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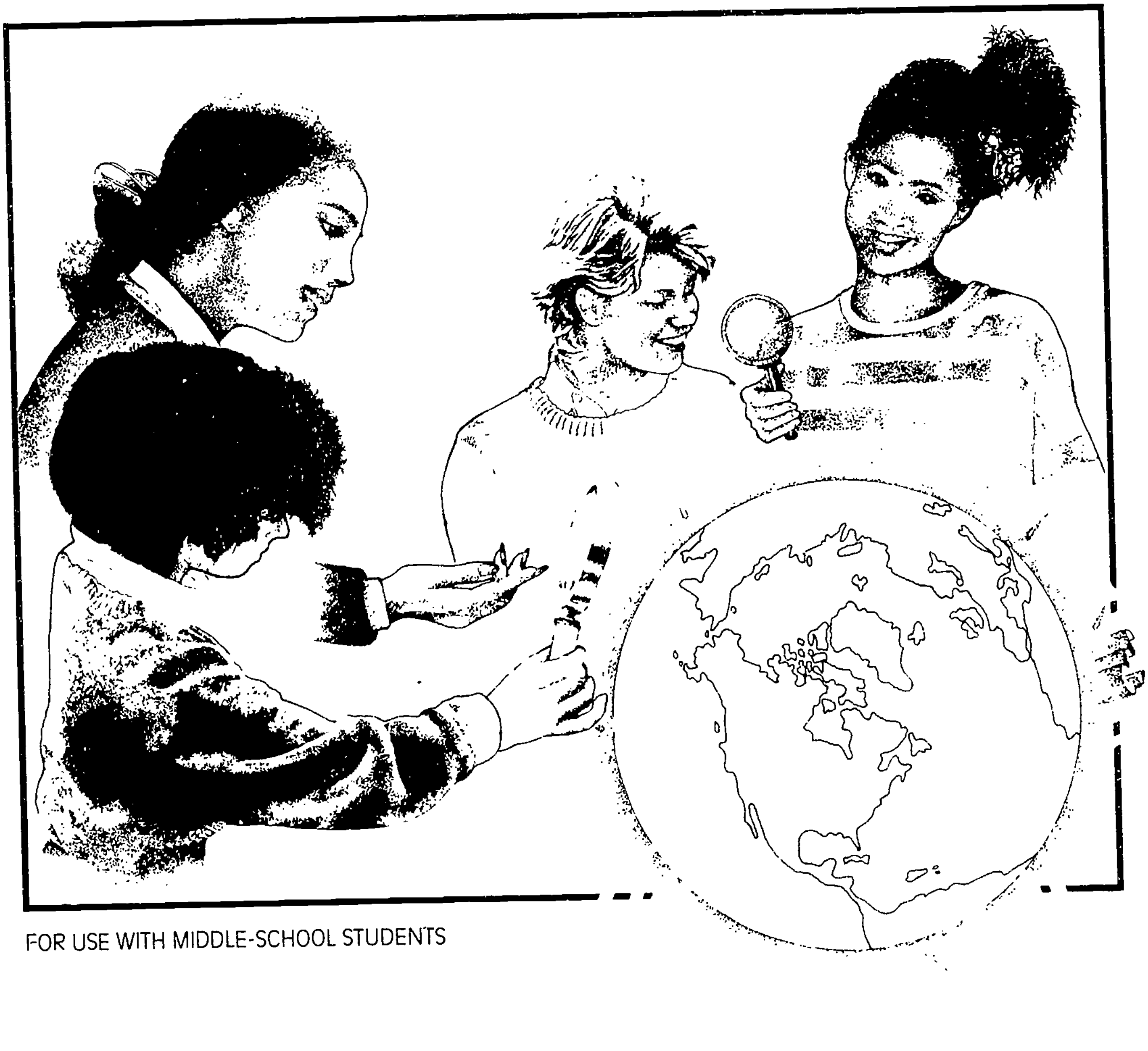
ABSTRACT

This atmospheric studies teacher's guide for use with middle school students blends lessons in chemistry, physics, and the life, earth, and space sciences in an attempt to accomplish the following: to nurture students' natural curiosity and excitement about science, mathematics, and technology; to encourage career exploration in science, mathematics, and technology; to foster critical and problem-solving skills; and to demystify science and demonstrate its relationship to other fields of study. The guide is divided into four sections, each of which follows the format of a detective case: (1) "The Scene: the Mysterious Atmosphere" explores the structure and composition of the Earth's atmosphere and its relationship to the planet, land, water, and sun; (2) "The Crime: Harming the Atmosphere" discusses greenhouse effect and ozone; (3) "The Suspects: Natural and Anthropogenic Causes" explores possible natural and human-caused sources of harmful change; and (4) "The Detectives: Working to Solve the Mysteries" gives students information about how scientists are working to answer questions about the atmosphere and how the students can become involved now and in the future. The 14 lesson provide background information for both students and teachers, hands-on activities, materials, procedure, open ended questions, reproducible activity sheets, suggestions for group or individual activities in other discipline areas, extension activities, and home activities to provide the opportunity for parent involvement. A glossary and resource section (lists of 16 related organizations, 11 publications, 6 videotapes, and brief information on NASA educational resources--Spacelink computer information service, satellite videoconferences, NASA Central Operation of Resources for Educators, and Teacher Resource Center Network) are included. (MCO)

Earth's Mysterious Atmosphere

ATLAS 1 Teacher's Guide with Activities



FOR USE WITH MIDDLE-SCHOOL STUDENTS

NASA
National Aeronautics and
Space Administration

EP-282/11-91

Earth's Mysterious Atmosphere
ATLAS 1 Teacher's Guide with Activities

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Preface

Please join us, the members of the ATLAS 1 team, on a voyage of great adventure and discovery. One of our mission's primary goals is to better understand the physics and chemistry of our atmosphere, the thin envelope of air that provides for human life and shields us from the harshness of space. The Space Shuttle Atlantis will carry the ATLAS 1 science instruments 296 km above Earth, so that they can look down into and through the various layers of the atmosphere. Five solar radiometers will precisely measure the amount of energy the Sun injects into Earth's environment. The chemistry at different altitudes will be measured very accurately by five other instruments called **spectrometers**. Much of our time in the cockpit of Atlantis will be devoted to two very exciting instruments that measure the auroras and the atmosphere's electrical characteristics. Finally, our ultraviolet telescope will probe the secrets of fascinating celestial objects.

We are very excited about playing a role in such interesting and important investigations. We hope you will join us on this exciting voyage and learn how atmospheric science is done from space.

This Teacher's Guide is designed as a detective story to help you appreciate some of the many questions currently studied by scientists around the world. Many complex factors affect our atmosphere today, possibly even changing the course of global climate. All of us who live on Earth must recognize that we play an ever-growing role in causing some of these changes. We must solve this great atmospheric mystery if we are to understand all these changes and know what to do about them.

ATLAS 1 is only the start of a series of ATLAS missions that will carry on this work. In addition, many satellites and many teams of scientists on the ground are working continually to solve the atmosphere's many mysteries. Satellites from the National Aeronautics and Space Administration's Mission to Planet Earth and the Earth Observing System will circle the globe using remote sensors to monitor the atmosphere's sheath. The Upper Atmosphere Research Satellite is already sending back valuable data. Together, all these programs will provide comprehensive information clues for scientists to use.

Col. Charles F. Bolden, Jr., Commander

Lt Col. Brian Duffy, Pilot

Dr. Kathryn D. Sullivan, Mission Specialist

Dr C Michael Foale, Mission Specialist

Capt David C Leestma, Mission Specialist

Dr Dirk D Frimout, Payload Specialist

Dr. Byron K. Lichtenberg, Payload Specialist

Dr Michael L Lampton, Payload Specialist

Dr C. Richard Chappell, Payload Specialist

ATLAS 1 Crew

Charles F. Bolden, Jr.

As a kid growing up in Columbia, South Carolina, I frequently dreamed of becoming a doctor or an engineer. Hoping to get just a hint of what medicine might be like, I often traveled around town with my uncle, a medical doctor. We visited neighbors to treat everything from runny noses to clipping puppies' tails and ears — a special favor to his patients, I guess. Over the years, my ambitions constantly changed but never strayed very far from science and exploration. Strangely, I never dreamed I would be a professional pilot — let alone an astronaut — back in those early days. Science fairs and tinkering with things around the house occupied most of my time while I was in high school.

After attending the United States Naval Academy at Annapolis, Maryland, I made the decisions to go into the U.S. Marine Corps and to try flight school. Those decisions proved to be important to the rest of my life. I fell in love with flying on my first flight and decided right then and there that one day I would be a test pilot. Now, I am excitedly preparing for my third Shuttle flight as part of the crew of ATLAS 1 — a mission dedicated to the study of our atmosphere. I hope our ATLAS 1 studies and our explanations about our observations both during and after the flight will excite the youth of the U.S. and the world and make them want to follow in our footsteps and EXPLORE!

Brian Duffy

Becoming an astronaut and participating in a project such as the ATLAS Space Shuttle mission were only a dream while growing up in Rockland, Massachusetts. It seemed like an unreachable goal for a student from a fairly small middle-class school. I remember reading books about aviation pioneers and the early days of NASA and wondering how anyone could be smart enough to leap the hurdles of aviation and space flight. While I never thought I would ever have the qualifications to become an astronaut, my interest in space flight never waned. Seeing math and science used as the tools to solve technical problems spurred my interest in them. That led me first to study mathematics in college and later to become a test pilot. Without a doubt, that combination made my participation in the ATLAS 1 mission possible. While the road that led me here has not always been easy, it has always been interesting and enjoyable. I now eagerly await the chance to do my part as a team member on my first space flight, and I look forward to an extremely successful mission.

Kathryn D. Sullivan

I have always wanted to explore Earth from as many perspectives as possible. At first, I could only explore by reading, but books taught me a lot about the countries, peoples, and landscapes of our planet. In high school, I became interested in geology and oceanography, and in college I learned how much fun it was to conduct field studies ashore and afloat. Earth science seemed the perfect career for me, since a good Earth scientist needs to know about the entire Earth and its many processes, just as a good doctor must understand the entire human body. I couldn't think of a better, more fun way to make my living!

NASA began its search for Space Shuttle astronauts just as I was finishing my advanced degree in marine geology, and I applied right away. I couldn't pass up the chance to see Earth with my own eyes from the incredible vantage point of the spacecraft. My job gives me the chance to play a key role in many research projects, covering a very broad range of subjects. The ATLAS 1 mission is a very special one to me because of its focus on our atmosphere. We have the opportunity to contribute important data bearing on the many environmental questions humankind currently faces. It's a great privilege to be a part of the ATLAS program.

C. Michael Foale

I was about 6 years old when I realized what fun my father was having as a pilot in the Royal Air Force. At the same time, my American grandmother started to give me books on astronomy, and I became interested in science. I remember visiting a state fair in Minnesota, where the first Mercury capsule flown by Alan Shepard was on display. It seemed obvious to me then, as now, that combining flying, exploration, and science would be a wonderful career to follow. Becoming an astronaut was the goal that I set for myself.

Of course, I also needed a good portion of luck, as well as good teachers and supportive parents, to actually achieve this goal. I have been fortunate enough to be able to understand physics and mathematics fairly well, and I studied these for several years at Cambridge University, in England. After having the opportunity to learn to fly airplanes and helicopters in the United States, I found my childhood dreams were becoming real.

The ATLAS mission is an important part of this country's goal to understand and take care of our planet. For me to be able to fly as a crewmember is a privilege and something for which I will always be very grateful.

David C. Leestma

My interest in flying was first stimulated by my Uncle Frank, who took me for my first airplane ride when I was 8 years old. Airplanes and a natural curiosity about how flying is possible led me to choose aeronautical engineering as my college major and to choose naval aviation as my career. Before becoming an astronaut, I was flying the Navy's F-14A Tomcat fighter jet. Now, it's the Space Shuttle. I never imagined that one day I might have the opportunity to gaze down upon this beautiful planet. The sight took my breath away and brought tears to my eyes. The ATLAS 1 team will use this special perspective to allow the scientific instruments and experiments carried aboard Atlantis to study the atmosphere and the Sun's effect on it.

We all have a vested interest in understanding Earth's atmosphere and its interactions with the Sun, and ATLAS 1 will certainly advance our knowledge in the field of atmospheric physics. There is so much we don't know, and every addition to our knowledge of the atmosphere and the Sun will aid future generations in their understanding and care of Earth's "spacesuit." The Space Shuttle is truly a unique flying vehicle and can be used for a variety of on-orbit tasks. Using it to study our planet's thin protective layer is a noble venture, and I am privileged and delighted to be a part of it.

Dirk D. Frimout

In high school, I liked to study mathematics and physics, and I always wanted to understand how things worked, so I decided to become an engineer. I was lucky to start my career in the Belgian Institute for Space Aeronomy, where I was involved in all kinds of atmospheric experiments. Because of the Institute's low budget, these experiments were mainly performed using what was called "the poor man's satellite," stratospheric balloons. These balloons gave us access to the ozone layer in the stratosphere, and that became the subject of my studies for advanced college degrees.

Later, I became involved in the design of an atmospheric experiment proposed for the first Spacelab flight, and this brought me to manned space flight. I didn't want just to design space experiments; I wanted to perform the experiments in space myself! As a first step, I joined the European Space Agency as experiment and crew training coordinator for the first flight of Spacelab. The ATLAS 1 mission will give me the long-awaited opportunity to fly in space.

This mission is special because it is an international mission. I am one of a group of scientists from eight countries participating in the mission. It is important that many nations work together for the health of our planet, because we are all passengers of the same spaceship, Earth.

Byron K. Lichtenberg

Even as a young student, I was interested in space, exploration, and science. These three interests have all come together in my role as a payload specialist. Although much of my formal training has been in biomedical engineering, my flight on Spacelab 1 broadened my horizons. The experiments that we conducted in the fields of space plasma physics and upper atmospheric physics intrigued me. Studying glowing auroras, the ozone hole, global warming, and how the Sun affects Earth adds much to our knowledge of Earth. Seeing our planet from 296 km high gives scientific knowledge and also provides probably the most awe-inspiring view that one can have. After several days come the realizations that Earth is not limitless and that the atmosphere, which keeps all living things alive, is very thin and tenuous. It is impossible not to realize that living creatures on Earth are connected through the atmosphere. I hope that ATLAS' study of the atmosphere, the surrounding magnetic field environment, and our Sun will lead to increased knowledge and better ways to protect our fragile planet and life as we know it. I am really looking forward to my second space flight and the beginning of the ATLAS series of space missions as a part of NASA's Mission to Planet Earth.

Michael L. Lampton

When I was 7 years old, I clearly remember reading the book *The Conquest of Space* by Willy Ley and Chesley Bonestell. Their descriptions of space travel and the illustrations of the Moon and planets were very exciting to me. I became an amateur astronomer as a teenager and particularly enjoyed observing the planets. In college, I studied physics, and ever since then I've been involved in space research, including physics of the Sun, Earth and its upper atmosphere, and the stars.

C. Richard Chappell

I have always been interested in mathematics and science because I wanted to understand how and why things around me work the way they do. After college, I decided to work toward an advanced degree in space science, because space flight was exciting and the chance to build and fly instruments in rockets and satellites was fascinating. In graduate school, I focused my studies on Earth's environment with a particular interest in the auroras — the northern and southern lights. The aurora occurs at the top of the atmosphere at an altitude of 97 km. It represents one of the few ways that humans can see the effect of the solar wind on Earth's environment. This "wind" of electrically charged particles moves past Earth at speeds of more than 1 million miles per hour and changes the motion, composition, and energy of the upper parts of our atmosphere.

From ATLAS 1, we will be able to look down on the aurora from above and study its changing colors and motions across broad regions of space. We even plan to create an artificial auroral spot during the mission by sending energetic electrons from the Shuttle down into the atmosphere. ATLAS will study Earth's environment in a broad way by observing the changing Sun and measuring our fragile atmosphere.

It is very exciting for me to be part of the ATLAS 1 mission, for it is the first Spacelab flight of NASA's Mission to Planet Earth. From the Shuttle, our crew will be able to observe many of the important aspects of global environmental change that will determine the future well-being of our home planet.

Introduction

There is a mystery story unfolding around us. It involves all Earth's inhabitants, making it one of the most important puzzles that has ever faced the citizens of our planet.

Noticeable changes are taking place in Earth's environment, a carefully balanced system involving interactions between Earth and its oceans, the atmosphere, and the Sun.

Many scientists, measuring changes in temperatures around the globe, think that Earth may be warming up. Significant changes in temperature could melt glaciers, causing the level of the sea to rise around the planet. Temperature increases could bring hotter summers to mild climates and perhaps create more hurricanes and droughts. Weather patterns could shift, turning farm lands into dry fields and deserts into flooded wastelands.

Researchers have also noticed that the ozone layer over many areas is becoming thinner; above the Antarctic, it now regularly develops a "hole." Located high above Earth in the stratosphere, ozone blocks dangerous ultraviolet (UV) radiation that is harmful to plants and animals.

And here is the mystery: What is causing these changes?

The world's finest detectives are on the case. They are scientists from many countries who are working together to unravel the puzzle of Earth's changing atmosphere. Like detectives, they look for the facts, what is known to be true now. They measure and observe the current state of the atmosphere, searching for clues about what has happened and is still going on. Researchers use supercomputers to model the complex interactions between land, clouds, wind and water currents, and sunlight. They try to predict the effects of natural and human-caused changes. When they think they have a possible answer, scientists test their theories with experiments and more measurements. Science detectives around the globe are working to understand Earth's mysterious atmosphere.

The United States Global Change Research Program is this country's effort to investigate Earth from its core to the outermost edges of the atmosphere. As its part, the National Aeronautics and Space Administration (NASA) has designed a number of programs to examine changes in the delicate balance between sunlight, atmosphere, water, land, and life on Earth. The Atmospheric Laboratory for Applications and Science (ATLAS), which probes the interactions between the Sun and the atmosphere, is one of these programs. Ten ATLAS Space Shuttle flights are scheduled at 12- to 18-month intervals, so that scientists can investigate solar and atmospheric conditions over a complete 11-year solar cycle. Researchers working on each mission will collect data, building a comprehensive library of information on the atmosphere. This and related research, such as information from the Upper Atmosphere Research Satellite (UARS) together with continuing ground, balloon, and aircraft observations, will enable atmospheric detectives to discover the causes and solutions to some of the planet's problems.

All these efforts are critical to today's students, who will be most affected by any deterioration of our planetary home. Some will be the scientists and researchers of tomorrow, but it is vitally important that all these students become scientifically literate citizens, capable of making informed decisions about environmental issues touching their lives.

Instructions for Using the Teacher's Guide

The young people sitting in your classroom are faced with an enormous challenge. Precipitous changes in the land, oceans, and air of their home planet have the potential to alter the nature of life on Earth, and scientists working to diagnose and solve these anomalies have only recently begun the long process of observation, measurement, and exploration. Today's students will be charged with continuing that process. They must be knowledgeable and enthusiastic about their roles in the future: as scientists, teachers, engineers, technicians, and citizens of a world united to preserve itself.

To help prepare these young detectives, this ATLAS 1 Teacher's Guide

✓ blends lessons in chemistry, physics, and the life, Earth, and space sciences

✓ nurtures students' natural curiosity and excitement about science, mathematics, and technology

✓ encourages students to see their questions as the seeds of careers in science, mathematics, and technology

✓ fosters creative and critical thinking and problem-solving skills

✓ demystifies science and demonstrates its relationship to other fields of study. The teacher's guide stresses the importance of all disciplines as vital parts of human life.

The ATLAS 1 Teacher's Guide is divided into four sections; each highlights a different aspect of atmospheric studies. Earth's atmosphere is complex; no element within it can change without affecting the entire system. To reinforce this concept, topics such as the greenhouse effect may be discussed at several places in the guide rather than in isolated sections.

The guide may be taught in its entirety, or you may choose to teach particular sections. You may even want to choose among the cases in each section. Cases and sections are designed to stand alone; the ideas contained in them do not depend on the rest of the guide.

The science concepts in the ATLAS 1 Teacher's Guide have been designed to complement the middle-school curriculum. However, many activities may be used with younger and older students. You may adapt the guide to your students' needs and interests.

I. The Scene: The Mysterious Atmosphere explores the structure and composition of Earth's atmosphere and the relationships among the planet, its land and waters, the atmosphere, and the Sun.

II. The Crime: Harming the Atmosphere discusses the enhanced greenhouse effect and the thinning of Earth's ozone layer.

III. The Suspects: Natural and Anthropogenic Causes explores possible natural and human-caused sources of harmful changes.

IV. The Detectives: Working to Solve the Mysteries gives students information about how scientists are working to answer questions about the atmosphere. It also tells students how they can become involved now and in the future.

All sections follow the format of a detective case.

Cases: Several cases appear in each major section. These are in the form of questions that student detectives might ask about the atmosphere — its functions, possible damage or changes, and causes and solutions.

Clues: These precede investigations and contain important background information for teacher and students.

Investigation: These hands-on activities focus and extend information in the **CLUES** section. There are two investigations per case. You may use one or both as teaching activities or reproduce them and assign as tasks to small groups.

Materials: This section lists the materials needed to perform the investigation. Household items are used whenever possible.

Procedure: This provides detailed instructions and cautions. Before beginning any procedure, encourage students to formulate hypotheses about what they think will happen.

Questions: Answers to most questions are found at the end of each of the four major sections. Some are open ended to stimulate creative thinking. Encourage students to support creative answers with what has been observed in the **Investigation** or learned in the **CLUES** section.

Investigator's Notebook: These activities may be reproduced for individual or small-group work. Students may collect these in a binder or folder.

Relating Science to . . . These sections provide suggestions for group or individual activities in other areas of study, such as art, literature, math, music, and social studies.

Helping Mother Earth: These facts and classroom discussion ideas extend the guide's scope beyond ATLAS' atmospheric research to include other areas of concern in the environment. Students may work on these activities in school or at home.

Home Activity : This page can be copied and sent home to provide the opportunity for parent involvement.

Be sure to save the ATLAS 1 Teacher's Guide. After ATLAS 1, nine more ATLAS flights will continue the work of investigating the mysterious atmosphere, increasing our store of knowledge and building on this document.

To begin, you may want to take some time to introduce the ATLAS 1 and Upper Atmosphere Research Satellite missions, described for teachers on p. ix. Additional sources of information can be found in **Resources**, pp. 60-62.

The Scene:

The Mysterious Atmosphere

Case No. 1 — What is the Atmosphere?

