposes in the sea. They offer a large number of hiding and living places for smaller animals. They also pump sea water in and out as a means of removing food and oxygen for themselves. In doing this, sponges filter and help cleanse the water. In our study you will examine the body structure of a sponge to understand how these two purposes come about.

What is a Sponge?
A sponge doesn’t look like an animal. It won’t squeak if you pinch it. Sponges never squeak. They never run from you and can’t see or hear you. It has no organs, arms, or spines. Yet, it is an animal.

About Sponges
Sponges have been on earth for at least 500 million years. They probably evolved from one-celled animals that lived in colonies. The cells became dependent on each other and lived together for mutual benefit. This close association of cells resulted in what we call a sponge.

A sponge is the most primitive animal on our planet. There are about 10,000 different kinds. They live only in water—there are no land sponges. They exist in tropical seas and polar oceans. The vast majority live in salt water. Some live in deep water up to 3.5 miles but most prefer shallow water. None move about. They are always found attached to rocks, timber, sand, coral, floating debris, shells, boats, piers, buoys, etc. Some require a microscope in order to see them; others reach 6 feet in diameter.

The single most important characteristic of a sponge is that it is a system of holes, pores, chambers, and compartments. A sponge therefore is made up mostly of enclosed spaces. It uses this system of spaces to pump a current of water and filter out its food. Other animals also use the spaces as places to live in. Sponges can contain thousands of different kinds of residents. Without the sponges they would have no place to live. Thus sponges permit large numbers of individuals to live in a small area.

Method I
Materials Needed:
Brown paper bag from grocery store
Natural or artificial commercial sponge from hardware store
Bread knife or scissors

Punch small holes in the paper bag with the scissor tips. Blow up the bag as you would do a balloon, holding it at the opening where it has been folded and gathered together. You simply want the bag to open up and round out. Now, permitting the air to escape, squeeze the bag's sides together. Continue to fold, squeeze and wrinkle in all directions until the bag is a ball of paper. You now have a copy of a sponge body. Take a minute and study the bag. Gradually flatten and straighten the bag, remembering that it is just like a sponge.

Now study the three basic canal systems of sponges which scientists call ascon, sycon and leucon:
The above drawings are the side views of the three body types of sponges after they are cut in half from top to bottom.

To verify the structure, cut your commercial sponge into pieces. Note the spaces and compartments. This is what holds the water and makes the sponge good for washing things. What kind of canal system does the commercial sponge have?

Method II

With an artificial or natural sponge you can get an idea of how much "space" there really is by conducting the following experiment:

1. Thoroughly dry a sponge
2. Weigh the dry sponge
3. Soak the sponge completely in a pan of water
4. Weigh the wet sponge
5. Calculate the per cent weight gain over dry weight
   a. Wet wt. - dry wt. = water wt. gain
   b. Water wt. gain/dry wt. x 100 = per cent wt. gain from water in spaces
   c. This tells us how much the weight of the dry sponge increased due to water

6. Calculate the per cent of water in total wet sponge weight
   a. Follow steps 1 through 4 above
   b. Total wt. = water wt. + dry wt.
   c. Water wt./total wt. x 100 = per cent water of total wt.
   d. This tells us how much of the total weight of a wet sponge is water
   e. For example, if your figure is 50% and your soaked sponge weighed 2 pounds, then .50 x 2 = 1 or 1 pound of water

Water Pumps Pump Water

Besides providing a place for other small animals to live, sponges must live too. They need to have oxygen and require food. They must also remove their waste products. They do this by maintaining a constant flow of water through their bodies. Usually the water is pumped in the side canals and out the top at the site of larger holes. The imaginary ring around a sponge which provides the water and food is known as the "diameter of supply."

Take a Guess

Using what you now know about sponges, try to answer the following, giving your reasons.

1. What does a sponge eat?
2. How does it breathe?
3. What are 2 or 3 of the main characteristics of sponges?
4. If sponges don't locomote, how can they be found in every ocean?
5. How does a sponge reproduce?
THE BARNACLE

You may have heard an old folk song about “Barnacle Bill” the seafarer. Now, we all know what a seafarer is, but what’s a barnacle? Let’s find out what a barnacle looks like, where it’s found, and how a biologist classifies it.

What’s a Barnacle?

Barnacles are marine crustaceans (krus-ta-ke-ans). “Crustacean” is the scientific classification for primarily aquatic animals which have jointed legs. All crustaceans have an outside skeleton (exo-skeleton). From time to time, this exoskeleton is shed and replaced with a new, larger one as the animal grows. To learn more about biological classification check with your leader for help.

Barnacles, like other crustaceans, go through a metamorphosis (met-a-mor-fo-sis). When a caterpillar changes to a butterfly it undergoes a metamorphosis. In much the same way, a barnacle undergoes a series of changes from an egg to an adult. A juvenile barnacle, after it hatches from the egg, becomes part of the ocean plankton (plank-ton). During a barnacle’s first month of life it goes through six changes in appearance. The life cycle explained here applies to only one of the four major orders of barnacles. See your leader if you are interested in learning about the other orders of barnacles.

The newly hatched barnacle is called a nauplius (naw-pli-us). It has a triangular body with a pair of hornlike structures that distinguish it from other crustacean larvae (lar-ve). A larva is just an immature form of a crustacean. At this time in its life cycle the barnacle has three pairs of bristly appendages and a single median eye.

During the second stage of metamorphosis, the nauplius changes to a cypris (sy-pris). This phase of growth is characterized by a weak-swimming, bivalved (2-sided) shell, six pairs of legs, antennae, and three eyes. The main function of the cypris is to locate a permanent location for the adult stage to live. When the cypris selects a site it secretes a cement from glands at the base of its antennae. Once attached, the barnacle goes through the last stage of its life cycle. There is a complete rearrangement of body parts. After the cypris cements itself in place, it loses its eyes, turns on its back, and secretes an outer calcareous (lime-like) shell. The barnacle is now a pinhead-sized version of the adult form.

Where are Barnacles Found?

Most barnacles are found along the intertidal zones of shores and beaches. If you walk along the shoreline, you are almost sure to see tiny volcano-like shells attached to piers or vacant seashells.

Some barnacles have four or six plates making up the sides of their shells. These are acorn barnacles. The “superglue” barnacles use as a holdfast lasts almost indefinitely. Thus, the shell remains long after the animal has died.

If the barnacle is alive and covered with water you may actually watch it feeding. Four plates that form a lid or top to the shell swing open and the feather-like feet start sweeping through the water. The feet strain bits of food from the water and pass them to the barnacle’s mouth. (Remember, it lies on its back as an adult.) If the barnacle is exposed to the air the door swings shut, trapping enough water inside the shell to keep the barnacle alive until the tide returns.

Another common type of barnacle is the goose-neck barnacle. Gooseneck barnacles can often be seen attached to ships or other floating objects, even whales. These barnacles are attached to a surface by a leathery stalk. The body is then found inside a group of plates (the shell) at the top of the stalk. The number of plates varies with each species of gooseneck barnacle. Scientists have found one species that attaches itself to an acorn barnacle which in turn has attached to a whale.

Still another type of barnacle is the wart barnacle. Its shell is shaped like an ornate box with a flip top lid. Wart barnacles have no stalk. They are normally found in subtidal areas along with gooseneck barnacles.

Friend or Foe of Man?

If you are a nature lover, you’ll probably find watching a barnacle feeding to be a spectacular event. If you are a ship’s captain, however, you will consider barnacles an unwanted menace. They will slow down the ship’s motion, and will have to be removed when the ship is put into dry-dock. This is a costly and time-consuming nuisance.
If you've ever cut yourself on a barnacle shell while walking along the shoreline you too will consider the barnacle a menace.

