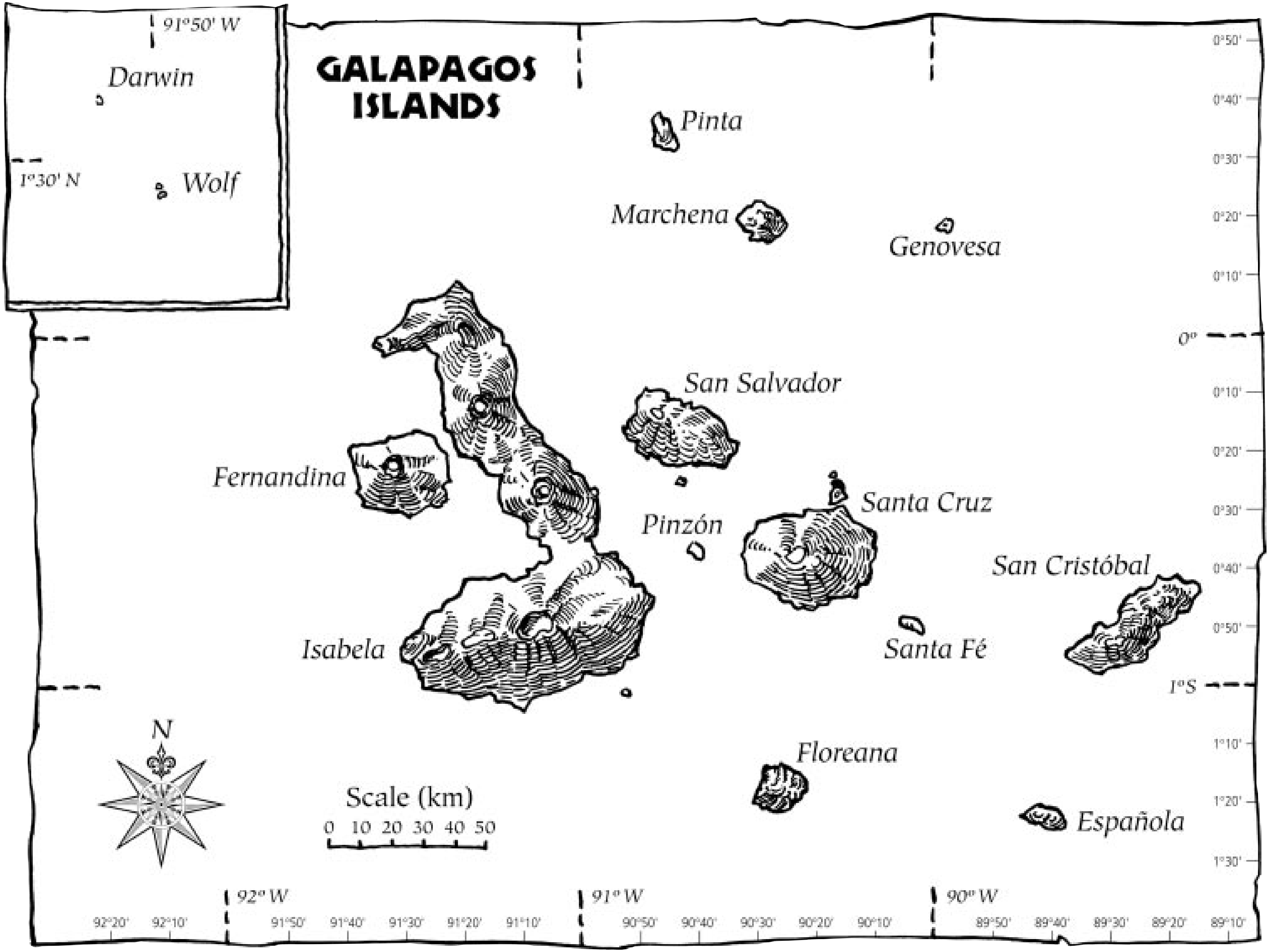
Teacher's Resource Guide

GALAPAGOS


GALAPAGOS ISLANDS
91°50' W
Darwin
1°30' N
Wolf
Pinta
Marchena
Genovesa
San Salvador
Fernandina
Pinzón
Santa Cruz
San Cristóbal
Isabela
Santa Fé
Floreana
Española
N
Scale (km)
0 10 20 30 40 50
0°
1°S
92° W
91° W
90° W
0°50'
0°40'
0°30'
0°20'
0°10'
0°10'
0°20'
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Teacher’s Resource Guide to

GALAPAGOS

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WRITER: Richard Benz, Wickliffe High School, Wickliffe, OH

EDITOR: Erin Miller, National Science Teachers Association

DIRECTOR OF SPECIAL PUBLICATIONS: Shirley Watt Ireton, National Science Teachers Association

TABLE OF CONTENTS

SCIENCE AND CURRICULUM ADVISORS:
Dr. Carole Baldwin, Smithsonian Institution, Washington, DC

Sue Cassidy, Bishop McNamara High School, Forestville, MD

Dr. Robert Hoffmann, Smithsonian Institution, Washington, DC

Sue Mander, Imax Ltd., Toronto, Canada

Laura McKie, Smithsonian Institution, Washington, DC

Dr. David Pawson, Smithsonian Institution, Washington, DC

Sharon Radford, Paideia School, Atlanta, GA

Dr. Irwin Slesnick, Western Washington University, Bellingham, WA

Dr. John Weld, Oklahoma State University, Stillwater, OK

Dr. Don Wilson, Smithsonian Institution, Washington, DC

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EXECUTIVE PRODUCERS: Laurence P. O'Reilly, Andrew Gellis, Peter Guber, Barry Clark

PRODUCERS/DIRECTORS: Al Giddings and David Clark

WRITERS: Barry Clark and David Clark

DIRECTOR OF UNDERWATER PHOTOGRAPHY: Al Giddings

DIRECTORS OF TOPSIDE PHOTOGRAPHY: Reed Smoot and Andrew Kitzanuk

NARRATOR: Kenneth Branagh

MUSIC COMPOSER AND PRODUCER: Mark Isham

RESOURCES

INTRODUCTION FOR TEACHERS

This *Teacher's Resource Guide* is intended as a classroom supplement for middle-school grades, and is consistent with the National Science Education Standards. Designed in conjunction with the IMAX® film *Galapagos*, this guide provides background information to the teacher on the subjects of Galápagos geography, geology, ecology, and evolution. Use the *Guide* to plan for post-viewing discussions and activities. The material is intended for flexible use, and teachers may modify and duplicate the copyrighted materials to suit their students' needs. We especially recommend for photocopying the pages marked "student section." These activities may be modified for elementary students.

FILM SYNOPSIS

Follow Smithsonian marine biologist Dr. Carole Baldwin as she retraces the steps of evolutionary pioneer Charles Darwin on his epic voyage to the Galápagos Islands. With the help of modern technology, students experience the spectacle and abundance of wildlife both on land and beneath the waters of the islands. The age-old powers of observation, combined with cameras, scuba gear, submersibles, and robot arms, allow today's scientists to extend their research to an undersea world that was far beyond the reach of Darwin when he visited the islands more than 160 years ago.

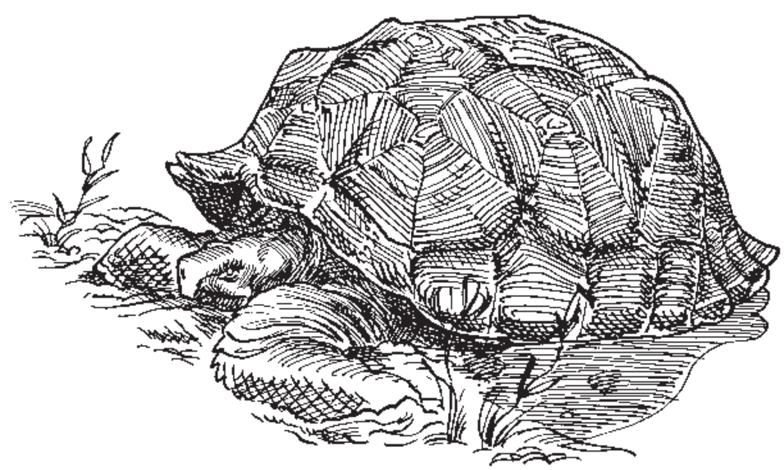
Students observe the variety of life—from families of sea lions and schools of sharks to trudging tortoises and impish iguanas—that demonstrates how the Galápagos' island geography and isolation from the mainland contributes to the evolution of species found nowhere else on Earth.

PRE-SCREENING DISCUSSION

Before visiting the film, familiarize your students with Darwin's role as the first person to publish the theory that new species originated from other species through evolution driven by natural selection (see the Resources section for further reading suggestions). Darwin's ideas were prompted by his trip to the Galápagos, which makes these islands an important landmark in scientific history.

The first section of this teacher's guide, "Where in the World?" can be used either as pre-screening or post-screening activities. As pre-visit exercises, they introduce students to the location of the islands and the importance of observation to the scientific process. This allows them to better understand the work performed by the scientists in the film.

A pre-visit discussion of some of the unusual animals shown in the film will stimulate your students' interest. Visit the *Galapagos* Web site at http://pubs.nsta.org/galapagos/ for pictures and information about some of these creatures, and instruct your students to look for them in the film. This Web site also provides details on how the activities meet the National Science Education Standards.



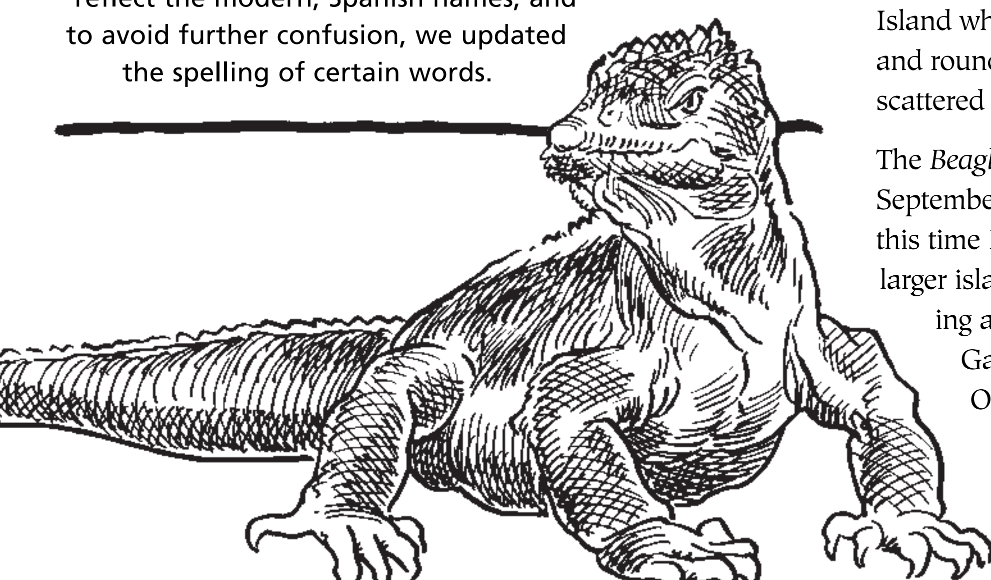
WHERE IN THE WORLD?

This archipelago consists of ten principal islands, of which five exceed the others in size. They are situated under the Equator, and between five and six hundred miles west … of the coast of America. They are all formed of volcanic rocks...Considering that these islands are placed directly under the equator, the climate is far from being excessively hot; this seems chiefly caused by the singularly low temperature of the surrounding water, brought here by the great southern Polar current. (Darwin, 1845)

So, where in the world are these islands that Darwin described as "A little world within itself"?

