GLENCOE

EARTH SCIENCE

Geology, the Environment, and the Universe

GeoLab and MiniLab Worksheets

Glencoe McGraw-Hill

New York, New York Columbus, Ohio Woodland Hills, California Peoria, Illinois

A Glencoe Program

Earth Science: Geology, the Environment, and the Universe

Laboratory Manual, SE and TE

GeoLab and MiniLab Worksheets

Exploring Environmental Problems, SE and TE

Study Guide for Content Mastery, SE and TE

Chapter Assessment

Performance Assessment in Earth Science

ExamView™ Pro CD-ROM Windows/Macintosh

Cooperative Learning in the Science Classroom

Performance Assessment in the Science Classroom

Alternate Assessment in the Science Classroom

Lesson Plans

Block Scheduling Lesson Plans

Section Focus Transparencies and Masters

Teaching Transparencies and Masters

MindJogger Videoquizzes, VHS/DVD

Puzzlemaker Software, Windows/Macintosh

Guided Reading Audio Program

Interactive Teacher Edition CD-ROM

Interactive Lesson Planner CD-ROM

Using the Internet in the Science Classroom

Glencoe Science Web Site: science.glencoe.com

Credits

ART CREDITS

Morgan-Cain and Associates: **13, 36, 62, 69, 70, 76, (b)77, (b)81, 85, 89, 111, 115, 122**; Precision Graphics: **31, 34, 50, 53, 75, (t)77, 78, 90, 109**

PHOTO CREDITS

8 United States Geological Survey; **13** (l to r)Charles D. Winters/Photo Researchers, Mark A. Schneider/Visuals Unlimited, Mark A. Schneider/Visuals Unlimited, Biophoto Associates/Photo Researchers, Runk/Schoenberger/Grant Heilman, Doug Martin; **23** John Cancalosi/Peter Arnold, Inc.; **42** United States Geological Survey; **81** (t)United States Geological Survey; **96** (l)Ken Lucas Photo/Visuals Unlimited, (r)Stephen J. Krasemann/DRK Photo; **113** NASA; **129** Jean-Charles Cuillandre/Canada-France-Hawaii Telescope/Science Photo Library/Photo Researchers

Glencoe/McGraw-Hill

A Division of The ***McGraw-Hill*** *Companies*

Send all inquiries to:
Glencoe/McGraw-Hill
8787 Orion Place
Columbus, OH 43240

ISBN 0-07-824578-8
Printed in the United States of America.
1 2 3 4 5 6 7 8 9 10 045 08 07 06 05 04 03 02 01

Contents

To the Teacher

Each activity in this booklet is an expanded version of each GeoLab or MiniLab that appears in the Student Edition of ***Earth Science: Geology, the Environment, and the Universe***. All materials lists, procedures, and questions are repeated so that students can read and complete a lab in most cases without having a textbook on the lab table. Data tables are enlarged so that students can record data in them. All lab questions are reprinted with lines on which students can write their answers. In addition, for student safety, all appropriate safety symbols and caution statements have been reproduced on these expanded pages. Answer pages for each MiniLab and GeoLab are included at the end of this booklet.

Standard Equipment List

Chemicals and Equipment

These easy-to-use tables of materials can help you prepare for your Earth science classes for the year. All quantities are for one lab setup of each *GeoLab* or *MiniLab* for the entire course. Before placing your order for supplies, determine how many classes you will be teaching and how many students you expect in each class. If you have ten groups of students in each of your five classes, multiply the quantities of materials for *GeoLabs* and *MiniLabs* by 50 to arrive at your total course requirements.

The standard list of equipment is made up of a set of equipment that is generally recommended for each lab bench station in the Earth science laboratory. For all lab activities in this program, it is assumed that your classroom is equipped with these items for each setup of a *GeoLab* or *MiniLab*. Additional equipment required for the course is listed under **Nonconsumables**. The listed amounts of **Consumables** and **Chemicals** for *GeoLabs* and *MiniLabs* are sufficient for one lab setup per student or group of students.

Standard Equipment List (for each station)	
apron, 1 per student	ruler, metric
goggles, 1 pair per student	scissors
beakers, 100-mL, 2	spoon, stainless steel
beakers, 250-mL, 2	stirring rods, 2
dropper	tweezers
graduated cylinder, 100-mL	watch glass
graduated cylinder, 250-mL, 2	

Classroom Equipment (for general use)	
balance, laboratory	markers, felt, assorted colors
balance, beam-type	meterstick
beakers, large, 1-L	microscope
beakers, assorted small, 100-mL, 150-mL	mortar and pestle
calculator	pen, grease
clamps, assorted	ring stand
colored pencils, assorted colors	rubber or Tygon® tubing
dishpan, plastic	rubber stoppers, assorted
graduated cylinders, 50-mL, 500-mL, 1-L	stereomicroscope
hot plate	stopwatch or timer
Internet access	thermometers, –10°C to 150°C

Equipment and Materials List

These easy-to-use tables of equipment and consumable materials can help you prepare for your Earth science classes for the year. Quantities listed for *GeoLabs* and *MiniLabs* are the maximum quantities you will need for one student group for the year. The Student Edition pages on which each item is used are listed in parentheses after the quantities. Refer to the interleaf pages in front of each chapter for a list of equipment and materials used for each laboratory activity in the chapter.

Non-Consumables

Item	GeoLab	MiniLab
baby food jar with lid	3 (p. 676)	6 (p. 674)
beaker, 100-mL	1 (p. 140)	7 (p. 394)
beaker, 150-mL		1 (p. 587)
beaker, 250-mL	2 (pp. 20, 70, 114)	1 (p. 474)
beaker, 1-L		1 (p. 394)
book		1 (p. 253)
bottle, small		7 (p. 394)
bowl, clear plastic		1 (p. 292)
catch basin		1 (p. 163)
compass, drafting	1 (p. 430)	1 (p. 761)
copper sample	1 (p. 92)	
dropper	1 (pp. 92, 406)	1 (p. 674)
encyclopedia	1 (p. 553)	
file, steel	1 (p. 92)	
flashlight		1 (p. 302)
fossil bivalves, different	4 (p. 618)	
fossil brachiopods, different	4 (p. 618)	
geologic time scale	1 (p. 553)	
glass dish, shallow	1 (p. 70)	
glass plate	1 (p. 92)	
globe		1 (p. 29)
graduated cylinder, 50-mL		1 (p. 587)
graduated cylinder, 100-mL		1 (p. 674)
graduated cylinder, 250-mL		1 (pp. 428, 688)
graduated cylinder, 500-mL	1 (p. 406)	
graduated cylinder, 1-L		1 (p. 394)
hand lens	1 (pp. 92, 114, 140)	
hole punch	1 (p. 232)	
hose	1 (p. 232)	
hurricane-tracking chart	1 (p. 354)	
ice-cube tray		1 (p. 350)
igneous rock samples		1 (p. 108)
jar, 1-L glass		3 (p. 636)
jar, glass		1 (p. 376)
jar, plastic with lid	1 (p. 174)	

Non-Consumables, *continued*

Item	GeoLab	MiniLab
lamp	1 (pp. 676, 704)	
liquid-crystal temperature strip	1 (p. 294)	
magnet, small	1 (p. 92)	
map, physiographic, Atlantic Ocean floor		1 (p. 536)
map, physiographic, United States		1 (p. 536)
map, topographic	1 (p. 430)	
map, topographic of Forest City, Florida	1 (p. 258)	
map, wind erosion		1 (p. 194)
map, world		1 (pp. 29, 456)
measuring tape	1 (pp. 572, 798)	
mineral samples, set	1 (p. 92)	1 (p. 79)
Mohs hardness scale	1 (p. 92)	
pan, large glass	1 (p. 676)	
pan, large metal	3 (p. 676)	
petri dish, plastic	4 (p. 114)	
photographs of dinosaur or reptile footprints		3 (p. 126)
plumb bob	1 (p. 232)	
protractor	1 (p. 232)	1 (pp. 761, 826)
psychrometer	1 (p. 378)	
reference books, set	1 (p. 553)	
relative humidity chart	1 (p. 378)	
ring stand with clamp	1 (p. 232)	
rock samples, assorted small	5 (p. 20)	
rocks, sedimentary	5 (p. 140)	
rocks, metamorphic	5 (p. 140)	
round objects, assorted sizes	1 (p. 798)	
shoe box, clear plastic		4 (pp. 229, 253)
sieves, set		1 (p. 428)
spoon		1 (p. 587)
spring scale	1 (p. 20)	
stirring rod	1 (p. 70)	1 (pp. 394, 474)
streak plate	1 (p. 92)	
thermometer	4 (pp. 12, 114, 378, 406, 704)	2 (p. 376)
thumbtack		5 (p. 777)
watch glass		1 (p. 587)
common objects in classroom (see Teacher Edition page for examples)		1 (p. 55)

Consumables

Item	GeoLab	MiniLab
aluminum foil (30 cm × 60 cm)	1 (p. 704)	
bag, self-sealing plastic		1 (p. 292)
balloon		1 (p. 845)
bleach, household		15 mL (p. 587)
bottle, 2-L plastic with cap	1 (p. 294)	
bottle, dishwashing-detergent with twist cap		1 (p. 350)
box, sturdy cardboard	3 (p. 704)	1 (p. 376)
cardboard (30 cm × 30 cm)		1 (p. 777)
clay		6 kg (pp. 229, 253, 636)
clay, white modeling		500 g (p. 616)
clay, yellow modeling		250 g (p. 616)
cupcake, cream-filled, frosted		2 (p. 718)
dishwashing liquid		120 mL (p. 474)
fabric (30 cm × 60 cm)	1 (p. 704)	
foamboard (60 cm × 60 cm)	1 (p. 704)	1 (p. 79)
food coloring	1 mL (p. 406)	
glue	10 mL (p. 704)	10 mL (p. 79)
gravel		6 kg (pp. 229, 636)
gravel, colored aquarium		60 g (p. 688)
halite chips	100 g (p. 174)	
knife, plastic		1 (p. 718)
labels		6 (p. 674)
milk jug, 1 gallon plastic		2 (p. 12)
mirrors, assorted small	10 (p. 704)	
napkin, paper		2 (p. 718)
oil, cooking		300 mL (pp. 428, 688)
paint, assorted colors	60 mL each (p. 704)	
paper clip	1 (p. 92)	
paper towels	10 (pp. 114, 174)	
paper, dark colored construction, sheet	1 (p. 114)	1 (p. 302)
paper, graph, sheet	5 (pp. 20, 258, 406, 430, 540)	2 (pp. 376, 826)
paper, tracing, sheet	3 (pp. 258, 464, 516)	1 (p. 536)
plastic sheet, clear (30 cm × 30 cm)	4 (pp. 676, 704)	
plastic wrap (30 cm × 30 cm)	1 (p. 70)	1 (p. 292)
plate, paper		1 (p. 718)
posterboard (50 cm × 75 cm)	1 (p. 572)	

Consumables, *continued*

Item	GeoLab	MiniLab
salt water	50 mL (p. 676)	
sand		3 kg (pp. 253, 636, 688)
sand, dry		5 kg (p. 229)
sand, white		100 g (p. 587)
sand grains and small pebbles		5 (p. 428)
silt		500 g (p. 636)
soap, bar		1 (p. 163)
soap, liquid		1 mL (p. 674)
soil		2 kg (p. 12)
steel wool		2 g (p. 587)
stones, small	10 (p. 704)	
straw, clear plastic drinking	4 (p. 294)	3 (p. 253)
string	1m (pp. 20, 42)	10 m (pp. 777, 826, 845)
tape, masking	50 cm (p. 798)	10 cm (p. 12)
tape, transparent	100 cm (p. 704)	
tape, vinyl gutter	1 m (p. 232)	
toothpick		1 (p. 163)
water sample, different		5 (p. 674)

Chemicals

Item	GeoLab	MiniLab
5% HCl	1 mL (p. 92)	
alum ($KAl(SO_4)_2 \cdot 12H_2O$)	50 g (p. 114)	
baking soda ($NaHCO_3$)		0.2 g (p. 394)
calcium chloride ($CaCl_2$)		1.1 g (p. 394)
magnesium chloride ($MgCl_2$)		5.0g (p. 394)
potassium bromide (KBr)		0.1 g (p. 394)
potassium chloride (KCl)		0.7g (p. 394)
sodium chloride (NaCl)	70 g (pp. 70, 406)	55 g (pp. 394, 474)
sodium sulfate (Na_2SO_4)		4.0 g (p. 394)

MiniLab 1 How do soil and water absorb and release heat?

Experiment to determine the relationship between variables.

Procedure

1. Obtain the materials for this lab from your teacher.
2. Put soil into one container until it is half full. Put water into the other container until it is half full.
3. Place one thermometer in the soil so that the bulb is barely covered. Use masking tape to secure another thermometer about 1 cm from the top of the soil.
4. Repeat step 3 with the container of water.
5. Put the containers on a very sunny windowsill. Record the temperature shown on each thermometer. Write these values in the table. Then record temperature readings every 5 minutes for half an hour.
6. Remove the containers from the windowsill and immediately record the temperature on each thermometer every 5 minutes for half an hour.

Time (minutes)	Thermometer 1 Temperature	Thermometer 2 Temperature
0		
5		
10		
15		
20		
25		
30		

Analyze and Conclude

1. Which substance absorbed heat faster?

2. Which substance lost heat faster?

3. What was your independent variable? Your dependent variable?

Name Class Date

GeoLab Measuring in SI

Suppose someone asked you to measure the area of your classroom in square cubits. What would you use? A cubit is an ancient unit of length equal to the distance from the elbow to the tip of the middle finger. Since this length varies among individuals, the cubit is not a standard unit of measure. SI units are standard units, which means that they are exact quantities that have been agreed upon to use for comparison. In this GeoLab, you will use SI units to measure various properties of rock samples.

PREPARATION

Problem

Measure various properties of rocks and use the measurements to explain the relationships among the properties.

Materials

water
250-mL beaker
graph paper
balance
pieces of string
spring scale
rock samples

Objectives

In this GeoLab, you will:

- **Measure** the area, volume, mass, and weight of several rock samples.
- **Calculate** the density of each sample.
- **Explain** the relationships among the quantities.

Safety Precautions

PROCEDURE

1. Use the information in the *Skill Handbook* to design a data table in which to record the following measurements for each sample: area, volume, mass, weight, and density.
2. Obtain rock samples from your teacher. Carefully trace the outline of each rock onto the graph paper. Determine the area of each sample and record the values in your data table.
3. Pour water into the beaker until it is half full. Record this volume in the table. Tie a piece of string securely around one rock sample. Slowly lower the sample into the beaker. Record the volume of the water. Subtract the two values to determine the volume of the rock sample.
4. Repeat step 3 for the other rocks. Make sure the original volume of water is the same as when you measured your first sample.
5. Follow your teacher's instructions about how to use the balance to determine the mass of each rock. Record the measurements in your table.
6. Again, secure each rock with a piece of dry string. Make a small loop in the other end of the string. Place the loop over the hook of the spring scale to determine the weight of each rock sample. Record the values in your data table.

Name Class Date

GeoLab Measuring in SI

DATA TABLE

ANALYZE

1. Compare the area of each of your samples with the areas determined by other students for the same samples. Explain any differences.

2. Compare the volume of each of your samples with the volumes determined by other students for the same samples. Explain any differences.

3. Compare the weight and mass of each of your samples with the values for these quantities determined by other students. Again, explain any differences.

GeoLab Measuring in SI

ANALYZE

4. Use your measurements to calculate the density of each sample using this formula: *density = mass/volume*. Record these values in your data table.

CONCLUDE AND APPLY

1. How accurate do you think your measurement of the area of each sample is? Explain.

2. What were the variables you used to determine the volume of each sample?

3. How could you find the volume of a rock such as pumice, which floats in water?

4. Does mass depend on the size or shape of a rock? Explain.

Name ______ Class ______ Date ______

MiniLab 2

How can you locate places on Earth?

Determine latitude and longitude for specific places.

Procedure

1. Use a world map or globe to locate the prime meridian and the equator.
2. Take a few moments to become familiar with the grid system. Examine lines of latitude and longitude on the map or globe.

Analyze and Conclude

1. Use a map to find the latitude and longitude of the following places.

   Mount St. Helens, Washington ______

   Niagara Falls, New York ______

   Mt. Everest, Nepal ______

   Great Barrier Reef, Australia ______

2. Use the map to find the name of the places with the following coordinates.

   0°03'S, 90°30'W ______

   27°07'S, 109°22'W ______

   41°10'N, 112°30'W ______

   35°02'N, 111°02'W ______

   3°04'S, 37°22'E ______

3. Find the latitude and longitude of your hometown, the nearest national or state park, and your state capital.

   ______

   ______

Mapping GeoLab

Using a Topographic Map

Topographic maps show two-dimensional representations of Earth's surface. With these maps, you can determine how steep a hill is, what direction streams flow, and where mines, wetlands, and other features are located.

PREPARATION

Problem

How can you use a topographic map to interpret information about an area?

Materials

ruler
string
pencil

PROCEDURE

1. Use the map to answer the following questions. Be sure to check the map's scale.
2. Use the string to measure distances between two points that are not in a straight line. Lay the string along the curves, and then measure the distance by laying the string along the ruler.
3. Remember that elevations on United States Geological Survey maps are given in feet.

ANALYZE

1. What is the contour interval?

____

2. Calculate the stream gradient of Big Wildhorse Creek from the Gravel Pit in section 21 to where the creek crosses the road in section 34.

____

____

____

3. What is the highest elevation of the jeep trail? If you followed the jeep trail from the highest point to where it intersects an unimproved road, what would be your change in elevation?

____

____

Mapping GeoLab

Using a Topographic Map

ANALYZE

4. If you started at the bench mark (BM) on the jeep trail and hiked along the trail and the road to the Gravel Pit in section 21, how far would you have hiked?

5. What is the straight-line distance between the two points in question 4? What is the change in elevation?

CONCLUDE AND APPLY

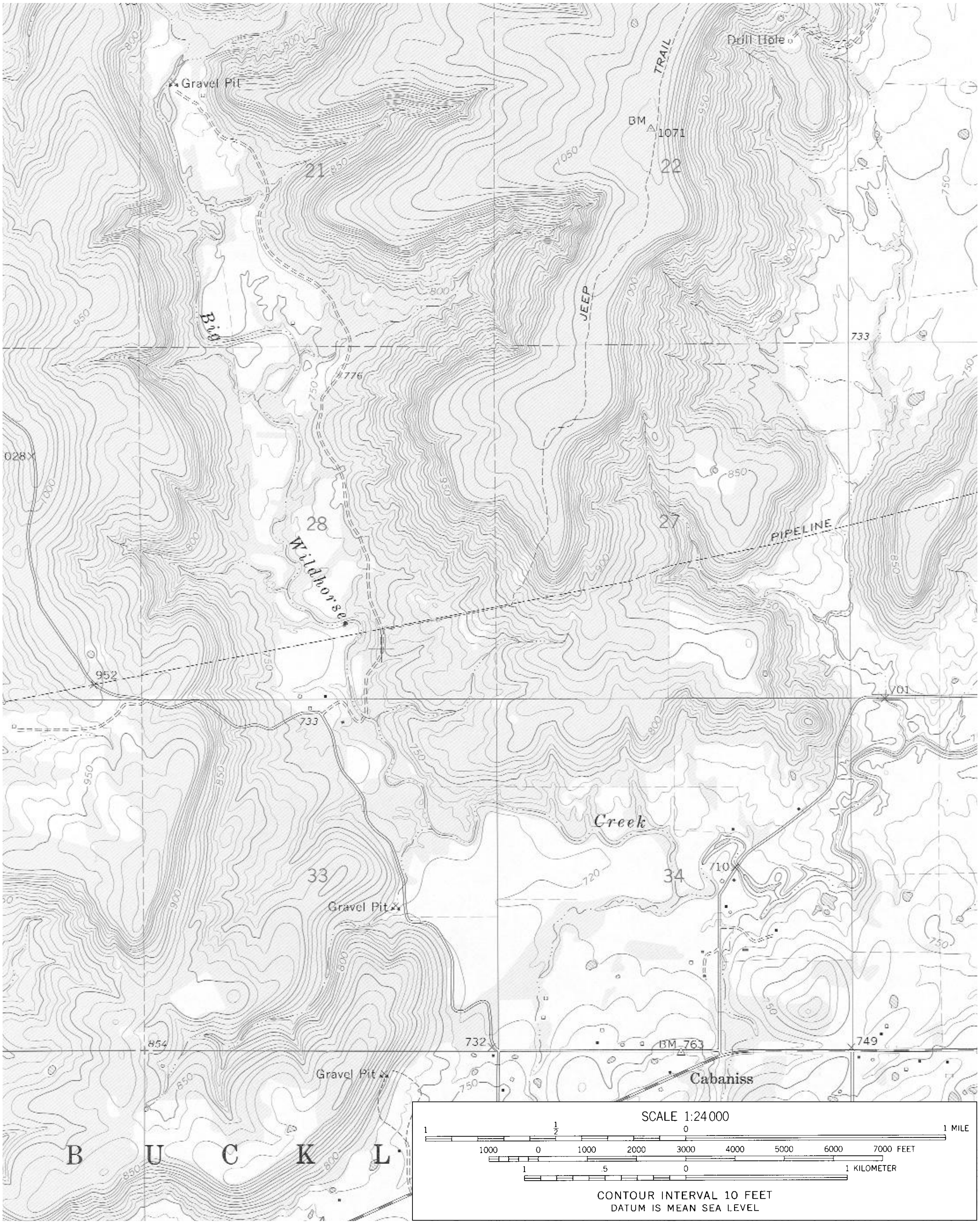
1. Does Big Wildhorse Creek flow all year round? Explain your answer.

2. What is the shortest distance along roads from the Gravel Pit in section 21 to the secondary highway?

3. In the space below, draw a profile of the land surface from the bench mark in section 22 to the Gravel Pit in section 33.

Name Class Date

Mapping GeoLab Using a Topographic Map



Name Class Date

MiniLab 3

Identifying Elements

Describe Most substances on Earth occur in the form of chemical compounds. Around your classroom, there are numerous objects or substances that consist mostly of a single element.

Procedure

1. Name three of these objects and the three different elements of which they are made.
2. List the atomic numbers of these elements and describe some of their properties.

Article	Element	Atomic Number	Properties

Analyze and Conclude

1. Matter can be solid, liquid, or gaseous. Give one example of a solid, liquid, and gaseous object or substance.

2. How does a liquid differ from a solid? How does a gas differ from a liquid?

Name Class Date

GeoLab Salt Precipitation

Many rocks on Earth form from salts precipitating out of seawater. Salt ions precipitate when a salt solution becomes saturated. Solubility is the ability of a substance to dissolve in a solution. When a solution is saturated, no more of that substance can be dissolved. What is the effect of temperature and evaporation on salt precipitation? How do precipitation rates affect the size of crystals?

PREPARATION

Problem

Under what conditions do salt solutions become saturated and under what conditions does salt precipitate out of solution?

Materials

halite (sodium chloride)
250-mL glass beakers (2)
distilled water
plastic wrap
laboratory scale
hot plate
shallow glass baking dish
refrigerator
glass stirring rod

Objectives

In this GeoLab, you will:

- **Observe** salt dissolving and precipitating from a saturated salt solution.
- **Identify** the precipitated salt crystals.
- **Compare** the salt crystals that precipitate out under different conditions.
- **Hypothesize** why different conditions produce different results.

Safety Precautions

Always wear safety goggles and an apron in the lab. Wash your hands after handling salt solutions. Use care in handling hot solutions. Use protection handling hot glassware.

PROCEDURE

1. Pour 150 mL of distilled water into a 250-mL glass beaker.
2. Measure 54 g of sodium chloride. Add the sodium chloride to the distilled water in the beaker and stir until only a few grains remain on the bottom of the beaker.
3. Place the beaker on the hot plate and turn the hot plate on. As the solution inside the beaker heats up, stir it until the last few grains of sodium chloride dissolve. The salt solution will then be saturated.
4. Pour 50 mL of the warm, saturated solution into the second 250-mL glass beaker. Cover this beaker with plastic wrap so that it forms a good seal. Put this beaker in the refrigerator.
5. Pour 50 mL of the saturated solution into the shallow glass baking dish. Place the dish on the hot plate and heat the salt solution until all the liquid evaporates. *CAUTION: The baking dish will be hot. Handle with care.*
6. Place the original beaker with 50 mL of the remaining solution on a shelf or windowsill. Do not cover the beaker.
7. Observe both beakers one day later. If crystals have not formed, wait another day to make your observations and conclusions.
8. Once crystals have formed in all three containers, observe the size and shape of the precipitated crystals. Describe your observations in your science journal.

GeoLab Salt Precipitation

ANALYZE

1. What is the shape of the precipitated crystals in the three containers? Does the shape of the crystals alone identify them as sodium chloride?

2. Why didn't all of the salt solution dissolve in step 2 above? How did heating affect the solubility of sodium chloride? Why did heating have the observed effect? Explain.

3. What effect does cooling have on the solubility of salt?

4. What happens when a salt solution evaporates? What effect does evaporation have on the solubility of salt?

5. Suppose you have two samples of volcanic rock of identical chemical composition but different crystal sizes. What conclusions can you make about the conditions under which each rock sample cooled?

Name Class Date

GeoLab Salt Precipitation

CONCLUDE AND APPLY

1. What are the sizes of the crystals in the different containers? Which container has the smallest crystals? Which crystals formed in the shortest time interval?

2. Why does salt precipitate from solution? How is crystal size related to precipitation rate?

3. Design an experiment to separate a heterogeneous mixture of different salts, such as NaCl and $MgCl_2$, into its components, by dissolving and precipitation.

Name Class Date

MiniLab 4

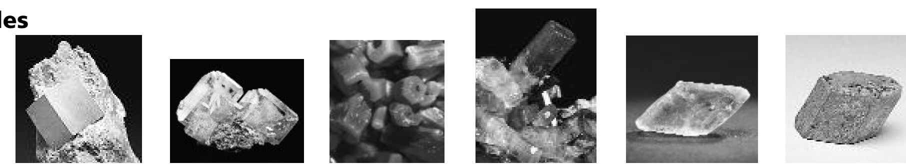
How can crystal systems be modeled?

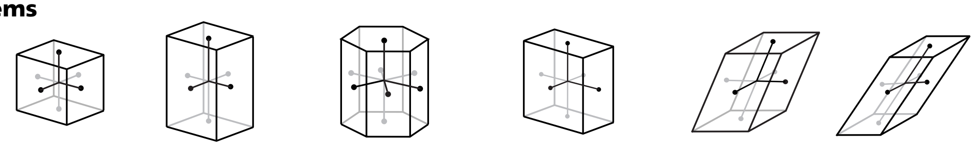
Model the six major crystal systems, then classify mineral samples according to these systems.

Procedure

1. Using ***Table 1*** for guidance, cut pieces of foam board into geometric shapes. Your largest geometric shape should be no more than about 8 cm in length. Your group will need about 38 various shapes.
2. Tape or glue the geometric shapes into models of the six major crystal systems. Again, use ***Table 1*** for guidance.
3. Use the mineral samples provided by your teacher to classify minerals according to their crystal shapes.

Table 1 Crystal Systems





Examples	Pyrite	Wulfenite	Pyromorphite	Topaz	Gypsum	Feldspar
Systems	Cubic	Tetragonal	Hexagonal	Orthorhombic	Monoclinic	Triclinic

Analyze and Conclude

1. What geometric shapes did you use to model the crystal systems?

____

2. Was the crystal structure readily apparent in all mineral samples? Infer why or why not.

____

____

____

3. Use ***Table 2*** to identify your minerals. Besides crystal shape, what properties did you use for identification purposes?

____

____

____

MiniLab 4

How can crystal systems be modeled?

Table 2 Minerals with Metallic Luster

Mineral (Formula)	Color	Streak	Hardness	Specific Gravity	Crystal System	Breakage Pattern	Uses and Other Properties
Bornite (Cu_5FeS_4)	bronze, tarnishes to dark blue purple	gray-black	3	4.9–5.4	tetragonal	uneven fracture	source of copper called "peacock ore" because of the purple shine when it tarnishes
Chalcopyrite ($CuFeS_2$)	brassy to golden yellow	greenish black	3.5–4	4.2	tetragonal	uneven fracture	main ore of copper
Chromite ($FeCr_2O_4$)	black or brown	brown to black	5.5	4.6	cubic	irregular fracture	ore of chromium, stainless steel, metallurgical bricks
Copper (Cu)	copper red	copper red	3	8.5–9	cubic	hackly	coins, pipes, gutters, wire, cooking utensils, jewelry, decorative plaques; malleable and ductile
Galena (PbS)	gray	gray to black	2.5	7.5	cubic	cubic cleavage perfect	source of lead, used in pipes, shields for X rays, fishing equipment sinkers
Gold (Au)	pale to golden yellow	yellow	2.5–3	19.3	cubic	hackly	jewelry, money, gold leaf, fillings for teeth, medicines; does not tarnish
Graphite (C)	black to gray	black to gray	1–2	2.3	hexagonal	basal cleavage (scales)	pencil lead, lubricants for locks, rods to control some small nuclear reactions, battery poles
Hematite (specular) (Fe_2O_3)	black or reddish brown	red or reddish brown	6	5.3	hexagonal	irregular fracture	source of iron; roasted in a blast furnace, converted to "pig" iron, made into steel
Magnetite (Fe_3O_4)	black	black	6	5.2	cubic	conchodial fracture	source of iron, naturally magnetic, called lodestone
Pyrite (FeS_2)	light, brassy yellow	greenish black	6.5	5.0	cubic	uneven fracture	source of iron, "fool's gold," alters to limonite
Pyrrhotite ($Fe_{1-x}S$)* *contains one less atom of Fe than S	bronze	gray-black	4	4.6	hexagonal	uneven fracture	an ore of iron and sulfur; may be magnetic
Silver (Ag)	silvery white, tarnishes to black	light gray to silver	2.5	10–12	cubic	hackly	coin, fillings for teeth, jewelry, silverplate, wires; malleable and ductile

Table 2 Minerals with Nonmetallic Luster

Mineral (Formula)	Color	Streak	Hardness	Specific Gravity	Crystal System	Breakage Pattern	Uses and Other Properties
Augite ((Ca, Na) (Mg, Fe, Al) (Al, Si)$_2$O$_6$)	black	colorless	6	3.3	monoclinic	2-directional cleavage	square or 8-sided cross section
Corundum (Al_2O_3)	colorless, blue, brown green, white pink, red	colorless	9	4.0	hexagonal	fracture	gemstones: ruby is red, sapphire is blue; industrial abrasive
Feldspar (orthoclase) ($KAlSi_3O_8$)	colorless white to gray, green, and yellow	colorless	6	2.5	monoclinic	two cleavage planes meet at 90° angle	insoluble in acids; used in the manufacture of porcelain
Feldspar (plagioclase) ($NaAlSi_3O_8$) ($CaAl_2Si_2O_8$)	gray, green, white	colorless	6	2.5	triclinic	two cleavage planes meet at 86° angle	used in ceramics; striations present on some faces
Fluorite (CaF_2)	colorless, white, blue, green, red, yellow, purple	colorless	4	3–3.2	cubic	cleavage	used in the manufacture of optical equipment; glows under ultraviolet light
Garnet (Mg, Fe, Ca, Mn)$_3$, (Al, Fe, Cr)$_2$, (SiO$_4$)$_3$	deep yellow-red, green, black	colorless	7.5	3.5	cubic	conchoidal fracture	used in jewelry; also used as an abrasive
Hornblende Ca$_2$Na(Mg, Fe^2)$_4$, (Al, Fe^3, Ti)$_3$, Si$_8$O$_{22}$(O, OH)$_2$	green to black	gray to white	5–6	3.4	monoclinic	cleavage in two directions	will transmit light on thin edges; 6-sided cross section
Limonite (hydrous iron oxides)	yellow, brown, black	yellow, brown	5.5	2.74–4.3	—	conchoidal fracture	source of iron; weathers easily, coloring matter of soils
Olivine ((Mg, Fe)$_2$ SiO$_4$)	olive green	colorless	6.5	3.5	orthorhombic	conchoidal fracture	gemstones, refractory sand
Quartz (SiO_2)	colorless, various colors	colorless	7	2.6	hexagonal	conchoidal fracture	used in glass manufacture, electronic equipment, radios, computers, watches, gemstones
Topaz (Al$_2$SiO$_4$ (F, OH)$_2$)	white, pink, yellow, pale blue, colorless	colorless	8	3.5	orthorhombic	basal cleavage	valuable gemstone

Name Class Date

DESIGN YOUR OWN GeoLab

Making a Field Guide to Minerals

Have you ever used a field guide to identify a bird, flower, rock, or insect? If so, you know that field guides include far more than simply photographs. A typical field guide for minerals might include background information about minerals in general, plus specific information about the formation, properties, and uses of each mineral. In this activity, you'll create a field guide to minerals.

PREPARATION

Problem

How would you go about identifying minerals? What physical and chemical properties would you test? Which of these properties should be included in a field guide to help others to identify unknown minerals?

Possible Materials

mineral samples
hand lens
glass plate
streak plate
Mohs scale of mineral hardness
5 percent hydrochloric acid (HCl) with dropper
Appendix H
steel file or nail
piece of copper
paper clip
magnet

Hypothesis

As a group, form a hypothesis about which property or properties might be most useful in identifying minerals. Write your hypothesis in the space below.

____

____

____

Objectives

In this GeoLab, you will:

- **Conduct** tests on unknown minerals to determine their physical and chemical properties.
- **Identify** minerals based on the results of your tests.
- **Design** a field guide for minerals.

Safety Precautions

Review the safe use of acids. HCl may cause burns. If a spill occurs, rinse your skin with water and notify your teacher immediately.

Name Class Date

DESIGN YOUR OWN GeoLab

Making a Field Guide to Minerals

PLAN THE EXPERIMENT

1. As a group, list the steps that you will take to test your hypothesis. Keep the available materials in mind as you plan your procedure. Be specific, describing exactly what you will do at each step. Properties that you may want to test include luster, color, reaction to HCl, magnetism, cleavage, fracture, texture, hardness, streak, double refraction, and density.

2. Should you test any of the properties more than once for any of the minerals? How will you determine whether certain properties indicate a specific mineral?

3. Design a data table to summarize your results. You can use this table as the basis for your field guide. Draw the table in the space below.

4. Read over your entire experiment to make sure that all steps are in a logical order.
5. Have you included a step for additional research? You may have to use the library or the Glencoe Science Web Site to gather all the necessary information for your field guide.
6. What information will be included in the field guide? Possible data include how each mineral formed, its uses, its chemical formula, and a labeled photograph or drawing of the mineral.

7. Make sure your teacher approves your plan before you proceed with your experiment.

Name Class Date

DESIGN YOUR OWN GeoLab

Making a Field Guide to Minerals

ANALYZE

1. **Interpreting Results** Which properties were most reliable for identifying minerals? Which properties were least reliable? Discuss reasons why one property is more useful than others.

2. **Defending Your Hypothesis** Was your hypothesis supported? Why or why not?

3. **Thinking Critically** How could you use a piece of paper, a steel knife, and a glass bottle to distinguish between Iceland spar and quartz?

4. **Observing and Inferring** What mineral reacted with the HCl? Why did the mineral bubble? Write the balanced equation that describes the chemical reaction that took place between the mineral and the acid.

5. **Conducting Research** What information did you include in the field guide? What resources did you use to gather your data? Describe the layout of your field guide.

Name Class Date

DESIGN YOUR OWN GeoLab

Making a Field Guide to Minerals

CONCLUDE AND APPLY

1. Compare and contrast your field guide with those of other groups. How could you improve your field guide?

2. What are the advantages and disadvantages of field guides?

3. Based on your results, is there any one definitive test that can always be used to identify a mineral? Explain.

MiniLab 5

How do igneous rocks differ?

Compare and **contrast** the different characteristics of igneous rocks.

Procedure

1. Using the igneous rock samples provided by your teacher, carefully observe the following characteristics of each rock: color, grain size, texture, and, if possible, mineral composition.
2. Design a data table to record your observations.

Analyze and Conclude

1. Classify your rock samples as extrusive or intrusive rocks.

2. What characteristics do the extrusive rocks share? How do they differ? What characteristics do the intrusive rocks share? How do they differ?

3. Classify your rock samples as felsic, intermediate, mafic, or ultramafic.

Name Class Date

DESIGN YOUR OWN GeoLab

Modeling Crystal Formation

The rate at which magma cools has an effect on the grain size of the resulting igneous rock. Observing the crystallization of magma is difficult because molten rock is very hot and the crystallization process is sometimes very slow. Other materials, however, crystallize at lower temperatures. These materials can be used to model crystal formation.

PREPARATION

Problem
Model the crystallization of minerals from magma.

Materials
clean, plastic petri dishes
saturated alum solution
200-mL glass beaker
magnifying glass
piece of dark-colored construction paper
thermometer
paper towels
water
hot plate

Objectives
In this GeoLab, you will:
- **Determine** the relationship between cooling rate and crystal size.
- **Compare** and **contrast** different crystal shapes.

Safety Precautions
The alum mixture can cause skin irritation and will be hot when it is first poured into the petri dishes. If splattering occurs, wash skin with cold water. Always wear safety goggles and an apron in the lab.

PROCEDURE

1. As a group, plan how you could change the cooling rate of a hot solution poured into a petri dish. For instance, you may want to put one sample in a freezer or refrigerator for a designated period of time. Assign each group member a petri dish to observe during the experiment.
2. Place a piece of dark-colored construction paper on a level surface where it won't be disturbed. Place the petri dishes on top of the paper.
3. Carefully pour a saturated alum solution that is about 95°C to 98°C, or just below boiling temperature, into each petri dish so that it is half-full. Use caution when pouring the hot liquid to avoid splatters and burns.
4. Observe the petri dishes. On the next page, draw a data table on which to record your observations. Below your data table, draw what you observe happening in the petri dish assigned to you.
5. Every 5 minutes for 30 minutes, record your observations of your petri dish. Make accurate, full-sized drawings of any crystals that begin to form.

Name Class Date

DESIGN YOUR OWN GeoLab

Modeling Crystal Formation

DATA TABLE

OBSERVATIONS

ANALYZE

1. How did you vary the cooling rate of the solutions in the petri dishes? Compare your methods with those of other groups. Did one method appear to work better than others? Explain.

____

____

2. Use a magnifying glass or binocular microscope to observe your alum crystals. What do the crystals look like? Are all the crystals the same size?

____

____

DESIGN YOUR OWN GeoLab

Modeling Crystal Formation

ANALYZE

3. Compare your drawings and petri dish with those of other students in your group. Which petri dish had the smallest average crystal size? Describe the conditions under which that petri dish cooled.

4. Do all the crystals have the same shape? Draw the most common shape. Share your drawings with other groups. Describe any patterns that you see.

CONCLUDE AND APPLY

1. What factors affected the size of the crystals in the different petri dishes? How do you know?

2. Infer why the crystals changed shape as they grew.

3. How is this experiment different from magma crystallization? How is it the same?

4. Describe the relationship between cooling rate and crystal formation.

Name Class Date

MiniLab 6

What happened here?

Interpret animal activity from patterns of fossil footprints.

Procedure

1. Study the photograph of a set of footprints that has been preserved in sedimentary rocks.
2. Write a description of how these tracks might have been made.

____

____

____

____

3. Draw your own diagram of a set of fossilized footprints that record the interactions of organisms in the environment. Use the space below.

4. Give your diagram to another student and have that student interpret what happened.

Analyze and Conclude

1. How many animals made the tracks shown?

____

2. What types of information can be inferred from a set of fossil footprints?

____

____

3. Did other students interpret your diagram the same way? What might have caused any differences?

____

____

Name Class Date

GeoLab Interpreting Changes in Rocks

As the rock cycle continues, and rocks change from one type to another, more changes occur than meet the eye. Color, grain size, texture and mineral composition are easily observed and described visually. Yet, with mineral changes come changes in crystal structure and density. How can these be accounted for and described? Studying pairs of sedimentary and metamorphic rocks can show you how.

PREPARATION

Problem

How do the characteristics of sedimentary and metamorphic rocks compare?

Materials

samples of sedimentary rocks and their metamorphic equivalents
magnifying glass or hand lens
paper
pencil
beam balance
100-mL graduated cylinder or beaker large enough to hold the rock samples
water

Objectives

In this GeoLab, you will:

- **Describe** the characteristics of sedimentary and metamorphic rocks.
- **Determine** the density of different rock types.
- **Infer** how metamorphism changes the structure of rocks.

Safety Precautions

Always wear safety goggles and an apron in the lab.

PROCEDURE

1. Use the data table on the next page. Add rows to the table if you are examining more than four samples.
2. Observe each rock sample. Record your observations in the data table.
3. Recall that density = mass/volume. Make a plan that will allow you to measure the mass and volume of a rock sample.
4. Determine the density of each rock sample and record this information in the data table.

Name Class Date

GeoLab Interpreting Changes in Rocks

Data Table

Sample number	Rock type	Specific characteristics	Mass	Volume	Density
1					
2					
3					
4					

ANALYZE

1. Compare and contrast a shale and a sandstone.

2. How does the grain size of a sandstone change during metamorphism?

3. What textural differences do you observe between a shale and a slate?

4. Compare the densities you calculated with other students. Does everybody have the same answer? What are some of the reasons that answers may vary?

Name Class Date

GeoLab Interpreting Changes in Rocks

CONCLUDE AND APPLY

1. Why does the color of a sedimentary rock change during metamorphism?

2. Compare the density of a slate and a quartzite. Which rock has a greater density? Explain.

3. Compare the densities of shale and slate, sandstone and quartzite, and limestone and marble. Does density always change in the same way? Explain the results that you observed.

MiniLab 7

How do rocks weather?

Model how rocks are exposed to their surrounding environment and slowly weather away.

Procedure

1. Carve your name deeply into a bar of soap with a toothpick. Weigh the soap and record the weight.

2. Measure and record the depth of the letters carved into the soap.

3. Place the bar of soap on its edge in a catch basin.
4. Sprinkle water over the bar of soap until a noticeable change occurs in the depth of the carved letters.
5. Measure and record the depth of the carved letters.

Analyze and Conclude

1. How did the depth of the letters carved into the bar of soap change?

2. Did the shape, size, or weight of the bar of soap change?

3. Where did the missing soap go?

4. What additional procedure could you follow to determine whether any soap wore away?

Name Class Date

GeoLab Effects of Weathering

Many factors affect the rate of weathering of Earth materials. Two major factors that affect the rate at which a rock weathers include the length of time it is exposed to a weathering agent and the composition of the rock.

PREPARATION

Problem

Investigate the relationship between time and the rate of weathering of halite chips.

Materials

plastic jar with lid
water (300 mL)
halite chips (100 g)
balance
timer
paper towels

Objectives

In this Geolab, you will:

- **Determine** the relationship between the length of time that rocks are exposed to running water and the degree of weathering of the rocks.
- **Describe** the appearance of weathered rocks.
- **Infer** what other factors may influence the rate of weathering.
- **Apply** your results to a real-world situation.

Safety Precautions

Wear splash-resistant safety goggles and an apron while you do this activity. Do not ingest the halite chips.

Weathering Data

Average Shaking Time in Minutes	Weight of Chips (g)
3	
6	
9	
12	

GeoLab Effects of Weathering

PROCEDURE

1. Soak 100 g of halite chips in water overnight.
2. As a class, decide on a uniform method of shaking the jars.
3. Pour off the water and place the halite chips in the plastic jar.
4. Add 300 mL of water to the jar.
5. Secure the lid on the jar.
6. Shake the jar for the assigned period of time.
7. Remove the water from the jar.
8. Use paper towels to dry the halite chips.
9. Use a balance to weigh the chips. Record your measurement in a data table similar to the one provided on page 28.