Still other forms such as the rock boring barnacles cause extensive damage to coastal areas. So, it's plain to see, not all barnacles are liked by man.

Barnacles form an important part of the ocean's food chain. Their empty shells provide a home for many juvenile marine organisms. The larger forms of barnacles are eaten in many parts of the world. American Indians in the Pacific Northwest frequently ate barnacles. In Chile and Peru, barnacles can be purchased in open markets. Some exotic restaurants in this country include barnacles on their menus.

In Japan, barnacles are harvested, dried, and used for fertilizer.

Scientists have been testing the composition and durability of barnacle glue. Hopefully, a duplicate of such a "super glue" might be used in medical surgery for such things as bone repairs. The dental field might be completely renovated with such a super glue. So, in the future, we may hear a lot more about the friendly barnacle and less about the fouling barnacle.

Matching

See if you can match the barnacle forms listed below with the appropriate picture. Write the letter that is beside each name on the line below the correct picture. Genus names are in parenthesis.

A. Cypris stage of acorn barnacle (Balanus)
B. Stalked gooseneck barnacle (Lepas)
C. Wart barnacle (Verruca)
D. Nauplius stage of acorn barnacle (Balanus)
E. Acorn barnacle (Balanus) feeding
F. Initial adult form of acorn barnacle (Balanus)
WHAT IS A CRAB?

If you were a crab, what would you be? Would you live in the desert or at the beach? What would you eat? How would you grow?

If you were a crab, you wouldn't have just one pair of legs like you do now. Instead, you would have five pairs of legs—10 legs in all. You would use four pairs of legs—eight in all for swimming and walking. Your front legs would each have a claw for catching food and for pinching other animals (including people!) that might want to eat you. Your eyes would be on stalks like a little submarine's periscope.

If you were a crab, there are a lot of places that you might live. As you might have guessed already, some crabs live on land and some live in the water. We are only going to talk about the crabs that live in the ocean around Florida or on Florida beaches.

If you were a crab, you would like to eat lots of things. Most crabs go around eating things other animals have left behind. They might eat dead fish, or bits of dead seaweed, or even part of someone's lunch that was left on the sand. Crabs also like to eat garbage that is on the sand or in the water.

If you were a crab, you wouldn't grow the way people grow. A crab doesn't have a skeleton inside like you do. Instead, it lives inside its skeleton, which is hard and crusty and protects the crab.

As the crab grows, its skeleton gets too small for it. The old skeleton splits across the back of the crab's shell, and the crab backs out of it! Underneath is a new skeleton that is soft and stretchy instead of being hard and crusty. Now the crab hides under something for a few days while the new skeleton expands and hardens. The new skeleton is larger than the old one, and the crab will have room to grow until the new skeleton starts to get too small. Then the crab will have to do the same thing all over again.

The biggest crab you might find at a Florida beach is the Stone Crab. Adult Stone Crabs are very secretive, and usually hide under things in the water, but you might find young Stone Crabs around oyster bars.

You might find young Stone Crabs no bigger than your fingernail. They are dark purple with three white spots on the back of their shells. They are small enough that you can pick them up, but don't try to pick up an adult! They have very strong claws that they use for crushing clam shells and eating the clams inside, and they can crush your finger just as easily.
Adult Stone Crabs are reddish-brown, and their heavy claws have black tips. A big crab may grow up to five inches across.

Stone Crabs are very good to eat. You can often see a pile of claws for sale at a fishmarket.

Another Florida crab that is good to eat is the Blue Crab. The Blue Crab spends all of its life in the water, and its back legs are shaped like paddles for swimming.

Sometimes in a fishmarket you may see crabs called Soft-Shelled Crabs. These are Blue Crabs too. The crab's skeleton (shell) is very soft when it has just shed the old one, and Blue Crabs caught at this time are called Soft-Shelled Crabs.

Fiddler Crabs and Sand Crabs live on the beach up above where the water reaches. Both kinds of crabs dig burrows in the sand and live there. Fiddlers and Sand Crabs are much smaller than Stone and Blue Crabs. You may find some that are less than an inch across.

Sand Crabs are sometimes called Ghost Crabs. They are the same color that the sand is on some beaches. If they sit very still on the sand, they will seem to vanish right before your eyes.

Female Fiddler Crabs have small claws on their two front legs, but male Fiddler Crabs have one small claw and one large claw. A male Fiddler will often stand in front of his burrow and "wave" his large claw to get a female's attention.

A Horseshoe Crab is not a true crab, and is even more closely related to the spiders than it is to the crabs. It is called a Horseshoe Crab because its body is shaped like a horse's foot. Its tail is like a long spine. You can commonly find Horseshoe Crabs in shallow water where the bottom is muddy sand. Some of them may be fairly small, but you may find big ones up to 14 inches long.
Despite what you might have heard, Horseshoe Crabs do not sting. If you stepped on a small Horseshoe's tail with your bare feet, the end of the tail, or some of the tiny "teeth" along its edge, might stick you a little. A Horseshoe Crab doesn't have anything to sting with.

Matching

On the next page are pictures of the crabs you learned about, and pictures that tell something about each of these crabs. Draw a line from the crab on the left to the picture on the right that tells something about it.
ANIMALS WITH SHELLS

seashells

Do you know what part of your body keeps you standing upright, instead of flopping loosely around like a stuffed animal? You do? That's right, of course, it's your skeleton. Even though it's inside your body where you can't see it, it's still there. Many animals have skeletons like yours, inside their bodies. Some you might commonly see are dogs, cats, birds, horses, and cows.

Not all animals have skeletons inside their bodies, though. Some animals have skeletons outside their bodies. If you have seen a common garden snail, or a snail in an aquarium or a pond, you have seen a good example of an animal with a skeleton outside its body.

How is a Snail like a Seashell?

Snails and seashells both have skeletons on the outside of their bodies. This type of skeleton is called an external skeleton or exoskeleton. Some other kinds of animals have different kinds of exoskeletons.

All animals that live in shells are called mollusks. Mollusks may be found almost anywhere: some live in trees, some live on the ground, some live in the water. Only mollusks that live in the ocean have shells that we call seashells.

How are Seashells made?

A seashell is formed by the mollusk that lives inside it. The mollusk uses minerals that are dissolved in the water to gradually "build" the shell. Since the seashell increases in size about as fast as the mollusk grows, the shell is always just the right size for the mollusk to live in.

A seashell is as important to a mollusk as your skeleton is to you. If a mollusk is pulled out of its shell, it will die. The shell protects the mollusk from animals that would like to eat it.

How many different kinds of Seashells are there?

There are about 100,000 kinds or species of seashells. They live all over the world, in shallow and deep water, in cold and warm water.

The most well-known seashells may be divided into two groups: The univalves (uni-valve) and the bivalves (bi-valve). Univalves have a shell that resembles a snail's shell—it is in one piece and is usually coiled. Bivalves have shells that are in two halves—they have a hinge on one side, and they open and close like a living pill box. Clams and oysters are examples of bivalves.

Studying Seashells

One of the easiest and most enjoyable ways to study seashells is to make a shell collection. You don't need to live near the beach to start a shell collection; since land-snails are also mollusks, you can learn many things about their ocean cousins by studying them. Many books about shell collecting are available; your leader has a list of some of them.

If you do decide to make a shell collection, however, there are some things that you should remember. The shell was at one time part of a living creature. Even if you see many of the same kind of mollusk where you are collecting, there is a limited number of each kind. Instead of taking every one you can find, take only one or two. You are not the only person who will want to collect some. If everyone took all they found, soon none would be left.