The Galápagos Archipelago, or island group, consists of 13 large islands, six smaller islands, and a great number of small volcanic islets or "rocca." These islands in the eastern Pacific Ocean are approximately 960 km (600 miles) west of mainland Ecuador in South America, situated along the Equator. They lie almost directly south of Chicago, Illinois, in the United States. The geographic position and isolation of the Galápagos are the key to the island group's natural history. To understand why the Galápagos Archipelago is renowned as a laboratory of evolution and adaptation, we must understand a little about the relationship of life forms to location. Your students will learn how absolute location of the islands compares with relative location, and discover how isolated the Galápagos Islands are from the rest of the world.

At the time Darwin wrote his journal, he referred to the islands by their English names. Because the islands are a part of Ecuador, we have changed Darwin's quotes to reflect the modern, Spanish names, and to avoid further confusion, we updated the spelling of certain words.



Aboard the HMS *Beagle*, Darwin traveled west from the coast of South America in 1835, and arrived off the coast of San Cristóbal on September 17.

"In the morning we landed on San Cristóbal Island which, like the others, rises with a tame and rounded outline, broken here and there by scattered hillocks, the remains of former craters."

The *Beagle* explored the Galápagos Islands from September 15 through October 20, 1835. During this time Darwin landed on at least six of the larger islands, starting at San Cristóbal and ending at Pinta Island. The *Beagle* left the Galápagos and sailed toward Tahiti on October 20.

ADVENTURING IN THE ARCHIPELAGO

Teacher Section

OBJECTIVE

To learn basic mapping skills and understand the difference between absolute and relative location.

MATERIALS

- globe
- map of your country
- local map with latitude and longitude
- copies of maps on the inside-front and inside-back covers
- copies of pages 6–7
- string
- pencil

Locate the Galápagos Islands on a globe, and measure the distance to the coast of Ecuador using a piece of string. Now take that same piece of string and place one end on your hometown, and find a city that is the same distance from you as the Galápagos are from the mainland. Ask your students how they think animals and plants located in that city would get to yours. Imagine the two cities are separated by water, and inform your students that these plants and animals don't swim! This will be dealt with later in the teacher's guide, but it will get your students thinking about the problems of colonizing a far-off island.

Now, using a map of your country, ask your students to describe their hometown's location in relative terms compared to the other city identified above. Next have your students find the absolute location of their hometown and other familiar locations on a map that shows latitude and longitude. After students are comfortable with absolute and relative location of familiar landmarks, ask them to describe their location in relation to the Galápagos Islands. Finally, describe the position of the Galápagos in relation to mainland Ecuador (see map on the inside back cover).

After completing this exercise, students should know where the Galápagos Islands are located, and they should understand their position in both absolute and relative terms.

Suppose you live in Milwaukee, Wisconsin. You could choose Washington, DC as your comparison city, the same distance on your piece of string. Your students would describe Milwaukee as being approximately 1,600 kilometers northwest of Washington or 200 km almost due north of Chicago. These are relative locations. The absolute location of Milwaukee is approximately Latitude 48° N, 88° W.

In this activity the students will follow Darwin's Galápagos adventures by locating some of his landing sites in the archipelago. Make copies of the Galápagos Islands map from the inside front cover and of Darwin's quotes on pages 6–7, and distribute to each student. Each site will be introduced by a short quote from Darwin's journals or from *The Voyage of the Beagle.* The absolute positions (latitude and longitude) are listed after each quote. The students should read the quote, note the absolute position and find the site on the map of the Galápagos Islands. When they find the site they should mark it with a small dot and list the date from the quote. (As an added element, students can calculate the mileage between stops, and add that to the map.) When all the sites have been located the students should "connect the dots" of Darwin's voyage around the Galápagos. As a final evaluation of this activity, the students can discuss this part of Darwin's journey or create a journal as though they had accompanied Darwin on this part of the trip.

ADVENTURING IN THE ARCHIPELAGO

Student Section

Now that you know where the Galápagos Islands are located, you are going to travel around this island group and get a feeling for what Charles Darwin found when he visited more than 160 years ago. Darwin, aboard the HMS *Beagle*, traveled west from the coast of South America in September 1835, and arrived off the coast of San Cristóbal Island on September 17.

Here are some quotes from Darwin's journal. Darwin's absolute position (defined by latitude and longitude) follows each quote. On the map your teacher has given you, make a small dot for the location of each quote, and write the date of the quote next to it.

After you have made a dot for each quote, play "connect the dots" starting with the first one, and connect them in order. You will see the approximate route Darwin took during his five weeks of exploration in the Galápagos Islands more than 160 years ago!

1 **September 17, 1835**

In the morning we landed on San Cristóbal Island, which, like the others, rises with a tame and rounded outline, broken here and there by scattered hillocks, the remains of former craters. Nothing could be less inviting than the first appearance. A broken field of black basaltic lava, thrown into the most rugged waves, and crossed by great fissures, is everywhere covered by stunted, sunburned brushwood, which shows little signs of life.

Location: 0°50′ S, 89°30′ W

2 **September 23, 1835**

The Beagle *proceeded to Floreana Island. This archipelago has long been frequented, first by the buccaneers, and latterly by whalers, but it is only within the last six years, that a small colony has been established here. The inhabitants are between two and three hundred in number; they are nearly all people of color, who have been banished for political crimes from the Republic of the Ecuador, of which Quito is the capital.*

Location: 1°15′ S, 90°20′ W

ADVENTURING IN THE ARCHIPELAGO

3 **September 29, 1835**

We doubled the south-west extremity of Isabela Island, and the next day were nearly becalmed between it and Fernandina Island. Both are covered with immense deluges of black naked lava, which have flowed either over the rims of the great caldrons, like pitch over the rim of a pot in which it has been boiled, or have burst forth from smaller orifices on the flanks; in their descent they have spread over miles of the sea-coast. On both of these islands, eruptions are known to have taken place; and in Isabela, we saw a small jet of smoke curling from the summit of one of the great craters.

Location: 0º20′ S, 91º15′ S

4 **October 8, 1835**

We arrived at Santiago Island. Mr. Bynoe, myself, and our servants were left here for a week, with provisions and a tent, whilst the Beagle *went for water. We found here a party of Spaniards, who had been sent from Floreana Island to dry fish, and to salt tortoise-meat.*

Location: 0º10′ S, 90º50′ W

5 **October 18, 1835**

Finished survey of Isabela Island

Location: 0º10′ N, 91º10′ W

6 **October 19, 1835**

To Pinta Island.

Location: 0º30′ N, 90º40′ W

7 **October 19, 1835**

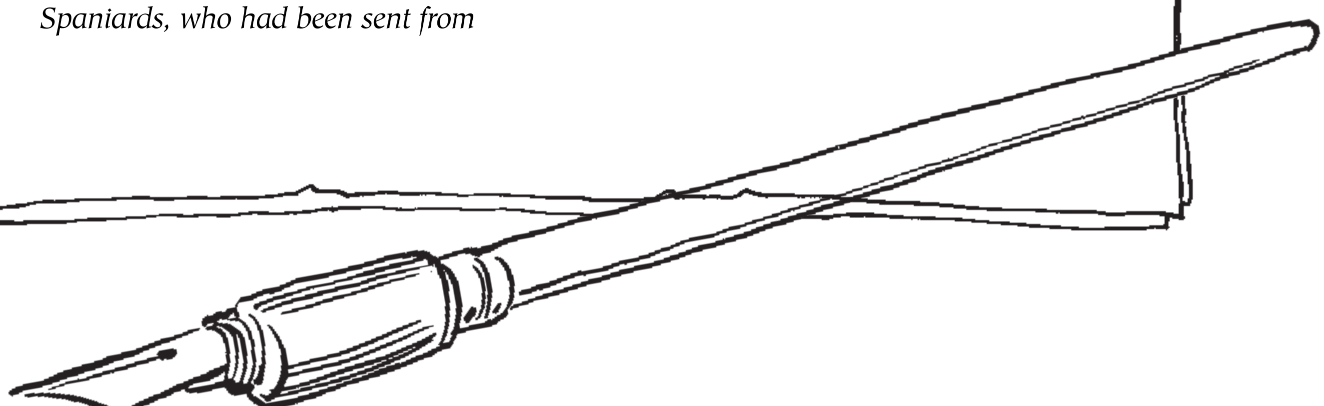
Darwin and Wolf Islands

Location: 1º30′ N, 92º0′ W

8 **October 20, 1835**

Headed for Tahiti

Location: 17º37′ N, 149º27′ W
(off the map)



ADVENTURING IN YOUR OWN BACKYARD

Teacher Section

OBJECTIVE

To understand the importance of careful observation, and make a permanent record of these observations.

MATERIALS

- Notebook or diary, used just for this project. Can be spiral bound or a binder; but something to which students can add pages is best.

Keeping a journal is a crucial part of any fieldwork. Explorers and scientists keep journals of their investigations and adventures. Scientists keep journals to provide a permanent record of what they witness in the natural world—like a diary of nature. When scientists look back at pages from weeks gone by, they will know the exact day when they saw a particular animal or other natural phenomena. If you keep a journal of your observations in the same area for several years, you will begin to notice patterns; eventually you'll be able to predict when certain animals will return to the area or when particular plants will bloom.

"This volume contains, in the form of a Journal, a history of our voyage, and a sketch of those observations in Natural History and Geology,"

Thus begins Darwin's *The Voyage Of the Beagle*. Throughout his life Darwin kept many volumes of journals from his observations and studies of nature. He carried a small notebook wherever he went, and later transferred his notes to the master journal that was kept on board the *Beagle*.

To understand the importance of recording observations, ask students to keep their own "fieldwork" journal. This activity can be limited to their study of evolution, or can be continued throughout the year. Students can observe and make entries in any kind of notebook, but a hardcover binder or a permanently bound notebook may help them to take this assignment seriously and encourage them to continue making journal entries after this activity is over.

You can structure this activity in a number of ways: One option is to direct where your students observe, e.g. in their own backyard or at a school site. Or, ask them to record their journey to and from school for a few days. Another alternative is to localize their observations to a small model ecosystem in a jar. Students can add a small amount of gravel, pond water, aquarium plants, and a snail to a one-quart jar, seal it, and place it in low light. They can start an "Aquatic Ecosystem" journal as though they were naturalists who discovered this habitat while on their own "voyage" of discovery. Encourage the students to draw pictures or "field sketches" whenever possible, to help illustrate and add detail to their observations. These observations can be discussed with the rest of the class at weekly intervals to help encourage continued participation.

ADVENTURING IN YOUR OWN BACKYARD

Student Section

This volume contains, in the form of a Journal, a history of our voyage, and a sketch of those observations in Natural History and Geology. (Darwin, 1845)

Thus begins *The Voyage Of the Beagle*. Throughout his life Darwin kept many volumes of journals from his observations and studies of nature. Like Darwin, you are a field scientist studying a newly discovered habitat. To help you remember what you observe, you will keep a journal. Scientists keep journals of their projects, and they do it for a reason: journals are invaluable for keeping track of, and making sense of, their work.

In your journal you will share your observations about a particular environment you are investigating. You will observe nature and ask why or how about the things you see. Why is the male cardinal a bright red, but the female a dull brown? Why doesn't a cactus need a lot of water compared to most plants? How can the ant carry a piece of bread several times its size? What, why, how, and where are the overriding questions that scientists ask. You need to think about the things you observe, and your journal is the place to record your observations, questions, and hypotheses.

