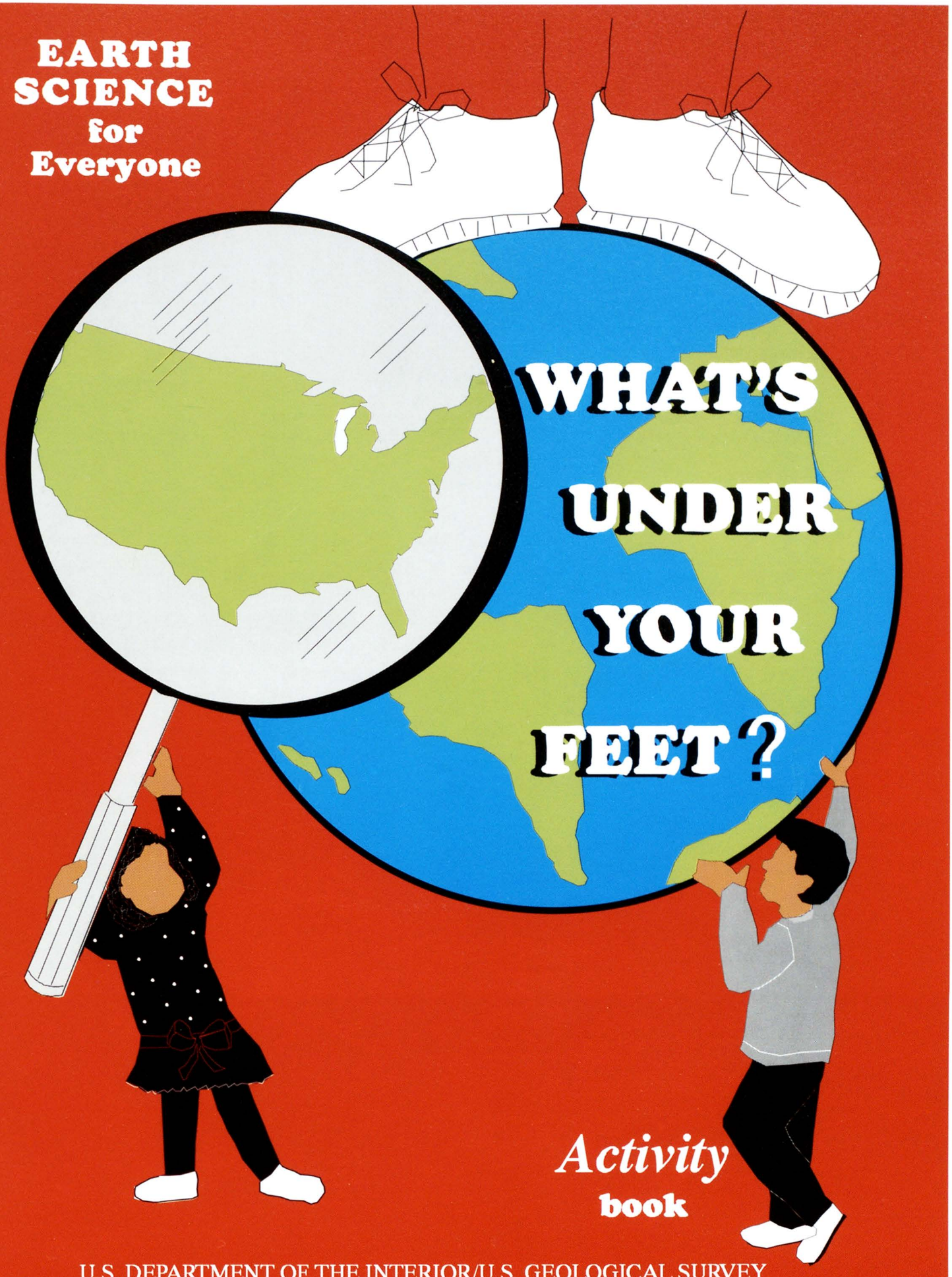
EARTH SCIENCE for Everyone



WHAT'S UNDER YOUR FEET?

Activity book

U.S. DEPARTMENT OF THE INTERIOR/U.S. GEOLOGICAL SURVEY

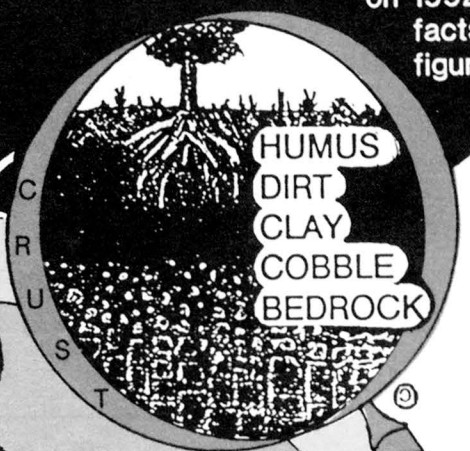
U.S. DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, Jr., Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

UNITED STATES GOVERNMENT PRINTING OFFICE: 1992

WHAT'S UNDER YOUR FEET ?

Based on 1992 facts & figures



Activity

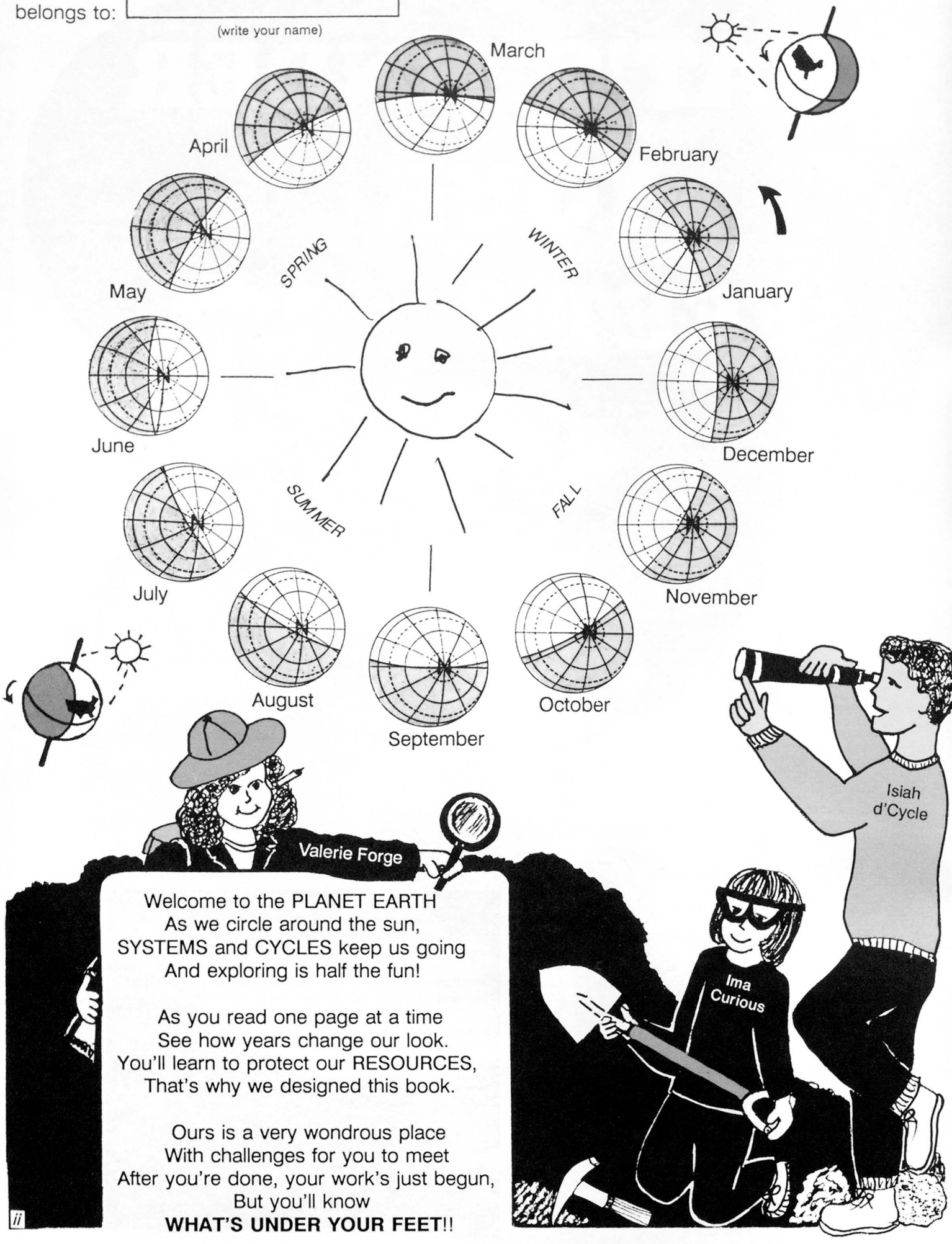
SEE EARTH'S LAYERS

By:
Penni Rubin
and
Eleanora I. Robbins

U.S. DEPARTMENT OF THE INTERIOR/U.S. GEOLOGICAL SURVEY

This Earth belongs to: _____

(write your name)



Welcome to the PLANET EARTH
As we circle around the sun,
SYSTEMS and CYCLES keep us going
And exploring is half the fun!

As you read one page at a time
See how years change our look.
You'll learn to protect our RESOURCES,
That's why we designed this book.

Ours is a very wondrous place
With challenges for you to meet
After you're done, your work's just begun,
But you'll know
WHAT'S UNDER YOUR FEET!!

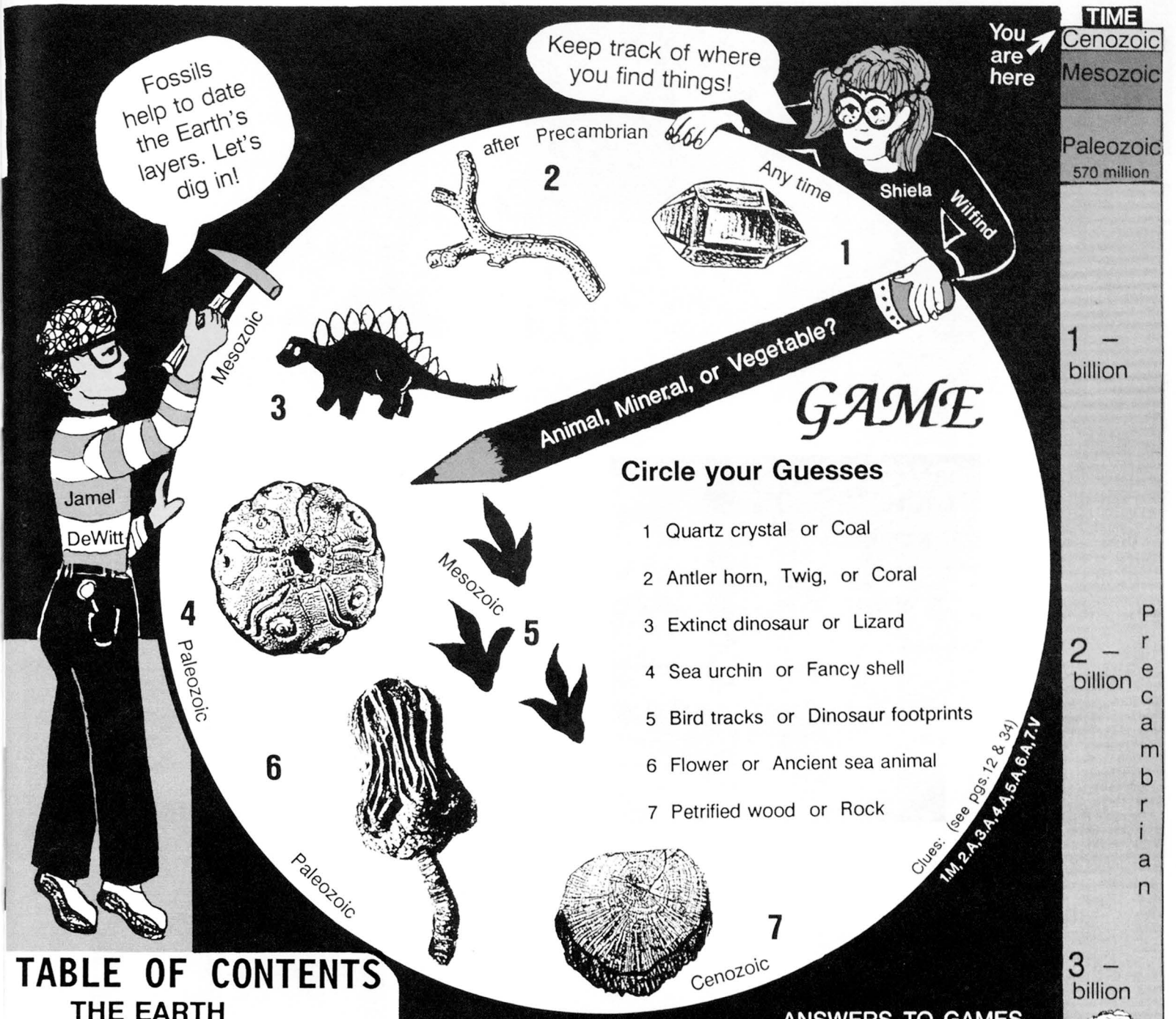


TABLE OF CONTENTS

POINT OF YOU (VIEW)

Mya View

On cold days we dress in layers. It gets hot inside. The EARTH is just like this!

DRAW WHAT'S UNDER YOUR FEET

The EARTH CYCLE:

Today's LAYER becomes
Tomorrow's ROCKS, and
Yesterday's BEDROCK is
Today's SOIL. (see pg. 24-26)

HOW TO READ MAPS

1 front view

2 side view (PROFILE)

3 top view (AERIAL)

4 bottom view

Ozzie Canu-see

How did the stuff in your yard get there? Trucks or bulldozers? Wind or rain? Glaciers or oceans? What do you think? ?

Activity

Mayo Jar
LAYERED MUDSHAKE
for "seeing" NOT DRINKING

2/3 WATER & 1/3
- CLAY
- FINE SAND
- COARSE SAND
- CLUMPS OF DIRT
- Careful! Pebbles & rocks break glass.

DRAW

Terra Topsoil

In a jar with water, MIX 2 or 3 of these dirts at a time. STIR with a wooden spoon and let SETTLE one day.

Get dirt from other places & try new combos. Can you guess which will reach the bottom first?

Picture an orange

5 side top

CROSS SECTION

The deepest we've ever drilled is 12 km (7.5 mi). Then the heat of the Earth ruined the equipment. (Peek at pg.25.)

Mr. Buggs

HUMUS
When plants, roots, worms, & bugs die, they decay & become part of the soil.

Some **SOILS** hold & drain water better than others.

Activity

Get some cups and fill each with a different type of **SEDIMENT** (clay, sand, small rocks, top soil). Plant a few grass seeds in each cup. Measure & use the same amount of water. Keep a record of the growth rates in each of your samples. In which soil do you get better results?

EARTHTONES

RED: contains iron
In States (pg.21): AL,CO,GA,MN,SC
YELLOW: contains sulfur or iron
In: AR,LA,MI,ND,NV,SD,TX,WY
WHITE: broken shells, sand, or snow
In: AK,AZ,CA,FL,IN,MT,NM,UT
BROWN: humus,sandstone, or wetlands
In: CT,DE,ID,IL,MA,ME,MD,MS,NH,NJ, NY,NC,OH,OK,OR,RI,TN,VA,VT,WV
BLACK: volcanic lava, coal, or loam
In: HI,IA,KS,KY,MO,NE,PA,WA,WI

SIZES (actual chart)

SOIL & DIRT

Dig a hole. What color is your dirt (first layer)? Dig somewhere else. Is it the same color? Dig deeper; check the sizes, colors, and areas on the charts of this page.

Rocks break up in many different sizes to make soil. Lighter grains stay near the top & heavier go to the bottom. Fine-grained clay & mud layers settle and become COMPACTED to make rocks again!

Loam
Earthy materials like sand and clay.

Get Down to Earth

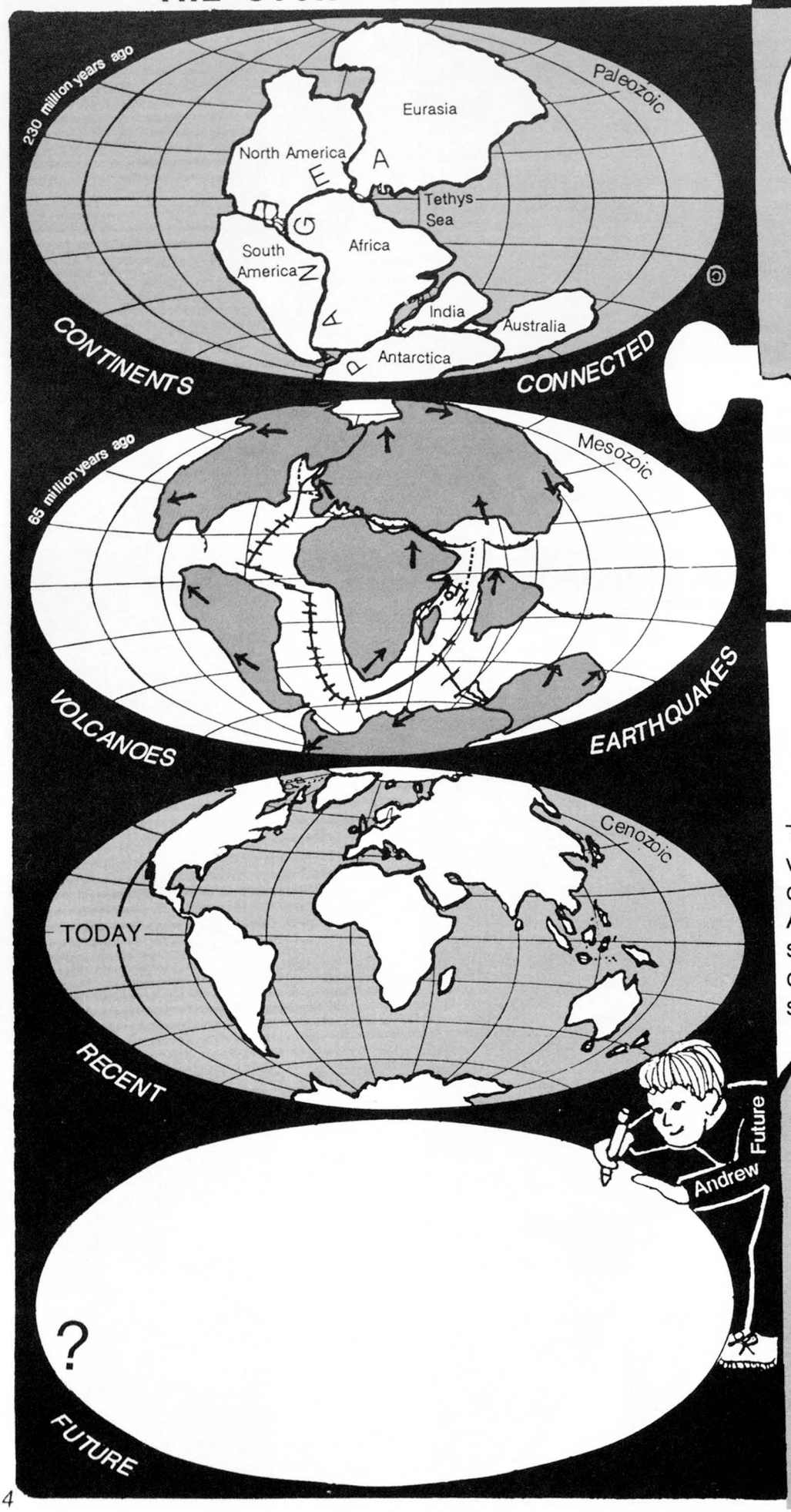
Kevin Mudd

ORGANIC MATTER like this helps Earth create coal, oil, & gas.

These patterns show the different soils of North America

FUN TRIP TIP
When going on trips, bring along clear film or pill containers and fill them with different colored dirt. Label where you find each sample.

THE STORY OF PANGEA

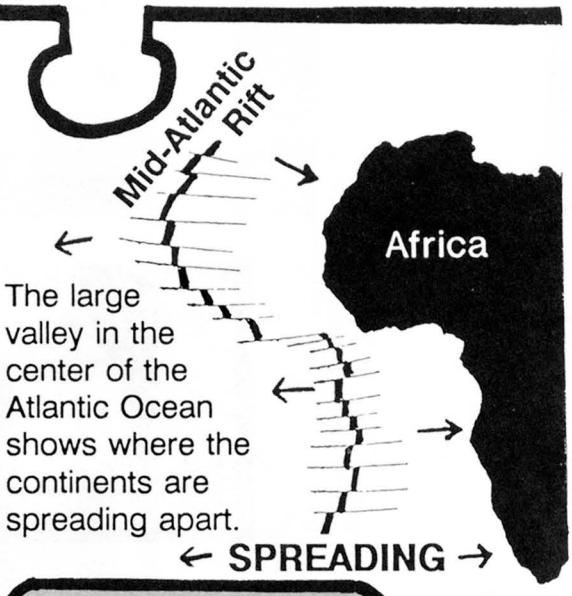


HOW DO WE KNOW

THE PUZZLE FITS

IN: Australia/India
gold deposits match
IN: North America/Europe
fossil plants same
IN: South America/Africa
same land reptiles

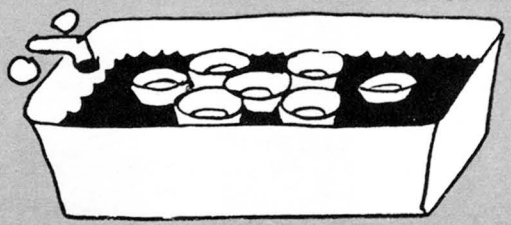
The same fossils & rocks have been found where the continents connected 200 million years ago.



The large valley in the center of the Atlantic Ocean shows where the continents are spreading apart.

Activity

PLATE TECTONICS



Float 7 plastic bowls (LANDPLATES) in the bathtub. Try to keep them together and wiggle the water (EARTHQUAKES). Watch how they float apart (CONTINENTAL DRIFT) & crash (MOUNTAIN BUILDING).

EARTHQUAKES

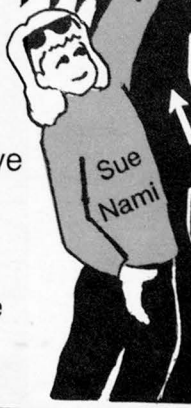
8 7 6 5 4 3 2 1

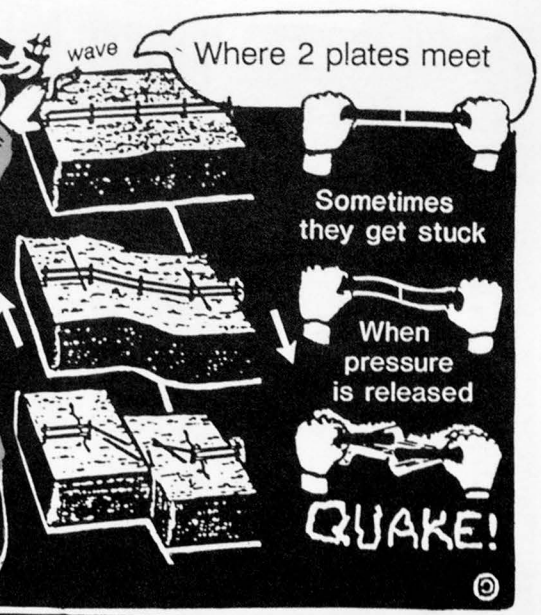
The higher scale number means it's 33 times more powerful.

RICHTER SCALE

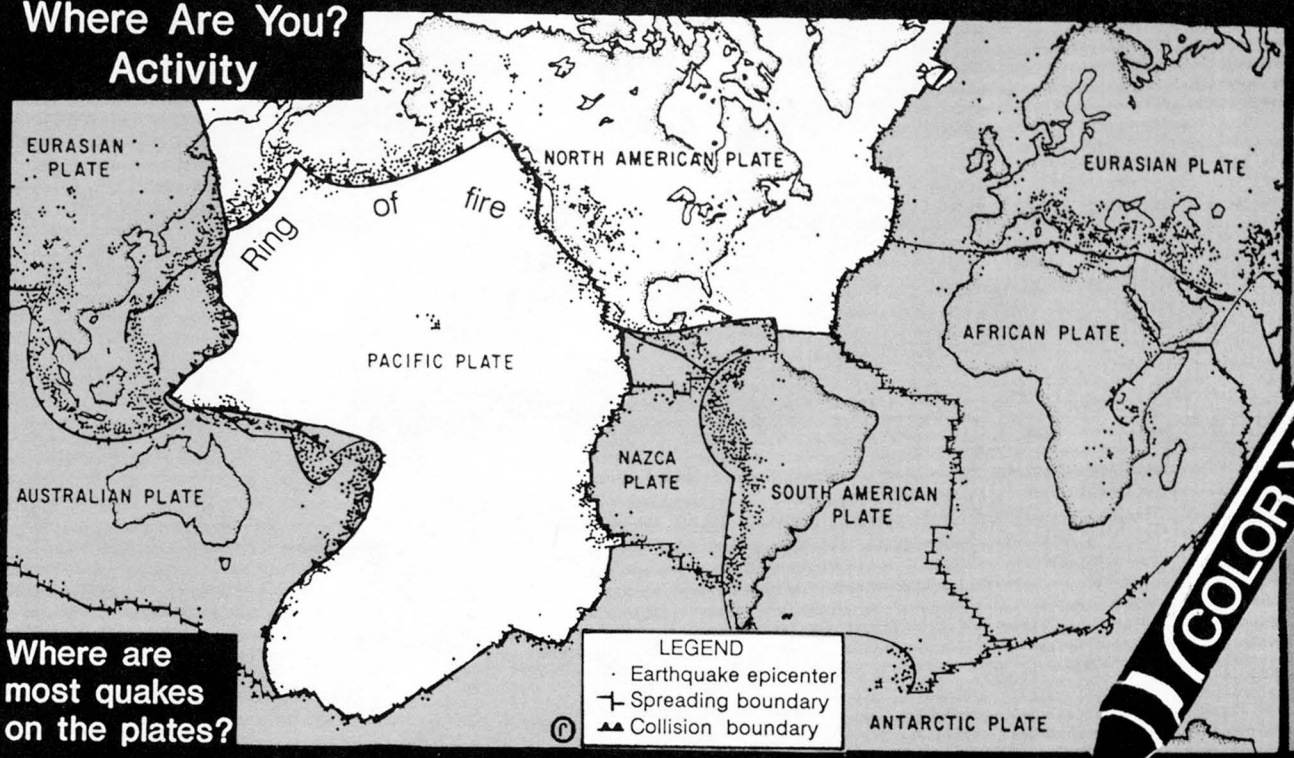
PEOPLE SCALE

8 - total damage
7 - buildings fall down
6 - buildings crack and things fall off shelves
5 - furniture & pictures move
3-4 - feel rumble in floor & hear noise overhead!
1-2 - you will not feel these (Some people are more sensitive and feel the smaller VIBRATIONS!)