Some Seashells common in Florida

Here are drawings of some seashells you might find on Florida's beaches. Decide which are bivalves and which are univalves. Then write "U" for univalve or "B" for bivalve on the line next to each shell.

Florida Cone

Florida Crown Conch

Florida Fighting Conch
Scallop

Common Janthina

Florida Coquina

Lightning Whelk

Giant Atlantic cockle shell

True Tulip

Turkey Wing

Banded Tulip

Triton's Trumpet

Angel Wing

Fargo's Worm-shell
SHARK FACTS

One of the first recorded shark attacks took place around 700 B.C. Since that time, sharks have been regarded as a fearful menace to man, and certain death to anyone who encounters them. Certain recent publicity has done much to worsen the shark's reputation.

But is this reputation really deserved? Let's find out a little more about them, and just how dangerous they are.

Some sharks seen in Florida waters

Nurse Shark

Tiger Shark

Lemon Shark

Hammerhead Shark
Words to explore
Some of these words may be new to you. If you already know them, write a short definition for them on another piece of paper. If not, look them up in a dictionary or encyclopedia and then write a short definition in your own words before you go on.

1) Reproduce 4) Scavenger
2) Plankton 5) Prey
3) Predator

Questions you might ask about sharks

Is a shark a fish?
A shark is a kind of fish, but sharks are different from other fish, because their skeleton is made of cartilage instead of bone. To get a good idea of what cartilage is, feel your ear above the lobe, which is made of cartilage. As you can feel, it is firm, not hard like bone, but strong enough to keep its shape. Sharks are related to fishes like the manta ray and sting-ray.

How many different kinds of sharks are there?
In the whole world there are about 250 different species (or kinds) of sharks. In the waters around Florida there are about 30 different species.

What do sharks look like?
A shark resembles a fish, but many are very slender and streamlined. Though all sharks are a little different, they have what we might call a “basic body plan.” All sharks resemble this “basic” shark, but many will not look exactly like it.

On the top side, or dorsum, our basic shark has two fins. The front, and larger one is the 1st dorsal fin, and the rear, and smaller one is called the 2nd dorsal fin.

The tail is also called caudal fin. On the bottom, or ventral side, our basic shark has two pairs of fins, and some sharks have one unpaired fin behind them. This farthest back, (posterior), unpaired fin is the anal fin. In front of it are paired fins, the pelvic fins. The largest pair, the front (anterior) pair, are the pectoral fins.

Like other fishes, the shark breathes by gills instead of lungs. Our basic shark has five gill slits, but some sharks have six or seven. The shark has a pair of nostrils, but they are used only for sensing of “odors” in the water, and not for breathing. For breathing, water is drawn in through the mouth and expelled through the gills.

On the drawing, locate and label the eye, gill slits, 1st and 2nd dorsal fins, caudal fin, anal fin, pelvic fin, pectoral fin, and the mouth and nostril.

How big do sharks get?
The smallest known shark is known as tsuranagakobitozame, which is a Japanese word that means “the dwarf shark with a long face.” It is about six inches long when fullgrown. Only a few have ever been captured.

The largest known shark is the whale shark. It may be up to 60 feet long and weigh several tons. Although it is called a whale shark, it is not a whale but a true shark. It is also the worlds largest fish. (Remember: a whale is not a fish!).

Where are sharks found?
Sharks are found all over the world. Some species have been seen captured only in water as deep as 9000 feet. Some species seen to prefer shallow water. Some are found in both deep and shallow water.
Many sharks are present along coastlines and beaches. Pilots of small planes have often seen them swimming among bathers and between bathers and the beach, and the people never knew they were there.

What is a shark's skin like?

A shark's skin is covered with tiny teeth called denticles. All the points on the denticles go in the same direction. If you stroked a shark from head to tail, the same direction the teeth point, the skin would feel smooth. If you stroked the shark the opposite direction, however, it would feel like a piece of coarse sandpaper and probably give you a bad scrape.

Is shark meat good to eat?

The meat of most sharks, when properly prepared, is quite tasty to humans. In Europe and Australia, shark meat is used widely for food.

Do sharks have any other commercial uses?

In the 1940's oil from sharks' livers was an important source of vitamin A. Since synthetic vitamin A has been developed, sharks are no longer hunted for this reason.

In America, the only uses for shark products are the skins for leather, and the fins in oriental cooking. Neither is used very much today.

Recently, some scientists have begun using some kinds of sharks as experimental animals.

How do sharks reproduce?

Some sharks lay eggs, but most bear living young. The young are able to care for themselves after hatching or birth, and the mother does not take care of them.

Do sharks have any natural enemies?

Most sharks have no oceanic enemies or predators except other sharks.

What do sharks eat?

Different kinds of sharks eat different things.

Some sharks, including the whale shark, feed on plankton in seawater, as well as some very small fish. Some eat only clams and snails.

Other sharks feed on live or dead marine organisms, or whatever else is available. Some of the larger sharks eat other sharks and fish up to half their own length.

What are sharks' teeth like?

There are two main forms of teeth in sharks.

The most common type is triangular in shape and knife-like. They are used for cutting and tearing.

The other type is long and spikelike. Sharks with this type of tooth catch their prey and hold it before swallowing it whole.

Sharks have several rows of teeth. They lose teeth from the outermost row regularly, and the ones behind move forward to fill the gap.

Sharks that feed on plankton have teeth so small they cannot be used for either cutting or holding prey.

How do sharks find food?

Sharks have three methods for locating prey. Sharks can "feel" vibrations in the water such as those that an injured and struggling fish might produce. They can feel these vibrations much farther away than they can smell or see what is causing them.

As a shark approaches a disturbance in the water, it uses smell to determine what the disturbance is. Sharks will be especially attracted to bait, blood, fish scraps, and anything else that might smell "fishy."

When a shark is about 50 feet from a disturbance in the water, it can finally see what it has been feeling and smelling. Sharks' vision is useful for finding food for a distance of only about 50 feet.

Are all sharks dangerous to man?

Sharks are present at most beaches where swimmers are, and the people usually don't know they are there. Attacks are far less frequent than some recent publicity would indicate. In Florida waters, only one swimmer in about five million has been bothered by a shark.

Man is not part of the shark's natural diet, and only a few species have ever been proven to have attacked man. You should, however, consider every shark potentially dangerous. Though the plankton-feeders cannot bite a man, a shark can nevertheless cause bad scrapes and bruises if it brushes against you.

Why do sharks attack man?

When a shark senses movement in the water that he thinks is food, he will bite it. If it happens to be a person, then you have a "shark attack." Some sharks may be merely curious. Some attacks have occurred when a swimmer grabbed a shark's tail or fin and attempted to hold or ride it.

What should you do if you see a shark while you're swimming?

Do not try to drive the shark away by splashing, yelling, or hitting rocks together underwater. This may attract the shark rather than frighten it away.

Do not, for any reason, try to touch or bother the shark in any way.

Do stay calm, and immediately wade or swim toward shore. Try not to make any noise or splashing you don't need to.

It is not a good idea to swim alone, as sharks seem to be less likely to attack swimmers in groups. Do not swim where blood, vomit, bait, or fish scraps are present, as these things attract sharks. Avoid swimming where the water is muddy or dirty, because you won't be able to see a shark if it is there.
Word-Hunt

Here are clues to words that are hidden in the "word-hunt." They may be written across, up and down, or sideways. Find as many as you can and draw a box around each word as shown. Some of the boxes may overlap. Happy word-hunting!