On your first day, write a detailed description of the place you are focusing upon. Use all of your senses—what does it look like, how does it smell, what sounds can you hear? Make sure to include where your place is located (in both absolute and relative terms, if possible). For all subsequent entries, make sure to list each day's date and the time you visited. See if you can find a central theme or idea, such as encountering a bird's nest and then recording the changes with each observation. Make sure to record each day while your thoughts are fresh. Your teacher will help direct your observations and your journal writing activity.

Charles Darwin kept a journal throughout his life. Much of what we know about the Galápagos Islands of the eighteenth and nineteenth centuries came from journals kept by explorers like Darwin. Dr. Carole Baldwin, from the *Galapagos* film, kept a journal of her entire trip. Dr. Baldwin is a marine biologist at the Smithsonian Institution. Here is one of her journal entries:

February 12, 1999, Cabo Douglas, Fernandina

Arrived here late yesterday morning and immediately saw hundreds of marine iguanas in the water and rocks covered with bright green algae. Also, there are a lot of sea turtles in the water, blue-footed boobies on the rock ledges, and sea lions. Got to see the blue-footed booby doing its sky-pointing mating dance. The beak points upwards, the tail points upwards, and each foot is alternately lifted high off the ground. You absolutely cannot look at this and not laugh! I get the same feeling from watching marine iguanas basking on rocks and spitting salt crystals. Nature can certainly be humorous... (Dr. Carole Baldwin, 1999)

Remember, to be a good scientist you must be curious and you must observe the world around you—**and** you must record what you see in your field journal.

HOW DID LIFE GET TO THE GALÁPAGOS?

I scarcely hesitate to affirm, that there must be in the whole archipelago at least two thousand craters—Nothing could be less inviting than the first appearance. (Darwin, 1845)

The Galápagos are a series of volcanoes arranged in a pattern with two major axes that run in an east-northeast and north-northwest direction. These volcanoes result from a "hot spot" fixed deep in Earth's interior.

Hot spots are concentrations of heat deep below the Earth's crust that produce plumes of hot rock, which work their way upward to form volcanoes. As plate tectonics slowly move the crust over thousands and millions of years, a new volcano forms directly over the hot spot, and older extinct volcanoes form a chain of islands. At times, nearby volcanoes coalesce to make a multi-volcano island, such as Isabela.

The oldest Galápagos Islands formed several million years ago and they also have the greatest diversity of plants and animals. The young western islands of Isabela and Fernandina are active volcanoes and thus are still forming.

The distinctive plants and animals throughout the archipelago are a direct result of this unusual combination of recent volcanic formation and vast distance from another land mass.

A volcanic island newly built above sea level would be bare, rugged, and largely sterile. How did the plants and animals arrive and what conditions would they need to survive? To answer this, we must investigate the wind patterns and ocean currents to find the mode of transportation for the pioneering plants and animals that came from the mainland and colonized the Galápagos Islands.

The Galápagos lie in a crossroads of wind and ocean currents that bring both cool (temperate-zone) and warm (tropical) water to the islands. Ocean currents brought an abundance of marine life that populated the islands' coastal waters. Wind currents brought birds, which fed on the rich marine life. Vegetation came in the form of seeds dropped by birds, or on "rafts" of soil and plants.

Scientists think land rafts—mats of logs and root masses washed out from flooding rivers—are one way in which many of the terrestrial animals arrived at the Galápagos. In October 1995, 15 iguanas arrived on the eastern shore of the Caribbean island Anguilla. The group, including a pregnant female, traveled more than 320 km from the distant island of Guadeloupe on a land raft. Before this event there were no iguanas on the island, but they survived and reproduced, forming a new population.

The unusual cross-section of life on the Galápagos includes temperate-zone organisms, like the sea lion, and tropical organisms, like the butterfly fish. This mix is made possible by the converging currents and wind patterns. Although the Galápagos are unique because many of the plants and animals that have evolved there (and nowhere else), the islands are not unique in terms of the process of evolution. Evolution exists wherever life forms are found. Changes that occur on isolated islands are sometimes easier to "see," but similar changes occur continuously throughout the living world.

CURRENT EVENTS IN THE OCEAN

Teacher Section

OBJECTIVE

To investigate how landforms and wind affect ocean surface currents, and how this relates to the ways in which life arrived to the Galápagos.

MATERIALS

For each student team:

- map of the eastern Pacific
- baking pan or clear plastic shoebox
- non-permanent marker
- modeling clay
- colored pencils
- black permanent marker
- food coloring
- towels or rags for cleanup

For each student:

- plastic drinking straw with a flexible elbow

Currents—large scale movements of water—occur throughout the ocean in both the surface and the subsurface layers. Wind moving over water drags surface water along its path, creating surface currents. A map showing prevailing wind direction correlates with a map showing surface currents in the major ocean basins (compare maps on pages 12 and 14). This activity allows students to simulate the flow of the Humboldt Current in the Pacific Ocean and experiment with how land formations and variations in wind direction can affect ocean currents. It is important, however, to lead students to the understanding that many factors determine current formation in the ocean and that this model presents just one of them. Current formation is an extremely complex aspect of oceanography.

The prevailing winds in the Pacific are called the "trade winds." (As an extra activity, you may want to have your students investigate how these winds became known as the trade winds.) The trade winds that move air over the South Pacific from the southeast toward the northwest are called South Easterlies. Near the Galápagos, these winds move up along the coast of Peru and then out towards the Galápagos. This wind pattern moves the ocean waters in the same direction forming the Humboldt Current.

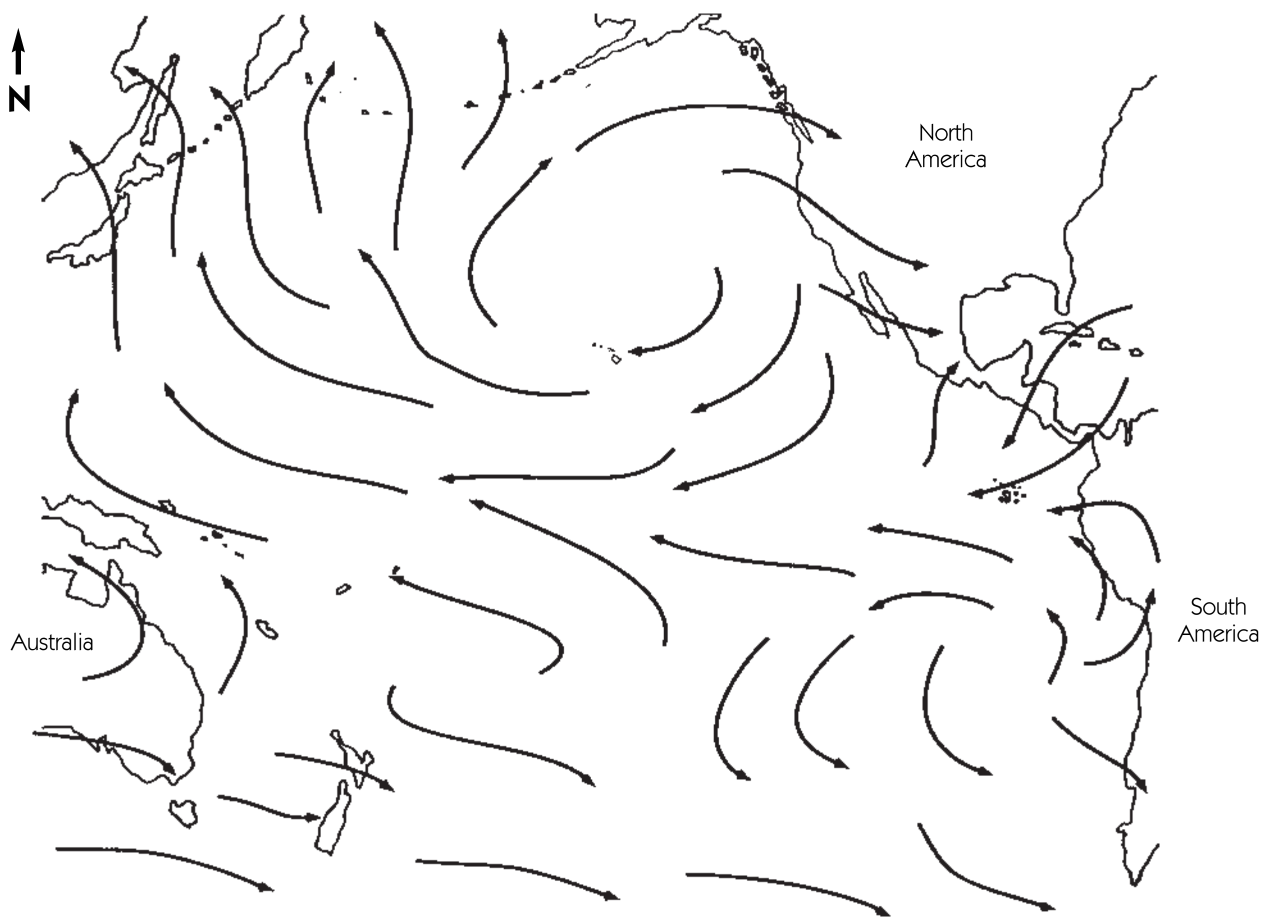
As the surface water current moves along the South American coast, off-shore winds push it westward allowing cooler, deeper water to come to the surface and to the Galápagos Islands. In addition, the South Equatorial Current moves warm water from the Panama Current directly from the coast of Ecuador west to the Galápagos (see page 12).

This movement of surface water away from the coast, bringing cold subsurface waters to the surface is a process known as "upwelling." This cold, nutrient-rich, upwelled water supports an abundance of sea life along the coast of South America and the Galápagos Islands. Biologists have discovered that many marine species are unusually dense in the Galápagos waters. They theorize that this is because of the nutrient-enriched water that first provides food to enormous numbers of microscopic life forms. These life forms then become food for small crustaceans and fish, which in turn become food for larger organisms. Because the increased nutrients in the water bolster the entire food chain, the area can support more life of all sizes. In the Galápagos, therefore, some predator species, such as hammerhead sharks or barracudas, appear in large schools—a behavior that is seldom seen anywhere else in the world.

CURRENT EVENTS IN THE OCEAN

Student Section

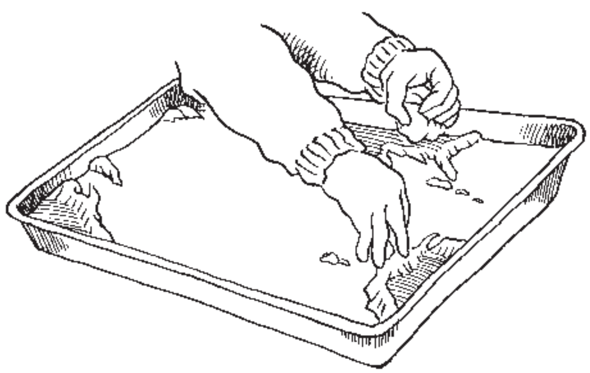
Sailors have known for centuries that ocean currents—large scale movements of water—can speed up or slow down a ship, just as airplane pilots know that it takes longer to fly from New York to California than the reverse, because of the jet stream. In modern times, scientists have discovered that ocean currents have major effects on weather patterns and on the ecology of the ocean and nearby land masses. One type of current is called a surface current, which, as you might have guessed, flows across the surface of the ocean almost like a river flows across dry land. However, a surface current lacks the solid banks of a river to direct its flow. As a result, the direction of a surface current may change when the wind blowing across it shifts, when it encounters warmer or colder water, or when it nears land. This activity will show how surface currents are affected by the direction of the wind.