Where Are You? Activity



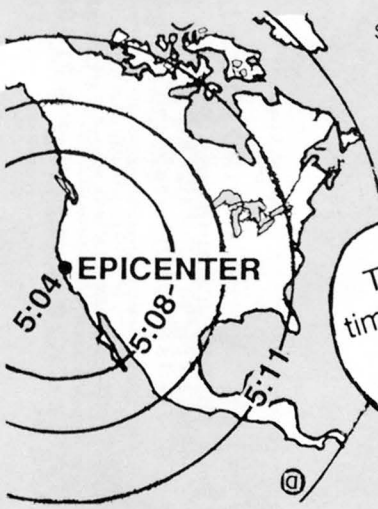
Where are most quakes on the plates?

COLOR YOUR PLATE

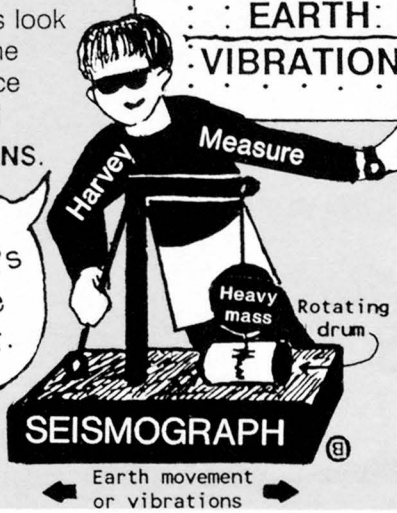
Coastal California & Hawaii, color the Pacific Plate

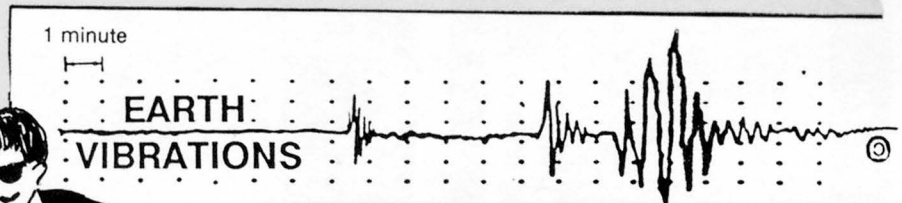
Eastern US & Alaska, color the N. American Plate

When a quake strikes, the time is recorded on machines (**SEISMOGRAPHS**) in many places. To find the **EPICENTER** where the quake begins, seismologists look at the time each place reported **VIBRATIONS**.



The earlier time means it's nearer the epicenter.





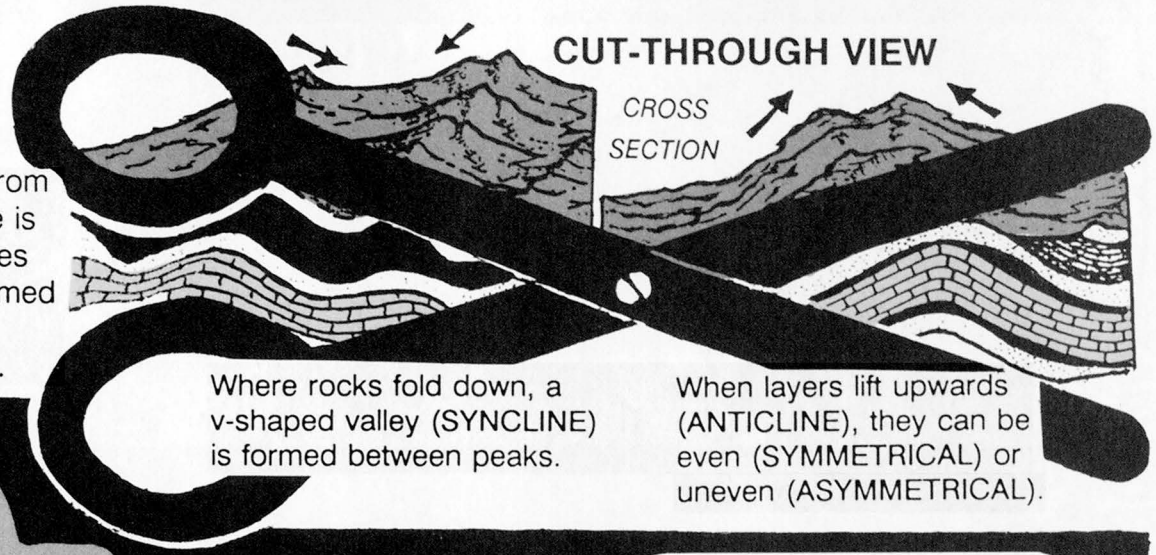
FAMOUS EARTHQUAKES

magnitude		year
8.8	New Madrid, MO.....	1812
8.7	Assam, India.....	1897
8.5	Southern Chile.....	1960
8.4	Anchorage, AK.....	1964
8.3	San Francisco, CA.....	1906
8.2	Tokyo, Japan.....	1923
7.8	T'angshan, China.....	1976
7.8	Chimote, Peru.....	1970
7.1	Loma Prieta, CA.....	1989
6.8	Armenia, USSR.....	1988

MOUNTAIN BUILDING

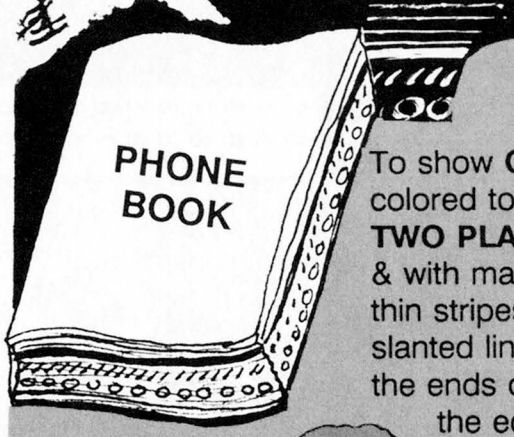
FOLDING AND FAULTING

The Earth is always moving because PRESSURE & HEAT from inside builds & moves the land plates. Sometimes one plate is affected & heat LIFTS or FOLDS the layers. Where two plates meet, they push or crash. Our highest mountain ranges formed where two plates crashed into each other! It takes a long time for these things to happen.



Where rocks fold down, a v-shaped valley (SYNCLINE) is formed between peaks.

When layers lift upwards (ANTICLINE), they can be even (SYMMETRICAL) or uneven (ASYMMETRICAL).



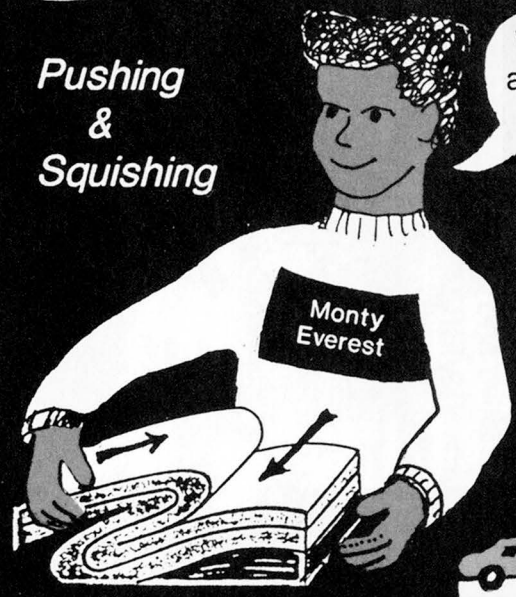
Activity

To show **ONE PLATE** action, fold three colored towels the long way. To show **TWO PLATE** action, use 2 phone books, & with markers, make rows of thick and thin stripes, small circles, and diagonal slanted lines on sides. When you push the ends of the towels and books, watch the edges and markings to see the layers squish (COMPRESS) or rise up, forming small openings or pockets where water, gases, and oil gather & get stored in the Earth.

Draw a line on top of two phone books, slide one to you and one away (**FAULT**). The San Andreas Fault is where two land plates slide apart.

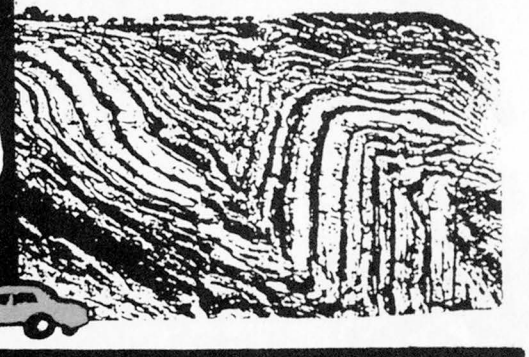
Push books together and see uplifting (**CONVERGENCE**).

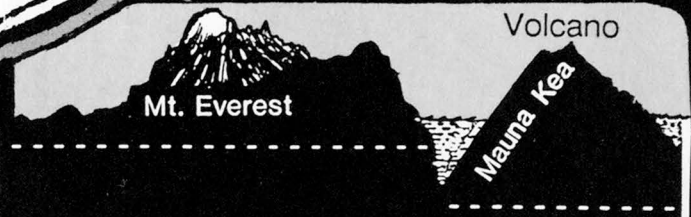
Pushing & Squishing



When one plate slides under another plate (SUBDUCTION), heat gets through and VOLCANOES appear.

EARTHQUAKE FOLDING





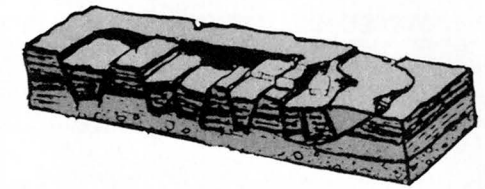
The highest mountain in the world is not Mt. Everest (8,800 meters), but Mauna Kea, a volcano in Hawaii. It measures 9,800 meters from its top to its bottom below the ocean (look at the profile above).

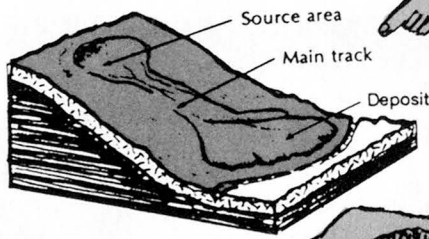
PROFILES OF MOUNTAINS

When driving past cut-through mountains, look at the LAYERS in the rocks. If you see folds, you know the rocks were under great PRESSURE. If you see round stones, you know a river was once there and now it's gone.

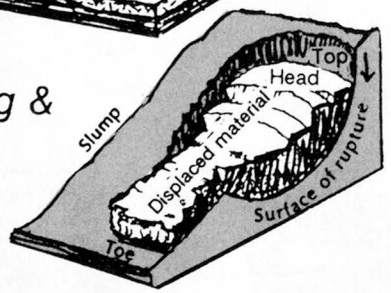
EROSION

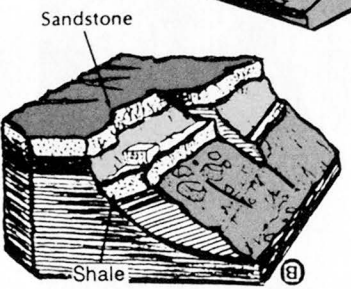
NATURAL DESTRUCTION





Slipping & Sliding





The rock beds in some layers are softer and break up, weathering easily. When bare rocks get wet and icy, the looser ones and even whole layers can fall down. BLOCK MOUNTAINS show how layers get rearranged when they slide and leave a SCARP. Storms and glaciers wear away at the top layers and water can seep in. Sometimes rocks & sediments hold water inside. Freezing and thawing action moves rocks too. Earthquakes & storms can start SLUMPS, LANDSLIDES, & AVALANCHES. (See pg. 24.)

GAME

TO PLAY: Decide if each is happy or sad

Plants help hold water and make soil richer.

Burning the rain forests exposes bare land to erosion.

Over-grazed land has few plants to hold soil and water.

Mud fences at building sites keep soil from washing away into streets and streams.

It takes years for soil of barren land to build so plants can grow.

Land developers cut down trees to build new buildings.

Less forest land means less plants and dirtier air.

More city means less land for wild animals.

Roads cut through the natural places help to create erosion.

MAN-MADE DESTRUCTION

T or F?

Layers of plastic and garbage slow down Earth's natural decaying activity.

Oil spills hurt the animals and plants on land & in the water.

Toxic wastes seep into our drinking water supply.

Swamp, marsh, and bog wetlands keep our water clean.

HELPING HANDS

Plantings help to keep the ground from eroding away.

Natural parks in cities make habitats for animals and plants, and keep our air cleaner.

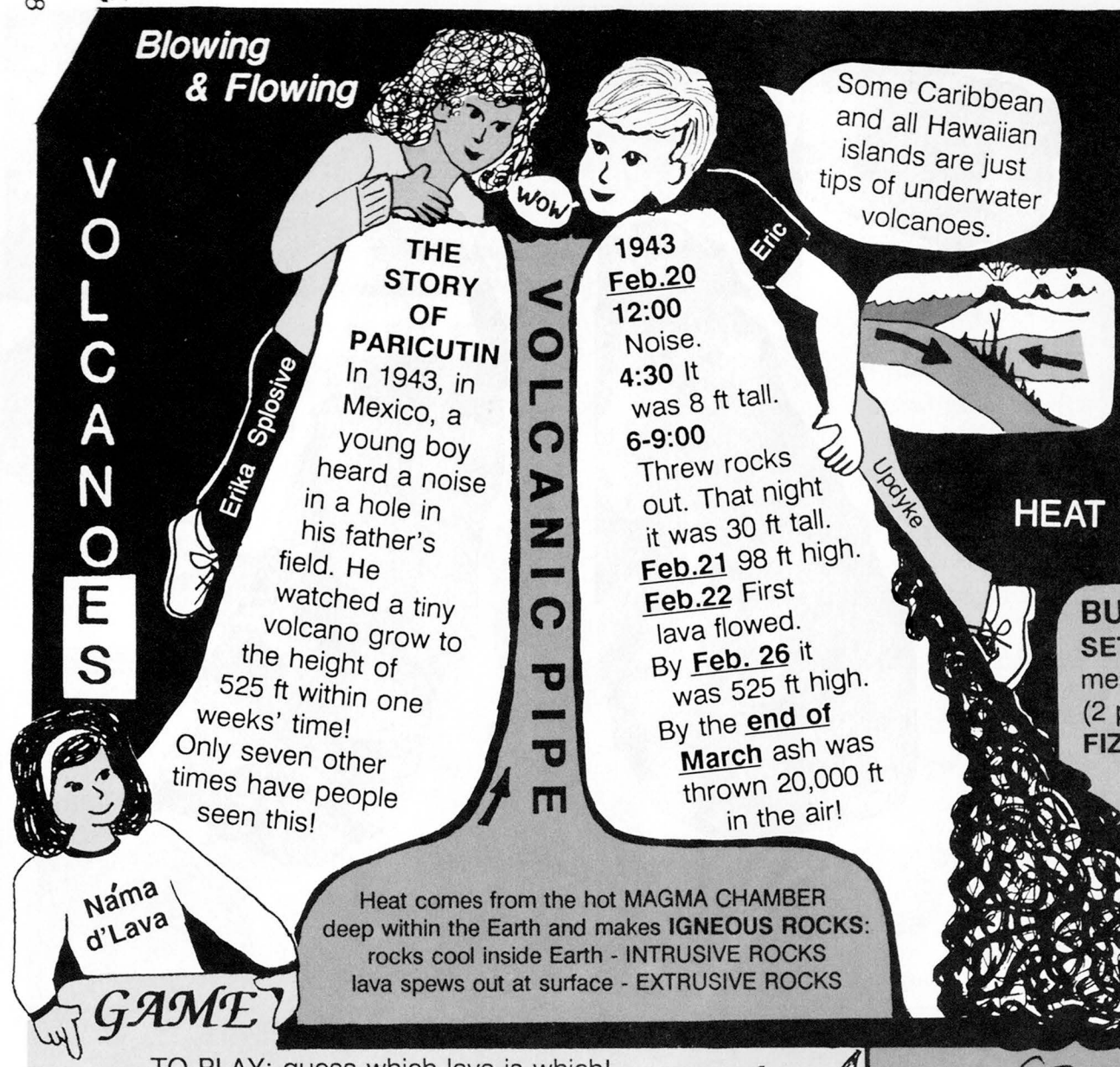
Trees need to be replanted because we use wood to make houses & paper.

WHAT YOU CAN DO

(peek on pg. 40)

VOLCANOES

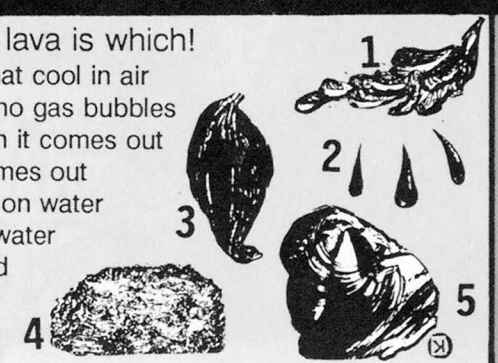
Blowing & Flowing



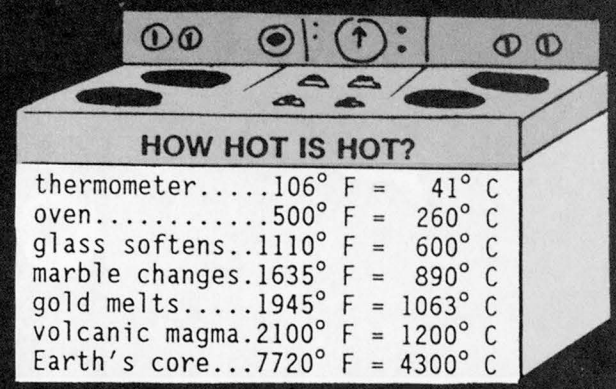
Heat comes from the hot MAGMA CHAMBER deep within the Earth and makes **IGNEOUS ROCKS**:
rocks cool inside Earth - INTRUSIVE ROCKS
lava spews out at surface - EXTRUSIVE ROCKS

TO PLAY: guess which lava is which!

- ☐ **PELE'S TEARS**: Tiny glass blobs that cool in air
- ☐ **OBSIDIAN**: Looks like glass & has no gas bubbles
- ☐ **ROPY (PAHOEHOE)**: Is runny when it comes out
- ☐ **BLOCKY (AA)**: Is sticky when it comes out
- ☐ **PUMICE**: Has gas bubbles & floats on water
- ☐ **PILLOW**: Erupts & puffs out under water
- ☐ **LAVA**: When it flows out hot & liquid
- ☐ **ASH**: Tiny broken pieces of glass
- ☐ **BOMB**: Thrown out & cools in air



A geologist found a granite pebble on the volcanic island Martinique. She knew that a French boat had to have brought the rock because it didn't belong with the other rocks nearby. Knowing history helps scientists.



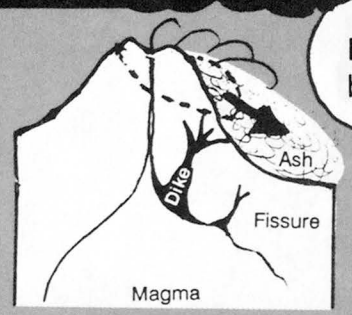
HOW HOT IS HOT?

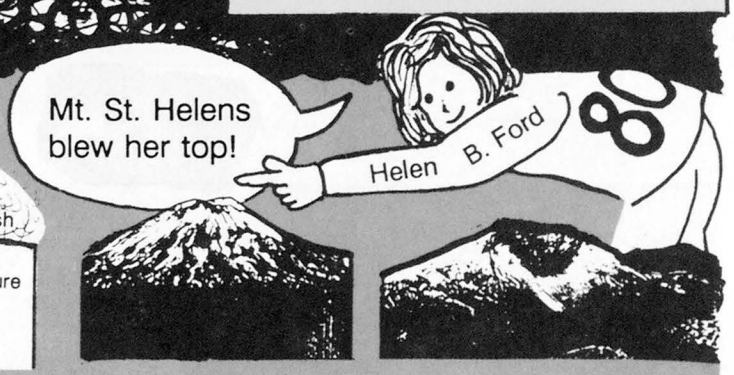
thermometer.....	106° F =	41° C
oven.....	500° F =	260° C
glass softens..	1110° F =	600° C
marble changes.	1635° F =	890° C
gold melts.....	1945° F =	1063° C
volcanic magma.	2100° F =	1200° C
Earth's core...	7720° F =	4300° C

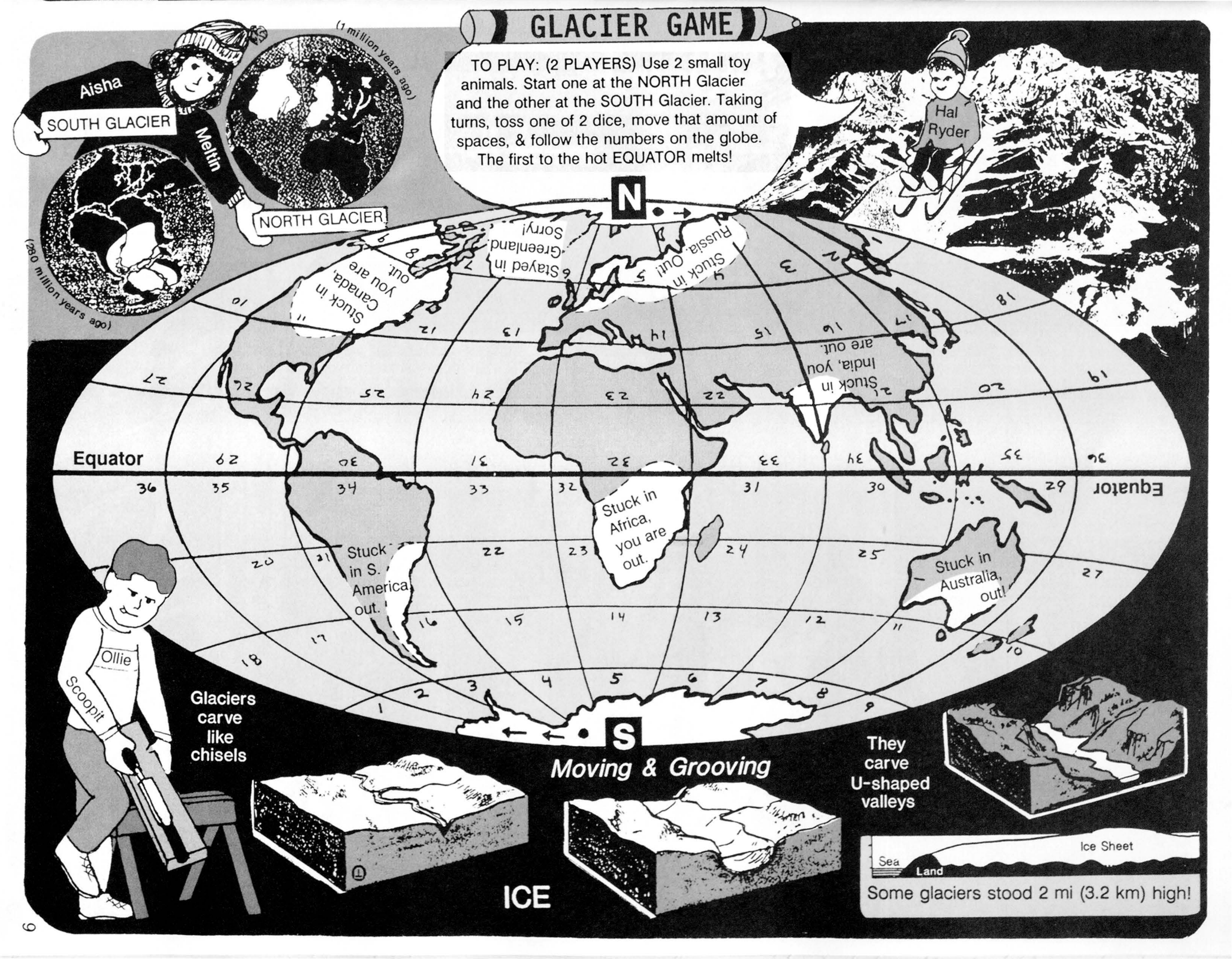
BUILD A VOLCANO *Activity*

SET UP: Place a can on a tray, & with foil or wire mesh and plaster of Paris, form a volcano shape. (2 parts plaster to 1 part cold water, mix.)