THE RETURN OF THE GREEN TURTLE

If you walk on one of Southeast Florida’s sandy beaches on a warm summer night, you may see the beginning of one of the great mysteries of the sea.

Suddenly, a small patch of sand in front of you wiggles and squirms as if it’s about to come alive! Up pops a little black head about the size of your thumb. In a minute, you see that the head is attached to a body smaller than your hand, and not the sand at all. Take a closer look. Why, it’s a little turtle that has just crawled up out of the sand! Look, there’s another one, and another—there must be nearly a hundred of them! Watch them racing madly toward the ocean. They’ve stopped for a second just at the edge of the water—there they go, disappearing into the next wave.

Where do they go? No one knows. Once the baby turtles reach the water, no one will ever see them again as babies.

As you walk, watch right at the edge of the water. Look ahead! See that dark lump just starting to come onto the beach? Be very still and quiet now, because a sudden movement or sound may send her scurrying back into the water.

Watch her lumber slowly up from the water, until she is well above the reach of the waves. In a minute she’ll start to dig. There she goes—see the sand flying?

We can walk right up to her now, and we won’t disturb her at all. Right now, she’s digging a pit with her flat, paddle-like flippers. Now, watch as she backs up into the pit, and uses her hind flippers to dig a nest at the bottom of the pit. There, now she’s finished!

Count her eggs as she lays them. There will be just about 100 of them.

Watch as she covers them up, them makes the nest harder to find by throwing sand around with her front flippers. There she goes, back into the sea. She’s been out of the water just over an hour.

Sometime each April, many green turtles appear in the shallow water around Cedar Key, on the west coast of Florida. These are young turtles, much bigger than the hatchling turtles that disappeared into the sea, but still smaller than a full-grown turtle. They are anywhere from dinner-plate sized to washtub sized, and weigh from 10 to 50 pounds. There are too many of them to be just the hatchlings from the Florida beaches, so some of them must come from somewhere else. Scientists that study them think that they may be from a place in Costa Rica called Turtle Bogue, where many, many green turtles lay their eggs. No one knows for sure, though, because nobody has ever figured out a way to find out where little turtles go when they enter the ocean.

Sometime in October or November the turtles leave Cedar Key. Where do they go? No one knows.

Now, let’s go back to the same beach where we saw all the baby turtles dashing frantically toward the water. This time, let’s go in the late spring or early summer. Instead of looking for baby turtles, we’re going to try to find a big one.
If you come back in about 2 months, maybe you'll get to see these very same eggs hatch into baby turtles.

Does it seem to you that we've left a lot of unanswered questions? For instance, what happens to baby green turtles when they enter the ocean? Where do the partly-grown turtles go when they leave Cedar Key? Where do adult green turtles go?

Here is what scientists who study green turtles think the turtles do:

Many adult green turtles lay their eggs at Turtle Bogue (bog) in the late spring and early summer of each year. Then the adult turtles scatter all over the Caribbean Sea, and go back to eating turtle grass, a kind of grass that grows on the bottom of shallow coastal waters. Some of them even come up into the Florida Keys.

When the baby turtles hatch, they disappear. Nobody seems to have any factual information about exactly where these new turtles go.

When the baby turtles are a little less than a year old, they drift into the Gulf of Mexico on ocean currents, and wind up around Cedar Key. By then they've grown a lot, and they aren't babies anymore, but are partly grown. Then they disapear again for awhile and eventually, when they become adults, they join all the other adult green turtles all around the Caribbean Sea. Then some spring, when all the turtles are going back to Turtle Bogue, the now-grown-up baby green turtles go with them, and the females lay their eggs on the very same beach where they hatched.

Bear in mind, now, that a lot of this is just ideas based on some things that scientists have been able to find out. Most of it hasn't been proven yet.

Now there are a lot more unanswered questions. What about the green turtles that nest on the Florida east coast? Why are fewer turtles laying eggs on Florida beaches than there are laying eggs at Turtle Bogue?

A hundred years ago, many turtles did nest on Florida's coasts. They probably still would if man hadn't bothered them. But sandy beaches that turtles like to nest on, also make great places to build hotels. Besides that, both green turtle eggs and green turtle meat are good to eat. People who lived near the coast had known that for a long time, but it wasn't until the last century or so that people in Europe discovered how really tasty green turtle soup can be.

Soon, a large turtle-fishing industry developed. Turtle-fishermen came to Florida from as far away as the Bahamas to fish for turtles. People collected eggs on the beaches. People even turned female turtles on their backs when they came up on the beaches to lay their eggs and hauled them away.

By about 1890, so many eggs and turtles had been collected that there were fewer and fewer for fishermen to catch. In a few years, no more green turtles came to Florida's beaches to lay their eggs. This same 'thing had happened to green turtles all over the Caribbean area. That makes Turtle Bogue a very special place. It is one of only two places in the world where large numbers of green turtles nest.

For a number of years, the only sea-turtles that anyone saw nest on Florida beaches were of another kind, or species, called the loggerhead. But in the last few years, something exciting has happened. People have begun seeing green turtles laying eggs on Florida's east coast again. There are three reasons for this apparent return: 1) They have been there all along. Only in the last few years have the beaches been regularly patrolled by
anyone looking for sea-turtles. It could just be that no one ever noticed them. 2) Since sea-turtles are better protected by law than they have been in the past, their number may be increasing since no one is bothering them. 3) The Florida Department of Natural Resources has been rearing baby green turtles from eggs until they are a year old and then releasing them. Some of these turtles may be coming back to Florida’s beaches to nest.

If you do see an adult turtle digging a nest on the beach at night, it will most probably be a female loggerhead turtle. But there is always the possibility that it may be a green turtle. NEVER, NEVER bother a nesting sea-turtle. Stand and watch, and enjoy seeing something that only a few people have ever seen, and that will be gone if we don’t take very good care of the few that are left. Man, by his interference with nature, is coming very close to robbing the future of all the different kinds of sea-turtles. Only by allowing both the loggerhead and the green turtle to nest in peace can man insure the survival of both of them.

MATCHING

Below are two sets of clues; match the phrase on the left to the one that goes with it on the right. Write the number next to the phrase on the left in the blank next to the phrase on the right. More than one answer may be correct.

1. Turtle grass  __  Are endangered by man
2. Sandy beaches  __  Loggerhead turtle
3. Many lay eggs  __  About 100 per nest
4. Number of eggs  __  Sea-turtles nest
5. Turtle eggs  __  A nesting sea-turtle
6. More common in Florida  __  Good to eat
7. Never bother  __  Turtle Bogue
8. All sea turtles  __  Green turtles eat
No matter where you live, you can look outside and see birds, flying in the air, sitting in trees, or hopping on the ground. Even in big cities, sparrows and pigeons thrive. Anywhere there is a patch of green plants, you can sometimes hear a mockingbird announcing his presence to the world.

If you go to the beach, the birds that you will see there are different kinds from those you can find in inland cities, or even in the country around lakes and streams. The birds that you see at the beach depend on the ocean to find food and to live. The birds that you see in other places are there because they depend on something in those places to find food and to live.

Birdwatching can be an interesting and enjoyable hobby. By watching birds as they find food and raise their young, you will learn about how birds live, how to observe wild creatures, and little about the world in which we live.

Birdwatching sometimes takes patience. If you go to the beach early in the morning or late in the evening, sit down on the sand near a group of birds and be very still and quiet. After a while, the birds may get much closer to you than you would be able to get to the birds by walking toward them. Remember, this is their home. Don’t make loud noises or throw things, or do anything else that might startle the birds. If you find what you think is a nest, leave it alone! Sit down and you may see an adult bird come to take care of baby birds or eggs.