ANALYZE

1. Why did you need to soak the chips before conducting the investigation?

2. How did the mass of the rocks change with the length of time they were shaken?

3. How did the shape of the rocks change as a result of being shaken in a jar with water?

4. What factors could have affected a team's results?

Name Class Date

GeoLab Effects of Weathering

CONCLUDE AND APPLY

1. What real-world process did you model in this investigation?

2. How would acid precipitation affect this process in the real world?

3. How would the results of your investigation be affected if you used pieces of quartz instead of halite?

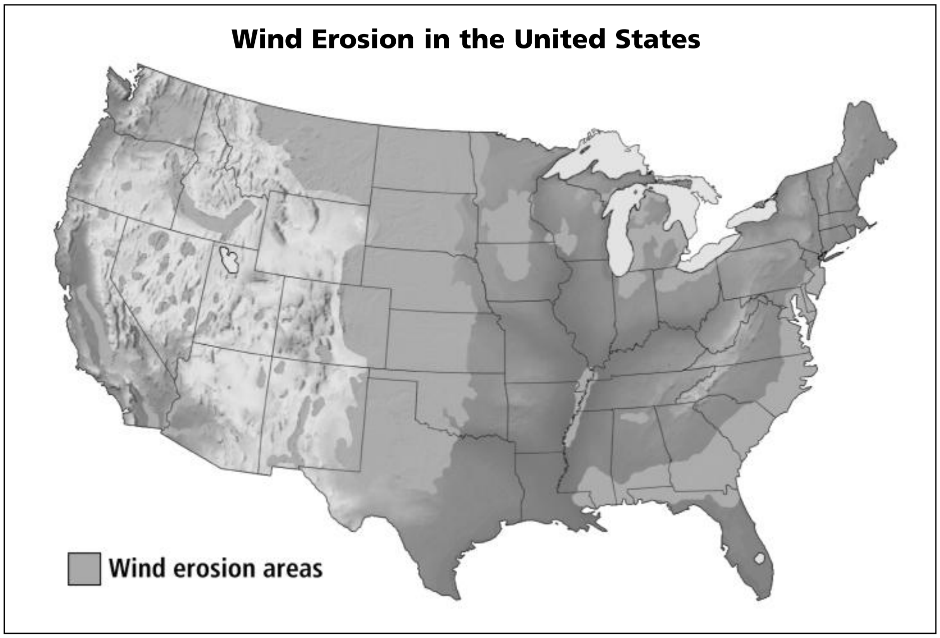
MiniLab 8

Where does wind erosion occur?

Interpret a wind erosion map to find out what parts of the United States are subject to wind erosion.

Procedure

Refer to the wind erosion map shown below to answer the following questions.



Analyze and Conclude

1. Which areas of the United States experience wind erosion?

____

____

2. Where is the largest area of wind erosion? The second largest?

____

____

3. What coastal areas are subject to wind erosion?

____

____

Name Class Date

Mapping GeoLab

Mapping a Landslide

Around midday on April 27, 1993, in a normally quiet, rural area of New York State, the landscape dramatically changed. Unexpectedly, almost 1 million m^3 of Earth debris slid over 300 m down the lower slope of Bare Mountain and into Tully Valley. The debris flowed over the road and buried nearby homes. The people who lived there had no knowledge of any prior landslides occurring in the area, yet this landslide was the largest to occur in New York State in more than 75 years. What caused this large mass of Earth material to move so suddenly?

PREPARATION

Problem

How can you use a drawing based on a topographic map to infer how the Tully Valley Landslide occurred?

Materials

metric ruler
pencil

PROCEDURE

1. Use the map to answer the following questions. Be sure to check the map's scale.
2. Measure and record the length and width of the Tully Valley in kilometers. Double-check your results.

____

ANALYZE

1. What does the shape of the valley tell you about how it formed?

____

2. In what direction did the landslide flow?

____

3. In what direction does the Onondaga Creek flow?

____

4. Infer from the map which side of Tully Valley has the steepest valley walls.

____

____

Name Class Date

Mapping GeoLab: Mapping a Landslide

ANALYZE

5. What conditions must have been present for the landslide to occur?

6. At the time of the Tully Valley Landslide, the trees were bare. How could this have affected the conditions that caused the landslide?

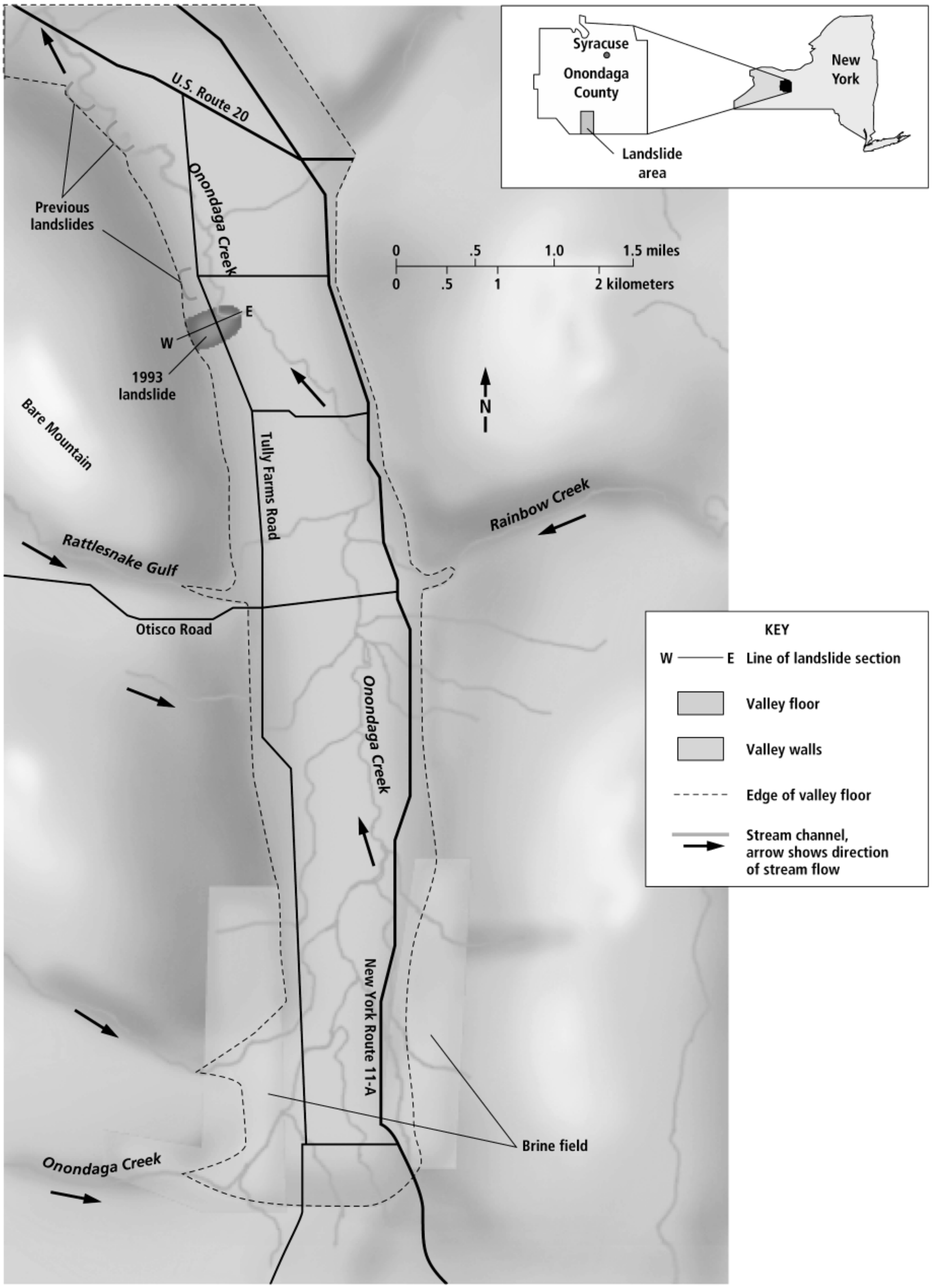
CONCLUDE AND APPLY

1. Why do you think the Tully Valley Landslide occurred?

2. If you planned to move into an area prone to mass movements, such as landslides, what information would you gather beforehand?

Name Class Date

Mapping GeoLab: Mapping a Landslide



Name Class Date

MiniLab 9 Surface materials determine where a lake can form.

Model how different Earth materials may allow lakes to form. Lakes form when depressions or low areas fill with water.

Procedure

CAUTION: Always wear safety goggles and an apron in the lab.

1. Use three clear, plastic shoe boxes. Half fill each one with earth materials: clay, sand, gravel.
2. Slightly compress the material in each shoe box. Then make a shallow depression in each surface.
3. Slowly pour 500 mL of water into each of the depressions.

Analyze and Conclude

1. Describe what happened to the 500 mL of water that was added to each shoe box.

2. How is this activity similar to what actually happens on Earth's surface when a lake forms?

3. What can you infer about the Earth materials in which lakes most commonly form?

Name Class Date

GeoLab Modeling Stream Velocity and Slope

Water in streams flows from areas of higher elevation to areas of lower elevation. The rate of stream flow varies from one stream to another and also in different areas of the same stream.

PREPARATION

Problem
Determine how slope may affect stream-flow velocity.

Materials
1-m length of vinyl gutter pipe
ring stand and clamp
water source with long hose
protractor with plumb bob
sink or container to catch water
stopwatch
grease pencil
meterstick
paper
hole punch

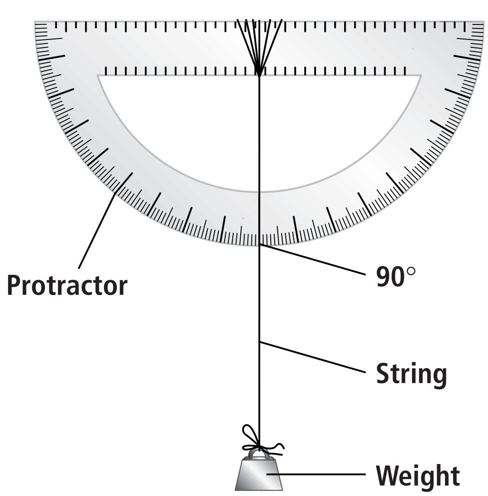
Objectives
In this GeoLab, you will:
- **Measure** the time it takes for water to flow down a channel at different slopes and depths.
- **Organize** your data in a table.
- **Plot** the data on a graph to show how stream velocity is directly proportional to the stream channel's slope and depth.
- **Describe** the relationship between slope and rate of stream flow.

Safety Precautions


Always wear safety goggles in the lab.

PROCEDURE

1. Use the hole punch to make 10 to 15 paper circles to be used as floating markers.
2. Use the illustration below as a guide to set up the protractor with the plumb bob.



3. Use the grease pencil to mark two lines across the inside of the gutter pipe at a distance of 40 cm apart.
4. Use the ring stand and clamp to hold the gutter pipe at an angle of 10°. Place the end of the pipe in a sink or basin to collect the discharged flow of water.
5. Attach a long hose to a water faucet in the sink.
6. Keep the hose in the sink until you are ready to use it. Then turn on the water and adjust the flow until the water is moving quickly enough to provide a steady flow.
7. Bend the hose temporarily to block the water flow until the hose is positioned at least 5 cm above the top line marked on the pipe.

GeoLab Modeling Stream Velocity and Slope

PROCEDURE

8. Keep the water moving at the same rate of flow for all slope angles being investigated.

9. Drop a floating marker approximately 4 cm above the top line on the pipe and into the flowing water. Measure the time it takes for the floating marker to move from the top line to the bottom line. Record the time in your science journal.

10. Repeat step 9 two more times.

11. Repeat steps 9 and 10 but change the slope to 20°, then 30°, and then 40°.

12. Make a line graph of the average stream-flow velocity, using the space below.

LINE GRAPH

ANALYZE

1. Why is it important to keep the water flow constant in this activity?

____

____

____

2. Which variables had to be controlled to avoid errors in your data?

____

3. Using your graph, predict the velocity of water flow for a 35° slope.

____

GeoLab Modeling Stream Velocity and Slope

CONCLUDE AND APPLY

1. What is the relationship between the rate of water flow and the angle of the slope?

2. Describe one reason why a stream's slope might change.

3. Where would you expect to find streams with the highest water-flow velocity?

MiniLab 10

How does an artesian well work?

Model the changes that an artesian aquifer undergoes when a well is dug into it. What causes the water to rise above the ground surface?

Procedure

CAUTION: Always wear safety goggles and an apron in the lab.

1. Half fill a plastic shoe box or other container with sand. Add enough water to saturate the sand. Cover the sand completely with a 1- or 2-cm layer of clay or a similar impermeable material.
2. Tilt the box at an angle of about 10°. Use a book for a prop.
3. Punch three holes through the clay, one each near the low end, the middle, and the high end of the box. Insert a clear straw through each hole into the sand below. Seal the holes around the straws.

Analyze and Conclude

1. Observe the water levels in the straws. Where is the water level the highest? The lowest?

   ____

2. Where is the water table in the box?

   ____

3. Where is the water under greatest pressure? Explain.

   ____

   ____

4. Predict what will happen to the water table and the surface to which the water flows from one of the straws.

   ____

   ____

Name Class Date

Mapping GeoLab

Mapping Pollution

You can use the map to estimate the direction of groundwater flow and the movement of a pollution plume from its source, such as a leaking underground gasoline storage tank.

PREPARATION

Problem

A major gasoline spill occurred at Jim's Gas Station near Riverside Acres, Florida. How can you determine the movement of the resulting pollution plume?

Materials

USGS topographic map of Forest City, Florida
transparent paper
graph paper
ruler
calculator

PROCEDURE

1. Identify the lakes and swamps in the southeast corner of this map, and list their names and elevations in the data table on the next page. Note: The elevations are given or can be estimated from the contour lines.
2. Place the transparent paper over the southeast part of the map and trace the approximate outlines of these lakes or swamps, as well as the major roads. Enter lake or swamp elevations on your overlay, and indicate the location of Jim's Gas Station on Forest City Rd., about 1400 feet north of the Seminole County line (at the 96 foot elevation mark).
3. Add contour lines to your overlay using a contour interval of 10 feet.
4. Construct a cross section of the surface topography and the water table from Lake Lotus to Lake Lucien (through Jim's Gas Station).

ANALYZE

1. What is the slope of the water table at Jim's Gas Station?

____

2. What is the approximate direction of the water table slope at Jim's Gas Station?

____

3. In which direction will the pollution plume move?

____

4. Which settlements or houses are threatened by this pollution plume?

____

Mapping GeoLab: Mapping Pollution

Name	Elevation (in feet)

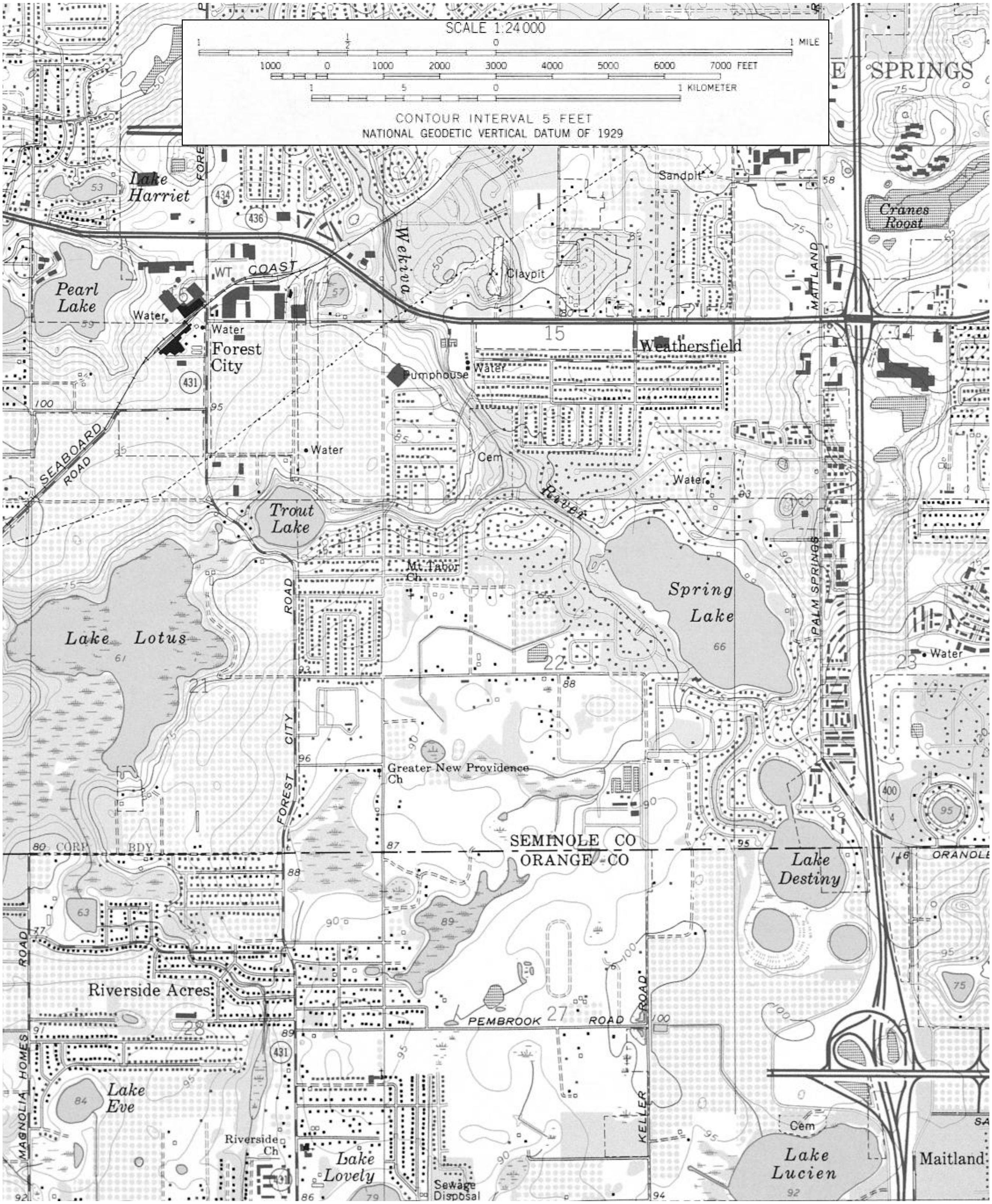
CONCLUDE AND APPLY

1. How far below the surface is the water table in this highest area?

2. What is the relationship of the water table to the surface topography?

Name Class Date

Mapping GeoLab: Mapping Pollution



Name Class Date

MiniLab 11

What affects the formation of clouds and precipitation?

Model the water cycle.

Procedure

1. Pour about 125 mL of warm water into a clear, plastic bowl.
2. Loosely cover the top of the bowl with plastic wrap. Overlap the edges by about 5 cm.
3. Fill a self-sealing plastic bag with ice cubes, seal it, and place it in the center of the plastic wrap on top of the bowl. Push the bag of ice down so that the plastic wrap sags in the center, but doesn't touch the surface of the water.
4. Use tape to seal the plastic wrap around the bowl.
5. Observe the surface of the plastic wrap directly under the ice cubes every 15 minutes for one hour, or until the ice melts.

Analyze and Conclude

1. What formed on the underside of the wrap? Infer why this happened.

2. Relate your observations to processes in the atmosphere.

3. Predict what would happen if you repeated this activity with hotter water.

Name Class Date

GeoLab Interpreting Pressure-Temperature Relationships

As you go up a mountain, both temperature and air pressure decrease. These effects are easily explained. Temperature decreases as you get farther away from the atmosphere's heat source, Earth's surface. Pressure decreases as you ascend the mountain because there are fewer and fewer particles of air above you. Pressure and temperature, however, are also related through the expansion and compression of air, regardless of height. In this activity, you will demonstrate that relationship.

PREPARATION

Problem

Demonstrate the relationship between temperature and pressure.

Objectives

In this GeoLab, you will:

- **Model** the temperature and pressure changes that take place as a result of the expansion and compression of air.
- **Relate** the changes to processes in the atmosphere.

Materials

clean, clear, plastic 2-L bottle with cap
plastic straws
scissors
thin, liquid-crystal temperature strip
tape
watch or timer

Safety Precautions

Always wear safety goggles and an apron in the lab.

PROCEDURE

1. Cut two pieces of straw, each the length of the temperature strip. Then cut two 2-cm pieces of straw. Lay the two long pieces on a table. Place the two shorter pieces within the space created by the longer pieces so that the four pieces form a supportive structure for the temperature strip.
2. Tape the four pieces of straw together. Place the temperature strip lengthwise upon the straws. Tape the strip to the straws.
3. Slide the temperature strip-straw assembly into the clean, dry bottle. Screw the cap on tightly.
4. Place the sealed bottle on the table so that the temperature strip faces you and is easy to read. Do not handle the bottle any more than is necessary so that the temperature inside will not be affected by the warmth of your hands.
5. Record the temperature of the air inside the bottle as indicated by the temperature strip.
6. Next, position the bottle so that about half its length extends beyond the edge of the table. Placing one hand on each end of the bottle, push down on both ends so that the bottle bends in the middle. Hold the bottle this way for 2 minutes. During this time, your partner should record the temperature every 15 seconds.
7. Release the pressure on the bottle. Observe and record the temperature every 15 seconds for the next 2 minutes.

Name Class Date

GeoLab Interpreting Pressure-Temperature Relationships

ANALYZE

1. What was the average temperature of the air inside the bottle as you applied pressure to the bottle? How did this differ from the average temperature of the bottled air when you released the pressure on the bottle?

2. Make a graph of the temperature changes you recorded throughout the experiment, using the space below.

3. Explain how these temperature changes are related to changes in pressure.

CONCLUDE AND APPLY

1. Predict how the experiment would change if you took the cap off the bottle.

2. Given your observations and what you know about the behavior of warm air, would you expect the air over an equatorial desert at midday to be characterized by high or low pressure?

MiniLab 12

How does the angle of the Sun's rays differ?

Model the angle at which sunlight reaches Earth's surface. This angle greatly affects the intensity of solar energy received in any one place.

Procedure

1. Hold a flashlight several centimeters above a piece of paper and point the flashlight straight down.
2. Use a pencil to trace the outline of the light on the paper. The outline models how the Sun's rays strike the equator.
3. Keeping the flashlight at the same distance above the paper, tilt the top of the flashlight to roughly a 30° angle.
4. Trace the new outline of the light. This is similar to how the Sun's rays are received at the poles.

Analyze and Conclude

1. Describe how the outline of the light differed between step 1 and step 3. Explain why it differed.

   ____

   ____

   ____

2. How do you think the change in area covered by the light affects the intensity of light received at any one place?

   ____

   ____

   ____

3. The flashlight models solar radiation striking the surface of Earth. Knowing this, compare how much heat energy is absorbed near the equator and near the poles.

   ____

   ____

   ____

Name Class Date

Mapping GeoLab: Interpreting a Weather Map

It's time to put your knowledge of meteorology into action. The surface weather map on the following page shows actual weather data for the United States. In this activity, you will use the station models, isobars, and pressure systems on the map to forecast the weather.

PREPARATION

Problem

How can you use a surface weather map to interpret information about current weather and to forecast future weather?

Materials

pencil
ruler

PROCEDURE

1. The map scale is given in nautical miles. Refer to the scale when calculating distances.
2. The unit for isobars is millibars (mb). In station models, pressure readings are abbreviated. For example, 1021.9 mb is plotted on a station model as 219 but read as 1021.9.
3. Wind shafts point in the direction from which the wind is blowing.

ANALYZE

1. What is the contour interval of the isobars?

____

2. What are the highest and lowest isobars? Where are they located?

____

____

____

____

3. In which direction are the winds blowing across Texas and Louisiana?

____

4. What and where are the coldest and warmest temperatures that you can find in the continental United States?

____

____

Name Class Date

Mapping GeoLab

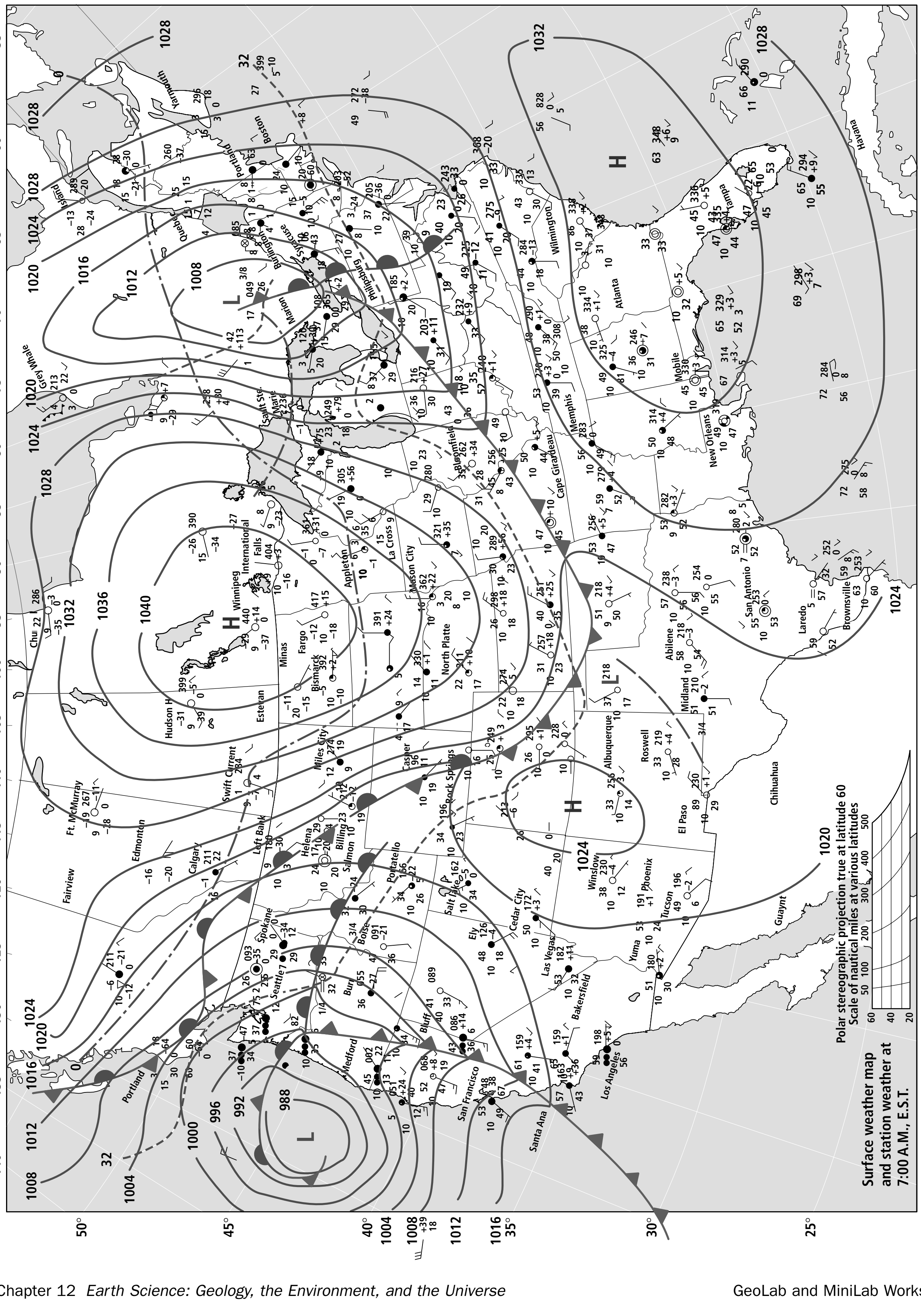
Interpreting a Weather Map

CONCLUDE AND APPLY

1. Would you expect the weather in Georgia and Florida to be clear or rainy? Why?

2. Both of the low-pressure systems in eastern Canada and off the Oregon coast are moving toward the east at about 15 mph. What kind of weather would you predict for Oregon and for northern New York for the next few hours? Explain.

Mapping GeoLab
Interpreting a Weather Map



Name Class Date

MiniLab 13

How can mild rains cause floods?

Model the effects of repeated, slow-moving storms that drop rain over the same area for a long period of time.

Procedure

1. Place an ice-cube tray on the bottom of a large sink or tub.
2. Pour water into a clean, plastic dishwashing-detergent bottle until it is two-thirds full. Replace the cap on the bottle.
3. Hold the bottle upside down with the cap open about 8 cm above one end of the ice-cube tray. Gently squeeze the bottle to maintain a constant flow of water into the tray. Slowly move the bottle from one end of the tray to the other over the course of 30 seconds. Try to put approximately equal amounts of water in each ice-cube compartment.
4. Measure the depth of water in each compartment. Calculate the average depth.

____

____

____

5. Repeat steps 1–4, but move the bottle across the ice-cube tray in 15 seconds.

____

____

____

Analyze and Conclude

1. How did the average depth of the water differ in steps 4 and 5? How might you account for the difference?

____

____

2. Based on these results, infer how the speed of a moving storm affects the amount of rain received in any one area.

____

____

3. How could you alter the experiment to simulate different rates of rainfall?

____

____

Name _______________ Class _______ Date _______

Internet GeoLab: Tracking a Hurricane

Hurricanes are violent storms. That's why it's important to have plenty of advance warning before they hit land. By tracking the changing position of a storm on a chart and connecting these positions with a line, you can determine a hurricane's path.

PREPARATION

Problem

What information can you obtain by studying the path of a hurricane?

Hypothesis

Use the Internet to gather information about the path of a hurricane. **Form a hypothesis** about how the hurricane's path can be used to predict the strength of the storm and where most damage might be inflicted.

____

____

____

Objectives

In this GeoLab, you will:

- **Gather** and **communicate** data about hurricanes.
- **Plot** data on a hurricane-tracking chart.
- **Predict** where storm-inflicted damage might occur.

Data Sources

Go to the Glencoe Science Web Site at science.glencoe.com to find links to hurricane data on the Internet, or use information provided by your teacher. Make copies of the hurricane-tracking chart in this lab or download a chart from the Web Site.

PLAN THE EXPERIMENT

1. Find a resource that lists major hurricanes that have occurred within the past five years. The Glencoe Science Web Site provides a list of sites that have information about hurricanes.
2. Choose a hurricane to research. Some recent major hurricanes include Hurricane Georges, Hurricane Fran, and Hurricane Bertha.
3. Gather data about the hurricane from the links on the Glencoe Science Web Site or the library.

PROCEDURE

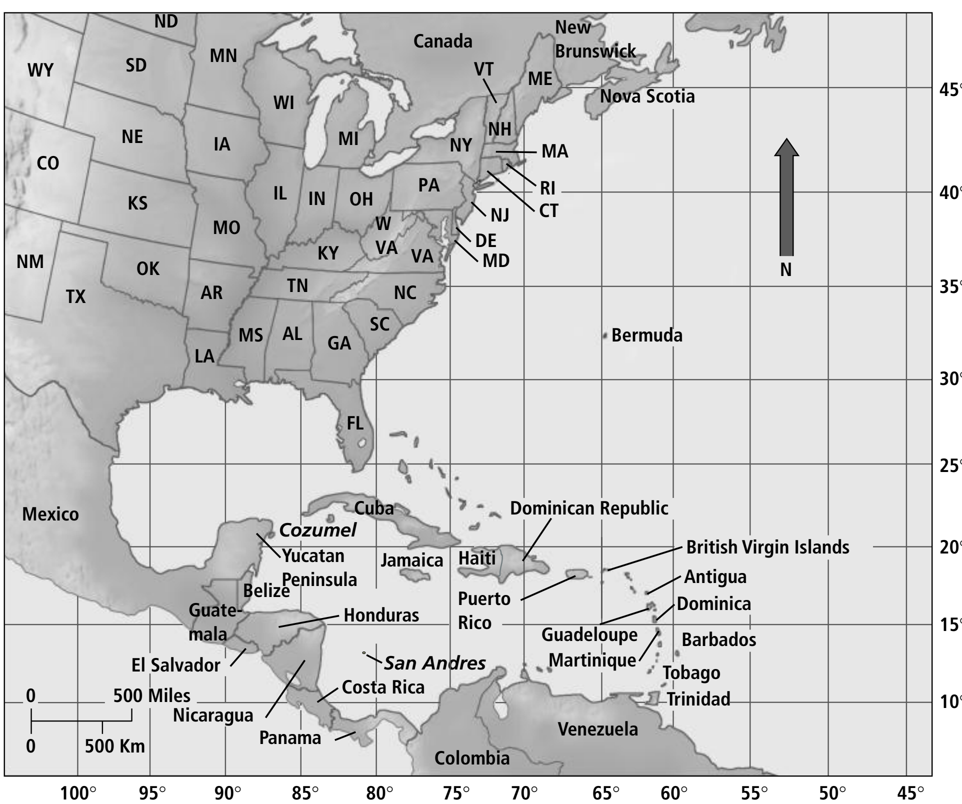
1. Draw a data table in the space provided on the next page. Incorporate your research into the table. Add any additional information that you think is important.
2. Go to the Glencoe Science Web Site at science.glencoe.com to post your data.
3. Visit sites listed on the Glencoe Science Web Site for information on other major hurricanes.

Name Class Date

Internet GeoLab

Tracking a Hurricane

DATA TABLE



Name Class Date

Internet GeoLab Tracking a Hurricane

CONCLUDE AND APPLY

Sharing Your Data Find this *Internet GeoLab* on the Glencoe Science Web Site at science.glencoe.com. Post your data in the table provided for this activity. Use the additional data from other students to complete your chart and answer the Conclude and Apply questions.

1. Plot the position, air pressure, wind speed, and stage of the hurricane at six-hour intervals throughout its existence.

2. Plot the changing position of the hurricane on your hurricane-tracking chart.

3. What was the maximum wind speed in knots that the hurricane reached?

____

4. Multiply the value from question 3 by 1.15 to find the wind speed in miles per hour. Based on this value, how would the hurricane be classified on the Saffir-Simpson scale?

____

____

5. Using your completed hurricane-tracking chart, list the landmasses over which the hurricane passed.

____

____

6. Where would you expect the storm surge to have been greatest? Explain. Compare your answer to the information you gathered on the damage inflicted by the storm. Was your answer correct?

____

____

7. How was the hurricane's strength affected when its center passed over land?

____

____

MiniLab 14

How does the atmosphere affect the transfer of energy?

Model the greenhouse effect.

Procedure

1. On a clear day, place a cardboard box outside in a shaded area. Prop two thermometers against the box. Make sure the thermometers are not in direct sun.
2. Cover one thermometer with a clean glass jar.
3. Observe and record the temperature changes of each thermometer every 2 minutes over a 30-minute period.

Analyze and Conclude

1. Make a graph showing how the temperatures of the two thermometers changed over time, using the space below.

2. Based on your graph, which thermometer experienced the greatest increase in temperature? Why?

3. Relate your observations to the greenhouse effect in the atmosphere.

Name Class Date

DESIGN YOUR OWN GeoLab

Microclimates

Microclimates can be caused by tall buildings, large bodies of water, and mountains, among other things. In this activity, you'll observe different microclimates and then attempt to determine which factors strengthen microclimates and how these factors change with distance from Earth's surface.

PREPARATION

Problem

Which type of surface creates the most pronounced microclimate?

Possible Materials

thermometer
psychrometer
paper strip or wind sock
meterstick
relative humidity chart *(Appendix F)*

Hypothesis

Hypothesize how different areas of Earth's surface, such as grassy lawns, asphalt parking lots, and bodies of water, affect local climates. Consider also whether distance from the ground might affect temperature, relative humidity, and wind speed.

Objectives

In this GeoLab, you will:

- **Design** and **carry out** an experiment to study microclimates both at Earth's surface and above its surface.
- **Observe** and **record** temperature, relative humidity, and wind speed.
- **Infer** how different surfaces and changes in height above these surfaces affect microclimates.

Safety Precautions

Be careful when you handle glass thermometers, especially those that contain mercury. If the thermometer breaks, do not touch it. Have your teacher properly dispose of the glass and the mercury.

PROCEDURE

1. As a group, write out your hypothesis. List the steps needed to test your hypothesis. Include in your plan how you will use your equipment to measure temperature, relative humidity, and wind speed at different surfaces and at various heights above these surfaces.

   ____
   ____
   ____
   ____
   ____

2. Select your sites. Possible sites include a grassy playground area, a paved parking lot, and a swimming pool.
3. Be sure to control variables. For instance, different members of your group should make observations at each site at the same time of day. You'll also need to record weather variables at several different distances above each surface. Possible distances include 5 cm, 1 m, and 2 m.
4. Make a map of your test sites. Design and construct data tables for recording your observations. You'll need separate data tables for each site. Draw your map and data tables in the space on the next page.

DESIGN YOUR OWN GeoLab

Microclimates

PROCEDURE

5. Read over your entire plan to make certain all steps are in logical order. Identify constants and variables in your plan.
6. Make sure your teacher approves your plan before you proceed with your experiment.
7. Carry out your plan.

MAPS, GRAPHS, AND DATA TABLE

Name Class Date

DESIGN YOUR OWN GeoLab

Microclimates

ANALYZE

1. **Comparing and Contrasting** Map your data. Color code the areas on your map to show which surfaces had the highest and lowest temperatures, the highest and lowest relative humidity, and the greatest and least wind speed. On your map, include data for surface areas only.

2. **Making and Using Graphs** Graph your data for each site, showing differences in temperature with height. Plot temperature on the *x*-axis and height on the *y*-axis. Repeat this step for relative humidity and wind speed.

3. **Interpreting Scientific Illustrations** Analyze your maps, graphs, and data to find patterns. Which surfaces had the most pronounced microclimates? Did height above the surface affect your data? Infer why or why not.

4. **Thinking Critically** Analyze your hypothesis and the results of your experiment. Was your hypothesis supported? Explain.

CONCLUDE AND APPLY

1. Why did some areas have more pronounced microclimates than others? Which factors seemed to contribute most to the development of microclimates?

2. Which variable changed most with height: temperature, relative humidity, or wind speed? Which variable changed least? Infer why some variables changed more than others with height.

Name Class Date

MiniLab 15

What is the chemical composition of seawater?

Determine the chemical composition of seawater using the following ingredients. The salinity of seawater is commonly measured in parts per thousand (ppt).

sodium chloride ($NaCl$)	23.48 g
magnesium chloride ($MgCl_2$)	4.98 g
sodium sulfate (Na_2SO_4)	3.92 g
calcium chloride ($CaCl_2$)	1.10 g
potassium chloride (KCl)	0.66 g
sodium bicarbonate ($NaHCO_3$)	0.19 g
potassium bromide (KBr)	0.10 g

Procedure

1. Carefully measure the ingredients and put them all in a large beaker.
2. Add 965.57 g of distilled water and mix.

Analyze and Conclude

1. How many grams of solution do you have? What percentage of this solution is made up of salts?

2. Given that 1 percent is equal to 10 ppt, what is the salinity of your solution in parts per thousand?

3. Identify the ions in your solution.

4. Infer how your solution differs from actual seawater.

Name Class Date

GeoLab Modeling Water Masses

The water in the oceans is layered because water masses with higher densities sink below those with lower densities. The density of seawater depends on its temperature and salinity. In this activity, you'll model different types of water masses to observe the effects of density firsthand.

PREPARATION

Problem

Determine how changes in salinity and temperature affect water density.

Materials

scale
graduated 500-mL cylinder
100-mL glass beakers (4)
water
red, yellow, and blue food coloring
salt
thermometer
eyedropper
graph paper
pencil
ruler
calculator

Objectives

In this GeoLab you will:

- **Compare** and **contrast** the movement of different water samples.
- **Determine** the relative densities of the water samples.
- **Predict** the arrangement of layers in a body of water.
- **Construct** and **interpret** a temperature profile.

Safety Precautions

Always wear safety goggles and an apron in the lab. Wash your hands after completing the lab.

PROCEDURE

1. Mix 200 mL of water and 7.5 g of salt in the graduated cylinder. Pour equal amounts of the salt solution into two beakers. Fill each of the two other beakers with 100 mL of freshwater.
2. Put a few drops of red food coloring in one of the salt solutions. Put a few drops of yellow food coloring in the other salt solution. Put a few drops of blue food coloring in one of the beakers of freshwater. Do not add food coloring to the other beaker of freshwater.
3. Place the beakers with the red salt solution and the blue freshwater in the refrigerator. Refrigerate them for 30 minutes.
4. Measure and record the temperature of the water in all four beakers.
5. Put several drops of the cold, red saltwater into the beaker with the warm, yellow saltwater and observe what happens. Record your observations.
6. Put several drops of the cold, blue freshwater into the beaker with the warm, clear freshwater and observe what happens. Record your observations.
7. Put several drops of the cold, blue freshwater into the beaker with the warm, yellow saltwater and observe what happens. Record your observations.

Name Class Date

GeoLab Modeling Water Masses

ANALYZE

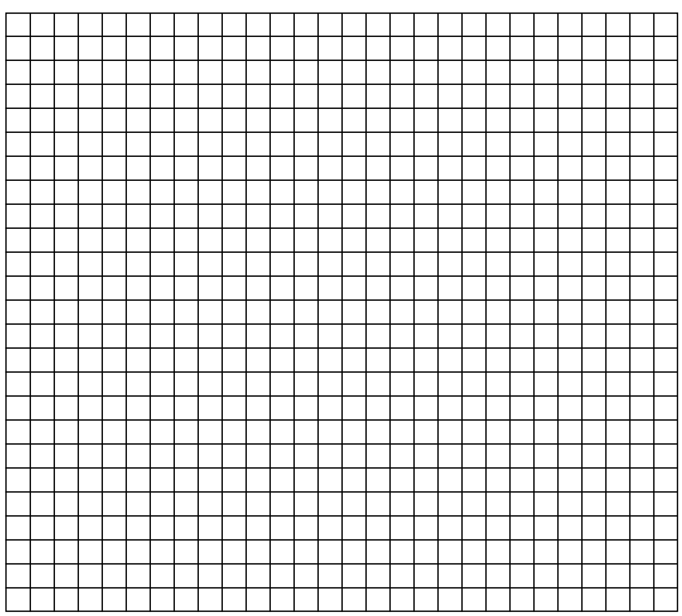
1. In your science journal, describe the movement of the cold, red saltwater in step 5. Compare this to the movement of the cold, blue freshwater in step 7. What accounts for the differences you observed?

2. Based on your observations, list the water samples by color in order of increasing density.

3. If you poured the four water samples into the graduated cylinder, how would they arrange themselves into layers by color, from top to bottom?

CONCLUDE AND APPLY

1. Assume that four water masses in a large body of water have the same characteristics as the water in the four beakers. The warm water layers are 100 m thick, and the cold layers are 1000 m thick. Graph the temperature profile of the large body of water.

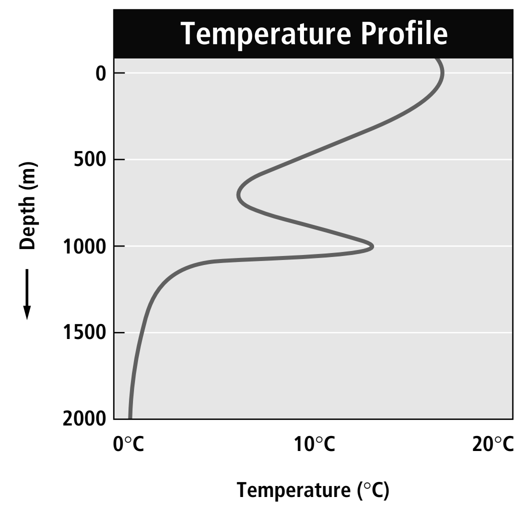


GeoLab Modeling Water Masses

CONCLUDE AND APPLY

2. What is the salinity in parts per thousand of the combined saline solutions? (*Hint:* ppt equals grams of salt per kilogram of solution. Assume that 200 mL of water has a mass of 200 g. Be sure to include the mass of the salt in the total mass of the solution.)

3. This temperature profile was constructed from measurements taken in the Atlantic Ocean off the coast of Spain. Study the profile, then infer why a high-temperature layer exists beneath the thermocline. Is this layer denser than the colder water above? Explain.



MiniLab 16

How fast do sediment grains sink?

Investigate how grain size affects settling speed.

Procedure

CAUTION: Always wear safety goggles and an apron in the lab.

1. Obtain five round pebbles and sand grains with approximate diameters of 0.5 mm, 1 mm, 2 mm, 5 mm, and 10 mm.
2. Measure the diameters of each specimen using a set of sieves. Record these measurements in the data table below.

Type of Particle	Diameter (mm)	Distance (cm)	Time (s)	Settling Speed (cm/s)

3. Fill a 250-mL graduated cylinder with cooking oil.
4. Drop the largest specimen into the oil. Measure the time it takes for the specimen to sink to the bottom of the cylinder. If the specimen doesn't fall quickly, measure the time it takes to fall a given distance. Record this time in your data table.
5. Repeat step 5 for the remaining specimens.
6. Calculate the settling speed for each specimen and fill in your data table.
7. Plot the settling speed (cm/s) against particle diameter (mm) on a graph.