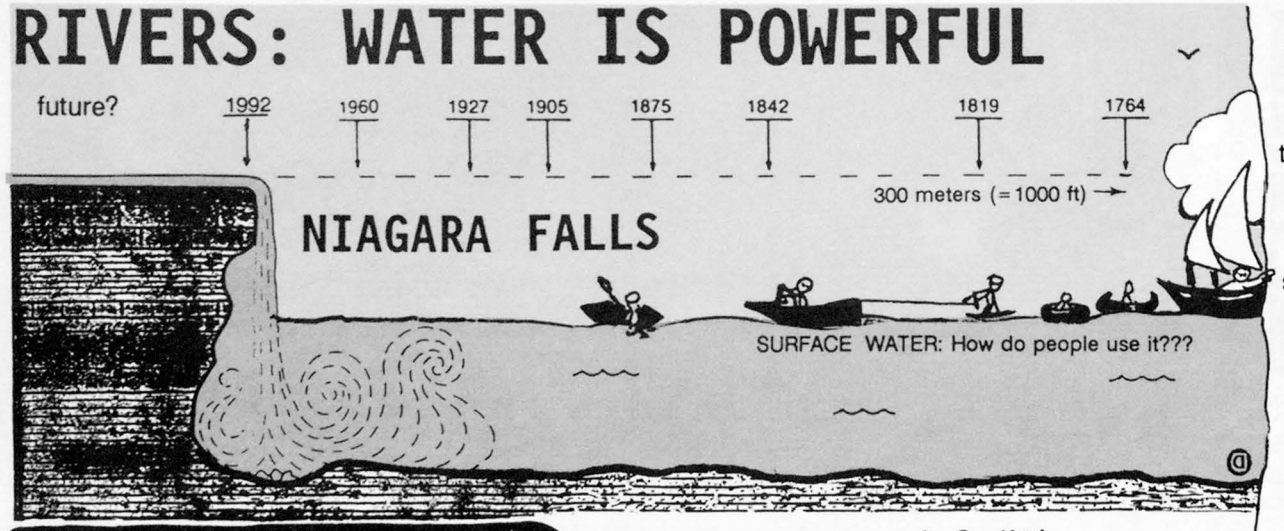
FIZZLING: Fill 1/3 can with baking soda. In a cup, mix 2 drops red food coloring & 2 drops liquid detergent. Add 1/3 cup vinegar. Pour liquid into baking soda & watch out!



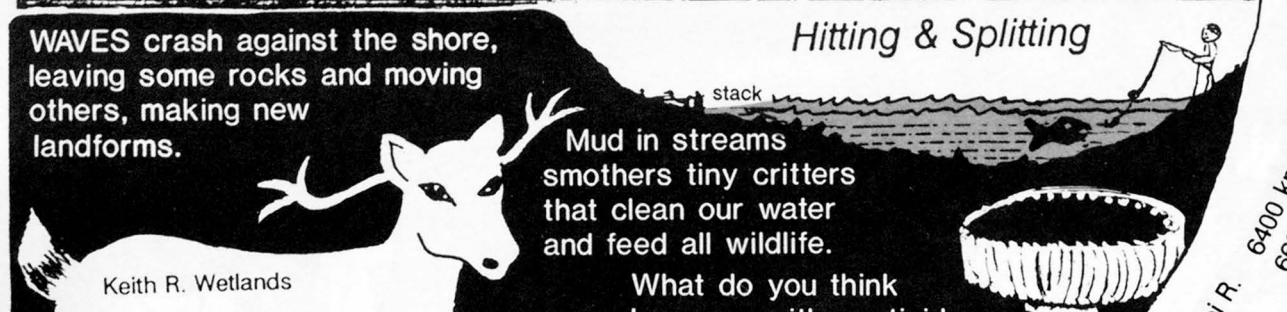


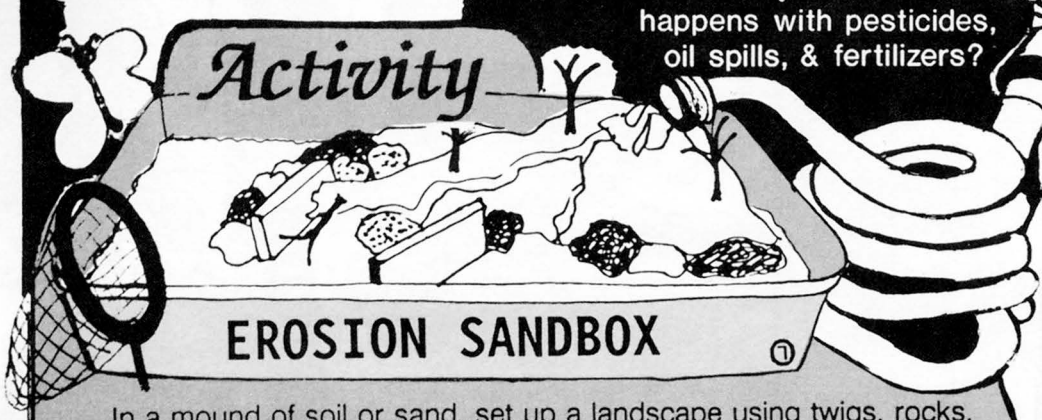

GLACIER GAME
TO PLAY: (2 PLAYERS) Use 2 small toy animals. Start one at the NORTH Glacier and the other at the SOUTH Glacier. Taking turns, toss one of 2 dice, move that amount of spaces, & follow the numbers on the globe. The first to the hot EQUATOR melts!
Aisha
Melvin
SOUTH GLACIER
NORTH GLACIER
(1 million years ago)
(280 million years ago)
Hal Ryder
N
S
Equator
Stuck in Africa, you are out.
Stuck in S. America, out.
Stuck in Australia, out!
Stuck in India, you are out.
Stuck in Russia. Out! 5
Stayed in Greenland. Sorry! 6
Stuck in Canada, you are out.
Ollie
Scoopit
Glaciers carve like chisels
Moving & Grooving
They carve U-shaped valleys
Ice Sheet
Sea
Land
Some glaciers stood 2 mi (3.2 km) high!
ICE

RIVERS: WATER IS POWERFUL



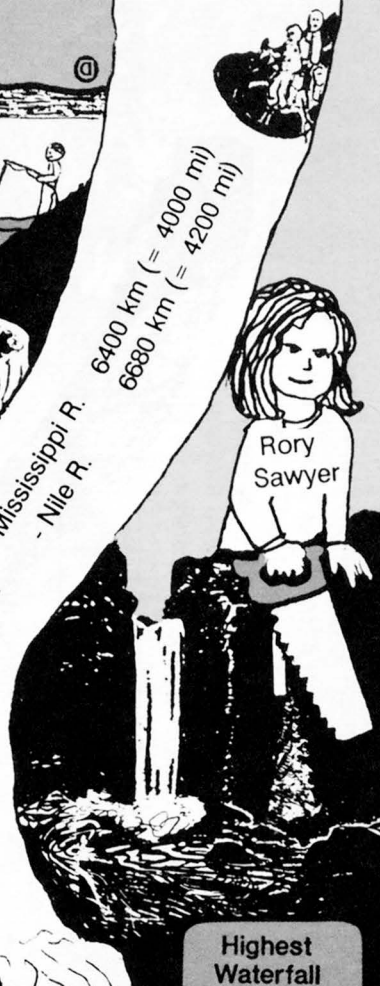
Water can eat away the softer layers. When the top layers break away, the waterfall moves back. The dates show how Niagara Falls has moved.





In a mound of soil or sand, set up a landscape using twigs, rocks, and dirt clumps. Pour water down your mountain. Watch how the stream erodes. Repeat several times. Does anything new happen?

Longest river in US - Mississippi R. 6400 km (= 4000 mi)
Longest river in World - Nile R. 6680 km (= 4200 mi)



Highest Waterfall

U.S.: Ribbon Falls, California 490 m=1608 ft

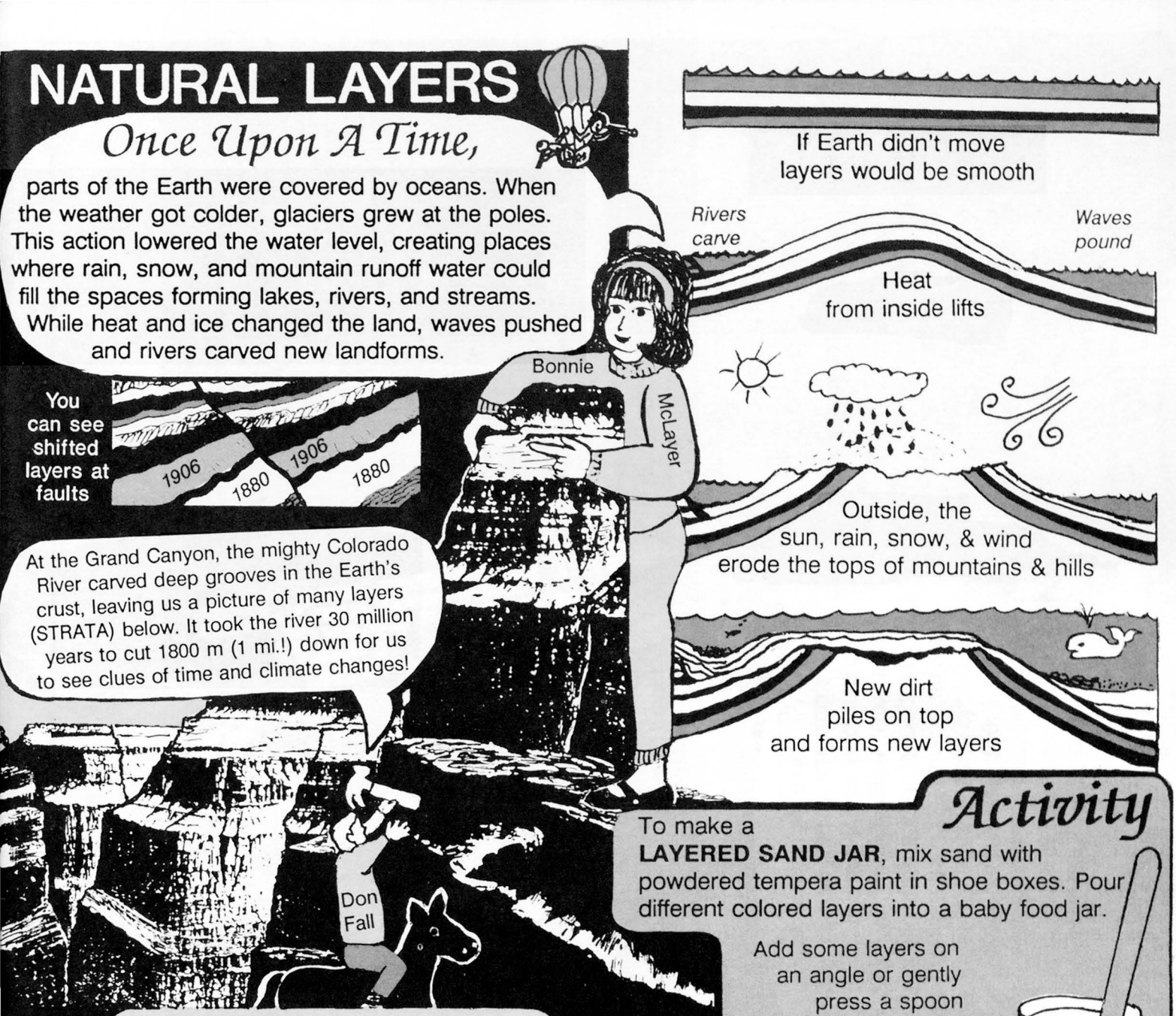
World: Angel Falls, Venezuela 810 m=2660 ft

Rivers cut their banks with each storm. How often do you think a State border changes when a river is there?

NATURAL LAYERS

Once Upon A Time,

parts of the Earth were covered by oceans. When the weather got colder, glaciers grew at the poles. This action lowered the water level, creating places where rain, snow, and mountain runoff water could fill the spaces forming lakes, rivers, and streams. While heat and ice changed the land, waves pushed and rivers carved new landforms.



You can see shifted layers at faults

At the Grand Canyon, the mighty Colorado River carved deep grooves in the Earth's crust, leaving us a picture of many layers (STRATA) below. It took the river 30 million years to cut 1800 m (1 mi.!) down for us to see clues of time and climate changes!

If Earth didn't move layers would be smooth

Outside, the sun, rain, snow, & wind erode the tops of mountains & hills

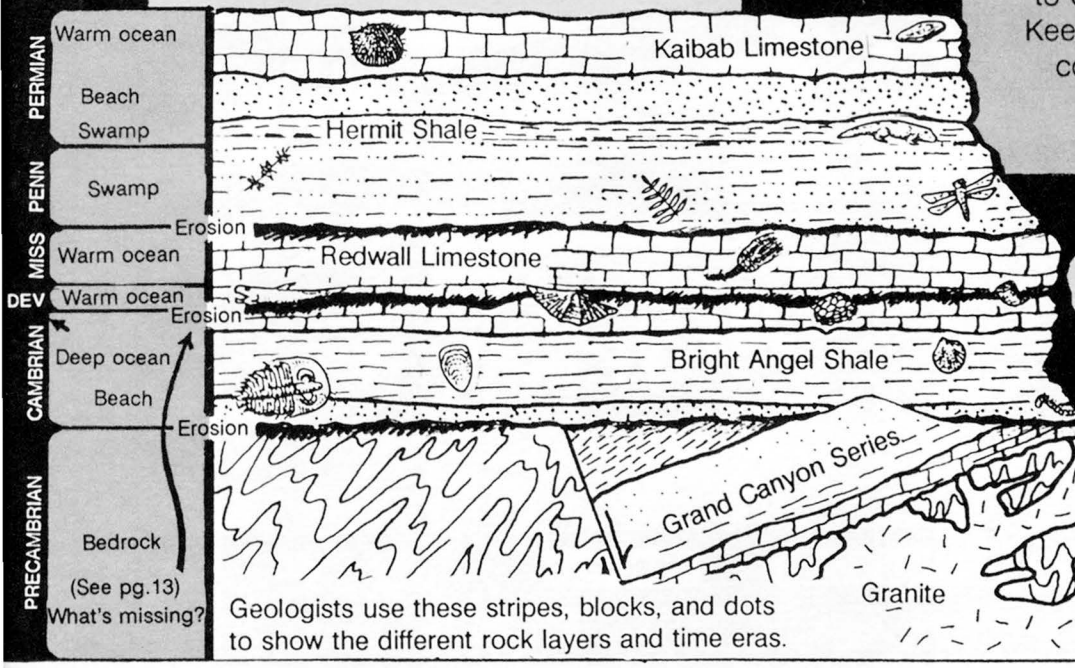
New dirt piles on top and forms new layers

Activity

To make a **LAYERED SAND JAR**, mix sand with powdered tempera paint in shoe boxes. Pour different colored layers into a baby food jar.

Add some layers on an angle or gently press a spoon around the edges to create scallops. Keep putting a new color on top and see how layers form on Earth.

THE GRAND CANYON



Geologists use these stripes, blocks, and dots to show the different rock layers and time eras.

By comparing the colors, the fossils, & the thicknesses of the layers in other parts of the world, we solve the mystery of Earth's history.

AGES & STAGES

INTERESTING INFO

Earth's inner forces (spreading, lifting, folding, faulting, and volcanoes) push up & build layers. The outer forces (glaciers, weather, and erosion) move and destroy layers. Because of this, the top layer could be from any time. Scientists needed a way to date the layers to know what time period they were digging in. They made charts to show what they found where, but how do you think they knew the time period?

Paleontologists from all over find the same kinds of fossils in certain layers. Older layers show single-celled plants. Newer layers show bones of extinct mammals. Our climate changes affected the plants (FLORA) and animals (FAUNA) throughout time. During big changes, new species grew. New names were given to such layers because at times land was underwater and at other times it was dry.

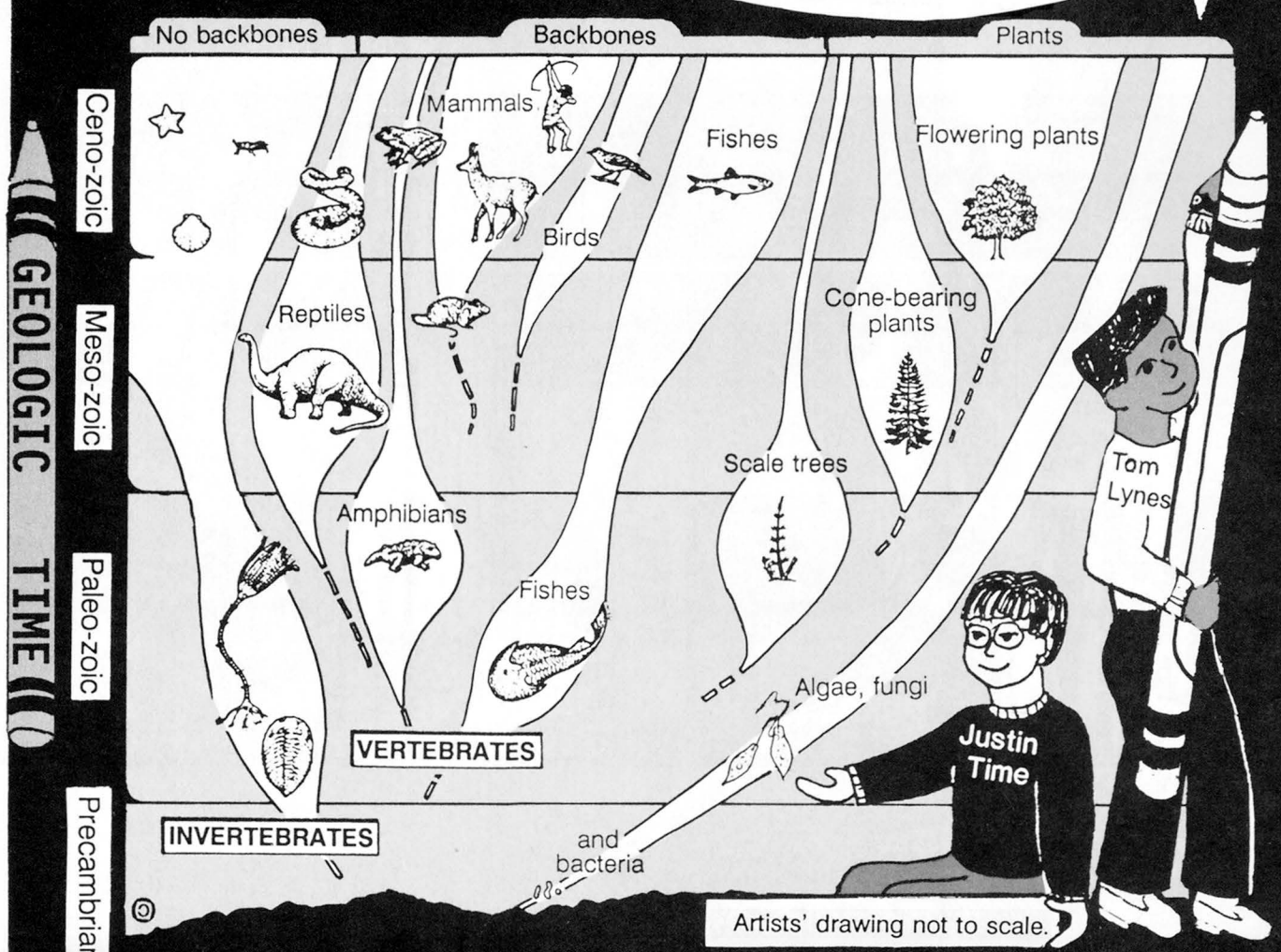
COLORING TIME Activity

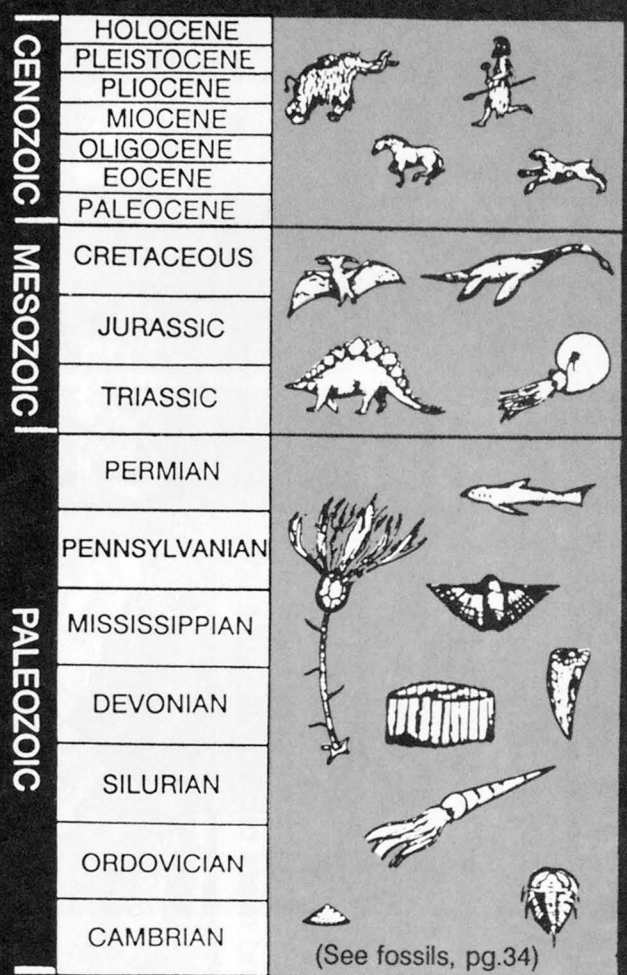
COLOR THE CHARTS on both pages by the time EPOCH or ERA. Can you see how long the Precambrian lasted? Most of these charts don't show all of geologic time.

LEGEND

[red]	HOLOCENE
[orange]	PLEISTOCENE
[yellow]	CENOZOIC
[green]	MESOZOIC
[blue]	PALEOZOIC
[violet]	PRECAMBRIAN

(See pg.23 to learn how these got named.)

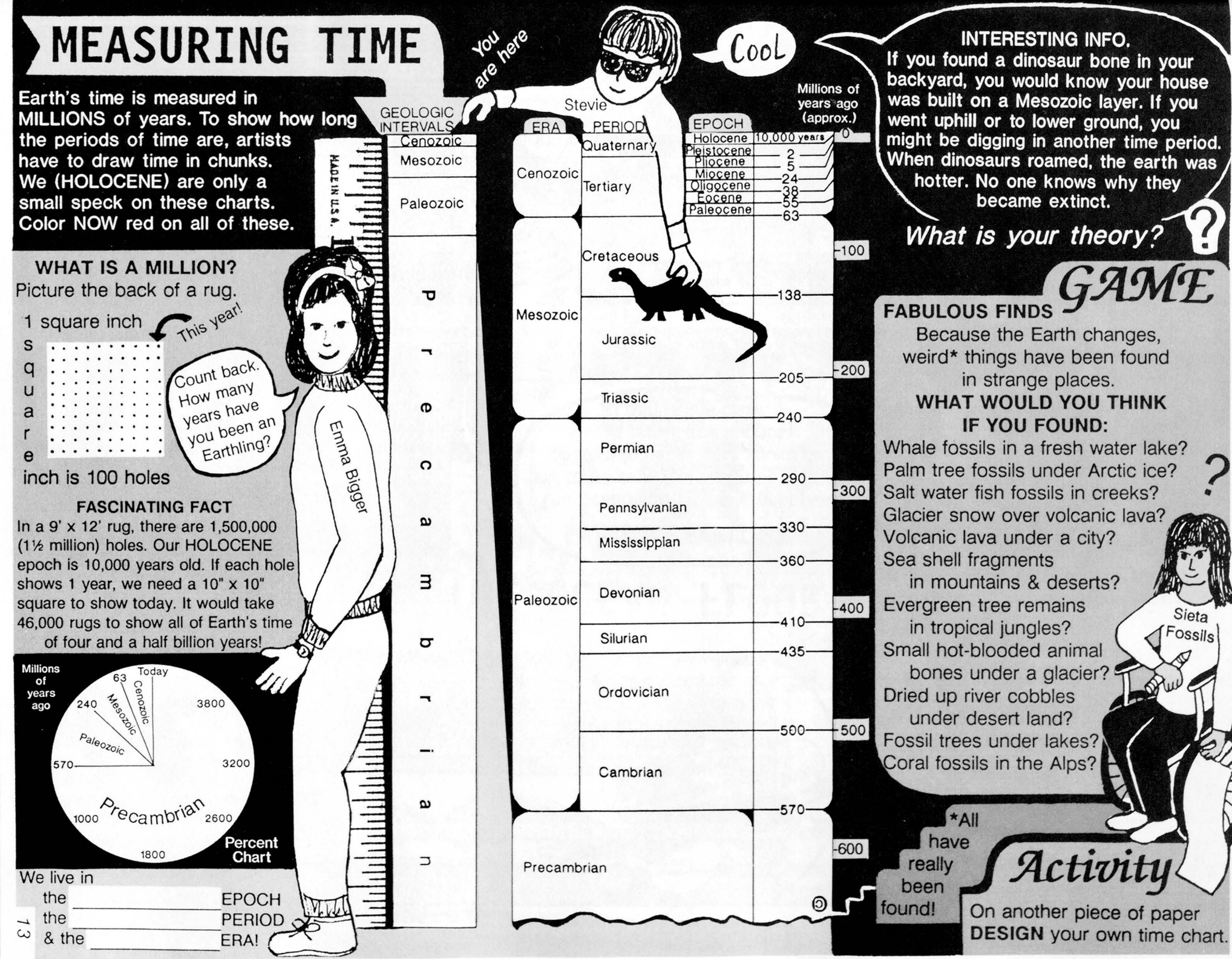




(See fossils, pg.34)

MEASURING TIME

Earth's time is measured in MILLIONS of years. To show how long the periods of time are, artists have to draw time in chunks. We (HOLOCENE) are only a small speck on these charts. Color NOW red on all of these.



WHAT IS A MILLION?

Picture the back of a rug.

1 square inch

This year!

s q u a r e

inch is 100 holes

FASCINATING FACT

In a 9' x 12' rug, there are 1,500,000 (1½ million) holes. Our HOLOCENE epoch is 10,000 years old. If each hole shows 1 year, we need a 10" x 10" square to show today. It would take 46,000 rugs to show all of Earth's time of four and a half billion years!

We live in
the _____ EPOCH
the _____ PERIOD
& the _____ ERA!

INTERESTING INFO.

