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U.S. Department of Energy
University and Science Education Program

Wildlife Conservation Society/Bronx Zoo
Living Systems Energy Module
Grant No.: DE-FG02-92ER 75755

Final Report

In August 1992 the U.S. Department of Energy granted \$100,000 to the Wildlife Conservation Society/Bronx Zoo (formerly NYZS/The Wildlife Conservation Society) to develop the *Living Systems Energy Module*. The effective period of the grant was September 1, 1992 through February 28, 1995 (a no-cost extension from August 31, 1994 to February 28, 1995 was granted by Ms. Christine Grady on July 25, 1994 and a subsequent three month reporting extension was granted in April, 1995). The total budgeted cost of this project was \$200,000 (reduced from \$218,630). The Society assumed \$100,000 (reduced from \$118,630) as its cost share. This final report covers the entire scope of the project, the period from October 1, 1992 through August 31, 1995.

Project Overview

The *Living Systems Energy Module*, renamed *Voyage from the Sun*, is a twenty-lesson curriculum designed to introduce students to the major ways in which energy is important in living systems. *Voyage from the Sun* tells the story of energy, describing its solar origins, how it is incorporated into living terrestrial systems through photosynthesis, how it flows from plants to herbivorous animals, and from herbivores to carnivores. A significant part of the unit is devoted to examining how humans use energy, and how human impact on natural habitats affects ecosystems. As students proceed through the unit, they read chapters of *Voyage from the Sun*, a comic book that describes the flow of energy in story form (Appendix A). During the course of the unit, an "Energy Pyramid" is erected in the classroom. This three-dimensional structure serves as a classroom exhibit, reminding students daily of the importance of energy and of the fragile nature of our living planet. Interactive activities teach students about adaptations that allow plants and animals to acquire, to use and to conserve energy. A complete list of curricular materials and copies of all activity sheets appear in Appendix B.

Project Objectives

By bringing difficult energy concepts within the grasp of children, *Voyage from the Sun* aims to increase science literacy, to encourage young people to consider careers in science, and to produce citizens prepared to understand and act upon issues related to resource use and conservation. These are aims shared by the U.S. Department of Energy and the Wildlife Conservation Society. The specific goals of the project are:

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- To equip students in grades 4-9 with a basic understanding of what energy is and how it flows through living systems, and to motivate students to study energy-related concepts
- To facilitate students' understanding of how human energy demands affect the environment
- To enhance and increase the instructional repertoire for teaching energy-related concepts by furnishing teachers of grades 4-9 with interactive materials that illustrate abstract energy concepts in a highly engaging manner
- To provide teachers with a clearly-written guide to teaching energy concepts within the context of habitat ecology

The Development Process

Before beginning design of the actual materials that make up the *Voyage from the Sun* curriculum, staff of the Bronx Zoo/Wildlife Conservation Park's Education Department visited classes in three schools (P.S. 15, P.S. 56, and P.S. 81 in New York City) in order to assess the needs of the teachers and students who would be served by the curriculum. These schools were chosen because their students came from a range of cultural and economic backgrounds considered typical of the New York City public schools. The main goal of these focus group sessions was to find out what students know about the role of energy in biology and to identify main areas of weakness in their knowledge. Brainstorming, concept mapping, and other activities were used to assess student knowledge. These classroom visits confirmed several of the conclusions that had become clear as a result of the Education Department's years of experience teaching ecological concepts to students of all grade levels. It was determined that, in general, students' knowledge and understanding of energy concepts was superficial. Some students had vague ideas about photosynthesis and were aware that sunlight is involved in the process, but the connection between the solar energy used by plants and the energy that allows animals to survive was not at all clear to them. It was determined that student knowledge of energy concepts occurs in disparate contexts, but the importance of energy as a unifying biological concept is not recognized by most students. Students also had a very limited understanding of the multitude of ways in which humans use energy, and of how human energy-use impacts on natural habitats.

The actual design process began with brainstorming sessions among Bronx Zoo staff in New York City, and in Orlando, Florida, among the staff of *Chesler, Garvie, and Daniels*--the design firm contracted for this project. These sessions resulted in initial design concepts and materials. They were followed by a meeting at the Bronx Zoo in April 1993 that included Designer, Richard Chesler; Ecologist/Consultant, Dr. Rick Sullivan; Project Director, Annette Berkovits; Project Coordinator, Tom Naiman; and other members of Education Department staff.