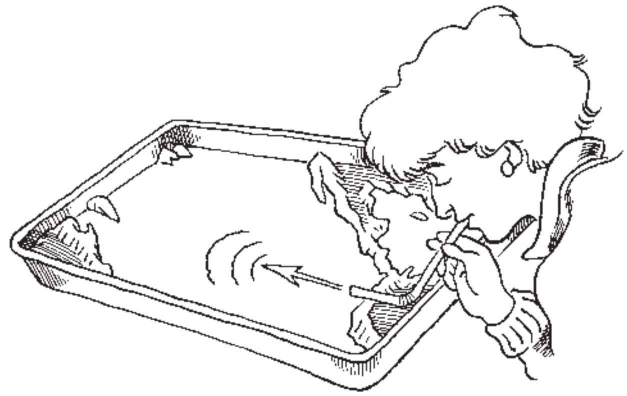
CURRENT EVENTS IN THE OCEAN

With your team:

1. Using a map of the eastern Pacific provided by your teacher, draw an outline of the western coast of North and South America near the right side of the pan or plastic shoebox with a crayon or non-permanent marker.
2. Following the pattern, place ridges of modeling clay along the bottom of the pan to contain the “ocean.” Press the clay firmly to the pan or plastic box and smooth the gaps between the clay and the pan. It is important to create a water-tight seal to prevent “oceanic” leaks.

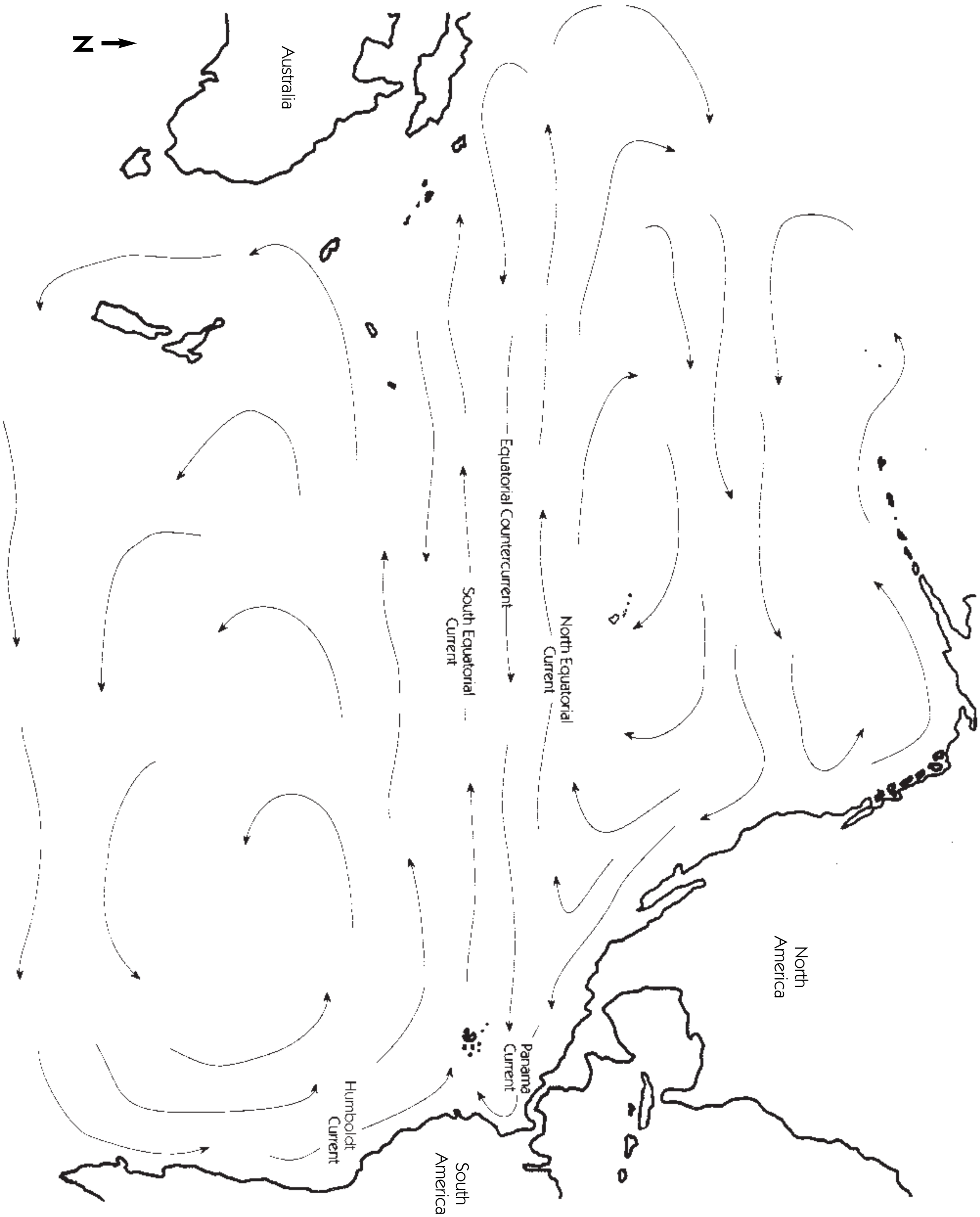


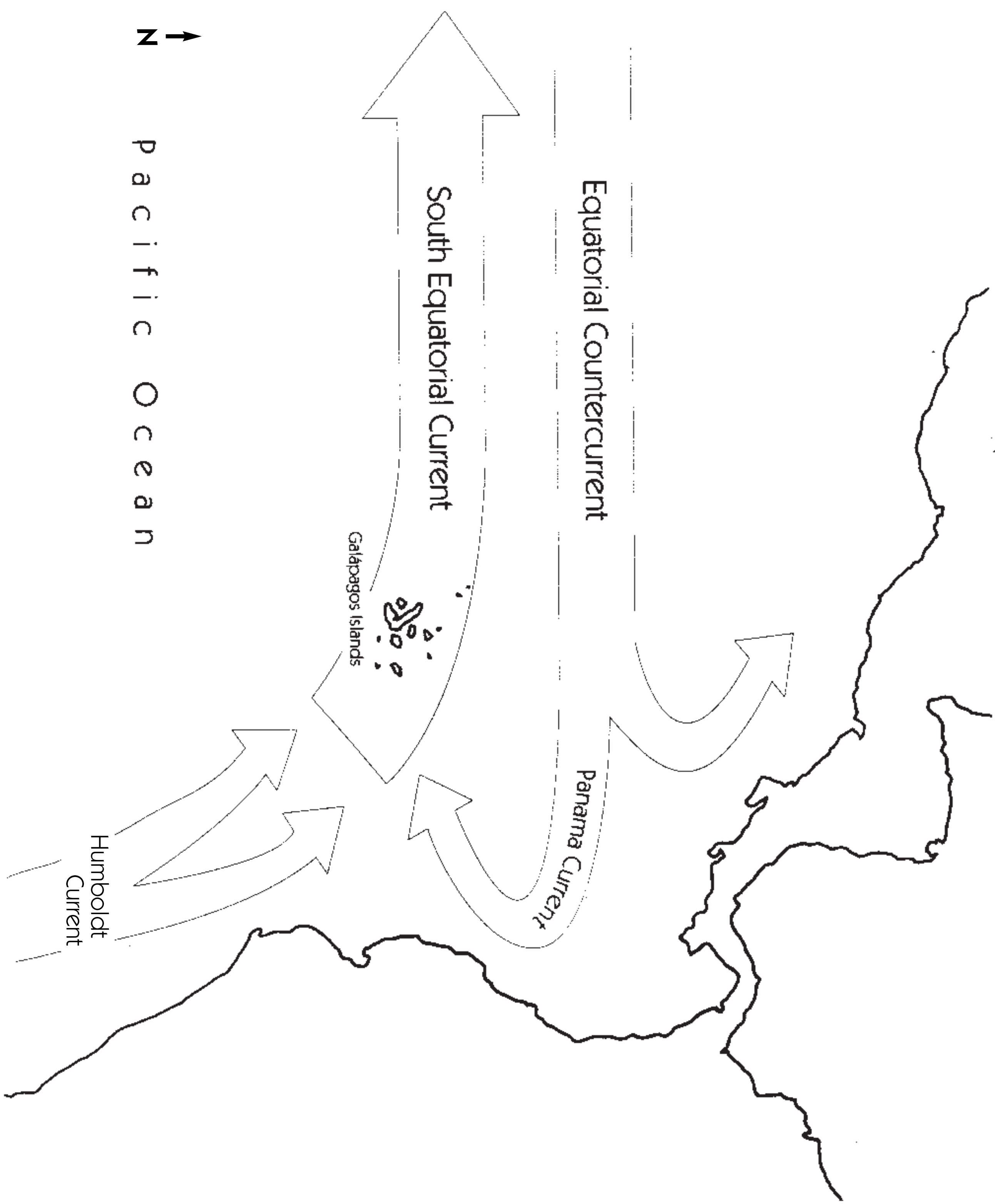
3. Create some island masses about 3cm west of South America at the position of the equator. This will represent the Galápagos Islands.
4. Fill the ocean area of your model with water. Wait for the water to settle.
5. Bend the straw at the elbow. Write your name on the short end of the straw with the permanent marker. This will identify your straw and remind you which end of the straw to point toward the water. Do not put the short end of the straw with your name on it into your mouth.



6. Try not to touch the pan or plastic box as you do the following:
   - Hold your straw so that the short end is parallel to the ocean surface.
   - Point your straw from the lower tip of South America toward the equator.
   - Have your partner place one or two drops of food coloring in the water near the end of your straw.
   - As soon as the food coloring is in the water blow gently through the straw and observe the patterns of ocean currents that the wind produces.
7. Repeat step 6 a few more times to develop a sense of the relationship between wind direction, landmass configuration and current patterns. You may need to get clean water if the “ocean” becomes too dark from food coloring.
8. Repeat step 6 once more, but this time blow gently along the coast of Central America towards South America (from north to south). This action represents the Panama Current that brings warmer water to the northern Galápagos Islands.
9. Describe the relationship between wind and ocean currents. How do variables, such as wind direction, wind speed, land formations, etc., seem to be related to ocean current patterns?

CURRENT EVENTS IN THE OCEAN




N
Pacific Ocean
South Equatorial Current
Equatorial Countercurrent
Galápagos Islands
Panama Current
Humboldt Current

HOT SIDE HOT, COOL SIDE COOL

Teacher Section

OBJECTIVES

To understand how cold and warm ocean currents interact, and the effect they have on nearby land masses

MATERIALS

For each student team:

- clear plastic shoebox or small aquarium
- 250 ml beaker
- 2 small paper drinking cups
- water
- food coloring
- 2 straight pins or push pins
- ice
- paper
- pens or pencils

This activity will help your students visualize what happens when liquids of different densities meet. Warm ocean water is less dense than cold and the two will not readily mix. As the cold Humboldt Current flows up the South American coast it tends to keep the warm Panama current from reaching the Galápagos. Eventually, the warm (lighter) water pushes over the colder (heavier) water, still not mixing with it. When this happens, the warm water reaches the northern islands and brings warm water species with it. There are tropical species of fishes in the northern islands of Darwin and Wolf that don't occur anywhere else.

In Part A, as the colored, cold water leaves the cup, it sinks to the bottom. Students should be able to see waves and currents that form as the warm and cold water meet. The food coloring should stay in the lower half of the container. In Part B the warm water will tend to float on top of the cold water in the container. See the illustrations on pages 17–18 for guidance.