If you found a dinosaur bone in your backyard, you would know your house was built on a Mesozoic layer. If you went uphill or to lower ground, you might be digging in another time period. When dinosaurs roamed, the earth was hotter. No one knows why they became extinct.

What is your theory?

GAME

FABULOUS FINDS

Because the Earth changes, weird* things have been found in strange places.

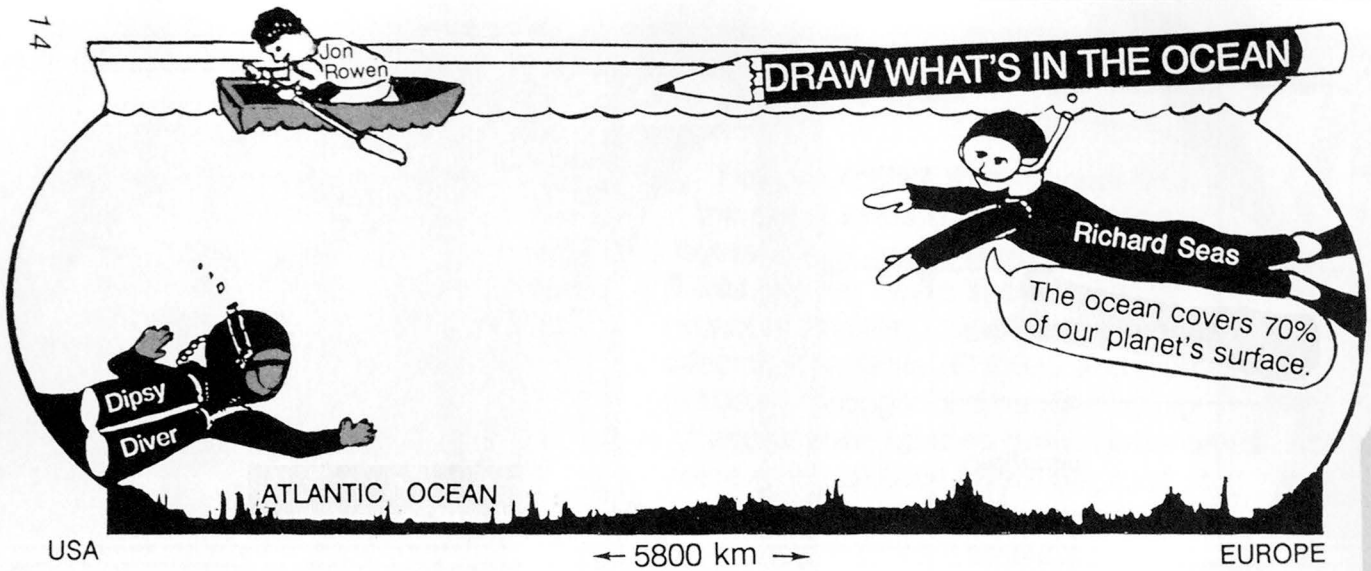
WHAT WOULD YOU THINK IF YOU FOUND:

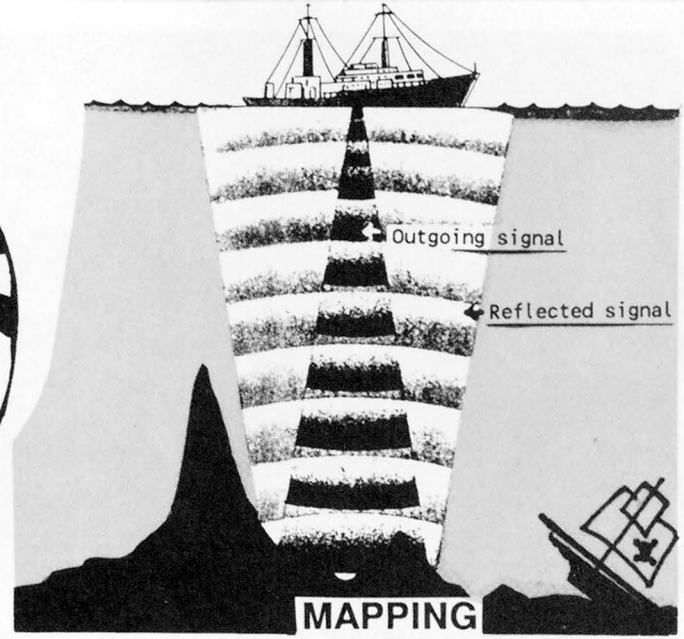
Whale fossils in a fresh water lake?
Palm tree fossils under Arctic ice?
Salt water fish fossils in creeks?
Glacier snow over volcanic lava?
Volcanic lava under a city?
Sea shell fragments in mountains & deserts?
Evergreen tree remains in tropical jungles?
Small hot-blooded animal bones under a glacier?
Dried up river cobbles under desert land?
Fossil trees under lakes?
Coral fossils in the Alps?

*All have really been found!

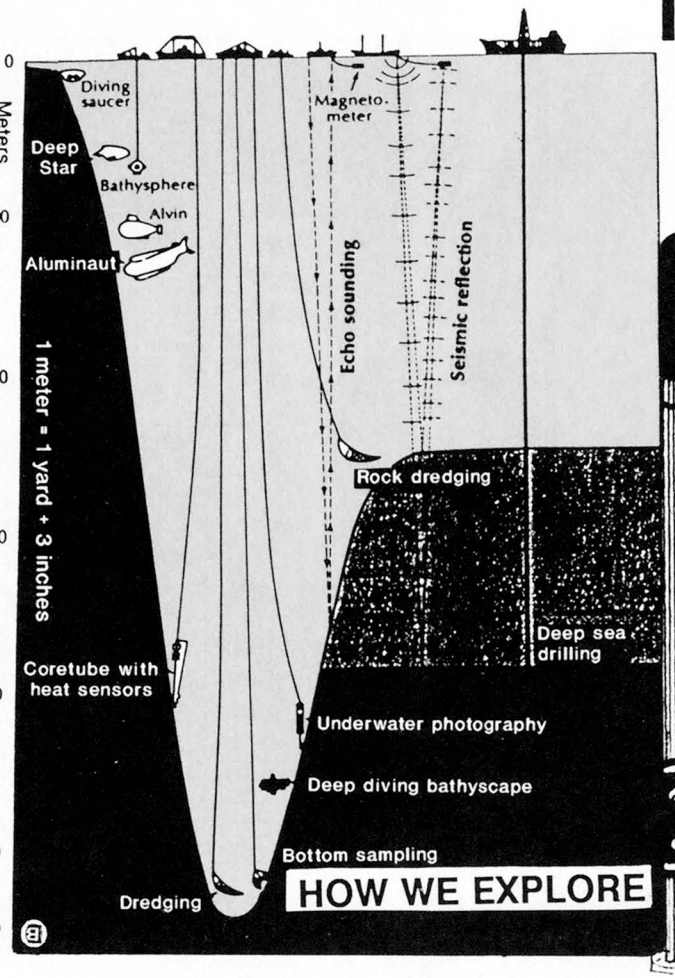
Activity

On another piece of paper **DESIGN** your own time chart.



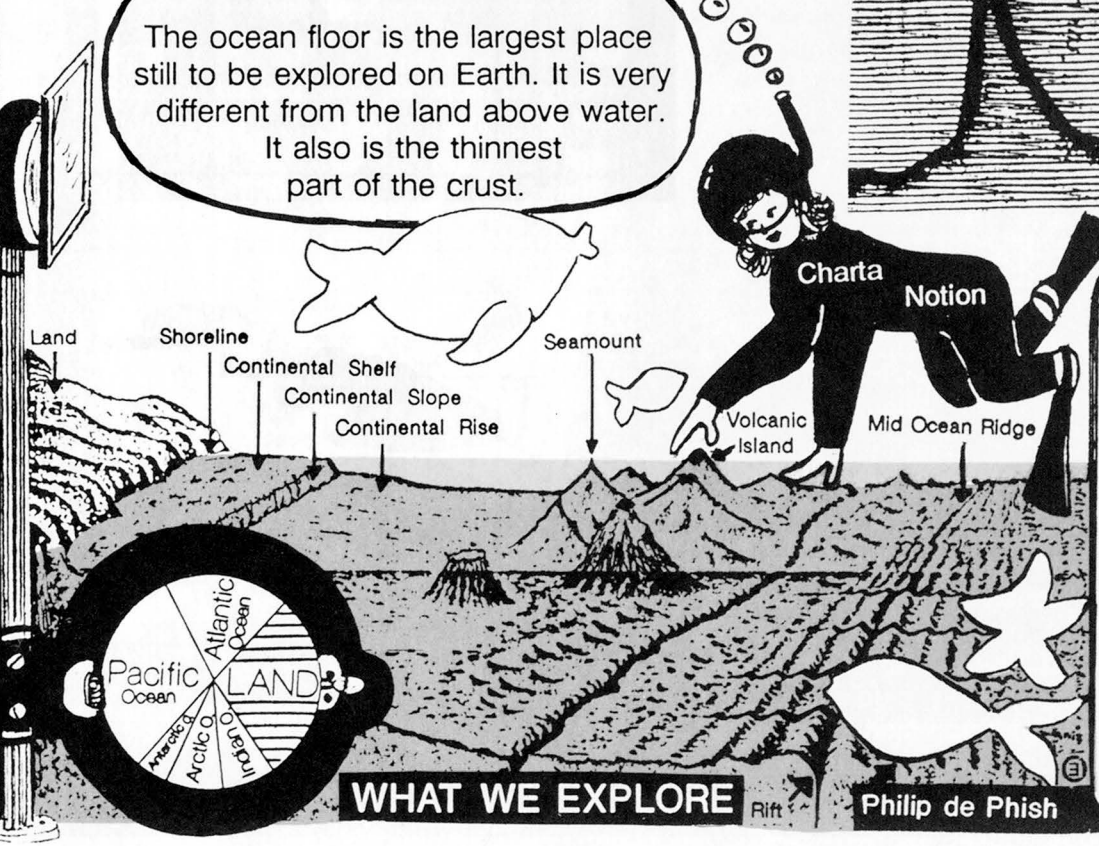


THE OCEAN FLOOR



WHY WE EXPLORE

The ocean floor is the largest place still to be explored on Earth. It is very different from the land above water. It also is the thinnest part of the crust.



SONAR: Scientists record the time it takes sound waves to get to the bottom and bounce back. They figure the depth by taking half the time and knowing the speed of sound in water.

Philip de Phish

GROUND WATER GAME

The darker places on this map show where there's lots of ground water. The left column shows the millions of gallons used each day!!! TO PLAY: Use an animal marker for each player; throw 1 of 2 dice; travel to bordering states; collect ground water for 10 turns each & add up the score! *Remember, these numbers are in **MILLIONS OF GALLONS** each day, so add **6 zeros** after your final score: ____,000,000.

DAILY USE * (in millions of gallons)	
Alabama	290
Alaska	49
Arizona	4,200
Arkansas	4,300
California	14,600
Colorado	2,800
Connecticut	150
Delaware	82
D.C.	1
Florida	3,800
Georgia	1,200
Hawaii	710
Idaho	6,300
Illinois	980
Indiana	1,100
Iowa	900
Kansas	5,600
Kentucky	180
Louisiana	1,800
Maine	80
Maryland	174
Massachusetts	320
Michigan	530
Minnesota	670
Mississippi	1,500
Missouri	470
Montana	200
Nebraska	7,100
Nevada	710
New Hampshire	65
New Jersey	730
New Mexico	1,800
New York	970
North Carolina	770
North Dakota	110
Ohio	740
Oklahoma	960
Oregon	1,100
Pennsylvania	1,000
Rhode Island	37
South Carolina	210
South Dakota	330
Tennessee	460
Texas	9,700
Utah	770
Vermont	45
Virginia	370
Washington	750
West Virginia	220
Wisconsin	580
Wyoming	+ 540
	,000,000

Marcy Snow

Greta Lakes

Starta Anywhere

Nancy Brooks

Donna Goback

Margo Filpots

Carrie

Seymore Creeks

WATER TABLE:
After a heavy rain, water soaks into land filling the empty spaces in the ground. It makes streams & ponds, and seeps into the soil. It runs off, emptying into rivers. We use billions of gallons of both surface water and ground water (see amount on left) every day! It is important that we don't pollute places where clean water is naturally stored!

WATER CONSERVATION
We need to find ways to save water.
IDEAS
1) Collect rain water for plants.
2) Don't run water when brushing teeth.
3) Place a water-filled 1 liter pop bottle in toilet tank to use less water per flush.

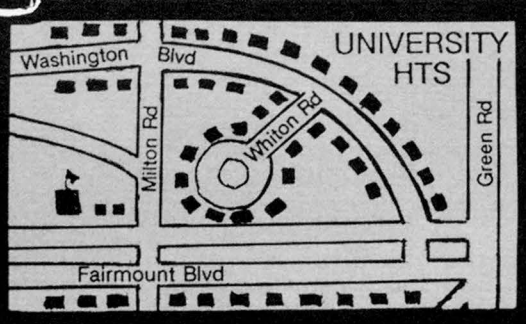
We also use millions of gallons of
SURFACE WATER
Lake
Water Table
Stream
Spring
Swamp
GROUND WATER
Creek
Clean water

MAKING MAPS

DRAW YOUR ROOM

YOUR HOUSE

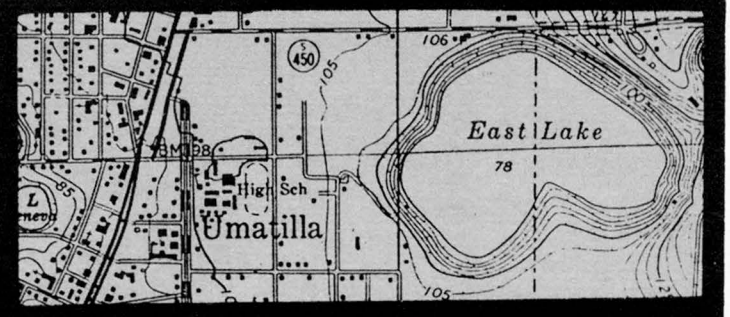
YOUR STREET



STREET MAP

LEGEND

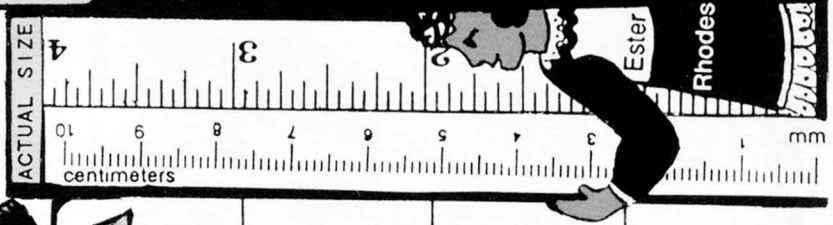
- house
- apartment
- school
- house of worship
- lake
- RR tracks
- road
- highway



CITY MAP

HOW TO MAP

Before airplanes & photography, people had to measure the land by foot. To make a picture of what they saw, they drew LANDMARKS and counted the footsteps between each place. Once they knew how far it was, they made CHARTS. These were just words or lines showing the DIRECTIONS. To make a map, decide how much land you will measure and how much space you will need to show it (SCALE). GRID LINES help to place landmarks.



Activity

DRAW YOUR CITY

HOW TO START: Decide which landmarks you will use. Locate your house, your school, & a main street. To make a LEGEND, make a column with a symbol for each place. Are there railroad tracks, an airport, a park? How will you show hills? Holes? Flat places? Colors can be used to show the changing height of the ground (ELEVATION).

BE A BIRD: Draw Aerial View

LEGEND

SCALE

METRIC

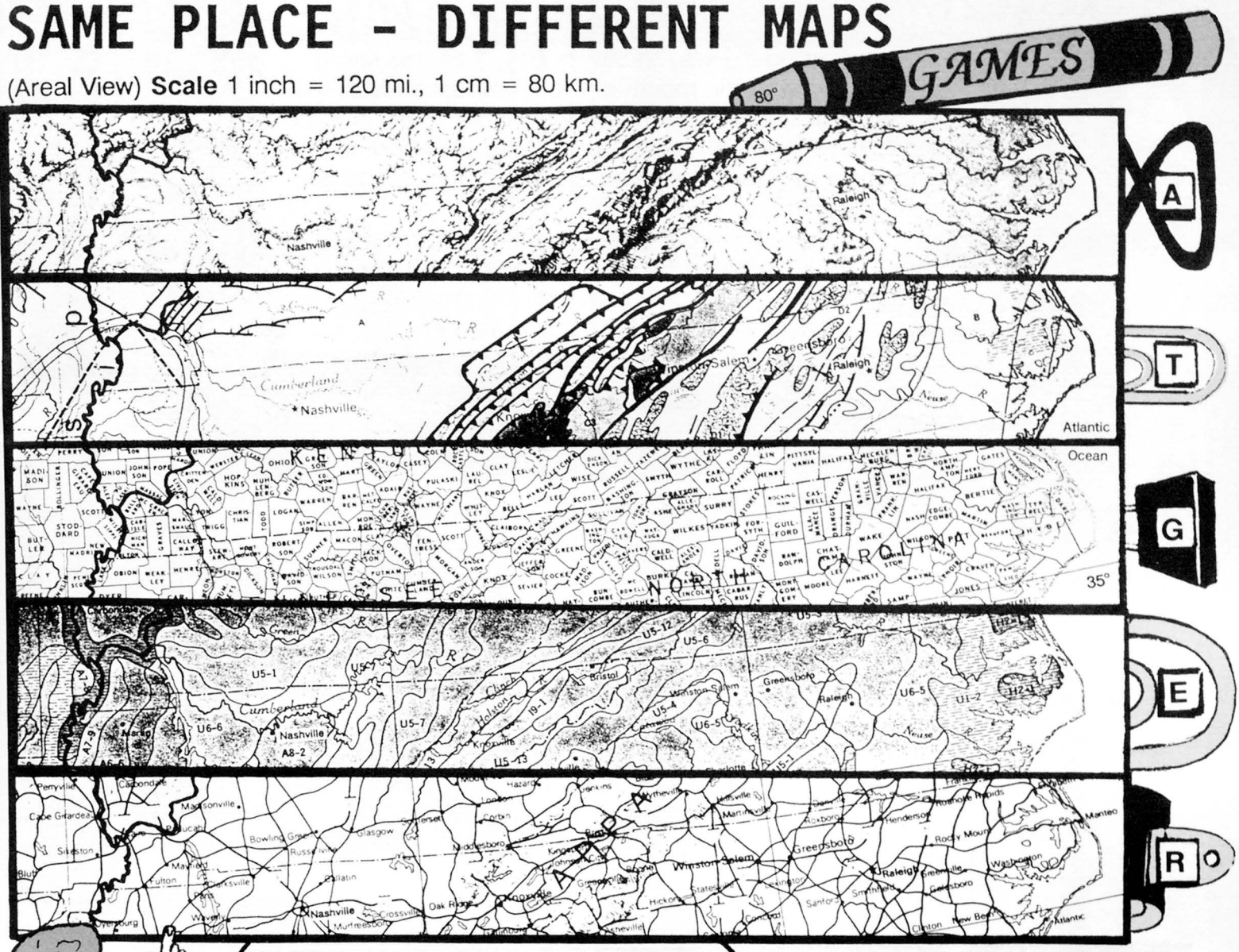
1 cm = ___ ? km

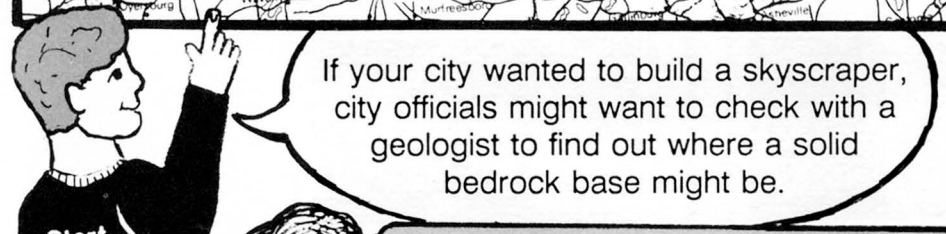
ENGLISH

1 inch = ___ ? mi

SAME PLACE - DIFFERENT MAPS

(Areal View) **Scale** 1 inch = 120 mi., 1 cm = 80 km.





If your city wanted to build a skyscraper, city officials might want to check with a geologist to find out where a solid bedrock base might be.

Scientists make different SURVEYS to get these kinds of information. Above are different maps of the same place from ground surveys.

Activity

On the right, color the row of islands on the _____ Ocean.
On the left, color the _____ River.
Color the _____ Mountains down the center.
Can you name the states on the maps?

Check maps on pgs. 15 & 21.

GAME

KISS YOUR BRAINS

TO PLAY: Match the following with the maps above

Which is Which ?

- ☐ This map shows the COUNTIES in each state.
- ☐ This map shows roads. It is a HIGHWAY map.
- ☐ This map shows gravel and swamps. It is a SOILS map.
- ☐ This map shows mountains and valleys. It is a RELIEF map.
- ☐ This map shows faults & where to look for oil. It is a GEOLOGIC map.

Job: Cartographer - a person who makes maps.

Could you draw a map of your State? What would you use for symbols to show different things? Do you know what natural resources are in your State? Find out and show these on your map!

the TREASURE HUNT GAME

One starless night on the way to Silvery Bay, 7 pirates sailed the 7 seas **SE** towards the mouth of the Shawnasee River. They slipped their ship behind the swamp. While their 7 sweethearts slept in the city, they swam along the shore to the suspension bridge. From there, they sneaked 17 paces **W** and spied the balancing rock due **S**.

They stepped 7 paces to this spectacular site and switched **SE** for 7 more paces to bury their booty. Were they smart, stupid, or sneaky sailors for selecting this site? Why?

Legend of

- TREE
- CITY — 21 to 23/210 to 280 — latitude longitude
- BRIDGE — 15/300 to 330
- HILLS
- MOUNTAIN
- BALANCING ROCK
- BOULDERS — 24 to 25/200 to 230
- LAKE — 23 to 33/260 to 350
- SWAMP — 6 to 7/40 to 130
- RIVER

COMPASS

N, E, S, & W are CARDINALS

INTERMEDIATES

NE Emerald City

W E

S

W Gorge Canyon

SW Silvery Bay

Longitude

Latitude*

Hints:

Fill in known facts from legend on map FIRST. Remember they suspected their ship would be searched when sailing into the city!

LOOKING DOWN - GRID MAP

paces 100 200

10

20 paces

30

The Earth has an iron core. It acts like a giant magnet. A compass needle will point to the North Pole.