Analyze and Conclude

1. How do settling speeds change as particle sizes decrease?

2. How much faster does a 10-mm particle sink compared to a 1-mm particle?

3. How long would it take a 1-mm sand grain and a 0.001-mm clay particle to settle to the bottom of the ocean at a depth of 5 km?

Name Class Date

Mapping GeoLab

Identifying Coastal Landforms

Topographic maps of coastal areas show a two-dimensional representation of coastal landforms. You can identify an emergent coast by the landforms along the coastline as well as landforms found inland.

PREPARATION

Problem

How can you identify and describe the coastal landforms of an emergent coast on a topographic map?

Materials

metric ruler
graph paper
drafting compass
calculator
pencil

PROCEDURE

1. Determine the map scale and the contour interval.
2. On the inset map, plot a west-east cross section of the coast just north of Islay Creek from the 60 ft depth contour to a point 5000 feet inland. Use a scale of 1:24 000 and a vertical exaggeration of 4.
3. Use both maps to answer the following questions.

ANALYZE

1. What kind of coastal landform is the Morro Rock Peninsula?

2. What kind of feature is Pillar Rock, and how was it formed?

3. On what coastal feature is Morro Bay State Park located? How was the feature formed?

4. What are the irregular sand hills in Morro Bay State Park?

Mapping GeoLab

Identifying Coastal Landforms

ANALYZE

5. What is the direction of the longshore transport along Morro Bay? Explain.

6. Your west-east cross section shows an elevated flat area next to the shoreline. What kind of coastal landform is this? How was it formed?

7. If sea level dropped 10 m, how would the shoreline change? How far would it move seaward? Would it become more regular or irregular? What would happen to Morro Bay?

8. If sea level rose 6 m, how would the coastal region change? Name three major changes.

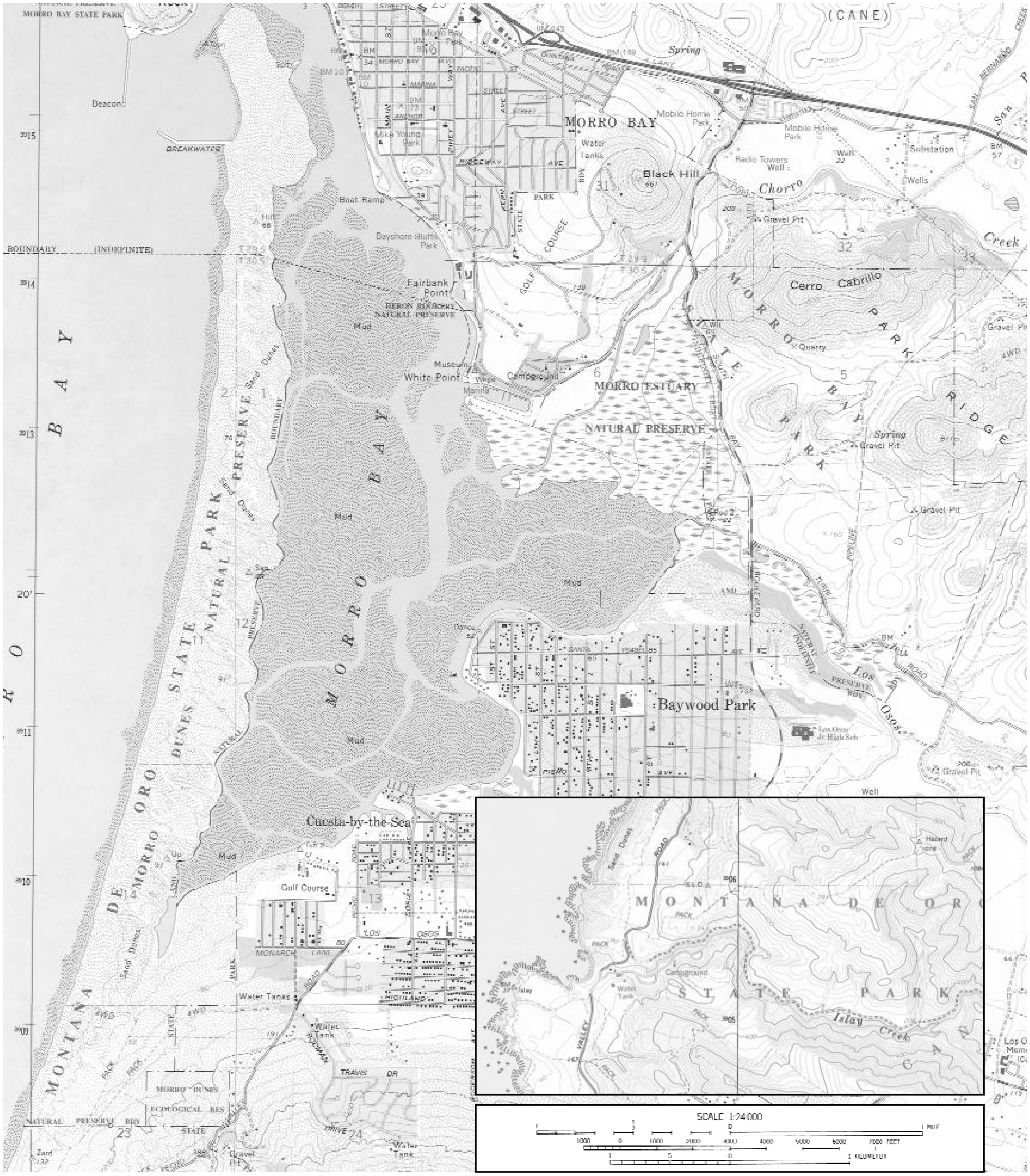
CONCLUDE AND APPLY

1. Is this portion of the California coast emergent or submergent? What features of this coastline provide evidence for your answer?

Name Class Date

Mapping GeoLab

Identifying Coastal Landforms



Name Class Date

MiniLab 17

Model ocean-basin formation

Model the formation of the South Atlantic Ocean.

Procedure

1. Use a world map to create paper templates of South America and Africa.
2. Place the two continental templates in the center of a piece of 11″ × 17″ paper and fit them together along their Atlantic coastlines.
3. Carefully trace around the templates with a pencil. Remove the templates and label the diagram "150 million years ago."
4. Use an average spreading rate of 4 cm/y and a map scale of 1 cm = 500 km to create a series of maps that accurately show the development of the Atlantic Ocean at 30-million-year intervals, beginning 150 million years ago.

Analyze and Conclude

1. Compare your last map with a world map. Is the actual width of the South Atlantic Ocean the same on both maps?

____

____

____

2. What might have caused any difference between the width in your model and the actual width of the present South Atlantic Ocean?

____

____

Name Class Date

Mapping GeoLab

Making a Paleomagnetic Map

Iron-bearing minerals in rocks record the orientation of Earth's magnetic field at the time of their formation. These preserved magnetic alignments in ocean-floor rocks can be used to date different parts of the seafloor and to determine rates of spreading along divergent plate margins.

PREPARATION

Problem

How can you use paleomagnetic data to interpret information about ocean-floor rocks?

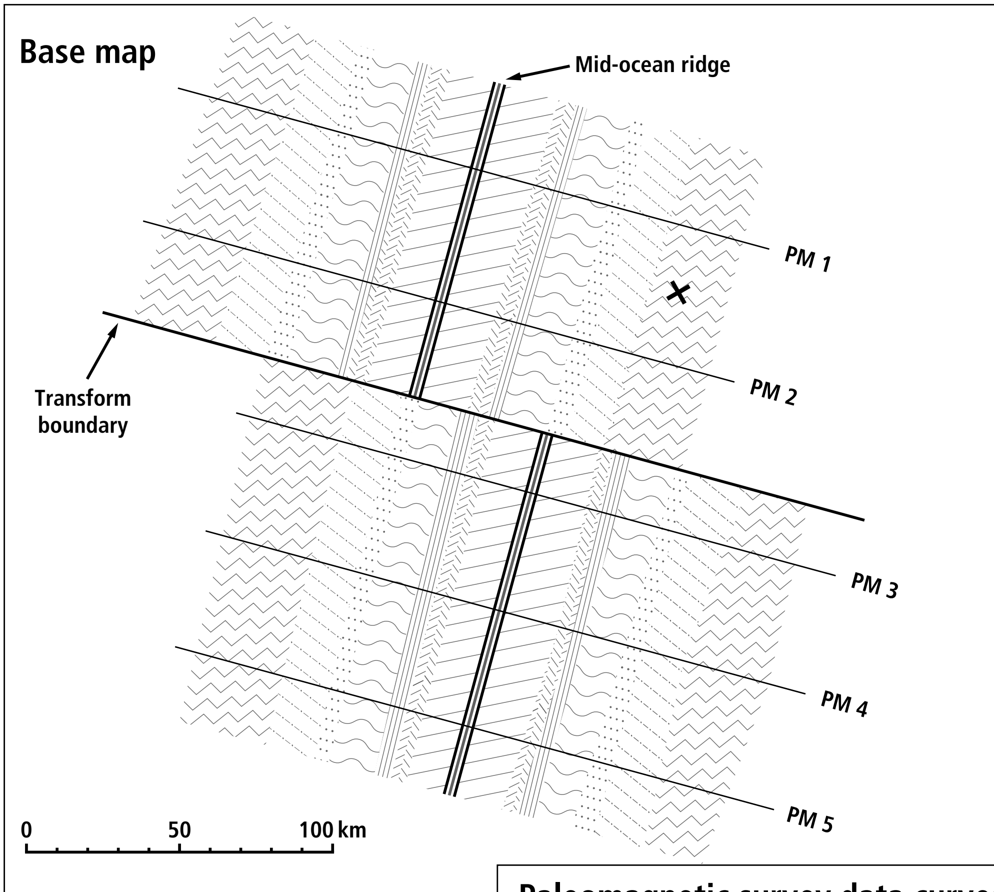
Materials

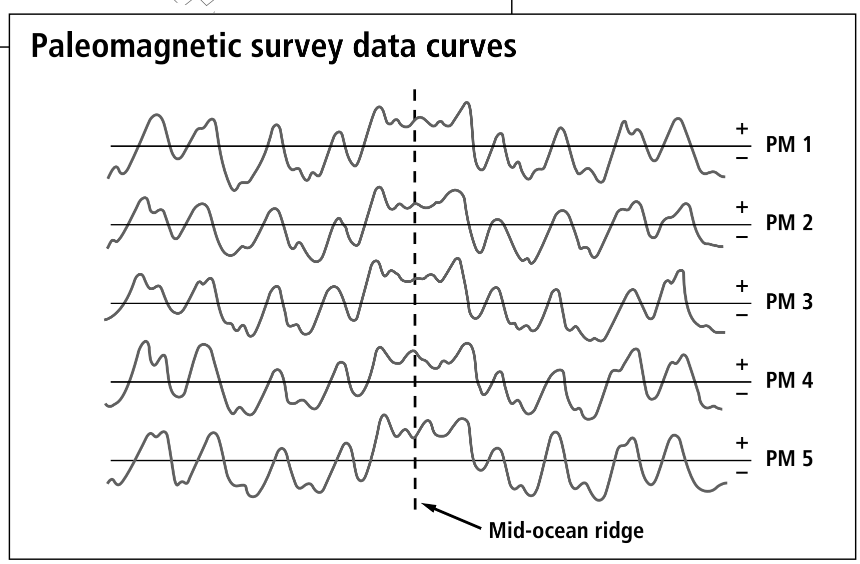
tracing paper
metric ruler
No. 2 pencil
colored pencils
Figure 1

PROCEDURE

1. Use the tracing paper and the No. 2 pencil to carefully copy the base map on the following page. Be sure to include the magnetic survey lines, the map scale, and the location indicated by the letter *X* on your tracing.
2. Transfer the magnetic survey data from PM1 to your tracing by placing the survey line on your map over the PM1 data curve on the following page. Be sure to align the mid-ocean ridge with the dashed line before you begin transferring the line. Label the line.
3. Repeat step 2 for the other four lines.
4. Next, use your ruler to draw a series of parallel lines between PM1 and PM2 to connect the corresponding positive and negative magnetic reversals. Draw the lines past PM2, but stop the lines at the transform boundary.
5. Draw another series of lines between survey lines PM3 and PM4 and between PM4 and PM5. Again, end these lines at the transform boundary.
6. The positive magnetic reading along the mid-ocean ridge represents the Brunhes Magnetic Epoch. The first negative anomaly on either side of the ridge marks the beginning of the Matuyama Magnetic Epoch. Use ***Figure 1*** to identify the magnetic reversals.
7. Assign a color for each magnetic reversal. Then, color the corresponding stripe on each side of the ridge.

Mapping GeoLab: Making a Paleomagnetic Map





Name Class Date

Mapping GeoLab

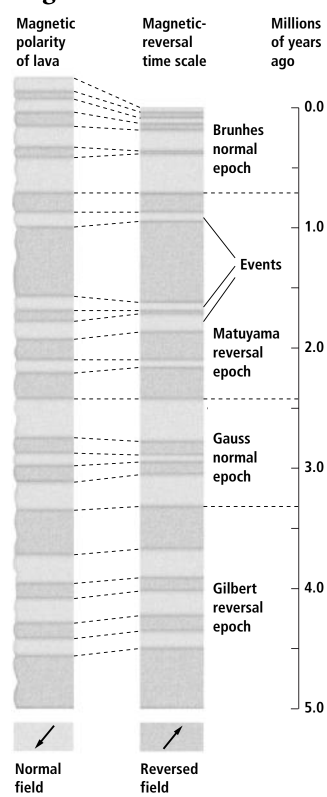
Making a Paleomagnetic Map

ANALYZE

1. Why was it necessary to color corresponding stripes on each side of the ridge in step 7?

2. Use ***Figure 1*** to determine the age of the seafloor at location *X*.

Figure 1



CONCLUDE AND APPLY

1. What might cause an individual magnetic stripe of ocean-floor crust to vary in width?

2. What is the average spreading rate along this section of the mid-ocean ridge?

Name Class Date

MiniLab 18

How does silica affect lava flow?

Model the changes in lava viscosity with the addition of silica.

Procedure

CAUTION: Always wear safety goggles and an apron in the lab.

1. Pour 120 mL of dishwashing liquid into a 250-mL beaker.
2. Stir the liquid with a stirring rod. Describe the viscosity.
3. Add 30 g of NaCl (table salt) to the liquid. Stir well. Describe what happens.
4. Repeat step 3 three more times.

Analyze and Conclude

1. What do the liquid and NaCl represent?

____

____

____

2. How does an increase in silica affect lava viscosity?

____

____

____

3. Basaltic eruptions are called flows because of the way they move across Earth's surface. What can you infer about the silica content of a basaltic flow?

____

____

____

Name Class Date

Internet GeoLab: Ranking Hazardous Volcanoes

Some volcanoes can be explosively dangerous. Along with clouds of ash and other volcanic debris that can linger in the air for years after an eruption, pyroclastic flows, landslides, and mudflows are common volcanic hazards. An explosive volcano may not be a hazard to human life and property, however, if it is located in a remote area or erupts infrequently. A number of factors must be taken into account to determine if a particular volcano poses a risk.

PREPARATION

Problem

Which volcanoes on our planet pose the greatest risk to human life and property?

Hypothesis

Form a hypothesis about where you think the most hazardous volcanoes are located on Earth. Think about the potential risk to people and property near the volcano when formulating your hypothesis. Write your hypothesis in the space below.

____

____

____

Objectives

In this GeoLab, you will:

- **Gather** and **communicate** data about three volcanoes in different parts of the world.
- **Form conclusions** about the hazards posed by the volcanoes based on their location, size, lava type, and eruptive history.

Data Sources

Go to the Glencoe Science Web Site at science.glencoe.com to find links to volcano data on the Internet. You can also use current reference books and scientific magazines to aid in the collection of data.

PROCEDURE

1. Select a country and find out if there are any volcanoes in that country. If there are no volcanoes, choose another country. If there are a lot of volcanoes in that country, narrow your search.
2. Repeat step 1 for two other volcanoes. Copy and complete the data table on the next page with the information about each of the three volcanoes you selected.

Internet GeoLab

Ranking Hazardous Volcanoes

RANKING OF SOME HAZARDOUS VOLCANOES			
Volcano name			
Country			
Location of volcano (latitude and longitude)			
Type of volcano			
Composition of lava/ Explosiveness			
Date of last eruption			
Eruption interval (number of eruptions over a period of time)			
Height of volcano			
Distance to nearest population center			
Approximate number of people living near the volcano			
Type(s) of potential hazards			
Human hazard ranking (high, medium, low)			

Internet GeoLab

Ranking Hazardous Volcanoes

CONCLUDE AND APPLY

Sharing Your Data Find this Internet GeoLab on the Glencoe Science Web Site at science.glencoe.com. Post your data in the table provided for this activity. Use the additional data from other students to complete your chart and answer the Conclude and Apply questions.

1. Which of the volcanoes you researched threatens the greatest number of people? Where is this volcano located?

2. Analyze the data posted by others at the science.glencoe.com site. Which country has the greatest number of potentially dangerous volcanoes? Why?

3. Which country has the greatest total population threatened by volcanoes?

MiniLab 19

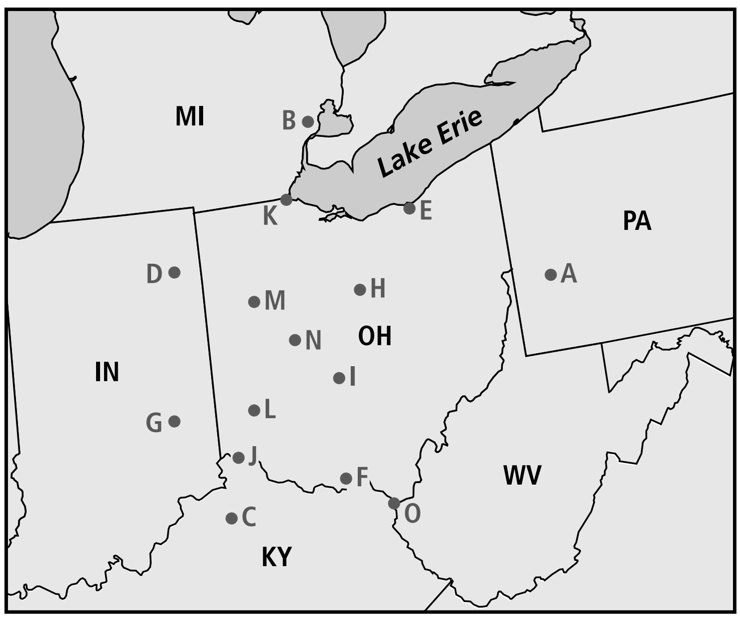
How is a seismic–intensity map made?

Make a Map using seismic–intensity data.

Procedure

1. Trace the map onto paper. Mark the locations indicated by the letters on the map.
2. Plot these Mercalli intensity values on the map next to the correct letter: A, I; B, III; C, II; D, III; E, IV; F, IV; G, IV; H, V; I, V; J, V; K, VI; L, VIII; M, VII; N, VIII; O, III.
3. Draw contours on the map to separate the intensity values.

Intensity Values of a Quake



Analyze and Conclude

1. What is the maximum intensity value?

2. Where is the maximum intensity value located?

3. Where is the earthquake's epicenter?

Name Class Date

GeoLab Locating an Epicenter

The separation of P- and S-waves on a seismogram allows you to estimate the distance between the seismic station that recorded the data and the epicenter of that earthquake. If the epicentral distance from three or more seismic stations is known, then the exact location of the quake's epicenter can be determined.

PREPARATION

Problem

Determine the epicenter location and the time of occurrence of an actual earthquake, using the travel times of P- and S-waves recorded at three seismic stations.

Materials

map on facing page
calculator
drafting compass
metric ruler
tracing paper

Objectives

In this GeoLab, you will:

- **Determine** the arrival times of P- and S-waves from a seismogram.
- **Interpret** travel-time curves.
- **Plot** an epicenter location on a map.
- **Relate** seismic data to plate tectonics.

Safety Precaution

GeoLab Data Table

Seismic Station	P-S Separation (min)	Epicenter Distance (km)	Map Distance (cm)
Berkeley, CA			
Boulder, CO	3.5		
Knoxville, TN	4.2		

PROCEDURE

1. The seismogram in ***Figure 1*** shows the arrival time of the first P-wave at 10 h, 50 min, 32 s GMT, Greenwich mean time. Estimate the arrival time of the first S-wave to the nearest tenth of a minute.
2. Subtract this S-wave time from the initial P-wave time. What is the P-S separation on the seismogram, in minutes and tenth of minutes? Enter this value in the data table for the Berkeley seismic station.
3. The P-S separation observed on two other seismograms, which are not shown, are also listed in the table. Use the travel-time curves in ***Figure 2*** to determine the distances at which the P- and S-curves are separated by the time intervals listed in the table. Enter these distances in the table under the Epicenter Distance.

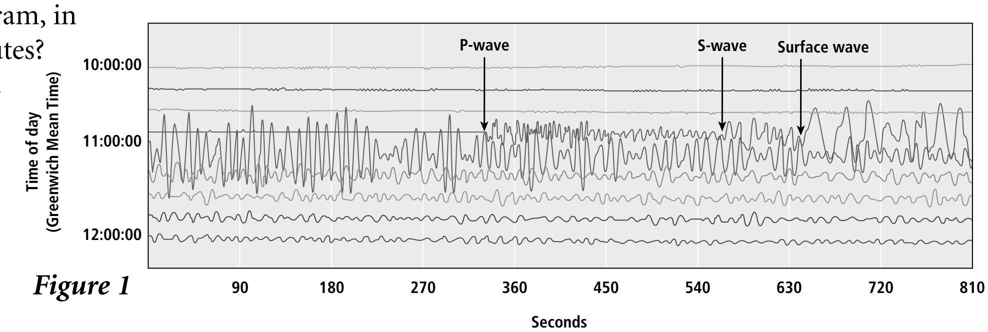


Figure 1

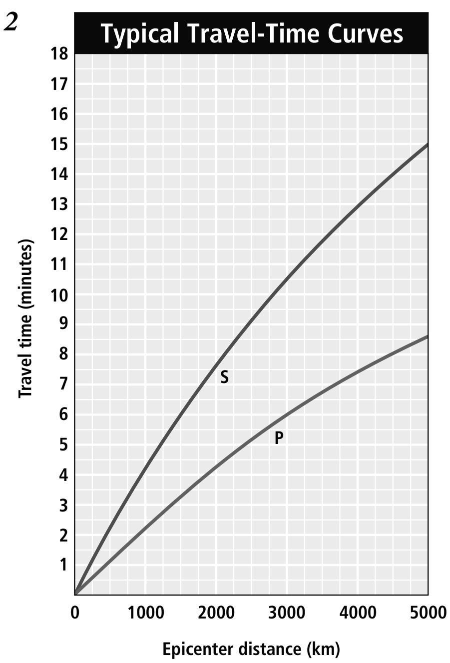
GeoLab Locating an Epicenter

PROCEDURE

4. Carefully trace the map on this page. Accurately mark the three seismic station locations.
5. Determine the epicentral distances on your tracing, using a scale of 1 cm = 500 km. Enter your values in the table under the Map Distance.
6. Use the compass to draw circles around each station on the map with the radius of each circle equal to the map distance, in cm, for that station.
7. Mark the point of intersection. This is the epicenter of the earthquake.
8. Determine the time of occurrence of this earthquake by reading the P-wave travel time from ***Figure 2*** for the epicentral distance for Berkeley. Subtract this from the initial P-wave arrival time at Berkeley, which was 10 h, 50.5 min. Express this time in terms of hours, minutes, and seconds.

United States and Mexico

Figure 2



Name Class Date

GeoLab Locating an Epicenter

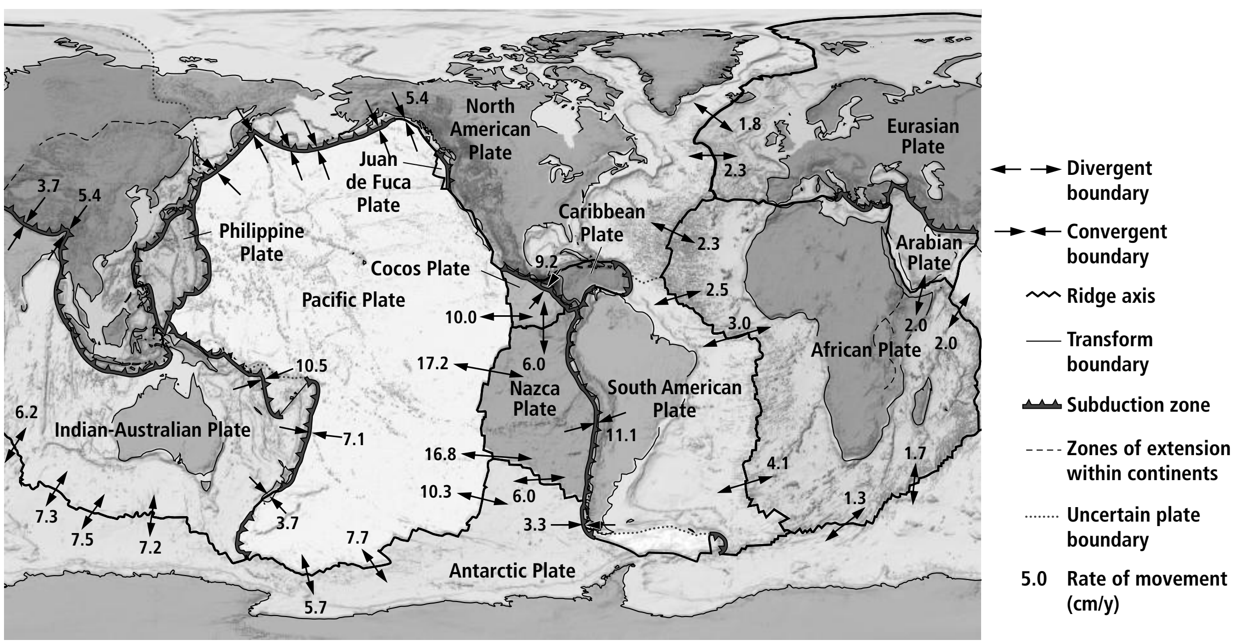
ANALYZE

1. Where is this epicenter located?

2. In which major seismic belt did this earthquake occur?

3. Use ***Figure 3*** to determine which plates form the boundary associated with this earthquake.

Figure 3 **Earth's Tectonic Plates**



CONCLUDE AND APPLY

1. What type of plate boundary is this?

2. Briefly describe the relative motion of the plates involved.

3. Describe the tectonic motions that caused the earthquake.

Name Class Date

MiniLab 20

How large is an ocean ridge?

Compare the width of part of an ocean ridge with the size of the United States.

Procedure

1. Obtain physiographic maps of the Atlantic Ocean floor and North America.
2. Use tracing paper to copy the general outline of a section of the Mid-Atlantic Ridge. The length of the section should be long enough to stretch from San Francisco to New York City. Mark the ridge axis on your tracing.
3. Place the same tracing paper on the map of North America with the ridge axis running east-west. Trace the general outline of the United States onto the paper.

Analyze and Conclude

1. How wide is the Mid-Atlantic Ridge?

2. Are there any parts of the United States that are not covered by your tracing?

3. If a mountain range the size of the Mid-Atlantic Ridge were located in the United States as you have drawn it, how would it affect the major river drainage patterns and climates in various parts of North America?

Mapping GeoLab

Making a Map Profile

A map profile, which is also called a cross section, is a side view of a geographic or geologic feature constructed from a topographic map. You will construct and analyze a profile of the Grand Tetons, a mountain range in Wyoming that formed when enormous blocks of rocks were faulted along their eastern flanks, causing the blocks to tilt to the west.

PREPARATION

Problem

How do you construct a map profile?

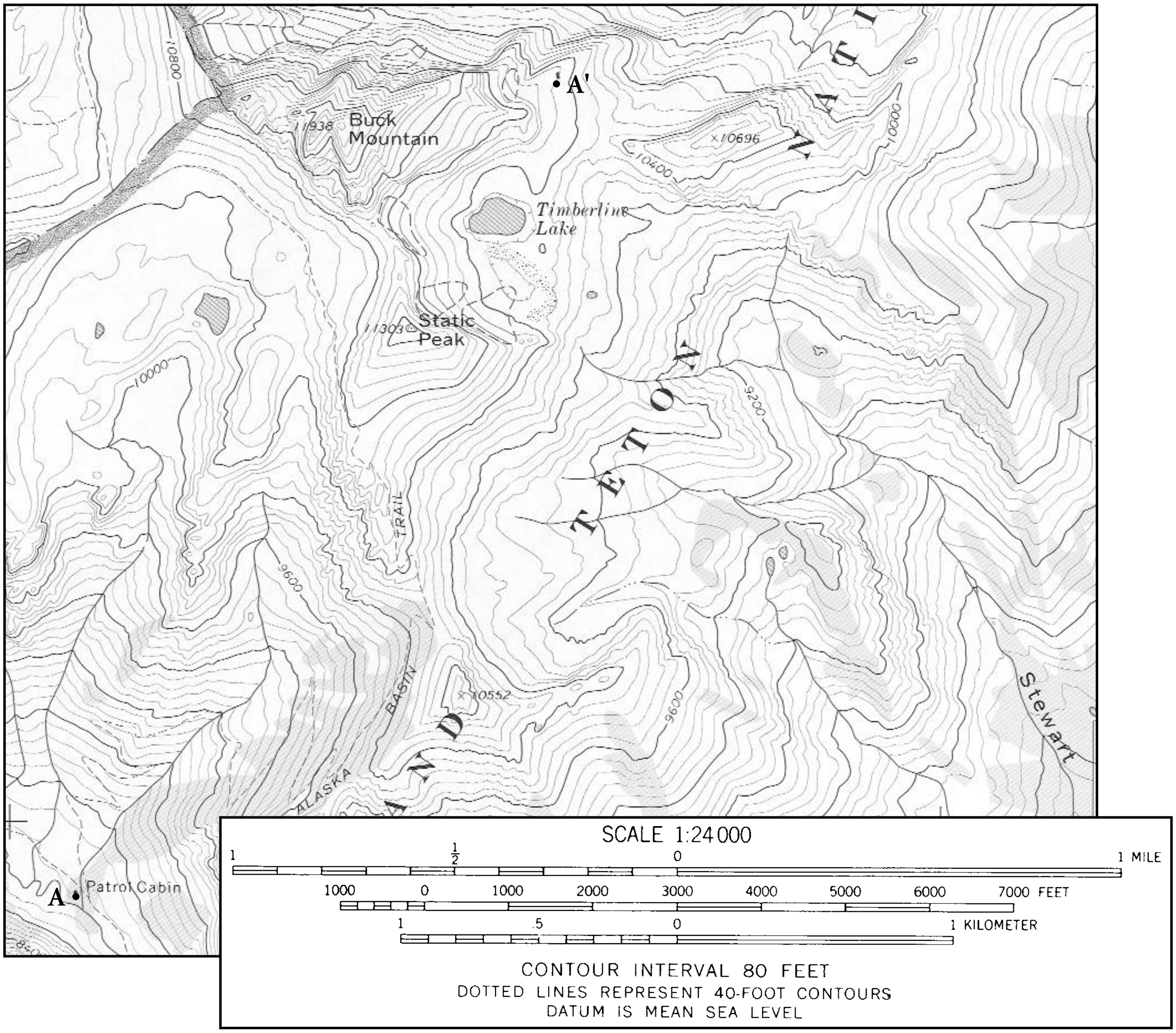
Materials

metric ruler
sharp pencil
graph paper

PROCEDURE

1. On the graph paper, make a grid like the one shown on the facing page.
2. Place the edge of a paper strip along the profile line AA' and mark where each major contour line intersects the strip.
3. Label each intersection point with the correct elevation.
4. Transfer the points from the paper strip to the profile grid.
5. Connect the points with a smooth line to construct a profile of the mountain range along line AA'.
6. Label the major geographic features on your profile.

Mapping GeoLab: Making a Map Profile



Name Class Date

Mapping GeoLab

Making a Map Profile

ANALYZE

1. Describe how the map profile changes with distance from point A.

2. What is the elevation of the highest point on the map profile? The lowest point?

3. What is the average elevation shown in the profile?

4. Calculate the total relief shown in the profile.

CONCLUDE AND APPLY

1. Is your map profile a scale model of the topography along line AA'? Explain.

2. What determined the scale of this map profile?

3. Why are map profiles made from topographic maps often exaggerated vertically?

Name Class Date

MiniLab 21

How is relative age determined?

Demonstrate how the principles of superposition, original horizontality, and cross-cutting relationships are used to determine the relative ages of rock layers.

Procedure

1. Draw a diagram of an outcrop with four horizontal layers. Label the layers 1 through 4.
2. Draw a vertical intrusion from layer 1 to layer 3.
3. Label the bottom-left corner of the diagram *X* and the top-right corner *Y*.
4. Cut the paper diagonally from *X* to *Y*. Move the left-hand piece 1.5 cm along the cut.

Analyze and Conclude

1. How can you determine the relative ages of the strata in your diagram?

____

____

____

2. How does the principle of cross-cutting relationships explain the age of the vertical intrusion?

____

____

____

3. What does line XY represent? Is line XY older or younger than the vertical intrusion and surrounding strata? Explain.

____

____

____

____

Name Class Date

DESIGN YOUR OWN GeoLab

Interpreting History-Shaping Events

What do volcanic eruptions, mountain building, flooding, and drought have in common? They are all events that in some way affect life and the surface of Earth. How strong an impact does each event have on the future of Earth? How different would things be if certain events in Earth's history had not happened?

PREPARATION

Problem

What are the most important events in Earth's history? Where do they fit in the long history of Earth's development? Why are these events important? Do some geologic time periods contain more history-shaping events than others?

Possible Materials

paper
pencil
posterboard
meterstick
tape measure
colored pencils
calculator
encyclopedia
reference books

Hypothesis

Brainstorm about Earth's history and the changes that Earth has experienced over time. Hypothesize which events had the most impact on the direction that Earth's development has taken. Determine where additional data might be available and collect resources to use as your references. Describe the best way to list and illustrate your choices.

Objectives

In this GeoLab, you will:

- **Hypothesize** about important events in Earth's development.
- **Explain** why such events had a significant impact on Earth's history.
- **Communicate** your results and interpretations.

PROCEDURE

1. Review the list of events in Table 1.
2. As a group, decide on and make a list of events that you think can help support your hypothesis.
3. Choose two other resources and use them to find at least ten more events to add to your list.
4. Design and construct a way to exhibit and explain your results.
5. Check your plan. Make sure your teacher has approved your plan before you proceed.
6. Carry out your plan.

Table 1 EARTH HISTORY-SHAPING EVENTS

Origin of the solar system	Dinosaurs are abundant, 180 M.Y.B.P.
Earth forms, 4.6 B.Y.B.P.	The first birds evolve, 180 M.Y.B.P.
Oceans form, 4.0 B.Y.B.P	Asteroid impact, 66 M.Y.B.P.
Primitive algae evolves, 3.3 B.Y.B.P	Modern groups of mammals appear, 60 M.Y.B.P.
First fossil evidence of multicellular organisms, 1.2 B.Y.B.P.	Earliest horses evolve, 60 M.Y.B.P.
Trilobites are abundant, algal reefs form, 600 M.Y.B.P.	Large mammals evolve, 40 M.Y.B.P.
First corals evolve, invertebrates dominate oceans, 500 M.Y.B.P.	Carnivores abundant, 11 M.Y.B.P.
First land plants evolve, insects appear, 440 M.Y.B.P.	Adirondack mountains uplifted, 11 M.Y.B.P.
Fishes are abundant, early amphibians evolve, 400 M.Y.B.P.	First humanoids evolve (*Australopithecus africanus*), 3 M.Y.B.P.
Forests that become coal swamps are present, 300 M.Y.B.P.	Ice Age of the Pleistocene begins, 1 M.Y.B.P.
Earliest reptiles evolve, 300 M.Y.B.P.	Mammoths and mastodons are abundant, 1 M.Y.B.P.
Allegheníán Orogeny occurs, 270 M.Y.B.P.	Large ice sheets retreat ~ 10 000 years ago
Trilobites become extinct, 270 M.Y.B.P.	Mount Vesuvius erupts and destroys Pompeii, A.D. 79
Earliest dinosaurs appear, 225 M.Y.B.P.	New Madrid Earthquake, 1811–1812
Pangaea breaks up, 225 M.Y.B.P.	Chicago Fire, 1871
Earliest mammals evolve, 200 M.Y.B.P.	Krakatoa eruption in Java, 1883
	Chicago Bulls win 5th World Championship, 1997

Name Class Date

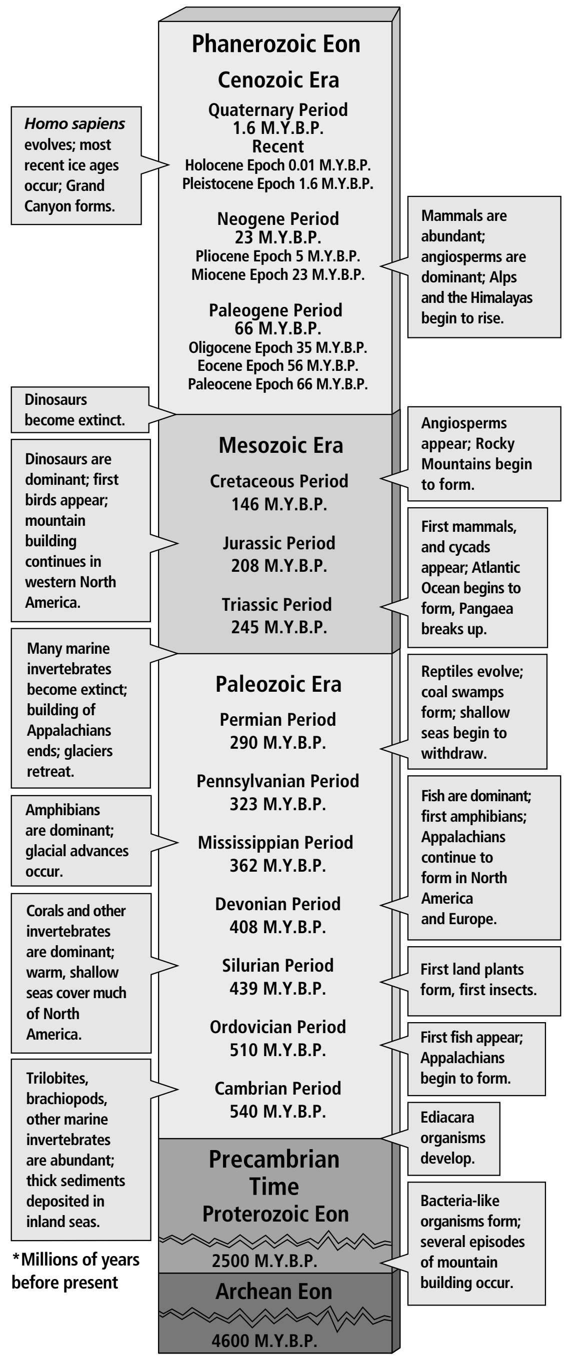
DESIGN YOUR OWN GeoLab

Interpreting History-Shaping Events

ANALYZE

1. Interpreting Observations Did more history-shaping events seem to have occurred early in Earth's history or later on? Explain.

2. Comparing and Contrasting Plot your list of events on the geologic time scale. Compare and contrast the number of events in each era. Does any geologic time period contain more history-shaping events than others? Explain.



Name Class Date

DESIGN YOUR OWN GeoLab

Interpreting History-Shaping Events

ANALYZE

3. Observing and Inferring Choose one event in the Mesozoic and infer how Earth's history might have progressed had the event not happened.

CONCLUDE AND APPLY

1. How do extinction events influence the development of life on Earth?

2. How do mountain-building events and glaciations affect the development of life on Earth?

3. If another planet experienced the same events that you chose, would that planet be identical to Earth? What would be similar or different?

Name Class Date

MiniLab 22

Why are red beds red?

Model the formation of red beds with iron, oxygen, and water.

Procedure

CAUTION: Steel wool can be sharp. Wear gloves in the lab.

1. Place 40 mL of white sand in a 150-mL beaker.
2. Add water so that the total volume is 120 mL.
3. Add 15 mL of bleach.
4. Place a piece of steel wool about the size of your thumbnail, in the beaker. Cover the beaker with a petri dish and allow it to stand in a quiet place for one day.
5. Remove the steel wool and stir the contents of the beaker. Allow the mixture to settle for 5 minutes after stirring.
6. Slowly pour off the water so that the iron-oxide sediment is left behind.
7. Stir the mixture again, then spoon some of the sand onto a watch glass and allow it to dry.

Analyze and Conclude

1. Describe how the color of the sediment changed.

___

___

___

2. Where does the iron in the experiment come from?

___

___

3. Where in nature does the red in rocks come from?

___

___

___

4. What do you think is the function of the bleach?

___

___

___

Name Class Date

Mapping GeoLab

Mapping Continental Growth

Plotting the distribution of the ages of rocks onto a map helps geologists to reconstruct the history of continental accretion. During the Precambrian, microcontinents and island arcs collided to form what would become the modern continents.

PREPARATION

Problem

How can the distribution of the ages of rocks plotted on a map be used to interpret the growth of a continent?

Materials

paper
pencil
colored pencils
metric ruler

PROCEDURE

1. Your teacher will set up locations with a rock sample at each location.
2. Make an outline map of your classroom similar to the map on the next page, using the scale 1 cm = 100 km. Use the space below.
3. Visit each location where a rock sample has been set out. Plot each location and record the age of each rock on the map.
4. After you have recorded all the locations, use a pencil to draw lines on the map that separate rocks of different ages. Be careful not to simply connect the dots.
5. Use a different colored pencil to shade in the areas on the map that contain rocks of the same age. These are your geologic age provinces.
6. Make a key for your map by drawing a small rectangle for each different geologic age province. Name the oldest province "Province A," the next oldest "Province B," and so on for all provinces.

Name Class Date

Mapping GeoLab: Mapping Continental Growth

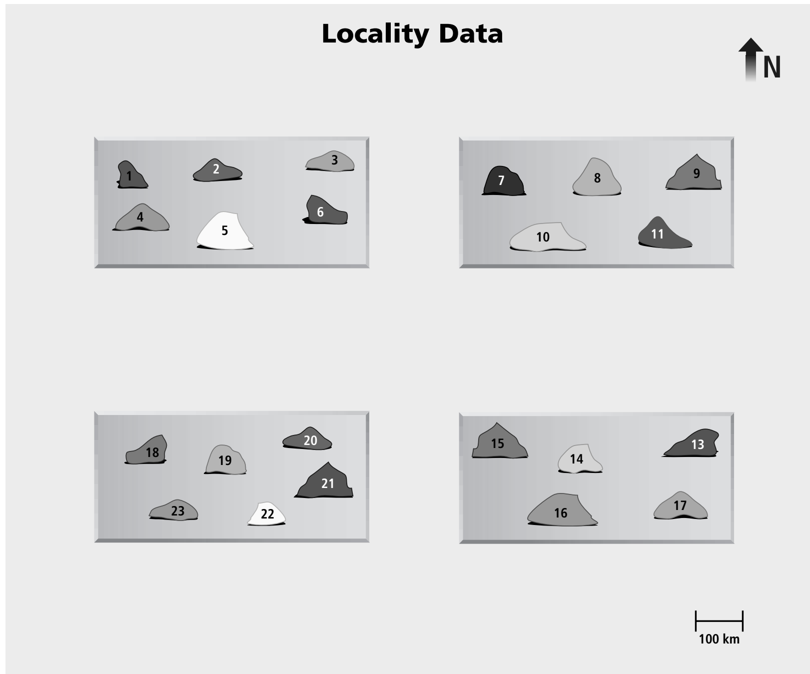


Figure 1

ANALYZE

1. Use the ruler to measure the east-to-west width of Province A. Convert the map scale to ground distance by using the scale 1 cm = 1 km.

2. Why do some of your classmates have different answers? Who is right?

3. Where is the oldest province located relative to all the other provinces?

Mapping GeoLab

Mapping Continental Growth

CONCLUDE AND APPLY

1. Based on the distribution of the geologic age provinces, describe the sequence of collisional events that formed the craton represented by your map.