During the spring and summer of 1993, more than 100 teachers of grades 4-9 were exposed to the concepts and materials of *Voyage from the Sun*. These teachers were asked for their overall reaction to the project, how it can fill gaps in their existing curriculum, where they saw particular strengths, weaknesses, or opportunities for improvement, and whether they would be interested in testing the module in their own classrooms. Overall, the teachers were very enthusiastic about the project. Many felt that it had the potential to be a valuable educational tool for children of many different grade levels, exhibiting a wide range of abilities. Most felt it could be geared up or down to suit the needs of their particular classes and that it had a direct link to their school curriculum.

In October 1993, the Designer, Ecologist/Consultant, and Bronx Zoo staff met again to discuss progress to that point and to evaluate developmental issues that resulted from teacher evaluations. Many improvements were made as a result of teacher feedback.

In November 1993, two groups of teachers were brought to the Bronx Zoo for introduction to *Voyage from the Sun* and training in how to use the first prototype materials with their students. They took a variety of prototype materials back to their schools and classroom testing occurred from November 1993 through January 1994. In February, 33 teachers handed in extensive evaluation materials. Also, two additional consultants were hired at this point: Jay Kirsch Ph.D., a physicist at MIT, and Richard Goodman, a master science teacher from Horace Greeley High School in Chappaqua, New York. Dr. Kirsch's role was to comment on the manner in which physical science issues were covered in the program. Mr. Goodman's role was to comment on heuristic aspects of the program and to test various program elements with students.

From March to June 1994, evaluation materials were assessed and program development continued, taking into account the results from the evaluations and advice from consultants. In July 1994, a grant amendment was received from DOE Chicago Operations office extending the grant period through February 28, 1995, without additional funds.

Beginning in July of 1994, new program elements were tested by 75 teachers in Bronx Zoo teacher-training workshops. In the months between September and November 1994, the first program elements were printed: the *Voyage from the Sun* comic book and the *Energy for Survival* poster. The *Voyage from the Sun* comic book serves as a "textbook" in which scientific concepts are presented creatively as the students follow the journey of "Professor Energy" and a bright but impulsive pupil, "Sunburst" on a voyage of discovery. Sophisticated scientific concepts are communicated clearly and in ways that make abstract concepts clear and accessible. The comic book has been among teachers' and students' favorite program materials (see evaluation section).

From December 1994 through February 1995 program development and printing of program materials continued. Five teacher training workshops were held for teachers who would test the finished prototype. The workshops were held at three sites: the Bronx Zoo; the Roger Williams Park Zoo in Providence, Rhode Island, and Union Point Elementary School in Greene County,

a rural school district outside of Athens, Georgia. In all, 67 teachers were trained in these sessions.

In March 1995 the printing of program materials was completed and finished prototype kits were shipped to schools. From April through June 1995 teachers tested the finished prototype in their schools and provided feedback on extensive evaluation forms (Appendix C). In April, the Wildlife Conservation Society requested and received permission from Ms. Christine Grady to delay final reporting from May 28, 1995 to August 31, 1995 so that final teachers' evaluations could be processed and analyzed.

Evaluation Strategy

The final evaluation of the *Voyage From The Sun* prototype has included four main components: teacher-training, classroom testing of the program, teacher response forms, and pre-unit and post-unit testing of student content knowledge. To date we have received responses from 31 teachers and the initial data are extremely promising. Of the 31 teachers who sent in their completed evaluation forms, all 31 expressed the desire to use the curriculum again in the future. Teacher responses indicate that the teachers believe *Voyage From The Sun* to be a valuable tool that motivates students, teaches them important concepts, and fits easily into most standard school curricula for grades 4-9. The student pre-unit and post-unit tests indicated a substantial increase in relevant content knowledge.