When you go birdwatching, a pair of binoculars will come in handy. A can of insect repellent will help to discourage mosquitoes and other biting insects.

On the next pages are pictures of some birds that you might see at the beach. If you see any that are not mentioned in this project, you may want to get a book that will help you identify them. Some of these field guides are listed in the Leader’s Guide.

Gulls and terns

Look overhead. Do you see the medium-sized birds flying above the water? If you look out on the water, you may see others sitting on the surf-face like ducks do. If you look closely at the birds in the air, you will see that some have broad, square tails (gulls), and some have forked tails (terns).

Terns often fly over the water and dive into it to catch small fish that they eat, but gulls rarely dive this way. Terns also eat worms that live in salt water, and mollusks, which are the animals that make seashells. Some of the terns that you are most likely to see are the Common Tern, the Least Tern, and the Royal Tern.
Gulls eat fish too, but they also eat the eggs of other birds, and insects, and sometimes they follow ships to eat the garbage that is thrown overboard.

Two gulls that you are likely to see on Florida beaches are the Ring-billed Gull and the Laughing Gull.

Birds are able to float for two reasons. The natural oil that is on their feathers shed water, so that the bird is really sitting on a very thin layer of oil that keeps it dry. Also, birds’ bones have large hollow spaces in them, so that they are very light. This helps the bird to float and fly.

Sometimes an oil tanker spills crude oil (what gasoline is made from), and this oil washes up on the beach. Birds who get this oil smeared on them will die unless it is washed off. What do you think would happen if you washed all the oil off a bird with soap and water? If you put the bird back in water right away, would it be able to float?

Full-webbed swimmers

Another group of birds that you will see on Florida beaches is the full-webbed swimmers. These birds have webbed feet like ducks do, but they have webs between all of their toes instead of just the front ones.

The largest full-webbed swimmers are the pelicans. A White Pelican’s wings may be 9 feet across when the bird is flying, but Brown Pelican’s are not quite as large. You might see a pelican “dive-bombing” into the water to scoop up fish. Pelicans sometimes sit on pilings and piers and beg fish from fishermen.
The Gannet is another full-webbed swimmer. Gannets are large white birds with long necks and pointed tails. They soar in large circles over the water, and always dive from the air into the water to catch fish.

If you see a large dark-colored bird sitting on a pier or tree branch that looks like someone spread it out to dry, you are seeing a Cormorant. Cormorants often spread their wings out in a "spread-eagle" pose, or sit upright. You might see a bird holding its wings the same way near freshwater lakes farther inland, but this is probably an Anhinga or Water Turkey. Cormorants are usually found near salt water, where they feed on fish. These two birds must dry out their wings after diving because they do not have oil glands to waterproof their feathers.

Sandpipers and plovers

You will see many different kinds of sandpipers and plovers on Florida beaches. These small, long-legged birds run about on the beaches and mudflats picking up small ocean creatures that live there and eat them. Plovers are chubbier and a little larger than sandpipers, and have shorter bills than do sandpipers. The plover that you are most likely to see is the Little Ringneck or Semipalmated Plover. The most common sandpipers are the Sanderling and the much larger Willet.
A crossword puzzle

On the next page is a crossword puzzle. You may have worked one of these before, but in case you haven’t, here’s how you do it: You are given a set of clues. Each clue describes a word you learned in this project. Decide what the word is and write it in the row of boxes with the same number as the clue. The row of boxes may read from top to bottom or from left to right. For example, clue #1 Down is “Common sandpiper”. You need a word with the same number of letters as there are boxes, six. The only word that will fit is “Willet”. It is written in for you. If you have trouble going on, your leader will help you.

Down

1. Common sandpiper
2. Let’s go_________________!
3. Full-webbed________________
5. You can find this bird almost anywhere
7. Water Turkey
8. A book to help you identify birds (2 words)

Across

3. Little Ringneck or_____________ Plover
4. Pelicans _________ into the water (2 words)
6. This salt-water bird looks like someone hung it out to dry
9. You are likely to see these terns: Least, Royal, and________
10. ________ and Terns
11. You are likely to see these gulls: Ring-billed and________
STinging ANiMALS
OF THE SEA

Did you ever go to the beach for a day of sun and fun only to have it ruined when a marine animal stung you? Let's learn what to look for so you won't get stung at one of our Florida beaches.

THE STING

The sting of a marine organism hurts because of a poison or toxin (tok-sin) that is injected into or on your body. Some toxins are mild, while others are strong enough to be fatal to the victim.

WHAT STINGS

The following marine animals should be avoided: Sea Anemones, Jellyfish, Portuguese Man-of-War, Corals, especially Fire Coral, Sea Urchins, Sting Rays, Cone Shells, and Scorpion Fish.

WHAT DO THEY LOOK LIKE?

The Sea Anemone, Jellyfish, Portuguese Man-of-War, and Coral all belong to the same animal phylum (fi-lum). A phylum is a branch of the animal kingdom. These animals belong to the phylum called Coelenterata (see-lent-e-ra-ta), which means "hollow intestine".

When Sea Anemones are open they look like flowers, but when closed they look like a bunch of flesh drawn into a knob. Anemones attach themselves to a solid surface and extend their petal-like tentacles upward to await unsuspecting victims. The anemone's mouth is in the center of the "crown" of tentacles. Although most anemones do not produce a painful sting, you should take care to limit direct contact with these animals.

Jellyfish are not really fish. Some of them are also called Sea Nettles or Sea Wasps because of their sting. They may be white, pink, or colorless. Most have tentacles which hang below the water's surface. Some common species have bell-shaped upper surfaces and move swiftly through the water by contracting their bodies.

The Portuguese Man-of-War has a beautiful iridescent blue, purple, or blue-green float with blue tentacles up to 60 feet long. The tentacles look like strings hanging from the underside of the float. Do not touch them even if they are out of the water on the beach. Do not try to swim under them because of the length of the tentacles.
Sting Rays belong to the phylum *Chordata* (kor-dot-uh). They are shaped like pancakes with a long slender tail. The tail has a poison spine (barb). They lie on the bottom where you may step on them. If you are stung, flush immediately with hot water, and get medical attention as soon as possible.

Cone Shells and Octopuses belong to the phylum *Mollusca* (mol-lus-ka). The shell-less Octopus has a bulb-shaped body and head and eight arms. On each arm are strong suction cups used for capturing prey and for locomotion. A parrot-like beak is at the center of its arms. Octopuses have bitten people, but it was probably only accidental. They have the ability to completely camouflage themselves, and are usually very shy.

Cone Shells are called poison-tongued shells because some species can cause death. Only an expert knows which are poisonous to man. Their shells are highly polished with delicate geometric designs. Avoid picking up cone shells even though most are not poisonous.
Corals are found in a variety of shapes and colors. The coral animal (polyp) lives inside its calcareous (lime-like) skeleton. Many live in colonies which may eventually form coral reefs. Under water, corals look like rigid flower beds. Each species has its own shape. The Fire Coral is the only stinging coral. The major danger to man from corals is being scratched by contact with the external (outside) skeleton. Prevention is to avoid contact.

Sea Urchins belong to the phylum Echinodermata (e-ki-no-dur-m-a-ta) meaning “spiny-skinned”. They are round with spines covering their outer skeleton. The spines can give you a painful puncture wound.

The Scorpion Fish is usually found hiding along the sandy bottom. It has poison spines across its back. Its camouflage is so good that sometimes the fish is almost impossible to see. It looks like a piece of rock covered with slime and seaweed. Do not step on one.