Instead of handing out pages 17–18, you may wish to divide your class into teams, and provide each with a set of the above materials. Have them devise a method for observing the effects of when warm and cool currents meet. You can have each team prepare a report of its procedure and findings to the rest of the class.

HOT SIDE HOT, COOL SIDE COOL

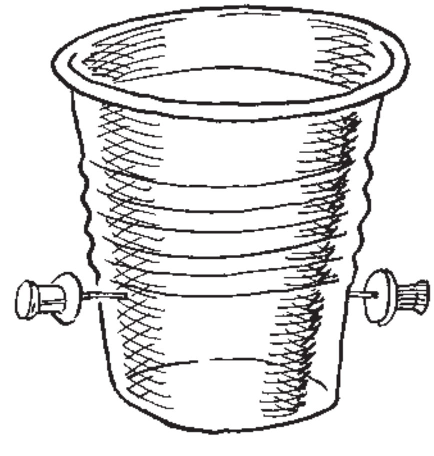
Student Section

Considering that these islands are placed directly under the equator, the climate is far from being excessively hot; this seems chiefly caused by the singularly low temperature of the surrounding water, brought here by the great southern Polar current. (Darwin, 1845)

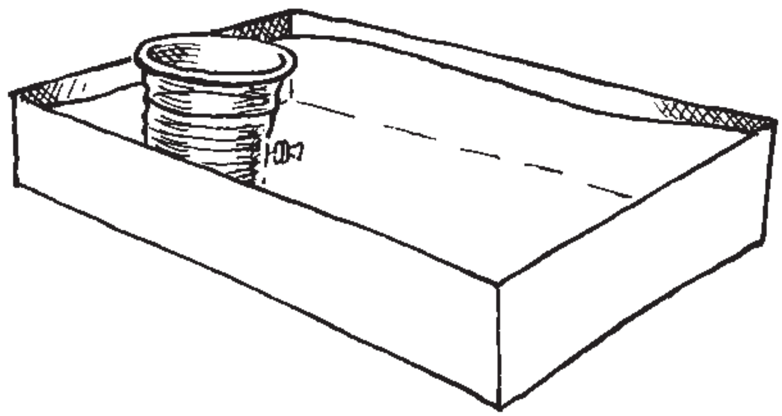
Darwin described the cold waters at the Earth's hottest latitude in 1845. Why do ocean currents bring cold waters to regions that are at the equator? Why don't warm waters mix with these cold water currents? What happens when cold water meets warm water? The climate of a region depends upon the movement of cold and warm water in its surrounding oceans. This activity will help you explore what happens when cold water and warm water meet.

Most people know that hot air rises—just watch the flight of a hot air balloon or feel the temperature rise as you climb the stairs on a warm summer day. Why does warm air rise above cold? Warm air is less dense than cold air and therefore floats above the heavier cold air in a room. Is this also true with water? Let's investigate.

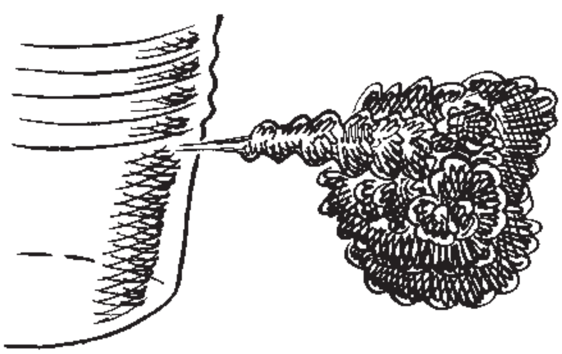
1. Fill the plastic shoebox or aquarium with lukewarm water—be sure to keep the water level below the height of the paper cup (e.g., if you have a cup that is 8 cm tall, be sure to only put 6.5 cm of water in the box).
2. Place two ice cubes in a 250 ml beaker, and add cool tap water. Add three or four drops of food coloring to the ice water in the beaker.
3. Wait a couple of minutes for the colored water in the beaker to cool down.
4. With one of your pins, punch a hole in the side of the paper cup about 2–3 cm from the bottom. Repeat with the other pin on the other side. Leave the pins in the cup; as they will act as temporary plugs (see illustration below).



Hot Side Hot, Cool Side Cool



5. Next, fill the cup with the colored ice water well above the level of the pins, and place the cup into the water-filled shoebox. Put the cup all the way to one side of the container, and wait for the water to become still.
6. Carefully remove the pins. Plan your procedure before you try it. As much as possible, try not to disrupt the water in the container. If no water leaves the cup, you may have to make the pin holes a little larger.



7. Describe what you observed when the cold, colored water entered the warm water in the container. In which direction did the cold water flow? What happened when the colored water hit the bottom of the container?

Now repeat the whole process, this time using cool water in the shoebox and warm water and food coloring in the plastic cup.

Write up the results of your experiments, and explain what might happen when the cold Humboldt Current meets the warm Panama Current near the Galápagos Islands.

MODERN-DAY DARWINS
Teacher Section

OBJECTIVE

To create model experiments to see how seeds may have traveled from the mainland to the islands and still survive to germinate into plants.

MATERIALS

These will vary depending on student creativity:

- various seeds (any seeds that are fast growing, or easy to obtain, such as radish seeds, beans, sunflower seeds, grass seeds, etc.)
- container to hold salt water
- tap water
- ocean water—if not available, then use a solution of 35g table salt (NaCl) per liter of water. ("Instant ocean mix" is sometimes available in pet supply stores.)
- planting containers (pots, trays, etc.)
- sterile (seedless) potting soil, purchased from a garden store
- materials to make simulated bird feet (straws, cotton swabs, tooth picks, other…)

During the years following Darwin's voyage on the *Beagle*, he worked on many projects relating to his observations. One topic that particularly fascinated him was how plants could have colonized the newly formed and relatively barren volcanic islands. Darwin conducted a series of experiments about seed dispersal to remote oceanic islands. In one experiment, Darwin found that out of 87 types of seeds, 64 germinated even after 28 days immersed in salt water, yet few survived immersion after 137 days.

In other experiments, Darwin investigated the possibility that seeds from the mainland were carried to the islands in mud stuck to the feet of birds that made their way to island landing sites. In one example, Darwin saved mud washed from the feet of a duck, and germinated 53 plants.

Can your students devise a series of experiments to find out if seeds could survive the long salt-water journey in currents from mainland South America? One way might be to vary the time seeds can last in salt water, yet still be able to germinate. What about seeds found in the mud stick to the feet of birds? One possible experiment is to mix seeds in potting soil and then have students devise model "bird feet." Students can "walk" their model feet through the soil and try to harvest seeds from the attached mud.

Below are some questions students may ask during the course of their investigation. If students are having problems designing experiments, consider using some of these prompts:

- What seeds should we use?
- How long should we put the seeds in the "ocean?"
- How do we make model birds' feet?
- How will my model bird "walk" in the mud?
- Where should we plant the seeds?
- How should we plant the seeds?
- How should we care for our newly planted seeds?

These discovery activities will help students understand the possible means of transport of plants that colonized the Galápagos Islands.

MODERN-DAY DARWINS

Student Section

After his trip to the Galápagos, Darwin wondered how plants got to the islands? Were they carried there by the ocean currents that travel from the coast of South America to the islands? Can seeds that fall into the ocean even survive the saltwater? Could birds have brought seeds to the island and if so, how?

In the 1850s Darwin conducted experiments to test both these hypotheses. Can you become a "modern-day" Darwin? Invent experiments to test whether seeds could travel ocean currents and survive the salt-water to take root on the distant barren islands. Create an experiment to test if birds may have carried seeds to the islands in the mud on their feet. Darwin collected birds from his own yard and washed mud off their feet and then put the mud in a container to see if any plants sprouted. Simulate Darwin's experiment, but don't capture a flock of birds and wash their feet!

With your team:

1. Develop a hypothesis about how plants might have colonized the Galápagos Islands.
2. Design an experiment that will show under what circumstances plants could have colonized the Galápagos. Show your experimental plan to your instructor for approval.
3. Conduct your experiment. Don't forget to keep detailed records of everything you do and observe, just as Darwin did during his experiments. Collect and record all your data including weights, measurements, or counts, as necessary.
4. Analyze the results of your experiment when it is over, and discuss them with your classmates.
5. Draw your conclusions. Have you come up with evidence to support how the barren Galápagos were populated by plants?

WHY DO SPECIES CHANGE?

By far the most remarkable feature in … this archipelago … is that the different islands… are inhabited by a different set of beings … I never dreamed that islands, about fifty or sixty miles apart, and most of them in sight of each other, … would have been differently [colonized] (Darwin, 1845)

We have studied the isolation of the Galápagos and the unusual conditions that exist because of their position at the crossroads of various currents. But what caused the "different set of beings" that Darwin wrote about? How and why did the species that initially arrived from the mainland eventually change? The Galápagos were a "blank slate" when founder individuals arrived, thus there were many environmental niches available. We know that plants and animals adapted and changed to fill different niches, but we haven't explained how they did this. The answer is the crux of evolution: adaptation and natural selection.

In this section we will investigate the biodiversity of the Galápagos Islands, and how natural selection of organisms led to their adaptation to these environments. An adaptation is a feature of an organism that enables it to survive and reproduce as well as, or better than other members of the species, or other species that don't have that feature.

Random genetic changes occur in species from generation to generation. While one change may allow an individual to find food more easily, another change may make an individual more likely to be spotted by a predator. The individuals with the disadvantageous changes are less likely to survive and less likely to reproduce; the disadvantageous features are therefore less likely to be passed on. This is "survival of the fittest," another term for natural selection.

Natural selection is the idea that there are many more organisms born than survive; that these organisms vary from one individual to another; and those individuals whose variations happen to be better suited for their environment will survive and are likely to produce more offspring. Although Darwin did not understand the mechanisms of this variation at the time he wrote *Origin of the Species*, he understood the importance of this variability on the survival of the species. We now know that the mechanism is genetic variability of offspring due to mutation and the recombination of genes.

"Fittest" does not necessarily mean the biggest and the strongest. For example, a bird with a small beak is better able to use small seeds than a bird with a huge beak designed for opening large seeds. This may be advantageous if the habitat has more small seeds than large ones.

If organisms that have adapted to a new niche cannot or do not reproduce with members of the original population, then a new species with a very different lifestyle will have formed or "evolved." A good example of this can be seen with the Galápagos land and marine iguanas, which evolved from one common ancestral species that diverged into two separate species, each able to exploit a different niche and habitat. The marine iguana feeds on abundant green algae, while the land iguana specializes in grass and terrestrial plants, especially the large prickly-pear cactus.

BIODIVERSITY OF THE GALAPAGOS

Teacher Section

OBJECTIVES

To understand how climate and water cycles affect the local environment, and form hypotheses about the effects of climate change on ecological zones and the species that inhabit them.

MATERIALS

For each student:

- student copies of page 23, “Vegetative Zones of a Galápagos Island”
- student copies of pages 24–25, “Plant Species of the Galápagos”
- pencils

Remind your students of the location and the volcanic origin of the Galápagos Islands, and ask how a volcanic island newly built above sea level looks (bare, rugged, and largely sterile). We’ve also discussed how vegetation arrived on the island, probably from seeds that were either blown, floated, or transported by animals from the mainland.