____

____

____

2. According to your map, where would you find metamorphic rocks? What type of metamorphism would have occurred?

____

____

____

____

____

____

The Precambrian Shield in North America

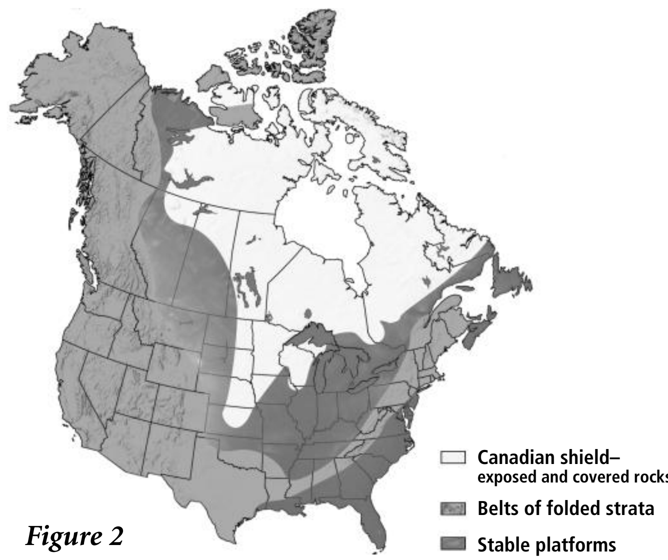


Figure 2

3. If your map represents an area composed of Precambrian-aged rocks, would the mountains that formed from collisions still be high and rugged? Explain.

____

____

____

4. Compare the distribution of age provinces on your map with ***Figure 2***. What are the similarities?

____

____

____

5. Based on what you learned in this activity, describe the formation of the North American Craton.

____

____

____

____

Name Class Date

MiniLab 23

Collisions and Shelves

Model the difference in continental shelf area between individual continents and one supercontinent.

Procedure

1. Using 250 g of modeling clay, make a sphere and flatten it into a disk that is 1/2 cm thick. This represents a craton.
2. Divide another 250 g of clay into 2 equal spheres and flatten them as above.
3. Roll 250 g of modeling clay into 3 long cylinders with 1/2 cm diameters. Wrap the cylinders around the edges of the clay disks. These represent continental shelves.
4. Using the formula area = πr^2, calculate the area of the large craton and the area of the large craton plus the continental shelf. Subtract the craton area from the total area. This equals the area of the continental shelf.
5. Repeat step 4 for each of the small models.

Analyze and Conclude

1. Which has more shelf area, two small continents or one large continent? Why?

____

____

____

2. Tropical oceans contain the greatest diversity of animals. If there is only one supercontinent, how does this further limit the amount of habitat space?

____

____

____

____

____

____

3. Explain how reduced habitat space, Pangaea, and the mass extinction at the end of the Permian are related.

____

____

____

____

GeoLab Symmetry, Shape, and Shells

Brachiopods and bivalves have been present in Earth's oceans since the Cambrian. Both have two shells and live in marine environments. But the similarity ends there. How can you tell the two apart? Oysters are bivalves that are known for the pearls they secrete inside their shells. Can you distinguish an oyster from a brachiopod? If you were searching for pearls, you would want to know how!

PREPARATION

Problem

Distinguish between brachiopods and bivalves and interpret the environment where a brachiopod lived based on its shell.

Materials

fossil brachiopods (4),
each belonging to a different species
fossil bivalves (4),
each belonging to a different species
paper
pencil

Objectives

In this GeoLab, you will:

- **Determine** if a fossil is a brachiopod or a bivalve.
- **Describe** the symmetry of fossil brachiopods and bivalves.
- **Infer** the environment in which different fossil brachiopods lived.

Safety Precautions

Always wear safety goggles and an apron in the lab.

PROCEDURE

1. Use the data table on the next page. If you choose to add more columns to record additional data, use the blank space provided.
2. Examine the fossils provided by your teacher.
3. Determine where the plane of symmetry is for each specimen. An organism that can be divided into two nearly identical halves has bilateral symmetry.
4. Identify the specimens as brachiopods or bivalves based on their symmetry and record this in your data table. Brachiopod symmetry runs across both shells. Bivalve symmetry runs between the shells.
5. Divide the brachiopods into two groups based on whether you think they lived in a deeper water, low-energy environment, or in a shallow water, high-energy environment. Record this in your data table.

Name Class Date

GeoLab Symmetry, Shape, and Shells

ANALYZE

1. **Interpreting Observations** Explain how symmetry is useful in determining whether a fossil is a brachiopod or a bivalve.

2. **Applying and Interpreting** If you only had one shell, how could you determine if it was the shell of a brachiopod or the shell of a bivalve?

3. **Comparing and Contrasting** Explain the similarities and differences between a streamlined auto and a smooth brachiopod, in terms of their place in wind or water.

FOSSIL DATA

Specimen	Brachiopod or Bivalve	Deeper water, low-energy environment or shallow water, high-energy environment
1		
2		
3		

Name Class Date

GeoLab Symmetry, Shape, and Shells

CONCLUDE AND APPLY

1. What principle did you use to determine the environment in which the fossil brachiopods lived? Explain.

2. Hypothesize about the reasons for the different shell types for brachiopods that live in different environments.

3. All living brachiopods pump water through their shells and filter organic particles out of that water to feed. Some brachiopod shells close along a straight line, whereas others close along a zigzag line. What is the benefit of having a zigzag opening for a filter feeding brachiopod?

MiniLab 24

Glaciers and Deposition

Model the deposition of sediment by melting glaciers.

Procedure

1. Pour water into a large, wide-mouthed jar until it is approximately 3/4 full.
2. Add a mixture of clay, silt, sand, and pebbles to the jar. Put the lid tightly on the jar.
3. Shake the jar for 30 seconds and allow the contents to settle.
4. Finely crush enough ice to fill approximately three-fourths of a second large, wide-mouthed jar. Stir a mixture of clay, silt, sand, and pebbles into the ice and pour the mixture into the jar.
5. Allow the ice to melt and the particles to settle overnight.

Analyze and Conclude

1. Describe the differences in the way the sediments settled in the two jars.

____

____

____

____

2. Compare and contrast the sorting of the grain sizes in the two jars.

____

____

____

3. How could geologists use this information to determine whether sediment had been deposited by a glacier or by running water?

____

____

____

____

____

Name Class Date

Internet GeoLab

Huge Appetites

The study of how an organism interacts with its environment is called ecology. Ecology includes how an organism obtains energy from its environment. Animals do this by eating. Determining the diet of modern animals is relatively easy to do. We can observe them in their habitat and watch what they eat, or we can examine their feces. Paleoecology is the ecology of ancient organisms. Part of dinosaur paleoecology includes determining what and how dinosaurs ate. Imagine how much food some dinosaurs must have eaten!

PREPARATION

Problem

How do paleontologists tell what types of food different dinosaurs ate?

Hypothesis

What kind of evidence might you use to determine what type of diets dinosaurs ate? What are the diets of different animals today? Think about the characteristics of these different animals. Do most meat eaters share certain characteristics? What about plant eaters? **Form a hypothesis** about the skeletal characteristics of plant eaters and meat eaters.

____

____

____

____

Objectives

In this GeoLab, you will:

- **Gather** data and **communicate** interpretations about the characteristics of meat eaters and plant eaters.
- **Form conclusions** about the characteristics of plant eating and meat eating dinosaurs.
- **Discover** how sauropods might have shared food resources.

Data Sources

Go to the Glencoe Science Web Site at science.glencoe.com to find links to fossil data on the Internet. You can also visit your library or local natural history museum to gather information about dinosaur diets.

This Late Cretaceous *Tyrannosaurus* is from Alberta, Canada.

Triceratops was an herbivore.

Name Class Date

Internet GeoLab: Huge Appetites

PLAN THE EXPERIMENT

1. Find a resource that describes skeletal characteristics of meat-eating and plant-eating dinosaurs. The Glencoe Science Web Site lists sites with information about dinosaurs.
2. Gather information from the links on the Glencoe Science Web Site or the library about the environments that these two types of dinosaurs lived in and which dinosaurs lived in the same environments.
3. Design a data table in the space below to record your research results. Include categories such as Dinosaur Name, Meat or Plant Eater, Food Preference, Skeletal Characteristics, Jaw and Teeth Characteristics, and so on.

PROCEDURE

1. Complete your data table, including all information that you think is important.
2. Go to the Glencoe Science Web Site at science.glencoe.com to post your data.
3. Visit sites listed on the Glencoe Science Web Site for more information on the diets of dinosaurs.

DATA TABLE

Name Class Date

Internet GeoLab Huge Appetites

CONCLUDE AND APPLY

Sharing Your Data Find this Internet GeoLab on the Glencoe Science Web Site at science.glencoe.com. Post your data in the table provided for this activity. Use the additional data from other students to complete your chart and answer the Conclude and Apply questions.

1. What part of a dinosaur skeleton is most important in determining its diet? Why? What is the likelihood that this part of a skeleton will be preserved?

2. What are some other characteristics associated with dinosaur skeletons that help paleontologists determine what their diets were like?

3. Which were more abundant, meat-eating dinosaurs or plant-eating dinosaurs? Why?

4. How did sauropods share food resources? Describe the evidence used by paleontologists to determine how sauropods shared food resources.

5. How could the same evidence that is used to determine the diets of dinosaurs be used for other animals?

MiniLab 25

Hard Water

Determine the hardness of water samples by observing how easily soap suds can be produced.

Procedure

1. Obtain six clean baby-food jars. Label them A through F.
2. Measure 20 mL of one water sample. Pour the water into the jar marked A.
3. Repeat step 2 four more times, using a different water sample for jars B through E.
4. Measure 20 mL of distilled water. Pour this water into jar F.
5. Place one drop of liquid soap in sample jars A through E. Do not place any soap in jar F. Tighten the lids. Then shake each jar vigorously for 5 seconds.
6. Using the following rating scale, record in your data table the amount of suds in each jar: 1—no suds, 2—few suds, 3—moderate amount of suds, 4—lots of suds.

Jar	Amount of Suds
A	
B	
C	
D	
E	
F	

Analyze and Conclude

1. List the water samples in order from hardest to softest.

____

2. What is the difference between hard and soft water?

____

____

____

3. What are some disadvantages of hard water?

____

____

____

Name Class Date

DESIGN YOUR OWN GeoLab

Designing a Solar Desalinator

Most of Earth's surface is covered with salty ocean water. Ocean water can be used for drinking water and other purposes if the salts are first removed. Solar energy can be used to evaporate water from seawater, leaving the salts behind. The evaporated water can then be condensed into freshwater.

PREPARATION

Problem

How can you build a small-scale, working solar desalinator?

Possible Materials

clear plastic or Plexiglas
large pans to hold water
salt water
collecting containers
lamp
glass pan or beaker
hot plate

Hypothesis

The Sun's energy can be collected to desalinate salt water.

Objectives

In this GeoLab, you will:

- **Design** a model of a working solar desalinator.
- **Assemble** the model from design plans.
- **Test** the effectiveness of the design model.
- **Analyze** the model to suggest possible improvements.

Safety Precautions

Always wear safety goggles and an apron in the lab. Be careful when handling hot materials.

Name Class Date

DESIGN YOUR OWN GeoLab

Designing a Solar Desalinator

PLAN THE EXPERIMENT

1. Use the library and go to science.glencoe.com to identify designs of solar desalinators.
2. Draw a design for your model desalinator below. (Hint: Solar energy must be collected in some way that allows sunlight to enter and causes an increase in temperature inside the container so that water in saturated air can condense and be collected.)
3. Make a list of the materials you will need, and then collect them.
4. Construct the desalinator you designed.
5. Test the desalinator by recording how long it takes to collect the purified water and how much water was collected.
6. Test the water to see if it has been purified by boiling the water away. If any salt remains in the container after the water has evaporated, your desalinator did not remove all of the salts from the salt water.

ANALYZE

1. **Interpreting Scientific Illustrations** Draw the desalinator that you constructed.

DESIGN YOUR OWN GeoLab

Designing a Solar Desalinator

ANALYZE

2. **Interpreting Observations** How well did your desalinator work? On what criteria did you base the effectiveness of your desalinator?

3. **Observing and Inferring** What problems did you encounter in this investigation?

4. **Comparing and Contrasting** Compare and contrast your desalinator with one of your classmate's. What were the advantages or disadvantages of your design?

CONCLUDE AND APPLY

1. What factors affected the efficiency of the desalinator?

2. How did your solar desalinator's efficiency compare with the efficiencies of other students' models?

3. How could you improve your desalinator?

4. What conclusions could be drawn from your investigation regarding the viability and use of solar-powered desalinators?

Name Class Date

MiniLab 26

Oil Migration

Model the migration of oil and natural gas upward through layers of porous rocks.

Procedure

1. Pour 20 mL of cooking oil into a 100-mL graduated cylinder.
2. Carefully pour sand into the graduated cylinder until the sand-oil mixture reaches the 40-mL mark.
3. Now add a layer of colored aquarium gravel above the sand until the gravel reaches the 70-mL mark.
4. Pour tap water into the graduated cylinder until the water reaches the 100-mL mark.
5. Let stand and observe for 5 minutes.

Analyze and Conclude

1. What does the cooking oil represent? What do the sand and aquarium gravel represent?

2. What happens when water is added to the mixture in the graduated cylinder? Why does adding water cause this change?

3. Predict what might occur in the graduated cylinder if a carbonated soft drink was added to the mixture instead of water. What would the bubbles represent?

Name Class Date

DESIGN YOUR OWN GeoLab

Designing an Energy-Efficient Building

Buildings can be designed to conserve heat energy. Some considerations involved in the design of a building that conserves heat include the materials that will be used in construction, the materials that will store heat, and the overall layout of the building.

PREPARATION

Problem

How can a building be designed to conserve energy? What building materials will work best, and what other factors need to be considered?

Possible Materials

glass or clear plastic
sturdy cardboard boxes
paints of various colors
thermometers
materials to cover the building
(paper, aluminum foil, foamboard, and so on)
interior materials
(stones, mirrors, fabric, and so on)
light source
scissors
tape
glue

Hypothesis

Brainstorm a list of design features that might contribute to the energy efficiency of a building. Hypothesize how you could incorporate some of these features into an energy-efficient building. Find out what materials are used in heat-efficient homes and research local sources of materials for your design. Decide how you will determine the heat efficiency of the building you construct. Be sure to plan for a control building for comparison.

Objectives

In this GeoLab, you will:

- **Research** what materials are used in the construction of energy-efficient buildings.
- **Design** a building that is energy efficient.
- **Construct** the building that you design.
- **Determine** the heat efficiency of the building by comparing it to a control building.
- **Interpret** the data that you collect to determine your success in developing an energy-efficient building.

Safety Precautions

Be careful when you are using scissors. Make sure to handle the light source carefully when it is hot. Always wear safety goggles and an apron in the lab.

PLAN THE EXPERIMENT

1. Review the data that you collected about building energy-efficient buildings. Also review your list of possible design features.
2. Design your building. Make a list of the heat-conserving issues that you addressed.
3. Decide on the materials that you will use to build your house. Collect those materials.
4. Construct the building and a control building for comparison.
5. Devise a way to test the heat-holding ability of each building.
6. Proceed with the test on each building. To test the buildings' heat energy efficiency, it may be necessary to heat the buildings and determine

Name ______________________ Class __________ Date __________

DESIGN YOUR OWN GeoLab

Designing an Energy-Efficient Building

PLAN THE EXPERIMENT

how long heat is conserved within each one. ***CAUTION:*** *Make sure the heat source is far enough away from the building materials so that they do not burn or melt.*

7. Draw a table and record your data. Then, make a graph of your data.

8. Make modifications to the design to improve the building's efficiency.

TABLE

GRAPH

ANALYZE

1. Checking Your Hypothesis Was the building that you designed more energy-efficient than the control building? Why did you construct a control building?

Name Class Date

DESIGN YOUR OWN GeoLab

Designing an Energy-Efficient Building

ANALYZE

2. Interpreting Observations What problems did you encounter, and how did you solve them?

3. Observing and Inferring How did your observations affect decisions that you might make if you were to repeat this lab? Why do you think your design worked or did not work?

4. Comparing and Contrasting Compare and contrast the building you designed and the control building. Compare and contrast your design and the designs of your classmates.

5. Thinking Critically Suppose you could use only naturally occurring materials. Would that limit your design? Explain your answer.

CONCLUDE AND APPLY

1. How could you incorporate some of your design elements in your own home?

2. How could your design be improved?

3. How could using different energy sources affect your results?

MiniLab 27

Reclamation

Model the procedure used by mining companies to reclaim an area after strip-mining.

Procedure

1. Using a plastic knife, make four or five cuts across the icing of one cream-filled, iced cupcake. Remove the pieces of icing.
2. Make four or five cuts down into the cake until you reach the cream filling. Cut horizontally just above the cream filling and remove the cake pieces.
3. Remove the cream filling. To restore the area, use the pieces of cake that you cut out to fill in the hole left when you removed the cream filling. Make the surface of the cupcake as level as possible.
4. Replace the icing so that it covers the surface of the restored cupcake.

Analyze and Conclude

1. On the restored cupcake, what does the icing represent? What does the cream filling represent?

____

____

____

2. Does the reclaimed cupcake resemble the original, untouched cupcake?

____

____

____

3. Can reclamation of an area that has been strip-mined restore the land to its original contours? Explain your answer.

____

____

____

Name Class Date

Mapping GeoLab

Pinpointing a Source of Pollution

Iris City and the surrounding region are shown in the map on the facing page. Iris City is a medium-sized city of 100 000. It is experiencing many types of environmental impacts. Study the map and the information given to identify these problems and possible solutions.

PREPARATION

Problem

How can the residents of Iris City identify the source of local water pollution?

Materials

metric ruler
pencil

PROCEDURE

1. Iris City obtains its drinking water from Opal Lake. Studies of the lake have detected increased levels of nitrogen, phosphorus, hydrocarbons, sewage, and silt. The northwest end of Opal Lake is experiencing increased development, while the remainder of the watershed is a mix of forest and logging clear-cuts.
2. Last spring, blooms of cyanobacteria choked parts of the Vista Estuary Nature Preserve. Commercial shellfish beds in Iris Bay have been closed because of sewage contamination.
3. A natural-gas power plant has been proposed for location A, near the Vista Cutoff, an abandoned channel of the Vista River. The plant would provide jobs as well as generate electricity. The company plans to divert 25 percent of the Vista River down the Vista Cutoff.
4. The Lucky Mine was abandoned 60 years ago. A mining company has applied for permits to reopen the mine. An estimated 1 million ounces of gold can be recovered using modern techniques.

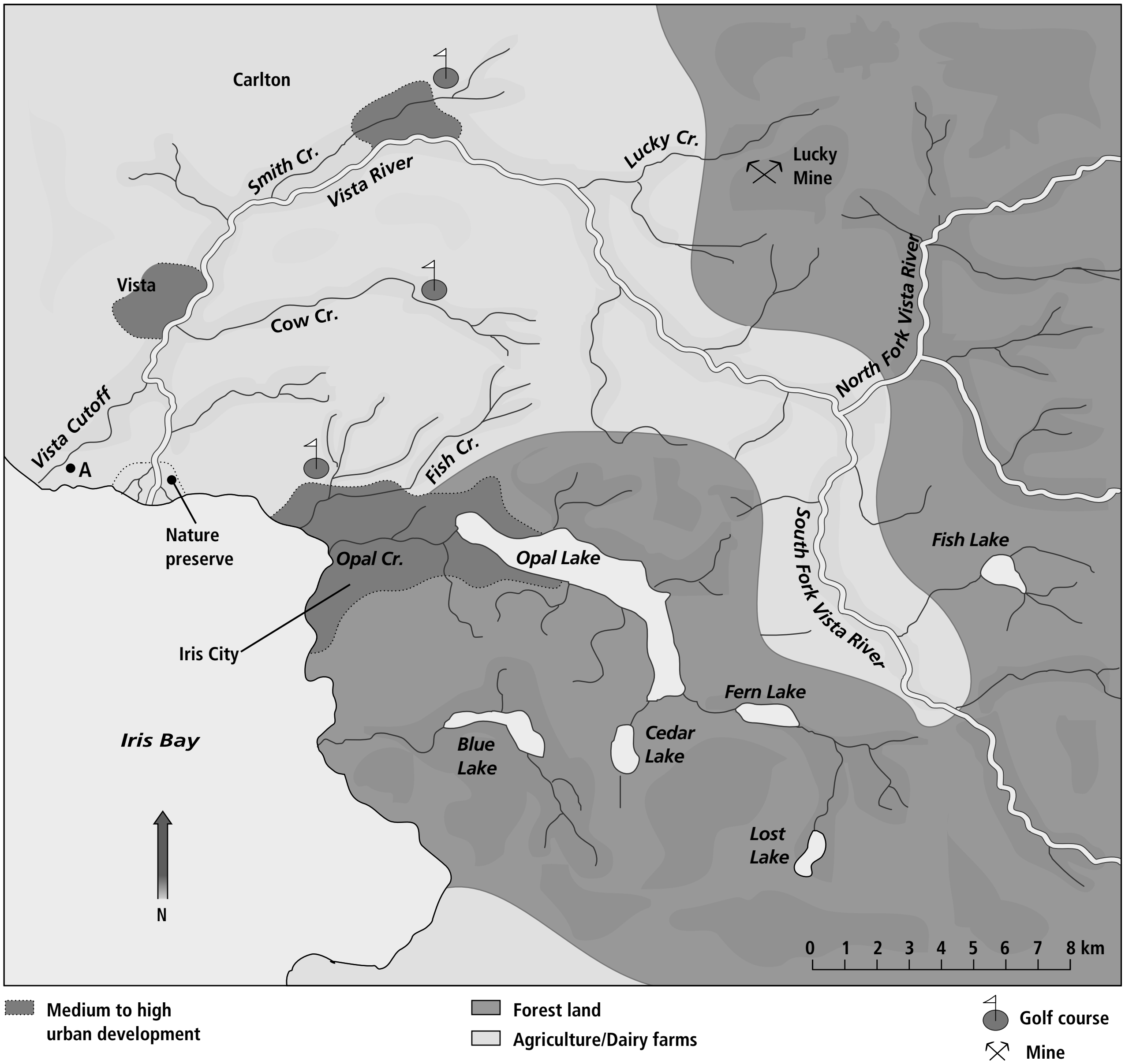
ANALYZE

1. What are some possible sources of water pollution in Opal Lake? What steps might the residents of Iris City take to protect their drinking water?

2. How are the blooms of cyanobacteria and the closing of the shellfish beds in Iris Bay related?

Name Class Date

Mapping GeoLab Pinpointing a Source of Pollution



ANALYZE

3. What are the positive and negative aspects of diverting water from the Vista River through the Vista Cutoff?

Name Class Date

Mapping GeoLab

Pinpointing a Source of Pollution

ANALYZE

4. If the Lucky Mine is reopened, what effects might it have on the populations of Carlton, Vista, and Iris City?

CONCLUDE AND APPLY

1. Identify the sources of water pollution in Iris Bay. Are these point or nonpoint sources of pollution?

2. How could you identify the source of pollution causing cyanobacteria blooms in the Vista Estuary?

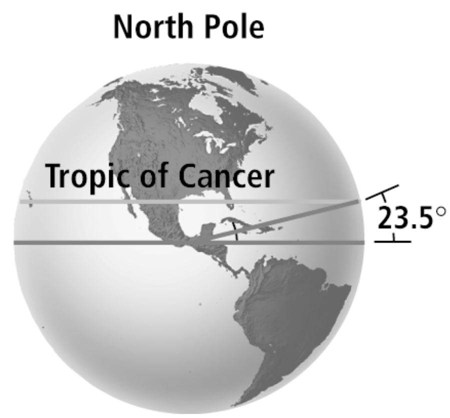
3. If the Vista Cutoff is used to divert water from the Vista River, how will the aquatic habitats of the river be affected?

4. If the Lucky Mine is reopened, what could the mining company do to minimize negative environmental impacts?

MiniLab 28

The Sun's Position

Model the overhead position of the Sun at various latitudes during the summer solstice.



Procedure

1. In the space below, draw a circle to represent Earth. Also draw the equator.
2. Use a protractor to find the location of the Tropic of Cancer. Draw a line from Earth's center to the Tropic of Cancer.
3. Using a map, locate that latitude at which you live. With the protractor, mark that latitude on your diagram. Draw a line from Earth's center to this location.
4. Measure the angle between the line to the Tropic of Cancer and the line to your location.
5. Choose two different latitudes, then repeat steps 3 and 4 for these latitudes.

Analyze and Conclude

1. How does the angle vary with latitude?

___

___

___

2. At what southern latitude would you not see the Sun above the horizon?

___

3. How would the angle change if you used the Tropic of Capricorn?

___

___

___

Name Class Date

Mapping GeoLab: Relative Ages of Lunar Features

It is possible to use the principle of cross-cutting relationships, discussed in Chapter 21, to determine the relative ages of surface features on the Moon. By observing which features cross-cut others, you can infer which is older.

PREPARATION

Problem

How can you use images of the Moon to interpret relative ages of lunar features?

Materials

metric ruler
pencil

PROCEDURE

1. Observe photos I and II. Use the letters to identify the oldest feature in each photo using the principle of cross-cutting relationships. List the other features in order of their relative ages.

2. Observe photo III. List the mare, rille, and craters in order of their relative ages.

3. Observe photo IV. Use the principle of cross-cutting relationships, along with your knowledge of lunar history, to identify the features and list them in order of their relative ages.

ANALYZE

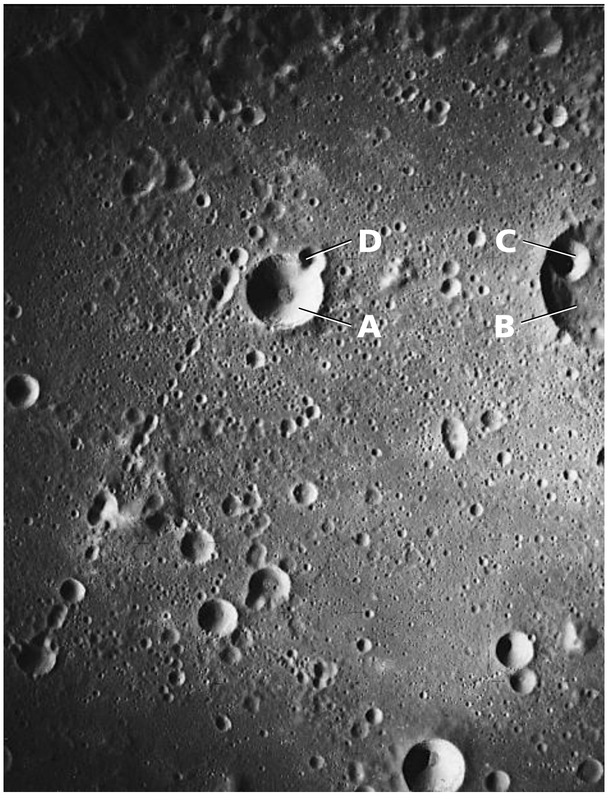
1. What problems did you encounter?

2. Based on information from all the photos, what features are usually the oldest? The youngest?

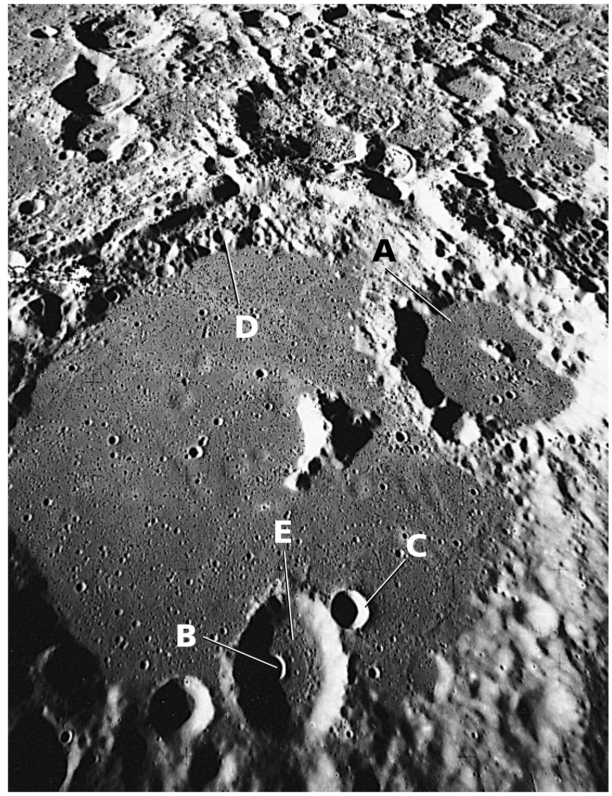
Mapping GeoLab

Relative Ages of Lunar Features

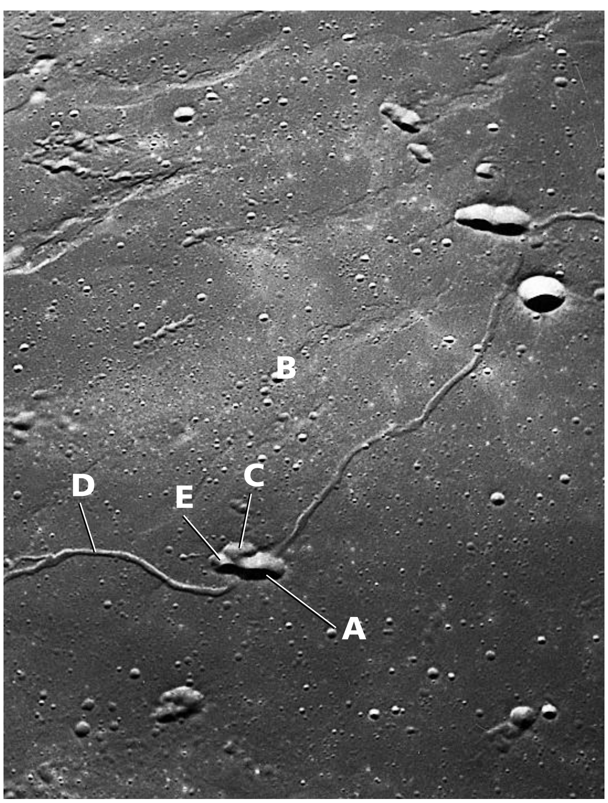
I



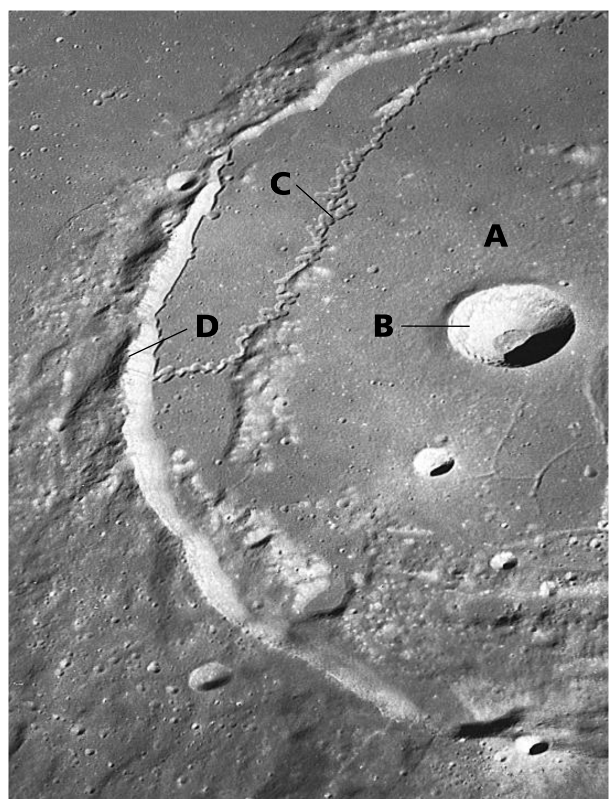
II



III



IV



Mapping GeoLab Relative Ages of Lunar Features

ANALYZE

3. Could scientists use the process you did to determine the exact age difference between two overlapping craters? Why or why not?

4. If the small crater in photo II, labeled A, is 44 km across, what is the scale for that photo? What is the size of the large crater, labeled D?

CONCLUDE AND APPLY

1. Which would be older, a crater that had rays crossing it or the crater that caused the rays? Explain.

2. Is there some type of relative-age dating that scientists can use to analyze craters on Earth? Explain.

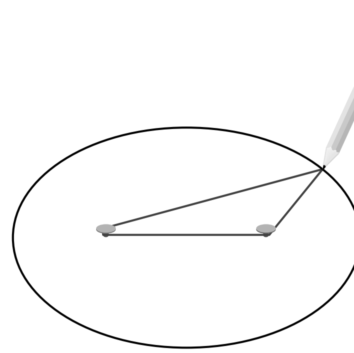
3. What do you think caused the chain of craters in photo I? If the crater labeled A is approximately 17 km across, how long is the chain of craters?

Name Class Date

MiniLab 29

Eccentricity

Measure the eccentricity of different ellipses. Eccentricity is the ratio of the distance between the foci to the length of the major axis.



Procedure

1. Tie a piece of string into a loop that fits on a piece of cardboard when it is laid out in a circle.
2. Place a sheet of paper on the cardboard.
3. Stick two pins through the paper close to the center but separated from each other by a few centimeters. Use caution when using sharp objects.
4. Loop the string over the pins and use the pencil to trace around them. Keep the string taut.
5. Measure the major axis and the distance between the pins. Calculate the eccentricity.
6. Repeat steps 3–5 for different separations of the pins.

Analyze and Conclude

1. What do the two pins represent?

____

____

2. How does the eccentricity change as the distance between the pins changes?

____

____

____

____

3. What kind of figure would you form if the two pins were at the same location? What would its eccentricity be?

____

____

____

____

Name Class Date

DESIGN YOUR OWN GeoLab

Scaling the Solar System

Astronomers are familiar with both the small, such as interstellar dust particles, and the large, such as the solar system. In order to understand the variety of sizes in the solar system, astronomers use models. These models can be as simple as putting people or objects in marked places or as complex as elaborate computer simulations. The most difficult task with many models is choosing a scale that will display all the information needed, such as distance, rotation rates, and size.

PREPARATION

Problem

How can the size of the solar system be converted to a scale that will easily demonstrate relative distances between objects in the solar system? Is distance the only measurement that can be demonstrated in a scale model?

Possible Materials

calculator
tape measure
meterstick
stopwatches
marker
masking tape
variety of sizes of common round objects

Hypothesis

Brainstorm about possible models and data needed to create them. Determine where these data are available, and collect them to use as a reference for your model. To have your model fit in your chosen area, make a hypothesis on the appropriate scale to use for distance from the Sun to each planet.

Hypothesize how additional solar system measurements can be included in your model. For example, think about including planet diameters, rotation rates, etc.

____

____

____

____

____

____

Objectives

In this GeoLab, you will:

- **Calculate** the distance from the Sun for each planet based on your scale.
- **Determine** how to incorporate additional solar system measurements into your model, or design another model to show that information.
- **Interpret** your results based on your scale, and decide if your scale was an appropriate one based on the problems that may have resulted.

DESIGN YOUR OWN GeoLab

Scaling the Solar System

PLAN THE EXPERIMENT

1. As a group, use a separate sheet of paper to make a list of possible ways you might test your hypotheses. Keep the available materials in mind as you plan your procedure.
2. Be sure your scale is appropriate for the information you are representing. Remember that a model should have the same scale throughout. You may have to try more than one scale before you are successful.
3. Record your procedure and list every step. Determine what materials are needed and the amounts of each.
4. Design and construct a data table for recording your original data and your scaled data, using the space below.
5. Check the plan. Make sure your teacher has approved your plan before you proceed with your experiment.
6. Carry out your plan.

Name Class Date

DESIGN YOUR OWN GeoLab

Scaling the Solar System

ANALYZE

1. **Checking Your Hypothesis** Which scale worked the best for your model? Explain.

2. **Interpreting Observations** What problems did you have in finding a scale? Explain how you corrected the problems.

3. **Calculating Results** List and explain the conversions that you used to create your scale model. If multiple steps were necessary to convert to your scale units, how could they be combined to make the process simpler?

4. **Observing and Inferring** What possible problems could result from using a very large scale? A small scale? Explain why depicting a scale model of the solar system on a sheet of notebook paper is extremely difficult.

DESIGN YOUR OWN GeoLab

Scaling the Solar System

ANALYZE

5. **Compare and Contrast** Compare and contrast your model with one of your classmates'. What were the advantages of the scale you used? What were the disadvantages? How would you improve your model?

6. **Thinking Critically** Suppose that the outer planets are three times farther away than they are now. How would this affect your model? What scale would you choose now? Explain.

CONCLUDE AND APPLY

1. Proxima Centauri, the closest star to our Sun, is about 4.01×10^{13} km from the Sun. Based on your scale, how far would Proxima Centauri be from the sun in your model? If you were to fit the distance between the Sun and Proxima Centauri into your classroom, how small would the scaled distance between Pluto and the Sun be?

2. An interstellar dust particle is 1.0×10^{-6} m in length. Convert this measurement to your scale. How many dust particles could fit in the distance between the Sun and Jupiter? Between Mars and Uranus?

MiniLab 30

Parallax in the Classroom

Model stellar parallax and the change in parallax angle with distance.

Procedure

1. Place a meterstick at a fixed position and attach a 4-m piece of string to each end.
2. Stand away from the meterstick and hold the two strings together to form a triangle. Be sure to hold the strings taut. Measure your distance from the meterstick. Record your measurement.
3. Measure the angle between the two pieces of string with a protractor. Record your measurement of the angle.
4. Repeat steps 2 and 3 for different distances from the meterstick by shortening or lengthening the string.
5. Make a graph in the space below of the angles versus their distance from the meterstick.

Analyze and Conclude

1. What does the length of the meterstick represent? The angle?

____

____

2. What does the graph show? How does parallax angle depend on distance?

____

____

3. Are the angles that you measured similar to actual stellar parallax angles? Explain.

____

____

Name Class Date

GeoLab Identifying Stellar Spectral Lines

An astronomer studying a star or other type of celestial object often starts by identifying the lines in the object's spectrum. The identity of the spectral lines gives astronomers information about the chemical composition of the distant object, along with data on its temperature and other properties.

PREPARATION

Problem

Identify stellar spectral lines based on two previously identified lines.

Materials

ruler

Objectives

In this Geolab, you will:

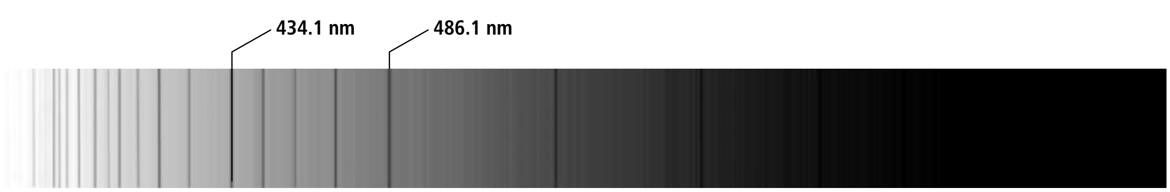
- **Develop** a scale based on the separation between two previously identified spectral lines.
- **Measure** wavelengths of spectral lines.
- **Compare** measured wavelengths to known wavelengths of elements to determine composition.

PROCEDURE

1. Measure the distance between the two identified spectral lines on star 1. Be sure to use units that are small enough to get accurate measurements.
2. Calculate the difference in wavelengths between the two identified spectral lines.
3. Set up your scale by dividing the difference in wavelengths by the measured distance between the two identified spectral lines. This will allow you to measure wavelengths based on your distance measurement unit. For example, 1 mm = 12 nm.
4. Measure the distance to spectral lines from one of the two previously identified spectral lines.
5. Convert your distances to wavelengths using your scale. You have measured the difference in wavelength. This difference must be added or subtracted to the wavelength of the line you measured from. If the line you measured from is to the right of the line you are identifying, then you must subtract. Otherwise, you add.
6. Compare your wavelength measurements to the table of wavelengths emitted by elements, and identify the elements in the spectrum.
7. Repeat this procedure for star 2.

Star 1

Star 2



GeoLab Identifying Stellar Spectral Lines

POSSIBLE ELEMENTS AND WAVELENGTHS

Element/Ion	Wavelengths (nm)
H	383.5, 388.9, 397.0, 410.2, 434.1, 486.1, 656.3
He	402.6, 447.1, 492.2, 587.6, 686.7
He^{+}	420.0, 454.1, 468.6, 541.2, 656.0
Na	475.2, 498.3, 589.0, 589.6
Ca^{+}	393.4, 480.0, 530.7

ANALYZE

1. What elements are present in the stars?

2. How does your list of elements compare with the list of elements seen in the periodic table on page 125?

3. Can you see any clues in the star's spectrum about which elements are most common in the stars? Explain.

Name Class Date

GeoLab Identifying Stellar Spectral Lines

CONCLUDE AND APPLY

1. Do both stars contain the same lines for all the elements in the table?

2. You should notice that some absorption lines are wider than others. What are some possible explanations for this?

3. How do the thicker absorption lines of some elements in a star's spectrum effect the accuracy of your measurements? Is there a way to improve your measurements? Explain.

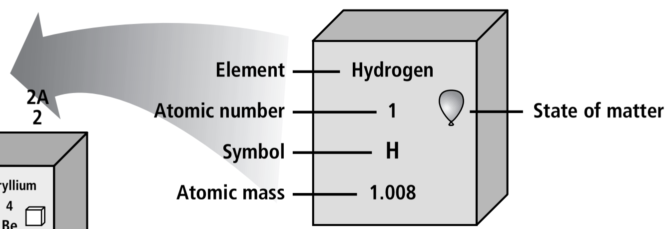
4. Using the following formula, calculate the percent deviation for five of your measured lines. Record your calculations in the space below.

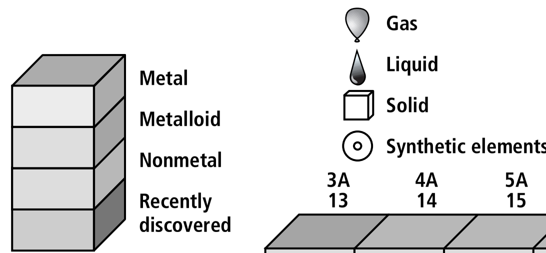
$$\text{Percent deviation} = \frac{\text{difference from accepted value}}{\text{accepted value}} \times 100$$

Is there a value that has a high percent deviation? If so, what are some possible explanations for this?

GeoLab Identifying Stellar Spectral Lines

PERIODIC TABLE OF THE ELEMENTS





	1A 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1	Hydrogen 1 H 1.008																	Helium 2 He 4.003
2	Lithium 3 Li 6.941	Beryllium 4 Be 9.012											Boron 5 B 10.811	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Neon 10 Ne 20.180
3	Sodium 11 Na 22.990	Magnesium 12 Mg 24.305											Aluminum 13 Al 26.982	Silicon 14 Si 28.086	Phosphorus 15 P 30.974	Sulfur 16 S 32.066	Chlorine 17 Cl 35.453	Argon 18 Ar 39.948
4	Potassium 19 K 39.098	Calcium 20 Ca 40.078	Scandium 21 Sc 44.956	Titanium 22 Ti 47.88	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.847	Cobalt 27 Co 58.933	Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.39	Gallium 31 Ga 69.723	Germanium 32 Ge 72.61	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Krypton 36 Kr 83.80
5	Rubidium 37 Rb 85.468	Strontium 38 Sr 87.62	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.94	Technetium 43 Tc 97.907	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.906	Palladium 46 Pd 106.42	Silver 47 Ag 107.868	Cadmium 48 Cd 112.411	Indium 49 In 114.82	Tin 50 Sn 118.710	Antimony 51 Sb 121.757	Tellurium 52 Te 127.60	Iodine 53 I 126.904	Xenon 54 Xe 131.290
6	Cesium 55 Cs 132.905	Barium 56 Ba 137.327	Lanthanum 57 La 138.906	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.948	Tungsten 74 W 183.84	Rhenium 75 Re 186.207	Osmium 76 Os 190.2	Iridium 77 Ir 192.22	Platinum 78 Pt 195.08	Gold 79 Au 196.967	Mercury 80 Hg 200.59	Thallium 81 Tl 204.383	Lead 82 Pb 207.2	Bismuth 83 Bi 208.980	Polonium 84 Po 208.982	Astatine 85 At 209.987	Radon 86 Rn 222.018
7	Francium 87 Fr 223.020	Radium 88 Ra 226.025	Actinium 89 Ac 227.028	Rutherfordium 104 Rf (261)	Dubnium 105 Db (262)	Seaborgium 106 Sg (263)	Bohrium 107 Bh (262)	Hassium 108 Hs (265)	Meitnerium 109 Mt (266)	Ununnilium * 110 Uun 269	Unununium * 111 Uuu 272	Ununbium * 112 Uub 277		Ununquadium * 114 Uuq 285		Ununhexium * 116 Uuh 289		Ununodium * 118 Uuo 293

* Names not officially assigned. Discovery of elements 114, 116, and 118 recently reported. Further information not yet available.