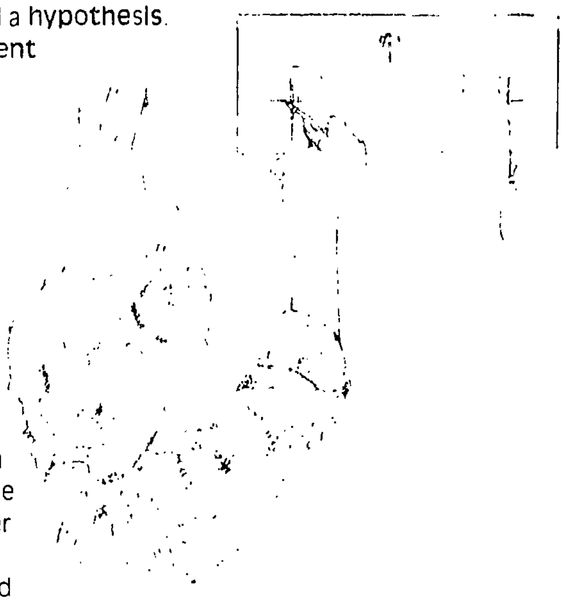
CLUES:

Scientists believe that millions of years ago our planet had a very thin atmosphere, which gradually became a protective blanket that maintained warmth and provided the necessary gases for life to evolve. Air bubbles in columns of ancient ice tell researchers that only 100,000 years ago — a brief moment in Earth's long history — our atmosphere was much different than it is now. Why has the atmosphere changed? How have changes in the atmosphere and weather affected life on Earth? Was weather related to the disappearance of giant dinosaurs? What is causing changes now? Will these changes have drastic effects? All of these are mysteries.

What do you know about the atmosphere? Wave your arm around quickly. Did you feel anything on or behind your hand? What you felt is air — our atmosphere. It surrounds us like an invisible ocean of gases and particles that has no definite boundaries but extends outward from the surface of Earth for thousands of miles. Most of us think of the atmosphere as just the air, but it works as part of an intricate system that includes the Sun, Earth's oceans, and land surfaces, each influencing the others We know much about the atmospheric system, but some of the ways in which the atmosphere, the oceans, and the land interact and change are still mysteries. For this reason, scientists travel Earth and into space to search for answers.

Investigation A: Balloon Science

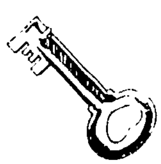
Here are some activities to help you discover important characteristics of the lower atmosphere. Does air have weight? Your guessed answer is called a **hypothesis**. Now, you will test that hypothesis with an **experiment**



Materials Needed:

- ✓ **two small latex balloons**
- ✓ **two 15-cm pieces of string**
- ✓ **30.5-cm ruler**
- ✓ **piece of notebook paper**
- ✓ **tape**

Procedure



Attach a balloon to each end of a ruler, being careful to use exactly the same lengths of string or tape to attach each balloon. Suspend the ruler on a string at approximately the 15-cm mark to create a balance. With tape, attach the top of the string to a wall about eye level. Tape the notebook paper to the wall behind the ruler. Put a pencil mark on the paper above and below each end of the ruler to mark its beginning position. Remove one of the balloons and blow into it, inflating it as much as possible. Tie and reattach the balloon with the same piece of string. Gently pull the string suspending the ruler away from the wall, allowing the ruler to readjust. Carefully release the string and check the ruler's new position. Mark the paper with the pencil again.

Questions

❶ Does the ruler still balance?

❷ Does one balloon now weigh more than the other?

❸ What does this tell you about air?

❹ Was your hypothesis correct? When a number of different experiments give the same results, the hypothesis may be accepted as a **theory**.

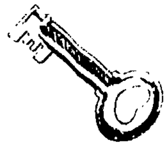
Investigation B: Be a Hero — or Just Experiment Like One.

In the year 50 A.D., a Greek engineer named Hero first demonstrated the presence of air. Be a "hero" and duplicate this experiment.

Materials Needed

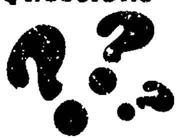
- ✓ **clear drinking glass**
- ✓ **facial tissue**
- ✓ **large glass bowl**
- ✓ **3 ℓ of water**

Procedure



Fill the bowl about three-fourths full of water. Put a ball of tissue in the bottom of a glass. Invert the glass and carefully put it into the glass bowl until the entire glass is under water.

Questions



❶ Does the tissue get wet?

❷ Why?

Investigator's Notebook: Measuring Up — An Abbreviated Activity

How far away is our star, the Sun? How far out from Earth does the atmosphere extend? How warm is our planet becoming? To answer these and other questions about our surroundings, scientists must measure. This activity will help you identify common units of measurement that you, like scientists, must use.

Where units are given, write the abbreviation. Check a dictionary or math book to be sure you capitalize correctly. Where abbreviations are given, write the unit of measurement. The first one is done for you as an example. Be sure to check your spelling.

Abbreviations

Metric Distance	Metric Volume	Metric Mass
❶ kilometer __km__	❶ liter ________	❶ kilogram ________
❷ meter ________	❷ ________ mℓ	❷ ________ g
❸ ________ cm		❸ ________ mg
❹ ________ mm		

The prefixes help you understand the relationships between the measurements.

Prefixes

Prefix	Meaning	Example	Abbreviation
❶ kilo-	1,000	kilogram	______
❷ deci-	1/10 or 0.1	decimeter	dm
❸ centi-	1/100 or ______	______	______
❹ milli-	______ or 0.001	milliliter	______

Equivalents

❶ 1 kilogram = ______ grams ❷ 1 decimeter = ______ of a meter ❸ 1 __________ = 0.001 of a gram

Many of these abbreviations are used in activities throughout this book. Look for them and make sure you know what they refer to.

Relating Science to . . .

Music: From space, ATLAS astronauts can see that much of the blue globe we call Earth is covered with water. In fact, 70 percent of Earth's surface is covered by water. With the atmosphere, oceans play a major role in collecting and distributing the Sun's heat, making our planet a warm and comfortable place to live. Listen to Handel's *Water Music* or Debussy's *La Mer*.

Art: While you listen to *Water Music*, use crayons, colored chalk, or colored pencils to create a picture of your feelings. White chalk and blue construction paper give a "watery" effect, as do watercolor paints

Social Studies: Earth's oceans touch all of us Look at a map of the Pacific Ocean. How many different countries are bordered by the Pacific? How many races of people are warmed by its currents and cooled by its breezes? List as many countries as you can.

Helping Mother Earth

Do you turn the faucet off while brushing your teeth? If you allow the water to run, you may use up to $1.3\,\ell$. If you brush your teeth twice a day for a year, you may use almost $950\,\ell$ of water a year. How could you use less water when washing your hands?

Case No. 2 — What gases are in the atmosphere? How much of each gas is there?

CLUES:

The race is almost over. You are running at top speed. You are breathing heavily, and your heart is pounding. You have to finish the race! "Inhale!" you tell yourself. "Exhale!"

What gases do you think you just breathed in? Mostly, you inhaled nitrogen and oxygen, which make up 99 percent of the air. You also took in water vapor and dust particles. You may even have taken in some very small quantities of the gases argon, neon, helium, krypton, and xenon, as well as hydrogen, methane, ozone, nitrous oxide, and carbon dioxide. This combination might be called "air soup." The most vital ingredient for humans and other animals is oxygen.

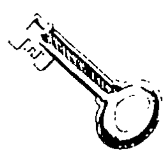
Investigation A: Pump Up the Volume.

All matter behaves in predictable ways — so predictable that scientists say that it follows laws. Here is a demonstration of one law concerning **air pressure**. The relationship between pressure and volume was discovered by a man named Robert Boyle in 1661.

<u>Materials Needed:</u>

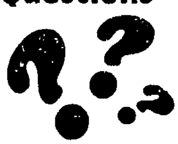
✓ **small latex balloon**

Procedure



Blow some air into the balloon and tie the end. Inflate it only slightly so that the balloon fits entirely into the palm of your hand. Hold the balloon in one hand and squeeze gently. If necessary, use both hands to contain the balloon completely.

Questions



❶ What happens to the **volume** of the air — the space it occupies — when you apply pressure?

❷ What happens when you release your hand?

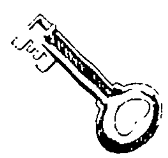
14

Investigation B: What Goes Around Comes Around.

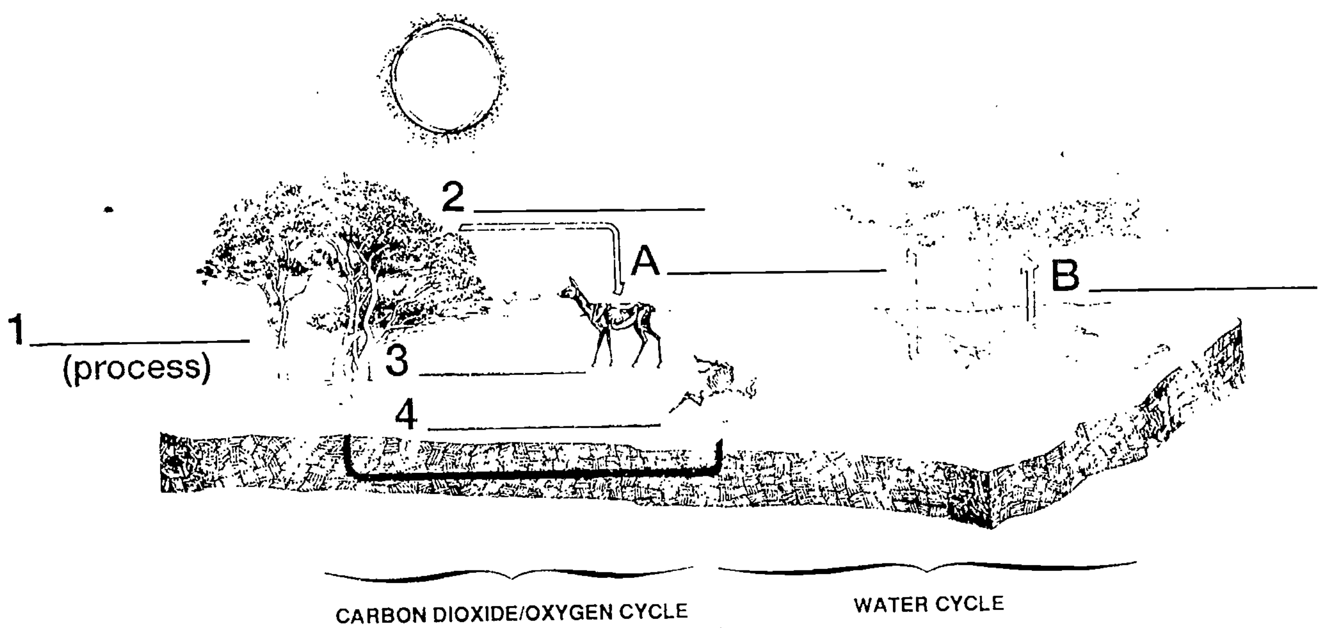
Who was the first recycler? It may surprise you to know that Nature originated that important process. Carbon dioxide and oxygen are recycled by plants and animals. During the solar-powered process called **photosynthesis**, green plants use carbon dioxide to make food and release oxygen. Animals use the oxygen produced by plants and exhale carbon dioxide. When animals and plants die and decay, carbon dioxide is released, providing **nutrients** and more essential gas for green plants. The carbon dioxide/oxygen cycle takes place on land and in lakes and oceans.

Water is recycled too, continually voyaging between land, the atmosphere, and bodies of water on and below Earth's surface. The Sun's powerful rays **evaporate** water, changing it from a liquid to a gas or **vapor.** As it rises and cools in the air, the vapor changes back to a liquid. It then falls to Earth as rain or may change to snow or sleet, depending on the temperature. Rain, snow, and sleet are called **precipitation**. On the ground, water may evaporate again, run off into streams, lakes, and oceans, or sink below Earth's surface. There, it may be taken up by green plants and used to produce food.

Procedure Using the word bank below and the information above, fill in the blanks on the illustration. Remember that this is a cycle.

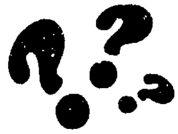


carbon dioxide	photosynthesis	precipitation (liquid)
oxygen	nutrients	evaporation (vapor)



Nature's balance is a delicate one and a change can alter the whole cycle. Add smokestacks to the picture to represent the burning of fossil fuels and the release of more carbon dioxide.

Questions



❶ What is the link between carbon dioxide, oxygen, and water in the illustration above?

❷ What might happen to the carbon dioxide/oxygen cycle when the smokestacks are added?

❸ If any element is changed, what happens to the rest of the cycle?

Investigator's Notebook: First Air Soup, Then Pie

Nitrogen makes up 78 percent of Earth's air. Oxygen makes up 21 percent. The remaining 1 percent is carbon dioxide, argon, water vapor, and the **trace gases** — those that exist in very small amounts, or traces. ATLAS instruments will precisely measure many of these rare but important gases.

These percentages and others are easier to understand if shown on a pie chart. Remember that a circle contains 360 degrees.

Materials Needed:

✓ **white construction paper**

✓ **protractor and pencil**

Procedure

To construct a pie chart, calculate 78 percent of 360 degrees. This is the number of degrees that will be in the nitrogen piece of the pie chart.

❶ Decimals. 0.78 x 360 = _______ Round answer to nearest unit = _______

❷ Fractions: 78/100 x 360 = ___________

Do the same with the remaining percentages:

OXYGEN

❸ ___________ : 0.21 x 360 = _______ Rounded = _______

❹ Fractions: ___________ x 360 = ___________

TRACE GASES/CARBON DIOXIDE/WATER VAPOR/ARGON

❺ Decimals: ______ x 360 = ______ Rounded = _______

❻ ___________ : 1/100 x 360 = ___________

With a compass, construct a circle with a radius of about 5 cm. Use a protractor to mark the sizes of the angles and construct your pie chart. Be sure to label the various "pieces" of the atmospheric pie.

Relating Science to . . .

Photography: Take color photographs or find pictures of a distant mountain or skyscraper on a clear day and a hazy day. Compare the two images. Notice that the colors on a hazy day are different. The mountain may be more blue than green.

What is in the atmosphere on a hazy day that would change the colors?

Helping Mother Earth

If you use products such as paint, hair spray, or deodorant that are packaged in aerosol cans, be sure to dispose of them safely. If you avoid puncturing the cans, you will help keep chemicals from entering the atmosphere.

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☛ Case No. 3 What is the structure of the atmosphere?

CLUES:

Earth has a "blender" atmosphere: except at high altitudes, the major chemicals in it are well mixed. The part of the atmosphere that you can reach out and touch is the **troposphere**, the lower part of the atmosphere where most clouds and weather occur. Humans can survive for limited periods of time above 8 km without their own air supplies, but the troposphere extends further upward about another 6 to 11 km. At the top of the troposphere, about 10 to 15 km above Earth's surface, is the **tropopause**, which divides the troposphere from the next layer.

Above the tropopause is the **stratosphere**, which rises to about 50 km above Earth. In this layer, ozone, a special form of oxygen, absorbs and scatters the Sun's harmful **ultraviolet** (UV) radiation. This important region is the scene of many chemical changes, so it is very interesting to ATLAS 1 scientists and others investigating the atmosphere.

The stratosphere and the next layer, the **mesosphere**, are called the middle atmosphere. The mesosphere begins just above the stratosphere and extends to 85 km above Earth. At about 100 km, primary ingredients in the atmosphere, such as nitrogen and oxygen, become less well mixed.

Above the mesosphere is the **thermosphere**, which reaches to about 600 km above our planet's surface. This part of the atmosphere is very thin — only one ten-millionth (0.0000001) as dense as the air at sea level.

A unique region called the **ionosphere** begins toward the top of the mesosphere and extends to the top of the thermosphere. In this region, there are many electrically charged particles called **ions** and **electrons**. Radio waves can be bounced off the electrons to send messages to distant parts of Earth. When bursts of energy erupt from the Sun (**solar flares**), the ionosphere is disturbed, and radio, telephone, and TV satellite communications can be disrupted.

Earth's magnetic field, called the **magnetosphere**, extends beyond the thermosphere into the vacuum of space. On the side of Earth facing the Sun, the magnetosphere extends outward to almost 9,660 km beyond Earth's surface. On the opposite side, where Earth's face is in darkness, the magnetosphere extends much farther.

ATLAS 1 instruments will measure gases from the troposphere to the thermosphere. These will be compared with earlier data and future measurements. Scientists will also examine the distribution of water vapor in the middle atmosphere. Other ATLAS 1 instruments will be used to study the upper regions and the interaction of these regions with the Sun.

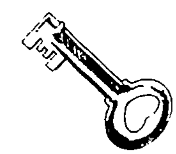
Investigation A: Air Planes

Earth's atmosphere is a rough sphere, thicker in some places than others. It even has large bulges. Scientists describe the atmosphere as existing in layers. To get an idea of how something might separate itself into layers, try this investigation.

Materials Needed

- ✓ **one package of layered gelatin dessert product, any flavor**
- ✓ **clear glass container(s)**

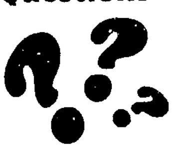
Procedure



Follow package directions to prepare gelatin. Pour into individual containers or one large container. Layers form in the gelatin because air that has been mixed into it rises as the product sits and cools. Like the atmosphere, the uppermost layers of the gelatin are the least dense.

Do not confuse the fluffy top layer of the gelatin with clouds; if this were the atmosphere, most clouds would appear in the lowest layer, directly above Earth's surface. Also, Earth's atmosphere has more layers than the gelatin, and our atmosphere's layers overlap, having no clearly defined boundaries.

Questions



❶ Which layer is the most dense?

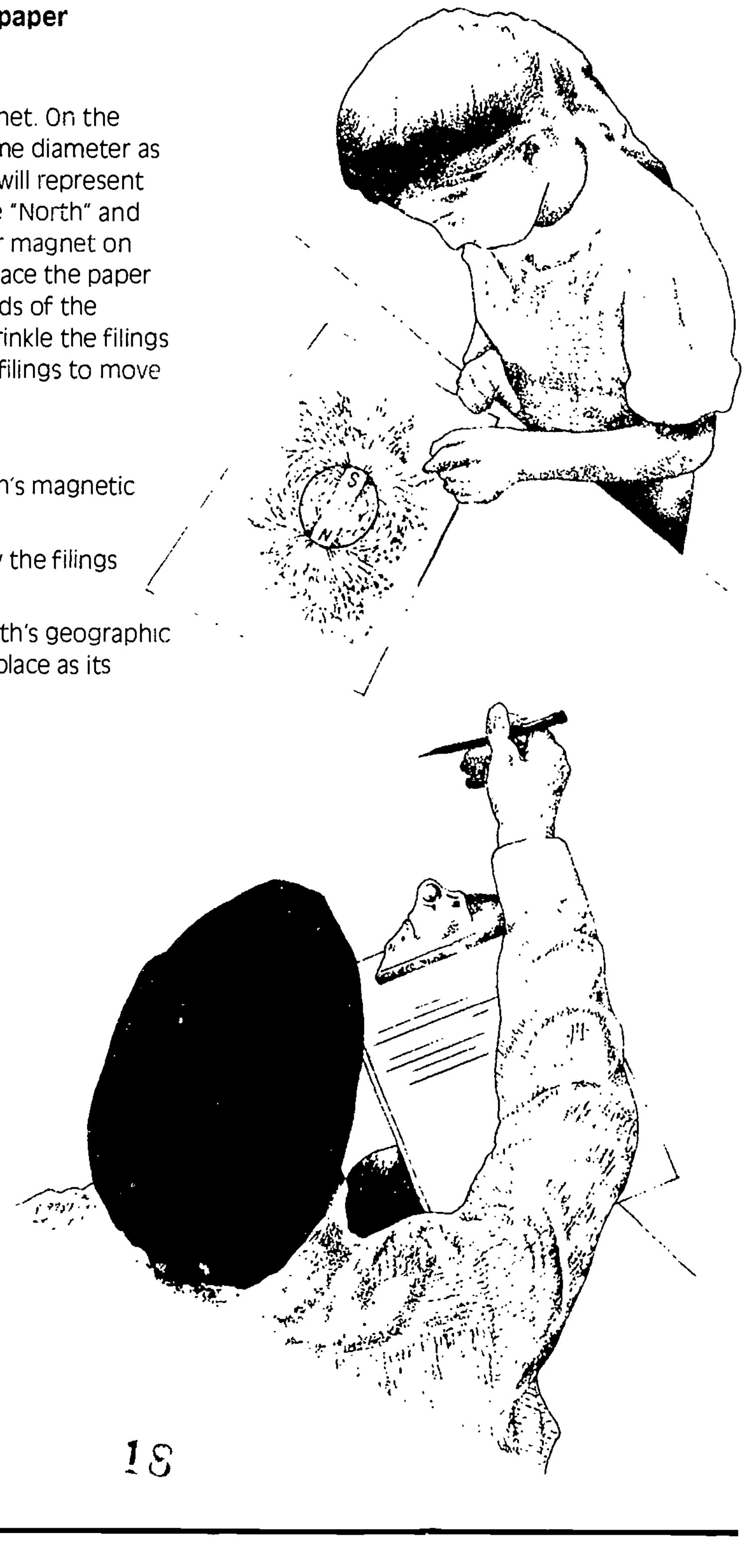
❷ What does this tell you about the part of the atmosphere that we breathe?

Investigation B: Behind Iron Bars

Earth's magnetic fields are not visibie to the naked eye, but when particles moving toward Earth interact with gas in the upper atmosphere, the light produced is sometimes visible as **auroras**. These are also called northern and southern lights. ATLAS 1 views these from space. You can get a general idea of the shape of the magnetosphere from this investigation.

Materials Needed

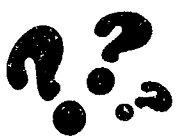
- ✓ **about 0.05 g of iron filings (a pad of coarse steel wool can be cut into fine pieces to substitute for iron filings)**
- ✓ **heavy white construction paper**
- ✓ **bar magnet**



Procedure

Measure the length of the magnet. On the paper, draw a circle with the same diameter as the length of the magnet. This will represent Earth. Mark the top of the circle "North" and the bottom "South." Lay the bar magnet on a flat surface, such as a table. Place the paper over the magnet so that the ends of the magnet are on the "North" and "South" marks. Sprinkle the filings over the paper. Gently tap the paper, allowing the filings to move Keep tapping until the pattern stops forming.

Questions



1. How can you tell where Earth's magnetic poles are?
2. What do the lines formed by the filings represent?
3. Look in an atlas to locate Earth's geographic poles. Are they in the same place as its magnetic poles?

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Investigator's Notebook: Hot Stuff

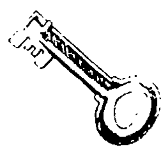
Because mountaintops are often covered with snow, most of us think that temperatures drop as we go higher into the atmosphere. This is true, up to a point. Within the troposphere, temperatures drop from about 17 °C to about -52 °C. At the tropopause, the decline in temperatures "pauses." In the stratosphere, ozone absorbs ultraviolet light. The energy from this reaction gives off heat, causing temperatures to gradually climb back up to -3 °C. Above the stratosphere is the mesosphere, the coldest layer, where temperatures drop to -93 °C. The next layer warms again: temperatures in the thermosphere may reach 1,727 °C.