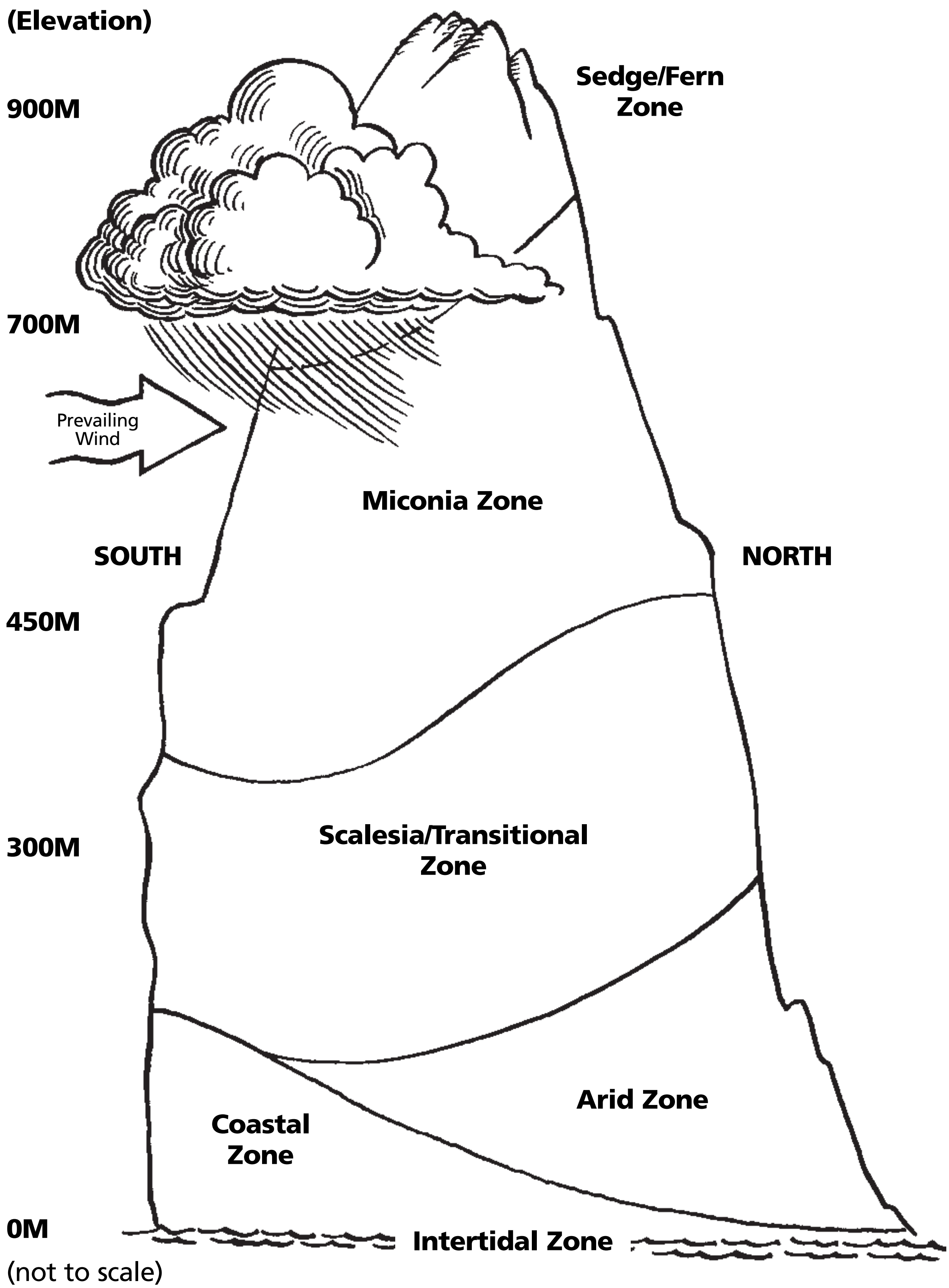
So, what conditions do plants need to grow? All plants need moisture, nourishment, and most need light, but plants vary greatly in their individual requirements. What growing conditions exist in the Galápagos? Soil is thin and relatively devoid of nutrients; rainfall is scant during most of the year, although there are better growing conditions in the highlands because of the increased moisture. So, given this information, ask students whether they would expect to find a wide variety of plants to be able to survive in these islands.

Review the water cycle with your students to help them understand how moisture is an intrinsic part of the environment, then distribute page 23. Explain that in the Galápagos, rain is infrequent, but rising moist air cools, resulting in misty precipitation high on the windward side of the island mountains. Just as with animals, different types of plant life adapt to different niches on a volcanic island. Plants are the basis of every terrestrial food chain, and this activity describes the dependence of vegetation on climatic conditions. The amount of biodiversity depends on the range of environments; the greater the range, the larger variety of plants, and thus a greater variety of animals that depend on the vegetation.

Next distribute student copies of pages 23–25; give students time to read the material. Using pages 24–25 as a guide, ask the students to mark on the island in which zones each of these plants appears.

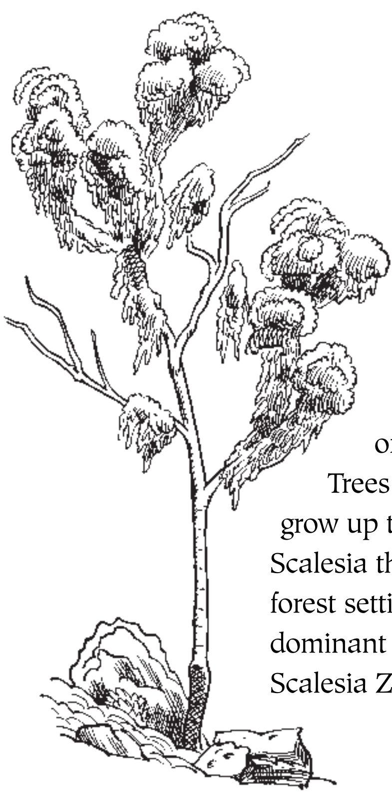
Discuss the changes that might occur in each region during exceptionally dry weather or exceptionally warm, wet weather, as in an El Niño year. What factors seem to be most important in determining the type of vegetation in each zone? (The amount and type of moisture available.) The island shown on page 23 is more than 900 meters (2,953 feet) high. If it were only 500 meters (1,644 feet), what kind of vegetation would grow in its top zone (humid area plants)?

VEGETATIVE ZONES OF A GALAPAGOS ISLAND



Highlands: Humid Area Plants
(Grow in Sedge/Fern, Miconia, and Scalesia/Transitional Zones)

SEDGE/FERNS—Ninety different species grow in the islands, some as large as 3 m tall (almost 10 ft). They reproduce by spores, which can travel great distances. They grow in the Scalesia and Miconia Zones.



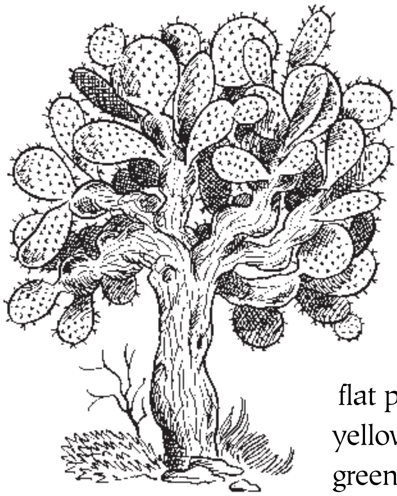
SCALESIA—This is the tallest member of the daisy family. Trees with white flowers grow up to 15 m (49 ft). Scalesia thrives in dense rain forest settings. It is the dominant plant in the Scalesia Zone.

MOSSES—There are also about 90 species of moss in the Galápagos. They are found in all humid zones, but predominantly in the Scalesia Zone.

LIVERWORTS—About 110 species of liverworts occur in the islands. They are found predominantly in the Miconia Zone.

MICONIA—This flowering shrub grows from 2–5 m tall (6.5–16 ft). Its green leaves turn red-orange during the dry season. Clusters of flowers grow at the tips of the branches. Its fruit is a blue-black berry. It is the dominant plant in the Miconia Zone.

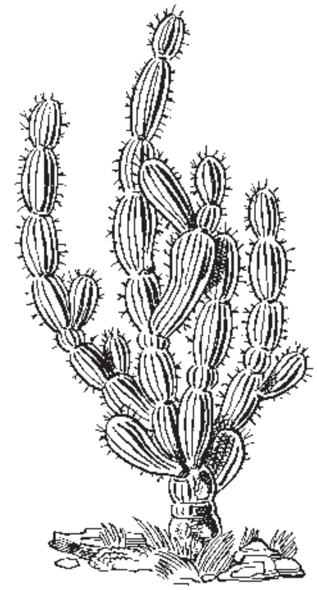
PLANT SPECIES OF THE GALAPAGOS

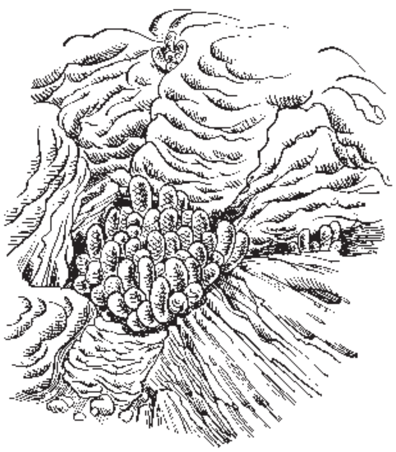


PRICKLY PEAR CACTUS—This cactus grows up to 12 m (39 ft) with a thick trunk, flat pads, spines, yellow flowers and greenish fruit.

Arid Zone: Dry Area Plants

CANDELABRA CACTUS—This species grows to about 7 m high (23 ft). Its branches look like organ pipes or like the arms of a giant candelabra.





LAVA CACTUS—This is a short; thick cactus only about 12 cm (5 in.) high. Each branch is covered with many spines, and lasts only a few years. Its flowers open before dawn, and shrivel by 7 or 8 a.m.

GALAPAGOS TOMATO—This variety of tomato is a small plant with spear-shaped leaves and small yellow or red fruit. Its seeds have evolved a thick coat to resist salt and drying. They usually sprout only after passing through the intestines of a tortoise or a mockingbird.

Mangrove Zone: Salt Resistant Plants

MANGROVE—Several species of flowering mangrove shrubs and trees grow at water's edge. Their branches may reach as high as 25 m (82 ft). Mangroves are able to resist salt, conserve water, and absorb oxygen from the air. Their roots are shallow but spread out over a wide distance. Mangroves send out prop roots from their branches to help anchor the plant. The tangle of their roots gives shelter to many small fish and marine animals.

GALAPAGOS ADAPTATIONS
Teacher Section

OBJECTIVE

To observe differences between closely related species, form hypotheses about their differences and their relationship to Galápagos environment.

MATERIALS

For each student:

- copies of pages 27–28
- pens
- paper

How have isolation and the diverse environments of the islands given rise to the unusual features of Galápagos animals? This activity will enable students to give examples of features from closely related species. The organisms of the Galápagos are in an area that is harsh in many ways, but which also offers some advantages. Because of the upwelling of cool, nutrient-rich waters, there is a greater abundance of food than is normally found in tropical waters. Temperatures on land tend to be cooler than elsewhere in the tropics because of the cool water. And until recently, the Galápagos's natural isolation prevented most predators from establishing significant numbers. These elements had an impact on the first species that first came to the islands. Over time, they adapted through natural selection to survive in these unusual conditions.

Direct students to work in pairs and distribute copies of pages 27–28. The paired drawings depict individuals of the same sex and size. Instruct students to compare the drawings carefully and to list any differences they notice, no matter how small. Even a tiny piece of data may turn out to be important.