Lanthanide series	Cerium 58 Ce 140.115	Praseodymium 59 Pr 140.908	Neodymium 60 Nd 144.24	Promethium 61 Pm 144.913	Samarium 62 Sm 150.36	Europium 63 Eu 151.965	Gadolinium 64 Gd 157.25	Terbium 65 Tb 158.925	Dysprosium 66 Dy 162.50	Holmium 67 Ho 164.930	Erbium 68 Er 167.26	Thulium 69 Tm 168.934	Ytterbium 70 Yb 173.04	Lutetium 71 Lu 174.967
Actinide series	Thorium 90 Th 232.038	Protactinium 91 Pa 231.036	Uranium 92 U 238.029	Neptunium 93 Np 237.048	Plutonium 94 Pu 244.064	Americium 95 Am 243.061	Curium 96 Cm 247.070	Berkelium 97 Bk 247.070	Californium 98 Cf 251.080	Einsteinium 99 Es 252.083	Fermium 100 Fm 257.095	Mendelevium 101 Md 258.099	Nobelium 102 No 259.101	Lawrencium 103 Lr 260.105

MiniLab 31

Measuring Redshifts

Model uniform expansion of the universe and the redshifts of galaxies that result from expansion.

Procedure

1. Use a felt tip marking pen to make four dots in a row, each separated by 1 cm, on the surface of an uninflated balloon. Label the dots 1, 2, 3, and 4.
2. Partially inflate the balloon. Using a piece of string and a meterstick, measure the distance from dot 1 to each of the other dots. Record your measurements.
3. Inflate the balloon further, and again measure the distance from dot 1 to each of the other dots. Record your measurements.
4. Repeat step 3 with the balloon fully inflated.

Analyze and Conclude

1. Are the dots still separated from each other by equal distances? Explain.

____

____

2. How far did each dot move away from dot 1 after each inflation?

____

____

____

____

3. What would be the result if you had measured the distances from dot 4 instead of dot 1? From dot 2?

____

____

4. How does this activity illustrate uniform expansion of the universe and redshifts of galaxies?

____

____

____

____

____

Name Class Date

Internet GeoLab

Classifying Galaxies

Edwin Hubble developed rules for classifying galaxies according to their shapes as seen in telescopic images. Astronomers are interested in the classification of galaxies. This information can indicate whether a certain type of galaxy is more likely to form than another and helps astronomers unravel the mystery of galaxy formation in the universe. Using the resources of the Internet and sharing data with your peers, you can learn how galaxies are classified.

PREPARATION

Problem

How can different galaxies be classified?

Hypothesis

How might galaxies be classified using Hubble's classification system? Are there absolute classifications based solely on shape? **Form a hypothesis** about how you can apply Hubble's galaxy classification system to galaxy images on the Internet.

____

____

____

____

Objectives

In this Geolab, you will:

- **Gather** and **communicate** details about galaxy images on the Internet.
- **Form conclusions** about the classification of different galaxies.
- **Reconstruct** the tuning-fork diagram with images that you find.

Data Sources

Go to the Glencoe Science Web Site at science.glencoe.com to find links to galaxy images on the Internet. You can also visit a local library or observatory to gather images of galaxies and information about them.

PLAN THE EXPERIMENT

1. Find a resource with multiple images of galaxies and, if possible, names or catalog numbers for the galaxies. The Glencoe Science Web Site lists sites that have galaxy images.
2. Choose one of the following types of galaxies to start your classification: spirals, ellipticals, or irregular galaxies.
3. Gather images and information, such as catalog numbers and names of galaxies, from the links on the Glencoe Science Web Site or the library.
4. Sort the images by basic types: spirals, ellipticals, or irregular galaxies.
5. For each basic type, compare the galaxies to each other and decide which galaxy best represents each class and subclass of Hubble's galaxy classification system: Sa, Sb, Sc, SBa, SBb, SBc, S0, E0–E7, and Irr. Try to find at least one galaxy for each subclass.
6. Arrange the galaxy images to construct a tuning-fork diagram like Hubble's.

Internet GeoLab Classifying Galaxies

GALAXY DATA

Galaxy Name	Sketch of Galaxy	Classification	Notes
NGC 3486		Sc	

PROCEDURE

1. Create a data table similar to the one above. Complete the data table. Add any additional information that you think is important.
2. Go to the Glencoe Science Web Site at science.glencoe.com to post your data.
3. Visit sites listed on the Glencoe Science Web Site for information about other galaxies.

CONCLUDE AND APPLY

Sharing Your Data Find this Internet GeoLab on the Glencoe Science Web Site at science.glencoe.com. Post your data in the table provided for this activity. Use the additional data from other students to complete your chart and answer the Conclude & Apply questions.

1. Were there any galaxy classes or subclasses that were difficult to find images for? If so, which ones?

2. How many of each type of galaxy—normal spiral, barred spiral, elliptical, and irregular—did you find?

3. Calculate the percentages of the total number of galaxies that each type represents. Do you think this reflects the actual percentage of each type of galaxy in the universe? Explain.

Internet GeoLab

Classifying Galaxies

CONCLUDE AND APPLY

4. Were there any galaxy images that you found that didn't fit your classification scheme? If so, why?

5. Was it difficult to distinguish between a normal spiral and a barred spiral in some cases? Explain your method.

6. What problems did you have with galaxies that are edge-on as seen from Earth?

7. Ellipticals are usually a difficult type of galaxy to classify. Why?

ANSWER PAGES

GeoLab and MiniLab Worksheets

Name Class Date

MiniLab 1 How do soil and water absorb and release heat?

Experiment to determine the relationship between variables.

Procedure

1. Obtain the materials for this lab from your teacher.
2. Put soil into one container until it is half full. Put water into the other container until it is half full.
3. Place one thermometer in the soil so that the bulb is barely covered. Use masking tape to secure another thermometer about 1 cm from the top of the soil.
4. Repeat step 3 with the container of water.
5. Put the containers on a very sunny windowsill. Record the temperature shown on each thermometer. Write these values in the table. Then record temperature readings every 5 minutes for half an hour.
6. Remove the containers from the windowsill and immediately record the temperature on each thermometer every 5 minutes for half an hour.

Time (minutes)	Thermometer 1 Temperature	Thermometer 2 Temperature
0		
5		
10		
15		
20		
25		
30		

Analyze and Conclude

1. Which substance absorbed heat faster?

The soil absorbed heat faster than the water did; that is, the temperature of the soil rose faster than the temperature of the water did.

2. Which substance lost heat faster?

The soil cooled more quickly than the water did when the containers were removed from the heat source.

3. What was your independent variable? Your dependent variable?

The independent variable was medium—soil or water. The dependent variable was temperature.

Name Class Date

GeoLab Measuring in SI

Suppose someone asked you to measure the area of your classroom in square cubits. What would you use? A cubit is an ancient unit of length equal to the distance from the elbow to the tip of the middle finger. Since this length varies among individuals, the cubit is not a standard unit of measure. SI units are standard units, which means that they are exact quantities that have been agreed upon to use for comparison. In this GeoLab, you will use SI units to measure various properties of rock samples.

PREPARATION

Problem

Measure various properties of rocks and use the measurements to explain the relationships among the properties.

Materials

water
250-mL beaker
graph paper
balance
pieces of string
spring scale
rock samples

Objectives

In this GeoLab, you will:

- **Measure** the area, volume, mass, and weight of several rock samples.
- **Calculate** the density of each sample.
- **Explain** the relationships among the quantities.

Safety Precautions

PROCEDURE

1. Use the information in the *Skill Handbook* to design a data table in which to record the following measurements for each sample: area, volume, mass, weight, and density.
2. Obtain rock samples from your teacher. Carefully trace the outline of each rock onto the graph paper. Determine the area of each sample and record the values in your data table.
3. Pour water into the beaker until it is half full. Record this volume in the table. Tie a piece of string securely around one rock sample. Slowly lower the sample into the beaker. Record the volume of the water. Subtract the two values to determine the volume of the rock sample.
4. Repeat step 3 for the other rocks. Make sure the original volume of water is the same as when you measured your first sample.
5. Follow your teacher's instructions about how to use the balance to determine the mass of each rock. Record the measurements in your table.
6. Again, secure each rock with a piece of dry string. Make a small loop in the other end of the string. Place the loop over the hook of the spring scale to determine the weight of each rock sample. Record the values in your data table.

Name Class Date

GeoLab Measuring in SI

DATA TABLE

ANALYZE

1. Compare the area of each of your samples with the areas determined by other students for the same samples. Explain any differences.

   Differences among measurements will depend on the orientation of the sample when its outline is traced and on the ability of students to accurately count squares to measure the area of an irregular solid.

2. Compare the volume of each of your samples with the volumes determined by other students for the same samples. Explain any differences.

   Volumes measured by different students for the same samples should agree, except for measurement errors, which should be small. Any large deviations are indications of serious mistakes in measurement.

3. Compare the weight and mass of each of your samples with the values for these quantities determined by other students. Again, explain any differences.

   The weights and masses for the same samples as measured by different students should agree. Any differences should represent only standard margins of error in measurement.

Name Class Date

GeoLab Measuring in SI

ANALYZE

4. Use your measurements to calculate the density of each sample using this formula: *density = mass/volume*. Record these values in your data table.

   Allow students to use calculators, if necessary, to do the computations.

CONCLUDE AND APPLY

1. How accurate do you think your measurement of the area of each sample is? Explain.

   The measurements of area will be both inaccurate and variable as a result of the orientation of the samples when they were traced.

2. What were the variables you used to determine the volume of each sample?

   The variables were the size of the samples and the change in the level of the water in the beaker.

3. How could you find the volume of a rock such as pumice, which floats in water?

   To find the volume of an object that floats on water, one could use a lower-density liquid, such as alcohol, or use a narrow stick to hold the sample below the water level and record the volume change. In the second method, one must assume that the volume of the stick is negligible compared to the volume of the sample.

4. Does mass depend on the size or shape of a rock? Explain.

   Mass depends only on the size of the sample, not its shape, because mass is a measure of the quantity of matter in a sample.

Name Class Date

MiniLab 2

How can you locate places on Earth?

Determine latitude and longitude for specific places.

Procedure

1. Use a world map or globe to locate the prime meridian and the equator.
2. Take a few moments to become familiar with the grid system. Examine lines of latitude and longitude on the map or globe.

Analyze and Conclude

1. Use a map to find the latitude and longitude of the following places.

   Mount St. Helens, Washington **46°12′N, 122°11′W**

   Niagara Falls, New York **43°05′N, 79°03′W**

   Mt. Everest, Nepal **27°59′N, 86°56′E**

   Great Barrier Reef, Australia **18°00′S, 145°50′E**

2. Use the map to find the name of the places with the following coordinates.

   0°03′S, 90°30′W **Galápagos Islands, Ecuador**

   27°07′S, 109°22′W **Easter Island, Chile**

   41°10′N, 112°30′W **Great Salt Lake, Utah**

   35°02′N, 111°02′W **Meteor Crater, Arizona**

   3°04′S, 37°22′E **Mt. Kilimanjaro, Tanzania**

3. Find the latitude and longitude of your hometown, the nearest national or state park, and your state capital.

   Answers will vary depending upon students' location.

Name Class Date

Mapping GeoLab

Using a Topographic Map

Topographic maps show two-dimensional representations of Earth's surface. With these maps, you can determine how steep a hill is, what direction streams flow, and where mines, wetlands, and other features are located.

PREPARATION

Problem

How can you use a topographic map to interpret information about an area?

Materials

ruler
string
pencil

PROCEDURE

1. Use the map to answer the following questions. Be sure to check the map's scale.
2. Use the string to measure distances between two points that are not in a straight line. Lay the string along the curves, and then measure the distance by laying the string along the ruler.
3. Remember that elevations on United States Geological Survey maps are given in feet.

ANALYZE

1. What is the contour interval?

   The contour interval is 50 ft.

2. Calculate the stream gradient of Big Wildhorse Creek from the Gravel Pit in section 21 to where the creek crosses the road in section 34.

   change in elevation is 750 ft − 710 ft = 40 ft; change in distance is 4 mi;

   stream gradient is 40 ft ÷ 4 mi = 10 ft/mi

3. What is the highest elevation of the jeep trail? If you followed the jeep trail from the highest point to where it intersects an unimproved road, what would be your change in elevation?

   highest elevation = 1071 ft; change in elevation = 1071 ft − 740 ft = 331 ft

Name Class Date

Mapping GeoLab: Using a Topographic Map

ANALYZE

4. If you started at the bench mark (BM) on the jeep trail and hiked along the trail and the road to the Gravel Pit in section 21, how far would you have hiked?

You would have hiked approximately 5.25 mi.

5. What is the straight-line distance between the two points in question 4? What is the change in elevation?

straight-line distance = 2 mi; change in elevation = 1071 ft − 750 ft = 321 ft

CONCLUDE AND APPLY

1. Does Big Wildhorse Creek flow all year round? Explain your answer.

No; the topographic map symbol for the stream indicates that it is an intermittent stream.

2. What is the shortest distance along roads from the Gravel Pit in section 21 to the secondary highway?

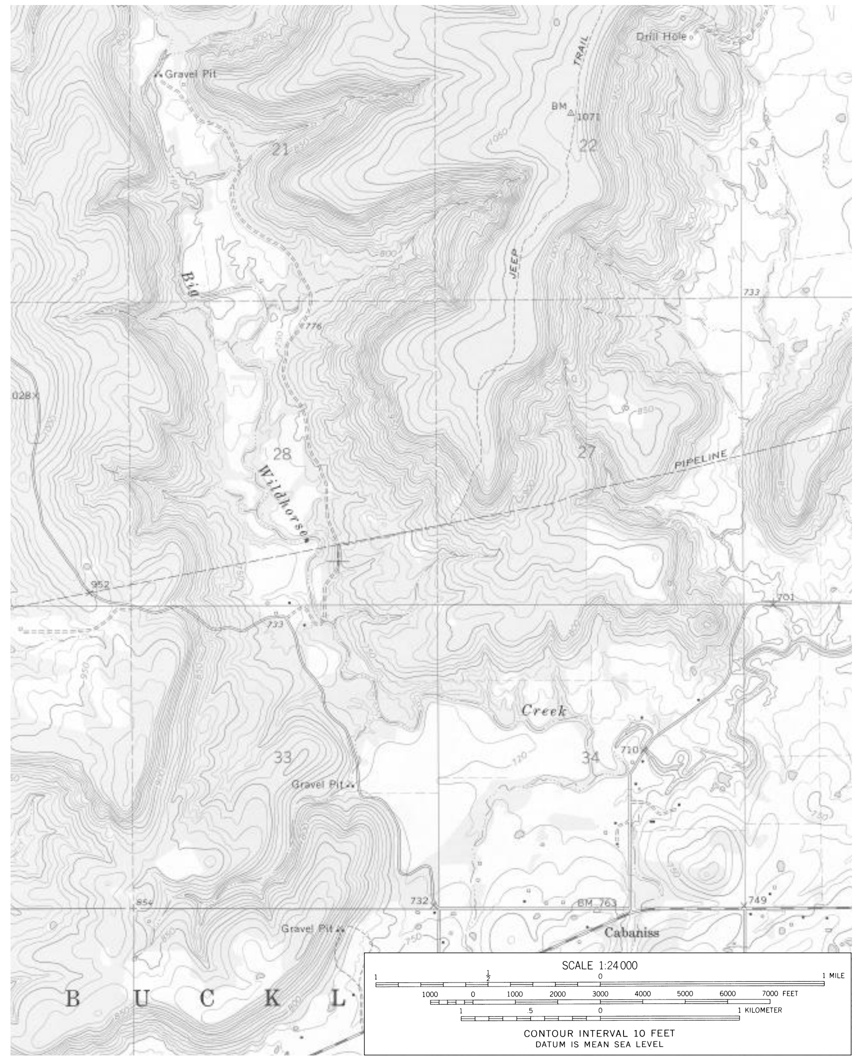
The shortest distance is slightly more than 3 mi.

3. In the space below, draw a profile of the land surface from the bench mark in section 22 to the Gravel Pit in section 33.

Student profiles should show a relatively flat, high elevation, followed by a steep decline in elevation of nearly 300 ft, ending with a gentle increase in elevation of roughly 80 ft.

Name Class Date

Mapping GeoLab: Using a Topographic Map



Name Class Date

MiniLab 3 Identifying Elements

Describe Most substances on Earth occur in the form of chemical compounds. Around your classroom, there are numerous objects or substances that consist mostly of a single element.

Procedure

1. Name three of these objects and the three different elements of which they are made.
2. List the atomic numbers of these elements and describe some of their properties.

Article	Element	Atomic Number	Properties

Analyze and Conclude

1. Matter can be solid, liquid, or gaseous. Give one example of a solid, liquid, and gaseous object or substance.

   Some examples include solids: most minerals; liquids: mercury, water, and gasoline; and gases: neon, helium, and air.

2. How does a liquid differ from a solid? How does a gas differ from a liquid?

   Solids have definite shapes and resist deformation, liquids deform readily and flow, and gases expand and fill all available space.

Name Class Date

GeoLab Salt Precipitation

Many rocks on Earth form from salts precipitating out of seawater. Salt ions precipitate when a salt solution becomes saturated. Solubility is the ability of a substance to dissolve in a solution. When a solution is saturated, no more of that substance can be dissolved. What is the effect of temperature and evaporation on salt precipitation? How do precipitation rates affect the size of crystals?

PREPARATION

Problem

Under what conditions do salt solutions become saturated and under what conditions does salt precipitate out of solution?

Materials

halite (sodium chloride)
250-mL glass beakers (2)
distilled water
plastic wrap
laboratory scale
hot plate
shallow glass baking dish
refrigerator
glass stirring rod

Objectives

In this GeoLab, you will:

- **Observe** salt dissolving and precipitating from a saturated salt solution.
- **Identify** the precipitated salt crystals.
- **Compare** the salt crystals that precipitate out under different conditions.
- **Hypothesize** why different conditions produce different results.

Safety Precautions

Always wear safety goggles and an apron in the lab. Wash your hands after handling salt solutions. Use care in handling hot solutions. Use protection handling hot glassware.

PROCEDURE

1. Pour 150 mL of distilled water into a 250-mL glass beaker.
2. Measure 54 g of sodium chloride. Add the sodium chloride to the distilled water in the beaker and stir until only a few grains remain on the bottom of the beaker.
3. Place the beaker on the hot plate and turn the hot plate on. As the solution inside the beaker heats up, stir it until the last few grains of sodium chloride dissolve. The salt solution will then be saturated.
4. Pour 50 mL of the warm, saturated solution into the second 250-mL glass beaker. Cover this beaker with plastic wrap so that it forms a good seal. Put this beaker in the refrigerator.
5. Pour 50 mL of the saturated solution into the shallow glass baking dish. Place the dish on the hot plate and heat the salt solution until all the liquid evaporates. *CAUTION: The baking dish will be hot. Handle with care.*
6. Place the original beaker with 50 mL of the remaining solution on a shelf or windowsill. Do not cover the beaker.
7. Observe both beakers one day later. If crystals have not formed, wait another day to make your observations and conclusions.
8. Once crystals have formed in all three containers, observe the size and shape of the precipitated crystals. Describe your observations in your science journal.

Name Class Date

GeoLab Salt Precipitation

ANALYZE

1. What is the shape of the precipitated crystals in the three containers? Does the shape of the crystals alone identify them as sodium chloride?

The crystals are cubic, and some may be in the form of flattened squares. No; compounds other than NaCl may have similar crystals.

2. Why didn't all of the salt solution dissolve in step 2 above? How did heating affect the solubility of sodium chloride? Why did heating have the observed effect? Explain.

The solution was saturated before all the salt could dissolve. Heating increased the solubility because increased thermal energy keeps salt ions from precipitating.

3. What effect does cooling have on the solubility of salt?

Cooling decreases the solubility of salt.

4. What happens when a salt solution evaporates? What effect does evaporation have on the solubility of salt?

When a salt solution evaporates, only the water molecules evaporate. The concentration of salt ions in the remaining liquid increases, the solution becomes supersaturated, and salt crystals precipitate.

5. Suppose you have two samples of volcanic rock of identical chemical composition but different crystal sizes. What conclusions can you make about the conditions under which each rock sample cooled?

The rocks must have cooled under different temperatures or at different rates.

Name Class Date

GeoLab Salt Precipitation

CONCLUDE AND APPLY

1. What are the sizes of the crystals in the different containers? Which container has the smallest crystals? Which crystals formed in the shortest time interval?

The crystals in the beakers are large—several millimeters in size. The smallest crystals formed in the baking dish in the shortest time interval.

2. Why does salt precipitate from solution? How is crystal size related to precipitation rate?

Salt precipitates from solution whenever the electrostatic attraction between salt ions overcomes the disruptive effect of thermal vibrations, either when the concentration of salt ions is high enough or the temperature is low enough. Slow precipitation rates allow the growth of large crystals.

3. Design an experiment to separate a heterogeneous mixture of different salts, such as NaCl and $MgCl_2$, into its components, by dissolving and precipitation.

Different salts have different solubilities. To separate two salts, dissolve a portion of the mixture. The solution will be enriched in one of the salts. Evaporate the solution and dissolve a portion of the residue. This will further enrich the solution in the more soluble salt. Repeat until the desired concentration is reached.

Name Class Date

MiniLab 4

How can crystal systems be modeled?

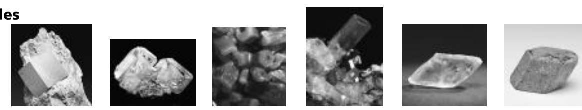
Model the six major crystal systems, then classify mineral samples according to these systems.

Procedure

1. Using ***Table 1*** for guidance, cut pieces of foam board into geometric shapes. Your largest geometric shape should be no more than about 8 cm in length. Your group will need about 38 various shapes.
2. Tape or glue the geometric shapes into models of the six major crystal systems. Again, use ***Table 1*** for guidance.
3. Use the mineral samples provided by your teacher to classify minerals according to their crystal shapes.

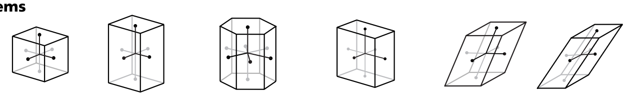
Table 1 Crystal Systems

Examples



Pyrite | Wulfenite | Pyromorphite | Topaz | Gypsum | Feldspar

Systems



Cubic | Tetragonal | Hexagonal | Orthorhombic | Monoclinic | Triclinic

Analyze and Conclude

1. What geometric shapes did you use to model the crystal systems?

   squares, rectangles, hexagons, and triangles

2. Was the crystal structure readily apparent in all mineral samples? Infer why or why not.

   Most minerals grow in restricted spaces; thus, their crystals are not well defined. Conversely, a mineral with a reasonably clear crystal structure probably formed in an unrestricted space.

3. Use ***Table 2*** to identify your minerals. Besides crystal shape, what properties did you use for identification purposes?

   Answers will vary depending on the samples used.

Name Class Date

MiniLab 4

How can crystal systems be modeled?

Table 2 Minerals with Metallic Luster

Mineral (Formula)	Color	Streak	Hardness	Specific Gravity	Crystal System	Breakage Pattern	Uses and Other Properties
Bornite (Cu_5FeS_4)	bronze, tarnishes to dark blue purple	gray-black	3	4.9–5.4	tetragonal	uneven fracture	source of copper called "peacock ore" because of the purple shine when it tarnishes
Chalcopyrite ($CuFeS_2$)	brassy to golden yellow	greenish black	3.5–4	4.2	tetragonal	uneven fracture	main ore of copper
Chromite ($FeCr_2O_4$)	black or brown	brown to black	5.5	4.6	cubic	irregular fracture	ore of chromium, stainless steel, metallurgical bricks
Copper (Cu)	copper red	copper red	3	8.5–9	cubic	hackly	coins, pipes, gutters, wire, cooking utensils, jewelry, decorative plaques; malleable and ductile
Galena (PbS)	gray	gray to black	2.5	7.5	cubic	cubic cleavage perfect	source of lead, used in pipes, shields for X rays, fishing equipment sinkers
Gold (Au)	pale to golden yellow	yellow	2.5–3	19.3	cubic	hackly	jewelry, money, gold leaf, fillings for teeth, medicines; does not tarnish
Graphite (C)	black to gray	black to gray	1–2	2.3	hexagonal	basal cleavage (scales)	pencil lead, lubricants for locks, rods to control some small nuclear reactions, battery poles
Hematite (specular) (Fe_2O_3)	black or reddish brown	red or reddish brown	6	5.3	hexagonal	irregular fracture	source of iron; roasted in a blast furnace, converted to "pig" iron, made into steel
Magnetite (Fe_3O_4)	black	black	6	5.2	cubic	conchodial fracture	source of iron, naturally magnetic, called lodestone
Pyrite (FeS_2)	light, brassy yellow	greenish black	6.5	5.0	cubic	uneven fracture	source of iron, "fool's gold," alters to limonite
Pyrrhotite ($Fe_{1-X}S$)* *contains one less atom of Fe than S	bronze	gray-black	4	4.6	hexagonal	uneven fracture	an ore of iron and sulfur; may be magnetic
Silver (Ag)	silvery white, tarnishes to black	light gray to silver	2.5	10–12	cubic	hackly	coin, fillings for teeth, jewelry, silverplate, wires; malleable and ductile

Table 2 Minerals with Nonmetallic Luster

Mineral (Formula)	Color	Streak	Hardness	Specific Gravity	Crystal System	Breakage Pattern	Uses and Other Properties
Augite ($(Ca, Na)(Mg, Fe, Al)(Al, Si)_2O_6$)	black	colorless	6	3.3	monoclinic	2-directional cleavage	square or 8-sided cross section
Corundum (Al_2O_3)	colorless, blue, brown green, white pink, red	colorless	9	4.0	hexagonal	fracture	gemstones: ruby is red, sapphire is blue; industrial abrasive
Feldspar (orthoclase) ($KAlSi_3O_8$)	colorless white to gray, green, and yellow	colorless	6	2.5	monoclinic	two cleavage planes meet at 90° angle	insoluble in acids; used in the manufacture of porcelain
Feldspar (plagioclase) ($NaAlSi_3O_8$) ($CaAl_2Si_3O_8$)	gray, green, white	colorless	6	2.5	triclinic	two cleavage planes meet at 86° angle	used in ceramics; striations present on some faces
Fluorite (CaF_2)	colorless, white, blue, green, red, yellow, purple	colorless	4	3–3.2	cubic	cleavage	used in the manufacture of optical equipment; glows under ultraviolet light
Garnet ($(Mg, Fe, Ca, Mn)_3, (Al, Fe, Cr)_2, (SiO_4)_3$)	deep yellow-red, green, black	colorless	7.5	3.5	cubic	conchoidal fracture	used in jewelry; also used as an abrasive
Hornblende $Ca_2Na(Mg, Fe^2)_4, (Al, Fe^3, Ti)_3, Si_8O_{22}(O, OH)_2$	green to black	gray to white	5–6	3.4	monoclinic	cleavage in two directions	will transmit light on thin edges; 6-sided cross section
Limonite (hydrous iron oxides)	yellow, brown, black	yellow, brown	5.5	2.74–4.3	—	conchoidal fracture	source of iron; weathers easily, coloring matter of soils
Olivine ($(Mg, Fe)_2SiO_4$)	olive green	colorless	6.5	3.5	orthorhombic	conchoidal fracture	gemstones, refractory sand
Quartz (SiO_2)	colorless, various colors	colorless	7	2.6	hexagonal	conchoidal fracture	used in glass manufacture, electronic equipment, radios, computers, watches, gemstones
Topaz ($Al_2SiO_4(F, OH)_2$)	white, pink, yellow, pale blue, colorless	colorless	8	3.5	orthorhombic	basal cleavage	valuable gemstone

Name Class Date

DESIGN YOUR OWN GeoLab

Making a Field Guide to Minerals

Have you ever used a field guide to identify a bird, flower, rock, or insect? If so, you know that field guides include far more than simply photographs. A typical field guide for minerals might include background information about minerals in general, plus specific information about the formation, properties, and uses of each mineral. In this activity, you'll create a field guide to minerals.

PREPARATION

Problem

How would you go about identifying minerals? What physical and chemical properties would you test? Which of these properties should be included in a field guide to help others to identify unknown minerals?

Possible Materials

mineral samples
hand lens
glass plate
streak plate
Mohs scale of mineral hardness
5 percent hydrochloric acid (HCl) with dropper
Appendix H
steel file or nail
piece of copper
paper clip
magnet

Hypothesis

As a group, form a hypothesis about which property or properties might be most useful in identifying minerals. Write your hypothesis in the space below.

Objectives

In this GeoLab, you will:

- **Conduct** tests on unknown minerals to determine their physical and chemical properties.
- **Identify** minerals based on the results of your tests.
- **Design** a field guide for minerals.

Safety Precautions

Review the safe use of acids. HCl may cause burns. If a spill occurs, rinse your skin with water and notify your teacher immediately.

Name Class Date

DESIGN YOUR OWN GeoLab

Making a Field Guide to Minerals

PLAN THE EXPERIMENT

1. As a group, list the steps that you will take to test your hypothesis. Keep the available materials in mind as you plan your procedure. Be specific, describing exactly what you will do at each step. Properties that you may want to test include luster, color, reaction to HCl, magnetism, cleavage, fracture, texture, hardness, streak, double refraction, and density.
2. Should you test any of the properties more than once for any of the minerals? How will you determine whether certain properties indicate a specific mineral?
3. Design a data table to summarize your results. You can use this table as the basis for your field guide. Draw the table in the space below.
4. Read over your entire experiment to make sure that all steps are in a logical order.
5. Have you included a step for additional research? You may have to use the library or the Glencoe Science Web Site to gather all the necessary information for your field guide.
6. What information will be included in the field guide? Possible data include how each mineral formed, its uses, its chemical formula, and a labeled photograph or drawing of the mineral.
7. Make sure your teacher approves your plan before you proceed with your experiment.

Name Class Date

DESIGN YOUR OWN GeoLab

Making a Field Guide to Minerals

ANALYZE

1. **Interpreting Results** Which properties were most reliable for identifying minerals? Which properties were least reliable? Discuss reasons why one property is more useful than others.

   Answers will vary. Special properties are most reliable for mineral identification because usually only one or two minerals share specific special properties. The least reliable properties for identification of a mineral are color, luster, and texture because many minerals share these same properties.

2. **Defending Your Hypothesis** Was your hypothesis supported? Why or why not?

   Answers will vary.

3. **Thinking Critically** How could you use a piece of paper, a steel knife, and a glass bottle to distinguish between Iceland spar and quartz?

   The Iceland spar will tear the paper, but it will not scratch the knife or glass. The quartz will tear the paper, and scratch the steel knife and glass bottle. This indicates that the quartz is harder than the Iceland spar.

4. **Observing and Inferring** What mineral reacted with the HCl? Why did the mineral bubble? Write the balanced equation that describes the chemical reaction that took place between the mineral and the acid.

   Calcite reacts with HCl. The HCl and calcium carbonate found in the calcite react to release carbon dioxide gas in the form of bubbles. The equation is $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$.

5. **Conducting Research** What information did you include in the field guide? What resources did you use to gather your data? Describe the layout of your field guide.

   Students should have included the name of each mineral, its properties, its uses, its chemical formula, and a photograph or sketch of the mineral. Students likely collected data from their tests, the library, the Internet, magazines, field guides, and mineral collections. Layouts should be clear and easy to follow.

Name Class Date

DESIGN YOUR OWN GeoLab

Making a Field Guide to Minerals

CONCLUDE AND APPLY

1. Compare and contrast your field guide with those of other groups. How could you improve your field guide?

   Answers will vary greatly. Use this opportunity to encourage a lively class discussion about the best features to include in a field guide to minerals.

2. What are the advantages and disadvantages of field guides?

   Answers will vary. The main advantage of a field guide is that it can be used to identify and classify objects using both physical and chemical properties. The main disadvantage is that it offers information in an abridged form.

3. Based on your results, is there any one definitive test that can always be used to identify a mineral? Explain.

   Students will likely find that a combination of tests worked better than any one particular test.

Name Class Date

MiniLab 5 How do igneous rocks differer?

Compare and **contrast** the different characteristics of igneous rocks.

Procedure

1. Using the igneous rock samples provided by your teacher, carefully observe the following characteristics of each rock: color, grain size, texture, and, if possible, mineral composition.
2. Design a data table to record your observations.

Analyze and Conclude

1. Classify your rock samples as extrusive or intrusive rocks.

   Answers will vary depending on the samples used. The coarse-grained samples such as granite, diorite, and gabbro are intrusive. The fine-grained samples such as obsidian, rhyolite, andesite, and basalt are extrusive.

2. What characteristics do the extrusive rocks share? How do they differ? What characteristics do the intrusive rocks share? How do they differ?

   Extrusive rocks are fine grained. They differ in color and some may show a porphyritic texture. Intrusive rocks are coarse grained. They differ in color and mineral composition.

3. Classify your rock samples as felsic, intermediate, mafic, or ultramafic.

   Answers will vary depending on the samples used. Light-colored samples such as granite and rhyolite are felsic. Medium-colored samples are intermediate, and dark-colored samples—other than obsidian—are mafic.

Name Class Date

DESIGN YOUR OWN GeoLab: Modeling Crystal Formation

The rate at which magma cools has an effect on the grain size of the resulting igneous rock. Observing the crystallization of magma is difficult because molten rock is very hot and the crystallization process is sometimes very slow. Other materials, however, crystallize at lower temperatures. These materials can be used to model crystal formation.

PREPARATION

Problem

Model the crystallization of minerals from magma.

Materials

clean, plastic petri dishes
saturated alum solution
200-mL glass beaker
magnifying glass
piece of dark-colored construction paper
thermometer
paper towels
water
hot plate

Objectives

In this GeoLab, you will:

- **Determine** the relationship between cooling rate and crystal size.
- **Compare** and **contrast** different crystal shapes.

Safety Precautions

The alum mixture can cause skin irritation and will be hot when it is first poured into the petri dishes. If splattering occurs, wash skin with cold water. Always wear safety goggles and an apron in the lab.

PROCEDURE

1. As a group, plan how you could change the cooling rate of a hot solution poured into a petri dish. For instance, you may want to put one sample in a freezer or refrigerator for a designated period of time. Assign each group member a petri dish to observe during the experiment.
2. Place a piece of dark-colored construction paper on a level surface where it won't be disturbed. Place the petri dishes on top of the paper.
3. Carefully pour a saturated alum solution that is about 95°C to 98°C, or just below boiling temperature, into each petri dish so that it is half-full. Use caution when pouring the hot liquid to avoid splatters and burns.
4. Observe the petri dishes. On the next page, draw a data table on which to record your observations. Below your data table, draw what you observe happening in the petri dish assigned to you.
5. Every 5 minutes for 30 minutes, record your observations of your petri dish. Make accurate, full-sized drawings of any crystals that begin to form.

Name Class Date

DESIGN YOUR OWN GeoLab: Modeling Crystal Formation

DATA TABLE

OBSERVATIONS

ANALYZE

1. How did you vary the cooling rate of the solutions in the petri dishes? Compare your methods with those of other groups. Did one method appear to work better than others? Explain.

   Answers will vary depending on the cooling method used. Possible methods are listed under Data and Observations.

2. Use a magnifying glass or binocular microscope to observe your alum crystals. What do the crystals look like? Are all the crystals the same size?

   Alum crystals are tabular and have six sides. They look like triangles with the corners cut off. The crystals may be different sizes.

Name Class Date

DESIGN YOUR OWN GeoLab: Modeling Crystal Formation

ANALYZE

3. Compare your drawings and petri dish with those of other students in your group. Which petri dish had the smallest average crystal size? Describe the conditions under which that petri dish cooled.

   The petri dish that cooled most quickly will have the smallest crystals. The conditions under which the petri dish cooled will vary, depending on the cooling method used.

4. Do all the crystals have the same shape? Draw the most common shape. Share your drawings with other groups. Describe any patterns that you see.

   The majority of the crystals will have the same shape until they begin to grow together.

CONCLUDE AND APPLY

1. What factors affected the size of the crystals in the different petri dishes? How do you know?

   The cooling rate affected the crystal size. This is evident because it is the only variable tested.

2. Infer why the crystals changed shape as they grew.

   The crystals grew larger but maintained a similar shape until they began to interfere with each other. Their shapes became distorted as they grew together.

3. How is this experiment different from magma crystallization? How is it the same?

   The experiment is different from magma crystallization in that magma crystallization involves the cooling of melted minerals, whereas this experiment involves the cooling of a hot solution containing dissolved minerals. The experiment is similar to magma crystallization in that the cooling rate affected crystal size in both cases, and the crystals grew by adding atoms to their surfaces.

4. Describe the relationship between cooling rate and crystal formation.

   A fast cooling rate results in small crystals; a slow cooling rate results in large crystals.

Name Class Date

MiniLab 6 What happened here?

Interpret animal activity from patterns of fossil footprints.

Procedure

1. Study the photograph of a set of footprints that has been preserved in sedimentary rocks.
2. Write a description of how these tracks might have been made.

3. Draw your own diagram of a set of fossilized footprints that record the interactions of organisms in the environment. Use the space below.

4. Give your diagram to another student and have that student interpret what happened.

Analyze and Conclude

1. How many animals made the tracks shown?

   one
2. What types of information can be inferred from a set of fossil footprints?

   types of animals, direction of travel, relative stride lengths and weights of the animals, number of toes, which tracks were made first, and so on
3. Did other students interpret your diagram the same way? What might have caused any differences?

   Diagrams will likely have multiple interpretations because different animal interactions may leave similar types of tracks.

Name Class Date

GeoLab Interpreting Changes in Rocks

As the rock cycle continues, and rocks change from one type to another, more changes occur than meet the eye. Color, grain size, texture and mineral composition are easily observed and described visually. Yet, with mineral changes come changes in crystal structure and density. How can these be accounted for and described? Studying pairs of sedimentary and metamorphic rocks can show you how.

PREPARATION

Problem

How do the characteristics of sedimentary and metamorphic rocks compare?

Materials

samples of sedimentary rocks and their metamorphic equivalents
magnifying glass or hand lens
paper
pencil
beam balance
100-mL graduated cylinder or beaker large enough to hold the rock samples
water

Objectives

In this GeoLab, you will:

- **Describe** the characteristics of sedimentary and metamorphic rocks.
- **Determine** the density of different rock types.
- **Infer** how metamorphism changes the structure of rocks.

Safety Precautions

Always wear safety goggles and an apron in the lab.

PROCEDURE

1. Use the data table on the next page. Add rows to the table if you are examining more than four samples.
2. Observe each rock sample. Record your observations in the data table.
3. Recall that density = mass/volume. Make a plan that will allow you to measure the mass and volume of a rock sample.
4. Determine the density of each rock sample and record this information in the data table.

Name Class Date

GeoLab Interpreting Changes in Rocks

Data Table

Sample number	Rock type	Specific characteristics	Mass	Volume	Density
1					
2					
3					
4					

ANALYZE

1. Compare and contrast a shale and a sandstone.

   shale–darker color, finer grained, thin layers; sandstone–lighter color, medium grained, thicker layers or massive

2. How does the grain size of a sandstone change during metamorphism?

   The grains become larger as they grow together.

3. What textural differences do you observe between a shale and a slate?

   Slate has thinner foliated layers and may have a smoother feel and shinier luster because of the presence of metamorphic mica minerals.

4. Compare the densities you calculated with other students. Does everybody have the same answer? What are some of the reasons that answers may vary?

   The calculated densities will be variable. Possible sources of error are mathematical mistakes, mass differences between wet and dry samples, lack of precision in volume measurement, and slight differences between samples.

Name Class Date

GeoLab Interpreting Changes in Rocks

CONCLUDE AND APPLY

1. Why does the color of a sedimentary rock change during metamorphism?

   The grain size is changing and new minerals are growing.

2. Compare the density of a slate and a quartzite. Which rock has a greater density? Explain.

   Depending upon samples used, the densities may be close. Slate will usually have a greater density than quartzite. Quartzite will have a density very close to quartz—2.6 g/cm^3. The mica minerals in slate often have a greater density than quartz does.

3. Compare the densities of shale and slate, sandstone and quartzite, and limestone and marble. Does density always change in the same way? Explain the results that you observed.

   The slate will be more dense than the shale because denser minerals have grown. Quartzite is denser than sandstone because silica has grown into the pore spaces that had previously been filled with air or water. Marble is more dense than limestone because the calcite has recrystallized into a denser, interlocking structure.

Name Class Date

MiniLab 7 How do rocks weather?

Model how rocks are exposed to their surrounding environment and slowly weather away.

Procedure

1. Carve your name deeply into a bar of soap with a toothpick. Weigh the soap and record the weight.
2. Measure and record the depth of the letters carved into the soap.
3. Place the bar of soap on its edge in a catch basin.
4. Sprinkle water over the bar of soap until a noticeable change occurs in the depth of the carved letters.
5. Measure and record the depth of the carved letters.

Analyze and Conclude

1. How did the depth of the letters carved into the bar of soap change?

   The depth of the letters carved in the bar of soap decreased as more water was poured over it.
2. Did the shape, size, or weight of the bar of soap change?

   The shape of the bar of soap became more rounded and the bar of soap became smaller. The soap might also have lost mass.
3. Where did the missing soap go?

   The missing soap dissolved in the water and eventually was carried away in the drain.
4. What additional procedure could you follow to determine whether any soap wore away?

   Measure the mass of the soap before and after water is added.

Name Class Date

GeoLab Effects of Weathering

Many factors affect the rate of weathering of Earth materials. Two major factors that affect the rate at which a rock weathers include the length of time it is exposed to a weathering agent and the composition of the rock.

PREPARATION

Problem

Investigate the relationship between time and the rate of weathering of halite chips.

Materials

plastic jar with lid
water (300 mL)
halite chips (100 g)
balance
timer
paper towels

Objectives

In this Geolab, you will:

- **Determine** the relationship between the length of time that rocks are exposed to running water and the degree of weathering of the rocks.
- **Describe** the appearance of weathered rocks.
- **Infer** what other factors may influence the rate of weathering.
- **Apply** your results to a real-world situation.

Safety Precautions

Wear splash-resistant safety goggles and an apron while you do this activity. Do not ingest the halite chips.

Weathering Data

Average Shaking Time in Minutes	Weight of Chips (g)
3	**Data should reflect**
6	**decreases in weight with**
9	**increases in shaking time.**
12	

Name Class Date

GeoLab Effects of Weathering

PROCEDURE

1. Soak 100 g of halite chips in water overnight.
2. As a class, decide on a uniform method of shaking the jars.
3. Pour off the water and place the halite chips in the plastic jar.
4. Add 300 mL of water to the jar.
5. Secure the lid on the jar.
6. Shake the jar for the assigned period of time.
7. Remove the water from the jar.
8. Use paper towels to dry the halite chips.
9. Use a balance to weigh the chips. Record your measurement in a data table similar to the one provided on page 28.

ANALYZE

1. Why did you need to soak the chips before conducting the investigation?

Soaking in water is important so that the chips have already absorbed all the water they can. Absorption of water during the lab would lead to inconsistencies in data.

2. How did the mass of the rocks change with the length of time they were shaken?

Overall weight decreased with an increase in shaking time.

3. How did the shape of the rocks change as a result of being shaken in a jar with water?

The rock chips became more rounded and smooth.

4. What factors could have affected a team's results?

degree of accuracy, care in not losing pieces of rock chips, not shaking in a similar manner in each lab group

Name Class Date

GeoLab Effects of Weathering

CONCLUDE AND APPLY

1. What real-world process did you model in this investigation?

rocks moving in a stream

2. How would acid precipitation affect this process in the real world?

Acid precipitation would speed up the rate of weathering by making the water more acidic.