The formative evaluation process was initiated in the earliest stages of development. The summative evaluation process began in December 1994, with the first of five teacher training workshops. The full-day workshops, led by Bronx Zoo staff, were designed to prepare teachers for classroom testing of *Voyage From The Sun*. The workshops included introduction to the program philosophy and materials, as well as relevant background information. Although all the curricular components were not yet printed, teachers were given the chance to participate directly in some of the program's main activities, enhancing their ability to facilitate their students' use of the program. The workshops, which included sixty-seven teachers of grades 4 through 9, were held at the Bronx Zoo, the Roger Williams Park Zoo in Providence, Rhode Island, and at Union Point Elementary School in Greene County, a rural school district outside of Athens, Georgia.

After the workshops, final production of the prototype continued. A problem in production of the Energy Pyramid, one of the program's central materials, delayed shipping of the kits until the end of March. Teachers received the kits in mid-April and about half of them immediately began using the curricular materials with their students. The remainder elected to delay their classroom testing until the coming fall semester of 1995. The results discussed below are based on evaluation forms received from 31 teachers of grades 4-6.

The evaluation program will continue in the 1995-1996 academic year as more students and teachers use the *Voyage From The Sun* curriculum.

Student Demographics

Teacher responses indicate that the program was tested with students from a wide range of geographic, cultural, and economic backgrounds. Of the 31 teachers, 19 (61 %) described their students as average academically, 13 (42%) described their students as below average. Two teachers (6%) described their students as above average, while 1 (3%) described her students as "Special Education." (Note: percentages do not always equal 100% because teachers occasionally chose two responses or elected not to respond to a question. Also, percentages were rounded to the nearest percent.) The percentage of students eligible for school lunch programs ranged from 2-100%. Teachers described their student populations as multicultural, middle class suburban, black and Hispanic, white middle class, and rural lower to middle class.

Teacher Response

Teacher responses indicated that *Voyage from the Sun* fits well into most mandated school curricula. Teachers cited the use of critical thinking skills, hands-on activities, and multi-disciplinary links as among the major reasons why *Voyage from the Sun* could be inserted easily into their standard curriculum.

When asked about unexpected outcomes of the program, teachers said that it bolsters self-esteem, that students developed an awareness of responsibility towards the environment, and that students looked forward to science class and the study of ecology.

A complete breakdown of teacher response appears in Appendix D. Several salient points are elaborated below.

As stated earlier in this report, of the 31 teachers who returned their evaluation forms, all 31 (100%) responded that they would like to use the program again in the future. When asked to rate the curriculum as "highly effective," "effective," or "ineffective," 11 (35%) chose "highly effective," 19 (61%) chose "effective" and 0 (0%) chose "ineffective." Of the 11 teachers who ranked the curriculum "effective," 9 explained that the late arrival of the materials was a factor in their decision not to choose "highly effective."

When asked to rate the program's effectiveness in stimulating students' interest in science, 17 (55%) chose "excellent," 14 (45%) chose "good," 0 (0%) chose "fair," and 0 (0%) chose "poor."

When asked if the curriculum provides "many new approaches/materials," "some new approaches/materials" or "duplicates other programs," 22 (71%) chose "many new approaches/materials," 9 (29%) chose "some new approaches/materials," and 26% chose "duplicates other programs."

When asked, "did the instructional activities address the stated aims [of the program]?" all 31

teachers (100%) responded "yes."

The main curricular components also received high ratings. 19 teachers (61%) rated the Teachers' Guide "very effective." 23 teachers (74%) rated the comic book "very effective." 21 teachers (67%) rated the Energy Pyramid "very effective." 24 teachers (77%) rated the plant and animal cards "very effective." 18 teachers (58%) rated the student activity sheets "very effective."

Student Content Test

A test was developed to measure student content knowledge before and after the use of the *Voyage from the Sun* Curriculum. A copy of the test is included in Appendix E. Teachers were asked to administer the test to their students before and after use of the program.

Twenty teachers administered the test properly, before and after use of the curriculum. Results of the student testing appear in Appendix F. For fourth grade, 112 students from four classes were tested. Their pre-unit mean test score was 15.1 (out of a possible 30) and their post-unit mean test score was 19.6. For fifth grade, 328 students from 12 classes were tested. Their pre-unit mean test score was 14.4 and their post-unit mean test score was 20.0. For sixth grade, 104 students from four classes were tested. Their pre-unit mean test score was 13.9 and their post-unit mean test score was 19.1.