When done, ask the students to brainstorm about why each of these closely related animals has evolved in such different ways. How do these adaptations allow each organism to thrive in its particular niche? Many Galápagos animals have adapted through natural selection to fit previously unoccupied niches, so they may look very different from species found elsewhere in the world—or even in a different niche right next door!

Niche—the ecological role of an organism in a community, especially in regard to food consumption

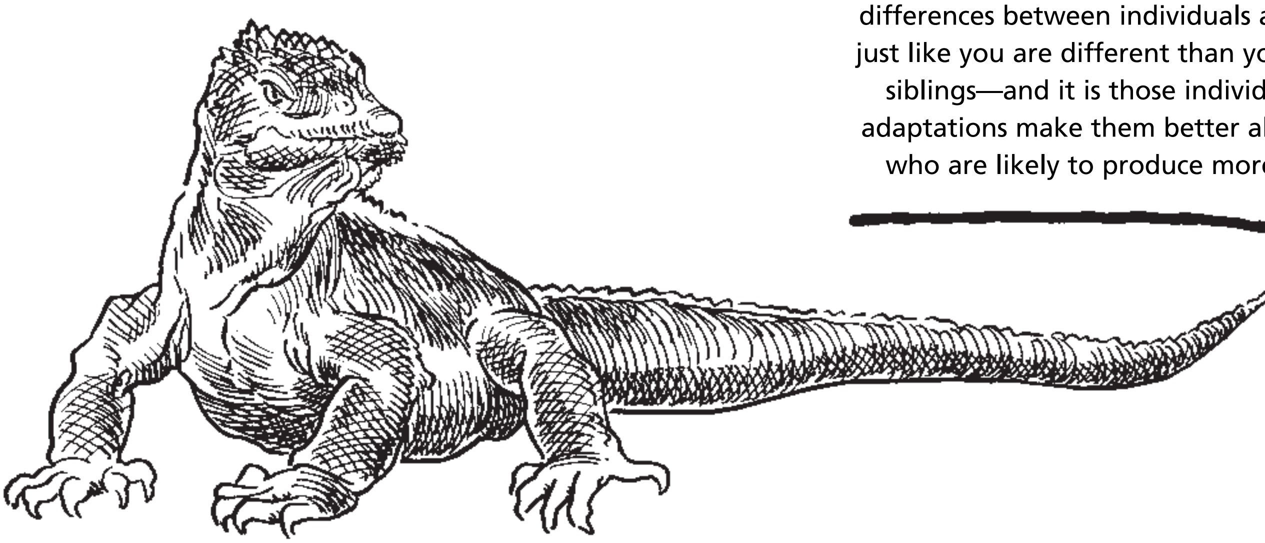
MARINE IGUANA	LAND IGUANA
Coastal zone	Arid zone
Long claws	Short claws
Short snout	Long, pointed snout
Dark color	Light color
Large bumps on head	Small bumps on head

SADDLEBACK TORTOISE	DOMED TORTOISE
Transition zone (drier)	Scalesia zone (wetter)
Highly arched shell opening	Low, rounded shell opening
Long neck	Short neck
Long legs	Short legs

GILBERT'S GOBY	BLUE-BANDED GOBY
8–9 bars	3–5 bars
White bars with dark edges	Blue bars
Smaller (to 4.5 cm)	Larger (to 6 cm)
21–22 fin rays in dorsal fin	22–26 fin rays in dorsal fin

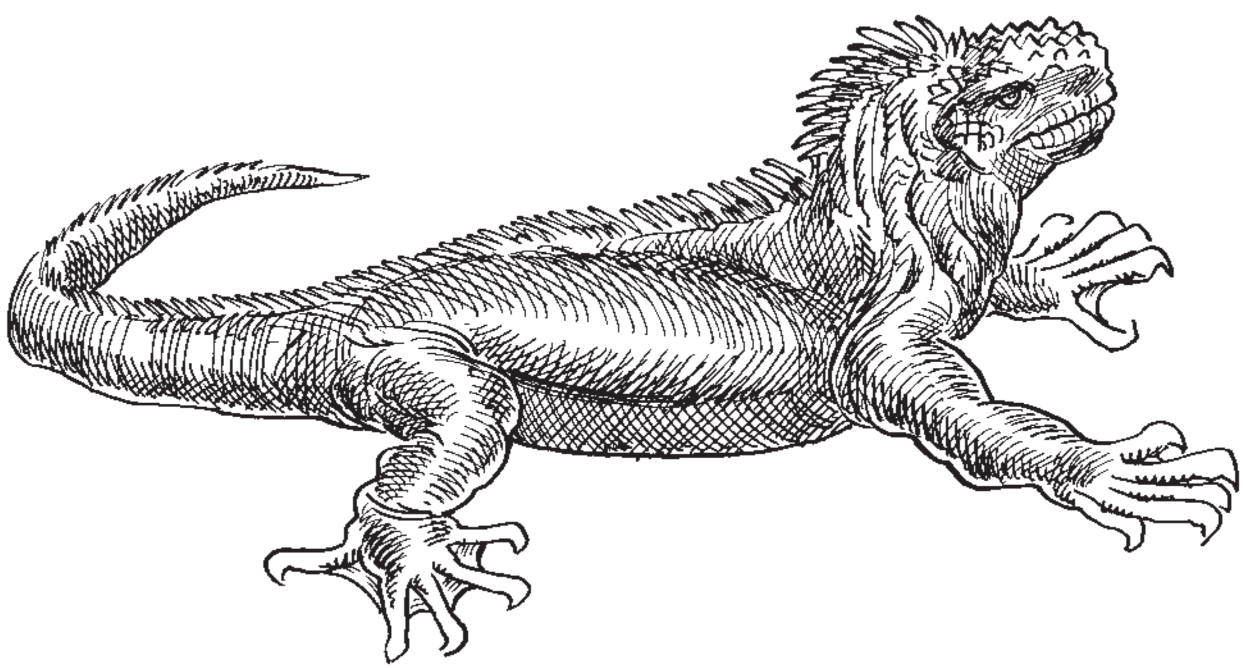
GALAPAGOS ADAPTATIONS

Remember, species don't "choose" to adapt to fit an environment or to avoid a predator. The differences between individuals are random—just like you are different than your parents or siblings—and it is those individuals whose adaptations make them better able to survive who are likely to produce more offspring.

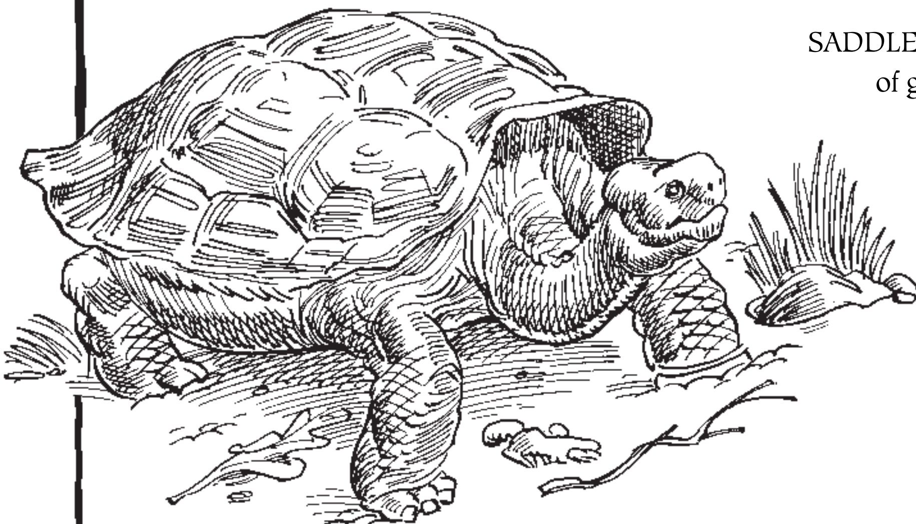


LAND IGUANA (ABOVE)—A large relative of the South American and Caribbean terrestrial iguanas, it has a round tail, a pointed nose and is brownish-red in color on top, yellow-orange underneath. It eats grass and terrestrial plants, especially the large prickly-pear cactus.

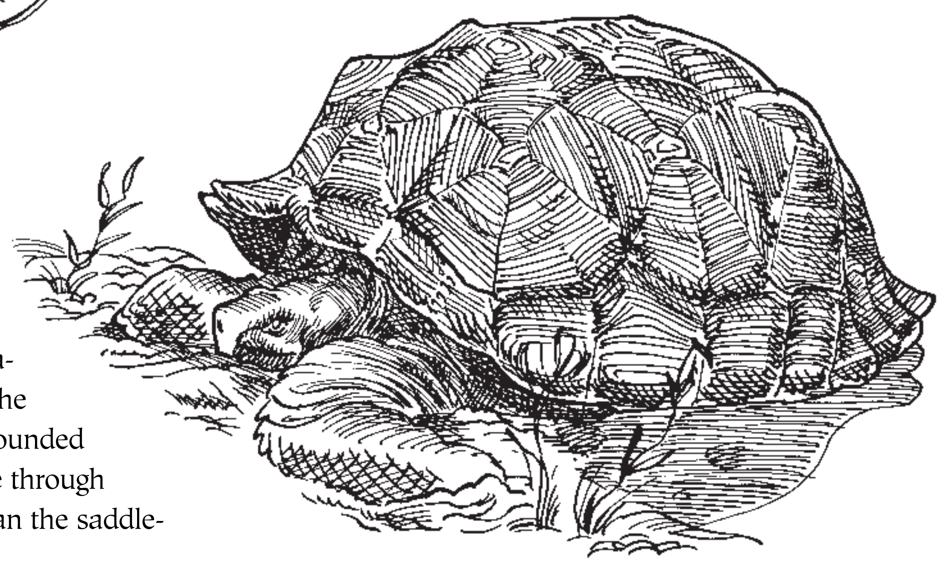
MARINE IGUANA (BELOW)—The only marine iguana in the world, it has a flat tail, a somewhat square nose, dark coloration, and partially webbed feet. The dark coloration allows young iguanas to be camouflaged by the dark lava on which on which they live, and enables them to absorb more heat from the sun.



GALAPAGOS ADAPTATIONS

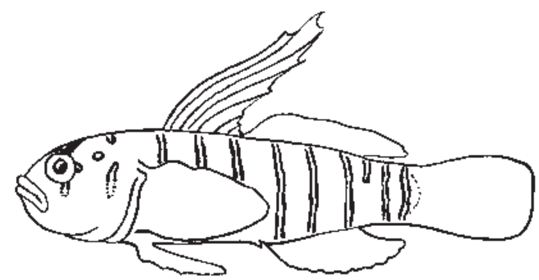


SADDLEBACK TORTOISE—One of major groups of giant tortoises in the Galápagos, the shell (carapace) is arched in the front and the tortoise has very long legs, a long snout, and a long neck that allow it to reach for its food high above the ground. The saddleback type of Galápagos tortoise has been found on the dry areas of Española, Pinzon, Pinta, and Fernandina islands.



DOMED TORTOISE—One of major groups of giant tortoises in the Galápagos, it has a rounded shell, blunt snout, and a shorter neck. The dome-shaped tortoise is found on islands with rich vegetation like Santa Cruz and Isabela. The tortoise is larger, heavier, and the rounded shape of the shell allows it to move through the thick vegetation more easily than the saddleback tortoise.