Materials Needed

✓ **pencil**

✓ **colored pencils**

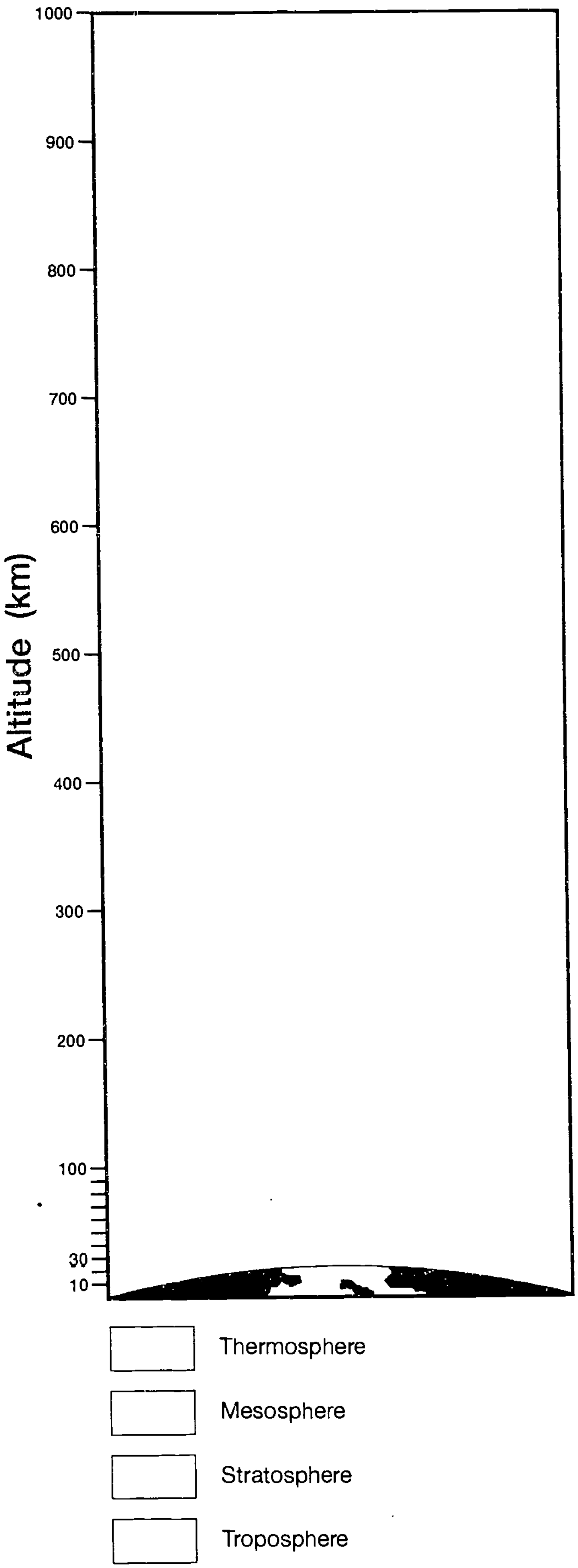
Procedure



On the left side of the chart, there are various altitudes shown. Use information from the **CLUES** section to draw lines to show where each layer begins and ends and label the layers. Now choose colors to represent each layer. Color the layers. Be sure to color the key shown at the bottom of the chart.

Questions

1. Which layer is the warmest? What color would be appropriate?
2. Which layer is the coldest? What color will you make it?
3. What colors will you choose for the remaining layers?
4. For the ATLAS 1 mission, the Shuttle orbits 296 km above Earth. In what layer does it travel?
5. Draw the Shuttle on the chart at the correct altitude. ATLAS 1 studies the middle and upper atmosphere. What layers do you think that includes?



Relating Science to . . .

Language: In a dictionary that gives word origins, look up the prefixes "trop-," "strat-," "mes-," and "therm-."

1. From what languages do these come?
2. What does each of them mean? Write another word that comes from each one of these roots. Work with a classmate to find the answers.

Here are some hints:

a. "trop" — the part of Planet Earth just above and below the equator: ______________________________

b. "strat" — a kind of cloud that looks as though it is layered: ____________________________

c. "mes" — the middle layer of human skin: ____________________________

d. "therm" — a kind of blanket that is very effective in holding in heat: ________________________ blanket

If you know these words in another language, share them with your class.

Helping Mother Earth

Releasing helium-filled balloons, sometimes containing messages, seems like an enjoyable activity, but balloons can be carried out onto the ocean from as far as the Midwest. Whales and turtles mistake the balloons for jellyfish and eat them, sometimes with harmful results. List three activities that communicate messages but do not harm the environment.

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☛ **Case No. 4**

Why is the atmosphere important?

CLUES:

Do you think that the essentials of life are food, TV, and lots of clothes? Food and clothing are essential, and TV is enjoyable, but there is something even more important: the atmosphere — the air we breathe. Human beings can survive only about 5 minutes without air, but because it is always there, odorless, tasteless, and invisible, we take it for granted. If you have ever flown in an airplane, you may have heard instructions for putting on an oxygen mask in case the cabin loses pressure. If that were to happen, the normal atmosphere of the airplane would be lost, exposing you to the very thin air at that altitude. Humans and other animals cannot survive without oxygen; green plants cannot survive without carbon dioxide. The atmosphere provides these essential gases.

Investigation A: Earth, Wind, and Fire

The gases in air are vital to life on Earth. Oxygen is necessary for **respiration**, or breathing, and is an element in water. Carbon dioxide is necessary for photosynthesis. Oxygen is also essential for **oxidation** processes, such as **corrosion** (rusting), and **combustion** (burning). To see one important function of oxygen, try this demonstration.

CAUTION. THIS ACTIVITY INVOLVES MATCHES. TEACHER SUPERVISION IS REQUIRED.

Materials Needed

- ✓ **small candle, about 8 cm high**
- ✓ **matches or lighter**
- ✓ **clear glass jar, about 1 ℓ**
- ✓ **flat pan, such as a pie pan, filled with about 0.5 mm of water**

Procedure

Light the candle and drip a puddle of wax about the size of a quarter into the center of the pan. Push the candle bottom into the wax and allow it to cool. This will hold the candle upright. Pour the water into the flat pan. Place the jar over the candle — the water will serve to seal the jar's edges. Watch the flame carefully.

Questions

1. What happened to the flame?
2. What could be some reasons why this happened?
3. What happened to the water?
4. Why did this happen?
5. Could you design an experiment to test the effects of lack of air on plants? What problems would be involved?

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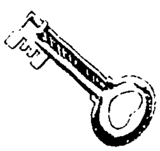
Investigation B: I Can't Take the Pressure!

High-altitude airplanes must be pressurized to maintain the normal atmosphere that humans breathe. Air pressure is the weight of the air above an object. Here is an activity to help you see how much air weighs CAUTION: THIS ACTIVITY INVOLVES MATCHES. TEACHER SUPERVISION IS REQUIRED.

Materials Needed

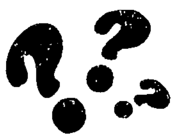
- ✓ **a cold, hard-boiled egg**
- ✓ **a jar with a mouth just slightly smaller than the egg**
- ✓ **about 5 mℓ of cooking oil**
- ✓ **one-half sheet of notebook paper**
- ✓ **matches**

Procedure



Peel the egg just before beginning. Wipe a little oil around the inside edge of the bottle. Set the egg on top of the bottle. Can you force the egg inside the bottle without crushing it? Now, remove the egg. Crumple the notebook paper and drop it in the bottle. CAREFULLY light a match and drop it onto the paper. Quickly replace the egg. Wait until the fire goes out.

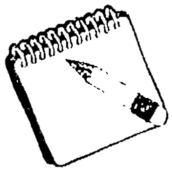
Questions



❶ What happens to the egg?

❷ Something pushed the egg into the bottle. What was it?

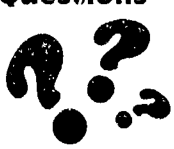
Investigator's Notebook: Element-ary, My Dear



The ATLAS 1 scientists make precise measurements of chemicals in the atmosphere. The gases are both **elements**, which are made up of **atoms**, and **compounds**, which are combinations of different kinds of atoms or **molecules**. Hydrogen and oxygen are elements. Elements have symbols: the symbol for an oxygen atom is O; the symbol for a hydrogen atom is H. When these elements are combined into compounds, their symbols are combined into **chemical formulas**. Water is a compound made up of hydrogen and oxygen. The formula for water is H_2O, because there are two atoms of hydrogen and one of oxygen in each molecule of water Following are some symbols and chemical formulas See if you can match them with the names of the elements and compounds in the second column.

CO_2	(1) ________	chlorine (element)
Ar	(2) ________	xenon (element)
N_2O	(3) ________	carbon dioxide (compound)
C	(4) ________	helium (element)
N	(5) ________	argon (element)
He	(6) ________	carbon (element)
Kr	(7) ________	nitrous oxide (compound)
Xe	(8) ________	ozone (a special form of the element oxygen)
Ne	(9) ________	krypton (element)
Cl	(10) ________	nitrogen (element)
O_3	(11) ________	neon (element)

Questions



1. How are the chemical formulas of the compounds different from the symbols for the elements?
2. Do you know any other chemical formulas?
3. Here are two formulas for some ordinary products. Ask a teacher or a parent or look them up in a chemistry book to find out what they stand for.

   a. NaCl b. $C_{12}H_{22}O_{11}$

Relating Science to . . .

History: Scientists have been investigating the mysteries of the atmosphere for thousands of years. Read an encyclopedia article on the atmosphere or look at Isaac Asimov's book *How Did We Find Out About the Atmosphere?* Make a timeline, marking the years when important discoveries were made. What were some discoveries made from space?

Helping Mother Earth

Is mowing the lawn one of your responsibilities? If so, have an adult set the mower blades about 5 to 7.5 cm high. Leaving grass a little long helps the lawn retain moisture so that it requires less watering, saving water. If you must water, do it early in the morning so that the day's heat does not evaporate the water too quickly.

☛ Case No. 5 If we wore oxygen masks, would we still need the atmosphere?

CLUES:

Not only would we look funny in oxygen masks, but they would not be enough to keep us alive without the atmosphere. Right now, the **global mean temperature** of Earth, the average of all temperatures around the globe throughout the year, is 15 °C. If we did not have the atmosphere, Earth would be like the Moon: very hot on the side exposed to the Sun and very cold on the other. Water vapor, carbon dioxide, and other gases in the atmosphere act like a filter, allowing the Sun's energy through to warm our planet and trapping Earth's reflected heat, making Earth the only planet in the solar system known to support life.

Too much heat is not good either, and the clouds in Earth's lower atmosphere reflect the Sun's visible light, helping keep the planet's surface from becoming too warm.

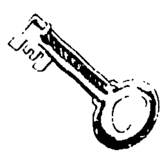
Investigation A: Life in a Goldfish Bowl

To see the effect of too little heat on animals, try this investigation. THIS ACTIVITY IS NOT HARMFUL TO THE FISH.

Materials Needed

- ✓ **two goldfish**
- ✓ **two 1-ℓ glass jars with quarters marked (canning jars work well)**
- ✓ **bottled or dechlorinated water to fill jars**
- ✓ **ice cubes made with bottled or dechlorinated water**

Procedure



Fill two jars half full with bottled or dechlorinated water. Allow the jars to sit until the water reaches room temperature, preferably overnight. Place one goldfish in each jar. Give the fish 10 to 15 minutes to get used to their environment. Observe each fish carefully for 1 minute, making a mark on a piece of paper for each noticeable movement (turns, dives, wiggles). Now, gently lower enough dechlorinated ice cubes into one of the jars to fill it to the three-quarter mark. The fish in this jar will be the **experimental** fish, the one whose environment is being changed. The other fish will be the **control**, the one whose surroundings will remain the same. Again, observe and record the activity level of each fish.

Questions

❶ Does the activity level of the experimental fish change?

❷ Because goldfish are cold blooded, they enter a state similar to hibernation when placed in a cold environment. Warm-blooded animals do not adapt to such temperature drops as quickly as cold-blooded creatures. What do you think would happen to many species of plants and animals if the temperature were to drop all over the planet?

Do not try to reheat the water; allow it to return slowly to room temperature. Return the fish to their aquarium.

Investigation B: Through the Magnifying Glass

To demonstrate the existence of the Sun's energy, try this experiment.
CAUTION: TEACHER SUPERVISION IS REQUIRED. PAPER MAY BURN.

Materials Needed

✓ **magnifying glass**

✓ **white notebook paper**

Procedure

Use the magnifying glass to focus the Sun's rays onto the piece of paper. CAUTION: DO NOT LOOK DIRECTLY AT THE POINT OF LIGHT, DO NOT PUT YOUR HAND UNDER THE POINT OF LIGHT. Move the glass up and down until you produce the smallest circle possible. Hold the magnifying glass steady.

Questions

❶ What happens to the paper?

❷ What clues might a sight-impaired person have about what has happened to the paper?

Investigator's Notebook: What a Gas!

Carbon dioxide, methane, nitrous oxide, and ozone are among the gases that trap energy and warm Earth. They make up only 1 percent of the gases in the lower atmosphere, but they are very effective heat collectors. For a colorful view of just how rare they are, try this activity.

Materials Needed

There will be enough beans, peas, and corn to fill several jars.

✓ **one 340-g package of dried kidney beans**

✓ **one 340-g package of dried corn**

✓ **one 340-g package of dried green peas**

✓ **one 1-ℓ glass jar with lid**

Procedure

(If you have already done the **Investigator's Notebook** activity **First Air Soup** . . ., p. 6, use the totals there to count out beans to represent nitrogen, corn to represent oxygen, and peas to represent trace gases.)

Air is not usually measured in liters or grams, so imagine that you want to mix up 300 "parts" of air. Nitrogen makes up 78 percent of the lower atmosphere, so calculate 78 percent of 300:

0.78 x 300 = ________

Count out that many beans to represent nitrogen.

Now, calculate the parts of oxygen by finding 21 percent of 300, since oxygen makes up 21 percent of the lower atmosphere.

0.21 x 300 = ________

Count out that many pieces of corn to represent oxygen.

Trace gases are only 1 percent of the atmosphere. Calculate the parts of trace gases and count out that many peas to represent these gases.

0.01 x 300 = ________

Put all the measured parts of beans, corn, and peas into the jar, screw the lid on firmly, and shake.

Questions

❶ Does it take very much carbon dioxide or other trace gases to warm the atmosphere?

❷ Can you find the peas that represent the trace gases?

❸ If humans add more carbon dioxide or other trace gases to warm the atmosphere, what happens?

❹ You shook the jar to mix the gases. How does Nature mix the gases?
[Hint: See the **CLUES**, for **The Scene: Case No. 3**, p. 7.]

Relating Science to . . .

Literature: A poet named Theodore Roethke grew up spending much time in his father's greenhouse where he came to appreciate the importance and beauty of growing things, both plants and animals. Read his poem *The Cycle*. What cycle is Roethke referring to? You might also want to read works by the Native American writer Leslie Marmon Silko.

Art: Illustrate one of Roethke's or Silko's poems.

Spanish: *Sol* is the name of a star in our galaxy, the Milky Way. In a Spanish dictionary, look up *Sol*. What does it mean? Why would ATLAS 1 instruments study the amount of energy produced by *Sol*?

Helping Mother Earth

NASA's missions, such as ATLAS 1, the Upper Atmosphere Research Satellite, and the Earth Observing System, are used to study the atmosphere. Individual instruments, like NASA's Total Ozone Mapping Spectrometer, are also used to monitor Earth's atmosphere — the essential ocean of air that surrounds us. Just as the atmosphere is our home, our planet's oceans are home for thousands of species of marine animals. Human activities can influence these animals' home. Plastic six-pack rings, for example, left on beaches or dumped into waterways with other garbage are harmful to birds, sea lions, and seals.

When you throw a six-pack ring away, cut each of the rings with scissors so that animals cannot become tangled in them. If you see the rings on the beach, cut them and then throw them in a trash container.

☛ Case No. 6 In what other ways is the atmosphere essential?

CLUES:

The atmosphere is Earth's "sunscreen." The wavelengths of energy given off by the Sun vary from the long, low-energy **radio waves** to the very short, highly energetic waves of **gamma rays**. The atmosphere is transparent, like glass, to radio waves, shorter **infrared rays**, and visible light traveling to Earth from the Sun. Fortunately, the atmosphere blocks all the deadly gamma rays and **X-rays**, and most of the harmful UV radiation. Too much UV radiation burns skin and eyes and causes skin cancer. This is why people must wear sunscreens and protective clothing in sunlight. Plants can be affected, too: plants exposed to large amounts of UV radiation can be seriously damaged. Scientists are doing extensive research to discover all the effects of UV radiation on both animals and plants.

ATLAS 1 instruments use UV and infrared radiation to help investigate the atmosphere. They also perform research on the ozone layer, which blocks harmful UV radiation.

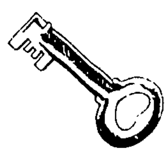
Investigation A: The Energizer

Visible light is only a tiny part of the different wavelengths of energy that come to us from the Sun. We cannot see the longer and shorter wavelengths on either side of the part of the **electromagnetic spectrum** that is produced when a prism breaks up visible light. Certain wavelengths are blocked by the atmosphere. To see how this occurs, try this demonstration. If your classroom does not have windows, find another location that does. This activity cannot be done outside because of the sensitivity of the blueprint paper. CAUTION: BE SURE TO PROVIDE ADEQUATE VENTILATION WHEN USING AMMONIA. A LABORATORY HOOD OR VENT FAN IS BEST.

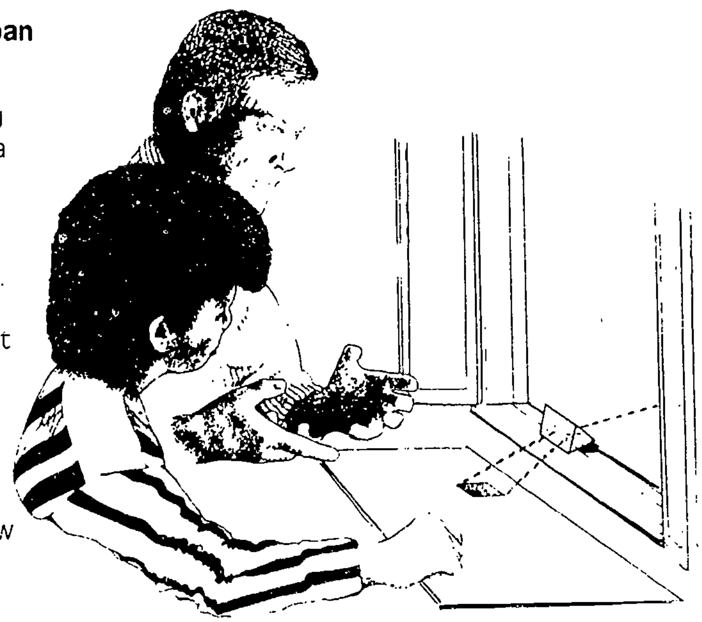
Materials Needed

- ✓ **a prism, mirror in a pan of water, or any object that will produce a spectrum**
- ✓ **several sheets of blueprint paper (available at most print shops)**
- ✓ **1 ℓ of household ammonia**
- ✓ **small flat pan, such as a pie pan**
- ✓ **light source**

Procedure



Using a prism and sunlight coming through an OPEN window, create a spectrum on a horizontal surface, such as a table. The prism should be resting on a stable object so that the spectrum does not move. Working as quickly as possible to prevent exposure of the paper to too much light, cut a piece of blueprint paper about four times larger than the spectrum. Place the blueprint paper so the spectrum falls on its center. Quickly outline the area covered by the spectrum with a felt-tip pen. Label the violet end. Pour just enough ammonia into the pan to cover the bottom. In front of an open window or beneath a vent fan, hold the paper over the ammonia so that the fumes will process the paper. Do not breathe the fumes.



Now, repeat the experiment exactly but use light from a CLOSED window. Compare the marks on the paper left by the spectra.

Questions

1. How are the two marks different?
2. Has the glass affected the radiation?

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Investigation B: SPF

Because ultraviolet radiation is damaging to skin, everyone should wear sunscreens. Fair-skinned people are most likely to be harmed, but dark-skinned people can also burn. How protective a sunscreen should you buy? These oils and lotions are rated by manufacturers by SPF, or sun protection factor. What does SPF mean? It means different things for different people, depending on the sensitivity of their skin. The SPF number on a sunscreen means that you can stay in the Sun that many times longer than usual without burning.

For example, if you usually burn after one-half hour in the Sun, a sunscreen with an SPF of 4 would allow you to stay exposed to sunlight for 2 hours. If you burn after 15 minutes, you could extend your stay in the Sun to only 1 hour.

Calculate how long a person could stay in the Sun according to these SPFs. Multiply the length of time by the SPF factor to get the new time limit.

Can stay in the Sun without burning	SPF	New time limit
15 minutes	4	(1) ________
	8	(2) ________
	10	(3) ________
	15	(4) ________
30 minutes	4	(5) ________
	8	(6) ________
	10	(7) ________
	15	(8) ________
1 hour	4	(9) ________
	8	(10) ________
	10	(11) ________
	15	(12) ________

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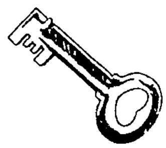
Investigator's Notebook: Making Rainbows

Do you know what the speed of light is? Do you know that light energy is made up of particles that travel in waves? All light energy travels at the rate of 300,000 km per second. The particles move at different **frequencies** or number of waves per second, depending on the source. Seven general categories of energy frequencies make up the spectrum. Moving from low-frequency to high-frequency categories, they are: radio waves, **microwaves**, infrared waves, visible light waves, ultraviolet waves, X-rays, and gamma rays. Each is able to penetrate Earth's sheltering atmosphere to a different altitude. Radio waves travel from space to Earth's surface. Microwaves, having a somewhat higher frequency, are absorbed by the atmosphere about 50 km above Earth, and most infrared radiation is absorbed by about 12 km. How close to Earth do you think visible light travels? Much of the ultraviolet is scattered by the atmosphere at about the same altitude as microwaves, but some still passes through to reach Earth. X-rays, which could severely damage living creatures on Earth, go no farther than about 30 km above infrared. Gamma rays, even more dangerous to humans than X-rays, extend approximately 10 km closer than X-rays but still do not reach Earth.