See if you can identify each of the marine animals mentioned above. Label each of the following illustrations with its proper name and indicate any parts you recognize. Your leader will help you if you have trouble.
EXPLORING BEACH SAND

Sand is all around us. In the bare patches in the
schoolyard you can see it mixed with dirt to make
soil. On a windy day you can sometimes see it
being blown along with the wind. You may have
played in a sandbox at some time. If you have
ever been to the beach, you have seen a great deal
of sand. It is this beach sand that we are going to
talk about. Beach sand has some things in it that
other sand does not have.

All sand is made up largely of the mineral quartz.
In addition, beach sand contains shell and shell
fragments. In some parts of Florida, beach sand is
predominantly shell fragments and coral fragments.
All of these things affect the color of the beach
sand. For instance, along the Gulf of Mexico near
Panama City and Pensacola, there are places where
the sand is almost pure white because it is almost
pure quartz. On the other hand, the beaches
around Fort Lauderdale are a golden tan because
of the shell fragments in the sand. And at Jackson-
ville beach, the blackish sparkling color is because
of the presence of heavy minerals such as rutile
and zircon.

The sand on Florida’s beaches came from the
mountains of the southeastern states. It was
originally rocks that have been broken up into
tiny pieces by the actions of the wind and water.
Rivers and streams then carried the sand to the
ocean, and then it was carried southward by
longshore currents.

Exploring Beach Sand

Materials needed:
1. Beach sand (if beach sand is not available,
   builder’s sand may be substituted)
2. A sheet of paper
3. A hand lens or magnifying glass
4. A magnet
5. A quart jar and lid
6. A little oil (dirty crankcase oil will be excellent)
7. A small bowl

The purpose of this project is to find out about
sand—what it is like, and what it will do. Where a
place is left for you to write an answer, do so.
Otherwise, just follow the directions and think
about what you are doing.

1. Look at your sample of sand. What color is it?

   __________________________ Why?_________________

   Do you think it has shell fragments in it?

2. Some heavy minerals, especially those with
   iron in them, will be attracted by a magnet.
   Put a magnet in contact with the sand. Are
   the grains attracted to it?

   __________________________

   Do you think your sand sample has any heavy
   minerals in it?
3. Pour a little of the sand onto a sheet of paper. Look at the grains through a magnifying glass or hand held lens. Do all the grains look the same? Shell fragments tend to be more rounded and less jagged-looking. Can you find one? If so, draw a picture of it. Draw a picture of a sand grain.

4. Pour a little sand into your hand. Describe what it feels like.

5. Put about an inch of sand in the jar, then fill it almost full with water. Put the lid on. Tip the jar. What does the sand do? Shake the jar. Does the sand settle back to the bottom immediately? The water in the oceans is constantly moving. Waves strike the beach endlessly, one after another. What effect do you think this constant movement of water might have on the sand that is under the water?

6. Put some dry sand in a bowl. Gently, blow on it. Can you blow some of the sand grains around? A breeze blows almost constantly at the beach. What effect do you think this might have on the sand of the beach?

7. Gently drain as much water as you can out of the jar. Into the sand, pour enough oil to get the sand covered with it. Then try to wash the oil out of the sand. Can you do it? Occasionally an oil tanker will spill some oil out at sea. This oil is much heavier and stickier than what you have just used. When it floats to the beach, it covers everything with sticky black goo. Do you think that oil spills might be a problem to clean up?

8. What other ways can you think of to experiment with sand?
Florida has more miles of sandy ocean beach than any other state. It has more than twice as much as Texas, which has more than any state but Florida. It is not surprising that Florida should become an attraction not only to tourists, but to people who want to study the beach and the ocean.

Many of you have been to the beach, many have not. When you finish this, you should have a better understanding of the beach.

A Typical Sandy Beach

Here are several terms you should be familiar with before you go. You can see the relationship these things have to one another on the drawing of the sandy beach on the next page.

Beach—the sandy area that is between the land and the sea. Used only for sandy beaches.

Shore—a more general term than “beach.” Shore includes beaches other than the sandy beaches we are talking about. Other types of shores will be mentioned later.

Coastline—a somewhat vague term indicating where the land and the ocean meet.

Dunes—piles of sand that are moved about by the wind. These will be discussed in more detail.

Tide—the rising and falling of the waters of the ocean that occurs twice a day in most places. On the drawing of the sandy beach, the highest and lowest levels of the water are shown.

Wave—a ridge of water that moves toward the land from the open sea. When it passes over the longshore bar of the beach, the top of it curls over and it rushes in to splash on the beach in a great flurry of surf and foam.

Longshore Bar—also called a sand bar. This is a shallow area that is parallel to the beach. At many beaches it is easy to see because it is so near the surface of the water. This is where the waves “break”, or curl over and fall apart into surf and foam.

What is a Beach

If you have ever been to a beach, you would probably answer this question by saying something like, “It’s a big sandy place where you play in the water,” or maybe, “it’s a place where you pick up seashells.”

If you looked up the word “beach,” you probably would find something like, “a shore of an ocean, sea, or lake, or the bank of a river.”

A beach is all of those things, and much more. It is a place where many small marine and land animals live. Some move around freely, like crabs; some burrow in the sand, like clams; some are attached to rocks, like barnacles.

As we talk about beaches, we will talk about only those which are ocean beaches. They are a different kind of beach from those that you find at a lake or river.

If you go to a beach, look for the things that affect it: the sand, the wind, and the water.
The Sand
Most Florida beaches are made of sand. Beach sand may be pure sand, or it may have many tiny shell fragments mixed in it. Shell fragments are seashells that have been broken into tiny bits by the action of the waves on them. Some beach sand may be almost all shell fragments, with little sand mixed in it. In addition, some beach sand contains heavy minerals such as zircon and rutile that may cause it to appear grey or even black.

The Wind
At the beach there is an almost constant breeze blowing. The wind picks up the beach sand and blows it around, a few grains at a time. The wind can build up the dunes, or it can flatten them.

The Water
The water waves move the sand around. They can flatten dunes that the wind has built, and during a storm, change the whole shape of the beach.

The wave action is responsible for how clean the sand is. At a beach that is in some way protected from the full force of the waves (in a bay or behind a well-built-up longshore bar, for example) the sand will contain dirt and mud. A few grasses will have a chance to grow. Where the beach receives the full force of the waves, however, the sand is washed very clean.

Florida Shores
Florida has four different kinds of shores. The type of shore found over most of the coastline is the Sandy Beach. The other types of shore found in Florida are the Marshy Shore, the Mangrove Swamp, and the Rocky Shore.

What does a Beach do?
The beach protects the land from the ocean and the action of the waves.

During stormy weather, storm waves erode the sand from the beach. They carry the sand out to the longshore bar and leave it there. As the bar becomes higher, the waves break on it instead of the beach, and no more erosion of the beach takes place.

When the storm has passed, the waves become what are known as “swells.” This is the type of wave that is usually seen in calm weather. This type of wave picks the sand on the longshore bar and carries it back to the beach, rebuilding what the storm waves eroded.

In this way, the beach and the longshore bar work with the ocean to keep the waves from carrying away the land.

Sand Dunes
Sand dunes are built by the actions of the wind on the sand. The wind picks up grains of sand and blows them along until they reach a large rock, or a fence, or a plant. If a plant is present, and it is one that can live under sandy, windy conditions, it will grow up above the little pile of sand the wind has left. Then the wind piles up a little more sand, and the plant grows a little taller, and the wind leaves some more sand. After this has gone on long enough, the pile of sand may become several feet high. This is how dunes are formed.