BLUE-BANDED GOBY—This fish is found from southern California to Ecuador, including Galápagos and Cocos Islands. It is bright red changing to orange near its tail, and it has a pair of narrow blue bars on its head and 3–5 similar bars on its body. This species is often found near brightly-colored purple sea urchins. It is larger than the Gilbert's Goby—up to 6 cm long—and has a long dorsal fin.



GILBERT'S GOBY—This fish is found only in the Galápagos Islands. It has a pinkish-orange head and a purplish brown body with 8–9 dark-edged white bars. This fish is often found near light-colored sponges—its light coloring and white bars may help the fish camouflage with the sponges. It is a small fish, up to 4.5 cm long, and has a small dorsal fin.

NATURAL SELECTION: THE "HOW" OF EVOLUTION

Teacher Section

OBJECTIVE

To understand the principles behind adaptation and natural selection, as they relate to predator/prey relationships.

MATERIALS

For each group:

- 50 cm square piece of patterned fabric or wrapping paper; the pattern can simulate a natural environment, such as a floral, leaf, or fruit print, and should have several colors and be of intricate design. Try to have multiple patterns so every group does not have the same.
- zip-type sandwich bag containing 120 paper dots (e.g., remnants from a hole punch), 20 each of six different colors (including black and white). If possible, cut dots out of the same material as the "habitat" to make sure the colors blend in. This bag should be labeled "beginning population."
- six sandwich bags each containing spare dots of a specific color. (You can have bags for each group, or communal bags.)
- paper
- pencils

For teacher:

- stopwatch or a wristwatch that displays seconds

We have investigated biodiversity and adaptations in the Galápagos. Now we will investigate the "how" of adaptation, that is, natural selection. The following is an activity that will help students understand natural selection as a result of predator/prey relationships. In fact, in the Galápagos, there are fewer natural predators than on the mainland so natural selection happened without much predator pressure. In the Galápagos, "survival of the fittest" refers to a species that makes best use of an environmental niche—either adapting to an unoccupied niche, or outcompeting another species for the same niche. However, this activity will provide students with a fun way to learn about some of the mechanisms behind "survival of the fittest" by simulating a predator-prey relationship and investigating how this type of selection pressure can influence evolution.

The "prey" will consist of paper dots spread on a piece of patterned paper or cloth, and the predators will be students in each lab group. Divide the class into teams of three or four, with one student assigned as the team "manager." Each team should have one piece of cloth and one "beginning population" bag. Have the "predators" close their eyes while the manager spreads the "beginning population" dots randomly on the fabric.

When all the teams are ready, begin timing for 30 seconds as the "predators" search for dots (you can vary the time length according to student level). At the end of that period, students should count the number and color of remaining dots, and have the manager record the number of each colored dot that "survived" to reproduce. Add three new dots of the same color for each dot that survived. Repeat these steps for as many "generations" as you like. Have the students graph the survival results of each generation in a bar graph, and answer the questions on their sheets. Students should be able to understand that dots that are easily seen on the cloth are quickly "eaten" by the predators and dots that are difficult to see "survive," and "reproduce."

Variations in the results from different groups can be compared with real life variations: different kinds of predators (more eager students); competition among predators (students who fight over their dots); or different habitats (a more complex fabric pattern may have more "niches" where colored dots can hide).

NATURAL SELECTION: THE "HOW" OF EVOLUTION

Student Section

1. Once assigned to a team, gather the materials from your teacher and decide who will be the manager and who will be the predators.
2. Examine the paper dots in the "beginning population" bag. There are 120 dots in six colors: each color represents a species; each dot an individual.
3. The manager spreads out the patterned cloth or paper to represent an island environment. All the predators should close their eyes, as the manager spreads out the dots from the "beginning population" bag across the pattern.
4. When all the groups are ready, the teacher will time 30 seconds during which the predators should open their eyes, and start picking up dots. Wait for the teacher's signal before you open your eyes!
5. After the teacher calls time, stop hunting and carefully collect all of the dots that remain on the fabric and sort them by color. The managers are responsible for recording the number and color remaining.
6. For every dot that "survived," add three dots of the same color from the extra-dot bags.
7. Continue this same process, recording the data at the end of each round. Then graph the results according to your teacher's instructions.
8. Write a summary report about how natural selection works based on your experience here. Be sure to include information on:
   - Which colors of paper dots, if any, survived better than others during the first round? What about after several generations?
   - What might be the reason that predators did not select these colors as often as they did other colors?
   - What effect did capturing a particular color dot have on the numbers of that color in the following generations?
   - Why might different groups have had different results?

GLOSSARY

Absolute location—on a map or globe, expressed as the intersection of lines of latitude and longitude.

Adapt—gradual change in response to environmental conditions.

Adaptation—feature of an organism that enhances survival and reproductive success.

Archipelago—a group of islands sharing common physical and location characteristics.

Biodiversity—biological diversity in an environment as indicated by numbers of different species of plants and animals.

Competition—rivalry between organisms for food, shelter, or control of a territory. Competition occurs both within the same species and among different species.

Coordinates—the latitude and longitude numbers that express location (in degrees north or south and east or west) as a point on a map or globe.

Current—the part of a fluid body moving continuously in a single direction.

Ecosystem—a community of plants and animals that function as an interrelated unit in nature.

Elevation—in maps, the altitude above sea level. Elevation provides a more objective measurement than height, which is altitude above the surrounding area.

Endemic species—native to a region; not introduced or merely resident.

Equator—an imaginary circle around the middle of the earth halfway between the North and South Poles, at 0 degrees Latitude.

Evolution—change in lineages of populations between generations.

Fault—a fracture in the crust of the Earth along which movement can be determined.

Germination—the development of a sprout or young plant from a seed that has been moistened.

Habitat—the environmental conditions of the place in which an organism lives.

Humboldt Current—also known as the Peru Coastal Current, cold-water current that flows counter-clockwise in the southern Pacific, going north along the west coast of South America to the Galapagos.

Hypothesis—a trial solution suggested for a scientific problem, subject to testing.

Island—a tract of land completely surrounded by water.

Journal—a record of events, observations, and thoughts written as they are experienced.

Latitude—the angular distance (in degrees) north and south of the equator.

Lava tubes—a cave or tunnel formed when the lava flow surface cools, forms a crust, and the molten interior continues to flow.

Longitude—the angular distance (in degrees) east and west of the prime meridian.

Natural selection—process by which individuals in a population that are best adapted to the environment increase in number relative to less well-adapted forms, over a number of generations.

Naturalist—a person who studies natural objects and organisms along with their evolution, origins, description, and interrelationships.

Niche—the ecological role of an organism in a community especially in regard to food consumption.

Panama Current—warm-water current that flows from Central America to the Galápagos.

Plate tectonics—the concept that the Earth's surface is broken into large, rigid plates that move slowly but relentlessly, relative to each other, experiencing major unrest at their margins.

Population—a group of individuals of the same species that occupy the same geographic region, interbreed, and produce viable offspring.

Prevailing—something that is in effect most often at the present time.

Prime Meridian—an imaginary line that runs from the North Pole to the South Pole and is known as zero longitude.

Relative location—the comparison of one location to another in terms of a reference point or an area.

Scale—the ratio between map distance and real Earth distance; for example, 1 centimeter represents 1 kilometer, or 1 inch represents 1 mile. Scale will vary from map to map.

South Easterlies—winds that move air from the southeast toward the northwest, south of the equator.

South Equatorial Current—equatorial current that flows westerly along and south of the Equator.

Species—a population of similar organisms that are capable of interbreeding (in the wild) and producing viable offspring, but do not interbreed with any other populations.

Theory—a hypothesis that relates and organizes much of the knowledge in a science and has been tested with success many times, until it has been accepted.

Trade wind—a wind blowing almost constantly in one direction, either south (called Easterlies) or north (called Westerlies) of the equator.

Undercurrent—a current that flows under other currents, usually in a different direction.

Upwelling—the flow of cold, deep water to the surface of a water body. This cold, nutrient-rich, upwelled water supports an abundance of sea life.

RESOURCES

TEACHING MATERIAL:

Ecology and Evolution: Islands of Change
By the National Science Teachers Association

Although evolution happens everywhere, the Galápagos Islands are considered a "living laboratory" because their volcanic origin, geographic isolation, sharply-defined ecozones, and relatively small number of species allows scientists and visitors alike to see the ongoing effects of the evolutionary process. Using the Galápagos as a case study, these activities and investigations explore geology, ecology, and evolutionary theory at the middle level. Available: April 2000. To order, contact NSTA, 1840 Wilson Blvd., Arlington, VA 22201-3000, 800-722-6782. Http://www.nsta.org/

FAMILY GUIDE:

Discover Galapagos: A Family Adventure Exploring Evolution and Biodiversity
By the Institute for Learning Innovation

Color photos, games, activities, and science information bring biodiversity and evolution to life in the Galápagos family guide, a resource kit developed for families to explore the concepts highlighted in the film. Check your local museum or Imax theater shop for availability, or contact the National Museum of Natural History Shop, Smithsonian Institution, Washington, DC 20560-0951, 202-357-1537.

CD-ROM:

Galápagos—The CD-ROM Encyclopedia
By Luis Die, Jonathan Green, Macarena Green, and Richard Polatty

More than 540 photos, more than 400 species descriptions, animations, and videos; there are clickable maps of the islands. A portion of the proceeds from the purchase of this CD-ROM goes to the Charles Darwin Foundation. To order, call 800-242-4775 x 15961 or visit http://www.naturalist.net/cdrom/.

BOOKS:

Boyce, Barry. *A Traveler's Guide to the Galapagos Islands.* Aptos California: Galapagos Travel, 1998.

Darwin, Charles. *Voyage of the Beagle.* London: John Murray, 1845.

Darwin, Charles. *On the Origin of the Species.* London: John Murray, 1859.

Jackson, Michael H. Galápagos: *A Natural History.* Calgary: University of Calgary Press, 1993.

De Roy, Tui, Spectacular *Galapagos: Exploring an Extraordinary World.* Berkeley, California: Publishers' Group West, 1999.

Weiner, Jonathan. *Beak of the Finch: A Story of Evolution in Our Time.* New York: Knopf, 1994.

WEB SITES:

Supplement to Teachers Resource Guide to Galapagos
By National Science Teachers Association
http://pubs.nsta.org/galapagos/

Galapagos
By Imax Ltd.
http://www.imax.com/galapagos/

National Museum of Natural History
http://www.mnh.si.edu/nmnhweb.html

Voyage of the Beagle
By The Biology Place
http://www.biology.com/visitors/ae/voyage/introduction.html

Virtual Galápagos
By TerraQuest
http://www.terraquest.com/galapagos/

Explore Galápagos
By Discovery Channel School
http://www.discoveryschool.com/schoolfeatures/featurestories/galapagos/index.html

The Galápagos: Pressures on Paradise
By World Wildlife Fund
http://www.wwf.org/galapagos/

Galapagos
By Charles Darwin Foundation, Charles Darwin Research Station, Galapagos Conservation Trust
http://www.galapagos.org/

Galápagos
By Naturalist Net
http://www.naturalist.net/

Global Volcanism Program
By National Museum of Natural History
http://www.volcano.si.edu/gvp/

Galápagos Volcano Tour
By Volcano World
http://volcano.und.nodak.edu/vwdocs/volc_tour/galapagos/gal_pgs.html

Enter Evolution: History and Theory
By University of California, Berkeley
http://www.ucmp.berkeley.edu/history/evolution.html

For more information, go to America Online Keyword: Galapagos

Central
America
10° N
Galápagos
Islands
0°
Ecuador
South America
10° S
N
Scale (km)
0 200 400 600 800 1000
20° S
90° W
80° W

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