Goldfield E

TREASURE

The TREASURE is buried at:

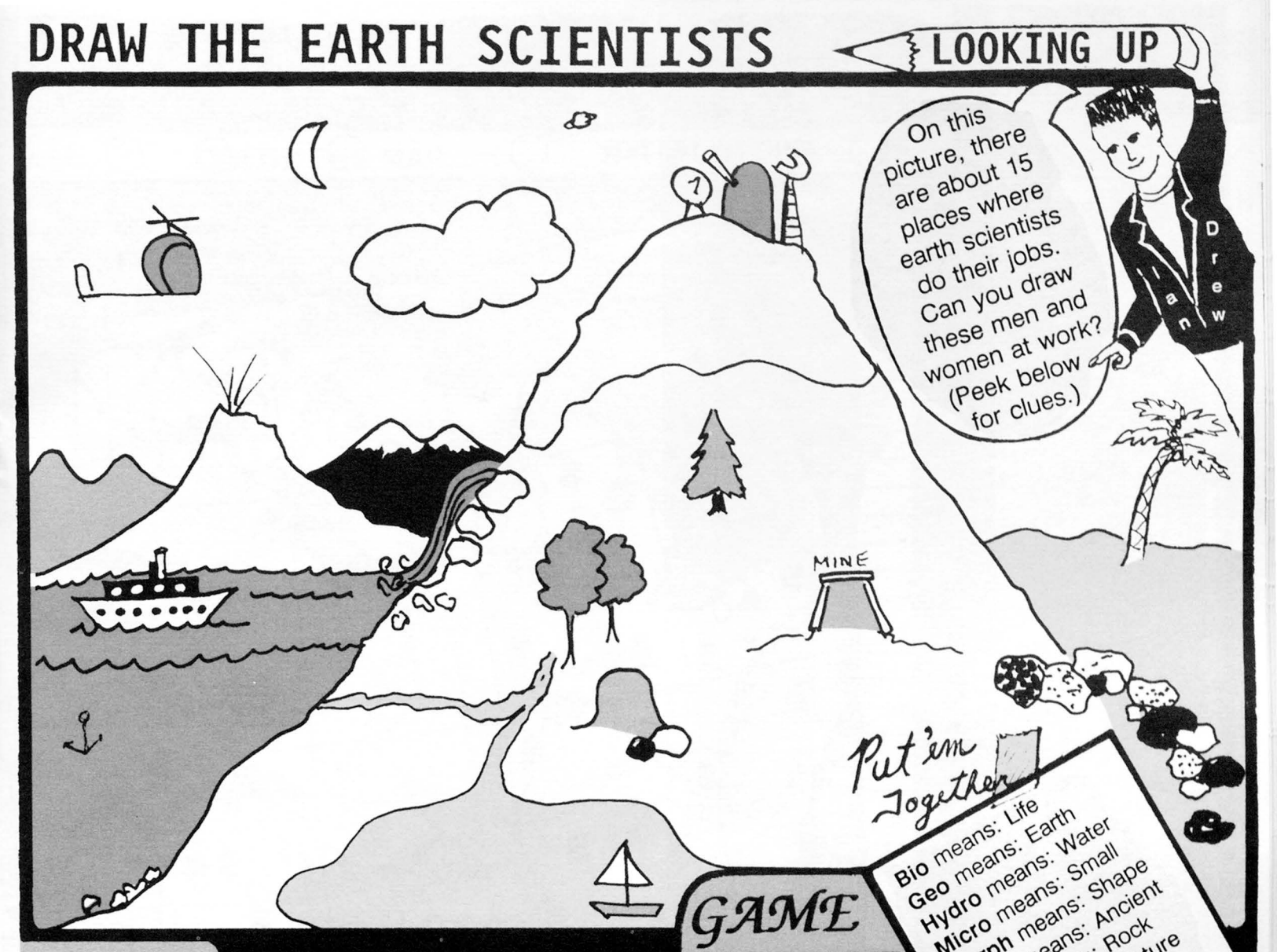
____ / ____

latitude longitude

SOLVE THE MYSTERY

DRAW THE EARTH SCIENTISTS

LOOKING UP

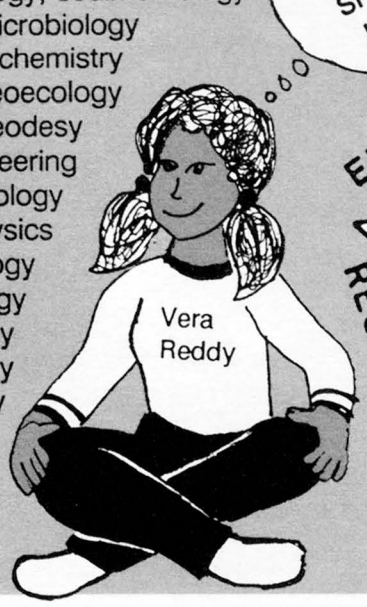


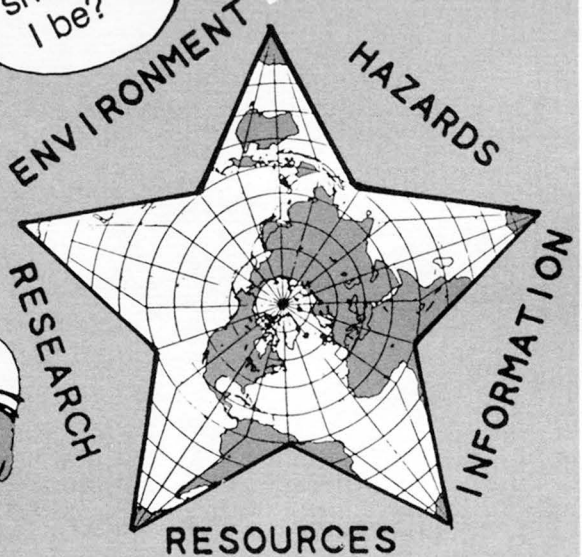
GAME

Bio means: Life
Geo means: Earth
Hydro means: Water
Micro means: Small
Morph means: Shape
Paleo means: Ancient
Petro means: Rock
Physi means: Nature
-ology means: Study
-ologist means: Person who studies

EARTH SCIENCE NAMES

JOB$ WITH:	
ROCKS	mapping, bedrock geology, stratigraphy, petrology
CHEMISTRY	geochemistry, organic chemistry, isotope geology
SOILS	engineering geology, soil mechanics, soil science
LAND	surficial geology, geomorphology, sedimentology
LIVING THINGS	biogeology, geobotany, geomicrobiology
FRESH WATER	hydrology, hydrogeology, geochemistry
FOSSILS	paleontology, palynology, paleoecology
DEEP EARTH	geophysics, geomagnetics, geodesy
EARTHQUAKES	seismology, earthquake engineering
METALS	economic geology, mining geology
MOUNTAINS	structural geology, tectonophysics
FUELS	petroleum geology, coal geology
PLANETS	astrogeology, planetary geology
VOLCANOES	volcanology, igneous petrology
THE OCEAN	marine geology, oceanography
SATELLITES	remote sensing, photogeology
MINERALS	mineralogy, crystallography
MONEY	mineral economics
BOOKS	geological editing
CHILDREN	science teacher
GLACIERS	glaciology





WATERFORMS GAME →

EXPLORERS GAME →

FIND MY LETTER

COLOR THE MAP

Park/Place	lat°N/long°W	STATE
Mauna Loa Volcano	19°/155°	
Mt. McKinley	62°/150°	
Arctic National Wildlife Refuge	70°/142°	
Tongass Forest	58°/132°	
Mt. Rainier	48°/122°	
Mt. St. Helens	46°/122°	
Crater Lake	43°/122°	
Lassen Volcano	41°/121°	
Yosemite Park	38°/120°	
Sequoia Forest	36°/119°	
Glacier Park	49°/114°	
Zion Park	37°/113°	
Bryce Canyon	38°/112°	
Grand Canyon	36°/112°	
Yellowstone Park	45°/111°	
Grand Teton Park	44°/111°	
Dinosaur Park	40°/109°	
Mesa Verde Park	37°/108°	
Rocky Mts. Park	40°/106°	
White Sands Mon.	33°/106°	
Black Hills	44°/104°	
Wind Cave	43°/104°	
Carlsbad Caverns	32°/104°	
Hot Springs	35°/94°	
Mammoth Cave	37°/86°	
Great Smoky Mts.	36°/84°	
Crystal Cave	42°/83°	
Indian Mounds	39°/82°	
Everglades Swamp	25°/81°	
Luray Caverns	39°/79°	
Shenandoah Forest	39°/79°	
Penn Cave	41°/78°	
Plymouth Rock	42°/71°	

125° 120° 115° 110° 105° 100° 95° 90° 85° 80° 75° 70°

45° 40° 35° 30°

North

LATITUDE

LONGITUDE

Pacific Time

Mountain Time

Central Time

Eastern Time

The Great Lakes hold 20% of our nation's fresh water supply!

ACTIVITY
Copy the map, then cut it out. Make your own U.S. puzzle!

Malaika

Clymen

Roni Stream

Ida Know

Me First

Kenya Find

Pete Moss

Gary Splore d'Hills

Dante Dwyane Everglades

Pérri Scope

Anita Mapp

RANGES

CASCADE RANGE

SIERRA NEVADA

COAST

ROCKY MOUNTAINS

APPALACHIAN MTS

Columbia R.

Snake R.

Yukon R.

Missouri R.

Mississippi R.

Ohio R.

Tennessee R.

Arkansas R.

Mississippi R.

Superior

Michigan

Huron

Erie

Ontario

ALASKA

HAWAII

Date Line

180°

170°E

170°W

50°

60°

140°

130°

160°

155°

25°

20°

Actual distance

MY LEGEND

my City

my State

Nearest to me:

Lake

Ocean

Mountains

Dinosaur

WHERE'S THE NEAREST?

- rocks with dinosaurs
- dinosaur fossils ⓓ
- $ gold flakes in creeks
- oil field
- volcano

The two authors live in two different parts of the country. One lives at 42° N/82° W, & the other at 38° N/77° W. Can you find where they live using the LATITUDE (side to side) & LONGITUDE (up & down) numbers on this map?
Where are you? ____°/____°

Read Latitude, then Longitude

0 100 mi
0 km 200
SCALE

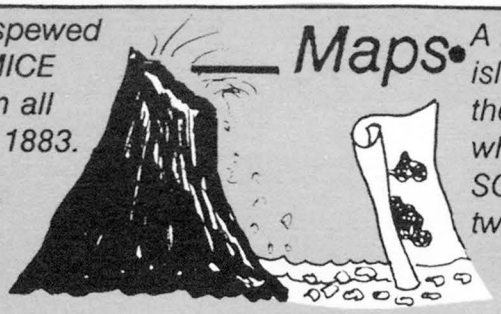
Alabama	AL
Alaska	AK
Arizona	AZ
Arkansas	AR
California	CA
Colorado	CO
Connecticut	CT
Delaware	DE
D.C.	DC
Florida	FL
Georgia	GA
Hawaii	HI
Idaho	ID
Illinois	IL
Indiana	IN
Iowa	IA
Kansas	KS
Kentucky	KY
Louisiana	LA
Maine	ME
Maryland	MD
Massachusetts	MA
Michigan	MI
Minnesota	MN
Mississippi	MS
Missouri	MO
Montana	MT
Nebraska	NE
Nevada	NV
New Hampshire	NH
New Jersey	NJ
New Mexico	NM
New York	NY
North Carolina	NC
North Dakota	ND
Ohio	OH
Oklahoma	OK
Oregon	OR
Pennsylvania	PA
Rhode Island	RI
South Carolina	SC
South Dakota	SD
Tennessee	TN
Texas	TX
Utah	UT
Vermont	VT
Virginia	VA
Washington	WA
West Virginia	WV
Wisconsin	WI
Wyoming	WY

FASCINATING FINDS

Volcanoes

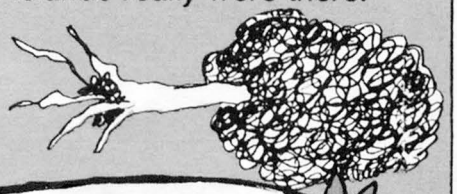
The volcano Krakatoa spewed out so many floating PUMICE rocks that ships saw them all over the Indian Ocean in 1883.

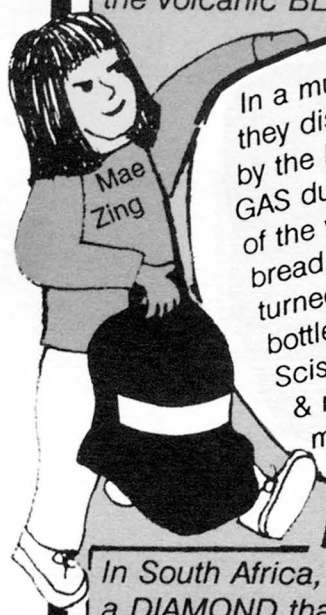
A volcano in Yellowstone Park erupted and buried a whole forest in Wyoming. When it was exposed by weathering, the PETRIFIED TREES were found standing in place. At Mt. Saint Helens, trees fell like toothpicks away from the volcanic BLAST.



Maps

A map from 1513 shows two islands in Antarctica where there is now ice. In 1957, people who study the deep Earth used SOUND WAVES and showed that two islands really were there.





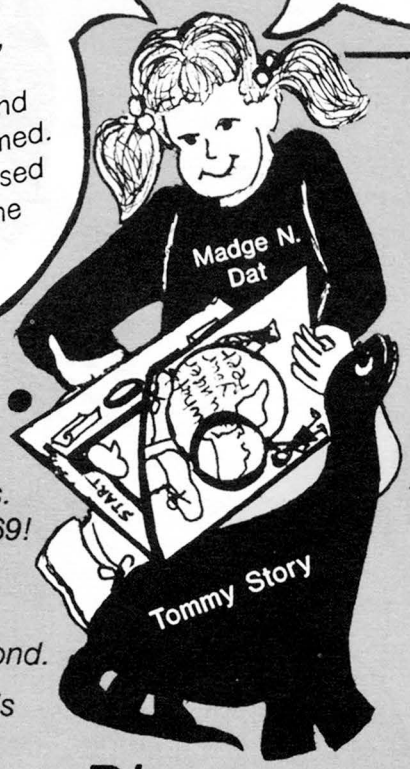
In a museum in Martinique, they display things changed by the heat of VOLCANIC GAS during the 1902 eruption of the volcano Pelee. Thread, bread, and coffee beans turned into carbon. A bell and bottles were actually deformed. Scissors and nails were fused & nothing happened to the marble statues. Why?
(Peek on pg. 8)

Diamonds

In South Africa, a boy discovered a DIAMOND that weighed 83 carats. This led to the diamond rush of 1869!

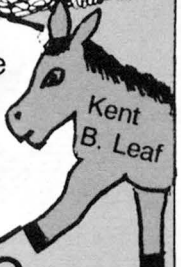
While playing golf in West Virginia, a boy & his dad found the 34-carat Punch Jones diamond.

One would think that diamonds are so hard that they cannot be destroyed. But they are so brittle that they can be smashed.



Dinosaurs

Even poop gets turned into rock. Scientists study fossilized FECAL PELLETS to discover what dinosaurs & other animals ate. Microscopic pellets even form oil (PETROLEUM).



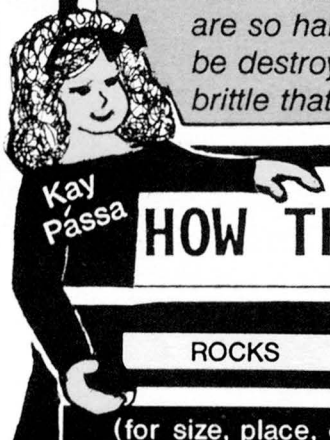
Two children in Maine discovered TOURMALINE in the roots of a tree that had fallen during a storm. Watermelon-color slices of this gem are used in jewelry.

Gems

In Columbia, a Spanish horseman saw that his horse was limping. When he stopped to look at its hoof, he found an EMERALD - the first discovered in this South American country.

When 12, Mary Anning found the first reptile SKELETON in England & started her own fossil business.

At a dinosaur birthday party dig in Maryland in 1989, a child found a real dinosaur bone!



HOW THINGS GET THEIR NAMES

Why not call me Todd or Brian, Ayana or Melanie?

ROCKS	MINERALS	DINOSAURS
(for size, place, or property)	(for people, places, or composition)	(Latin words for characteristics)
GRANITE = grain (Latin)	ADAMITE = Mr. Adam	TRICERATOPS = three-horned face
SANDSTONE = sand (Ger.)	CHILDRENITE = Mr. Children	SAURUS = reptile REX = king
SCHIST = split (Greek)	ZUNYITE = Zuni Mine, Colo.	BRONTO=thunder
LIMESTONE = smear (Lat.)	GALENA = lead (Latin)	STEGO=roof

WHERE SHALL WE START?

TO PLAY: Copy each section at right on a different colored paper; cut each word apart & fold it. Place in 4 piles & pick one from each. Draw your colorful adventure.

GAME PIECES

Choose a place (A),
Pick up a vehicle (B),
Pack your bag (C),
Lug your gear (D).

Chuck D.

Cargo

Ruby

Vaii

Uri

Turn

Colleen

Dover

Ethan

Digget

Katie

Did

Trip d'Jour

DRAW YOUR STUFF!

What kind of scientist are you (pg. 19)?

What are you looking for?

What are you taking along?

LOCATION

A

	pg.
Space	38
Volcano	8
Mountain	6
Fault	5
Observatory	19
Quarry	33
Ocean Floor	14
River	10
Glacier	9
Desert	24
City	39

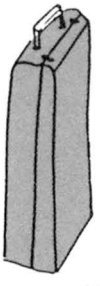
TRANSPORTATION

B

- Camel
- Motorcycle
- Land Rover
- Dingy Row Boat
- Car
- Helicopter
- Bicycle
- Spaceship
- Motor Boat
- Airplane
- Ocean Liner
- Elephant

CLOTHING

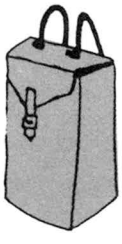
C



- Raincoat
- Hiking Boots
- Gloves
- Flippers
- Warm Parka
- Spacesuit
- Bathing Suit
- Wading Boots
- Jeans
- Hard Hat
- Heavy Coat

EQUIPMENT

D



- Oxygen Mask
- Scuba Gear
- Pick Axe
- Magnifying Glass
- Notebook
- Labels
- Computer
- Geiger Counter
- Sample Bags
- Oars
- Anti-perspirant*
- Shovel

TIME PERIODS (where first found)	EPOCHS & ERAS (Latin/Greek words)
JURASSIC = Jura Mts. (Switz.)	ZOIC = life
PENNSYLVANIAN = the State	CENE = new
ORDOVICIAN = a tribe (Eng.)	PALEO/MESO/CENO = ancient/middle/recent
MISSISSIPPIAN = Miss. River	
PERMIAN = Perm Mts. (Rus.)	

*AMAZING ANTIDOTE

Geologists are often in poison ivy. They protect themselves at the start of the day by rubbing their exposed skin with anti-perspirant having aluminum. At night, they take their clothes off inside out and shower. Campers, remember this!

THE OUTSIDE STORY

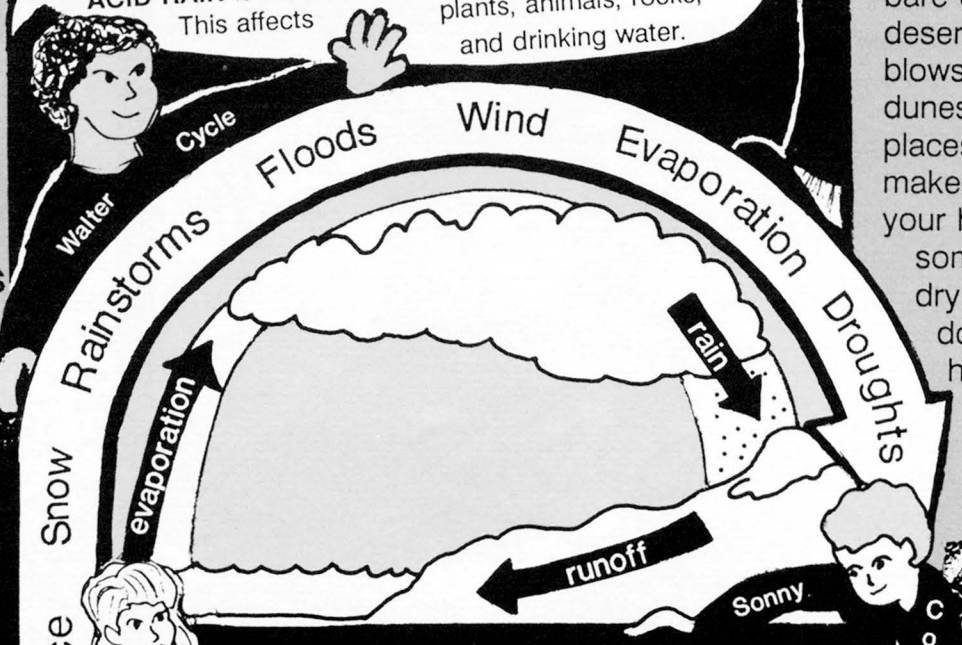
Earth's SYSTEMS work together & CYCLES repeat themselves. We study the past to look to the future, forming ideas (THEORIES) as to what might happen.

GREENHOUSE EFFECT: Our atmosphere is a mixture of gases which blankets the Earth & keeps us from freezing. Burning wood, coal, & oil adds extra gases (CO_2), making our climate even warmer. **GLOBAL WARMING** means the atmosphere will get hotter, melting glaciers and raising sea level. **GLOBAL COOLING** means the atmosphere may cool and glaciers will grow.

The **OZONE LAYER** protects us from harmful radiation from the sun. Pollutants & other gases make holes in this layer. **ACID RAIN** is formed when pollutants get into rain-water. This affects plants, animals, rocks, and drinking water.

Activity

Flood waters move rocks & soil when rivers overflow their banks. Make a pile of dirt, twigs, & rocks on a driveway & circle the mound with chalk. Watch how **WEATHER MOVES** these natural materials.



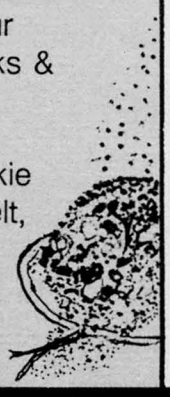
Activity

The **SUN BAKES** bare dirt. In the desert, the wind blows sand making dunes. In wetter places, dried up mud makes cracks. Make your hand print in some mud & let it dry outside. How long does it take to harden? Carve the year on it and bury it with wet mud to create a future fossil!

PHYSICAL WEATHERING

Activity

Water expands when frozen. Freezing and thawing move and crack rocks. (Are there potholes in your street?) When glaciers melt, falling rocks & snow cause landslides. To recreate **GLACIER ACTION**, place a variety of rocks, sand, and dirt clumps on a cookie tray with several ice cubes. As they melt, watch how the water moves the stuff. Even large materials can be moved by melting snow, which carries all sizes of pieces (SEDIMENTS) to other places.

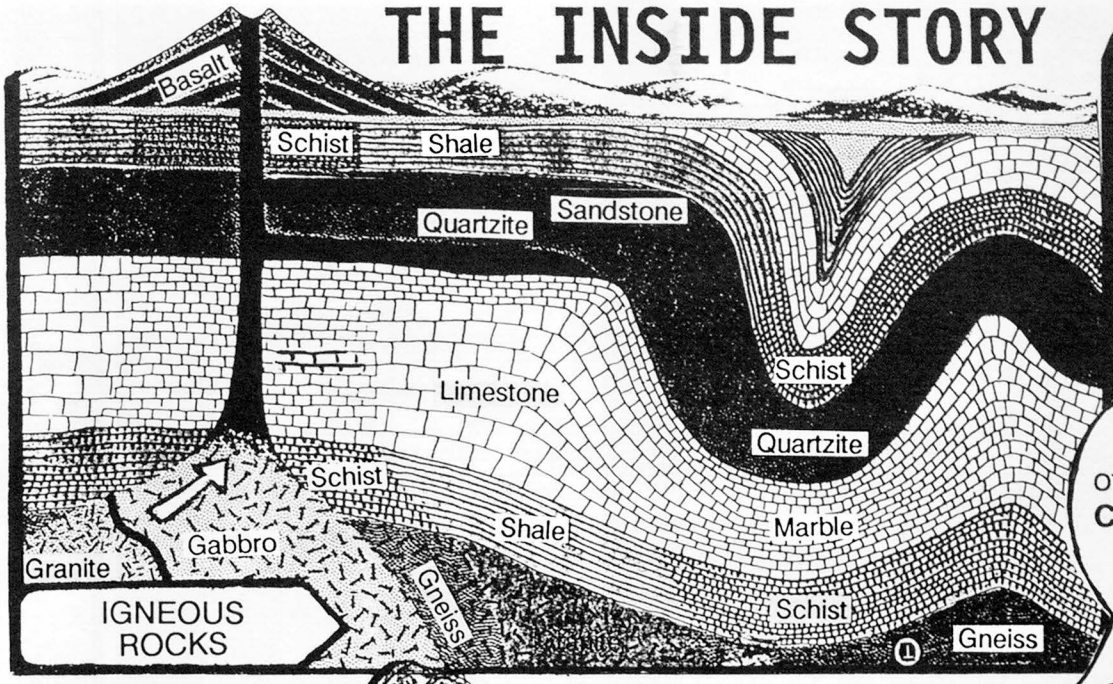


Activity

If you BAKE a round loaf of bread, you can see how the oven (our SUN) bakes the outside **CRUST** making it very hard, yet the inside remains soft and stays piping hot. If you place a glass bowl over the bread (EARTH'S **ATMOSPHERE**), you would see steam rising (CLOUDS), forming WATER VAPOR just inside the glass. As the air around it cools, rain falls & seeps in the cracks in the bread (EARTH & ROCKS). Heat works both outside & inside. It makes steam geysers, melts rocks, heats air, evaporates, and completes the **WATER CYCLE.**

Living RAIN FORESTS and WETLANDS produce much of Earth's OXYGEN & preserve SPECIES. When these places are cleared or burned, they affect our water cycle & our environment. To keep the system working, we need to CONSERVE nature.

THE INSIDE STORY



Activity

sand paper
cardboard
tissue paper
brown bags
bubble packing
sponge sheets

Some rock beds are harder & more solid, while others are softer. To see natural **COMPRESSION**, place different papers in a stack. Press the center. What happens at the edges? in the middle?