What are Dunes for?
In very bad storms dunes work with the beach and the longshore bar to protect the land. If the storm is very bad, the water may rise as high as the dunes. Then sand from the dunes is carried out to build up the longshore bar. When the storm is over, the sand is carried back to the beach so the wind and the plants can rebuild the dunes.

Life on the Beach and Dunes
If you turn over a rock in damp sand, you may see what looks like a shell with legs, scurrying away. This is a Hermit Crab, who makes his home in empty shells. Other small crabs you will find here are Fiddler Crabs. When you finish looking, be sure to put the rock back so the crabs can get back under it.

On rocks that are washed by waves, you will find many barnacles and limpets. These animals spend their whole lives in one place—don’t try to pull them off; they are stuck down! Here also will be many small snails, and various salt-water plants called algae.

At the edge of the water, you can find large snails, and some clams. Many of them burrow into the sand.

On the dunes are several types of grasses, and sea oats. You should not pick any of these plants. Dunes are an important part of the beach, and the plants are necessary to keep the wind from eroding the dunes. Here you will also find a number of insects.

If you go to a beach, always remember: It won’t hurt the beach for you to take a few pretty shells you find. But don’t take away anything that is alive, because it needs the ocean to live. Try to leave everything as you found it. The beach is important, and care should be taken to protect it.

MATCHING—find out what you’ve learned!
Match the words on the left side to the ones on the right side. Write the number of the word on the left in the blank by the word on the right.

1. Longshore Bar □ Erode the beach
2. Tides □ Not many
3. Rocky Shores □ Protect the land
4. Mangrove □ Sand bar
5. Beach and Dunes □ Swamp
6. Storm Waves □ Hermit Crabs
7. Under a Rock □ Water
LET'S GO BEACHCOMBING

Have you ever read a story in which someone who is walking on the beach finds a bottle with a note in it, or maybe even a gold coin washed up from some ship, wrecked long ago? If you walk on Florida's beaches, you might find either of these things. Even if you don't find anything as exciting as gold doubloons and notes from shipwrecked sailors, you will be able to pick up many small treasures of the sea any time you walk on the beach—the waves are always bringing in something new.

When you walk along the beach and pick up whatever you can find, you are doing something that many people have done before you; it is called beachcombing, and the people who do it are called beachcombers. Some people actually spend their whole lives this way, and live on whatever they can find at the beach!

The best time to go beachcombing is at low tide, especially an early-morning low tide. At low tide, you can walk on the beach that would be covered by water during high tide. Early in the morning, not very many people are at the beach yet, and you will get the first chance at whatever the waves have washed up during the night. If you are interested in learning more about tides and how they work, read “What Makes the Tides?” in this publication.

When you walk on the beach at low tide, you may see what looks like a lot of trash in a long line along the beach. This is material that the waves left there during the last high tide, and this area is called the beachwreck. By searching through the beachwreck, you will find a great variety of items. Also look between the beachwreck and the edge of the water.

When you go beachcombing, you need to carry a hand trowel to dig with, and a pail to take your “catch” home in. Make it a rule to take along a pair of sneakers—some beaches have sharp rocks and oyster shells on them that can cut your feet badly. Sneakers will also protect your feet from broken glass and rusty nails that may be in old boards.

When you go beachcombing, you need to be careful of one other thing: the tides. Don't get too far from shore on a shallow sandbar; when the tide comes back in, you may be surrounded by deep water and not be able to get back to the shore. In a few places in Florida there are steep cliffs you can get trapped in front of if you are between them and the water when the tide comes in. In any case, it's a good idea to tell an adult where you are going and when you expect to get back, and to take another person along.

What will you find when you go beachcombing? On this page and the following pages are pictures of some of the things you are most likely to find on a beachcombing trip. Your leader has a list of books you can also look in to help you identify what you find.

One of the first things that you will notice on the beachwreck is a lot of stringy, ropey stuff that looks like a bunch of weeds. Most of it will be
brown or purplish-brown, but some of it may be red or green. Sometimes it smells bad! These seaweeds are plants that live in the ocean. Some of them are good to eat. If you want to know more about seaweeds, read "Ocean-Going Plants—Seaweeds," in this publication.

Sometimes jellyfish wash up on the beach. They may be any of several colors—blue, pink, white, orange, or even clear. Some may be as small as one inch across, but a large one may be several feet across. Some jellyfish can sting you, so look but don't touch! Jellyfish do not have skeletons, but depend on the water to support them. When jellyfish are washed up on the beach they usually die, even if they are put back in the water right away.

Another group of animals that you may find is the Echinoderms. (This is just a scientific way of saying "spiny skin," which describes these animals very well.) Starfish, sand dollars, and sea urchins are all Echinoderms. Some sea urchins have very sharp spines that can stick in your foot if you step on them. Echinoderms move around by using their "tube feet". Tube feet are long, thin suction cups which the animals use in attaching to things to pull themselves along. They also hunt food with their tube feet.

You will not find very many insects at the beach. You will find a lot of animals closely related to insects, though. These animals are called crustaceans. Crustaceans include crabs, lobsters, horseshoe crabs, shrimp, barnacles, and many other animals that you will not see because they are so small. If you look around, you may see holes in the sand, they are probably dug by crabs. A crustacean carries its skeleton around on the outside of its body, and when it gets too big for the skeleton, the animal sheds it and leaves it behind. Some crustaceans are good for fishbait, and some of them are good for people to eat. Be careful about picking up large crustaceans—some of them can pinch hard, and may give you a bad cut.

On almost any beach in Florida, you will find what look like small pieces of broken china that have been worn smooth by the water. On a few beaches, however, you will find the whole seashells that these pieces came from. A living animal once made and lived in each one of the seashells. Some of them are curled up just like a land snail's shell, and some are made of two pieces that fit together like two halves of a living pillbox. If you want to know more about seashells, read "Animals with Shells—Seashells" in this publication.
Have you ever seen your mother wash anything with a sponge? Most sponges in stores today are man-made, but until a few years ago, the sponges people bought were from the ocean. More sponges come from the Tarpon Springs area of Florida than from anywhere else in the United States. Each different kind of sponge grows a different shape and color. If you find a sponge in the beachwrack it will probably be hard and dry; if you place it in water it will become much softer and easy to squeeze. If you want to find out more about sponges, read "Sponges: Houses and Water Pumps of the Sea" in this publication.

Not all of the things you will find on the beach originally came from the sea. Often you will find things that humans have made, but that have been lost or thrown away. Boards, planks, and other pieces of wood are common. Watch out for nails! Look at the wood and see the barnacles growing there. If the wood has a lot of small holes in it, try to break it open. The tiny white animals that look like worms are little seashell-animals that bore holes in floating wood. They can do a lot of damage to wooden boats. If you are near a coastal city, you may find bits of garbage and debris from ships and industry. Very rarely, some lucky beachcomber finds a gold coin that has been washed up from some wrecked ship offshore. These ships are usually several hundred years old, and are so buried by soft sand and mud that sometimes even professional treasure hunters cannot find them.

These are just a few of the many treasures of the sea that you may find on the beaches of Florida. Good beachcombing!