We compared the pre-unit and post-unit test scores for each grade and for the whole sample using a t-Test of significance at $p = .05$. We found that there was a highly significant difference between pre-unit and post-unit test scores for each individual grade (4,5,6) and for the entire combined sample of 544 students. These highly significant improvements in content knowledge suggest that use of the *Voyage from the Sun* curriculum dramatically increases student knowledge and understanding of energy-related concepts in biology.

Conclusions

A summary of the evaluation data presented in the previous section and in Appendices D and E, suggests that many of the project's goals have been achieved.

Teacher response indicates that the new *Voyage from the Sun* curriculum fills gaps in existing science curricula while successfully motivating teachers and students to pursue energy-related subjects. Student test results indicate that students using the curriculum are improving their understanding of energy-related concepts and of how human energy demands affect the environment. Student content knowledge in science is also increased as a result of the curriculum. A sample of four teachers' comments appears below:

"(The students) were learning and retaining more information than in any other lessons I have taught in science."

Tracey Paladino-Sherding, 4th grade teacher, P.S. 29, Yonkers, N.Y.

"Several children who were difficult to motivate became very enthusiastic about science through the use of this program."

Susan Chiesa, 5th grade teacher, Howell Road School, Valley Stream, N.Y.

"The children loved Photosynthesis Bingo and begged me to play it again and again. They spent their free time looking at and reading the pyramid cards and facts. This was a great way to teach them about the relationship between energy, plants, and animals."

Jean Weissman, 4th grade teacher, John Lewis Childs School, Floral Park, N.Y.

"I was flabbergasted at the difference in children's understanding and change in vocabulary. It was a great experience."

Phoebe Kaston, 5th grade teacher, P.S. 33, Queens Village, N.Y.

Of the 67 teachers who received the curriculum in spring 1995, those who were unable to use the material in this academic year have all agreed to use them in the 1995-96 school year. In addition, all of the teachers who did use the curriculum this year expressed the desire to use it again next year.

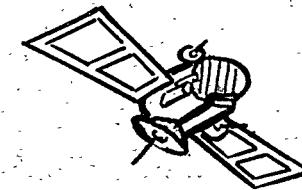
The Wildlife Conservation Society has applied to DOE for a grant of \$122,238 to support nationwide dissemination of *Voyage from the Sun*. In the meantime, the Society has received \$12,500 from the General Electric Foundation to support this dissemination effort.

Evaluation will continue throughout the dissemination of prototypes and further improvements will be incorporated into future reprints of the materials.

VOYAGE FROM THE

GET ENERGIZED!

WARNING:
HIGH ENERGY
ADVENTURE!





STORY: TOM NAIMAN
ILLUSTRATION: SIMON CÔTE

INTRODUCTION

MEET **PROFESSOR ENERGY** AND **SUNBURST**, THE "STARS" OF THIS ROUND-THE-WORLD ADVENTURE!

PROFESSOR ENERGY HAS A TOUGH JOB AHEAD: TO PREPARE SUNBURST FOR A MISSION ON THE PLANET EARTH. TRAVEL WITH THEM ON THEIR JOURNEY AND SEE HOW THE FRAZZLED BUT KIND-HEARTED PROFESSOR GUIDES HIS OVERLY-ENERGIZED STUDENT, SUNBURST, THROUGH A CLOSE ENCOUNTER OF THE PHOTOSYNTHETIC KIND. SEE WHAT'S IN STORE FOR SUNBURST AS HE TAKES THE HEAT FROM FEROIOUS EAGLES AND TANGLES WITH THE FORCES OF NATURE! **WILL SUNBURST EVER ACCOMPLISH HIS MISSION?**

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Chesler, Garvie & Daniels
Design/Production

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Special thanks for additional comments on *Voyage From The Sun*: Eunice Kang, Emily Laber, Don Lisowy, Lauraine Merlini, Anne Nesbet, Lyn Stevens.

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the Department of Energy.

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General Electric Foundation
Candice and John Frawley

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FOUNDED IN 1895 AS THE NEW YORK ZOOLOGICAL SOCIETY

CHAPTER 1

Somewhere in the Sun...

OK Sunburst, let's review.
Please define the word "Energy."