PRESSURE

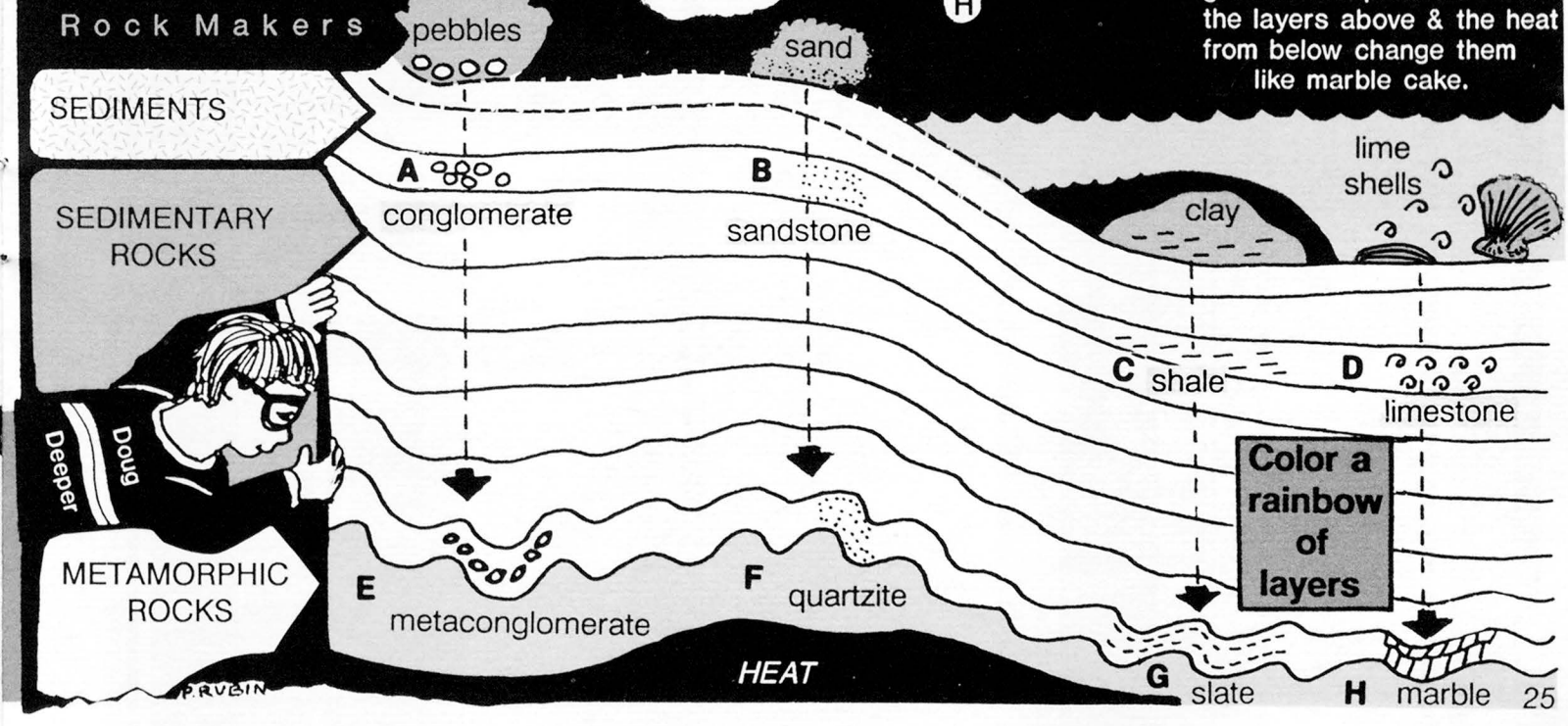
TIME

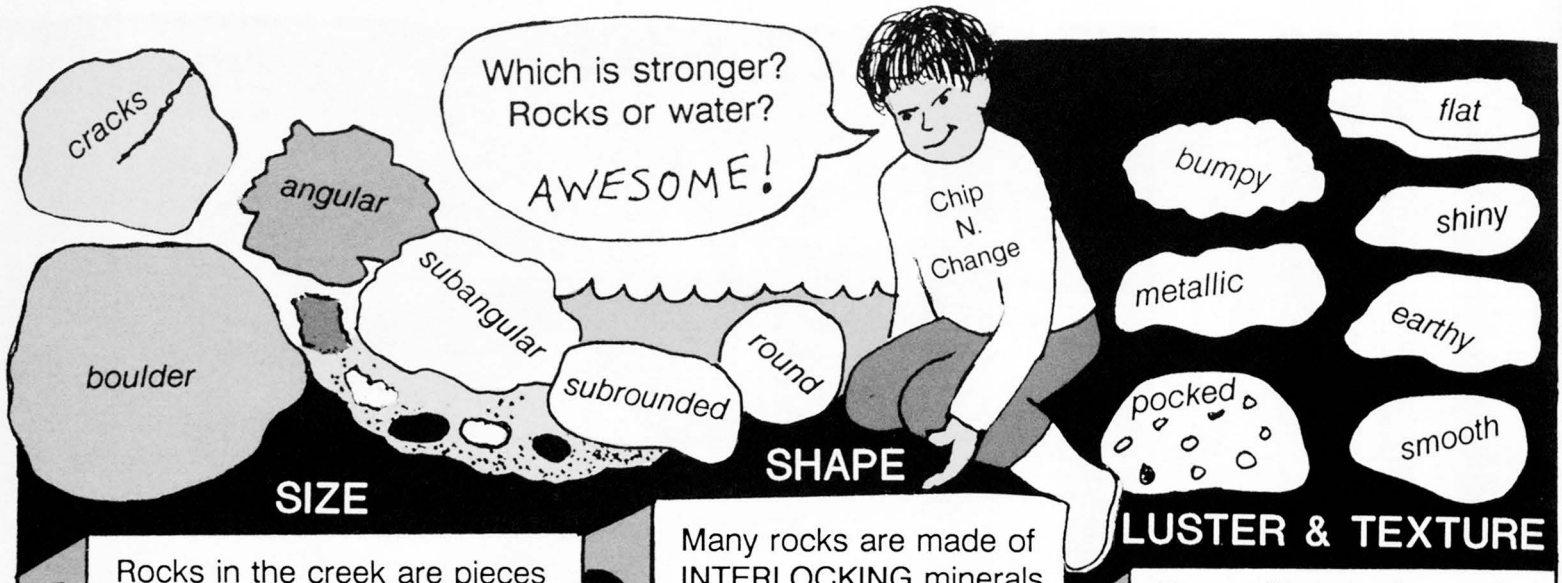
SEDIMENTARY ROCKS
are formed when loose dirt, mud, sand, rocks, or shells get buried; they harden & cement together like no-bake fudge.

IGNEOUS ROCKS
are formed as hot liquid magma cools & hardens like ice cubes from water.

METAMORPHIC ROCKS
come from sedimentary, igneous, or other rocks that get buried deep in the ground. The pressure from the layers above & the heat from below change them like marble cake.

Rock Makers





SIZE

Rocks in the creek are pieces of still larger rocks that fell or broke apart. When rocks fall apart, they make SOIL. When rocks are in water, they bang together, breaking into smaller & smaller chips, making the edges smooth and round.

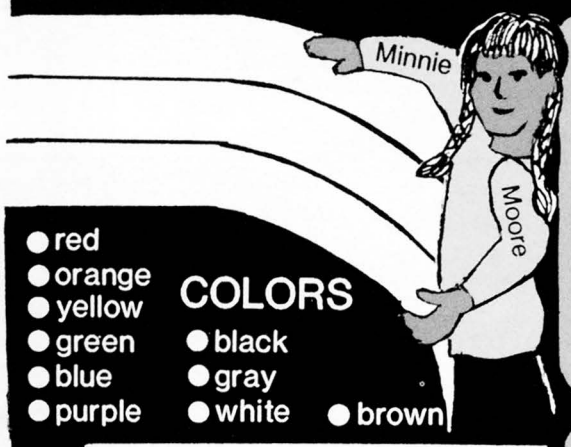
SHAPE

Many rocks are made of INTERLOCKING minerals. Some are harder/tighter. Some are softer/looser. Rocks crack into even, uneven, rough, & sharp pieces. Loosely BONDED rocks wear away faster, changing the size, shape, & texture of the chunks.

LUSTER & TEXTURE

Depending on what rocks are made of & how they formed, many things can change them. Sometimes weather affects them and at times, ores & minerals seep in with water. The outsides & insides are always changing as they get WEATHERED & worn.

CHEMICAL WEATHERING



- red
- orange
- yellow
- green
- blue
- purple

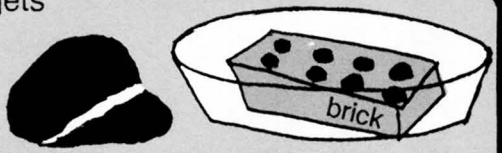
COLORS

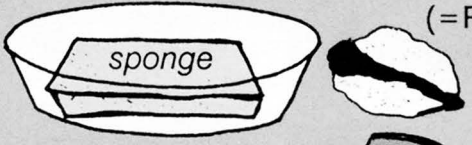
- black
- gray
- white
- brown

Minerals come in different colors. The more of one color mineral in a rock, the more color is added (peek at pg. 3, Earthtones). CHEMICALS SEEP through cracks and holes, leaving deposits and creating CRYSTALS or VEINS. When all of the same mineral or chemical stays after the water evaporates or leaves, new colored layers can appear in rocks.

Activity

To see how **WATER SEEPS** & gets ABSORBED in the Earth's crust, place a dry sponge in a bowl & pour colored water around it. Wait & watch how the level of water rises up the sponge.

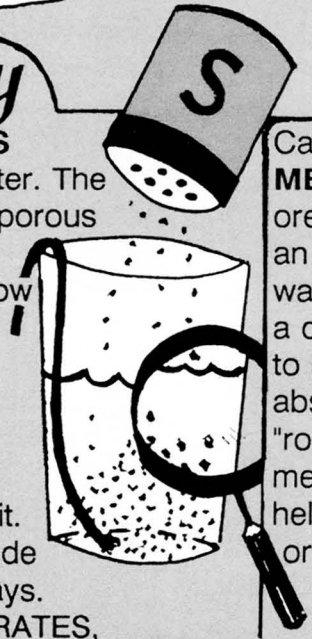




To test how **ROCKS HOLD WATER** (=POROUS) & minerals, use salt water & a dry brick. In a few days you'll see a CRYSTALLIZED layer (VEIN) through the brick.

Activity

Some **MINERALS DISSOLVE** in water. The water seeps into porous places and into cracks. To test how minerals form crystals, fill a glass ¼ full of salt. Add just enough warm water to cover it. Hang a string inside and wait a few days. As water EVAPORATES, crystals of salt grow.



Activity

Carried by water, **METALS GATHER** to form ore. To see this action, put an iron nail in a bowl with water. After rust forms, add a dry sponge. Wait a few days to see how the rust gets absorbed by your sponge "rock." Inside the Earth, the metals seep into cracks, helping to form veins of silver or copper. (See pg.30).

Which of these is reversible? ?

MINERALS Around Your House

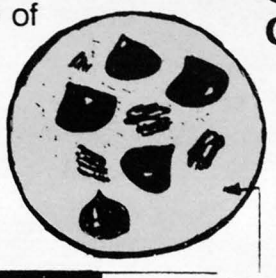
Like a cookie, a rock is made of different minerals.

GRANITE ROCKS

INGREDIENTS:
quartz, feldspar, mica, & hornblende.

BAKE at 800° under pressure for 1000 years

GRANITE



COOKIE

What happens when you fold a hot cookie? When it cools, can you unfold it? Think about how rocks & minerals soften when heated & get folded (just like mountain building!)

CHOCOLATE CHIP COOKIES:

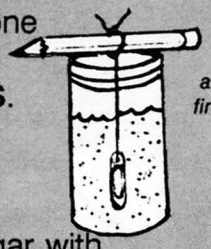
Do you have a rock roof?

INGREDIENTS:
½ C white sugar
½ C brown sugar
½ C butter (creamed)
½ tsp vanilla
1 egg (beat in)
1 C & 2 T flour
½ tsp each salt & baking soda
½ C each chips & walnuts
Drop spoonfuls onto greased pan

BAKE at 375° for 10 minutes

Activity ROCK CANDY

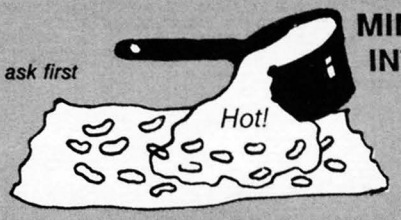
Rock candy shows how one mineral forms. Minerals can grow into **CRYSTALS**. When all the same ingredients cool, they harden.



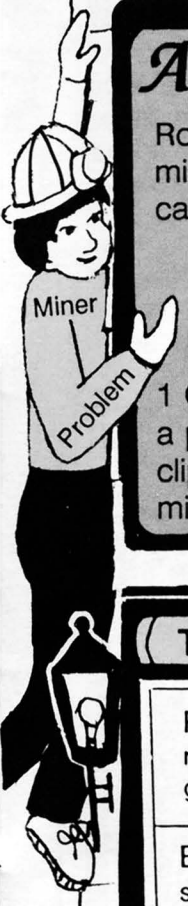
Dissolve 1 3/4 C of sugar with 1 C boiling water (HOT!). Wrap string on a pencil & weight the string with a paper clip at the bottom of a skinny jar. Pour in mixture. Cover with wrap & wait a week!

Activity PEANUT BRITTLE

shows how two **MINERALS GET INTERLOCKED.** When hot liquid begins to harden, it grabs other minerals.



Lay 1/2 C unsalted, shelled peanuts on wax paper. Heat 2 C sugar to light brown syrup color (stir constantly). Pour over peanuts. Let cool! What happens?



THE GEMSTONES

RED ruby garnet	YELLOW citrine	GREEN emerald tourmaline
BLUE sapphire turquoise	PURPLE amethyst	BLACK onyx

Streak Test

When rocks and minerals are WEATHERED, it's hard to tell what's in them. Softer minerals will leave a streak of color if you draw a line with them on the back of a mosaic tile. See if your rocks write!

light bulbs: tungsten
roofs & driveways: tar
beams & magnets: iron
dry wall & plaster: gypsum
pipes & wiring: lead & copper
window glass & mirrors: silica
bathtubs & sinks: clay minerals

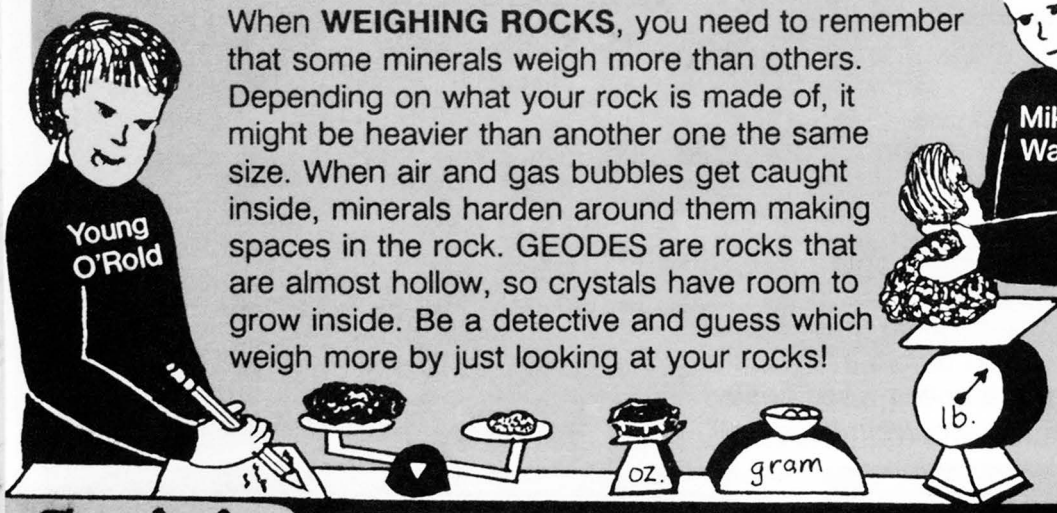
Get a piece of the planet!

OTHER STUFF MADE FROM MINERALS:
toothpaste - cleanser - potting soil - plant food
bicycles - teddy bears - clothes dryer - shovels
televisions - radios - refrigerators - cars - swings
eyeglasses - pencils - stove - pots & pans - carriages

Can you guess what these things are made of?

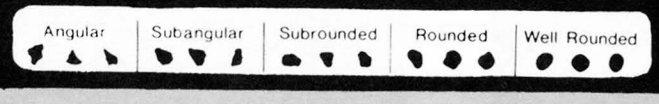
Activity TOOLS & TESTS Activity

When **WEIGHING ROCKS**, you need to remember that some minerals weigh more than others. Depending on what your rock is made of, it might be heavier than another one the same size. When air and gas bubbles get caught inside, minerals harden around them making spaces in the rock. GEODES are rocks that are almost hollow, so crystals have room to grow inside. Be a detective and guess which weigh more by just looking at your rocks!



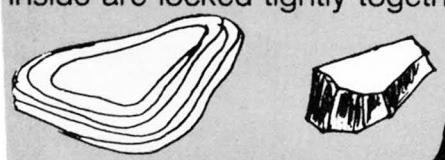
When **COLLECTING** rocks, take along markers, rulers, baggies, pad & pencil. In a notebook, write: DATE & PLACE, SHAPE, COLOR(S), SIZE, and TEXTURE. Make note of markings on rocks or ones that are shiny, metal-like or oily (LUSTER). Geologists don't always know what kinds they find! Look in books to identify your samples, or try the tests below.

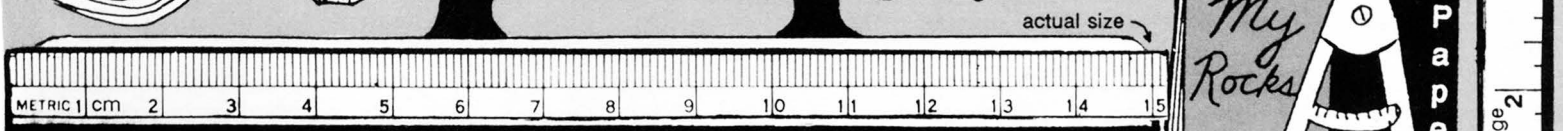
Activity



Another way geologists tell what kind of rocks they find is by looking at how they formed. Some rocks form in flat thin layers or break with sharp edges (CLEAVAGE). A **TEST YOU CAN DO** is to break your rocks (FRACTURE). Put a rock in a plastic baggie and hit it with a hammer. If it is hard to break, the minerals inside are locked tightly together.

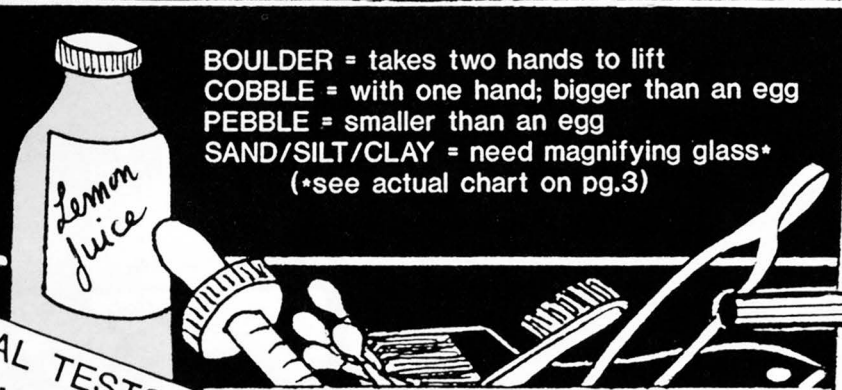
Guess before you crack them!





SIZE

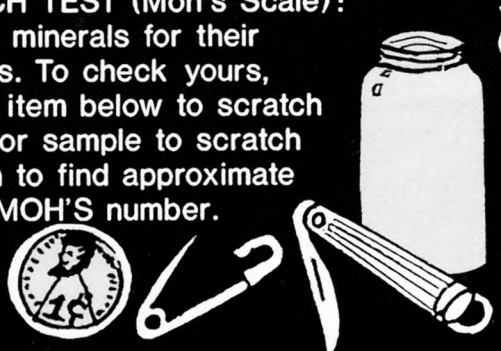
BOULDER = takes two hands to lift
COBBLE = with one hand; bigger than an egg
PEBBLE = smaller than an egg
SAND/SILT/CLAY = need magnifying glass*
(*see actual chart on pg.3)



MINERAL TESTS:

- Color
- Luster
- Crystals
- Streak (pg.27)
- Scratch
- Cleavage
- Fracture

SCRATCH TEST (Moh's Scale): We test minerals for their hardness. To check yours, use the item below to scratch sample or sample to scratch the item to find approximate MOH'S number.



SOFTEST
(use:) *fingernail =
*copper penny =
*safety pin =
*knife blade =

*will scratch glass jar

HARDEST

TALC =	1	
	2½	
	3	
	4	
	5½	
	6	
QUARTZ =	7	G
	8	E
	9	M
DIAMOND =	10	S

ROCK HOUNDS ROCK HOUNDS

Remember to label rocks out in the field where you collect them. At home, paint a spot with white correction fluid, let dry. Write number, when dry, cover with clear nail polish.

Activity

Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6

ROCK TESTS

SHAPE: round? angular? pointy? flattened?
MARKS: spots-holes? stripes?
POROUS: water drop seeps?
COMPOSITION: all same? mixture? has crystals? drop of lemon juice,* fizzes?
TEXTURE: rough? smooth? wavy? sandy?
TEMPERATURE: holds heat? feels cold?

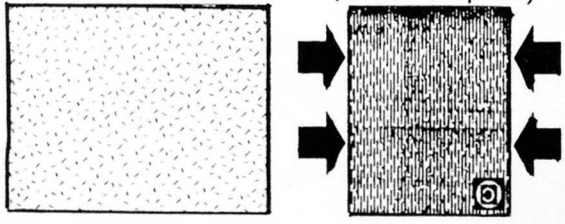
MINERAL TESTS

COLOR: color(s)? same inside/outside?
STREAK: (writes on tile back) yes/no? color?
SHINE (LUSTER): shiny? metallic/not? oily?
HARDNESS: scratched with what tool?
FRACTURE: curved? straight lines (cleavage)? breaks easily or not?

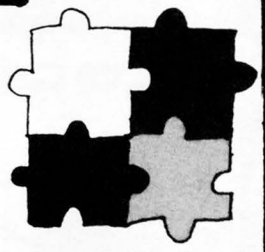
The history of rocks

Before (sedimentary)

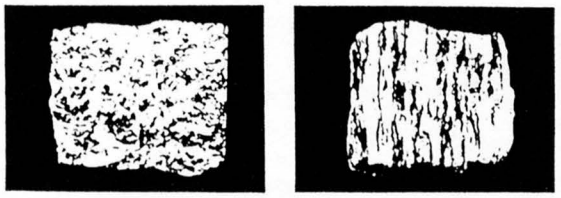
After (metamorphic)



Crystals interlock or line up.

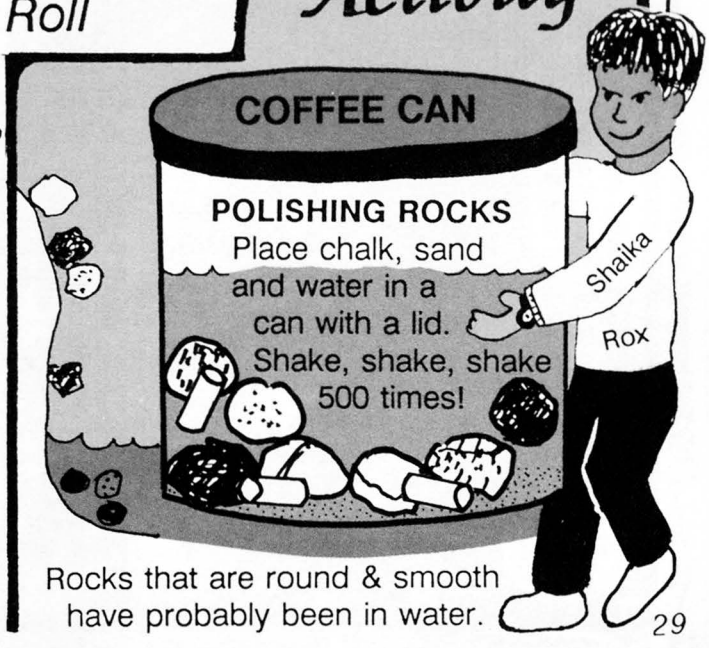


When squished, SPOTS become STRIPES!



Rock & Roll

Activity



Rocks that are round & smooth have probably been in water.

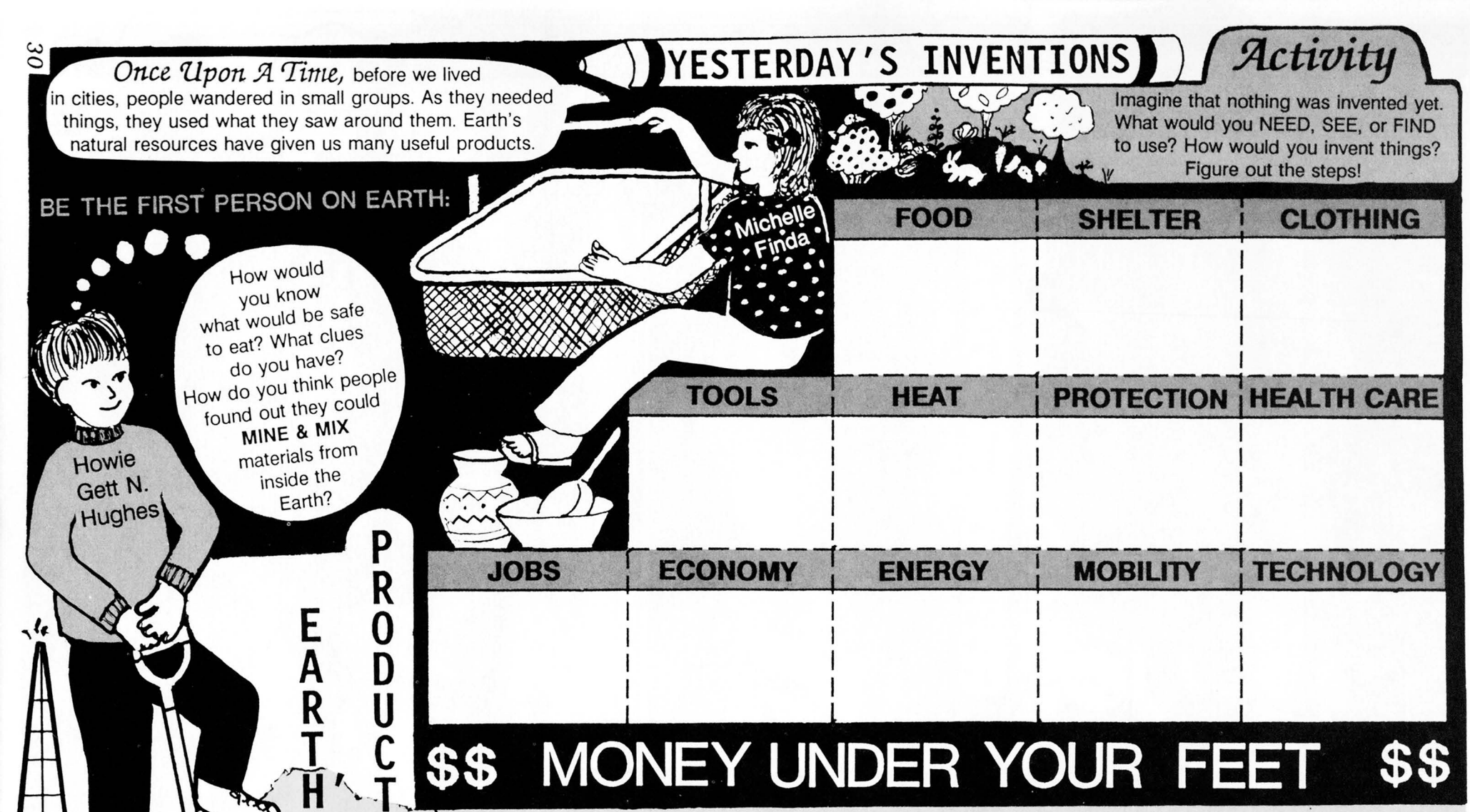
YESTERDAY'S INVENTIONS

Activity

Once Upon A Time, before we lived in cities, people wandered in small groups. As they needed things, they used what they saw around them. Earth's natural resources have given us many useful products.

Imagine that nothing was invented yet. What would you NEED, SEE, or FIND to use? How would you invent things? Figure out the steps!