On some beaches on the West Coast of Florida, you may sometimes find a lot of bones and teeth. These are fossils, preserved bits and pieces of animals that lived a long time ago. Some of the fossils you may find may be several million years old! Perhaps the most exciting fossil you may find is a shark's tooth. Some of them are small, just one inch long, but a large one may be up to six inches long.
A crossword puzzle

On the next page is a crossword puzzle. Many of you have probably seen or worked one of these; in case you haven’t, here’s how to do it. You are given a set of clues. Each clue describes a word you learned in this project. Figure out what each word is. Then write it in the row of boxes that begins with the same number that is beside the clue. The boxes may read from left to right or from top to bottom. An example is given for you: Clue number 1 across is “You may find teeth from this animal on a Florida beach”. You need a word that has the same number of letters as there are boxes: five. The word is “shark”. It has been filled in for you. If you have trouble going on, your leader will help you.

Down

1. An animal once lived in this
2. Many sponges come from here
4. Plants that live in the ocean
7. You mother may use this to wash things

Across

1. You may find teeth from this animal on a Florida beach
3. The material the waves leave on the beach
4. You should wear these on your feet
5. These may be several million years old
6. These may be blue, pink, white, orange, or even clear
7. These can do a lot of damage to wooden boats
8. Buried treasure (2 words)
9. ______ feet
WHAT MAKES THE TIDES?

Throughout history, men have tried to explain things that they don’t understand. Many times their explanations have had no basis in fact.

For instance, men tried to explain the tides. Those who lived near the sea watched the level of the water rise and fall, in most places twice a day, day after day, year after year. They made up stories to explain what was happening. One of these stories said that there was a god under the sea, and when he swallowed water, he caused a low tide. Then when he spat the water out again, he caused a high tide.

Today, of course, we know this is not true. Tides are like everything else: there is a natural explanation for them, even though it took a long time to find the explanation.

What are Tides?

Tides are changes in the level of the water. If you live near the ocean, you may have observed that sometimes rocks and parts of the beach are covered with water, and other times these same areas are not covered. What you are seeing are the tides.

When the water level is high, more of the beach is covered with water, and it may appear to be a very small or narrow beach. This is called a “high” or “flood” tide.

When the water is low, less of the beach is covered with water, and it appears to be a much larger or wider beach. This is called a “low” or “ebb” tide. Along some coasts, the difference between the ebb and flood tides is only a few inches, but in some places the difference may be as great as 40 feet.

What causes the Tides?

You may have heard that the tides are caused by the Moon’s gravity pulling on the oceans of the Earth. While this is part of the reason, two other things also affect the tides. We will examine each of these three things separately.

First, let’s build a model of what the Earth and the Moon look like, hanging in space. You will need a yardstick or meter stick, a volleyball or another ball of a similar size, a tennis ball, and some heavy string. Fasten the two balls to opposite ends of the stick with the string. Your leader will help you. Now by balancing the stick on your finger, locate the point between the balls at which the stick will stay balanced and level. This point will be much nearer the large ball than it is the small ball. Tie a piece of string tightly around the stick at this point. Then hang the stick by this piece of string.

The point you have just located is the center of gravitation. If you cut the stick in half where it is tied with the string and weighed each end, along with the balls that are attached to each end, they would both weigh the same amount.

The real Earth and the real Moon also have a center of gravitation. Instead of being between the Earth and the Moon, however, this point is inside the Earth (find the center of gravitation on the drawing, below.) The Earth and Moon both rotate around this center of gravity, which makes the Moon appear to move around the Earth. By grasping the stick where it is tied and turning it gently, you can make your Earth-Moon Model rotate around its center of gravitation.
As your Model does this, you will notice something else: instead of hanging straight down, the model Earth and model Moon lean outward, as though they were trying to get away from each other. The faster the Model turns, the farther out they lean.

Centrifugal force is pushing the model Earth and model Moon apart. Everything that spins around and around experiences centrifugal force, including the real Earth and the real Moon. Instead of being held together by a stick, though, they are held together by gravity. Centrifugal force causes a bulge of water on the side of the earth opposite the moon (see diagram below). The “tidal bulges” are exaggerated so they are easy to see.

**Water in the Oceans**

"Tidal Bulge"

**Earth**

**MOON**

The Moon

Even though the moon doesn’t cause the whole earth to move toward it, it does attract the water on the side nearest to it. This causes a second bulge of water (see diagram below.)

"Tidal Bulge"

**Earth**

"Tidal Bulge"

**MOON**

The Sun

If there were no Moon, the ocean would still have tides. They would be much smaller and less noticeable tides, and would be called “solar tides”, because they would be caused by the Sun. The Sun would produce tides in the same way that the Moon now produces them.

Actually, the sun does affect the tides, even though there is a Moon. When the Sun and the Earth and the Moon are all lined up (when you see a full Moon or a new Moon), the Sun’s affect “adds on to” the Moon’s effect. This causes the high tide to be higher and the low tide to be lower than they are at any other time. This happens about every fourteen days, or twice each month (there is one full Moon and one new Moon each month).

Halfway between the full and new Moons, when the Earth, Moon and Sun are not lined up, the Sun’s effect “subtracts from” the Moon’s effect. As a result, the difference in the low and high tides is less than it is at any other time.

Why are the tides at different times each day?

Since the Earth itself revolves every 24 hours, each place on the Earth passes through one of the tidal “bulges” about every 12 hours. This produces two high tides and two low tides each day.

The Earth moves around the center of gravity a little faster than the Moon does. This means that the Moon is in a little different place each day, with respect to the Earth. The Moon moves all the way around the Earth every 28 days. That means that there is one full Moon, one new Moon, and two half-Moons each 28 days, which is what causes the two very high tides each month.

Since the Moon moves a little each day with respect to the Earth, the time of the high and low tides changes each day. The Moon rises about 50 minutes later (a little less than an hour) each day. Instead of the tides being exactly 1/2 of a day apart, they are 1/2 of a day + 1/2 x 50 minutes, or 12 hours and 25 minutes apart. This is why the times of the tides changes every day.
Don't the Continents get in the way? Obviously, the answer to this question is "yes". So, let's use another model to show exactly what happens: You will need a jar or glass and a little water.

Put the water in the jar. Then swirl it around and around, until you get it to move smoothly in a circular motion without splashing all over the place. What you have just done is create a mini-tide. The motion of your hand is the action of the Moon and the Sun on the tides. The sides of the glass or jar are the edges of the continents. The smooth motion of the water as it swirls around in the jar is the tide itself.

If you watch closely, you will notice that the motion of the water has a rhythm. It moves around and around at the same rate all the time. If you make the jar move slower or faster, the water will stop moving in this rhythm, and will start to splash all over the place again.

This is also what happens in the ocean. Each body of water is in some way enclosed. The enclosed part of the body of water is in what is called a basin. Each basin has its own natural rhythm. The Moon and the Sun act on the water in each basin in the way that we have been talking about. Then the tides flow back and forth, according to the natural rhythm of each basin.

Let's look at the Gulf of Mexico, for example. If you look at a map, you can see that the Gulf is almost round. You should be able to see that the Gulf is contained in a basin between Florida and other points of land that stick out into the water. As the Sun and the Moon act on the water of the Gulf, the tides rise and fall. But the natural rhythm of the Gulf is not anywhere near the 12 hours and 25 minutes that we have mentioned previously. Instead, its natural rhythm is about 24 hours, or one day. Because of this, there is only one high and one low tide in the Gulf each day.

Get a different size jar or glass. Put some water in it, and swirl it around. Is the natural rhythm of this container different from the first one? Try changing the amount (depth) of the water. Is it different now?

Every ocean and sea acts this way. Almost nowhere will you find high tides and low tides that are exactly 12 hours and 25 minutes apart. Even though the Moon and the Sun always pull and push on the water with this rhythm, the natural rhythm and the depth of each basin has the ability to determine exactly how far apart the tides will actually be.