Procedure

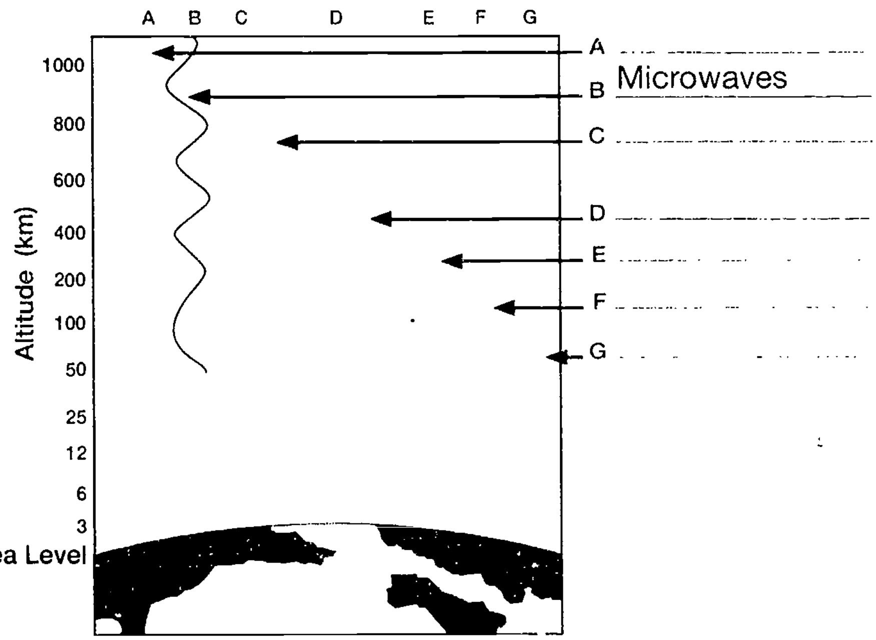


Draw lines to represent each of the seven frequencies of light, stopping at the altitudes indicated in the paragraph above. Not each of the altitudes is given; you will have to read carefully and perform some calculations to know where to stop above Earth's surface. The line for microwaves is given for you in the illustration. Be sure to put more "waves" in the lines for higher frequencies.

Questions

❶ The Space Shuttle carrying ATLAS 1 instruments will orbit at 296 km above Earth to study the atmosphere. What energy frequencies will it encounter?

❷ What kinds of special equipment might be needed to protect the scientists and astronauts in the Shuttle from exposure?



Relating Science to . . .

Art: Sometimes you can see the colors contained in visible light after a storm. Where does this occur? Draw the object being described.

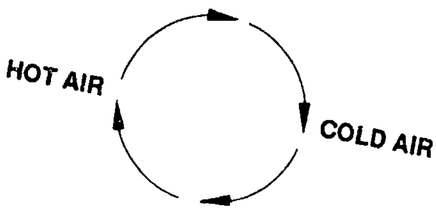
Helping Mother Earth

Lights use one-fifth of all electricity consumed in the United States. To produce more electricity, we burn more fossil fuels in power plants. As more fossil fuels are burned, more greenhouse gases are released. To save electricity, turn off lights when they are not being used.

☛ Case No. 7 — How does the atmosphere affect the weather?

CLUES:

One of the things that influences weather is **air currents**, which are produced by uneven heating of Earth's surface. When air is heated, its density changes. Heat causes the air to expand and become less dense. The air then rises, leaving an area of low pressure. Because the cooler air higher in the atmosphere is more dense, it sinks and replaces the air that has risen, creating an area of high pressure. When this new air sinks toward Earth, it is warmed, and the cycle continues. The replacement of the warmed, less dense air by cooler, more dense air is called a **convection current**, or wind. Convection currents also occur in the oceans.



Investigation A: In Hot Water

The convection currents responsible for much of Earth's weather take place because warm air is less dense than cool air and rises.

❶ Why is warm air less dense?

❷ Formulate a hypothesis, then try this investigation.

CAUTION: BECAUSE VERY HOT WATER IS USED,
THIS SHOULD BE DONE ONLY WITH ADULT SUPERVISION.

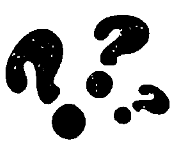
Materials Needed

✓ **two 200-mℓ drinking glasses**
✓ **eye dropper**
✓ **very cold milk**

Procedure

Fill the first glass about half-full with water and place in a freezer for about 10 minutes. Put about the same amount of very hot water into the second glass. Fill the eye dropper with milk and gently place four drops of milk on the surface of the water in each glass. Observe carefully for about 3 minutes, watching for signs of mixing.

Questions



❶ In which glass did the milk mix most quickly with the water?

❷ What does this tell you about the motion of heated water molecules as compared to cooled water molecules?

❸ What might be seen coming off the surface of the very hot water?

❹ Why?

Investigation B: Full of Hot Air

This investigation will help you see the next step in convection.
CAUTION: BECAUSE VERY HOT WATER IS USED, THIS SHOULD BE DONE ONLY WITH ADULT SUPERVISION.

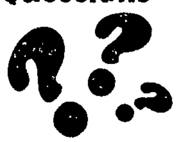
Materials Needed

- ✓ **small latex balloon**
- ✓ **rubber bands**
- ✓ **0.5-ℓ glass or plastic bottle (large salad dressing bottles work well)**
- ✓ **VERY hot water**
- ✓ **large rectangular pan, about 33 x 23 cm**

Procedure

Attach the mouth of the balloon to the top of the bottle. If necessary, use rubber bands to ensure a tight fit. Pour the hot water into the pan to about 2.5 cm from the top. CAREFULLY place the bottle in the hot water. It may be necessary to hold the bottle down.

Questions



1. What happens to the air in the bottle?
2. How can you tell?
3. What part of the convection process was demonstrated?

Investigator's Notebook: Are You Dense?

What does *dense* mean? A 1-cm cube of sugar is much less dense than an identical cube of lead. **Density** is the relationship between **mass**, the amount of matter in an object, and **volume**. Volume is the amount of space an object occupies. This relationship can be expressed in an equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Mass is usually expressed in grams, and volume is expressed in milliliters or cubic centimeters. This means that the answer, density, is expressed in grams per milliliter, written $\frac{g}{m\ell}$ or grams per cubic centimeter $\frac{g}{cm^3}$.

If a substance has a mass of 8 g and a volume of 4 cm³, what is its density?

$$\text{density} = \frac{8\ g}{4\ cm^3} \qquad \text{Reduced to lowest terms, density} = \frac{2\ g}{cm^3}$$

Do these other density problems. The last is a challenge problem.

1. mass = 12 g
   volume = 6 cm³
   density = $\_\_\_\_\ \frac{g}{cm^3}$
2. mass = 3 g
   volume = 2 mℓ
   density = $\_\_\_\_\ \frac{g}{m\ell}$
3. mass = ____ g
   volume = 5 cm³
   density = $\frac{3\ g}{cm^3}$

Relating Science to . . .

Spanish: *El Niño* is a powerful climate pattern that results from the interaction of the Pacific Ocean with the atmosphere. *El Niño* occurs irregularly, about every 3 to 5 years, and creates widespread changes in weather, such as flooding rains and droughts. Scientists are hoping to learn more about weather by studying *El Niño*. In a Spanish dictionary, look up the word *niño*. What does it mean? Why do you think a weather pattern was given this name?

Creative Writing: Create a story explaining how *El Niño* got its name.

Art: Illustrate your *El Niño* story or draw a picture of things affected by air currents. Include both living and non-living things, such as birds, airplanes, balloons, and kites.

Helping Mother Earth

Glass, like the bottle used in **Investigation B, Full of Hot Air**, p. 21, can be recycled. Find out if your community recycles glass. If it does, keep a large, covered plastic pail outside for storage. Sort clear, green, and brown glass, removing metal or plastic caps. Recycling glass saves energy and conserves natural resources. If your recycling program pays for collected glass, you may be able to earn extra funds for class activities.

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Answers: The Scene

CASE #1 ANSWERS

Investigation A

❶ No, the ruler does not balance. ❷ The inflated balloon weighs more. ❸ Air has weight. ❹ Correctness depends on student's hypothesis.

Investigation B

❶ No, the tissue does not get wet ❷ It does not get wet because the air trapped in the glass keeps the water out.

Investigator's Notebook

Abbreviations

Metric Distance	Metric Volume	Metric Mass
(1) Given	(1) ℓ	(1) kg
(2) m	(2) milliliter	(2) gram
(3) centimeter		(3) milligram
(4) millimeter		

Prefixes

(1) kg (2) Given (3) 0.01, centimeter, cm (4) 1/1000, mℓ

Equivalents

(1) 1 kilogram = 1,000 grams (2) 1 decimeter = 1/10 or 0.1 of a meter (3) 1 milligram = 0.001 of a gram

Relating Science to . . .

Music: Hearing-impaired students may want to "feel" the music by holding an inflated balloon on the speaker while the music is playing Encourage hearing students to feel the music, too.

Social Studies: Student answers would include the United States, Canada, Honduras, Ecuador, Chile, Japan, the Philippines, Australia, etc

CASE #2 ANSWERS

Investigation A

Note to Teacher: This is a good activity for sight-impaired learners and those requiring tactile/kinesthetic learning activities.

❶ If the balloon was contained completely in the palm, students should be able to feel an increase in pressure as volume is decreased. **Note to Teacher:** Have students state findings in the form of a law: as pressure on the balloon increases, its volume decreases

❷ When the balloon is released, pressure decreases and volume increases

Investigation B

Illustration

1. photosynthesis 2. oxygen 3. carbon dioxide 4. nutrients a. precipitation b. evaporation

Questions

❶ Carbon dioxide, oxygen, and water are all part of the important plant process of photosynthesis. Animals eat plants and need water. All three operate in the same environment All three are essential for life.

❷ It is no longer balanced

❸ A change in any one element can affect the others.

Investigator's Notebook

NITROGEN

❶ Decimals. 280.8 degrees; round off to 281 degrees

❷ Fractions: 280 4/5 degrees

OXYGEN

❸ Decimals: 75.6 degrees; round off to 76 degrees

❹ Fractions: 21/100 75 3/5 degrees

TRACE GASES

❺ Decimals: 0.01; 3.6 degrees; round off to 4 degrees

❻ Fractions 3 3/5 degrees

Note to Teacher: Explain to students that the total for these is 361 degrees because each number has been rounded up. Fractional answers can reinforce the concept that gases in the atmosphere do not exist in precise quantities.

Relating Science to . . .

Photography: Dust in the atmosphere bends and scatters light and changes the colors.

CASE #3 ANSWERS

Investigation A

❶ The bottom layer is the most dense. ❷ The total density of the atmosphere decreases with increasing altitude. The troposphere, which surrounds us on Earth's surface and provides the air we breathe, is the densest layer of the atmosphere.

Investigation B

❶ Earth's magnetic poles will be shown as north and south poles of the magnet. ❷ The lines represent Earth's magnetic field. ❸ No, Earth's magnetic poles are not in the same locations as its geographic poles.

Investigator's Notebook

❶ The thermosphere is the warmest — a "hot" color, such as red or orange. ❷ The mesosphere is coldest — a "cold" color, such as blue or green. ❸ The troposphere could be a medium color, such as light green or peach; the stratosphere should be a warmer color. ❹ The Shuttle travels in the thermosphere during the ATLAS 1 mission. ❺ ATLAS studies the middle atmosphere (the stratosphere and mesosphere) and the upper atmosphere (the thermosphere and ionosphere).

Relating Science to . . .

Language: ❶ Greek and Latin. ❷ "Trop" from Greek means turn or curve. "Strat" from Latin means spread out or scatter. "Mes" from Greek means in the middle. "Therm" from Greek means heat.

Hints: **a.** tropics **b.** stratus **c.** mesoderm **d.** thermal

CASE #4 ANSWERS

Investigation A

❶ After a few seconds, the flame went out. ❷ Oxygen ran out, or the carbon dioxide emitted during combustion extinguished the flame before the oxygen was used up. ❸ Water was forced out; then more came back in. ❹ Water was forced out by heat. More water came back in as the air cooled and became less dense, decreasing pressure. ❺ Individual answers. Possible: Yes, but it would be difficult because if they are without air, how could you water them? Which would plants die from, lack of air or water?

Investigation B

❶ The egg is pushed into the bottle. ❷ The weight of the air above the bottle was greater than the weight inside it. The flame heated the air so that it expanded, moving out of the bottle past the egg. When the flame went out, the air inside the bottle cooled and became less dense than the air outside the bottle. The denser, heavier air pushed the egg down into the bottle. This weight is called air pressure

Investigator's Notebook

(1) Cl—chlorine (2) Xe—xenon (3) CO_2—carbon dioxide (4) He—helium (5) Ar—argon (6) C—carbon
(7) N_2O—nitrous oxide (8) O_3—ozone (9) Kr—krypton (10) N—nitrogen (11) Ne—neon

Questions

❶ Formulas for compounds have at least two capital letters and sometimes have numbers ❷ Individual answers.
❸a. NaCl — sodium chloride (table salt) ❸**b.** $C_{12}H_{22}O_{11}$ — sugar

CASE #5 ANSWERS

Investigation A

❶ The experimental fish moves less and moves more slowly. ❷ Individual answers should suggest less activity, gradual physical changes, perhaps extinction of some species.

Investigation B

❶ The paper heats and may turn brown and smoke. ❷ A sight-impaired person would not see the effect but might smell the smoke

Investigator's Notebook

Nitrogen = 0.78 x 300 = 234 Oxygen = 0.21 x 300 = 63 Trace Gases = 0.01 x 300 = 3

❶ No. Trace gases are very effective. ❷ Students observe jars and answer. ❸ More carbon dioxide will probably increase warming — "enhanced greenhouse effect." ❹ Gases are mixed by Earth's winds.

Relating Science to . . .

Literature: The water cycle.
Spanish: *Sol* is Spanish for Sun. It is related to this lesson because it is the Sun's energy that warms Earth, making life possible.

CASE #6 ANSWERS

Investigation A

❶ The mark left from the open-window experiment shows exposure in the UV range; the mark from the closed-window experiment does not **Note to Teacher:** Experiment results are noticeable but not dramatic. Differences between spectra will be subtle ❷ Glass blocks UV radiation.

Investigation B

(1)	15 minutes x 4 = 1 hour	(9)	1 hour x 4 = 4 hours
(2)	x 8 = 2 hours	(10)	x 8 = 8 hours
(3)	x 10 = 2 hours, 30 minutes	(11)	x 10 = 10 hours
(4)	x 15 = 3 hours, 45 minutes	(12)	x 15 = 15 hours
(5)	30 minutes x 4 = 2 hours		
(6)	x 8 = 4 hours		
(7)	x 10 = 5 hours		
(8)	x 15 = 7 hours, 30 minutes		

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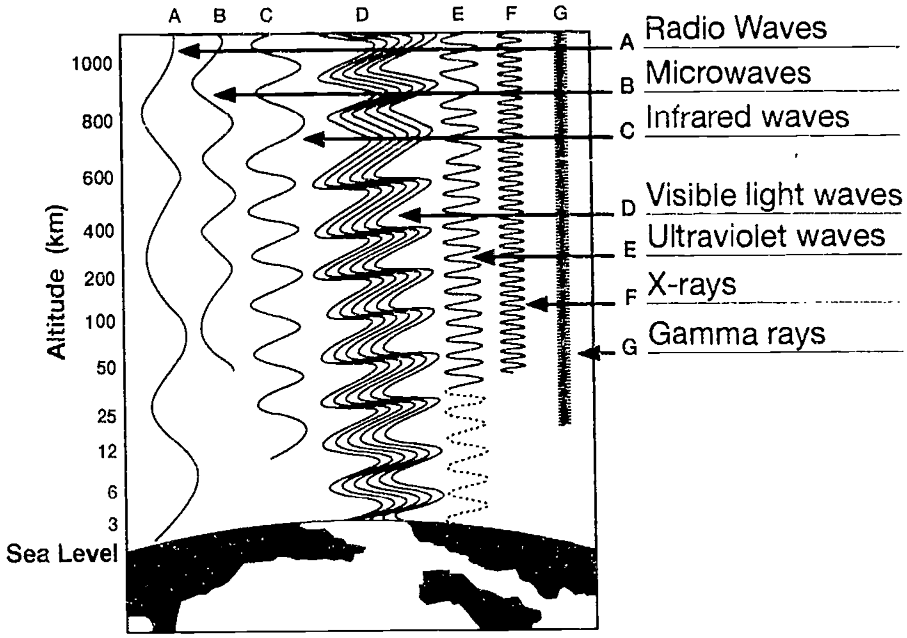
Case #6 Answers continued on next page. ➔



Questions

❶ The Space Shuttle will encounter all light frequencies ❷ Open-ended question. Possible answers are that astronauts would be protected by the Shuttle's metal skin. Special glass is used in the Shuttle's windows. If astronauts travel outside the Shuttle, they are somewhat protected by spacesuits but probably cannot remain outside too long.

Relating Science to . . .

Art: In a rainbow

CASE #7 ANSWERS

Investigation A

❶ The molecules of warm air contain more energy than the molecules of cool air and move farther apart.
❷ Student answers will vary.

Questions

❶ Hot-water glass. ❷ Heated water molecules are moving more than cooled water molecules ❸ Hot water might give off steam. ❹ Water molecules are heated to the point where they change from the liquid phase to the gas phase.

Investigation B

❶ Air in the bottle expands. ❷ You can tell because it expands to fill the balloon. ❸ The part of convection shown was the heating and rising of air.

Investigator's Notebook

❶ 2g/cm³ ❷ 1.5g/mℓ ❸ 15 g

Note to Teacher: To help students experience the concept of density, try this activity:

Materials Needed

✓ two shoe boxes, exactly the same size
✓ enough marshmallows to fill one box
✓ enough nails, sand, or dirt to fill one box

Procedure

Fill each box and replace the lids Place both boxes on a desk or table. Ask students to hypothesize about the weight of the boxes. Then ask a student to push each box 12 cm along the tables, using only one finger.

Questions

❶ Do the boxes occupy the same volume? (Yes) ❷ Do they have the same mass? (No) ❸ Do they have the same density? (No)

Relating Science to . . .

1. Male child. 2. Have students research the answer.

The Crime:

Harming the Atmosphere

☛ Case No. 1 What is the "greenhouse effect"? Is it bad?

CLUES:

You have probably heard the term on the TV or radio news. You may have heard it in the classroom — the "greenhouse effect." What is it? A greenhouse is a glass building in which young plants are raised. The glass allows sunlight to penetrate the greenhouse and warm the plants while it keeps cold air out. Our atmosphere creates a kind of "greenhouse" for us, providing a warm planet. Without this atmospheric greenhouse effect, we could not live here at all.

Because plants and animals on Earth have evolved and exist comfortably in a certain temperature range, some scientists are concerned about an "enhanced," or increased, greenhouse effect that would create temperature increases great enough to change life on Earth. Not even scientists are sure what all the effects of an even warmer greenhouse would be. Researchers think that temperature increases in the troposphere could range from 1.6 to 5 °C over the next 30 or so years. This seems very slight, but a *decrease* of the same amount would put our planet in another ice age.

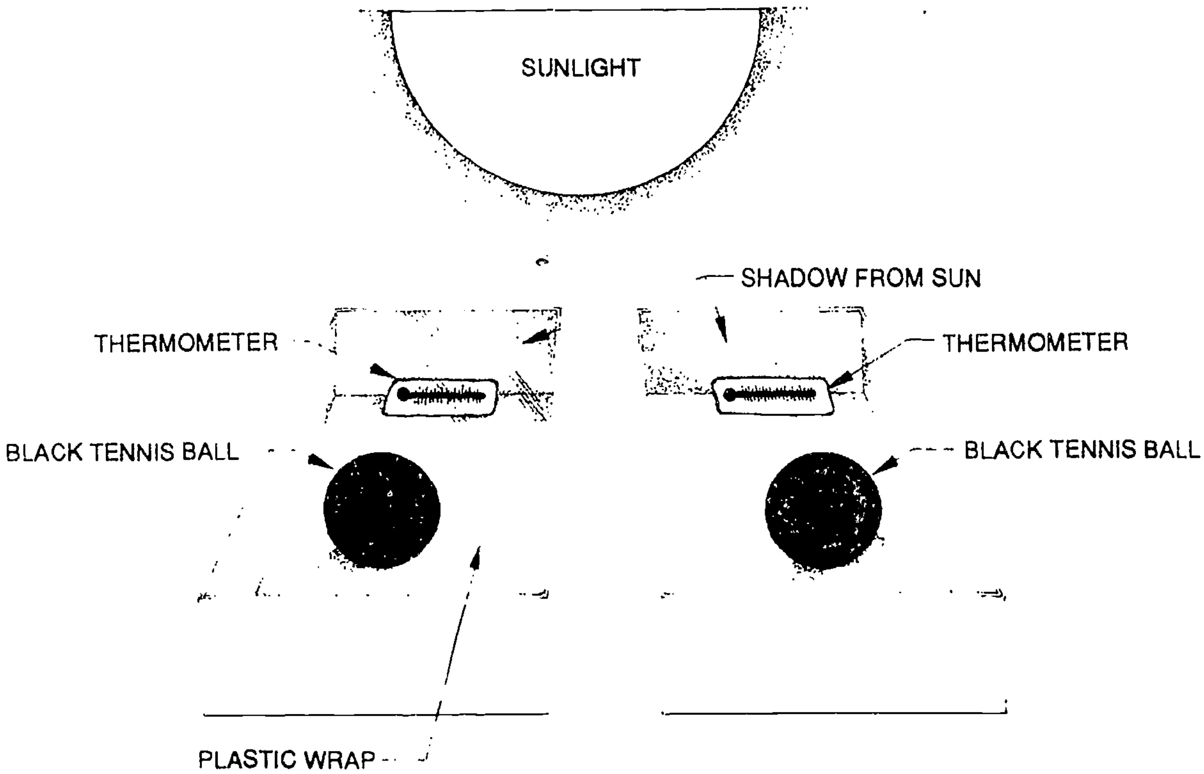
During the 1980s, Earth experienced four of the hottest years ever recorded. Heat-absorbing carbon dioxide in the atmosphere has increased by 25 percent since 1860, the height of the Industrial Revolution. The temperature changes have followed predictions: greater warming in winters than in summers; greater warming at high latitudes; cooling in the stratosphere.

Investigation A:
People Who Live in Greenhouses . . .

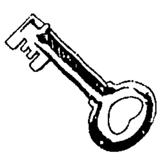
To see how a greenhouse works, try this investigation.

Materials Needed

- ✓ black paint or two pieces of black construction paper
- ✓ two old tennis balls
- ✓ two cardboard shoe boxes, sides cut down to about 10 cm high (higher sides will block sunlight)
- ✓ two weather thermometers
- ✓ clear plastic flexible wrap, about 30 x 30 cm



Procedure



Paint the tennis balls black or wrap each in black construction paper. Place the balls toward the short sides of each box, anchoring underneath with tape if necessary. Place the boxes in the sunlight at an angle to create shadows at one end of both boxes while leaving the balls directly in the sunlight. Prop one thermometer horizontally in the shadow at the top of each box. Tightly cover one box with the clear plastic wrap.