3. How would the results of your investigation be affected if you used pieces of quartz instead of halite?

The pieces of quartz would not wear away in the time allotted for this investigation.

Name Class Date

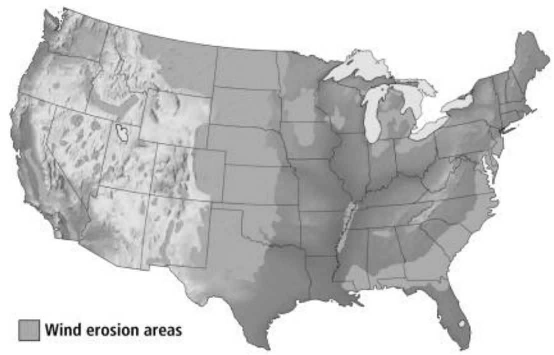
MiniLab 8

Where does wind erosion occur?

Interpret a wind erosion map to find out what parts of the United States are subject to wind erosion.

Procedure
Refer to the wind erosion map shown below to answer the following questions.

Wind Erosion in the United States



Analyze and Conclude

1. Which areas of the United States experience wind erosion?
   Wind erosion occurs in the Great Plains area and along eastern and southern shorelines.
2. Where is the largest area of wind erosion? The second largest?
   The largest area of wind erosion is the Great Plains, and the second largest is along the eastern and southern shorelines.
3. What coastal areas are subject to wind erosion?
   the mid-Atlantic and southern shorelines and shorelines along the northern and western portions of the Gulf of Mexico

Name Class Date

Mapping GeoLab

Mapping a Landslide

Around midday on April 27, 1993, in a normally quiet, rural area of New York State, the landscape dramatically changed. Unexpectedly, almost 1 million m^3 of Earth debris slid over 300 m down the lower slope of Bare Mountain and into Tully Valley. The debris flowed over the road and buried nearby homes. The people who lived there had no knowledge of any prior landslides occurring in the area, yet this landslide was the largest to occur in New York State in more than 75 years. What caused this large mass of Earth material to move so suddenly?

PREPARATION

Problem
How can you use a drawing based on a topographic map to infer how the Tully Valley Landslide occurred?

Materials
metric ruler
pencil

PROCEDURE

1. Use the map to answer the following questions. Be sure to check the map's scale.
2. Measure and record the length and width of the Tully Valley in kilometers. Double-check your results.

ANALYZE

1. What does the shape of the valley tell you about how it formed?
   The shape of the valley indicates that it was formed by glacial activity.
2. In what direction did the landslide flow?
   west to east
3. In what direction does the Onondaga Creek flow?
   north
4. Infer from the map which side of Tully Valley has the steepest valley walls.
   Students should infer from the map that the western side has experienced landslides in the past and is steepest.

Name Class Date

Mapping GeoLab — Mapping a Landslide

ANALYZE

5. What conditions must have been present for the landslide to occur?

The ground had to be saturated with water.

6. At the time of the Tully Valley Landslide, the trees were bare. How could this have affected the conditions that caused the landslide?

Trees with leaves would have soaked up more of the water in the ground and the landslide may not have occurred.

CONCLUDE AND APPLY

1. Why do you think the Tully Valley Landslide occurred?

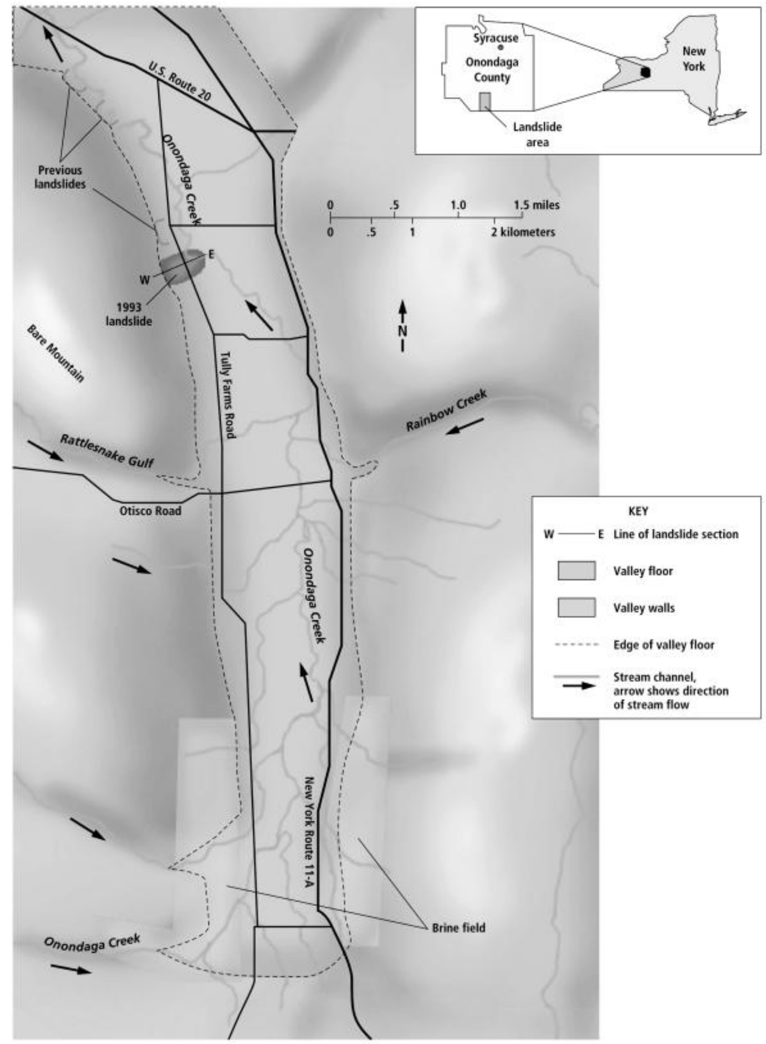
The fine particles that made up the sediments in the valley were saturated with water. The water reduced friction between the particles and allowed the rock material to slide downslope.

2. If you planned to move into an area prone to mass movements, such as landslides, what information would you gather beforehand?

Check with local planning boards and other governmental agencies and groups to determine the past history of the area; scout the area out and look for possible signs of previous slumping, erosion, and so on; and do not purchase or build in geologically questionable sites such as at the base of a steep mountain.

Name Class Date

Mapping GeoLab — Mapping a Landslide



Name Class Date

MiniLab 9 Surface materials determine where a lake can form.

Model how different Earth materials may allow lakes to form. Lakes form when depressions or low areas fill with water.

Procedure

CAUTION: Always wear safety goggles and an apron in the lab.

1. Use three clear, plastic shoe boxes. Half fill each one with earth materials: clay, sand, gravel.
2. Slightly compress the material in each shoe box. Then make a shallow depression in each surface.
3. Slowly pour 500 mL of water into each of the depressions.

Analyze and Conclude

1. Describe what happened to the 500 mL of water that was added to each shoe box.

   The water should quickly flow through the gravel. The water will flow through the sand less quickly. The water will remain on the top of the clay the longest.

2. How is this activity similar to what actually happens on Earth's surface when a lake forms?

   When water collects in an area where the spaces between the particles of surface material are small, the water is more likely to remain on top of Earth's surface and form a lake.

3. What can you infer about the Earth materials in which lakes most commonly form?

   Earth surface materials that lead to the formation of lakes do not allow water to easily pass through them.

Name Class Date

GeoLab Modeling Stream Velocity and Slope

Water in streams flows from areas of higher elevation to areas of lower elevation. The rate of stream flow varies from one stream to another and also in different areas of the same stream.

PREPARATION

Problem

Determine how slope may affect stream-flow velocity.

Materials

1-m length of vinyl gutter pipe
ring stand and clamp
water source with long hose
protractor with plumb bob
sink or container to catch water
stopwatch
grease pencil
meterstick
paper
hole punch

Objectives

In this GeoLab, you will:

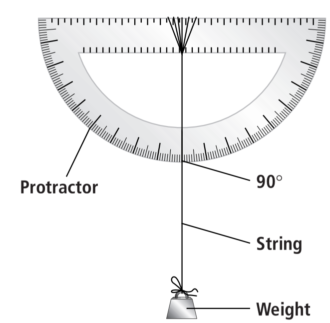
- **Measure** the time it takes for water to flow down a channel at different slopes and depths.
- **Organize** your data in a table.
- **Plot** the data on a graph to show how stream velocity is directly proportional to the stream channel's slope and depth.
- **Describe** the relationship between slope and rate of stream flow.

Safety Precautions

Always wear safety goggles in the lab.

PROCEDURE

1. Use the hole punch to make 10 to 15 paper circles to be used as floating markers.
2. Use the illustration below as a guide to set up the protractor with the plumb bob.



3. Use the grease pencil to mark two lines across the inside of the gutter pipe at a distance of 40 cm apart.
4. Use the ring stand and clamp to hold the gutter pipe at an angle of 10°. Place the end of the pipe in a sink or basin to collect the discharged flow of water.
5. Attach a long hose to a water faucet in the sink.
6. Keep the hose in the sink until you are ready to use it. Then turn on the water and adjust the flow until the water is moving quickly enough to provide a steady flow.
7. Bend the hose temporarily to block the water flow until the hose is positioned at least 5 cm above the top line marked on the pipe.

GeoLab Modeling Stream Velocity and Slope

PROCEDURE

8. Keep the water moving at the same rate of flow for all slope angles being investigated.
9. Drop a floating marker approximately 4 cm above the top line on the pipe and into the flowing water. Measure the time it takes for the floating marker to move from the top line to the bottom line. Record the time in your science journal.
10. Repeat step 9 two more times.
11. Repeat steps 9 and 10 but change the slope to 20°, then 30°, and then 40°.
12. Make a line graph of the average stream-flow velocity, using the space below.

LINE GRAPH

ANALYZE

1. Why is it important to keep the water flow constant in this activity?

   A change in water flow would result in either a higher or lower reading. If there were a change in water flow, the data collected would reflect the change in water volume instead of only the change in slope.

2. Which variables had to be controlled to avoid errors in your data?

   the rate of water flow from the hose and the volume of water from the hose

3. Using your graph, predict the velocity of water flow for a 35° slope.

   Answers will vary depending on student data.

GeoLab Modeling Stream Velocity and Slope

CONCLUDE AND APPLY

1. What is the relationship between the rate of water flow and the angle of the slope?

   There is a direct relationship between the rate of flow and the angle of the slope. Velocity increases as the angle of the slope increases.

2. Describe one reason why a stream's slope might change.

   As a stream erodes its base, the stream's slope is reduced.

3. Where would you expect to find streams with the highest water-flow velocity?

   at higher elevations

Name Class Date

MiniLab 10 How does an artesian well work?

Model the changes that an artesian aquifer undergoes when a well is dug into it. What causes the water to rise above the ground surface?

Procedure

CAUTION: Always wear safety goggles and an apron in the lab.

1. Half fill a plastic shoe box or other container with sand. Add enough water to saturate the sand. Cover the sand completely with a 1- or 2-cm layer of clay or a similar impermeable material.
2. Tilt the box at an angle of about 10°. Use a book for a prop.
3. Punch three holes through the clay, one each near the low end, the middle, and the high end of the box. Insert a clear straw through each hole into the sand below. Seal the holes around the straws.

Analyze and Conclude

1. Observe the water levels in the straws. Where is the water level the highest? The lowest?

   highest in the lowest straw, lowest in the highest straw

2. Where is the water table in the box?

   below the silicone putty

3. Where is the water under greatest pressure? Explain.

   at low end of container because of the hydrostatic pressure produced by the weight of the water above that level

4. Predict what will happen to the water table and the surface to which the water flows from one of the straws.

   Both the water table in the sand and the pressure surface will be lowered.

Name Class Date

Mapping GeoLab Mapping Pollution

You can use the map to estimate the direction of groundwater flow and the movement of a pollution plume from its source, such as a leaking underground gasoline storage tank.

PREPARATION

Problem

A major gasoline spill occurred at Jim's Gas Station near Riverside Acres, Florida. How can you determine the movement of the resulting pollution plume?

Materials

USGS topographic map of Forest City, Florida
transparent paper
graph paper
ruler
calculator

PROCEDURE

1. Identify the lakes and swamps in the southeast corner of this map, and list their names and elevations in the data table on the next page. Note: The elevations are given or can be estimated from the contour lines.
2. Place the transparent paper over the southeast part of the map and trace the approximate outlines of these lakes or swamps, as well as the major roads. Enter lake or swamp elevations on your overlay, and indicate the location of Jim's Gas Station on Forest City Rd., about 1400 feet north of the Seminole County line (at the 96 foot elevation mark).
3. Add contour lines to your overlay using a contour interval of 10 feet.
4. Construct a cross section of the surface topography and the water table from Lake Lotus to Lake Lucien (through Jim's Gas Station).

ANALYZE

1. What is the slope of the water table at Jim's Gas Station?

   at most, 1/100 (10′/1000′)

2. What is the approximate direction of the water table slope at Jim's Gas Station?

   northwest

3. In which direction will the pollution plume move?

   northwest

4. Which settlements or houses are threatened by this pollution plume?

   none

Name Class Date

Mapping GeoLab

Mapping Pollution

Name	Elevation (in feet)
Gandy	74
Bosse	61
Eve	84
Lotus	61
Unnamed 1	63
Trout	59
Unnamed 2	57
Pearl	59
Forest	65
Harriet	53
Cranes Roost	49
Spring	66
Unnamed 3	54
Orienta	61
Destiny	89
Unnamed 4	95
Charity	69
Lucien	92
Unnamed 5	89

CONCLUDE AND APPLY

1. How far below the surface is the water table in this highest area?

about 25 feet

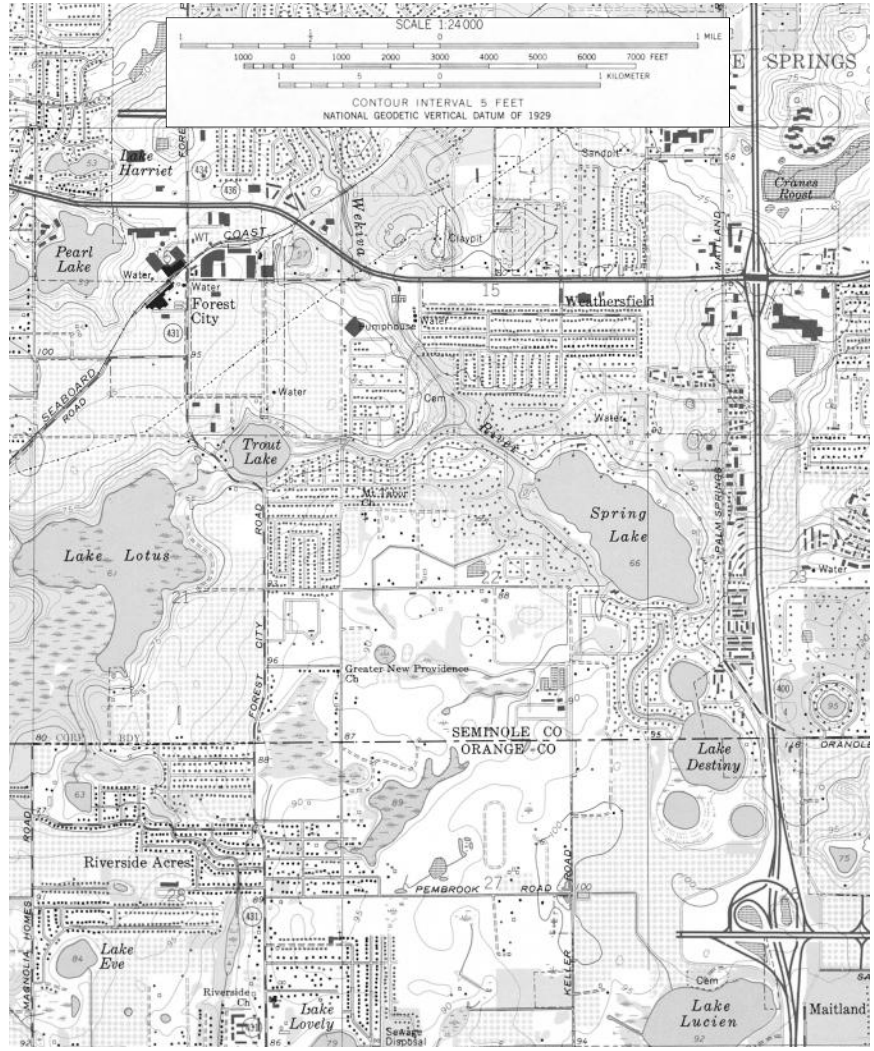
2. What is the relationship of the water table to the surface topography?

The water table generally follows the surface topography.

Name Class Date

Mapping GeoLab

Mapping Pollution



MiniLab 11 What affects the formation of clouds and precipitation?

Model the water cycle.

Procedure

1. Pour about 125 mL of warm water into a clear, plastic bowl.
2. Loosely cover the top of the bowl with plastic wrap. Overlap the edges by about 5 cm.
3. Fill a self-sealing plastic bag with ice cubes, seal it, and place it in the center of the plastic wrap on top of the bowl. Push the bag of ice down so that the plastic wrap sags in the center, but doesn't touch the surface of the water.
4. Use tape to seal the plastic wrap around the bowl.
5. Observe the surface of the plastic wrap directly under the ice cubes every 15 minutes for one hour, or until the ice melts.

Analyze and Conclude

1. What formed on the underside of the wrap? Infer why this happened.

   Water droplets formed as rising, warm air condensed near the ice.

2. Relate your observations to processes in the atmosphere.

   The rising, warm air models evaporation, the water droplets model condensation, and the falling droplets model precipitation.

3. Predict what would happen if you repeated this activity with hotter water.

   More precipitation would have formed more rapidly. The air would have risen more quickly, which in turn would have caused a faster rate of condensation.

GeoLab Interpreting Pressure-Temperature Relationships

As you go up a mountain, both temperature and air pressure decrease. These effects are easily explained. Temperature decreases as you get farther away from the atmosphere's heat source, Earth's surface. Pressure decreases as you ascend the mountain because there are fewer and fewer particles of air above you. Pressure and temperature, however, are also related through the expansion and compression of air, regardless of height. In this activity, you will demonstrate that relationship.

PREPARATION

Problem

Demonstrate the relationship between temperature and pressure.

Objectives

In this GeoLab, you will:

- **Model** the temperature and pressure changes that take place as a result of the expansion and compression of air.
- **Relate** the changes to processes in the atmosphere.

Materials

clean, clear, plastic 2-L bottle with cap
plastic straws
scissors
thin, liquid-crystal temperature strip
tape
watch or timer

Safety Precautions

Always wear safety goggles and an apron in the lab.

PROCEDURE

1. Cut two pieces of straw, each the length of the temperature strip. Then cut two 2-cm pieces of straw. Lay the two long pieces on a table. Place the two shorter pieces within the space created by the longer pieces so that the four pieces form a supportive structure for the temperature strip.
2. Tape the four pieces of straw together. Place the temperature strip lengthwise upon the straws. Tape the strip to the straws.
3. Slide the temperature strip-straw assembly into the clean, dry bottle. Screw the cap on tightly.
4. Place the sealed bottle on the table so that the temperature strip faces you and is easy to read. Do not handle the bottle any more than is necessary so that the temperature inside will not be affected by the warmth of your hands.
5. Record the temperature of the air inside the bottle as indicated by the temperature strip.
6. Next, position the bottle so that about half its length extends beyond the edge of the table. Placing one hand on each end of the bottle, push down on both ends so that the bottle bends in the middle. Hold the bottle this way for 2 minutes. During this time, your partner should record the temperature every 15 seconds.
7. Release the pressure on the bottle. Observe and record the temperature every 15 seconds for the next 2 minutes.

Name Class Date

GeoLab Interpreting Pressure-Temperature Relationships

ANALYZE

1. What was the average temperature of the air inside the bottle as you applied pressure to the bottle? How did this differ from the average temperature of the bottled air when you released the pressure on the bottle?

Average temperatures will differ. However, in all cases, temperature should have decreased when pressure was released.

2. Make a graph of the temperature changes you recorded throughout the experiment, using the space below.

Graphs will vary, but all should show that temperature increased when pressure was applied and decreased when pressure was released.

3. Explain how these temperature changes are related to changes in pressure.

As pressure increases, the molecules that make up air are packed more tightly together. This creates more collisions and produces more heat.

CONCLUDE AND APPLY

1. Predict how the experiment would change if you took the cap off the bottle.

Air would escape when pressure was applied on the bottle. There would be no change in pressure and thus no change in temperature.

2. Given your observations and what you know about the behavior of warm air, would you expect the air over an equatorial desert at midday to be characterized by high or low pressure?

Low pressure; in the atmosphere, the hot desert air would be less dense than the air around it and therefore would rise. When air rises, it pushes down with less force, which lowers atmospheric pressure.

Name Class Date

MiniLab 12 How does the angle of the Sun's rays differ?

Model the angle at which sunlight reaches Earth's surface. This angle greatly affects the intensity of solar energy received in any one place.

Procedure

1. Hold a flashlight several centimeters above a piece of paper and point the flashlight straight down.
2. Use a pencil to trace the outline of the light on the paper. The outline models how the Sun's rays strike the equator.
3. Keeping the flashlight at the same distance above the paper, tilt the top of the flashlight to roughly a 30° angle.
4. Trace the new outline of the light. This is similar to how the Sun's rays are received at the poles.

Analyze and Conclude

1. Describe how the outline of the light differed between step 1 and step 3. Explain why it differed.

The outline of the light was larger in step 3. It changed because the light covered a larger area.

2. How do you think the change in area covered by the light affects the intensity of light received at any one place?

The amount of light received at any one place decreases when the light covers a larger area.

3. The flashlight models solar radiation striking the surface of Earth. Knowing this, compare how much heat energy is absorbed near the equator and near the poles.

Solar energy is spread over a large area at the poles; thus, polar regions receive less solar radiation than do areas near the equator.

Name Class Date

Mapping GeoLab: Interpreting a Weather Map

It's time to put your knowledge of meteorology into action. The surface weather map on the following page shows actual weather data for the United States. In this activity, you will use the station models, isobars, and pressure systems on the map to forecast the weather.

PREPARATION

Problem

How can you use a surface weather map to interpret information about current weather and to forecast future weather?

Materials

pencil
ruler

PROCEDURE

1. The map scale is given in nautical miles. Refer to the scale when calculating distances.
2. The unit for isobars is millibars (mb). In station models, pressure readings are abbreviated. For example, 1021.9 mb is plotted on a station model as 219 but read as 1021.9.
3. Wind shafts point in the direction from which the wind is blowing.

ANALYZE

1. What is the contour interval of the isobars?

   4 mb

2. What are the highest and lowest isobars? Where are they located?

   The highest isobar is 1040 mb and is around the high-pressure center in South-Central Canada. The lowest isobar is 988 mb and is around the low-pressure center off the coast of Oregon.

3. In which direction are the winds blowing across Texas and Louisiana?

   They are blowing mainly from the south or southeast.

4. What and where are the coldest and warmest temperatures that you can find in the continental United States?

   The coldest is −12°F at Fargo, North Dakota. The warmest is 65°F at both Miami and Key West, Florida.

Name Class Date

Mapping GeoLab: Interpreting a Weather Map

CONCLUDE AND APPLY

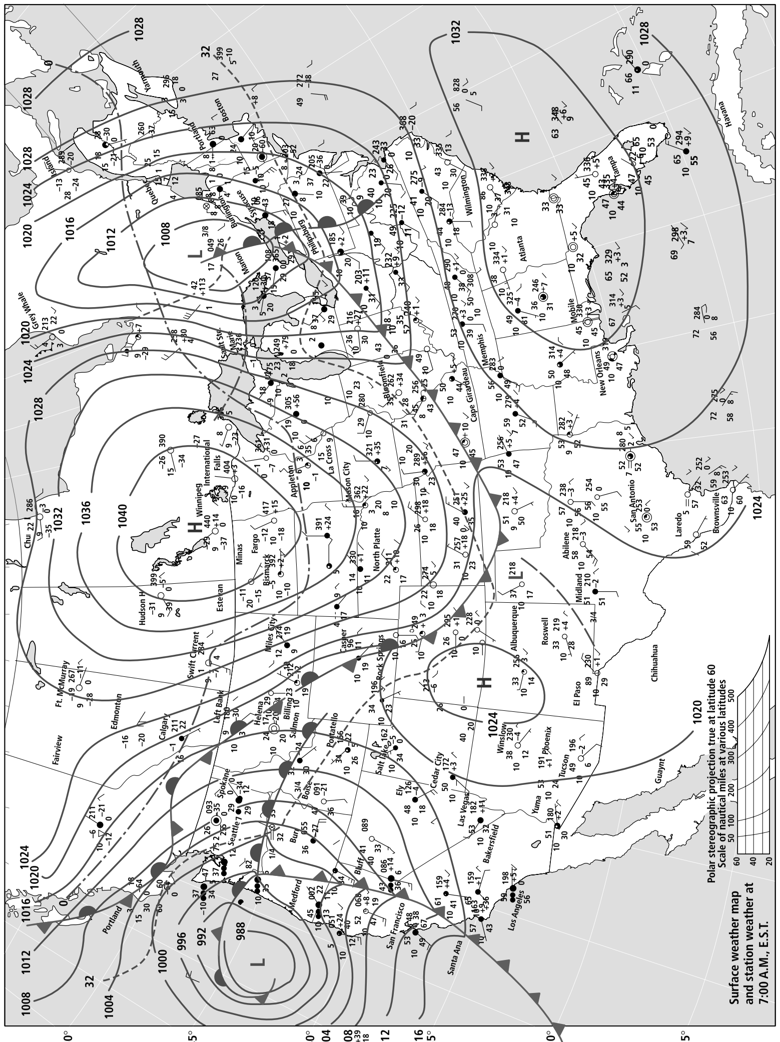
1. Would you expect the weather in Georgia and Florida to be clear or rainy? Why?

   It would probably be clear because the high-pressure system along the coast would cause air to sink and dry out.

2. Both of the low-pressure systems in eastern Canada and off the Oregon coast are moving toward the east at about 15 mph. What kind of weather would you predict for Oregon and for northern New York for the next few hours? Explain.

   The low-pressure systems would cause air to rise and produce clouds and rain.

Mapping GeoLab: Interpreting a Weather Map



MiniLab 13: How can mild rains cause floods?

Model the effects of repeated, slow-moving storms that drop rain over the same area for a long period of time.

Procedure

1. Place an ice-cube tray on the bottom of a large sink or tub.
2. Pour water into a clean, plastic dishwashing-detergent bottle until it is two-thirds full. Replace the cap on the bottle.
3. Hold the bottle upside down with the cap open about 8 cm above one end of the ice-cube tray. Gently squeeze the bottle to maintain a constant flow of water into the tray. Slowly move the bottle from one end of the tray to the other over the course of 30 seconds. Try to put approximately equal amounts of water in each ice-cube compartment.
4. Measure the depth of water in each compartment. Calculate the average depth.

5. Repeat steps 1–4, but move the bottle across the ice-cube tray in 15 seconds.

Analyze and Conclude

1. How did the average depth of the water differ in steps 4 and 5? How might you account for the difference?

   The average depth decreased in step 5 because the water fell over each compartment in a shorter amount of time.

2. Based on these results, infer how the speed of a moving storm affects the amount of rain received in any one area.

   Storms that move slowly can release more rain over any one place than can storms that move quickly.

3. How could you alter the experiment to simulate different rates of rainfall?

   speed up or slow down the motion of the water bottle; open or close the twist top slightly to simulate heavier or lighter rainfall

Name Class Date

Internet GeoLab: Tracking a Hurricane

Hurricanes are violent storms. That's why it's important to have plenty of advance warning before they hit land. By tracking the changing position of a storm on a chart and connecting these positions with a line, you can determine a hurricane's path.

PREPARATION

Problem
What information can you obtain by studying the path of a hurricane?

Hypothesis
Use the Internet to gather information about the path of a hurricane. **Form a hypothesis** about how the hurricane's path can be used to predict the strength of the storm and where most damage might be inflicted.

____

____

____

Objectives
In this GeoLab, you will:
- **Gather** and **communicate** data about hurricanes.
- **Plot** data on a hurricane-tracking chart.
- **Predict** where storm-inflicted damage might occur.

Data Sources
Go to the Glencoe Science Web Site at science.glencoe.com to find links to hurricane data on the Internet, or use information provided by your teacher. Make copies of the hurricane-tracking chart in this lab or download a chart from the Web Site.

PLAN THE EXPERIMENT

1. Find a resource that lists major hurricanes that have occurred within the past five years. The Glencoe Science Web Site provides a list of sites that have information about hurricanes.
2. Choose a hurricane to research. Some recent major hurricanes include Hurricane Georges, Hurricane Fran, and Hurricane Bertha.
3. Gather data about the hurricane from the links on the Glencoe Science Web Site or the library.

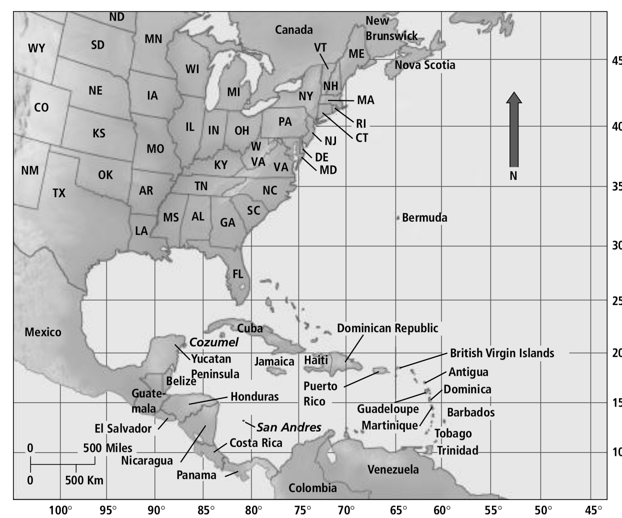
PROCEDURE

1. Draw a data table in the space provided on the next page. Incorporate your research into the table. Add any additional information that you think is important.
2. Go to the Glencoe Science Web Site at science.glencoe.com to post your data.
3. Visit sites listed on the Glencoe Science Web Site for information on other major hurricanes.

Name Class Date

Internet GeoLab: Tracking a Hurricane

DATA TABLE



Name Class Date

Internet GeoLab: Tracking a Hurricane

CONCLUDE AND APPLY

Sharing Your Data Find this *Internet GeoLab* on the Glencoe Science Web Site at science.glencoe.com. Post your data in the table provided for this activity. Use the additional data from other students to complete your chart and answer the Conclude and Apply questions.

1. Plot the position, air pressure, wind speed, and stage of the hurricane at six-hour intervals throughout its existence.
2. Plot the changing position of the hurricane on your hurricane-tracking chart.
3. What was the maximum wind speed in knots that the hurricane reached?
   Answers will vary depending on which hurricane students researched.
4. Multiply the value from question 3 by 1.15 to find the wind speed in miles per hour. Based on this value, how would the hurricane be classified on the Saffir-Simpson scale?
   Answers will vary depending on which hurricane students researched.
5. Using your completed hurricane-tracking chart, list the landmasses over which the hurricane passed.
   Answers will vary depending on which hurricane students researched.
6. Where would you expect the storm surge to have been greatest? Explain. Compare your answer to the information you gathered on the damage inflicted by the storm. Was your answer correct?
   The storm surge would be strongest on the side of the storm where onshore winds developed as the storm center moved inland.
7. How was the hurricane's strength affected when its center passed over land?
   Wind speeds decrease rapidly when a storm center moves inland because the storm becomes cut off from its energy source and weakens.

Name Class Date

MiniLab 14: How does the atmosphere affect the transfer of energy?

Model the greenhouse effect.

Procedure

1. On a clear day, place a cardboard box outside in a shaded area. Prop two thermometers against the box. Make sure the thermometers are not in direct sun.
2. Cover one thermometer with a clean glass jar.
3. Observe and record the temperature changes of each thermometer every 2 minutes over a 30-minute period.

Analyze and Conclude

1. Make a graph showing how the temperatures of the two thermometers changed over time, using the space below.
   Graphs will vary depending on student measurements.
2. Based on your graph, which thermometer experienced the greatest increase in temperature? Why?
   The thermometer in the jar should show higher readings than does the uncovered thermometer. The air was trapped inside the jar.
3. Relate your observations to the greenhouse effect in the atmosphere.
   In the atmosphere, greenhouse gases absorb and trap solar radiation, much like the glass jar absorbed and trapped energy from the Sun.

Name ____________ Class ______ Date ______

DESIGN YOUR OWN GeoLab Microclimates

Microclimates can be caused by tall buildings, large bodies of water, and mountains, among other things. In this activity, you'll observe different microclimates and then attempt to determine which factors strengthen microclimates and how these factors change with distance from Earth's surface.

PREPARATION

Problem
Which type of surface creates the most pronounced microclimate?

Possible Materials
thermometer
psychrometer
paper strip or wind sock
meterstick
relative humidity chart *(Appendix F)*

Hypothesis
Hypothesize how different areas of Earth's surface, such as grassy lawns, asphalt parking lots, and bodies of water, affect local climates. Consider also whether distance from the ground might affect temperature, relative humidity, and wind speed.

Objectives
In this GeoLab, you will:
- **Design** and **carry out** an experiment to study microclimates both at Earth's surface and above its surface.
- **Observe** and **record** temperature, relative humidity, and wind speed.
- **Infer** how different surfaces and changes in height above these surfaces affect microclimates.

Safety Precautions
Be careful when you handle glass thermometers, especially those that contain mercury. If the thermometer breaks, do not touch it. Have your teacher properly dispose of the glass and the mercury.

PROCEDURE

1. As a group, write out your hypothesis. List the steps needed to test your hypothesis. Include in your plan how you will use your equipment to measure temperature, relative humidity, and wind speed at different surfaces and at various heights above these surfaces.

____
____
____
____
____

2. Select your sites. Possible sites include a grassy playground area, a paved parking lot, and a swimming pool.
3. Be sure to control variables. For instance, different members of your group should make observations at each site at the same time of day. You'll also need to record weather variables at several different distances above each surface. Possible distances include 5 cm, 1 m, and 2 m.
4. Make a map of your test sites. Design and construct data tables for recording your observations. You'll need separate data tables for each site. Draw your map and data tables in the space on the next page.

Name ____________ Class ______ Date ______

DESIGN YOUR OWN GeoLab Microclimates

PROCEDURE

5. Read over your entire plan to make certain all steps are in logical order. Identify constants and variables in your plan.
6. Make sure your teacher approves your plan before you proceed with your experiment.
7. Carry out your plan.

MAPS, GRAPHS, AND DATA TABLE

Name Class Date

DESIGN YOUR OWN GeoLab

Microclimates

ANALYZE

1. **Comparing and Contrasting** Map your data. Color code the areas on your map to show which surfaces had the highest and lowest temperatures, the highest and lowest relative humidity, and the greatest and least wind speed. On your map, include data for surface areas only.
   Student maps will vary. Generally, the larger the scale of the map, the easier the data are to plot and read.

2. **Making and Using Graphs** Graph your data for each site, showing differences in temperature with height. Plot temperature on the x-axis and height on the y-axis. Repeat this step for relative humidity and wind speed.
   Graphs will vary but should reflect collected data.

3. **Interpreting Scientific Illustrations** Analyze your maps, graphs, and data to find patterns. Which surfaces had the most pronounced microclimates? Did height above the surface affect your data? Infer why or why not.
   Students should find that darker and denser surfaces are generally warmer and less humid than are lighter and less dense surfaces. With increasing height, temperature should decrease, and humidity and wind speed should increase.

4. **Thinking Critically** Analyze your hypothesis and the results of your experiment. Was your hypothesis supported? Explain.
   Answers will vary depending on individual results. If the weather variables showed appropriate changes with different heights and surfaces, student hypotheses were likely supported.

CONCLUDE AND APPLY

1. Why did some areas have more pronounced microclimates than others? Which factors seemed to contribute most to the development of microclimates?
   Darker and denser surfaces absorb more sunlight and therefore warm up faster. This higher rate of absorption also affects relative humidity. Areas protected from the wind likely experienced the most variation.

2. Which variable changed most with height: temperature, relative humidity, or wind speed? Which variable changed least? Infer why some variables changed more than others with height.
   Answers will vary depending on the exposure of individual locations. Any of the variables might show the most change, but normally, temperature varies most. Wind is least likely to change, but again, this depends on the exposure of the location.

Name Class Date

MiniLab 15

What is the chemical composition of seawater?

Determine the chemical composition of seawater using the following ingredients. The salinity of seawater is commonly measured in parts per thousand (ppt).

sodium chloride (NaCl)	23.48 g
magnesium chloride ($MgCl_2$)	4.98 g
sodium sulfate (Na_2SO_4)	3.92 g
calcium chloride ($CaCl_2$)	1.10 g
potassium chloride (KCl)	0.66 g
sodium bicarbonate ($NaHCO_3$)	0.19 g
potassium bromide (KBr)	0.10 g

Procedure

1. Carefully measure the ingredients and put them all in a large beaker.
2. Add 965.57 g of distilled water and mix.

Analyze and Conclude

1. How many grams of solution do you have? What percentage of this solution is made up of salts?
   34.43 g of salt + 965.57 g of water = 1000 g of saltwater
   34.43 g ÷ 1000 g = 0.03443 or 3.443 percent
2. Given that 1 percent is equal to 10 ppt, what is the salinity of your solution in parts per thousand?
   3.443 percent = 34.43 ppt
3. Identify the ions in your solution.
   Cl^-, Na^+, SO_4^{2-}, Mg^{2+}, Ca^{2+}, K^+, HCO_3^-, Br^-
4. Infer how your solution differs from actual seawater.
   The solution doesn't contain the trace elements and nutrients dissolved in seawater.

Name Class Date

GeoLab Modeling Water Masses

The water in the oceans is layered because water masses with higher densities sink below those with lower densities. The density of seawater depends on its temperature and salinity. In this activity, you'll model different types of water masses to observe the effects of density firsthand.

PREPARATION

Problem

Determine how changes in salinity and temperature affect water density.

Materials

scale
graduated 500-mL cylinder
100-mL glass beakers (4)
water
red, yellow, and blue food coloring
salt
thermometer
eyedropper
graph paper
pencil
ruler
calculator

Objectives

In this GeoLab you will:

- **Compare** and **contrast** the movement of different water samples.
- **Determine** the relative densities of the water samples.
- **Predict** the arrangement of layers in a body of water.
- **Construct** and **interpret** a temperature profile.

Safety Precautions

Always wear safety goggles and an apron in the lab. Wash your hands after completing the lab.

PROCEDURE

1. Mix 200 mL of water and 7.5 g of salt in the graduated cylinder. Pour equal amounts of the salt solution into two beakers. Fill each of the two other beakers with 100 mL of freshwater.
2. Put a few drops of red food coloring in one of the salt solutions. Put a few drops of yellow food coloring in the other salt solution. Put a few drops of blue food coloring in one of the beakers of freshwater. Do not add food coloring to the other beaker of freshwater.
3. Place the beakers with the red salt solution and the blue freshwater in the refrigerator. Refrigerate them for 30 minutes.
4. Measure and record the temperature of the water in all four beakers.
5. Put several drops of the cold, red saltwater into the beaker with the warm, yellow saltwater and observe what happens. Record your observations.
6. Put several drops of the cold, blue freshwater into the beaker with the warm, clear freshwater and observe what happens. Record your observations.
7. Put several drops of the cold, blue freshwater into the beaker with the warm, yellow saltwater and observe what happens. Record your observations.

Name Class Date

GeoLab Modeling Water Masses

ANALYZE

1. In your science journal, describe the movement of the cold, red saltwater in step 5. Compare this to the movement of the cold, blue freshwater in step 7. What accounts for the differences you observed?

   Cold saltwater sinks in warm saltwater; cold freshwater floats in warm saltwater. Cold saltwater is denser than warm saltwater; cold freshwater is less dense than warm or cold saltwater. The amount of salinity in the water accounts for the differences observed.

2. Based on your observations, list the water samples by color in order of increasing density.

   clear, blue, yellow, red

3. If you poured the four water samples into the graduated cylinder, how would they arrange themselves into layers by color, from top to bottom?

   clear, blue, yellow, red

CONCLUDE AND APPLY

1. Assume that four water masses in a large body of water have the same characteristics as the water in the four beakers. The warm water layers are 100 m thick, and the cold layers are 1000 m thick. Graph the temperature profile of the large body of water.

   Student graphs should show that the first layer extends to a depth of 100 m and has a temperature of 20°C. The second layer extends to 1100 m and has a temperature of 5°C. The third layer extends to 1200 m and has a temperature of 20°C. The fourth layer extends to 2200 m and has a temperature of 5°C.

Name Class Date

GeoLab Modeling Water Masses

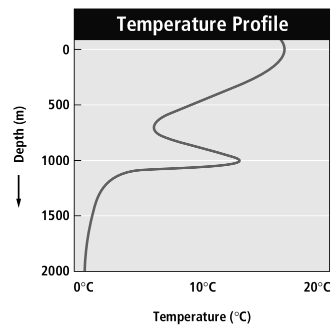
CONCLUDE AND APPLY

2. What is the salinity in parts per thousand of the combined saline solutions? (*Hint:* ppt equals grams of salt per kilogram of solution. Assume that 200 mL of water has a mass of 200 g. Be sure to include the mass of the salt in the total mass of the solution.)

mass of solution: 207.5 g

salinity = 7.5 g ÷ 207.5 g = 0.036 = 36 ppt

3. This temperature profile was constructed from measurements taken in the Atlantic Ocean off the coast of Spain. Study the profile, then infer why a high-temperature layer exists beneath the thermocline. Is this layer denser than the colder water above? Explain.



The high-temperature layer is saltier than the colder thermocline above it. It is therefore denser than the thermocline because salinity causes an increase in density.

Name Class Date

MiniLab 16 How fast do sediment grains sink?

Investigate how grain size affects settling speed.

Procedure

CAUTION: Always wear safety goggles and an apron in the lab.

1. Obtain five round pebbles and sand grains with approximate diameters of 0.5 mm, 1 mm, 2 mm, 5 mm, and 10 mm.
2. Measure the diameters of each specimen using a set of sieves. Record these measurements in the data table below.

Type of Particle	Diameter (mm)	Distance (cm)	Time (s)	Settling Speed (cm/s)

3. Fill a 250-mL graduated cylinder with cooking oil.
4. Drop the largest specimen into the oil. Measure the time it takes for the specimen to sink to the bottom of the cylinder. If the specimen doesn't fall quickly, measure the time it takes to fall a given distance. Record this time in your data table.
5. Repeat step 5 for the remaining specimens.
6. Calculate the settling speed for each specimen and fill in your data table.
7. Plot the settling speed (cm/s) against particle diameter (mm) on a graph.

Analyze and Conclude

1. How do settling speeds change as particle sizes decrease?

Settling speeds decrease with decreasing size.

2. How much faster does a 10-mm particle sink compared to a 1-mm particle?

A 10-mm particle sinks almost 30 times as fast as a 1-mm particle.

3. How long would it take a 1-mm sand grain and a 0.001-mm clay particle to settle to the bottom of the ocean at a depth of 5 km?

A 1-mm sand particle would take 8.7 h (31 250 s) to settle 5 km. A 0.001-mm particle would take 26.7 y (31 250 s × 30^3). Note: Students' results will vary.

Name Class Date

Mapping GeoLab: Identifying Coastal Landforms

Topographic maps of coastal areas show a two-dimensional representation of coastal landforms. You can identify an emergent coast by the landforms along the coastline as well as landforms found inland.

PREPARATION

Problem

How can you identify and describe the coastal landforms of an emergent coast on a topographic map?

Materials

metric ruler
graph paper
drafting compass
calculator
pencil

PROCEDURE

1. Determine the map scale and the contour interval.
2. On the inset map, plot a west-east cross section of the coast just north of Islay Creek from the 60 ft depth contour to a point 5000 feet inland. Use a scale of 1:24 000 and a vertical exaggeration of 4.
3. Use both maps to answer the following questions.