BE THE FIRST PERSON ON EARTH:



FOOD	SHELTER	CLOTHING

TOOLS	HEAT	PROTECTION	HEALTH CARE

JOBS	ECONOMY	ENERGY	MOBILITY	TECHNOLOGY

$$ MONEY UNDER YOUR FEET $$

Each American uses 40,000 pounds of minerals every year!

CARS **GROW** !?!

Body/engine	- metals
Trim (bumpers)	- chrome
Windows	- silica sand
Wiring	- copper
Knobs/handles	- oil
Tires	- sulfur
Lubricants	- oil
Gasoline	- refined oil
Brakes	- asbestos

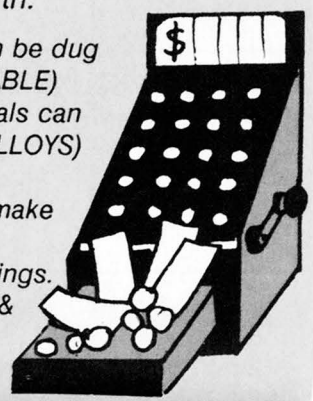
Over long periods of time, under heat and pressure, many things form in the layers of the Earth.

METALS can be made from ores; these SOLIDS can be dug out. If heated, these materials can be bent (MALLEABLE) and can be shaped into useful products. Some metals can pass heat (CONDUCTORS), or can be combined (ALLOYS) to make stronger metals that will not rust.

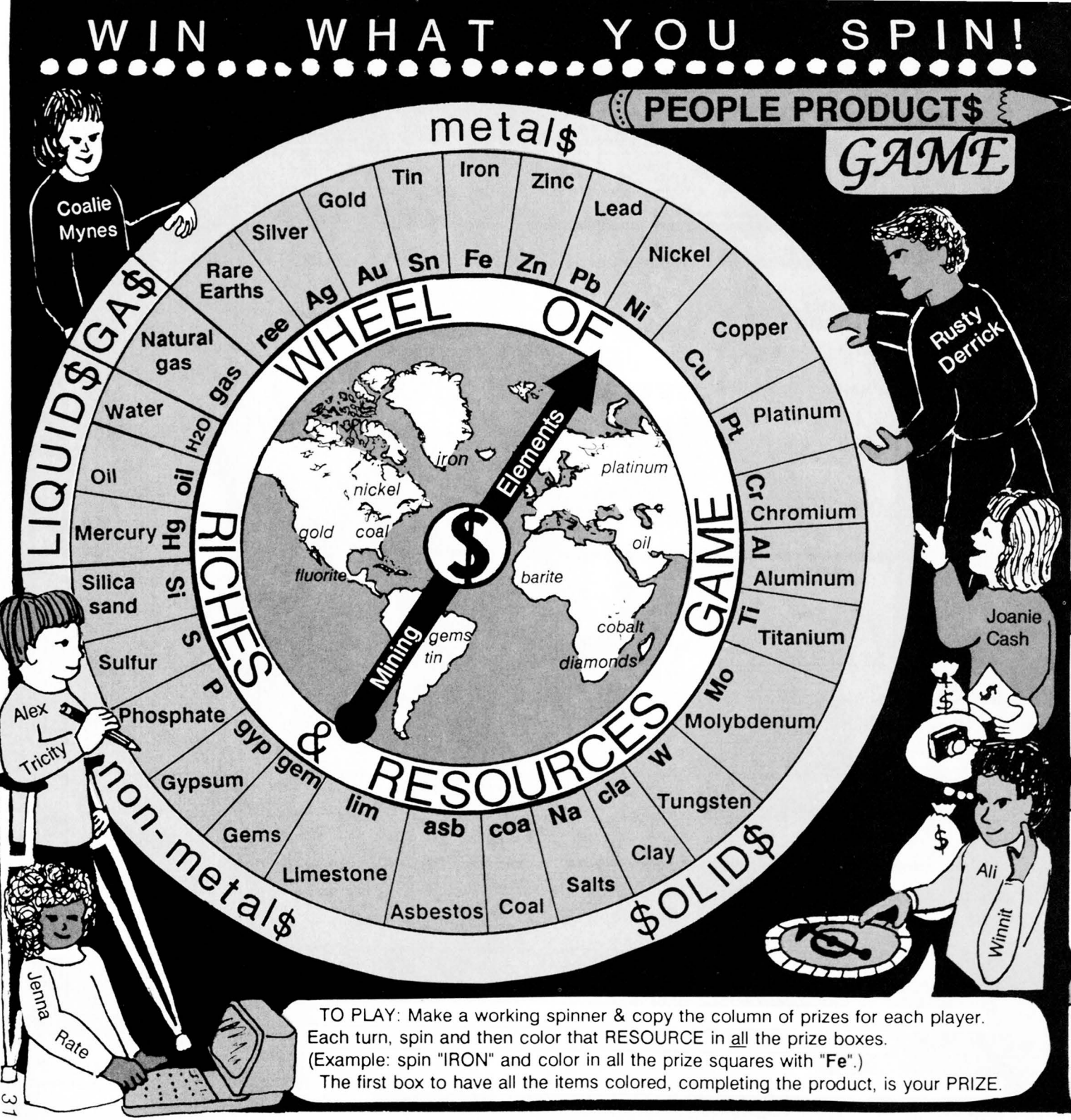
NON-METALS can be ground up and combined to make chemicals and medicines.

ROCKS & GRAVEL can be used for roads and buildings.

LIQUIDS & GASES can be used for heating houses & running machines such as cars and engines.



WIN WHAT YOU SPIN!



STEREO	COMPUTER
○ case - oil	○ case - oil,Fe
○ tape - Cr,Fe,oil	○ wires - Cu,Au
○ record - oil	○ circuit boards - cla
○ paint - Ti, oil	○ monitor -ree,Si
○ needle - Cr,gem	

DINNERWARE	TOASTER OVEN
○ dishes - cla,Si	○ wiring - Cu
○ glasses - Na,Si	○ case - Al,Fe,oil
○ silverware - Fe or Ag	○ heating elements - W or Ni,Cr
○ casting - Si, H_2O	○ glass - Si

NEW CAR	FREE CASH
(see above)	○ coins - Fe,Zn,Cu
○ engine - Fe or Al	○ paper - cla
○ exhaust system - Pt	○ ink - oil
○ trim - Cr,Zn	○ molds - Fe,Cr,Ni
○ gasoline - oil	
○ battery - Pb	

NEW HOUSE	REFRIGERATOR
○ foundation -lim,H_2O	○ body - Fe or Al
○ roof - asb,oil	○ wires - Cu
○ walls - gyp	○ molding - oil
○ siding - Al	○ paint - Ti,oil
○ pipes & wire - Cu	○ light - W
○ thermostat - Hg	

FREE FOOD	AIRPLANE TRIP
○ preservatives -Na	○ airplane - Al,Ti
○ fertilizer - P,S	○ wiring - Cu
○ machinery - Fe,Cr	○ fuel - oil
○ cans - Fe,Sn or Al	○ engine - Fe,Cr,Mo
○ irrigation - H_2O	

JEWELRY	CAMERA
○ metal - Au,Ag,Pt	○ film - Ag,oil
○ molds - Si,Cr	○ body - Al,Fe
○ stones - gem	○ strap - oil
○ heat - oil,gas,coal	○ lenses - Si,Na
	○ paper - cla

TO PLAY: Make a working spinner & copy the column of prizes for each player.
Each turn, spin and then color that RESOURCE in all the prize boxes.
(Example: spin "IRON" and color in all the prize squares with "**Fe**".)
The first box to have all the items colored, completing the product, is your PRIZE.

How the Earth makes

PRECIOUS STUFF

MATCH THE RESOURCE WITH THE REBUS

LEGEND.....

- IDEA
- EARTH
- WATER
- METALS
- Ag SILVER
- VOLCANO, VOLCANIC
- S SULFUR
- LITTLE PLANTS (ALGAE)
- OCEAN
- FLOOR
- GRAINS OF DIRT (SEDIMENT)
- CAN
- OIL
- TREES
- PRESSED COAL
- HOT, HEAT
- ROCKS
- Kt GOLD
- CRACKS
- WEATHER
- MANTLE
- PIPE
- STEAM SHOVEL
- DIG
- DIAMONDS

Iggy Knorr

Rocki Vane

Robbie Feingold

Cory Mineshaft

SILVER
OIL
GOLD
COAL
DIAMONDS

CLUES where to look

Jules Enruff

1 1 IS THAT DEEP IN THE , GROUND- DISSOLVES PRECIOUS LIKE Ag. THE MOVES 2 THE SURFACE WITH LAVA. IT DEPOSITS Ag MIXED WITH S MINERALS.

2 LIVED IN THE , DIED & FELL 2 THE . THEY GOT BURIED BY OTHER . AFTER MANY YEARS OF BURIAL & , U FIND .

3 DIED & GOT BURIED IN THE WITH OTHER . IF THEY GET , THEY BECOME .

4 , DEEP WITHIN THE MOVES THROUGH OLDER THAT HAD Kt. THE PICKS UP THE Kt & MOVES IT 2 THE SURFACE WITH QUARTZ ALONG . WHEN THE , THE Kt IS LEFT BEHIND.

5 THESE R MADE 13 MILES IN THE . IF A BLOWS A HOLE IN THE 'S SURFACE & FORMS A , AFTER THE 2 BLUE DIRT, A & FIND .

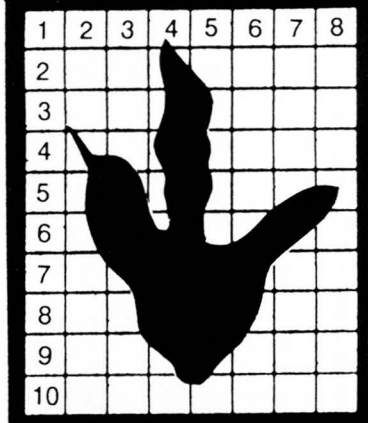
Julie Geode

I wonder how most gems form?

When certain chemicals come together and cool slowly, colored crystals can grow.

James Stone

(peek on pg.26-28)



Activity

In Culpeper, Virginia, 2,000 fossil footprints were found in a rock quarry. To copy this unknown **DINOSAUR FOOTPRINT**, use a sheet of graph paper & grid the lines. Enlarge your footprint to 8" x 10".

AMAZING ANECDOTE

When my co-author sister was visiting my house, she said she could get me a casting of a dinosaur track. She said she would bring it when visiting again. When she got home, she called & said she left her field shoes at my house. I mailed her one shoe with a note saying: "You don't walk around this planet until I get my dinosaur track!"

GAME DINOSAURS

S	N	A	I	B	I	H	P	M	A	N
C	E	D	Y	E	G	G	S	A	T	O
S	P	I	S	S	O	P	U	P	B	R
A	T	M	P	U	X	E	R	A	S	P
R	E	E	O	R	E	T	U	T	U	E
E	R	T	T	U	D	Y	A	O	R	N
C	O	R	A	S	I	N	S	S	U	T
I	D	O	R	E	N	O	O	A	A	H
O	A	D	E	L	O	P	N	U	S	E
Z	C	O	C	I	S	E	N	R	O	B
O	T	N	I	T	A	O	A	U	G	A
S	Y	L	R	P	U	P	R	S	E	L
E	L	A	T	E	R	L	Y	S	T	H
M	S	E	G	R	S	E	T	Z	S	A

FIND ME

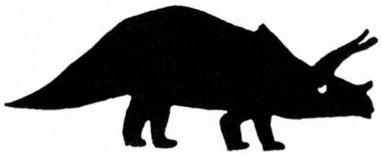
Dinosaurs
Mesozoic Era
Reptiles
Eggs
Amphibians
Apatosaurus
Dimetrodon*
Stegosaurus
Pterodactyls*
Triceratops
Tyrannosaurus rex
No people

WHO AM I? *GAME*

1* _____

2 _____

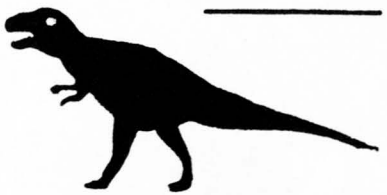
3 _____



4 _____

5* _____

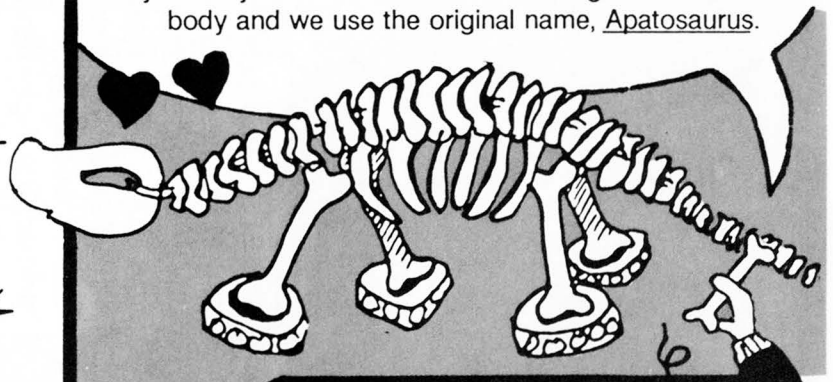
6 _____



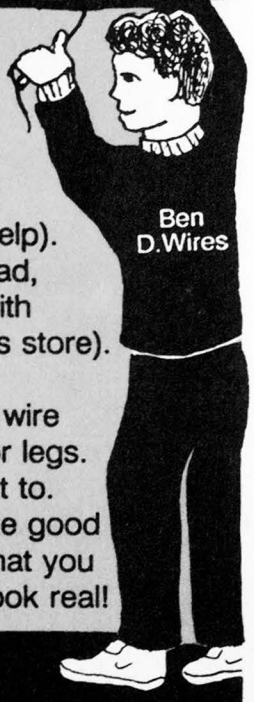
*These are not dinosaurs!

KEEPING AHEAD

FACT: Museums pay more money for whole fossil skeletons.
REAL LIFE: Paleontologists fight to find them.
WHAT WOULD YOU DO?: In the 1870's, a famous fossil hunter found pieces of Apatosaurus first, and then a more complete skeleton and named it Brontosaurus. Neither frame had a head, so he added a small head from the same area. The press loved the Brontosaurus find, but several years later, someone discovered the cover-up! Didn't you ever wonder how such a small jaw could get enough food to feed a huge body? Today we know which head belongs with the dinosaur body and we use the original name, Apatosaurus.



Activity



MAKE A TURKEYSAURUS ©

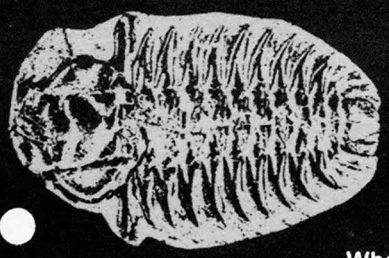
SET UP: Clean chicken and turkey bones using water & bleach (with help). With telephone wires or strong thread, attach bones to framework made with pliable ground-wire (from electronics store).

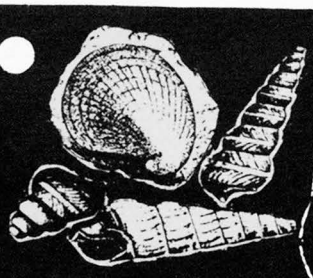
WORK: String neck bones on main wire to form spine. Wire bigger bones for legs. Add a rib cage & anything you want to. Round bones & salmon bones make good feet & toes. Look for other bones that you could add to make your dinosaur look real!

FOOTNOTE

To be correct, always underline Latin & Greek names. For other name facts, peek on pg. 22.

THE WORLD OF FOSSILS

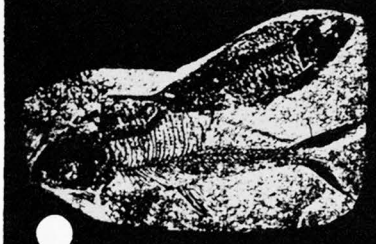




Who am I? GAME

Bill Collector

Things buried near water can get covered by mud, dirt, and gravel. If they are buried, they turn into rocks. Sometimes animals get stuck in swamps, quicksand, or tar pits where their soft parts can be found. Bones are hard & PRESERVE easily. Ice can also preserve whole remains. Scientists study fossils to help date the layers of the Earth. They can also tell what the climate was like when the plant or animal lived.



a.

FISH. Bones, scales, & teeth are all that remains from water animals. The skull of the largest fossil fish ever found was 10 ft long.

BONES & TEETH

b.

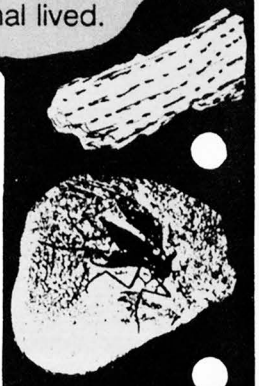
SHELLS & CORALS are skeletons that can turn into rock by being buried. They tell where an ocean, lake, or river used to be.

c.

Cliff Hanger

d.

INSECTS can be found in lake shale & in AMBER. Bugs got stuck in this FOSSILIZED tree sap, which preserved them. The more insects inside the amber, the higher the price!



e.

PLANT imprints are black or white. **ROOTS** leave casts or molds. **TREES** that become rocks are known as PETRIFIED wood.

f.

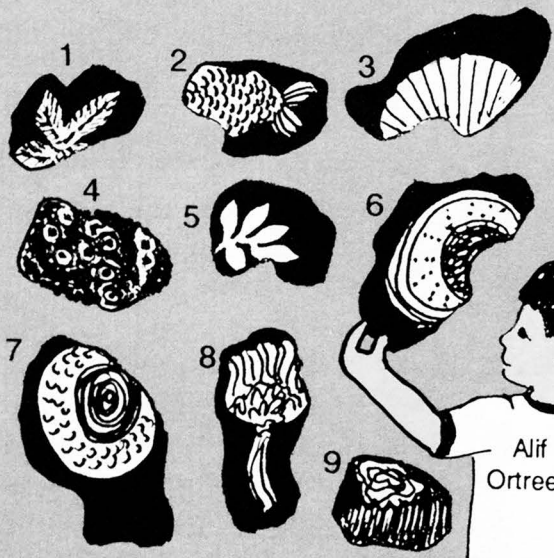
WORM HOLES & BURROWS are signs of past life. Go to creeks & look for rocks with marks you cannot explain. They may be tracks from yesteryear!

PLANT OR ANIMAL GAME

1 [ ]
2 [ ]
3 [ ]
4 [ ]
5 [ ]
6 [ ]
7 [ ]
8 [ ]
9 [ ]

Paleontologists usually find pieces (FRAGMENTS) of fossilized remains. Can you identify these?

A=animal **P**=plant **?**=not sure

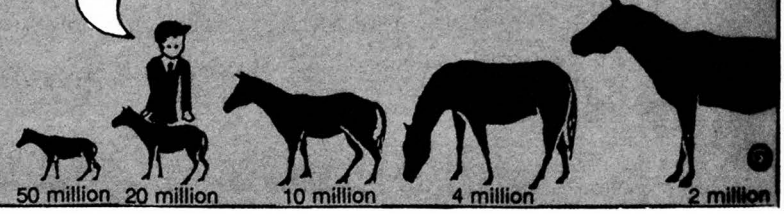


Alif Ortree

g.

TRACKS & BODY MARKS: As animals drag their bodies along muddy paths, they leave trails. If trails get filled with clay that hardens, fossilized marks can be seen. Rock quarries are good places to find these along with footprints.

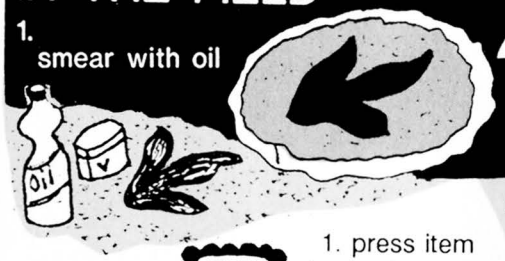
SKELETONS show how things have grown over the years. Look how big horses have gotten over millions of years!



MAKING FOSSILS

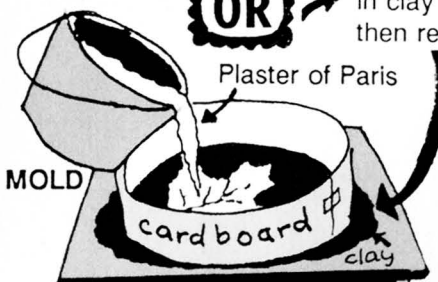
IN THE FIELD

1. smear with oil



2. Build wall around
3. pour plaster (2 pts powder into 1 pt water)
4. let dry
5. carefully remove

OR 1. press item in clay then remove.



AT HOME

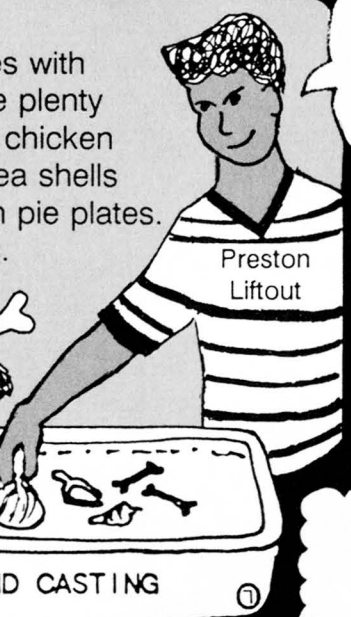
Activity

MAKING MOLDS AND CASTS

Pour over

SET UP: 1. Clean bones with bleach & water. 2. Have plenty of bleached turkey and chicken bones, sand, & small sea shells on hand. Use aluminum pie plates. 3. Need plaster of Paris.

WORK: 3. (**a**) Sprinkle sand in pie tin and then place bones and shells to make a design. (**b**) or **Sand Casting**: press them into wet sand in sandbox and carefully remove. 4. **Then** mix plaster & pour it over them, place a bent pipe cleaner in wet plaster for hanging, and let dry.



LASTING IMPRESSIONS

What did one **ROCK** say to the other **ROCK**? (You crack me up!)

What did the **GOLD MINER** say to the **CREEK**? (What's yours is yours, & what's **MINE** is mine.)

What did one **CONTINENT** say to the other? (It's not my **FAULT**!)

What did one **FOSSIL** say to the other? (I'm older than you!)

What did the **DIAMOND** have for lunch? (14 CARATS)

What did the mountain say to the **VOLCANO**? (You're hot stuff!)

What did the **VOLCANO** say to the **ROCK**? (Don't eat too much **BASALT** & have a **GNEISS** day!)

What did the **GLACIER** say to the mountain? (I've got you on ice!)

What did the mama **ROCK** do when the baby rock cried? (She rocked her to sleep!)

Knock knock. Who's there? **GRANITE**. Granite who? Don't take me for granite!

What did one **STREAM** say to the other? (I can run faster than you!)

How do you know when a **VOLCANO** is angry? (It blows its top!)

Who is the politest ancient reptile? (A plesiosaur.)

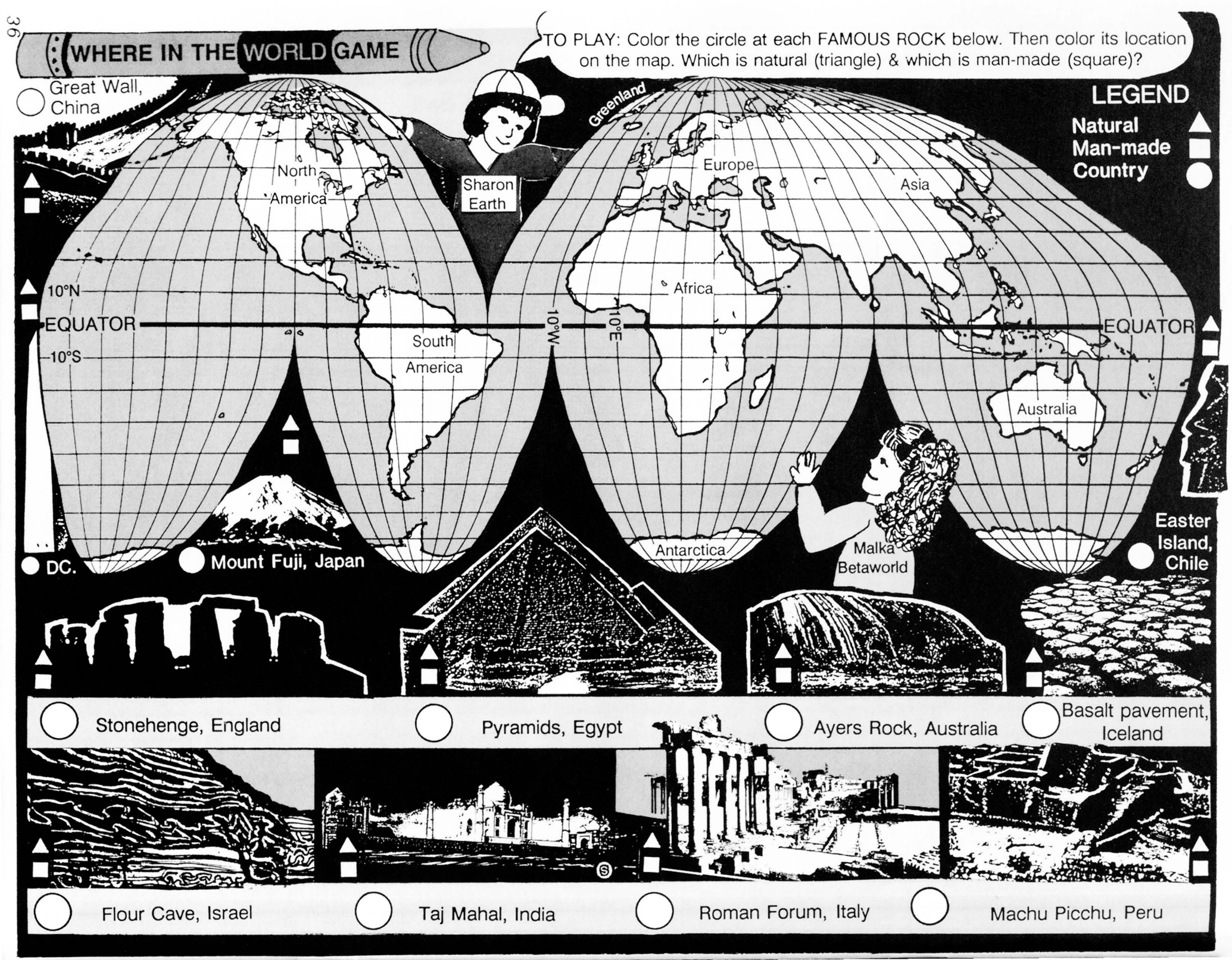
What did the **ROUND ROCK** say to the **SQUARE ROCK**? (Get in shape.)