After 10 minutes, write down the two temperature readings.

Questions

1. Was there a temperature difference?
2. What effect does the clear wrap have on the temperature?
3. How is the clear glass in a greenhouse similar to the atmosphere?
4. How is it different?
5. What does this investigation tell you about the temperature inside closed, parked cars?
6. Should pets or children be left in closed cars?

Investigation B: . . . Shouldn't Wear Black.

An overefficient greenhouse would become too warm. To see the effects of too much heat on plants, build a small greenhouse.

<u>Materials Needed</u>

- ✓ **two planted seedlings (bean, tomato, or another plant)**
- ✓ **two 1-ℓ glass jars**
- ✓ **black construction paper**

Procedure

Put one seedling in each glass jar. Place one jar on a piece of black paper and cover lightly with another piece. Rest the control jar on a lighter colored surface and do not cover. Place both jars in direct sunlight. Results should be visible in one day.

Questions

1. Why was black paper used?
2. What happens to the plants in the jar covered with black paper?
3. Why?
4. What might happen to animals subjected to an overefficient greenhouse?

Investigator's Notebook: Checking the Temperature

Temperature changes predicted by scientists might be enough to make Earth feel like an overefficient greenhouse. To see what these temperatures might be like, try this activity.

<u>Materials Needed</u>

- ✓ **computer images**
- ✓ **colored pencils or crayons**

Procedure

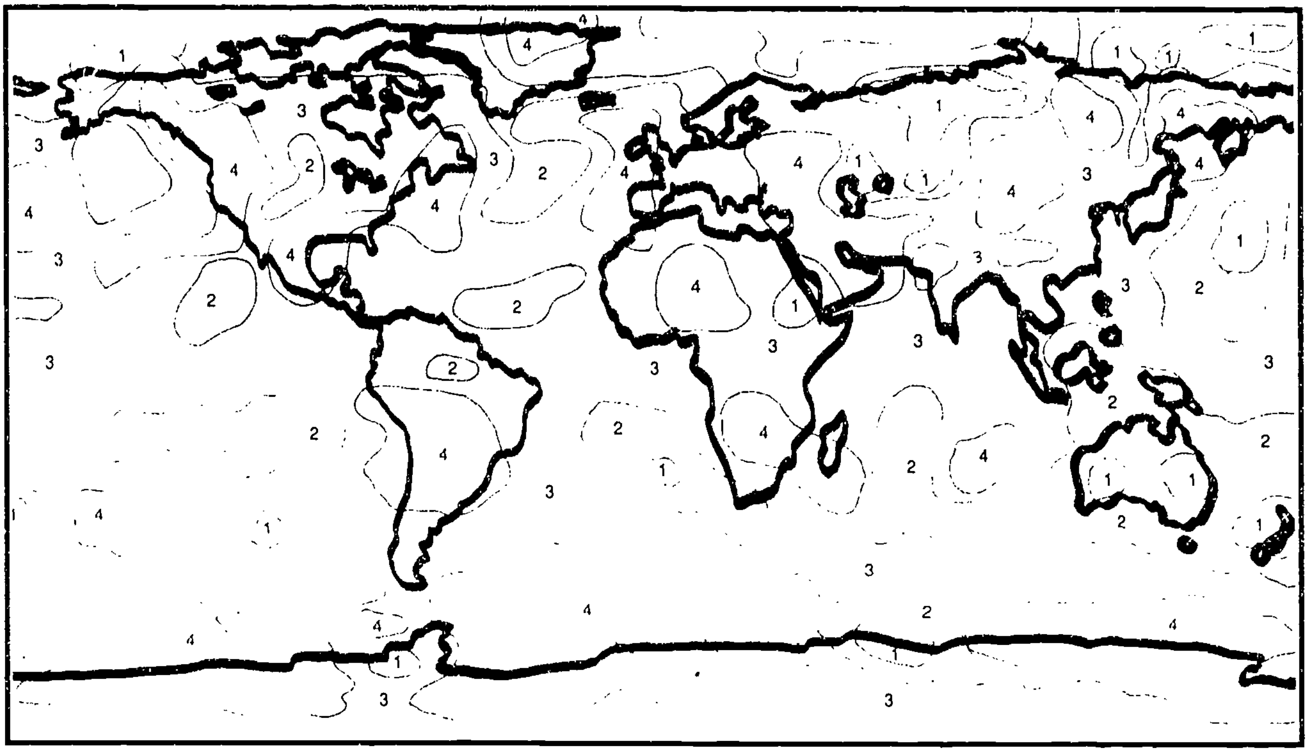
On page 29 are two computer images. Image A shows temperature conditions in July 1987. The areas without numbers were not experiencing climate changes at that time Areas with the number 1 were cooling. Regions labeled 2, 3, or 4 were warming from 2 to 9 °C.

Many scientists predict that some parts of Earth will warm in the future. These possible changes are shown in Image B. Use the key to color the maps.

Questions

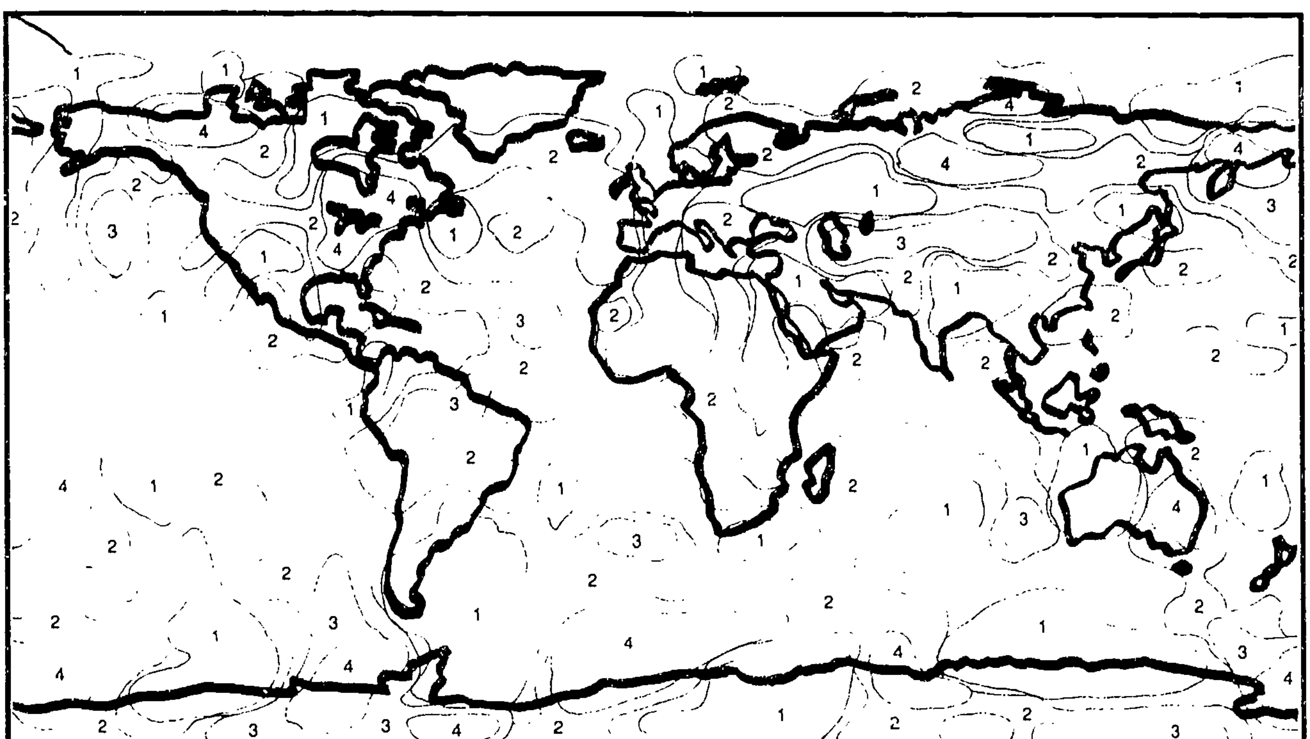
1. Check an almanac to find the temperature range in your region of the U.S. in 1987.
2. If you live in a region where there may be warming in the future, what do scientists think the temperature range might be in 2029?

Image A



	White.......no change
1	Blue ....cooling
2	Yellow ......warming
3	Orange.....increasing warmth
4	Red .... warmest

Image B



Relating Science to . . .

Creative Writing: Scientists predict that as Earth warms, the upper latitudes will warm more noticeably than areas near the equator. Also, heat will cause the oceans to expand and the sea level to rise. Imagine that you live on a small island off the coast of South Carolina and that your family supports itself through fishing. As the sea level rises, what kinds of changes will take place? Where will your family go? How will they earn a living? What will happen to birds and other shoreline animals? To buildings, roads, and homes? Write a letter describing your problem to a friend in the mountains. If you live in the city, write about what would happen there. How would people get in and out of buildings? What would the street be like? How would you go from one place to another? What would happen to subways and buses? Would your parents' jobs be affected?

Social Studies: Visit the library and look for information on one of the Ice Ages. What was the temperature on the part of Earth where you live? What different kinds of animals lived on Earth then? Are any of those species still on Earth? Write a 3-paragraph report on those species, what they are and where they live. Or, draw some of these creatures, and write a brief description of each.

History: In an encyclopedia, look up the Industrial Revolution. What years did it include? What kinds of industry developed then? What was the major source of power? Do you think that there was pollution during that time? Write a 3-paragraph report on what the air and water might have been like during the Industrial Revolution.

Geography: Check an atlas to locate major coastal cities that would be affected by a rise in sea level.

Helping Mother Earth

Carbon dioxide helps create the "enhanced greenhouse effect." For every liter of gasoline a car uses, it puts 11.7 kg of carbon dioxide into the atmosphere. To help prevent increases in atmospheric carbon dioxide, walk or ride your bicycle whenever possible, instead of riding in a car.

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☛ Case No. 2 What is causing thinning of the ozone layer?

CLUES:

Amounts of ozone in the stratosphere are changing all the time. The seasons of the year, changing winds in the middle atmosphere, and even **sunspots** affect ozone levels. At the same time that sunspots appear, UV radiation from the Sun seems to increase The amount of UV radiation can increase or decrease the number of ozone molecules. All of these are natural changes.

Anthropogenic changes, those caused by humans, are occurring as well. In the lower atmosphere, **chlorofluorocarbons** (CFCs) released by industry act as greenhouse gases, overheating Earth. When they rise to the stratosphere, they break down into other chemicals, eventually producing **chlorine**, the same chemical that purifies drinking water and swimming pools. In the stratosphere, chlorine destroys ozone, allowing more dangerous UV radiation to reach our planet. The two CFCs used to blow plastic foam and to cool refrigerators and air conditioners are the most widely used. Scientists have found that these chemicals are increasing in the atmosphere at an annual rate of about 5 percent. Other CFCs and gases that destroy ozone are also increasing.

In some locations, scientists have detected thin spots in Earth's protective ozone layer. In 1985, British researchers discovered that the amount of ozone expected to be over the Antarctic during the spring had decreased by almost half since the 1960s. Why over the Antarctic? Chemicals like CFCs that destroy ozone exist everywhere over Earth. Above the Antarctic, high, icy-cold clouds of water and other chemicals combine to make chlorine into a form that is more active. Combined with sunlight, this chlorine destroys the protective ozone layer Some smaller losses of ozone have occurred above the Arctic also

Temperatures over lower latitudes are too warm for these ice clouds to form, but other reactions can have the effect of reducing ozone Clouds are made up of water vapor, and water vapor in the atmosphere may be increasing because of human activities As more high clouds form, more reactions can take place In fact, ozone over the Northern Hemisphere has decreased slightly in the last 20 years

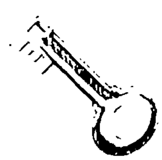
Investigation A: Recycled Greenhouses

If you would like to make your own greenhouse and recycle at the same time, here is an activity for you. (This makes one greenhouse)

Materials Needed

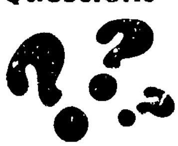
- ✓ **one empty 2-ℓ soft drink jug with removable plastic base**
- ✓ **about 450 g of potting soil**
- ✓ **one package of seeds (tomato, green bean, pumpkin, or watermelon work well)**
- ✓ **water to moisten soil**
- ✓ **scissors**

Procedure



Carefully remove the plastic base from the jug With the scissors, cut off the top of the jug, beginning just at the point where the jug curves upward toward the spout. Fill the base with potting soil to within about 1 cm of the top. Plant seeds according to instructions on the package. Water to moisten soil. Turn the larger piece of the jug upside down and insert into the base. Carefully move the soil toward the center if the top will not fit Place this "greenhouse" in the sunlight. Keep the soil moist. Once the seedling has appeared, watch closely to be sure that heat in the greenhouse does not become too intense.

Questions



❶ When the greenhouse is heated in the sunlight, where does moisture collect?

❷ Why does this happen?

❸ If this greenhouse overheats, what can happen to the seedling?

❹ How does this relate to Earth's enhanced greenhouse effect?

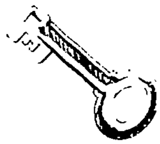
Investigation B: Welcome to the "O"-Zone.

There typically are only one to ten units of ozone in every million units of gas or particles in the stratosphere, but they protect Earth by absorbing most of the UV rays from the Sun ATLAS 1 instruments measure ozone in parts per million (ppm). It may be difficult to imagine such small amounts, so try this activity.

Materials Needed

- ✓ measuring tape about 3-m long
- ✓ large, good quality cardboard box, about 61 x 61 x 61 cm
- ✓ paring knife or scissors
- ✓ glue

Procedure

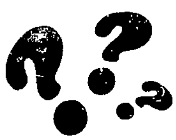


Cut the box into flat sheets. Divide the sheets into 1-cm squares, marking the squares with a pencil. Cut out the cardboard squares. Stack the flat squares on top of each other to form blocks about 1 cm high, and glue. These cubes will represent units of ozone

Measure the length, width, and height of your classroom in centimeters. Multiply the three numbers together to find the room's volume in cubic units. To make a model of 1 ppm, divide by one million (move the decimal point six places to the left) to find out how many of these cubes you will need for the volume of your classroom. To make 10 ppm, multiply your answer by 10.

Suspend the cubes around your classroom on pieces of string. This gives you some idea of the amount of ozone in the stratosphere Remember that the rest of the space is not empty, it is filled with units of other gases, particles, and water vapor.

Questions



From what this investigation shows you, do you think a great deal of ozone is required to absorb UV radiation?

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Investigator's Notebook: Hole-y Moly!

The ozone hole over the Antarctic is most noticeable in the Antarctic or austral spring, which occurs in October. During this season, increasing sunlight and frigid temperatures combine to convert chlorine into active forms that break down ozone. Later in the spring, the area of low ozone, sometimes called a hole, begins to break up. Higher ozone air from the mid latitudes moves toward the poles and "fills in" the hole. The low-ozone air moves into lower latitudes, and the atmosphere over the Antarctic becomes more normal. However, the hole has reappeared every year since it was first detected in the mid 1980s.

From space, ATLAS 1 scientists measure concentrations of ozone and other gases in the atmosphere. With surveys made over a long period of time, they assess changes in Earth's essential atmosphere.

To visualize decreases in the amount of ozone over the Antarctic, try this activity.

Procedure

Following the numbers, color the numbered areas within the heavy black lines. The yellow indicates areas of heaviest ozone concentration, and purple indicates areas where the ozone is thinnest. Carefully cut out the printed squares. Place the blocks in order, stacking with the earliest year at the bottom. Staple the block at the top left and right. Use your thumb to fan the papers, creating the illusion of a moving picture.

Questions

❶ What has happened to the areas rich in ozone?

❷ What advantages are there to viewing the atmosphere from space?

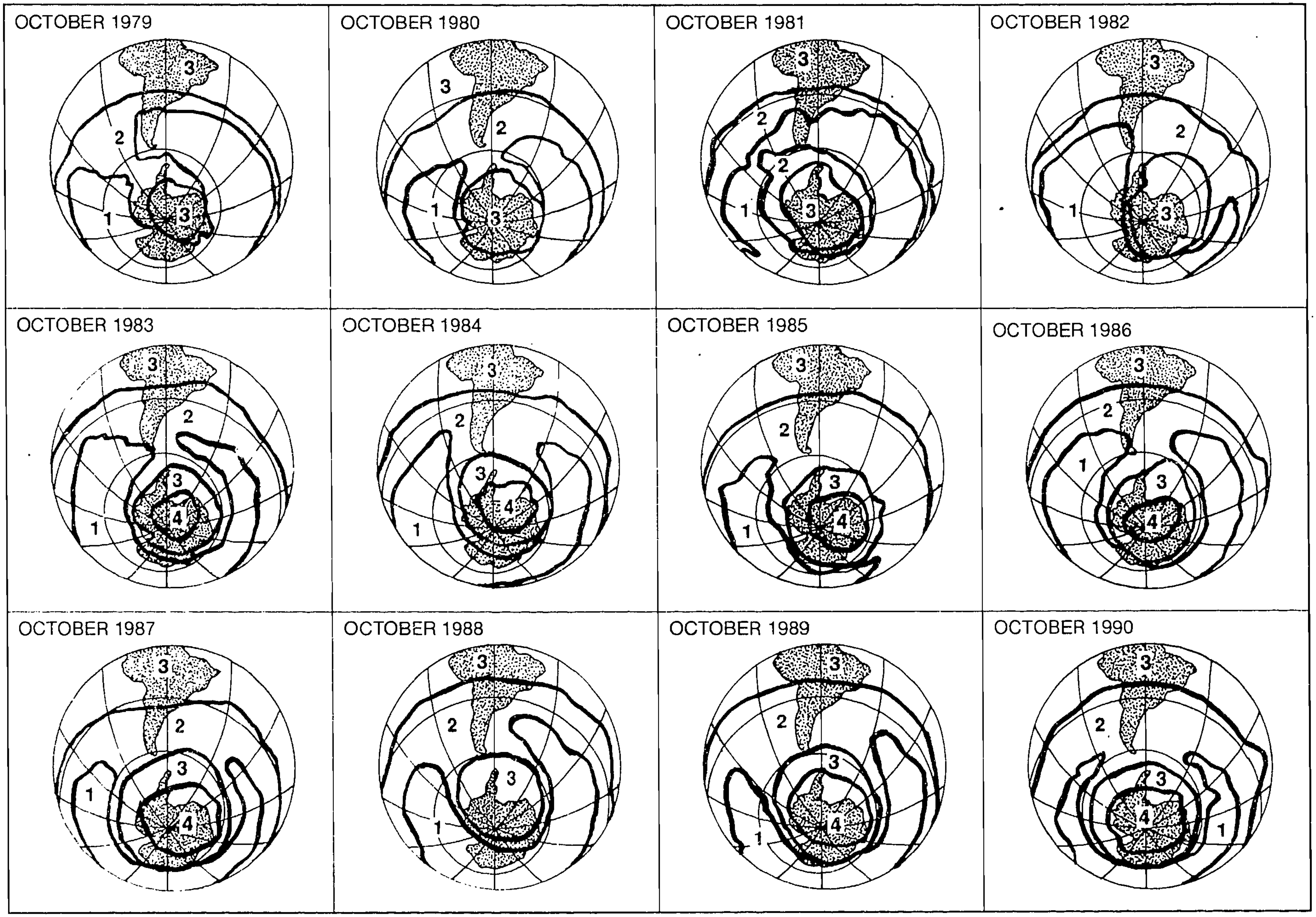
Relating Science to . . .

Creative Thinking: List 10 ideas for packaging that use only natural, recyclable materials.

Helping Mother Earth

Plastic can be recycled, too. Recycling saves energy and preserves natural resources, so make sure that the plastic jugs used in any experiments are taken to a recycling area.

43



YELLOW [1] Thickest Layer of Ozone   GREEN [2] Thick Layer of Ozone   BLUE [3] Thin Layer of Ozone   PURPLE [4] Thinnest Layer of Ozone

☛ Case No. 3 Why are scientists concerned about thinning of the ozone layer?

CLUES:

Ozone protects plant and animal life by absorbing much of the Sun's UV radiation. Scientists are not quite sure what will happen if the ozone layer becomes thin all over the planet, but because they know the harmful effects of short-wavelength UV radiation on living things, they are concerned. Even a hole over the Antarctic could have serious results. The cold oceans of the Antarctic are filled with one-celled algae called **phytoplankton**, a name that means "drifting plant." Surprisingly enough, all life in the world's oceans depends on these tiny plants. Through the process of photosynthesis, phytoplankton convert carbon dioxide and water into carbohydrates, fats, and proteins. If they are destroyed by UV radiation, the entire ocean **food web**, a whole system of **food chains**, would be upset. Also, scientists believe that these tiny plants remove about half the carbon dioxide entering the atmosphere. More carbon dioxide in the atmosphere could raise the temperature in Earth's greenhouse. This would affect all life on Earth, too.

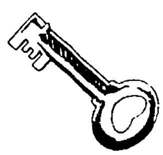
Investigation A: Itty Bitty Swimming Things

Phytoplankton are at the bottom, or beginning, of a food chain. They are **producers**, creating their own food using the Sun's energy and nutrients in the water. They are eaten by small animals, which are in turn eaten by larger and larger animals. Eventually, the largest animals die and are broken down into nutrients by **decomposers**. The producers then use these same nutrients to create food, and the whole process continues. Scientists can guess what will happen if phytoplankton are exposed to too much UV radiation. No conclusive research has yet been done on the effect of UV radiation on decomposers. In this investigation, you will be able to look at some common decomposers.

Materials Needed

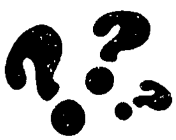
- ✓ **1 ℓ of tap water, or pond water if available**
- ✓ **dried grass or hay**
- ✓ **medicine dropper**
- ✓ **glass slides**
- ✓ **1-ℓ glass jar**
- ✓ **microscope**

Procedure



(If using tap water, allow it to age in an open container for several days.) Pour the water into the small jar to within about 2.5 cm of the top. Add a small handful of grass or hay to the water and cover the jar loosely. Allow it to sit for about 1 week out of direct sunlight. Using the medicine dropper, take a few drops from near the top of the water's surface. Place the drops on the slide and examine them under the microscope. Sketch what you see. These are **protozoa**, single-celled creatures that have both plant and animal characteristics. These protozoa are decomposers.

Questions



❶ Why should the tap water be aged?

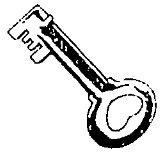
❷ Where did the protozoa come from?