ANALYZE

1. What kind of coastal landform is the Morro Rock Peninsula?

headland

2. What kind of feature is Pillar Rock, and how was it formed?

sea stack; formed by differential erosion

3. On what coastal feature is Morro Bay State Park located? How was the feature formed?

baymouth bar; formed when a spit crosses a bay

4. What are the irregular sand hills in Morro Bay State Park?

sand dunes

Name Class Date

Mapping GeoLab: Identifying Coastal Landforms

ANALYZE

5. What is the direction of the longshore transport along Morro Bay? Explain.

To the north; sand is piling up on the south side of the breakwater.

6. Your west-east cross section shows an elevated flat area next to the shoreline. What kind of coastal landform is this? How was it formed?

an elevated marine terrace; formed by uplifting of a wave-cut platform

7. If sea level dropped 10 m, how would the shoreline change? How far would it move seaward? Would it become more regular or irregular? What would happen to Morro Bay?

The shoreline would move 2000 ft seaward and become more regular. Morro Bay would dry up.

8. If sea level rose 6 m, how would the coastal region change? Name three major changes.

Morro Rock would become an island, most of the coastal communities would be flooded, the coastline would become more irregular, and Morro Bay would become a large, branching estuary extending almost 2 mi further inland.

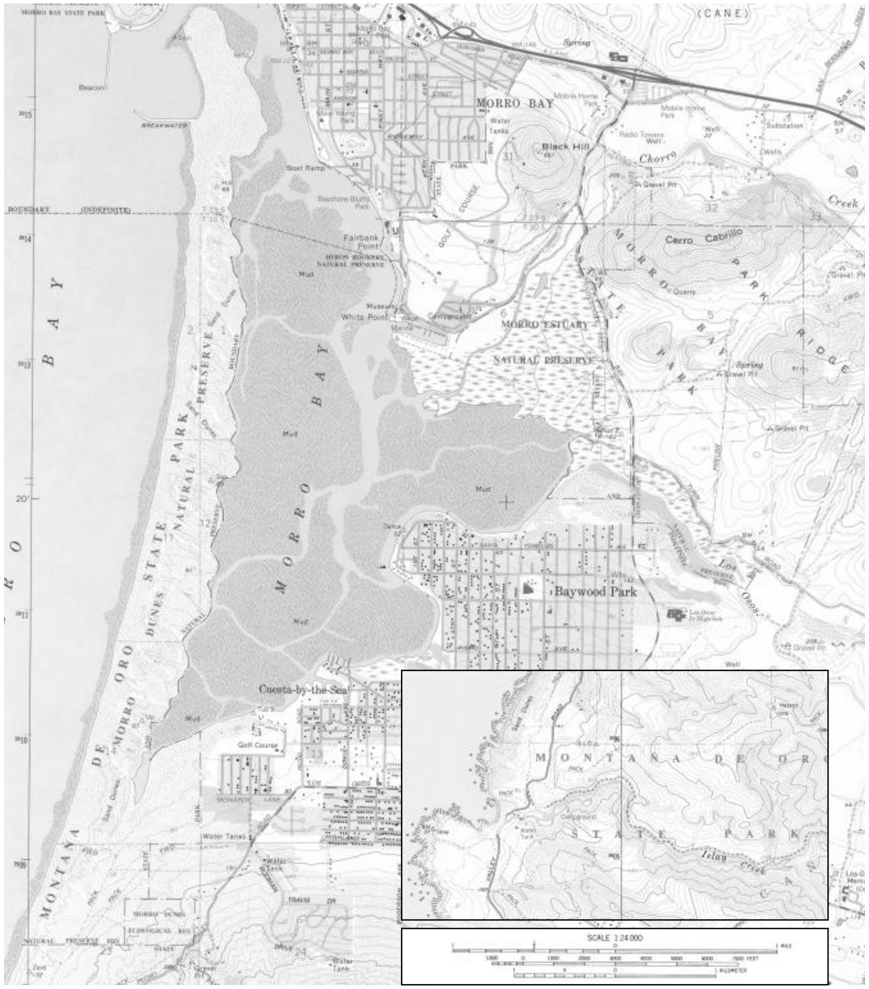
CONCLUDE AND APPLY

1. Is this portion of the California coast emergent or submergent? What features of this coastline provide evidence for your answer?

this coast is emergent; elevated marine terraces, fairly straight shoreline

Name Class Date

Mapping GeoLab Identifying Coastal Landforms



Name Class Date

MiniLab 17 Model ocean-basin formation

Model the formation of the South Atlantic Ocean.

Procedure

1. Use a world map to create paper templates of South America and Africa.
2. Place the two continental templates in the center of a piece of 11″ × 17″ paper and fit them together along their Atlantic coastlines.
3. Carefully trace around the templates with a pencil. Remove the templates and label the diagram "150 million years ago."
4. Use an average spreading rate of 4 cm/y and a map scale of 1 cm = 500 km to create a series of maps that accurately show the development of the Atlantic Ocean at 30-million-year intervals, beginning 150 million years ago.

Analyze and Conclude

1. Compare your last map with a world map. Is the actual width of the South Atlantic Ocean the same on both maps?

   The model's width of 6000 km is greater than the actual width of the Atlantic Ocean, which is between 4500 and 5500 km.

2. What might have caused any difference between the width in your model and the actual width of the present South Atlantic Ocean?

   The spreading rate used in the model is faster than the actual spreading rate.

Name Class Date

Mapping GeoLab: Making a Paleomagnetic Map

Iron-bearing minerals in rocks record the orientation of Earth's magnetic field at the time of their formation. These preserved magnetic alignments in ocean-floor rocks can be used to date different parts of the seafloor and to determine rates of spreading along divergent plate margins.

PREPARATION

Problem

How can you use paleomagnetic data to interpret information about ocean-floor rocks?

Materials

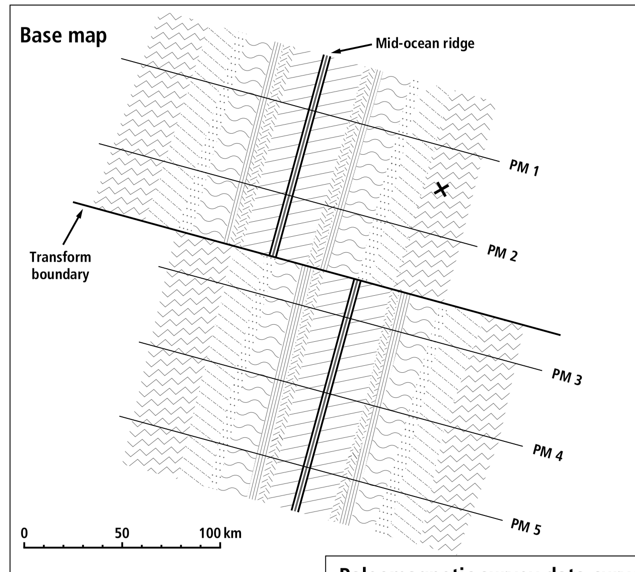
tracing paper
metric ruler
No. 2 pencil
colored pencils
Figure 1

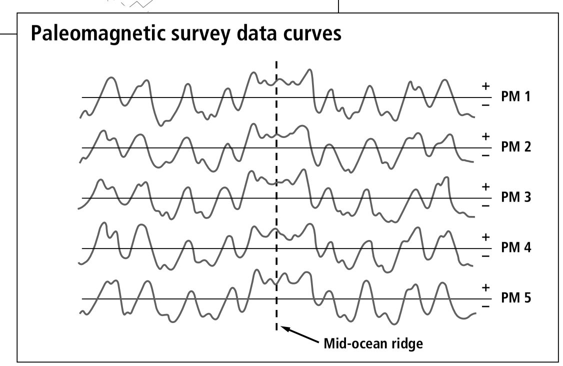
PROCEDURE

1. Use the tracing paper and the No. 2 pencil to carefully copy the base map on the following page. Be sure to include the magnetic survey lines, the map scale, and the location indicated by the letter *X* on your tracing.
2. Transfer the magnetic survey data from PM1 to your tracing by placing the survey line on your map over the PM1 data curve on the following page. Be sure to align the mid-ocean ridge with the dashed line before you begin transferring the line. Label the line.
3. Repeat step 2 for the other four lines.
4. Next, use your ruler to draw a series of parallel lines between PM1 and PM2 to connect the corresponding positive and negative magnetic reversals. Draw the lines past PM2, but stop the lines at the transform boundary.
5. Draw another series of lines between survey lines PM3 and PM4 and between PM4 and PM5. Again, end these lines at the transform boundary.
6. The positive magnetic reading along the mid-ocean ridge represents the Brunhes Magnetic Epoch. The first negative anomaly on either side of the ridge marks the beginning of the Matuyama Magnetic Epoch. Use ***Figure 1*** to identify the magnetic reversals.
7. Assign a color for each magnetic reversal. Then, color the corresponding stripe on each side of the ridge.

Name Class Date

Mapping GeoLab: Making a Paleomagnetic Map





Name Class Date

Mapping GeoLab: Making a Paleomagnetic Map

ANALYZE

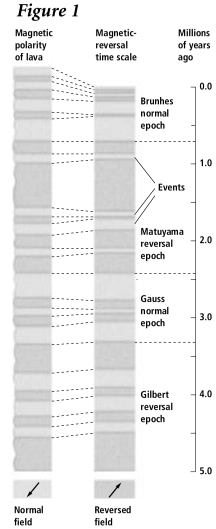
1. Why was it necessary to color corresponding stripes on each side of the ridge in step 7?

The two stripes formed as a single band along the ridge axis. Seafloor spreading split the band in two to form stripes that moved in opposite directions in relation to the ridge.

2. Use *Figure 1* to determine the age of the seafloor at location *X*.

The age of the crust at point *X* is about 2.8 million years.

Figure 1



CONCLUDE AND APPLY

1. What might cause an individual magnetic stripe of ocean-floor crust to vary in width?

variable spreading rates along the ridge

2. What is the average spreading rate along this section of the mid-ocean ridge?

The average spreading rate is about 5 cm/y. Students can calculate this rate by measuring the distance between location *X* and the corresponding point on the opposite side of the ridge, which is about 145 km. The age of the crust at point *X* is 2.8 million years, and 145 km ÷ 2.8 million years = 5.2 cm/y.

Name Class Date

MiniLab 18: How does silica affect lava flow?

Model the changes in lava viscosity with the addition of silica.

Procedure

CAUTION: Always wear safety goggles and an apron in the lab.

1. Pour 120 mL of dishwashing liquid into a 250-mL beaker.
2. Stir the liquid with a stirring rod. Describe the viscosity.
3. Add 30 g of NaCl (table salt) to the liquid. Stir well. Describe what happens.
4. Repeat step 3 three more times.

Analyze and Conclude

1. What do the liquid and NaCl represent?

liquid—lava; NaCl—silica

2. How does an increase in silica affect lava viscosity?

As the silica content increases, the viscosity of lava increases.

3. Basaltic eruptions are called flows because of the way they move across Earth's surface. What can you infer about the silica content of a basaltic flow?

It is low.

Name Class Date

Internet GeoLab Ranking Hazardous Volcanoes

Some volcanoes can be explosively dangerous. Along with clouds of ash and other volcanic debris that can linger in the air for years after an eruption, pyroclastic flows, landslides, and mudflows are common volcanic hazards. An explosive volcano may not be a hazard to human life and property, however, if it is located in a remote area or erupts infrequently. A number of factors must be taken into account to determine if a particular volcano poses a risk.

PREPARATION

Problem

Which volcanoes on our planet pose the greatest risk to human life and property?

Hypothesis

Form a hypothesis about where you think the most hazardous volcanoes are located on Earth. Think about the potential risk to people and property near the volcano when formulating your hypothesis. Write your hypothesis in the space below.

___

___

___

Objectives

In this GeoLab, you will:

- **Gather** and **communicate** data about three volcanoes in different parts of the world.
- **Form conclusions** about the hazards posed by the volcanoes based on their location, size, lava type, and eruptive history.

Data Sources

Go to the Glencoe Science Web Site at science.glencoe.com to find links to volcano data on the Internet. You can also use current reference books and scientific magazines to aid in the collection of data.

PROCEDURE

1. Select a country and find out if there are any volcanoes in that country. If there are no volcanoes, choose another country. If there are a lot of volcanoes in that country, narrow your search.
2. Repeat step 1 for two other volcanoes. Copy and complete the data table on the next page with the information about each of the three volcanoes you selected.

Name Class Date

Internet GeoLab Ranking Hazardous Volcanoes

RANKING OF SOME HAZARDOUS VOLCANOES			
Volcano name			
Country			
Location of volcano (latitude and longitude)			
Type of volcano			
Composition of lava/ Explosiveness			
Date of last eruption			
Eruption interval (number of eruptions over a period of time)			
Height of volcano			
Distance to nearest population center			
Approximate number of people living near the volcano			
Type(s) of potential hazards			
Human hazard ranking (high, medium, low)			

Name Class Date

Internet GeoLab: Ranking Hazardous Volcanoes

CONCLUDE AND APPLY

Sharing Your Data Find this Internet GeoLab on the Glencoe Science Web Site at science.glencoe.com. Post your data in the table provided for this activity. Use the additional data from other students to complete your chart and answer the Conclude and Apply questions.

1. Which of the volcanoes you researched threatens the greatest number of people? Where is this volcano located?

   Answers will vary; discuss students' results as a class.

2. Analyze the data posted by others at the science.glencoe.com site. Which country has the greatest number of potentially dangerous volcanoes? Why?

   Students might select Russia or Indonesia. The high number of dangerous volcanoes in these two countries is a result of their proximity to subduction zones.

3. Which country has the greatest total population threatened by volcanoes?

   Japan probably has the largest population threatened by dangerous volcanoes because the country is densely populated. Most of Russia's volcanoes are in sparsely populated areas.

Name Class Date

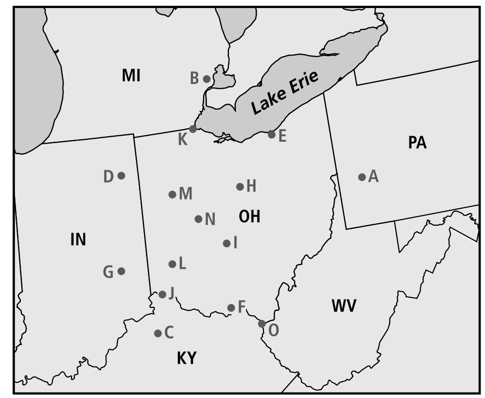
MiniLab 19: How is a seismic–intensity map made?

Make a Map using seismic–intensity data.

Procedure

1. Trace the map onto paper. Mark the locations indicated by the letters on the map.
2. Plot these Mercalli intensity values on the map next to the correct letter:
   A, I; B, III; C, II; D, III; E, IV; F, IV; G, IV; H, V; I, V; J, V; K, VI; L, VIII; M, VII; N, VIII; O, III.
3. Draw contours on the map to separate the intensity values.

Intensity Values of a Quake



Analyze and Conclude

1. What is the maximum intensity value?

   The maximum intensity value is VIII.

2. Where is the maximum intensity value located?

   It is located at stations L and N.

3. Where is the earthquake's epicenter?

   between stations L and N

Name Class Date

GeoLab Locating an Epicenter

The separation of P- and S-waves on a seismogram allows you to estimate the distance between the seismic station that recorded the data and the epicenter of that earthquake. If the epicentral distance from three or more seismic stations is known, then the exact location of the quake's epicenter can be determined.

PREPARATION

Problem

Determine the epicenter location and the time of occurrence of an actual earthquake, using the travel times of P- and S-waves recorded at three seismic stations.

Materials

map on facing page
calculator
drafting compass
metric ruler
tracing paper

Objectives

In this GeoLab, you will:

- **Determine** the arrival times of P- and S-waves from a seismogram.
- **Interpret** travel-time curves.
- **Plot** an epicenter location on a map.
- **Relate** seismic data to plate tectonics.

Safety Precaution

GeoLab Data Table

Seismic Station	P-S Separation (min)	Epicenter Distance (km)	Map Distance (cm)
Berkeley, CA	**3.9**	**2300**	**6.6**
Boulder, CO	3.5	**1900**	**5.4**
Knoxville, TN	4.2	**2600**	**7.4**

PROCEDURE

1. The seismogram in ***Figure 1*** shows the arrival time of the first P-wave at 10 h, 50 min, 32 s GMT, Greenwich mean time. Estimate the arrival time of the first S-wave to the nearest tenth of a minute. **S-wave arrival: 10 h, 54.4 min GMT**
2. Subtract this S-wave time from the initial P-wave time. What is the P-S separation on the seismogram, in minutes and tenth of minutes? Enter this value in the data table for the Berkeley seismic station. **P-S separation: 3.9 min**
3. The P-S separation observed on two other seismograms, which are not shown, are also listed in the table. Use the travel-time curves in ***Figure 2*** to determine the distances at which the P- and S-curves are separated by the time intervals listed in the table. Enter these distances in the table under the Epicenter Distance.

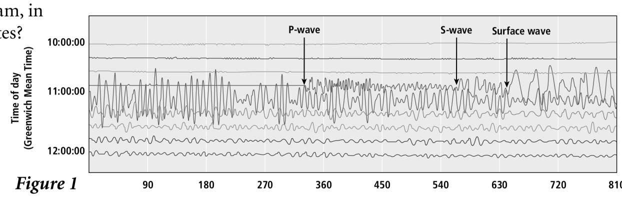


Figure 1

Name Class Date

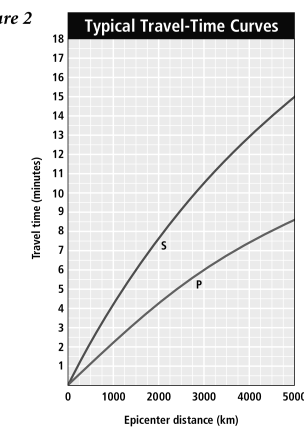
GeoLab Locating an Epicenter

PROCEDURE

4. Carefully trace the map on this page. Accurately mark the three seismic station locations.
5. Determine the epicentral distances on your tracing, using a scale of 1 cm = 500 km. Enter your values in the table under the Map Distance.
6. Use the compass to draw circles around each station on the map with the radius of each circle equal to the map distance, in cm, for that station.
7. Mark the point of intersection. This is the epicenter of the earthquake.
8. Determine the time of occurrence of this earthquake by reading the P-wave travel time from ***Figure 2*** for the epicentral distance for Berkeley. Subtract this from the initial P-wave arrival time at Berkeley, which was 10 h, 50.5 min. Express this time in terms of hours, minutes, and seconds.
10 h, 45 min, 45 s GMT

United States and Mexico

Figure 2



Name Class Date

GeoLab Locating an Epicenter

ANALYZE

1. Where is this epicenter located?

near Mazatlan, Mexico

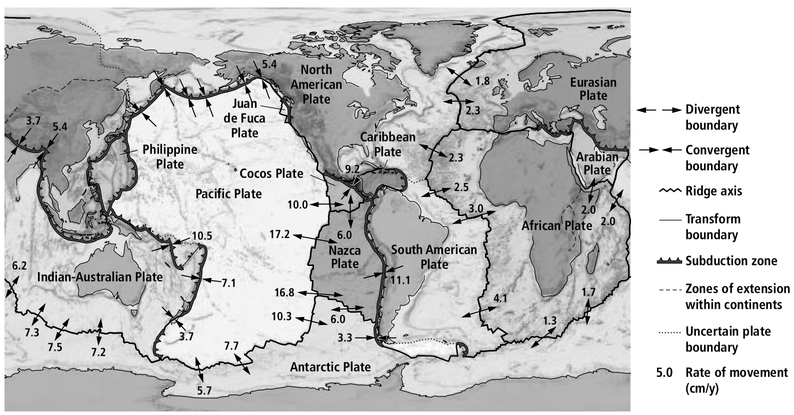
2. In which major seismic belt did this earthquake occur?

Circum-Pacific Belt

3. Use *Figure 3* to determine which plates form the boundary associated with this earthquake.

the North American and Pacific Plates

Figure 3 **Earth's Tectonic Plates**



CONCLUDE AND APPLY

1. What type of plate boundary is this?

divergent

2. Briefly describe the relative motion of the plates involved.

The Pacific Plate is moving toward the northwest in relation to the North American Plate.

3. Describe the tectonic motions that caused the earthquake.

The quake was caused by movements along the transform faults that offset the divergent boundary.

Name Class Date

MiniLab 20 How large is an ocean ridge?

Compare the width of part of an ocean ridge with the size of the United States.

Procedure

1. Obtain physiographic maps of the Atlantic Ocean floor and North America.
2. Use tracing paper to copy the general outline of a section of the Mid-Atlantic Ridge. The length of the section should be long enough to stretch from San Francisco to New York City. Mark the ridge axis on your tracing.
3. Place the same tracing paper on the map of North America with the ridge axis running east-west. Trace the general outline of the United States onto the paper.

Analyze and Conclude

1. How wide is the Mid-Atlantic Ridge?

The width varies from less than 1000 km to more than 3000 km.

2. Are there any parts of the United States that are not covered by your tracing?

Depending upon where students place the ridge axis and which section of the ridge they traced, only Florida and the southern tip of Texas are not covered by the ridge.

3. If a mountain range the size of the Mid-Atlantic Ridge were located in the United States as you have drawn it, how would it affect the major river drainage patterns and climates in various parts of North America?

The Mississippi River would be smaller because half of it would flow north. The Colorado River and the Rio Grande might actually be larger because they would receive more southerly drainage from the mountain. The climate in the Great Plains would be much different. The northern part would probably be much colder and drier, while the southern part would be wetter and warmer.

Name Class Date

Mapping GeoLab Making a Map Profile

A map profile, which is also called a cross section, is a side view of a geographic or geologic feature constructed from a topographic map. You will construct and analyze a profile of the Grand Tetons, a mountain range in Wyoming that formed when enormous blocks of rocks were faulted along their eastern flanks, causing the blocks to tilt to the west.

PREPARATION

Problem

How do you construct a map profile?

Materials

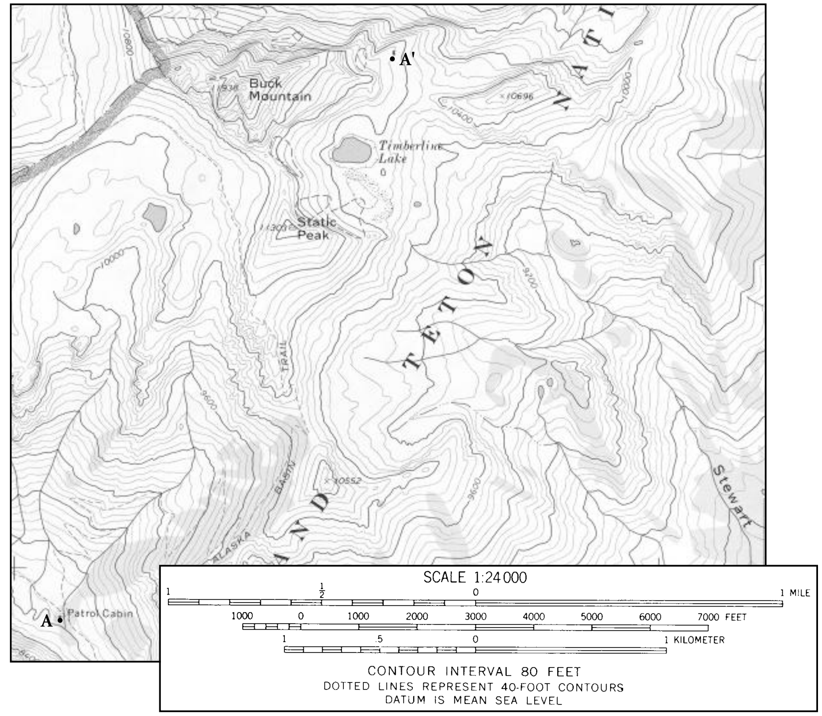
metric ruler
sharp pencil
graph paper

PROCEDURE

1. On the graph paper, make a grid like the one shown on the facing page.
2. Place the edge of a paper strip along the profile line AA' and mark where each major contour line intersects the strip.
3. Label each intersection point with the correct elevation.
4. Transfer the points from the paper strip to the profile grid.
5. Connect the points with a smooth line to construct a profile of the mountain range along line AA'.
6. Label the major geographic features on your profile.

Name Class Date

Mapping GeoLab Making a Map Profile



Name Class Date

Mapping GeoLab

Making a Map Profile

ANALYZE

1. Describe how the map profile changes with distance from point A.

Elevation steadily increases until Static Peak is encountered. Elevation then decreases.

2. What is the elevation of the highest point on the map profile? The lowest point?

Static Peak is 11 303′ high. The Patrol Cabin is at 7840′.

3. What is the average elevation shown in the profile?

The average elevation along the profile is about 9600′.

4. Calculate the total relief shown in the profile.

11 303′ − 7840′ = 3463′

CONCLUDE AND APPLY

1. Is your map profile a scale model of the topography along line AA'? Explain.

No; the vertical and horizontal scales are different, and therefore the profile is not to scale.

2. What determined the scale of this map profile?

The horizontal scale was determined by the scale of the map. The vertical scale was chosen to correspond to the total relief of the area in question.

3. Why are map profiles made from topographic maps often exaggerated vertically?

In reality, the relief of Earth's surface is very small when compared to the horizontal distances. Vertical exaggeration is used to make details more obvious.

Name Class Date

MiniLab 21

How is relative age determined?

Demonstrate how the principles of superposition, original horizontality, and cross-cutting relationships are used to determine the relative ages of rock layers.

Procedure

1. Draw a diagram of an outcrop with four horizontal layers. Label the layers 1 through 4.
2. Draw a vertical intrusion from layer 1 to layer 3.
3. Label the bottom-left corner of the diagram *X* and the top-right corner *Y*.
4. Cut the paper diagonally from *X* to *Y*. Move the left-hand piece 1.5 cm along the cut.

Analyze and Conclude

1. How can you determine the relative ages of the strata in your diagram?

Use the principles of superposition, cross-cutting relationships, and original horizontality to determine the relative ages.

2. How does the principle of cross-cutting relationships explain the age of the vertical intrusion?

Because the intrusion cuts across layers 1, 2, and 3, but not layer 4, it is older than layer 4 and younger than layers 1, 2, and 3.

3. What does line XY represent? Is line XY older or younger than the vertical intrusion and surrounding strata? Explain.

Line XY on the model represents a fault. It is the youngest feature because it cuts across all other layers.

DESIGN YOUR OWN GeoLab: Interpreting History-Shaping Events

What do volcanic eruptions, mountain building, flooding, and drought have in common? They are all events that in some way affect life and the surface of Earth. How strong an impact does each event have on the future of Earth? How different would things be if certain events in Earth's history had not happened?

PREPARATION

Problem

What are the most important events in Earth's history? Where do they fit in the long history of Earth's development? Why are these events important? Do some geologic time periods contain more history-shaping events than others?

Possible Materials

paper	colored pencils
pencil	calculator
posterboard	encyclopedia
meterstick	reference books
tape measure	

Hypothesis

Brainstorm about Earth's history and the changes that Earth has experienced over time. Hypothesize which events had the most impact on the direction that Earth's development has taken. Determine where additional data might be available and collect resources to use as your references. Describe the best way to list and illustrate your choices.

Objectives

In this GeoLab, you will:

- **Hypothesize** about important events in Earth's development.
- **Explain** why such events had a significant impact on Earth's history.
- **Communicate** your results and interpretations.

PROCEDURE

1. Review the list of events in Table 1.
2. As a group, decide on and make a list of events that you think can help support your hypothesis.
3. Choose two other resources and use them to find at least ten more events to add to your list.
4. Design and construct a way to exhibit and explain your results.
5. Check your plan. Make sure your teacher has approved your plan before you proceed.
6. Carry out your plan.

Table 1 EARTH HISTORY-SHAPING EVENTS

Origin of the solar system	Dinosaurs are abundant, 180 M.Y.B.P.
Earth forms, 4.6 B.Y.B.P.	The first birds evolve, 180 M.Y.B.P.
Oceans form, 4.0 B.Y.B.P	Asteroid impact, 66 M.Y.B.P.
Primitive algae evolves, 3.3 B.Y.B.P	Modern groups of mammals appear, 60 M.Y.B.P.
First fossil evidence of multicellular organisms, 1.2 B.Y.B.P.	Earliest horses evolve, 60 M.Y.B.P.
Trilobites are abundant, algal reefs form, 600 M.Y.B.P.	Large mammals evolve, 40 M.Y.B.P.
First corals evolve, invertebrates dominate oceans, 500 M.Y.B.P.	Carnivores abundant, 11 M.Y.B.P.
First land plants evolve, insects appear, 440 M.Y.B.P.	Adirondack mountains uplifted, 11 M.Y.B.P.
Fishes are abundant, early amphibians evolve, 400 M.Y.B.P.	First humanoids evolve (*Australopithecus africanus*), 3 M.Y.B.P.
Forests that become coal swamps are present, 300 M.Y.B.P.	Ice Age of the Pleistocene begins, 1 M.Y.B.P.
Earliest reptiles evolve, 300 M.Y.B.P.	Mammoths and mastodons are abundant, 1 M.Y.B.P.
Alleghenian Orogeny occurs, 270 M.Y.B.P.	Large ice sheets retreat ~ 10 000 years ago
Trilobites become extinct, 270 M.Y.B.P.	Mount Vesuvius erupts and destroys Pompeii, A.D. 79
Earliest dinosaurs appear, 225 M.Y.B.P.	New Madrid Earthquake, 1811–1812
Pangaea breaks up, 225 M.Y.B.P.	Chicago Fire, 1871
Earliest mammals evolve, 200 M.Y.B.P.	Krakatoa eruption in Java, 1883
	Chicago Bulls win 5th World Championship, 1997

DESIGN YOUR OWN GeoLab: Interpreting History-Shaping Events

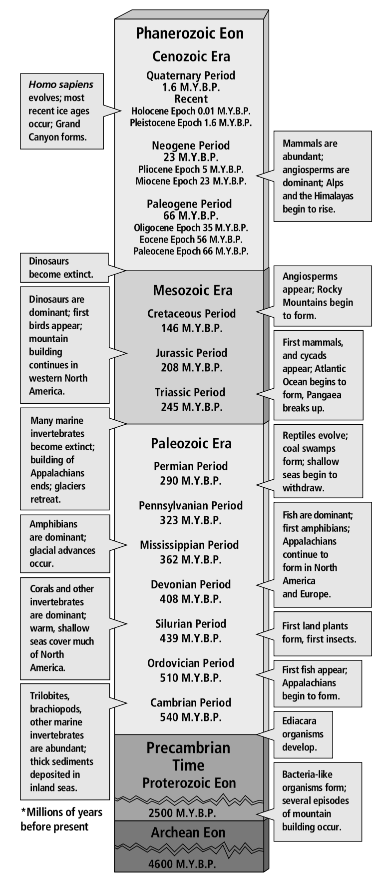
ANALYZE

1. **Interpreting Observations** Did more history-shaping events seem to have occurred early in Earth's history or later on? Explain.

   Answers may vary depending on students' selections of Earth history-shaping events. The main idea is that there have been many such events throughout geologic time.

2. **Comparing and Contrasting** Plot your list of events on the geologic time scale. Compare and contrast the number of events in each era. Does any geologic time period contain more history-shaping events than others? Explain.

   Answers will vary depending upon the events selected by students. Some students may therefore think that the Mesozoic Era had the most Earth history-shaping events.



Name Class Date

DESIGN YOUR OWN GeoLab: Interpreting History-Shaping Events

ANALYZE

3. Observing and Inferring Choose one event in the Mesozoic and infer how Earth's history might have progressed had the event not happened.

Answers will vary greatly. One example might represent a scenario in which dinosaurs did not become extinct. In this case, the significance of mammals might have been greatly reduced.

CONCLUDE AND APPLY

1. How do extinction events influence the development of life on Earth?

The extinction of existing forms of life opened environmental niches for surviving species to thrive and proliferate.

2. How do mountain-building events and glaciations affect the development of life on Earth?

Large-scale mountain-building events such as the one that formed the Alleghenies, create barriers, not only in terms of elevation, but also in terms of amount of precipitation and other climatic factors. Species are prevented from interacting, thus effectively impeding the evolutionary process either by extinction, isolation, or interactions of species.

3. If another planet experienced the same events that you chose, would that planet be identical to Earth? What would be similar or different?

Answers will vary depending on the planet selected. For example, if Mars was selected, weathering and erosion would be considerably different. Wind erosion and the alteration of surface features would be more prevalent on a planet-wide basis as compared to Earth.

Name Class Date

MiniLab 22: Why are red beds red?

Model the formation of red beds with iron, oxygen, and water.

Procedure

CAUTION: Steel wool can be sharp. Wear gloves in the lab.

1. Place 40 mL of white sand in a 150-mL beaker.
2. Add water so that the total volume is 120 mL.
3. Add 15 mL of bleach.
4. Place a piece of steel wool about the size of your thumbnail, in the beaker. Cover the beaker with a petri dish and allow it to stand in a quiet place for one day.
5. Remove the steel wool and stir the contents of the beaker. Allow the mixture to settle for 5 minutes after stirring.
6. Slowly pour off the water so that the iron-oxide sediment is left behind.
7. Stir the mixture again, then spoon some of the sand onto a watch glass and allow it to dry.

Analyze and Conclude

1. Describe how the color of the sediment changed.

The sediment changed from white to orange-red.

2. Where does the iron in the experiment come from?

It comes from the iron contained in the steel wool.

3. Where in nature does the red in rocks come from?

The red comes from the oxidized iron contained in iron-bearing minerals in the rocks.

4. What do you think is the function of the bleach?

The bleach speeds up the reaction. It is a catalyst.

Name Class Date

Mapping GeoLab

Mapping Continental Growth

Plotting the distribution of the ages of rocks onto a map helps geologists to reconstruct the history of continental accretion. During the Precambrian, microcontinents and island arcs collided to form what would become the modern continents.

PREPARATION

Problem

How can the distribution of the ages of rocks plotted on a map be used to interpret the growth of a continent?

Materials

paper, colored pencils, pencil, metric ruler

PROCEDURE

1. Your teacher will set up locations with a rock sample at each location.
2. Make an outline map of your classroom similar to the map on the next page, using the scale 1 cm = 100 km. Use the space below.
3. Visit each location where a rock sample has been set out. Plot each location and record the age of each rock on the map.
4. After you have recorded all the locations, use a pencil to draw lines on the map that separate rocks of different ages. Be careful not to simply connect the dots.
5. Use a different colored pencil to shade in the areas on the map that contain rocks of the same age. These are your geologic age provinces.
6. Make a key for your map by drawing a small rectangle for each different geologic age province. Name the oldest province "Province A," the next oldest "Province B," and so on for all provinces.

Name Class Date

Mapping GeoLab

Mapping Continental Growth

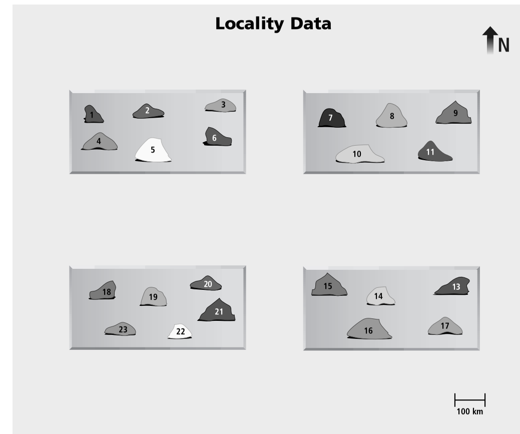


Figure 1

ANALYZE

1. Use the ruler to measure the east-to-west width of Province A. Convert the map scale to ground distance by using the scale 1 cm = 1 km.

   For example, If the map is 8 cm wide, then the distance on the ground is 8 km.

2. Why do some of your classmates have different answers? Who is right?

   The answers are all different. In order for the numbers to be all nearly the same, a very large number of data points would be needed. Thus, there is no "right" answer, only answers that correctly model the data.

3. Where is the oldest province located relative to all the other provinces?

   The oldest province is in the center of the map area.

Name Class Date

Mapping GeoLab Mapping Continental Growth

CONCLUDE AND APPLY

The Precambrian Shield in North America

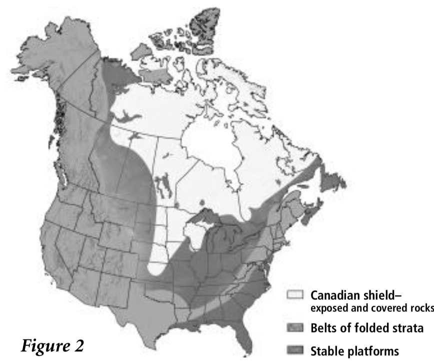


Figure 2

1. Based on the distribution of the geologic age provinces, describe the sequence of collisional events that formed the craton represented by your map.

The younger provinces must have accreted around the oldest province.

2. According to your map, where would you find metamorphic rocks? What type of metamorphism would have occurred?

Metamorphic rocks would be found at the province boundaries. Regional metamorphism would have resulted from the collisions. If any igneous activity was generated, contact metamorphism also could have occurred.

3. If your map represents an area composed of Precambrian-aged rocks, would the mountains that formed from collisions still be high and rugged? Explain.

No; the mountains would have been exposed to the agents of weathering and erosion for so many years that the mountains would be worn down, rounded, and low in elevation as compared to newly formed mountains.

4. Compare the distribution of age provinces on your map with *Figure 2*. What are the similarities?

The distribution is similar. The oldest province is near the center of the North American Craton, and the younger provinces are around the margin of the craton.

5. Based on what you learned in this activity, describe the formation of the North American Craton.

The younger provinces must have accreted around the margin of the craton through geologic time. That is, the craton grew by accreting younger provinces along its margins.

Name Class Date

MiniLab 23 Collisions and Shelves

Model the difference in continental shelf area between individual continents and one supercontinent.

Procedure

1. Using 250 g of modeling clay, make a sphere and flatten it into a disk that is 1/2 cm thick. This represents a craton.
2. Divide another 250 g of clay into 2 equal spheres and flatten them as above.
3. Roll 250 g of modeling clay into 3 long cylinders with 1/2 cm diameters. Wrap the cylinders around the edges of the clay disks. These represent continental shelves.
4. Using the formula area = πr^2, calculate the area of the large craton and the area of the large craton plus the continental shelf. Subtract the craton area from the total area. This equals the area of the continental shelf.
5. Repeat step 4 for each of the small models.

Analyze and Conclude

1. Which has more shelf area, two small continents or one large continent? Why?

two small continents; because their shelf area is a greater proportion of the total area

2. Tropical oceans contain the greatest diversity of animals. If there is only one supercontinent, how does this further limit the amount of habitat space?

If there is only one supercontinent and part of it is situated over the equator, then the area of a warm, shallow-water habitat is restricted to only that part of one continent. However, if there are many continents in tropical latitudes, then the area of habitat space is much greater.

3. Explain how reduced habitat space, Pangaea, and the mass extinction at the end of the Permian are related.

Pangaea formed over the equator; tropical marine habitat space was reduced; and diverse organisms were forced into a smaller space, which stressed the communities and caused Earth's greatest extinction event

Name Class Date

GeoLab Symmetry, Shape, and Shells

Brachiopods and bivalves have been present in Earth's oceans since the Cambrian. Both have two shells and live in marine environments. But the similarity ends there. How can you tell the two apart? Oysters are bivalves that are known for the pearls they secrete inside their shells. Can you distinguish an oyster from a brachiopod? If you were searching for pearls, you would want to know how!

PREPARATION

Problem

Distinguish between brachiopods and bivalves and interpret the environment where a brachiopod lived based on its shell.

Materials

fossil brachiopods (4),
each belonging to a different species
fossil bivalves (4),
each belonging to a different species
paper
pencil

Objectives

In this GeoLab, you will:

- **Determine** if a fossil is a brachiopod or a bivalve.
- **Describe** the symmetry of fossil brachiopods and bivalves.
- **Infer** the environment in which different fossil brachiopods lived.

Safety Precautions

Always wear safety goggles and an apron in the lab.

PROCEDURE

1. Use the data table on the next page. If you choose to add more columns to record additional data, use the blank space provided.
2. Examine the fossils provided by your teacher.
3. Determine where the plane of symmetry is for each specimen. An organism that can be divided into two nearly identical halves has bilateral symmetry.
4. Identify the specimens as brachiopods or bivalves based on their symmetry and record this in your data table. Brachiopod symmetry runs across both shells. Bivalve symmetry runs between the shells.
5. Divide the brachiopods into two groups based on whether you think they lived in a deeper water, low-energy environment, or in a shallow water, high-energy environment. Record this in your data table.

Name Class Date

GeoLab Symmetry, Shape, and Shells

ANALYZE

1. **Interpreting Observations** Explain how symmetry is useful in determining whether a fossil is a brachiopod or a bivalve.

Each shell of a brachiopod is bilaterally symmetrical, while bivalve shells are asymmetrical. This is useful because, many times, only a single shell of a fossil is found.

2. **Applying and Interpreting** If you only had one shell, how could you determine if it was the shell of a brachiopod or the shell of a bivalve?

If the shell was bilaterally symmetrical, it would be a brachiopod; if it was not bilaterally symmetrical, it would be a bivalve.

3. **Comparing and Contrasting** Explain the similarities and differences between a streamlined auto and a smooth brachiopod, in terms of their place in wind or water.

Streamlined autos are not highly affected by air friction. Similarly, currents flow over and around smooth brachiopods with little obstruction.

FOSSIL DATA

Specimen	Brachiopod or Bivalve	Deeper water, low-energy environment or shallow water, high-energy environment
1		
2		
3		

Name Class Date

GeoLab Symmetry, Shape, and Shells

CONCLUDE AND APPLY

1. What principle did you use to determine the environment in which the fossil brachiopods lived? Explain.

The principle of uniformitarianism; the lifestyles of modern organisms are used to infer the lifestyles of ancient organisms.

2. Hypothesize about the reasons for the different shell types for brachiopods that live in different environments.

Winged and ribbed shells are found in higher energy water. These shapes help keep the shell oriented in the current. Smooth shells are not protected in this way. Thus, they are commonly found in quieter waters.

3. All living brachiopods pump water through their shells and filter organic particles out of that water to feed. Some brachiopod shells close along a straight line, whereas others close along a zigzag line. What is the benefit of having a zigzag opening for a filter feeding brachiopod?

A zigzag opening between the shells is larger than a straight opening. Greater volumes of water and food can be passed through this opening with roughly the same amount of energy in the same amount of time.

Name Class Date

MiniLab 24 Glaciers and Deposition

Model the deposition of sediment by melting glaciers.

Procedure

1. Pour water into a large, wide-mouthed jar until it is approximately 3/4 full.
2. Add a mixture of clay, silt, sand, and pebbles to the jar. Put the lid tightly on the jar.
3. Shake the jar for 30 seconds and allow the contents to settle.
4. Finely crush enough ice to fill approximately three-fourths of a second large, wide-mouthed jar. Stir a mixture of clay, silt, sand, and pebbles into the ice and pour the mixture into the jar.
5. Allow the ice to melt and the particles to settle overnight.

Analyze and Conclude

1. Describe the differences in the way the sediments settled in the two jars.

The water-only jar will have the coarse grains at the bottom and the finer grains at the top. The sediment sizes in the ice-and-water jar will be randomly distributed.

2. Compare and contrast the sorting of the grain sizes in the two jars.

The sediment in the jar that contained water is sorted, and the sediment in the jar that contained the ice is poorly sorted.

3. How could geologists use this information to determine whether sediment had been deposited by a glacier or by running water?

Sediment that is very poorly sorted suggests that the sediment was not deposited by moving water, but by melting ice.

Name Class Date

Internet GeoLab: Huge Appetites

The study of how an organism interacts with its environment is called ecology. Ecology includes how an organism obtains energy from its environment. Animals do this by eating. Determining the diet of modern animals is relatively easy to do. We can observe them in their habitat and watch what they eat, or we can examine their feces. Paleoecology is the ecology of ancient organisms. Part of dinosaur paleoecology includes determining what and how dinosaurs ate. Imagine how much food some dinosaurs must have eaten!

PREPARATION

Problem

How do paleontologists tell what types of food different dinosaurs ate?

Hypothesis

What kind of evidence might you use to determine what type of diets dinosaurs ate? What are the diets of different animals today? Think about the characteristics of these different animals. Do most meat eaters share certain characteristics? What about plant eaters? **Form a hypothesis** about the skeletal characteristics of plant eaters and meat eaters.