ENERGY

Gee, Professor E,
that's a tough one.

You mean
to tell me
you still don't
know the first
thing about
energy? Energy
is what enables
us to do every-
thing we do...
like bouncing
that yo-yo
every time
my back is
turned.

OOPS!

Try to concentrate now, Sunburst. For months I've been trying to
prepare you for a great mission. As a little piece of the Sun's energy,
you must travel down to Earth and provide energy to the plants
and animals that live there. They're depending on you.

The rest of your family and all your classmates
have left already. But I can't let you go until you've
learned what you need to know.

Are you coming too?

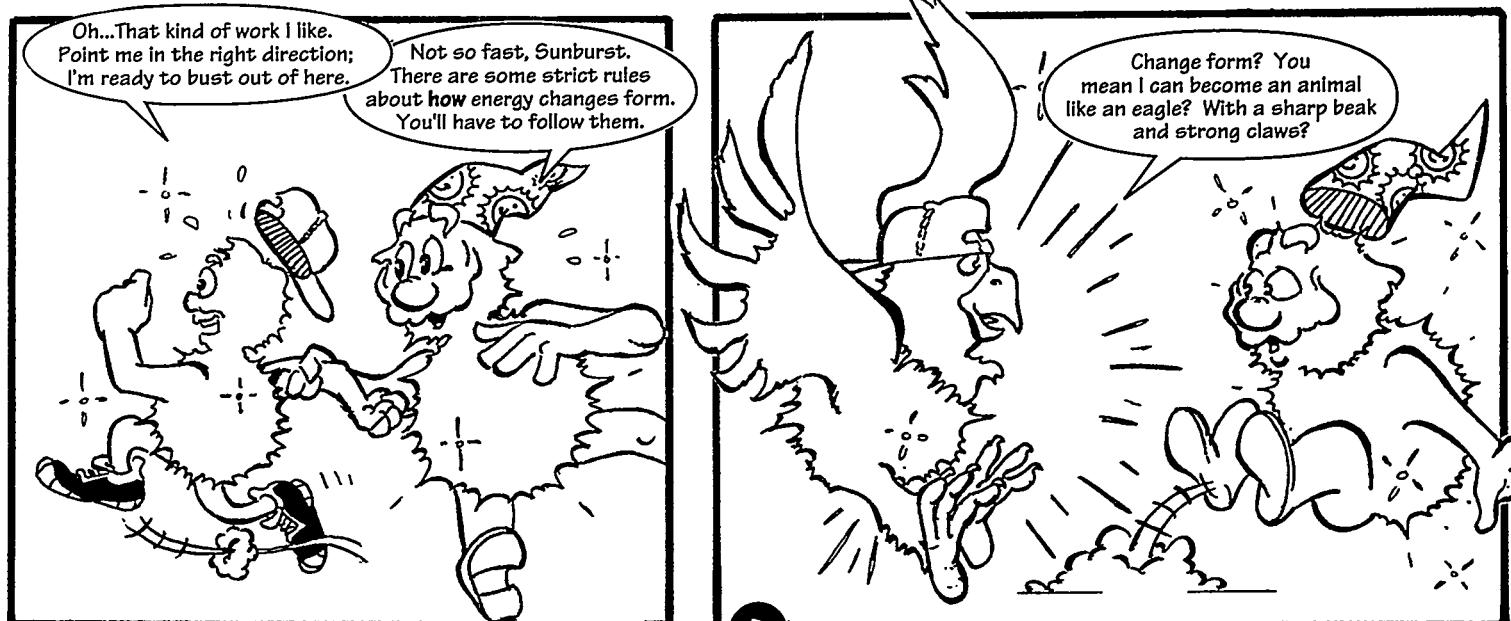
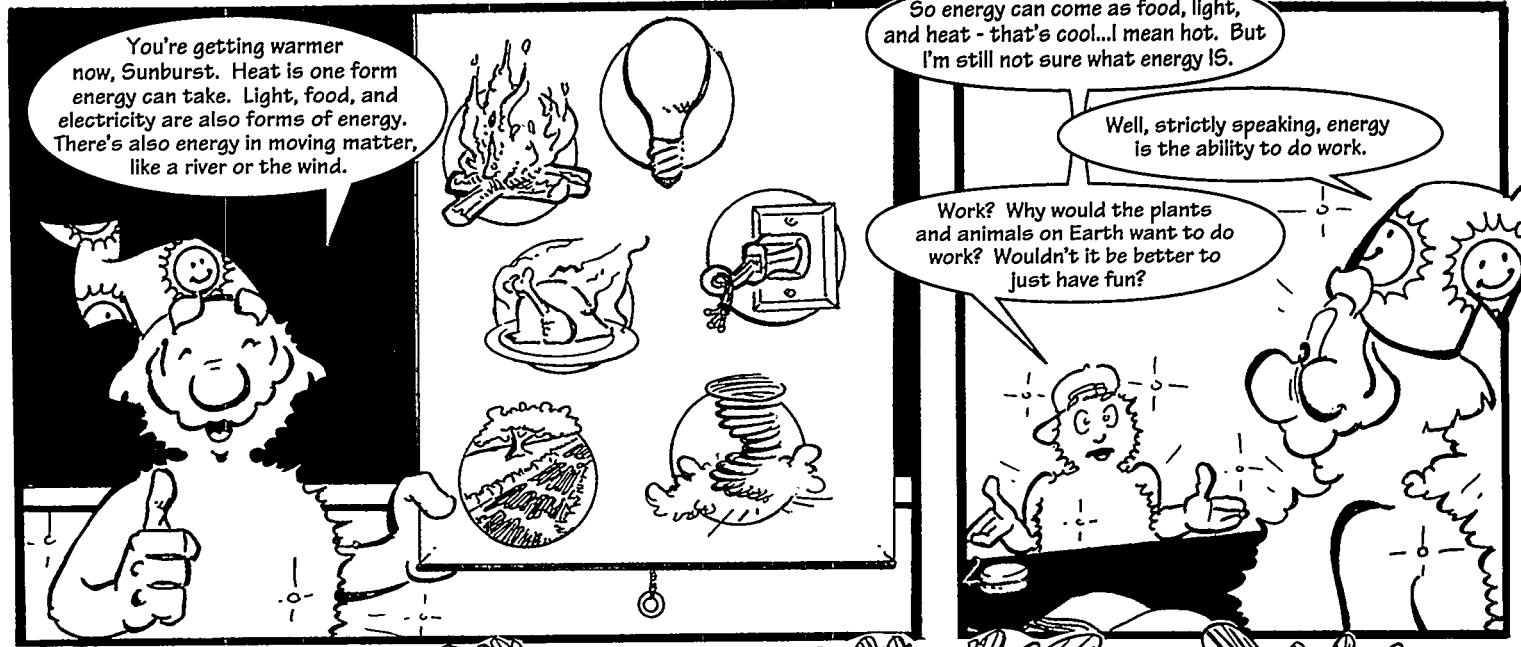
Great Grandma Sunny