Investigation B: Food — Beginnings and Endings

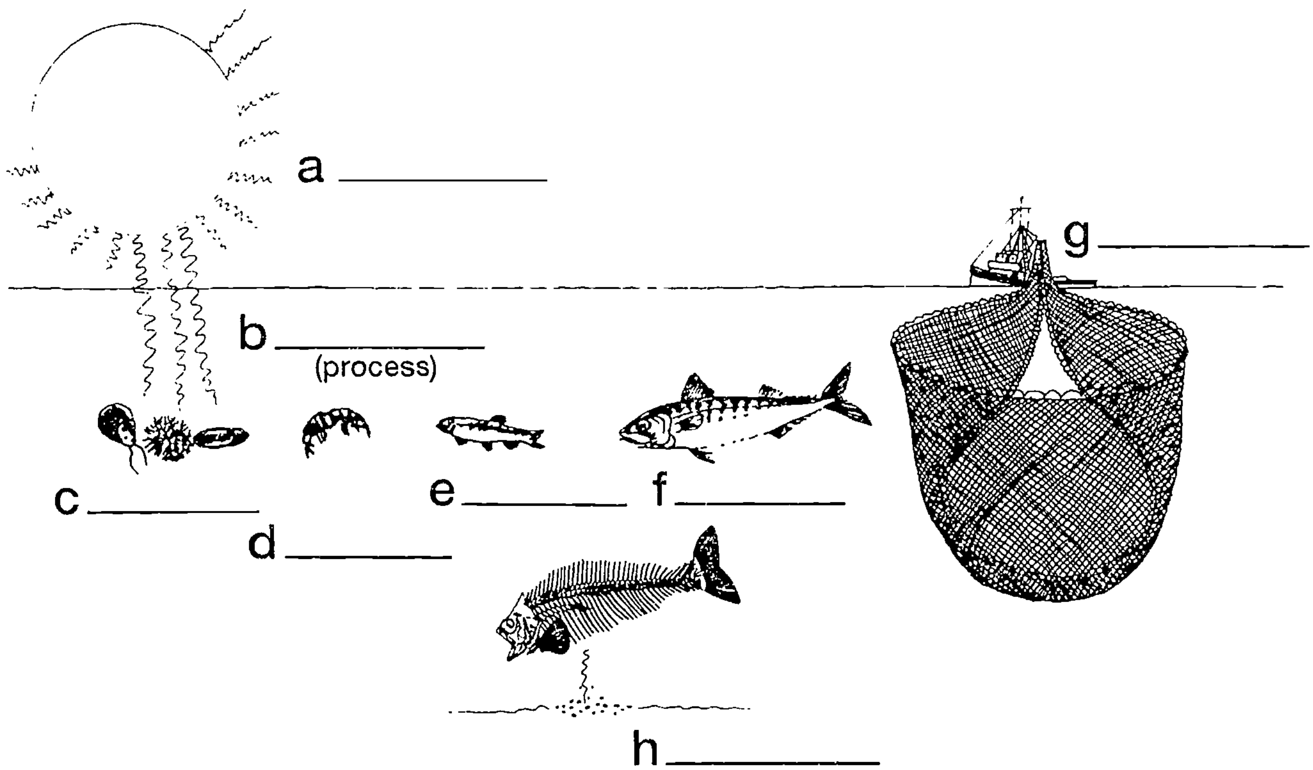
Below is a word bank listing some of the elements and events in an ocean food chain:

Sun	people	zooplankton	phytoplankton
sardines	tuna	decomposers	photosynthesis

Procedure



Using the terms in the word bank, correctly identify each element in the illustrated food chain.



Questions

❶ Briefly describe the process of photosynthesis.

❷ What are the producers in this food chain?

❸ What organism is at the top of this food chain?

❹ When fish or plankton die and sink to the bottom, what organisms break down their bodies?

Investigator's Notebook: Kilogram for Kilogram

How much do you weigh? Because humans are consumers in a food web, every kilogram of our bodies was built out of nutrients from other plants and animals. Scientists estimate that the **ratio** is about 1 to 10 (1:10). This means that to make 1 kg of your weight, your body required about 10 kg of nutrients. Those 10 kg were made from 10 times that amount of the next item in the food chain.

If you had been raised on a diet of seafood, this is the number of kilograms it might have taken to reach your present weight:

______ kg your weight x10→ ______ kg shrimp x10→ ______ kg larvae x10→ ______ kg phytoplankton

Try the same exercise with a beef diet

______ kg your weight x10→ ______ kg beef x10→ ______ kg grain

And with a vegetarian diet

______ kg your weight x10→ ______ kg corn or rice

Questions

1. Can you calculate how much plankton a 130-metric-ton whale had to eat to reach its weight? (They are next to each other on the food chain.)

2. What does this tell you about the importance of the tiny plankton?

3. Why would it be a serious problem if too much UV light damaged the plankton?

Relating Science to . . .

Creative Writing: Every living creature has a vital function in nature's plan. Decomposers, like the ones investigated above, break down dead matter. What do you think would happen if decomposers like these were killed off or damaged by UV radiation? Write a story about a small pond, filled with turtles, fish, and plants, that suddenly loses its decomposers.

Helping Mother Earth

Take a class poll. How many students in your class drink at least one aluminum can of soda or juice every day? Did you know that if only 0.1 percent of the people in the U.S. recycled just one can a day, we could save the energy equivalent of over 13 million liters of gas per day? Extend the poll to the rest of your school.

Answers: The Crime

CASE #1 ANSWERS

Investigation A

❶ Yes, there is a temperature difference. ❷ Plastic wrap allows warming rays through and traps heat. ❸ Individual answers: both glass and atmosphere allow light through (you can see through them); both trap heat, other answers. ❹ Individual answers: glass is dense; atmosphere is not. **Note to Teacher:** Students may say glass is solid; use this to lead to discussion of density. Encourage discussion of the fact that both are made of molecules, but molecules of glass are much more dense ❺ Closed, parked cars will be very hot ❻ No.

Investigation B

❶ It absorbs heat. ❷ Individual answers: they wilt, collapse, die, dry out, "cook" ❸ Too much heat was absorbed
❹ Animals could not withstand intense heat. **Note to Teacher:** Lead to discussion of balance or equilibrium. Plants and animals need just the right amount of heat: not too much, not too little. If nature or humans disturb the equilibrium, living creatures are harmed.

Investigator's Notebook

❶ Answers will depend on the region of the U.S in which students are living ❷ Answers should be 2 to 9 °C higher than current temperatures.

Relating Science to . . .

Creative Writing: Encourage students to spend some time imagining before they write.

Social Studies: Student research.

History: The Industrial Revolution began in the late 1700s, most historians set the dates as 1790 to 1850 Manufacturing of items such as clothing and shoes, which had once been done in homes, was now done in factories. Machines began to be used for farming, and factories now built those machines The major source of power was coal Some water power was used. **Note to Teacher:** Students should be helped to see the link between the use of fossil fuels for power and the increase of carbon dioxide

CASE #2 ANSWERS

Investigation A

❶ Moisture collects at the top of the greenhouse ❷ Because the heat rises and the water vapor is carried to the top There it condenses against the plastic, which is cooled by outside air. ❸ The seedling could wilt and die. ❹ Earth's plants and animals would not do well in a too-warm environment.

Investigation B

No. If students do not reach a negative conclusion here, point out the number of particles contained in the rest of the atmosphere.

Investigator's Notebook

❶ The size of the areas rich in ozone appears to be decreasing. ❷ From space, scientists can measure the atmosphere in a number of places; they can also take measurements high above Earth. If measurements are performed over a long period of time, comparisons can be made, and potential problems and changes can be identified

CASE #3 ANSWERS

Investigation A

❶ **Note to Teacher:** Give students time to think about this. Ask Was there something in the water that would inhibit growth of protozoa? What do we put in our drinking water to kill bacteria? **Answer:** Chlorine. Chlorine would inhibit growth of protozoa Aging allows chlorine to dissipate

❷ Protozoa were on the grass or hay.

Investigation B

Procedure

(a) Sun (b) photosynthesis (c) phytoplankton (d) zooplankton (e) sardines (f) tuna (g) people (h) decomposers

Questions

❶ In photosynthesis, green plants use chlorophyll and light to transform water and carbon dioxide into food in the form of glucose (sugar). Oxygen and more water are also produced. ❷ Phytoplankton ❸ People ❹ Decomposers

Investigator's Notebook

Answers will depend on students' weights **Note to Teacher:** Students probably know their weights in pounds Have them convert to kilograms first. (1) A 130-metric-ton whale would have to have eaten <u>1,300 metric tons</u> of plankton to reach its weight (2) Individual answers Encourage students to see the importance of plankton (3) Entire food webs would be affected

Relating Science to . . .

Note to Teacher: Be sure to have students formulate hypotheses before they begin This is fairly new research Answers are not known.

The Suspects:

Natural and Anthropogenic Causes

☛ Case No. 1 What is causing the warming of the lower atmosphere?

CLUES:

Believe it or not, Nature itself may be a major cause. The Sun, Earth's land areas, winds, and oceans work together in a constantly changing system that goes through cycles of heating and cooling.

The Sun's energy is a major influence on Earth's temperature. The amount of energy received from the Sun, or **solar radiance**, changes in several ways. Our planet rotates daily, creating night and day. Because Earth is tilted on its axis and revolves around the Sun, areas of the planet are exposed to greater or lesser amounts of solar energy throughout the year, causing changes in the seasons. In addition, the Sun goes through 11-year **solar cycles**. During the first half of each cycle, sunspots and UV radiation from the Sun increase, for the second half, they decrease. These changes in solar activity mean that Earth receives varying amounts of solar radiation. Measuring solar radiance is difficult, but ATLAS has instruments designed especially for the task.

Other natural changes occur on Earth. Volcanic eruptions toss ash and gases into the air. Winds pick up sea spray from the oceans and erode soil from land areas, adding sea salt and small dust specks called **particulates** to the atmosphere. Moisture forms around these particles and increases the planet's cloud cover, and clouds can act to hold heat in the atmosphere.

The oceans are storehouses of heat, and as water currents move across the globe, they heat both land and air. The planet's winds sweep along in currents that change according to location, season, and altitude. For example, about every 13 months, wind direction shifts in the stratosphere above the equator, carrying UV-blocking ozone away from the equator. Because ATLAS missions will take measurements during different seasons, scientists can track these movements and changes.

Investigation A: Very Current Events

Try this simple investigation to trace the air currents in your classroom.

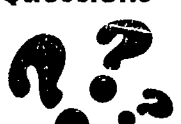
Materials Needed

✓ matches

Procedure

The teacher lights a match and then blows it out. Students close their eyes and raise their hands when they are able to smell the smoke.

Questions



❶ How did the smoke travel?

❷ Did it spread out evenly in all directions?

Investigation B: A New Angle

To see how the Sun's angle affects temperature on Earth at different times of the year, try this activity.

Materials Needed

✓ two sheets of black paper
✓ weather thermometer
✓ flashlight
✓ ruler
✓ tape

Procedure

Lay the thermometer on the paper Hold the flashlight so that the beam shines directly down onto the thermometer. Tape the flashlight to the ruler so that the beam begins at about the 12.5-cm mark. Observe and record the temperature after 5 minutes. This represents the Sun's light falling more directly on the United States during the summer months To represent sunlight falling on the United States during winter, repeat the experiment after the thermometer has returned to room temperature. Hold the flashlight and ruler at an angle so that the flashlight lamp is still about 12.5 cm from the thermometer. Observe and record the temperature after 5 minutes.

Questions

❶ Which "Sun" angle produced higher temperatures?

Investigator's Notebook: Seeing (Sun)spots

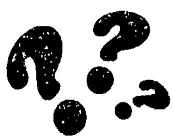
Increased solar activity means more warming of Earth's atmosphere. Scientists have been keeping track of sunspots, evidence of such activity, since the year 1700. Below is a table of the number of sunspots occurring each year between 1955 and 1990. Many of these were studied by instruments aboard satellites. Notice the large number of spots recorded in 1957. This is the highest number of sunspots ever recorded.

Data:

1955	38	1967	94	1979	155
1956	142	1968	106	1980	155
1957	190	1969	106	1981	140
1958	184	1970	105	1982	116
1959	159	1971	67	1983	67
1960	112	1972	69	1984	46
1961	54	1973	38	1985	18
1962	38	1974	35	1986	13
1963	28	1975	16	1987	29
1964	10	1976	13	1988	100
1965	15	1977	28	1989	158
1966	47	1978	93	1990	142

Make a chart and plot the number of sunspots per year, putting years on the **horizontal axis** and numbers of sunspots on the **vertical axis**. Mark the vertical axis in increments of 10, placing the increments 0.5 cm apart.

Questions



❶ Where are we now on the solar cycle?

❷ Where will we be in 6 years?

❸ Why do scientists need to study the atmosphere over a number of years?

Relating Science to . . .

Creative Writing: When people living in ancient times did not understand things they saw, they made up stories, or **myths**, to explain them. The Greeks believed that the Sun was being pulled across the sky by the god Phoebus' chariot. They also thought that winter occurred when the goddess Persephone was kidnapped and taken to an underworld for part of the year. Sunspots were one of the first things that primitive people noticed about the Sun. Imagine that you are living in the distant past. Write a myth to explain sunspots.

Literature: Different cultures have different myths. Research an Aztec, African, Chinese, or Native American myth.

Art: Illustrate your myth.

Music: Listen to Vivaldi's *The Four Seasons*. Can you identify which season the composer was trying to describe in each movement? What clues did you have?

Helping Mother Earth

Use solar energy to make tea. Fill a 2-ℓ glass jar with cold water. Add one family-size tea bag, allowing the string to extend out of the top of the jar. Cap the jar loosely, catching the string under the cap so that the tea bag does not sink to the bottom. Leave in hot, direct sunlight for 3 to 4 hours. Notice the convection currents that eventually "mix" the tea. These are somewhat similar to atmospheric currents.

Refrigerate the tea within 5 hours of the time you started brewing it.

☛ Case No. 2 Are there anthropogenic causes of atmospheric warming?

CLUES:

Carbon dioxide, methane, nitrous oxide, CFCs, and ozone, the important gases that help trap the Sun's infrared energy and warm Earth, seem to be increasing in the atmosphere at much higher rates than before. More and more carbon dioxide is added to Earth's atmosphere when industries burn fossil fuels — coal, oil, and gas — to power their plants to produce goods and electrical energy, which communities need. Methane and nitrous oxide are also released when fossil fuels are burned. As the rain forests in countries near the equator are cut and burned to clear land for crops, the burning releases carbon dioxide. At the same time, trees that use carbon dioxide for photosynthesis and give off oxygen are destroyed. Nitrous oxide can enter the atmosphere from fertilizers spread on fields. CFCs, gases used to create foam products and used in refrigerators and air conditioners, are also being released into the atmosphere in great quantities. Together, these gases released by anthropogenic activities may be acting to warm Earth's natural greenhouse too much.

Investigation A: Tiny Bubbles

Carbon dioxide is very common. You probably know it as the bubbles, or carbonation, in soft drinks. Radiation that passes through the atmosphere from the Sun is absorbed by Earth; this energy then radiates back as infrared radiation that is absorbed by carbon dioxide.

You can easily make carbon dioxide in the classroom.
CAUTION: THIS ACTIVITY INVOLVES MATCHES. TEACHER SUPERVISION IS REQUIRED.

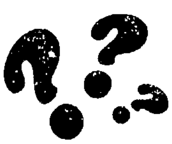
Materials Needed

- ✓ **0.12 ℓ of vinegar**
- ✓ **30 mℓ of baking soda**
- ✓ **clean 4-ℓ coated paper milk container**
- ✓ **candle**
- ✓ **matches or lighter**
- ✓ **scissors**

Procedure

Cut the top off the milk carton to form an open container. Pour the vinegar into the milk container. Add the baking soda and gently swirl the contents. You have formed carbon dioxide. To prove that the gas is there, "pour" the gas (not the liquid) from one corner of the container over the candle flame.

Questions



❶ What happens to the flame?

❷ What does this show you about combustion?

❸ Do you think that some fire extinguishers use carbon dioxide?

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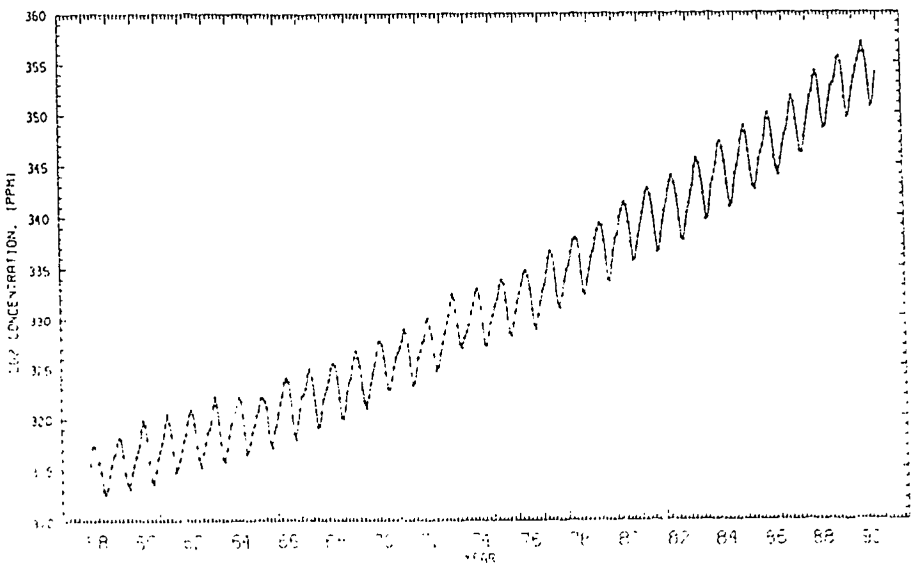
Investigation B: Living, Breathing Earth

Does Earth breathe? In a sense, it does. The graph below gives a visible demonstration. At an observatory in Hawaii, researchers measured concentrations of carbon dioxide for a number of years. The line showing these concentrations goes up and down, almost as if Earth were breathing in and out with the seasons.

MONTHLY AVERAGE CARBON DIOXIDE CONCENTRATION



Interpreting this chart shows what is happening to levels of this important greenhouse gas in the atmosphere. The numbers on the vertical axis represent parts per million (ppm) of carbon dioxide in air. Answer the questions below to also see how plant life affects levels of carbon dioxide.

Questions

❶ What was the highest ppm number of carbon dioxide at this location in 1986?

❷ What was the highest ppm number in 1958?

❸ What is the percent of increase? To calculate the percent of increase, follow this procedure:

________ ppm in 1986 – ________ ppm in 1958 = ________ ppm (amount of change)

amount of change ÷ ________ ppm in 1958 x 100 = ________ percent increase

Now, look at the jagged pattern shown on the graph. Place a small piece of paper at the year 1960 on the graph. Place another at the point for 1961, so that you can clearly see the dots just for the year 1960.

❹ How many dots are there?

❺ What do you think each of these dots represents?

❻ If plants use carbon dioxide for photosynthesis, would there be more of the gas present in the atmosphere in summer or winter?

❼ What season do the low points in the jagged line represent?

❽ What season do the high points represent? Earth's plants absorb carbon dioxide during their growing season. In winter, when they are less active, carbon dioxide in the atmosphere increases.

CHALLENGE: Calculate the approximate percent of decrease between ppm of carbon dioxide in the winter and summer for 1 year.

Investigator's Notebook: Living in a Greenhouse

I allow some sunlight to pass through me.

Dust and clouds within me reflect some sunlight back into space.

I trap infrared radiation coming from Earth. What am I?

The "I" in the riddle is the atmosphere, and the effect being described is the greenhouse effect.

The Sun's rays constantly pour down over Earth like a solar shower. Some of the radiation penetrates the atmosphere; some is reflected back into space by the dust and clouds in the lower atmosphere. The energy that reaches Earth's surface may be reflected by snow, ice, water, or sand. If it strikes land, the energy is absorbed by Earth, producing heat, or infrared radiation. The reflected energy and these long infrared waves emitted by Earth are trapped by certain gases in the atmosphere, such as water vapor, carbon dioxide, some CFCs, methane, nitrous oxide, and tropospheric ozone. (This is "bad" ozone, as opposed to the "good" ozone that blocks UV rays in the stratosphere.) Because the infrared radiation is trapped, the surface temperature of Earth rises; this is called the "greenhouse effect." Because burning of fossil fuels is increasing the concentration of these gases in the atmosphere, Earth's temperature may go from pleasantly warm to unpleasantly hot.

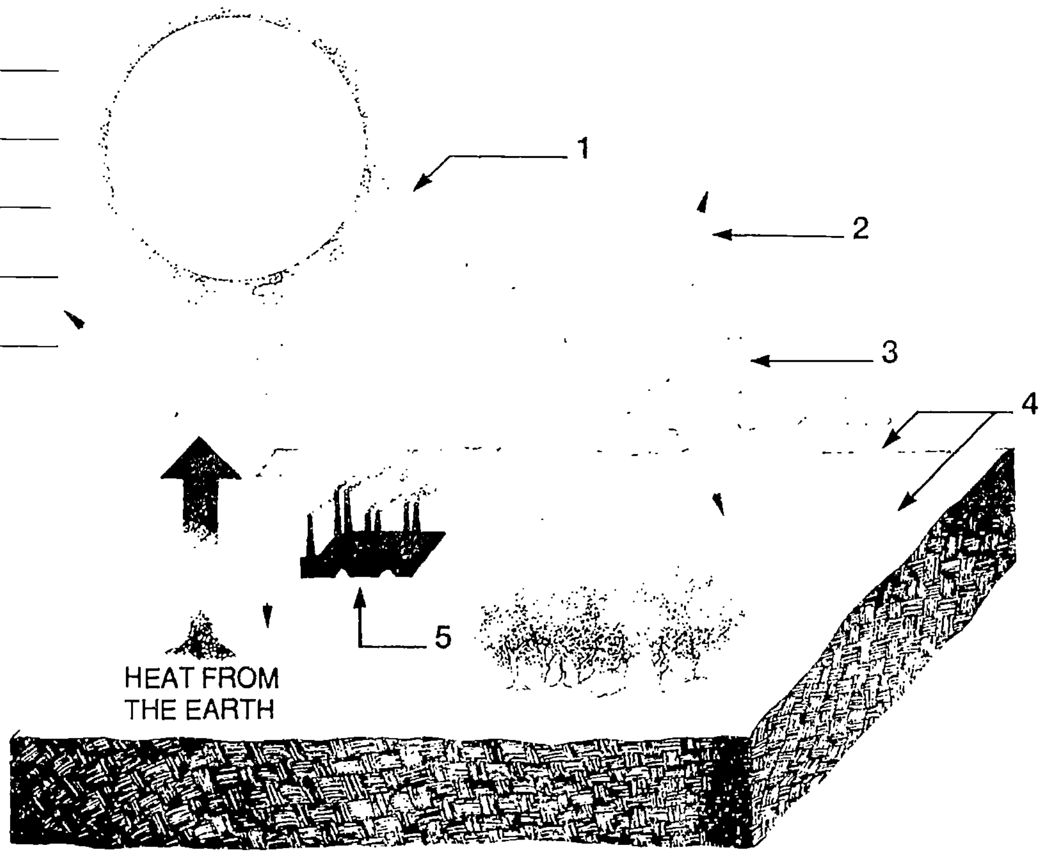
1 ____________________

2 ____________________

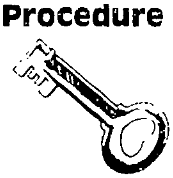
3 ____________________

4 ____________________

5 ____________________



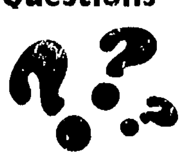
Procedure



Using the information provided above and the word bank below, label the blanks in the illustration.

outgoing infrared radiation	clouds	incoming solar radiation
Earth's surface	fossil fuel burning	

Questions



❶ What different things can happen to incoming solar radiation?