____

____

____

____

Objectives

In this GeoLab, you will:

- **Gather** data and **communicate** interpretations about the characteristics of meat eaters and plant eaters.
- **Form conclusions** about the characteristics of plant eating and meat eating dinosaurs.
- **Discover** how sauropods might have shared food resources.

Data Sources

Go to the Glencoe Science Web Site at science.glencoe.com to find links to fossil data on the Internet. You can also visit your library or local natural history museum to gather information about dinosaur diets.

This Late Cretaceous *Tyrannosaurus* is from Alberta, Canada.

Triceratops was an herbivore.

Name Class Date

Internet GeoLab: Huge Appetites

PLAN THE EXPERIMENT

1. Find a resource that describes skeletal characteristics of meat-eating and plant-eating dinosaurs. The Glencoe Science Web Site lists sites with information about dinosaurs.
2. Gather information from the links on the Glencoe Science Web Site or the library about the environments that these two types of dinosaurs lived in and which dinosaurs lived in the same environments.
3. Design a data table in the space below to record your research results. Include categories such as Dinosaur Name, Meat or Plant Eater, Food Preference, Skeletal Characteristics, Jaw and Teeth Characteristics, and so on.

PROCEDURE

1. Complete your data table, including all information that you think is important.
2. Go to the Glencoe Science Web Site at science.glencoe.com to post your data.
3. Visit sites listed on the Glencoe Science Web Site for more information on the diets of dinosaurs.

DATA TABLE

Name Class Date

Internet GeoLab: Huge Appetites

CONCLUDE AND APPLY

Sharing Your Data Find this Internet GeoLab on the Glencoe Science Web Site at science.glencoe.com. Post your data in the table provided for this activity. Use the additional data from other students to complete your chart and answer the Conclude and Apply questions.

1. What part of a dinosaur skeleton is most important in determining its diet? Why? What is the likelihood that this part of a skeleton will be preserved?

   Dentition (tooth structure) is one of the most abundant lines of evidence useful for determining dinosaur diets. Tooth shape and form have evolved in response to food sources. Teeth are more likely to be fossilized.

2. What are some other characteristics associated with dinosaur skeletons that help paleontologists determine what their diets were like?

   Body size and shape also can be used to infer diet. Large sauropods were cowlike, with large guts. Leaner body types that were equipped with claws were adapted for attacking and eating prey.

3. Which were more abundant, meat-eating dinosaurs or plant-eating dinosaurs? Why?

   Plant eaters were more abundant. If there had been too many meat eaters, they soon would have exhausted their supply of food, the plant eaters, and starved.

4. How did sauropods share food resources? Describe the evidence used by paleontologists to determine how sauropods shared food resources.

   Sauropods shared food resources by selectively eating vegetation of a specific kind or at a different height from the vegetation that other sauropods ate. Different wear patterns on teeth and the skeletal structures of the skulls of different sauropods are used by paleontologists to support the hypothesis that sauropods shared food resources in this way.

5. How could the same evidence that is used to determine the diets of dinosaurs be used for other animals?

   Teeth and skeletal structure can be used to infer whether any animal was or is an herbivore or a carnivore. The same relationships are usually true.

Name Class Date

MiniLab 25: Hard Water

Determine the hardness of water samples by observing how easily soap suds can be produced.

Procedure

1. Obtain six clean baby-food jars. Label them A through F.
2. Measure 20 mL of one water sample. Pour the water into the jar marked A.
3. Repeat step 2 four more times, using a different water sample for jars B through E.
4. Measure 20 mL of distilled water. Pour this water into jar F.
5. Place one drop of liquid soap in sample jars A through E. Do not place any soap in jar F. Tighten the lids. Then shake each jar vigorously for 5 seconds.
6. Using the following rating scale, record in your data table the amount of suds in each jar: 1—no suds, 2—few suds, 3—moderate amount of suds, 4—lots of suds.

Jar	Amount of Suds
A	
B	
C	
D	
E	
F	

Analyze and Conclude

1. List the water samples in order from hardest to softest.

   Student answers will vary.

2. What is the difference between hard and soft water?

   Softer water will make suds more easily and will feel silkier to the touch than hard water.

3. What are some disadvantages of hard water?

   More soap is needed to get things clean; scum often forms in sinks, tubs, or around clothes in the washing process.

Name Class Date

DESIGN YOUR OWN GeoLab

Designing a Solar Desalinator

Most of Earth's surface is covered with salty ocean water. Ocean water can be used for drinking water and other purposes if the salts are first removed. Solar energy can be used to evaporate water from seawater, leaving the salts behind. The evaporated water can then be condensed into freshwater.

PREPARATION

Problem

How can you build a small-scale, working solar desalinator?

Possible Materials

clear plastic or Plexiglas
large pans to hold water
salt water
collecting containers
lamp
glass pan or beaker
hot plate

Hypothesis

The Sun's energy can be collected to desalinate salt water.

Objectives

In this GeoLab, you will:

- **Design** a model of a working solar desalinator.
- **Assemble** the model from design plans.
- **Test** the effectiveness of the design model.
- **Analyze** the model to suggest possible improvements.

Safety Precautions

Always wear safety goggles and an apron in the lab. Be careful when handling hot materials.

Name Class Date

DESIGN YOUR OWN GeoLab

Designing a Solar Desalinator

PLAN THE EXPERIMENT

1. Use the library and go to science.glencoe.com to identify designs of solar desalinators.
2. Draw a design for your model desalinator below. (Hint: Solar energy must be collected in some way that allows sunlight to enter and causes an increase in temperature inside the container so that water in saturated air can condense and be collected.)
3. Make a list of the materials you will need, and then collect them.
4. Construct the desalinator you designed.
5. Test the desalinator by recording how long it takes to collect the purified water and how much water was collected.
6. Test the water to see if it has been purified by boiling the water away. If any salt remains in the container after the water has evaporated, your desalinator did not remove all of the salts from the salt water.

ANALYZE

1. **Interpreting Scientific Illustrations** Draw the desalinator that you constructed.

   Models should be drawn to scale and be accompanied by a list of materials used.

Name Class Date

DESIGN YOUR OWN GeoLab

Designing a Solar Desalinator

ANALYZE

2. **Interpreting Observations** How well did your desalinator work? On what criteria did you base the effectiveness of your desalinator?

   The length of time needed to collect a suitable sample may be the criterion used to determine effectiveness. Water quality may also be a criterion.

3. **Observing and Inferring** What problems did you encounter in this investigation?

   Problems will vary. Students may run into difficulty sustaining a warm enough environment to keep the evaporation and condensation cycle going.

4. **Comparing and Contrasting** Compare and contrast your desalinator with one of your classmate's. What were the advantages or disadvantages of your design?

   Answers will vary.

CONCLUDE AND APPLY

1. What factors affected the efficiency of the desalinator?

   Factors that can affect a desalinator's efficiency may include its ability to hold in solar heat and the water-collection design.

2. How did your solar desalinator's efficiency compare with the efficiencies of other students' models?

   Answers will vary.

3. How could you improve your desalinator?

   Possible suggestions for future models may include making it larger or insulating it better.

4. What conclusions could be drawn from your investigation regarding the viability and use of solar-powered desalinators?

   Solar-powered desalinators may be viable in consistently sunny locations.

Name Class Date

MiniLab 26

Oil Migration

Model the migration of oil and natural gas upward through layers of porous rocks.

Procedure

1. Pour 20 mL of cooking oil into a 100-mL graduated cylinder.
2. Carefully pour sand into the graduated cylinder until the sand-oil mixture reaches the 40-mL mark.
3. Now add a layer of colored aquarium gravel above the sand until the gravel reaches the 70-mL mark.
4. Pour tap water into the graduated cylinder until the water reaches the 100-mL mark.
5. Let stand and observe for 5 minutes.

Analyze and Conclude

1. What does the cooking oil represent? What do the sand and aquarium gravel represent?

   crude oil; layers of rocks and their pores

2. What happens when water is added to the mixture in the graduated cylinder? Why does adding water cause this change?

   The oil moves until it is floating on top of the water. It is less dense than water.

3. Predict what might occur in the graduated cylinder if a carbonated soft drink was added to the mixture instead of water. What would the bubbles represent?

   Students may predict that the bubbles of the soft drink will rise to the top as the drink sinks to the bottom of the cylinder. The bubbles in the soft drink represent natural gas.

DESIGN YOUR OWN GeoLab: Designing an Energy-Efficient Building

Buildings can be designed to conserve heat energy. Some considerations involved in the design of a building that conserves heat include the materials that will be used in construction, the materials that will store heat, and the overall layout of the building.

PREPARATION

Problem
How can a building be designed to conserve energy? What building materials will work best, and what other factors need to be considered?

Possible Materials
glass or clear plastic
sturdy cardboard boxes
paints of various colors
thermometers
materials to cover the building
(paper, aluminum foil, foamboard, and so on)
interior materials
(stones, mirrors, fabric, and so on)
light source
scissors
tape
glue

Hypothesis
Brainstorm a list of design features that might contribute to the energy efficiency of a building. Hypothesize how you could incorporate some of these features into an energy-efficient building. Find out what materials are used in heat-efficient homes and research local sources of materials for your design. Decide how you will determine the heat efficiency of the building you construct. Be sure to plan for a control building for comparison.

Objectives
In this GeoLab, you will:
- **Research** what materials are used in the construction of energy-efficient buildings.
- **Design** a building that is energy efficient.
- **Construct** the building that you design.
- **Determine** the heat efficiency of the building by comparing it to a control building.
- **Interpret** the data that you collect to determine your success in developing an energy-efficient building.

Safety Precautions
Be careful when you are using scissors. Make sure to handle the light source carefully when it is hot. Always wear safety goggles and an apron in the lab.

PLAN THE EXPERIMENT

1. Review the data that you collected about building energy-efficient buildings. Also review your list of possible design features.
2. Design your building. Make a list of the heat-conserving issues that you addressed.
3. Decide on the materials that you will use to build your house. Collect those materials.
4. Construct the building and a control building for comparison.
5. Devise a way to test the heat-holding ability of each building.
6. Proceed with the test on each building. To test the buildings' heat energy efficiency, it may be necessary to heat the buildings and determine

PLAN THE EXPERIMENT

how long heat is conserved within each one. ***CAUTION:*** *Make sure the heat source is far enough away from the building materials so that they do not burn or melt.*

7. Draw a table and record your data. Then, make a graph of your data.
8. Make modifications to the design to improve the building's efficiency.

TABLE

GRAPH

ANALYZE

1. **Checking Your Hypothesis** Was the building that you designed more energy-efficient than the control building? Why did you construct a control building?

   Students should be able to use the data that they collected from their models and the control to determine the effectiveness of their designs.

Name Class Date

DESIGN YOUR OWN GeoLab

Designing an Energy-Efficient Building

ANALYZE

2. **Interpreting Observations** What problems did you encounter, and how did you solve them?

Students must be assured that listing problems is important in any experiment.

3. **Observing and Inferring** How did your observations affect decisions that you might make if you were to repeat this lab? Why do you think your design worked or did not work?

Evaluating by observing and inferring helps students to make concrete applications of the concept of heat storage and of the scientific process.

4. **Comparing and Contrasting** Compare and contrast the building you designed and the control building. Compare and contrast your design and the designs of your classmates.

Lead students to understand that if the control and design models showed no difference, then the methods employed likely did not affect what was being measured—either heat absorbed or heat retained.

5. **Thinking Critically** Suppose you could use only naturally occurring materials. Would that limit your design? Explain your answer.

Asking students to consider specific materials will help them realize that decisions sometimes have to be made after balancing the options. To make a decision of this type, priorities may need to be established and compromises made.

CONCLUDE AND APPLY

1. How could you incorporate some of your design elements in your own home?
2. How could your design be improved?
3. How could using different energy sources affect your results?

Student answers will vary depending on their designs and their success. In all cases, improvements will be possible either in the type or amount of material used and in the orientation of the buildings. Possible sources or error in the testing phases are also important to look for and consider when analyzing the results obtained.

Name Class Date

MiniLab 27

Reclamation

Model the procedure used by mining companies to reclaim an area after strip-mining.

Procedure

1. Using a plastic knife, make four or five cuts across the icing of one cream-filled, iced cupcake. Remove the pieces of icing.
2. Make four or five cuts down into the cake until you reach the cream filling. Cut horizontally just above the cream filling and remove the cake pieces.
3. Remove the cream filling. To restore the area, use the pieces of cake that you cut out to fill in the hole left when you removed the cream filling. Make the surface of the cupcake as level as possible.
4. Replace the icing so that it covers the surface of the restored cupcake.

Analyze and Conclude

1. On the restored cupcake, what does the icing represent? What does the cream filling represent?

The icing represents the topsoil; the cream represents the extracted resource.

2. Does the reclaimed cupcake resemble the original, untouched cupcake?

The reclaimed cupcake resembles the untouched cupcake but it is shorter and has a broken surface.

3. Can reclamation of an area that has been strip-mined restore the land to its original contours? Explain your answer.

Reclamation cannot restore the original contours because some material has been removed.

Name Class Date

Mapping GeoLab: Pinpointing a Source of Pollution

Iris City and the surrounding region are shown in the map on the facing page. Iris City is a medium-sized city of 100 000. It is experiencing many types of environmental impacts. Study the map and the information given to identify these problems and possible solutions.

PREPARATION

Problem

How can the residents of Iris City identify the source of local water pollution?

Materials

metric ruler
pencil

PROCEDURE

1. Iris City obtains its drinking water from Opal Lake. Studies of the lake have detected increased levels of nitrogen, phosphorus, hydrocarbons, sewage, and silt. The northwest end of Opal Lake is experiencing increased development, while the remainder of the watershed is a mix of forest and logging clear-cuts.
2. Last spring, blooms of cyanobacteria choked parts of the Vista Estuary Nature Preserve. Commercial shellfish beds in Iris Bay have been closed because of sewage contamination.
3. A natural-gas power plant has been proposed for location A, near the Vista Cutoff, an abandoned channel of the Vista River. The plant would provide jobs as well as generate electricity. The company plans to divert 25 percent of the Vista River down the Vista Cutoff.
4. The Lucky Mine was abandoned 60 years ago. A mining company has applied for permits to reopen the mine. An estimated 1 million ounces of gold can be recovered using modern techniques.

ANALYZE

1. What are some possible sources of water pollution in Opal Lake? What steps might the residents of Iris City take to protect their drinking water?

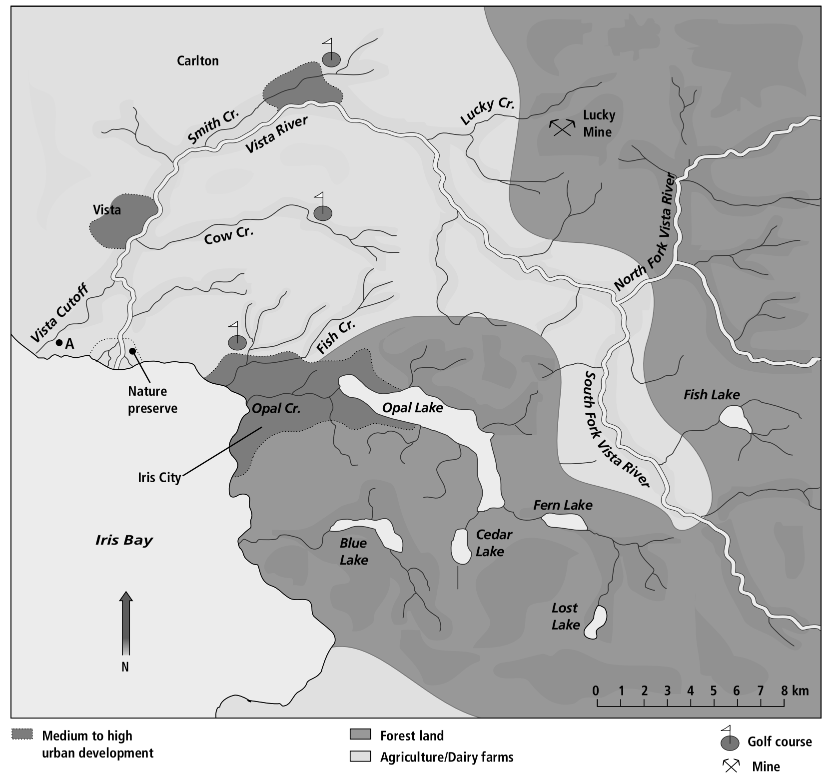
Possible pollution sources are increased development around the lake, logging operations, and power boating. Solutions include controlling runoff from development, buffer zones and selective cutting during logging, and banning powerboats from Opal Lake.

2. How are the blooms of cyanobacteria and the closing of the shellfish beds in Iris Bay related?

One cause of cyanobacterial blooms is sewage waste containing excess nutrients. If the cities and dairy farms along the Vista River were releasing improperly treated sewage into the river, this would cause both cyanobacterial blooms and the contamination of shellfish beds.

Name Class Date

Mapping GeoLab: Pinpointing a Source of Pollution



ANALYZE

3. What are the positive and negative aspects of diverting water from the Vista River through the Vista Cutoff?

Positive aspects are new jobs, more electricity production, and possibly new wetlands at the mouth of Vista Cutoff. Negative aspects are increased pollution and reduction in freshwater flow to the Vista estuary region, which will cause saltwater intrusion and loss of habitat.

Name Class Date

Mapping GeoLab: Pinpointing a Source of Pollution

ANALYZE

4. If the Lucky Mine is reopened, what effects might it have on the populations of Carlton, Vista, and Iris City?

There will be economic benefits for all three cities. Pollution problems from mining activities will primarily affect Vista and Carlton because they are located along the river.

CONCLUDE AND APPLY

1. Identify the sources of water pollution in Iris Bay. Are these point or nonpoint sources of pollution?

Fertilizer and pesticides can come from farming operations, golf courses, and general urban development. Oil and gasoline pollution comes from street runoff, powerboats, and harbor operations. Excess silt comes from urban development and logging. Unfortunately, most of these are nonpoint sources and difficult to control. Each golf course and farm could be considered a point source.

2. How could you identify the source of pollution causing cyanobacteria blooms in the Vista Estuary?

The source of pollution could be located by analyzing water samples while traveling up the Vista River until the source was identified.

3. If the Vista Cutoff is used to divert water from the Vista River, how will the aquatic habitats of the river be affected?

The Vista River will have lower flow downstream of the diversion. This could result in shallower water and increased temperature. Also, the freshwater-saltwater balance in the estuary would be changed, resulting in loss of habitat and organisms.

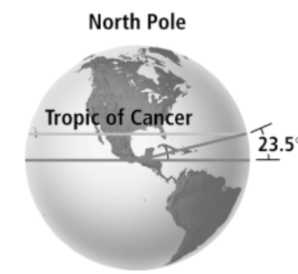
4. If the Lucky Mine is reopened, what could the mining company do to minimize negative environmental impacts?

The mining company could build containment ponds and filtration barriers to prevent liquid wastes from entering the streams. The tailing pipes could be landscaped to help replace the habitat that was buried.

Name Class Date

MiniLab 28: The Sun's Position

Model the overhead position of the Sun at various latitudes during the summer solstice.



Procedure

1. In the space below, draw a circle to represent Earth. Also draw the equator.

2. Use a protractor to find the location of the Tropic of Cancer. Draw a line from Earth's center to the Tropic of Cancer.

3. Using a map, locate that latitude at which you live. With the protractor, mark that latitude on your diagram. Draw a line from Earth's center to this location.

4. Measure the angle between the line to the Tropic of Cancer and the line to your location.

5. Choose two different latitudes, then repeat steps 3 and 4 for these latitudes.

Analyze and Conclude

1. How does the angle vary with latitude?

The farther north your location, the more the angle between the line to the Tropic of Cancer and the line to your location increases. Hence, the Sun is lower in the sky on the solstices for more northerly latitudes.

2. At what southern latitude would you not see the Sun above the horizon?

66.5° south latitude

3. How would the angle change if you used the Tropic of Capricorn?

The angle would be larger. For any latitudes above 66.5° north, the angle would be more than 90°.

Name Class Date

Mapping GeoLab: Relative Ages of Lunar Features

It is possible to use the principle of cross-cutting relationships, discussed in Chapter 21, to determine the relative ages of surface features on the Moon. By observing which features cross-cut others, you can infer which is older.

PREPARATION

Problem

How can you use images of the Moon to interpret relative ages of lunar features?

Materials

metric ruler
pencil

PROCEDURE

1. Observe photos I and II. Use the letters to identify the oldest feature in each photo using the principle of cross-cutting relationships. List the other features in order of their relative ages.

   Photo I: A is older than D; B is older than C. Photo II: D is the oldest; A is younger than D; E is younger than D; B and C are younger than E.

2. Observe photo III. List the mare, rille, and craters in order of their relative ages.

   Photo III: B is the oldest; D is the next oldest; then E and C; A is the youngest.

3. Observe photo IV. Use the principle of cross-cutting relationships, along with your knowledge of lunar history, to identify the features and list them in order of their relative ages.

   Photo IV: D is the oldest; A is the next oldest; C or B is the youngest.

ANALYZE

1. What problems did you encounter?

   When two craters don't overlap, you can't tell which is older. Some features could have formed at the same time, such as the rille and small crater on the mare in Photo IV. Sometimes, the overlap is not distinct enough to tell which is older.

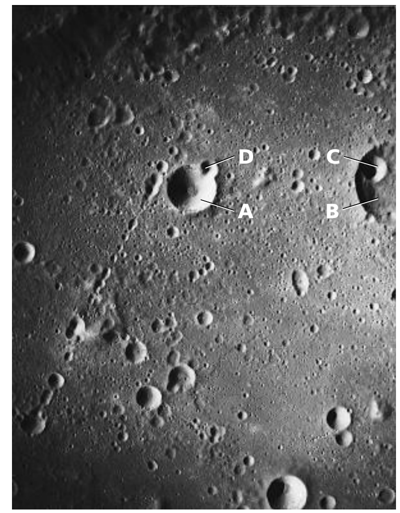
2. Based on information from all the photos, what features are usually the oldest? The youngest?

   Crater alone or craters that formed maria are the oldest. Craters in maria or rilles are the youngest.

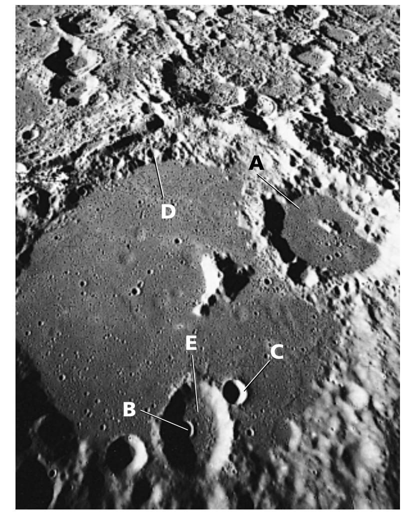
Name Class Date

Mapping GeoLab: Relative Ages of Lunar Features

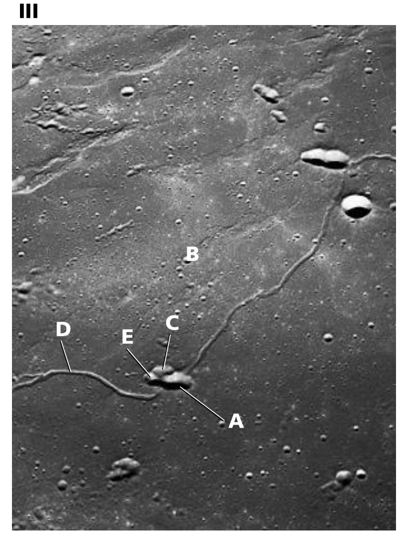
I



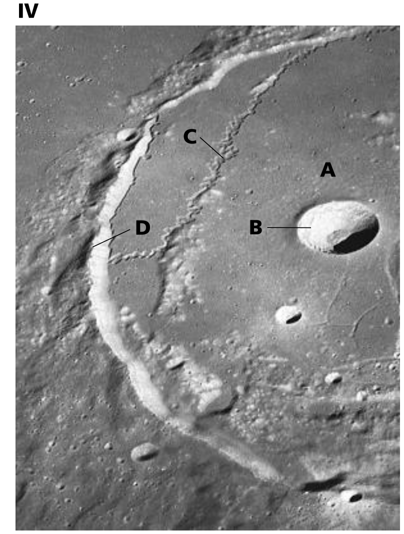
II



III



IV



Name Class Date

Mapping GeoLab Relative Ages of Lunar Features

ANALYZE

3. Could scientists use the process you did to determine the exact age difference between two overlapping craters? Why or why not?

Exact age differences cannot be determined from the principle of cross-cutting relationships; only relative ages can be. From the photos, there is no way to tell whether the age difference is 10 minutes or 10 million years.

4. If the small crater in photo II, labeled A, is 44 km across, what is the scale for that photo? What is the size of the large crater, labeled D?

After multiple measurements to average out the size of crater A because of its imperfect shape, the scale is approximately 1 cm = 20 km. Crater D is about 130 km in diameter.

CONCLUDE AND APPLY

1. Which would be older, a crater that had rays crossing it or the crater that caused the rays? Explain.

A crater that has rays crossing it would be older than the crater from which the rays originate.

2. Is there some type of relative-age dating that scientists can use to analyze craters on Earth? Explain.

Relative ages of craters on Earth cannot be based on the principle of cross-cutting relationships, because the remaining craters are so sparse that they never overlap.

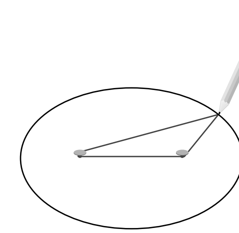
3. What do you think caused the chain of craters in photo I? If the crater labeled A is approximately 17 km across, how long is the chain of craters?

The chain of craters was probably caused by a fragmented impactor that arrived as a series of pieces instead of one big chunk. The scale would be approximately 1 cm = 16.2 km, so the chain of craters is about 102.1 km.

Name Class Date

MiniLab 29 Eccentricity

Measure the eccentricity of different ellipses. Eccentricity is the ratio of the distance between the foci to the length of the major axis.



Procedure

1. Tie a piece of string into a loop that fits on a piece of cardboard when it is laid out in a circle.
2. Place a sheet of paper on the cardboard.
3. Stick two pins through the paper close to the center but separated from each other by a few centimeters. Use caution when using sharp objects.
4. Loop the string over the pins and use the pencil to trace around them. Keep the string taut.
5. Measure the major axis and the distance between the pins. Calculate the eccentricity.
6. Repeat steps 3–5 for different separations of the pins.

Analyze and Conclude

1. What do the two pins represent?

   The two pins represent the foci of the elliptical orbit.

2. How does the eccentricity change as the distance between the pins changes?

   The eccentricity becomes smaller as the two pins are moved closer together, and larger as the pins become more widely separated.

3. What kind of figure would you form if the two pins were at the same location? What would its eccentricity be?

   If the two pins were at the same location, the figure would be a circle. Its eccentricity would be zero because the numerator in the eccentricity formula, the distance between foci, would be zero.

Name Class Date

DESIGN YOUR OWN GeoLab Scaling the Solar System

Astronomers are familiar with both the small, such as interstellar dust particles, and the large, such as the solar system. In order to understand the variety of sizes in the solar system, astronomers use models. These models can be as simple as putting people or objects in marked places or as complex as elaborate computer simulations. The most difficult task with many models is choosing a scale that will display all the information needed, such as distance, rotation rates, and size.

PREPARATION

Problem

How can the size of the solar system be converted to a scale that will easily demonstrate relative distances between objects in the solar system? Is distance the only measurement that can be demonstrated in a scale model?

Possible Materials

calculator
tape measure
meterstick
stopwatches
marker
masking tape
variety of sizes of common round objects

Hypothesis

Brainstorm about possible models and data needed to create them. Determine where these data are available, and collect them to use as a reference for your model. To have your model fit in your chosen area, make a hypothesis on the appropriate scale to use for distance from the Sun to each planet.

Hypothesize how additional solar system measurements can be included in your model. For example, think about including planet diameters, rotation rates, etc.

Objectives

In this GeoLab, you will:

- **Calculate** the distance from the Sun for each planet based on your scale.
- **Determine** how to incorporate additional solar system measurements into your model, or design another model to show that information.
- **Interpret** your results based on your scale, and decide if your scale was an appropriate one based on the problems that may have resulted.

Name Class Date

DESIGN YOUR OWN GeoLab Scaling the Solar System

PLAN THE EXPERIMENT

1. As a group, use a separate sheet of paper to make a list of possible ways you might test your hypotheses. Keep the available materials in mind as you plan your procedure.
2. Be sure your scale is appropriate for the information you are representing. Remember that a model should have the same scale throughout. You may have to try more than one scale before you are successful.
3. Record your procedure and list every step. Determine what materials are needed and the amounts of each.
4. Design and construct a data table for recording your original data and your scaled data, using the space below.
5. Check the plan. Make sure your teacher has approved your plan before you proceed with your experiment.
6. Carry out your plan.

Name Class Date

DESIGN YOUR OWN GeoLab: Scaling the Solar System

ANALYZE

1. **Checking Your Hypothesis** Which scale worked the best for your model? Explain.

Students' answers will vary. Generally, larger scales will include more information.

2. **Interpreting Observations** What problems did you have in finding a scale? Explain how you corrected the problems.

Answers will vary. Initially, students will typically choose a scale that is too small.

3. **Calculating Results** List and explain the conversions that you used to create your scale model. If multiple steps were necessary to convert to your scale units, how could they be combined to make the process simpler?

Conversions will vary. If students converted from AUs to kilometers to meters, they can multiply their conversion factors to convert directly from AUs to meters.

4. **Observing and Inferring** What possible problems could result from using a very large scale? A small scale? Explain why depicting a scale model of the solar system on a sheet of notebook paper is extremely difficult.

Answers will vary. Large scales can be unmanageable, while small scales make it difficult to fit all the details in. Using a sheet of notebook paper makes it difficult because all the inner planets are crunched together.

Name Class Date

DESIGN YOUR OWN GeoLab: Scaling the Solar System

ANALYZE

5. **Compare and Contrast** Compare and contrast your model with one of your classmates'. What were the advantages of the scale you used? What were the disadvantages? How would you improve your model?

Answers will vary.

6. **Thinking Critically** Suppose that the outer planets are three times farther away than they are now. How would this affect your model? What scale would you choose now? Explain.

Answers will vary.

CONCLUDE AND APPLY

1. Proxima Centauri, the closest star to our Sun, is about 4.01×10^{13} km from the Sun. Based on your scale, how far would Proxima Centauri be from the sun in your model? If you were to fit the distance between the Sun and Proxima Centauri into your classroom, how small would the scaled distance between Pluto and the Sun be?

Answers will vary depending on students' scales.

2. An interstellar dust particle is 1.0×10^{-6} m in length. Convert this measurement to your scale. How many dust particles could fit in the distance between the Sun and Jupiter? Between Mars and Uranus?

Answers will vary depending on students' scales.

Name Class Date

MiniLab 30 Parallax in the Classroom

Model stellar parallax and the change in parallax angle with distance.

Procedure

1. Place a meterstick at a fixed position and attach a 4-m piece of string to each end.
2. Stand away from the meterstick and hold the two strings together to form a triangle. Be sure to hold the strings taut. Measure your distance from the meterstick. Record your measurement.
3. Measure the angle between the two pieces of string with a protractor. Record your measurement of the angle.
4. Repeat steps 2 and 3 for different distances from the meterstick by shortening or lengthening the string.
5. Make a graph in the space below of the angles versus their distance from the meterstick.

Analyze and Conclude

1. What does the length of the meterstick represent? The angle?

The meterstick represents 2 AU. The angle represents the parallax angle.

2. What does the graph show? How does parallax angle depend on distance?

The graph shows the relationship between parallax angle and distance. This is an inverse proportionality.

3. Are the angles that you measured similar to actual stellar parallax angles? Explain.

The angles measured in this experiment are far larger than any actual stellar parallax angles.

Name Class Date

GeoLab Identifying Stellar Spectral Lines

An astronomer studying a star or other type of celestial object often starts by identifying the lines in the object's spectrum. The identity of the spectral lines gives astronomers information about the chemical composition of the distant object, along with data on its temperature and other properties.

PREPARATION

Problem

Identify stellar spectral lines based on two previously identified lines.

Materials

ruler

Objectives

In this Geolab, you will:

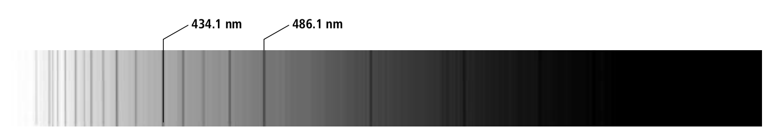
- **Develop** a scale based on the separation between two previously identified spectral lines.
- **Measure** wavelengths of spectral lines.
- **Compare** measured wavelengths to known wavelengths of elements to determine composition.

PROCEDURE

1. Measure the distance between the two identified spectral lines on star 1. Be sure to use units that are small enough to get accurate measurements.
2. Calculate the difference in wavelengths between the two identified spectral lines.
3. Set up your scale by dividing the difference in wavelengths by the measured distance between the two identified spectral lines. This will allow you to measure wavelengths based on your distance measurement unit. For example, 1 mm = 12 nm.
4. Measure the distance to spectral lines from one of the two previously identified spectral lines.
5. Convert your distances to wavelengths using your scale. You have measured the difference in wavelength. This difference must be added or subtracted to the wavelength of the line you measured from. If the line you measured from is to the right of the line you are identifying, then you must subtract. Otherwise, you add.
6. Compare your wavelength measurements to the table of wavelengths emitted by elements, and identify the elements in the spectrum.
7. Repeat this procedure for star 2.

Star 1

Star 2



Name Class Date

GeoLab Identifying Stellar Spectral Lines

POSSIBLE ELEMENTS AND WAVELENGTHS

Element/Ion	Wavelengths (nm)
H	383.5, 388.9, 397.0, 410.2, 434.1, 486.1, 656.3
He	402.6, 447.1, 492.2, 587.6, 686.7
He^+	420.0, 454.1, 468.6, 541.2, 656.0
Na	475.2, 498.3, 589.0, 589.6
Ca^+	393.4, 480.0, 530.7

ANALYZE

1. What elements are present in the stars?

Star 1: H (383.5 nm, 388.9 nm, 397.0 nm, 410.2 nm, 434.1 nm, 486.1 nm, 656.3 nm); Ca^+ (393.4 nm); Na (589.6 or 589.0—too close to tell)

Star 2: H (383.5 nm, 388.9 nm, 397.0 nm, 410.2 nm, 656.3 nm); He (402.6 nm, 447.1 nm, 587.6 nm, 686.7 nm); He^+ (420.0 nm, 454.1 nm, 468.6 nm, 686.7 nm); Ca^+ (393.4 nm)

2. How does your list of elements compare with the list of elements seen in the periodic table on page 125?

Most of the identified elements are hydrogen and helium. There is a very small number of elements in stars compared to the periodic table.

3. Can you see any clues in the star's spectrum about which elements are most common in the stars? Explain.

Most of the lines are hydrogen and helium lines. Thickness of spectral lines is an indication, but it also depends on the temperature.

Name Class Date

GeoLab Identifying Stellar Spectral Lines

CONCLUDE AND APPLY

1. Do both stars contain the same lines for all the elements in the table?

No. Star 1 does not have helium (neutral or ionized). Star 2 does not have sodium lines. In reality, both stars have all the same elements. The difference in their spectra is as a result of temperature effects.

2. You should notice that some absorption lines are wider than others. What are some possible explanations for this?

Students might suggest such reasons as different temperatures, different abundances, and so on.

3. How do the thicker absorption lines of some elements in a star's spectrum effect the accuracy of your measurements? Is there a way to improve your measurements? Explain.

To correct this, students should measure from the middle (width), where the line is darkest. As the band increases in width, it will increase the same amount on both sides. Thus, always measuring from the center will eliminate any error from increased width.

4. Using the following formula, calculate the percent deviation for five of your measured lines. Record your calculations in the space below.

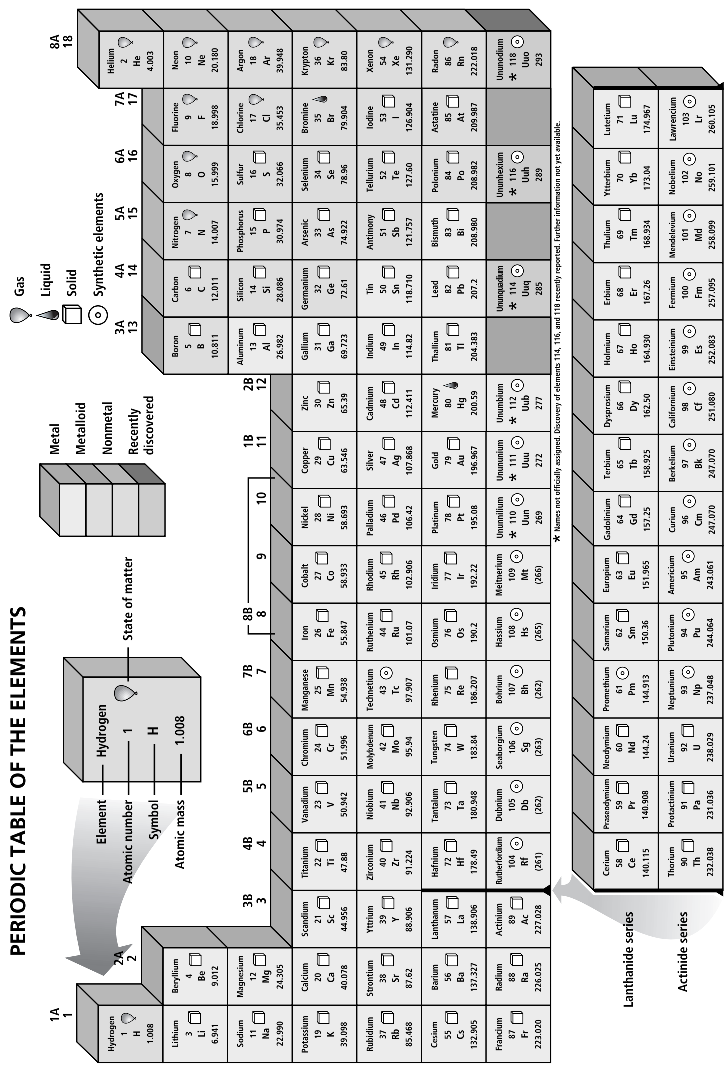
$$\text{Percent deviation} = \frac{\text{difference from accepted value}}{\text{accepted value}} \times 100$$

Is there a value that has a high percent deviation? If so, what are some possible explanations for this?

Student answers will vary. Possibly, students could have identified a different adjacent line. Also, measurements are very sensitive.

Name Class Date

GeoLab Identifying Stellar Spectral Lines



Name Class Date

MiniLab 31 Measuring Redshifts

Model uniform expansion of the universe and the redshifts of galaxies that result from expansion.

Procedure

1. Use a felt tip marking pen to make four dots in a row, each separated by 1 cm, on the surface of an uninflated balloon. Label the dots 1, 2, 3, and 4.
2. Partially inflate the balloon. Using a piece of string and a meterstick, measure the distance from dot 1 to each of the other dots. Record your measurements.
3. Inflate the balloon further, and again measure the distance from dot 1 to each of the other dots. Record your measurements.
4. Repeat step 3 with the balloon fully inflated.

Analyze and Conclude

1. Are the dots still separated from each other by equal distances? Explain.

   The dots are still separated from each other by equal distances because the separations have grown uniformly as the balloon was inflated.

2. How far did each dot move away from dot 1 after each inflation?

   The distance of each dot from dot 1 should increase in proportion to its original separation from dot 1. Thus, at an intermediate point, dot 2 would be 2 cm from dot 1 instead of 1 cm, dot 3 would be 4 cm from dot 1 instead of 2 cm, and so on. At a later point, the separations would all be tripled, and so on.

3. What would be the result if you had measured the distances from dot 4 instead of dot 1? From dot 2?

   The result would have been the same no matter which dot was chosen as the reference point.

4. How does this activity illustrate uniform expansion of the universe and redshifts of galaxies?

   It shows how galaxies (the dots) move away from each other at rates that are proportional to their original separations, and it shows that the observed expansion looks the same from any galaxy.

Name Class Date

Internet GeoLab: Classifying Galaxies

Edwin Hubble developed rules for classifying galaxies according to their shapes as seen in telescopic images. Astronomers are interested in the classification of galaxies. This information can indicate whether a certain type of galaxy is more likely to form than another and helps astronomers unravel the mystery of galaxy formation in the universe. Using the resources of the Internet and sharing data with your peers, you can learn how galaxies are classified.

PREPARATION

Problem

How can different galaxies be classified?

Hypothesis

How might galaxies be classified using Hubble's classification system? Are there absolute classifications based solely on shape? **Form a hypothesis** about how you can apply Hubble's galaxy classification system to galaxy images on the Internet.

Objectives

In this Geolab, you will:

- **Gather** and **communicate** details about galaxy images on the Internet.
- **Form conclusions** about the classification of different galaxies.
- **Reconstruct** the tuning-fork diagram with images that you find.

Data Sources

Go to the Glencoe Science Web Site at science.glencoe.com to find links to galaxy images on the Internet. You can also visit a local library or observatory to gather images of galaxies and information about them.

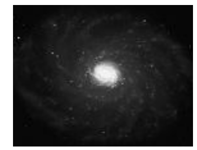
PLAN THE EXPERIMENT

1. Find a resource with multiple images of galaxies and, if possible, names or catalog numbers for the galaxies. The Glencoe Science Web Site lists sites that have galaxy images.
2. Choose one of the following types of galaxies to start your classification: spirals, ellipticals, or irregular galaxies.
3. Gather images and information, such as catalog numbers and names of galaxies, from the links on the Glencoe Science Web Site or the library.
4. Sort the images by basic types: spirals, ellipticals, or irregular galaxies.
5. For each basic type, compare the galaxies to each other and decide which galaxy best represents each class and subclass of Hubble's galaxy classification system: Sa, Sb, Sc, SBa, SBb, SBc, S0, E0–E7, and Irr. Try to find at least one galaxy for each subclass.
6. Arrange the galaxy images to construct a tuning-fork diagram like Hubble's.

Name Class Date

Internet GeoLab: Classifying Galaxies

GALAXY DATA

Galaxy Name	Sketch of Galaxy	Classification	Notes
NGC 3486		Sc	

PROCEDURE

1. Create a data table similar to the one above. Complete the data table. Add any additional information that you think is important.
2. Go to the Glencoe Science Web Site at science.glencoe.com to post your data.
3. Visit sites listed on the Glencoe Science Web Site for information about other galaxies.

CONCLUDE AND APPLY

Sharing Your Data Find this Internet GeoLab on the Glencoe Science Web Site at science.glencoe.com. Post your data in the table provided for this activity. Use the additional data from other students to complete your chart and answer the Conclude & Apply questions.

1. Were there any galaxy classes or subclasses that were difficult to find images for? If so, which ones?

   Answers will vary.

2. How many of each type of galaxy—normal spiral, barred spiral, elliptical, and irregular—did you find?

   Answers will vary.

3. Calculate the percentages of the total number of galaxies that each type represents. Do you think this reflects the actual percentage of each type of galaxy in the universe? Explain.

   Answers will vary. There are more ellipticals, but students' results will depend on the images available, which generally do not represent the number of a certain type.

Name Class Date

Internet GeoLab Classifying Galaxies

CONCLUDE AND APPLY

4. Were there any galaxy images that you found that didn't fit your classification scheme? If so, why?

Irregular galaxies and some active galaxies will not fit into the Hubble classification scheme because of their unusual shapes.

5. Was it difficult to distinguish between a normal spiral and a barred spiral in some cases? Explain your method.

It can be difficult. Determining how close to the nucleus the arms are and whether the nucleus is elongated helps.

6. What problems did you have with galaxies that are edge-on as seen from Earth?

Edge-on galaxies are generally spirals. If it isn't possible to see the arms and nucleus, it isn't possible to classify an edge-on galaxy any further than as a spiral.

7. Ellipticals are usually a difficult type of galaxy to classify. Why?

There is not a large amount of variation in appearance between adjacent subclasses. Astronomers actually use a formula that helps to determine the subclasses more accurately. Also, an elliptical galaxy may look very different from a different perspective within the universe. Because of this, elliptical subclasses are not definitive classifications.