CAN YOU MAKE UP A GEOLOGY JOKE?

GEO JOKES

WHERE IN THE WORLD GAME

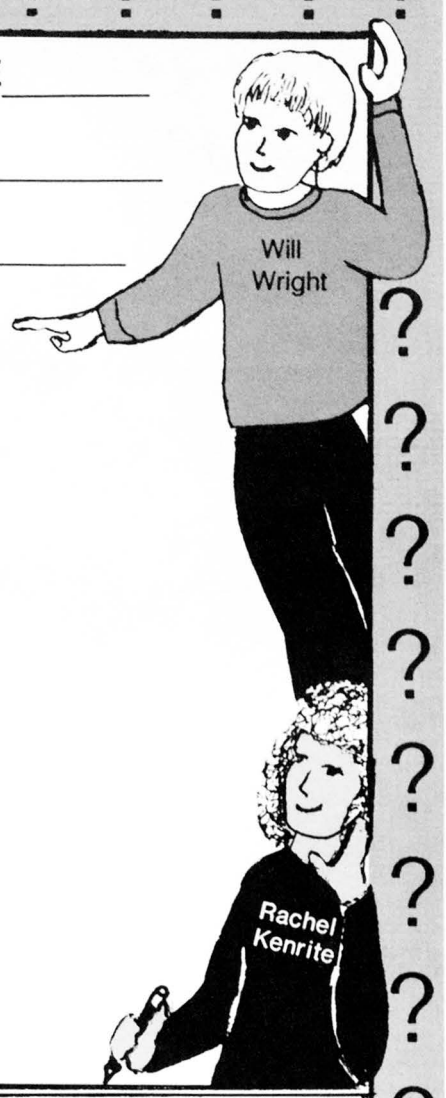
TO PLAY: Color the circle at each FAMOUS ROCK below. Then color its location on the map. Which is natural (triangle) & which is man-made (square)?



NAME _____ AGE _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____



WHAT DO YOU WONDER ABOUT?

I'M CURIOUS ABOUT...

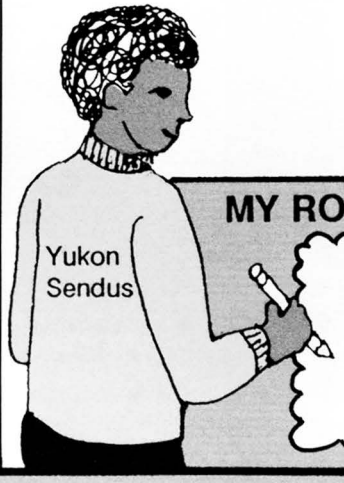
MY FAVORITE:

ROCK...

ACTIVITY...

GAME...

CHARACTERS...



MY ROCK JOKE...

Copy & send to:

Earth Science Information Center
Attn: Penni Rubin or Dr. E.I. Robbins
U.S. Geological Survey
507 National Center
Reston, VA 22092

GAMES

NAME THAT CONTINENT

Nation

A _____

C _____

B _____

D _____

E _____

F _____

G _____

How Many Moons

A. 1
B. 0
C. 2
D. 0
E. 1

F. 8
G. 15
H. 18
I. 16

NAME THAT PLANET

SIZE UP THE PLANETS

HINTS:

A. Pluto	(2,300)*	E. Earth	(12,800)
B. Mercury	(4,900)	F. Neptune	(45,500)
C. Mars	(6,800)	G. Uranus	(51,100)
D. Venus	(12,100)	H. Saturn	(120,500)
		I. Jupiter	(143,000)

(Diameters in km)

MOONS

Moon surfaces

Earth

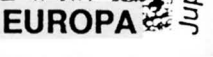
LUNA

Mars

PHOBOS

Saturn

MIRANDA



Jupiter

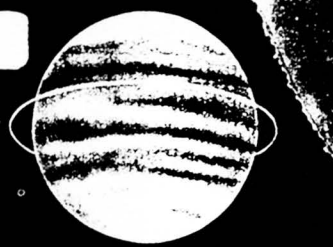
EUROPA

FAR OUT ROCKS IN SPACE

When we study planets and moons in our solar system, all we can do is compare what we see on Earth with the images sent back from cameras in outer space. Many times even the scientists are puzzled; how come some planets are rocky & some are giant balls of gas? Other puzzles are:

1) Why are **POLES** made of different stuff? Mars has 1 of frozen water & 1 covered by frozen gas.
2) Why do most planets have **RINGS**? And why are some made of ice & others made of rock chunks?
3) How could **STORMS** be as big as the Earth on Jupiter or cover all of Mars?

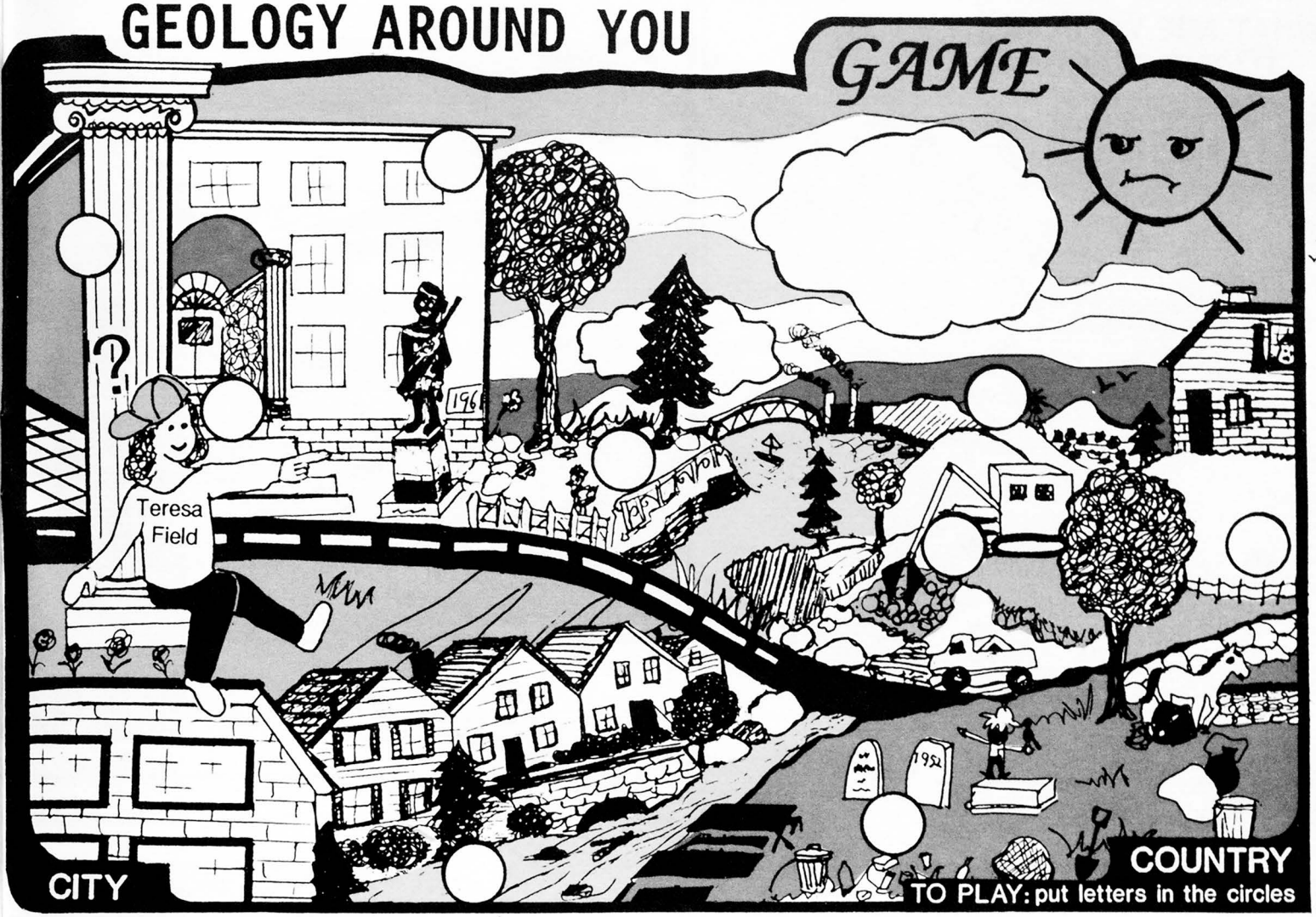
Why do SURFACES vary so much? On Mars, we see lines that look like rivers, but there's no running water now. The images of the MOONS on the right don't look like anything we see on Earth. On Jupiter and Saturn, there are small moons and big ones. Some people think that the smaller ones are captured asteroids. Orbiting moons are formed by either big chunks breaking off a planet or chunks falling from space, and some spin the reverse of ours.



Why do **VOLCANOES** on other planets and moons spew different stuff than ours? Jupiter's moon Io spews sulfur!

What's your theory about these puzzling events?

GEOLOGY AROUND YOU GAME



A COLUMNS/ARCHES

Look at the surfaces of these carved rocks. Often they are made from polished slabs of granite or marble. Look to see if they show weathering.

Hints: Dull edges, cracks, pock marks.

B VALLEYS & HILLS

When looking down from a cliff or hill, notice the landforms below. Look for any signs of erosion. Can you see water? Where does it collect? Which way does the water flow?

C CITY PARKS

Grassy areas allow people in cities to have pretty, natural surroundings. Look for rocks & interesting landforms. Can you find places where animals and plants make their homes?

D WALLS/FLOORS

Buildings such as the library, court house, & justice center use beautiful marble and granite. Look for colors and fossils in polished rock slabs.

E EMPTY FIELDS

Find a place where you can dig holes to look for rocks & minerals. Check out the color of the soil & watch where the water settles. Go many times & see what changes.

F CREEKS/RIVERS

Look for erosion & how the water moves. Lay rocks in streams & watch what happens. Can you make a rock bridge? Is the river straight or wiggly? Go back to see changes.

G STATUES & GRAVESTONES

Many of these are made from rocks. These stand up to water because they are strong materials. Look for weathering.

Hints: Words hard to read, corners rounded.

H BUILDING SITES

When land is cleared, soil becomes exposed. What color is it? Does it look like dynamite was used to clear the land? Look for layers, boulders, or solid rocks in the pit.

I OLD BUILDINGS

Find the cornerstone to see when it was built. Look at the edges; any signs of wear?

Hints: cracks, pock marks.

FIND OR SEEK

Mystery Game: How many kids' names in this book can you remember?

WHAT ARE WE DOING TO THE PLANET

EARTH ?

ENERGY SAVERS

Activity

WATCH FORCE

- Pick up trash to keep our Earth clean.
- Don't buy over-packaged products. Think first!
- Try to fix things instead of throwing them away.
- Plant trees! We dump 307 million lbs. of paper every day.
- Help neighbors recycle. Start your own business!

YOU CAN HELP:

- Reuse plastic bottles, forks, & spoons to save oil.
- Use real stuff instead of paper towels, plates, & napkins.
- Turn off lights & TV when not in use to save energy.
- Don't let water run when not in use; always run full loads.
- Carpool or ride your bike for short trips. Or walk!!!

Sava Glass

Sava Cann

Sava Tree

GAME

Watch the news. Read the newspaper. When you learn of an environmental problem, write to let someone know!

Complain

Collin

POLLUTION

chips

pop

HOW LONG DOES IT TAKE TO DECOMPOSE?
W. WEEKS
M. MONTHS
Y. YEARS

1.	Aluminum	200-500
2.	Banana peels	1-6
3.	Cigarette filters	10-20
4.	Cotton clothes	1-5
5.	Degradable plastic bag	2-3
6.	Disposable diapers	450
7.	Glass jars/bottles	1 million
8.	Paper towels	2-4
9.	Paper cup	up to 5
10.	Painted wood	13
11.	Plastic (anything)	450
12.	Railroad tie	30
13.	Rope	3-14
14.	®Styrofoam	10-20
15.	Tin cans (steel)	100
16.	Traffic ticket	2-4
17.	Unpainted wood	1-4
18.	Wool sock	1

ANSWERS: 1. Y 2. M 3. Y 4. M 5. M 6. Y 7. Y 8. W 9. Y 10. Y 11. Y 12. Y 13. M 14. Y 15. Y 16. W 17. Y 18. Y

SHARE YOUR OPINION!

President _____
1600 Pennsylvania Ave. NW
Washington, DC 20500

Senator _____
U.S. Senate
Washington, DC 20510

Representative _____
U.S. House of Representatives
Washington, DC 20515

State Senator _____
(look yours up & write!
Your State, His/Her Zip

Pitch in, the WORLD is worth saving!!!

We all live together, breathe the same air, see the same sun & moon.

Rocks tell the history of the Earth. Once you can read the rocks, you can figure out the mystery. Here are some mysteries: did dinosaurs roam where you now make your home? Did glaciers move in your neighborhood? Was there once a deep ocean where you walk to school? If you pan for gold in a nearby stream will you find any?

Hidden within the layers is evidence of climate changes, extinct animals, and plant life. You can discover if these lived in ancient rivers or oceans. They paint a picture of how the Earth looked a long time ago.

We dump 862 million tons of garbage every day.

Can you dig it man?

Supta US

GARBAGE IN

GARBAGE OUT

Get on the ball. Clean up your act!

Reid N. Learn

GOOD BOOKS FOR CHILDREN

ADVENTURES WITH ROCKS AND MINERALS--GEOLOGY EXPERIMENTS FOR YOUNG PEOPLE. 1991. L.H. Barrow. Hillsdale, NJ.

CRYSTALS AND CRYSTAL GARDENS YOU CAN GROW. 1990. J. Strangl. Watts, NY.

DINOSAURS. 1990. J.E. Greenberg and H.H. Carey. Raintree, Milwaukee, WI.

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GLACIERS. 1988, W.V. Tangborn. Crowell, NY.

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THE OCEANS. 1987. M. Bramwell. Watts, NY.

RIVERS AND LAKES. 1986, M. Bramwell. Watts, NY.

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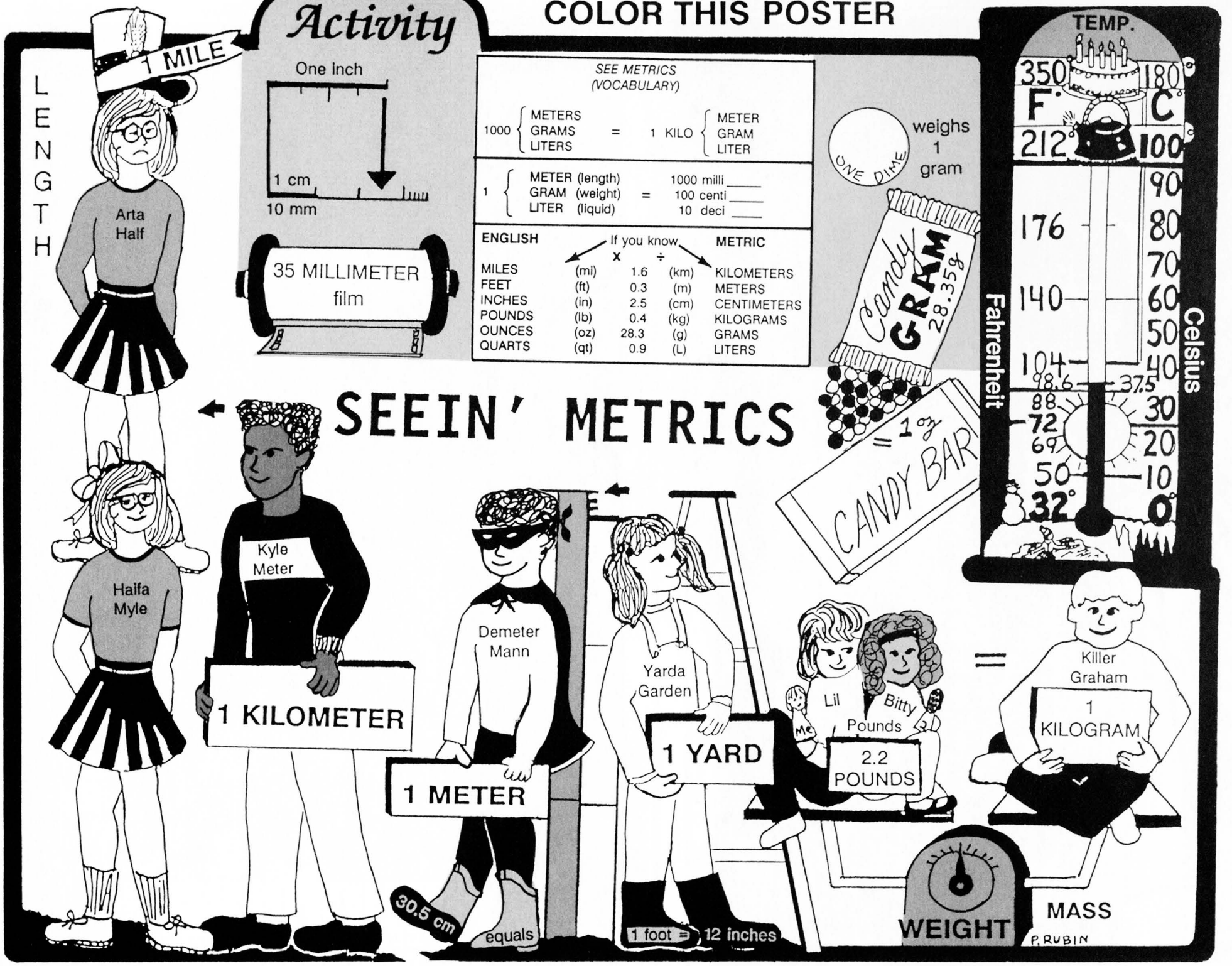
FIELD GUIDE. MINERALS, ROCKS, & FOSSILS. 1974. W.R. Hamilton, A.R. Wooley, and A.C. Bishop. H. Holt and Co., NY.

TEACHER PACKET. Request on letterhead to U.S. Geological Survey, Geologic Inquiries Group, 907 National Center, Reston, VA 22092

If we keep dumping garbage, will the Earth still make diamonds?

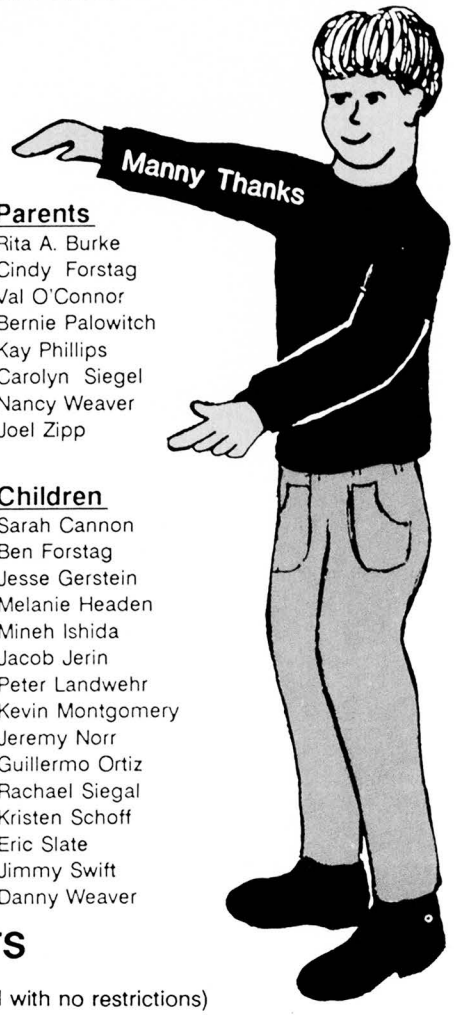

Activity
COLOR THIS POSTER
LENGTH
1 MILE
Arta Half
Halfa Myle
One Inch
1 cm
10 mm
35 MILLIMETER film
SEE METRICS (VOCABULARY)
1000 { METERS, GRAMS, LITERS } = 1 KILO { METER, GRAM, LITER }
1 { METER (length), GRAM (weight), LITER (liquid) } = 1000 milli ____, 100 centi ____, 10 deci ____
ENGLISH | If you know x ÷ | METRIC
MILES (mi) 1.6 (km) KILOMETERS
FEET (ft) 0.3 (m) METERS
INCHES (in) 2.5 (cm) CENTIMETERS
POUNDS (lb) 0.4 (kg) KILOGRAMS
OUNCES (oz) 28.3 (g) GRAMS
QUARTS (qt) 0.9 (L) LITERS
ONE DIME
weighs 1 gram
Candy GRAM 28.35g
= 1g CANDY BAR
SEEIN' METRICS
TEMP.
350 F° 180 C°
212 100
176 140 104 98.6 88 72 69 50 32°
90 80 70 60 50 40 37.5 30 20 10 0°
Fahrenheit
Celsius
Kyle Meter
1 KILOMETER
Demeter Mann
1 METER
30.5 cm equals
Yarda Garden
1 YARD
1 foot = 12 inches
Lil Bitty Pounds
2.2 POUNDS
=
Killer Graham
1 KILOGRAM
WEIGHT
MASS
P.RUBIN

ABOUT THE AUTHORS

PENNI IBERALL RUBIN is an Educational Resource Specialist, educational consultant, freelance writer, and artist. She is currently developing the WONDER Lab Discovery Center in Cleveland, Ohio. She holds a degree in Early Childhood Education/ Childhood Enrichment/ Communications. She has been on the staff of the English Nannies School since 1985. She performs educational programs & writes songs and books, including the "Mommy I Have Nothing To Do" Book; "DO-RE Musical Me"; "Math in Motion"; "Science in the Sandbox and WONDER-ful Stuff"; the "Instead of TV Newsletter"; "Recycle and Build Toys that Build Skills"; and "Crazy Daze" cassette & song book. Penni founded and has directed the Crafty Cuties pre-school Enrichment Centers since 1970. She travels the country presenting PROJECT S.A.M. (Science, Art, & Math) to train primary school educators. She lectures at PTA's and ECED teacher conferences, presenting workshops for those who want to challenge children to develop their creative potential and scientific prowess.

Her sister, **DR. ELEANORA IBERALL ROBBINS,** has been a geologist with the U.S. Geological Survey since 1967. Her degrees in Geology and Geosciences are from Ohio State University, University of Arizona, and Pennsylvania State University. She is the author of more than 100 professional publications, including "Palynology of Ore Deposits." She has travelled extensively around the world, starting from the time she was a Peace Corps volunteer in Tanzania. Eleanora won the U.S. Department of Interior Points of Light award for her volunteer efforts teaching field geology to inner city children in Washington, D.C.

Another sister, Dr. Thea Iberall of C.P. Garth Software, is developing a Macintosh HyperCard stack to supplement this book.



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Phil Davis
John DeYoung
Alex Downs
Terry Edgar
Art Frankel
Judy Fretwell
Bernardo Grossling
Linda Gunderson
Jane Hammarstrom
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Arthur Iberall
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Ted Maxwell
Dick Meyer
Betty Miller
Susan Russell-Robinson
Mike Ryan
Moto Sato
Carl Stover
Michael Tevesz
Susan Tewalt
Alta Walker
Rob Weems
Richie Williams

Teachers

Sue Ballinger
Donald Cammiso
George Cannon
Mary Kate Cross
Christa DeVore
Roberta Herman
Nancy Moore
Anne Schoff
Katheryn Shaw
Deborah Tynes

Technical Support

Frank Dulong
Nancy Gardner
Kathleen Gohn
Joe Graham
Sharon Harris
Dave Hockey
Ann Hoopfer
Audrey Hwang
Anna Marcus
John Keith
Carole Messick
Joe Pillera
Dee Dee Poole
Mary Queen
Brian Robbins
Helene Rubenstein
Melanie Rubin
Richard Rubin
Rory Rubin
Barbara Schwimmer
Ron Stanton
Roger Thomas
Laure Wallace

Parents

Rita A. Burke
Cindy Forstag
Val O'Connor
Bernie Palowitch
Kay Phillips
Carolyn Siegel
Nancy Weaver
Joel Zipp

Children

Sarah Cannon
Ben Forstag
Jesse Gerstein
Melanie Headen
Mineh Ishida
Jacob Jerin
Peter Landwehr
Kevin Montgomery
Jeremy Norr
Guillermo Ortiz
Rachael Siegal
Kristen Schoff
Eric Slate
Jimmy Swift
Danny Weaver

ANSWERS TO GAMES AND ACTIVITIES: (pgs.)

1. 1.quartz,2.coral,3.dino,4.urchin,5.dino print,6.sea animal,7.either
7. All statements are TRUE
8. 1.ropy,2.tears,3.bomb,4.pumice,5.obsidian
17. Atlantic,Mississippi,Appalachian,GREAT
18. 26°/199°
20. ABCDEFGHIJ
32. 1.silver,2.oil,3.coal,4.gold,5.diamonds
33. pterodactyl,Apato.,Stego.,Tricera.,Dimetrodon,T.rex
34. clockwise from left, c,c,a,c,c,e,d,e,f,g
1.P,2.A,3.A,4.A,5.P,6.?,7.A,8.A,9.P
38. See pgs.4 or 36 for continents;1.Mercury,2.Venus,3.Earth, 4.Mars,5.Jupiter,6.Saturn,7.Uranus,8.Neptune,9.Pluto

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