❷ Name some things that act to reflect energy and cool Earth.

Relating Science to . . .

Language: Look up anthropogenic.

❶ What two root words come together to form this word? From what language do they come?

❷ List three other words that come from these same roots.

Astronomy: Another planet — Venus — has an atmosphere very rich in carbon dioxide, creating an intense greenhouse effect. Look in an astronomy book or encyclopedia for answers to the following questions:

❶ What is the temperature on Venus?

❷ As far as we know, does anything grow there?

Helping Mother Earth

A full-grown tree can consume almost 6 kg of carbon dioxide in 1 year, but 28 million acres of tropical rain forest are destroyed every year. In the United States alone, 300,000 acres of trees are cut down annually, but during the 1980s, only one tree was planted for every four removed from cities and towns. Trees absorb carbon dioxide in the atmosphere; planting more trees could slow the process of global warming. Plant a tree!

Answers: The Suspects

CASE #1 ANSWERS

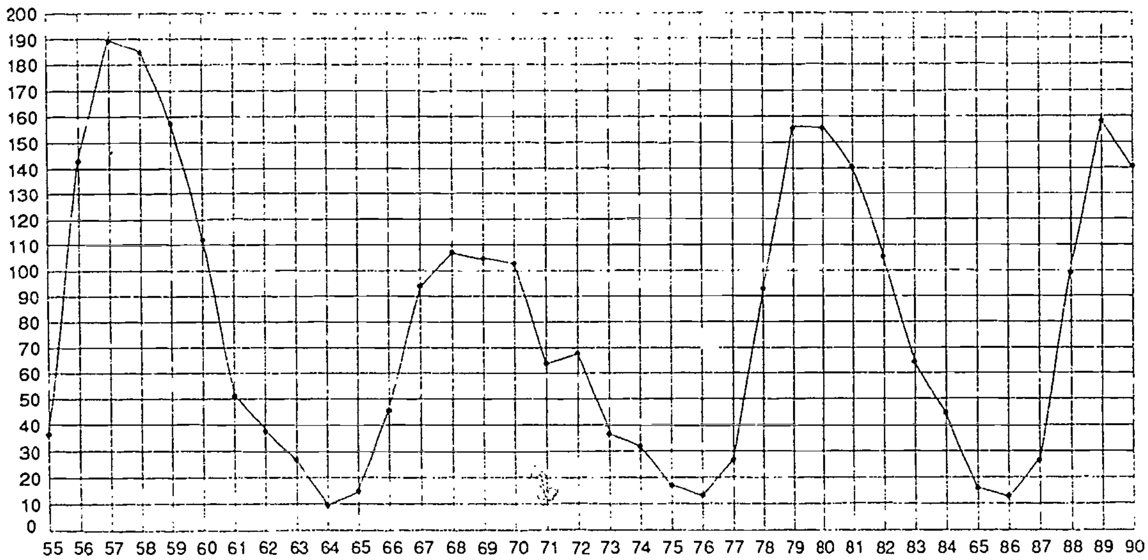
Investigation A

Answers will depend on air currents in classroom

Investigation B

Direct "Sun"

Investigator's Notebook



❶ Answer will depend on the year ❷ Answer will depend on the year. [At the time of printing (1992), the Sun is on the downward half of a cycle Around 2000, solar activity peaks again.] ❸ Studying the atmosphere over a number of years gives a more complete picture of the long-term interactions between the Sun and Earth's atmosphere

CASE #2 ANSWERS

Investigation A

❶ It goes out. ❷ Combustion requires oxygen; carbon dioxide smothers combustion ❸ Yes.

Investigation B

❶ 350 ppm ❷ 318 ppm ❸ <u>350</u> ppm 1986 - <u>318</u> ppm = <u>32</u> ppm amount of change

<u>32</u> ppm ÷ <u>318</u> ppm x 100 = <u>10</u> percent increase ❹ Twelve dots ❺ Months of the year

❻ More carbon dioxide is present in winter ❼ Low points represent summer. ❽ High points represent winter.

Challenge: Answer depends somewhat on the year There is approximately a 6-ppm difference between summer and winter, or 2 percent

Investigator's Notebook

Illustration

(1) incoming solar radiation (2) outgoing infrared radiation (3) clouds (4) Earth's surface (5) fossil fuel burning

Questions

❶ Solar radiation may be reflected by clouds, reflected by water, ice, snow, or sand, or may be absorbed by water and Earth's land surfaces ❷ Clouds, ice, snow, and sand all reflect energy and cool Earth Water reflects and absorbs energy.

Relating Science to . . .

Language: ❶ Anthropogenic comes from the Greek "anthropos," meaning human being, and "genesis," which also came from the Greek language. Genesis means birth or beginning. ❷ Other words anthropology, genetic, anthropocentric, carcinogenic

Astronomy: ❶ Temperatures on Venus range from 470 °C to 327 °C. ❷ Not as far as we know.

The Detectives: Working to Solve the Mysteries

☛ Case No. 1 How are scientists investigating these mysteries?

CLUES:

Low, medium, and high. Volume settings on a radio? No, they are altitudes at which scientists can learn about the atmosphere For thousands of years, people curious about the atmosphere have studied the air around them. They have even traveled up mountains to investigate air high above them. Ground investigations in laboratories and in the field are still a vital part of atmospheric research.

At medium altitudes, airplanes soar above mountains through the cold to near the top of the troposphere, about 11 km. To carry their instruments higher, scientists use balloons. Hot-air balloons were the first way to reach the upper portions of the atmosphere. Today, helium balloons, which can go higher still, are used for research. The largest of these can travel about 50 km above the surface of the globe Here, above some of the protective layers of the atmosphere, scientists can study the other parts of the atmosphere, the Sun, and the galaxy. Instruments on rockets can sample the gases in the atmosphere up to 200 km.

The Space Shuttle can carry scientific instruments even higher. The first of 10 Shuttle flights of the ATLAS program, scheduled for spring of 1992, will carry out atmospheric and solar research about 300 km up. On this mission, scientists will investigate how Earth's middle and upper atmospheres and climate are affected by the Sun and by activities on Earth.

Satellites have been used for research since the 1960s and are still valuable because they can orbit Earth even higher than the Shuttle and for longer times, giving a more comprehensive view of the atmosphere. For example, NASA's Total Ozone Mapping Spectrometer aboard the Nimbus 7 satellite confirmed ground observations of the Antarctic hole in the ozone layer. The Upper Atmosphere Research Satellite (UARS) follows a 584-km high orbit and provides data on temperatures, winds, composition, and other conditions in the atmosphere, especially in the stratosphere and mesosphere Scientists will use data from ATLAS and UARS to put together a comprehensive picture of the health of the atmosphere.

Together, all these investigations will provide valuable information on the airy envelope that surrounds our home planet.

Investigation A: A Remote Possibility

ATLAS 1 and UARS, like many Shuttle missions and satellites before them, will perform **remote sensing**, which means that they will carry instruments that will examine the atmosphere from a distance. A camera is a form of remote-sensing instrument; its detector records events at a distance. Remote-sensing devices can spot hurricanes and floods, measure the destruction of rain forests and the spread of deserts, and sample the stratosphere for ozone. Remote-sensing instruments use visible, infrared, microwave, and UV wavelengths to record data, which may then be made into computer images resembling photographs.

The remote-sensing instruments carried by ATLAS 1 and UARS are varied and complex and will focus on the middle and upper levels of the atmosphere. To see one advantage of remote sensing, try this.

Materials Needed

✓ **a patch of thin grass**

Procedure

While standing, look straight down at the patch of grass. Then, get down on your hands and knees and look across the grass from just above the ground.

Questions

❶ Does the grass look thicker or thinner than it did from above? If you are not sure, stand up and look down again.

❷ What is the advantage of being able to look at things from a distance?

❸ Which gives a more complete picture of how thick the grass is?

Investigation B: From Coast to Coast

When scientists view Earth from great distances, they must be able to calculate the actual size of what is seen. The map on p. 49 was created by putting together many photographs made from space at a scale of 1:25,000,000. This means that every centimeter on the photograph is equal to 25,000,000 centimeters on land. It is read as "1 to 25,000,000" and may be written as 1/25,000,000. When this is converted to kilometers, we see that 1 cm equals 250 km.

Materials Needed

✓ **Map, p. 49**

✓ **ruler**

✓ **about 15 straight pins**

✓ **20- to 30-cm piece of string**

Procedure

Glue a copy of the map onto a piece of cardboard. Tie a knot in the end of a piece of string. To measure the east coast of the United States, push a straight pin through the knot and into the cardboard at Point A. Push straight pins into the cardboard, following the outline of the coast to Point B. Wind the string in and out of the pins, making sure the string runs along the outline of the coast from Point A to Point B. Write down the number of centimeters of string it takes to reach Point B. Repeat that procedure to measure the south coast from Point B to Point C and the west coast from Point D to Point E. On the scale on your map, 600 km is equal to 2.4 cm; this means that 1 cm of string is equal to 250 km. Multiply each measurement by 250 km to find the length of each coastline.

Questions

❶ What is the approximate length of the east coastline?

❷ What is the approximate length of the south coastline?

❸ What is the approximate length of the west coastline?

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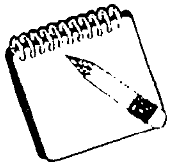
Investigator's Notebook: Measuring Up

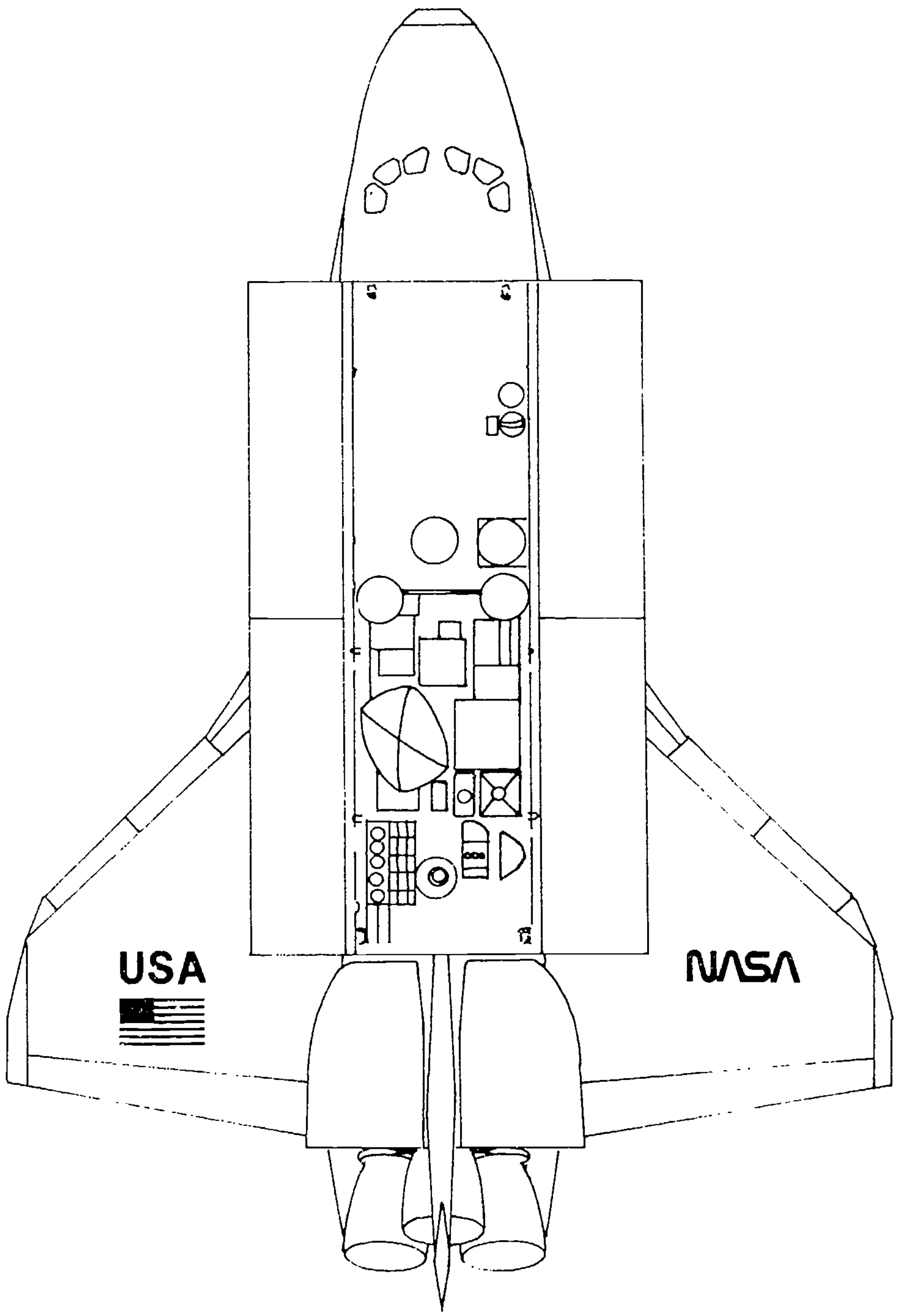


Measure the drawing of the Shuttle that will carry the ATLAS 1 mission On a large piece of graph paper, redraw the object, assuming that 1 cm on the original is equal to 2.5 cm in the new drawing.

Begin by measuring the entire length of the Shuttle drawing, from nose to tail. Calculate the new length and draw in the new nose and tail, including the rocket engines. Next, measure the span of the wings at the widest point. Calculate the new width and draw the wings Draw in the curved Shuttle lines free-hand You may also want to measure and redraw the open payload bay, including the payload bay doors on each side

❶ What is the length of the redrawn Shuttle?

❷ What is the span of the wings?



Relating Science to . . .

Art: Design your own Space Shuttle and invent instruments that can be used to study Earth from a distance. Label the instruments and describe what they will do.

Geography:

❶ When viewing Earth from space, would borders between countries be visible?

❷ Is it possible to say which countries will be affected by changes in the atmosphere? Which will not?

❸ Research NASA's ATLAS 1 mission. How many countries will have instruments in the ATLAS 1 payload?

Social Studies: Look for articles in recent magazines about the tropical rain forests. Why are the people there burning and clearing the forests? What part do we play in this process, even though we do not live in the tropics? What are burning and clearing doing to the atmosphere? Give an oral report to the class on what you have learned.

Writing/Career Exploration: Read the ATLAS 1 crew biographies, beginning on p. v. Write your own biography (or a friend's) as if either of you were a scientist preparing for a mission. What kind of Earth or space science would your interests prepare you for?

Helping Mother Earth

Can you imagine loving mosquitos and other insects? Bats do. These mammals consume thousands of mosquitos daily and pollinate fruit trees as well.

Both bats and the ATLAS 1 instruments use remote sensing. Bats use it to locate their prey — the insects. ATLAS 1 uses remote sensing to investigate the chemistry of the atmosphere. Contact your library or Bat Conservation International for more information on natural ways to control pests instead of using pesticides.

☛ Case No. 2 How can I help solve these atmospheric mysteries?

CLUES:

There is much you can do to help now and in the future. As a student and a member of your community, you can learn all you can and do your best to protect important natural resources like trees, water, and clean air. The **Helping Mother Earth** hints in this guide can get you started with ideas for recycling, using fewer chemicals such as pesticides, and being careful with gasoline and electrical energy usage.

You can also start working now toward a career in mathematics, science, or technology. Do you like working puzzles or solving mysteries? Is the health of Earth and its atmosphere important to you? Do you get excited when you think you are doing something good for Earth? These qualities are a good beginning. If you like a challenge, you can work to be a biologist, a chemist, a physicist, an engineer, a computer specialist, or an astronomer. Cartographers, science teachers, mathematicians, and many different kinds of technicians will also play important roles in carefully tending our precious atmosphere.

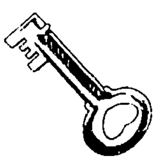
Investigation A: From a Distance

One of the most vital tools scientists use to study the atmosphere is remote sensing. In this "long-distance seeing," performed with satellites and aboard the Space Shuttle, researchers use infrared, visible, microwave, and UV radiation to investigate the atmosphere and photograph Earth. To be effective, remote sensing must be performed over a long period to provide the most accurate results. The ATLAS program involves missions flying for the next 10 years. Their results will be compared with data from the Upper Atmosphere Research Satellite and the satellites of the Earth Observing System, as well as information from ground measurements. Why must these investigations be so comprehensive and continue for so long? Try this investigation to find out.

Materials Needed

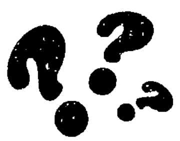
- ✓ **notebooks**
- ✓ **pencil**
- ✓ **graph paper**
- ✓ **if available, an instant or video camera, with film or videotape**

Procedure



Set up as flexible an observation schedule as possible. Photograph the cafeteria or gym at your school at various times before, during, and after the school day. If a camera is not available, choose a central location within the cafeteria or gym and try to count the number of students there for a 1-minute period several times daily. Construct a graph with the times shown on the horizontal axis and numbers of students on the vertical axis.

Questions



❶ Is there a noticeable difference in numbers of students present at various times?

❷ Could you make accurate statements about how many students use the cafeteria or gym by looking at results of one observation?

❸ What does this tell you about the need for long-term observations from space?

Investigation B: Back to BASIC

Computers are important tools in the effort to solve atmospheric mysteries. Giant supercomputers are used to model and predict the interactions between land, the Sun, wind, and water. Other computers are used to improve and interpret pictures taken of Earth from space.

Computers use different languages, depending on their purpose. One of the languages used by smaller computers is BASIC.

Procedure

Below is a BASIC program used to calculate the amount of energy needed to increase the temperature of water. You will need to know that * means multiply and that to calculate the number of calories, you must multiply the grams of water by the change in temperature in degrees.

CH represents the change in temperature between **C1**, the beginning temperature, and **C2**, the ending temperature.

H stands for the amount of heat, measured in calories.

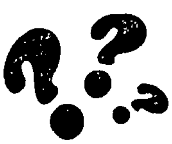
G is the number of grams of water.

Can you fill in line 170?

This formula is only good for figuring the effect of heat on water and works only for a range of 0 to 100 °C, because at 100 °C, water turns to steam. Be sure to check your computer's BASIC manual to make sure the same symbols and commands are used.

```
100 PRINT
110 PRINT ">>> THIS PROGRAM MEASURES THE CALORIES USED TO HEAT WATER <<<"
120 PRINT
130 INPUT "Grams of Water";G
140 INPUT "What is the beginning Celsius temperature";C1
150 INPUT "What is the ending Celsius temperature";C2
160 CH = C2 - C1
170 H = __________
180 PRINT
190 PRINT "For an increase of <";CH;"> degrees Celsius"
200 PRINT "The number of calories used is <";H;"> calories."
210 END
```

Questions



1. What should line 170 be?

2. Use the program to calculate the number of calories needed to heat 3 g of water from 10 °C above freezing to 10 °C below boiling. What answer does the program give you?

Investigator's Notebook: Truth Detector

Below are a number of statements about the environment Mark each of these "True" or "False." Below each, tell how you made the decision. Compare your answers with your classmates and find out why they made their decisions. Discuss these statements before finding out the correct answer from your teacher.

(1) ______ Many life-saving medicines come from plants in rain forests.

(2) ______ Volcanoes may have helped change Earth's early atmosphere

(3) ______ North Americans "throw out" 500,000 trees per week in the form of old newspapers.

(4) ______ At one time, Earth's atmosphere would have been poisonous to human life.

(5) ______ Creatures in the Antarctic seas are part of your food web.

(6) ______ The average American family produces 45 kg of trash each week.

(7) ______ You can wash out plastic bags and reuse them.

(8) ______ Only 3 percent of Earth's water is fresh water.

(9) ______ 379 ℓ of water is needed to produce a pat of butter.

(10) ______ Earth's magnetic poles have reversed several times during Earth's history, reversing magnetic north and south.

Relating Science to . . .

Creative Writing: Imagine that you are a reporter. Using information from this guide's Preface, p. iii, write a brief story about the ATLAS 1 mission or UARS flight. Be sure to include the important facts: who, what, when, where, why, and how Use descriptive words so your readers can enjoy the excitement and importance of these investigations. If you need more information, ask your teacher to contact the nearest NASA center or NASA Spacelink for more facts.

Creative Thinking: One very strange mystery is that the worldwide population of frogs seems to be decreasing. Scientists are not sure why. Based on what you have learned about the changing environment, list 10 reasons why this might be happening. This can also be done as a group brainstorming activity. Appoint a record-keeper. Each person should then offer one reason why he or she thinks the frog population has decreased; the record-keeper should write these reasons down. Remember that, in brainstorming, every idea — no matter how unusual — is given equal attention.

Language: Look up the word "cartographer." What does it mean? Present this information to the class.

History: In a world history book or encyclopedia, try to find some famous cartographers. The Americas took their name from one renowned cartographer. Find out who and dramatize an event in his life.

Helping Mother Earth

If your home has a dishwasher, set it to skip the "heated drying" cycle to help save energy. If you wash dishes by hand, rinse all of the dishes at once rather than letting the water run while you rinse one at a time. This will help save water.

Answers: The Detectives

CASE #1 ANSWERS

Investigation A

❶ Grass blades should look farther apart from above
❷ Distance and angle give a bigger picture
❸ A high-altitude view gives a more complete picture.

Investigation B

❶ Point A to Point B Approximately 14 cm of string x 250 km = 3,500 km (approximate lengt' of east coastline)
❷ Point B to Point C Approximately 11 cm of string x 250 km = 2,750 km (approximate length of south coastline)
❸ Point D to Point E Approximately 8.5 cm of string x 250 km = 2,125 km (approximate length of west coastline)

Investigator's Notebook:

❶ Redrawn Shuttle length	approximately 45 cm
❷ Span of redrawn wings	approximately 32 cm
Redrawn payload bay length	approximately 24 cm
Redrawn payload bay width	approximately 14 cm

Relating Science to . . .

Geography: ❶ Borders are not visible from space, most are political borders rather than natural ❷ We cannot say which countries will be affected or not affected. ❸ Investigators from eight countries will have instruments on ATLAS 1

Social Studies: Allow students to draw conclusions from what they read

Helping Mother Earth

The Resource List in the back of this teacher's guide provides students more sources of information on bats A resource for information on martins, birds that also consume insects, is listed in the back as well

CASE #2 ANSWERS

Investigation A

❶ Answers will depend on observation times Answer will probably be yes. ❷ No ❸ Observations from space must be made at different times of the day and during different months and seasons of the year To give a complete picture, they should take place over a number of years as well

Investigation B

Typical output for the data given·

>>> THIS PROGRAM MEASURES THE CALORIES USED TO HEAT WATER <<<
Grams of Water? 3
What is the beginning Celsius temperature? 10
What is the ending Celsius temperature? 90
For an increase of <80> degrees Celsius
The number of calories used is <240> calories.
OK

Questions

❶ 170 H = G * CH
❷ 240 calories

Investigator's Notebook

All answers are true

(1) "One in four pharmaceuticals comes from a plant in a tropical rainforest" *50 Simple Things You Can Do to Save the Earth*, The Earth Works Group, Berkeley, CA, p 75.
(2) Scientists believe that volcanoes spewed carbon dioxide, creating Earth's early atmosphere This collected warmth and provided environment for life
(3) Source *50 Simple Things You Can Do to Save the Earth*
(4) Scientists think that Earth's earliest atmosphere may have contained a great deal of methane This was lost and later replaced with an atmosphere more conducive to life as we know it
(5) Phytoplankton are a food source for fish, crabs, and other sea life.
(6) Source *50 Simple Things You Can Do to Save the Earth*
(7) Source· *50 Simple Things You Can Do to Save the Earth.*
(8) Source *50 Simple Things You Can Do to Save the Earth*
(9) Source. *50 Simple Things You Can Do to Save the Earth.*
(10) This happens at very infrequent intervals

Relating Science to . . .

Language: A cartographer is a mapmaker.
History: The famous cartographer is Amerigo Vespucci

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☛ Home Activity

Dear Parent or Guardian,

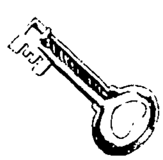
Our class has been studying the changes taking place in the atmosphere. We have been concentrating on how the lower atmosphere is warmed — the greenhouse effect — and the thinning of the ozone found in the middle atmosphere.

One of the suspected causes of an enhanced greenhouse effect is the release of gases that absorb heat Many of these gases are released through burning fossil fuels, like gasoline. To help your children investigate this problem of air pollution and others caused by dust and burning, you may wish to try the activity below with them. On the other side of this letter are some of the tips on **Helping Mother Earth** that we have talked about in class. You and your child may want to discuss these and choose several to work on at home.

Materials Needed

- ✓ white, unlined index cards (for a larger sample, use a sheet of clear contact paper)
- ✓ two-sided transparent tape
- ✓ ruler
- ✓ thumbtacks

Procedure

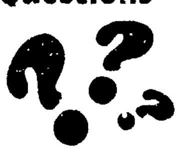


With the ruler and a pen, draw lines to create several squares on the index cards as shown above. Cover the squares with the two-sided tape. Tack the index cards in various places: backyard, kitchen, bedroom, street corner, parking lot, and so on. If you work in a location some distance away, it might be interesting to put up an index card there as well.

After 3 or 4 days, remove the cards, label them by their location, and bring them home for examination. Try to count the small particles that have accumulated on the tape inside the squares. Perform counts on several of the squares; then average the counts.

For an additional math challenge, try this exercise: Make each block on the index card 1 cm square. Calculate the area where the particles were collected. To do this, multiply the length and width of the location to find the area in square centimeters Then multiply this area by the average number of particles collected on one square centimeter of the card. This figure gives an approximation of the number of particles that fall in the entire location.

Questions



Which location had the greatest number of particles? Why would one room of a house have more particles than another? Why would an area near cars have more particles?

Do you turn the faucet off while brushing your teeth? If you allow the water to run, you may use up to 1.3 ℓ. If you brush your teeth twice a day for a year, you may use almost 950 ℓ of water a year. How could you use less water whe vashing your hands?

If you use products such as paint, hair spray, or deodorant that are packaged in aerosol cans, be sure to dispose of them safely. If you avoid puncturing the cans, you will help keep chemicals from entering the atmosphere.

Is mowing the lawn one of your responsibilities? If so, have an adult set the mower blades about 5 to 7.5 cm high. Leaving grass a little long helps the lawn retain moisture so that it requires less watering, saving water. If you must water, do it early in the morning so that the day's heat does not evaporate the water too quickly.

Lights use one-fifth of all the electricity consumed in the United States. To produce more electricity, we burn more fossil fuels in power plants. As more fossil fuels are burned, more greenhouse gases are released. To save electricity, turn off lights when they are not being used.

Glass can be recycled. Find out if your community recycles glass. If it does, keep a large, covered plastic pail outside for storage. Sort clear, green, and brown glass, removing metal or plastic caps. Recycling glass saves energy and conserves natural resources.

Carbon dioxide helps create the "enhanced greenhouse effect." For every liter of gas a car uses, it puts 11.7 kg of carbon dioxide into the atmosphere. To help prevent increases in atmospheric carbon dioxide, walk or ride your bicycle whenever possible, instead of riding in a car.

Use solar energy to make tea. Fill a 2-ℓ glass jar with cold water. Add one family-size tea bag, allowing the string to extend out of the top of the jar. Cap the jar loosely, catching the string under the cap so that the tea bag does not sink to the bottom. Leave in hot, direct sunlight for 3 to 4 hours. Notice the convection currents that eventually "mix" the tea. These are somewhat similar to atmospheric currents. Refrigerate tea within 5 hours after brewing it.

A full-grown tree can consume almost 6 kg of carbon dioxide in 1 year, but 28 million acres of tropical rain forest are destroyed every year. In the United States alone, 300,000 acres of trees are cut down annually, but during the 1980s, only one tree was planted for every four removed from cities and towns. Trees absorb carbon dioxide in the atmosphere; planting more trees could slow the process of global warming. Plant a tree!

Can you imagine loving mosquitos and other insects? Bats do. These mammals consume thousands of mosquitos daily and pollinate fruit trees as well. Both bats and the ATLAS 1 instruments use remote sensing. Bats use it to locate their prey — the insects. ATLAS 1 uses remote sensing to investigate the chemistry of the atmosphere. Contact your library or Bat Conservation International for more information on natural ways to control pests instead of using pesticides.

If your home has a dishwasher, set it to skip the "heated drying" cycle to help save energy. If you wash dishes by hand, rinse all of the dishes at once rather than letting the water run while you rinse one at a time. This will help save water.

Glossary

air currents: Air movements, usually in a certain direction, caused by uneven heating of Earth's surface

air pressure: The amount of force applied by air to a unit of area

anthropogenic: Caused by human beings

atom: The smallest particle of a chemical element that can take part in a chemical reaction without being changed. Atoms form molecules; a molecule of water (H_2O) consists of 2 atoms of hydrogen and 1 atom of oxygen.

auroras: Bands of light that may be visible in the night skies, usually around Earth's poles. Auroras are created when charged particles travel along Earth's magnetic field and collide with its atmosphere.

chemical formulas: Symbols for chemical ingredients. H_2O is the formula for water.

chlorine: A chemical element important in the destruction of ozone. Its symbol is Cl.

chlorofluorocarbons: Groups of chemical compounds containing the elements carbon, chlorine, and fluorine; used in refrigerants and aerosol propellants and in the manufacture of plastic foam; also called CFCs

combustion: The process by which a substance reacts with oxygen to produce heat and light. We call this "burning."

compound: A combination of two or more chemical elements

control: The part of an experiment that remains unchanged or whose change is carefully regulated. The control is compared to the experimental subject to see if change occurs.

convection current: Air movement caused by the different weights of warm and cool air. We call this movement "wind."

corrosion: A chemical reaction in which oxygen combines with a metal. Rusting is an example of corrosion.

decomposers: Substances that break down matter into basic chemical parts

density: The ratio of a material's mass to its volume

electromagnetic spectrum: The arrangement of wavelengths of energy

electron: A small particle with a negative electric charge

elements: The basic parts of chemicals. Elements are made up of atoms that are all chemically alike; iron and oxygen are elements.

evaporate: To change from a liquid to a vapor

experiment: A test of a scientific idea under controlled conditions

experimental subject: The subject of a scientific test

food chain: Plants and animals that feed on one another and, as a result, pass food energy from one organism to another

food web: All the food chains in a particular ecosystem

frequency: The number of complete waves passing a set point in a unit of time, such as seconds or minutes

gamma rays: The highest energy part of the electromagnetic spectrum

global mean temperature: The average of all temperatures around the world

horizontal axis: The horizontal number line of a graph

hypothesis: A scientific "guess" that is made to test the result of an action

infrared rays: Electromagnetic energy just beyond the red end of the visible spectrum

ion: An atom with a negative or positive electric charge

ionosphere: The part of Earth's atmosphere containing electrically charged particles that reflect radio waves

magnetosphere: A region dominated by the magnetic fields that surround Earth

mass: A measurement of a body's weight that takes into account its resistance to movement

mesosphere: The part of the atmosphere that begins just above the stratosphere and it extends to 85 km above Earth. It is the coldest layer of the atmosphere.

microwave: Low-energy radiation between infrared and radio waves in the electromagnetic spectrum

molecule: The smallest particle into which a compound can be divided without changing its chemical and physical properties

myth: A story used to explain nature or certain beliefs

nutrient: A substance that provides the energy to maintain life processes

oxidation: The union of a material with oxygen, resulting in combustion or other chemical processes

particulates: Small particles, especially those in the atmosphere

photosynthesis: The chemical process by which green plants convert light, carbon dioxide, and water into food energy

phytoplankton: Small plants that float or drift in water

precipitation: Rain, snow, or ice that condenses from atmospheric water vapor and falls to Earth

producers: Green plants that obtain their energy directly from sunlight

protozoa: Single-celled, microscopic animals

radius: The straight line that joins the center of a circle to any point on the circle itself

radio waves: The lowest energy part of the electromagnetic spectrum

ratio: A mathematical relationship between 2 numbers; expressed as the division of one number by another, such as 1:2 or 1/2

remote sensing: One way that instruments in space gather data about Earth and its atmosphere. Such instruments study portions of our planet from a distance.

respiration: Breathing. Animals do this by inhaling and exhaling.

solar cycle: Cycle of the Sun's activity that lasts approximately 11 years

solar flare: A burst of gases from the Sun's surface

solar radiance: The electromagnetic energy that Earth receives from the Sun

spectrometer: An instrument that measures the light emitted by the Sun and other stars; ATLAS 1 carries 5 spectrometers.

stratosphere: A layer of Earth's atmosphere just above the tropopause, extending from about 15 km above Earth to about 50 km

sunspots: Temporary dark regions on the Sun's surface. Sunspots are connected with very strong magnetic fields.

theory: An explanation or model based on observations, experiments, and reasoning

thermosphere: The region of Earth's atmosphere that extends from about 85 km to 600 km

trace gases: Gases that are present in small amounts in Earth's atmosphere

tropopause: The transition region between the troposphere and the stratosphere

troposphere: The lowest part of Earth's atmosphere. Most weather takes place in the troposphere.

ultraviolet: High-energy electromagnetic radiation that lies beyond the purple end of the visible spectrum

vapor: The gaseous state of a substance that is liquid or solid under ordinary conditions

vertical axis: The vertical number line on a graph

volume: The space that is occupied by a material

X-rays: High-energy radiation between ultraviolet and gamma rays in the electromagnetic spectrum

zooplankton: Small animals that float or drift in water

Organizations

This list of independent organizations represents possible sources of educational materials and information not available from the National Aeronautics and Space Administration and is offered without recommendation or endorsement by NASA.

American Geophysical Union
2000 Florida Avenue, NW
Washington, DC 20009
Phone: 202-462-6903

American Meteorological Society
45 Beacon Street
Boston, MA 02108
Phone 617-227-2425

Aspen Global Change Institute
100 East Francis
Aspen, CO 81611
Phone: 303-925-7376

Bat Conservation International
P.O. Box 162603
Austin, TX 787 [illegible]
Phone: 512-327-9721

Conservation International Foundation
1015 18th Street, NW, Suite 1002
Washington, DC 20036
Phone: 202-429-5660

Cousteau Society
930 W. 21st Street
Norfolk, VA 23517
Phone: 804-627-1144

Environmental Action Foundation
6930 Carroll Avenue
Suite 600
Takoma Park, MD 20912
Phone: 301-891-1100

Friends of the Earth
Public Information Office
218 D Street, SE
Washington, DC 20003
Phone: 202-544-2600

Global ReLeaf
c/o American Forestry Association
P.O. Box 2000M
Washington, DC 20013
Phone: 800-368-5748

National Arbor Day Foundation
100 Arbor Avenue
Nebraska City, NE 68410
Phone: 402-474-5655

National Center for Atmospheric Research
P.O. Box 3000
Boulder, CO 80307 3000
Phone: 303-497-8600 or 8606

National Geographic Society
17th and M Street, NW
Washington, DC 20036
Phone: 202-857-7000

National Wildlife Federation
8925 Leesburg Pike
Vienna, VA 22184-0001
Phone: 703-790-4000

Purple Martin Conservation Association
Edinboro University of Pennsylvania
Edinboro, PA 16444
Phone 814-734-4420

Sierra Club
Public Affairs Department
930 Polk Street
San Francisco, CA 94109
Phone: 415-923-5660

U S. Environmental Protection Agency
Public Information Center
401 M Street, SW
Washington, DC 20460
Phone: 202-260-7751

Publications

Asimov, Isaac *How Did We Find Out About the Atmosphere?* New York. Walker and Co., 1985.

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1. "What Is Ozone?, What Are Chlorofluorocarbons?, What is the Connection?"
2. "What is the Greenhouse Effect?"
3. "TOMS (Total Ozone Mapping Spectrometer) Monitoring and Measuring Ozone"

NASA, HQL-207, UARS Lithograph

NASA, MW-007/8-91, Mission Watch, STS-48 Upper Atmosphere Research Satellite.

Videotapes

NASA, MH-007/10-91, Mission Highlights, STS-48.

Videotapes are available through NASA Teacher Resource Rooms or Central Operation of Resources for Education (CORE) See pp 60 and 61 for current addresses and phone numbers.

NASA, "Beyond the Clouds: The Upper Atmosphere" (length 12.10)

NASA, "Beyond the Clouds, Video Resource Guide," VRG-002 8/91

NASA, "Liftoff to Learning: Space Basics" (length 20:55)

NASA, "Liftoff to Learning: Space Basics, Video Resource Guide." VRG-001 1/91

☛ NASA Educational Resources

NASA Spacelink: An Electronic Information System

NASA Spacelink is a computer information service that allows individuals to receive news about current NASA programs, activities, and other space-related information, including historical and astronaut data, lesson plans and classroom activities, and even entire publications. Although primarily intended as a resource for teachers, anyone with a personal computer and modem can access the network.

The Spacelink computer access number is 205-895-0028. Users need a computer, modem, communications software, and a long-distance telephone line to access Spacelink. The data word format is 8 bits, no parity, and 1 stop bit. For more information, contact:

Spacelink Administrator
NASA Marshall Space Flight Center
Mail Code CA21
Marshall Space Flight Center, AL 35812
Phone: 205-544-0038

NASA Educational Satellite Videoconferences

During the school year, a series of educational programs is delivered by satellite to teachers across the country. The content of each videoconference varies, but all cover aeronautics or space science topics of interest to the educational community. The broadcasts are interactive: a number is flashed across the bottom of the screen, and viewers can call collect to ask questions or take part in a discussion. For further information, contact:

Videoconference Coordinator
NASA Aerospace Education Services Program
300 North Cordell
Oklahoma State University
Stillwater, OK 74078-0422
Phone: 405-744-7015

Dr. Malcom V. Phelps
Educational Technology Branch
Education Division
Code FET
NASA Headquarters
Washington, DC 20546
Phone: 202-453-8388

NASA Central Operation of Resources for Educators (CORE)

CORE was established for the national and international distribution of NASA-produced educational materials in audiovisual format. Submit a written request on your school letterhead for a catalogue and order forms. Orders are processed for a small fee that includes the cost of the media. For more information, contact:

NASA CORE
Lorain County Joint Vocational School
15181 Route 58 South
Oberlin, OH 44074
Phone: 216-774-1051, Ext. 293 or 294

Teacher Resource Center Network

To make information available to the educational community, the Education Division has created the NASA Teacher Resource Center Network. Teacher Resource Centers (TRCs) contain a wealth of information for educators: publications, reference books, slides, audio cassettes, videocassettes, telelecture programs, computer programs, lesson plans and activities, and lists of publications available from government and nongovernment sources. Because each NASA field center has its own areas of expertise, no two TRCs are exactly alike. Phone calls are welcome if you are unable to visit the TRC that serves your geographic area. The chart on the next page delineates the geographic regions and provides addresses.

For more information about Elementary and Secondary Programs

If you live in:		Center Education Programs Officer	Teacher Resource Center
Alaska Arizona California Hawaii Idaho Montana	Nevada Oregon Utah Washington Wyoming	Mr. Garth A. Hull Chief, Educational Programs Branch Mail Stop T025 NASA Ames Research Center Moffett Fie d, CA 94035 Phone: 415-604-5543	NASA Ames Research Center Attn: Teacher Resource Center Mail Stop T025 Moffett Field, CA 94035 Phone: 415-604-3574
Connecticut Delaware District of Columbia Maine Maryland Massachusetts	New Hampshire New Jersey New York Pennsylvania Rhode Island Vermont	Mr. Elva Bailey Chief, Educational Programs Public Affairs Office (130) NASA Goddard Space Flight Center Greenbelt, MD 20771 Phone: 301-286-7207	Attn: Teacher Resource Laboratory Mail Code 130.3 NASA Goddard Space Flight Center Greenbelt, MD 20771 Phone: 301-286-8570
Colorado Kansas Nebraska New Mexico	North Dakota Oklahoma South Dakota Texas	Dr. Robert W. Fitzmaurice Center Education Program Officer Public Affairs Office (AP-4) NASA Johnson Space Center Houston, TX 77058 Phone: 713-483-1257	NASA Teacher Resource Room Mail Code AP-4 NASA Johnson Space Center Houston, TX 77058 Phone. 713-483-8696
Florida Georgia	Puerto Rico Virgin Islands	Mr. Raymond R Corey Chief, Education and Awareness Branch Mail Code PA-EAB NASA Kennedy Space Center Kennedy Space Center, FL 32899 Phone: 407-867-4444	NASA Educators Resources Laboratory Mail Code ERL NASA Kennedy Space Center Kennedy Space Center, FL 32899 Phone: 407-867-4090
Kentucky North Carolina South Carolina	Virginia West Virginia	Dr. Karen R. Credeur Head, Office of Public Services Mail Stop 154 NASA Langley Research Center Hampton, VA 23665-5225 Phone. 804-864-3307	NASA Teacher Resource Center Mail Stop 146 NASA Langley Research Center Hampton, VA 23665-5225 Phone: 804-864-3293
Illinois Indiana Michigan	Minnesota Ohio Wisconsin	Dr. Lynn Bondurant Chief, Educational Services Office Mail Stop 7-4 NASA Lewis Research Center 21000 Brookpark Road Cleveland, OH 44135 Phone: 216-433-5583	NASA Teacher Resource Center Mail Stop 8-1 NASA Lewis Research Center 21000 Brookpark Road Cleveland, OH 44135 Phone: 216-433-2017
Alabama Arkansas Iowa	Louisiana Missouri Tennessee	Mr. William E. Anderson Chief, Education Services Branch Public Affairs Office (CA21) NASA Marshall Space Flight Center Marshall Space Flight Center, AL 35812 Phone 205-544-7391	Attn: NASA Teacher Resource Center U.S Space and Rocket Center Huntsville, AL 35807 Phone: 205-544-5812
Mississippi		Mr. Marco Giardino Center Education Program Officer Mail Stop AA00 NASA John C. Stennis Space Center Stennis Space Center, MS 39529 Phone. 601-688-2739	NASA Teacher Resource Center Building 1200 NASA John C. Stennis Space Center Stennis Space Center, MS 39529 Phone: 601-688-3338
The Jet Propulsion Laboratory (JPL) serves inquiries related to space and planetary exploration and other JPL activites		Mr Richard Alvidrez Manager, Public Education Mail Code 180-205 Jet Propulsion Laboratory 4800 Oak Grove Drive Pasadena, C 91109 Phone 81 54-8592	NASA Teacher Resource Center JPL Educational Outreach Mail Stop CS-530 Jet Propulsion Laboratory 4800 Oak Grove Drive Pasadena, CA 91109 Phone 818-354-6916

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Acknowledgements

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NASA Headquarters, Washington, DC

Office of Space Science and Applications
Flight Systems Division
Earth Science and Applications Division
Administration and Resources Management Division

Office of Human Resources and Education
Education Division
Office of Public Affairs

Marshall Space Flight Center, Huntsville, Alabama

Payload Projects Office

Public Affairs Office

Johnson Space Center, Houston, Texas

Astronaut Office

Scientists, teachers, and others who gave their time and creativity in recognition of the importance of the space program in inspiring and educating students

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For **Helping Mother Earth**: This and other hints for a better environment were inspired by *50 Simple Things You Can Do to Save the Earth*, The Earth Works Group, Earthworks Press, Berkeley, California, 1989

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Educators and scientists at the National Aeronautics and Space Administration would appreciate your taking a few minutes to select the appropriate response to the statements below. Postage has been provided.

SA — Strongly Agree
A — Agree
U — Undecided
D — Disagree
SD — Strongly Disagree

ATLAS 1 Teacher's Guide: Earth's Mysterious Atmosphere

1. The ATLAS 1 Teacher's Guide is easily integrated into the curriculum.	SA	A	U	D	SD
2. The **procedures** for the **investigations** have sufficient information and are easily understood.	SA	A	U	D	SD
3. The illustrations are adequate to explain **procedures** and concepts.	SA	A	U	D	SD
4. **Investigations** effectively demonstrate concepts and are appropriate for the grade level I teach.	SA	A	U	D	SD

5. a. What features of the ATLAS 1 Teacher's Guide are particularly helpful in your teaching?

____

b. What changes would make the ATLAS 1 Teacher's Guide more effective for you?

____

6. I teach ________ grade. Subjects ______________________________

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Additional comments

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