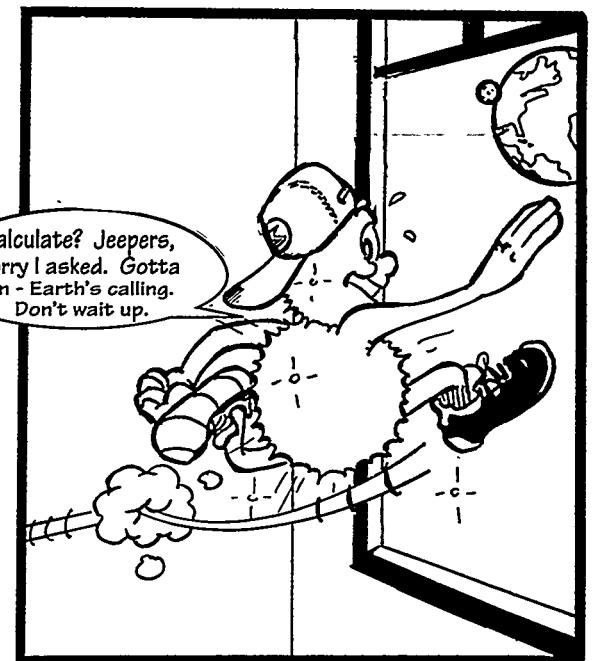
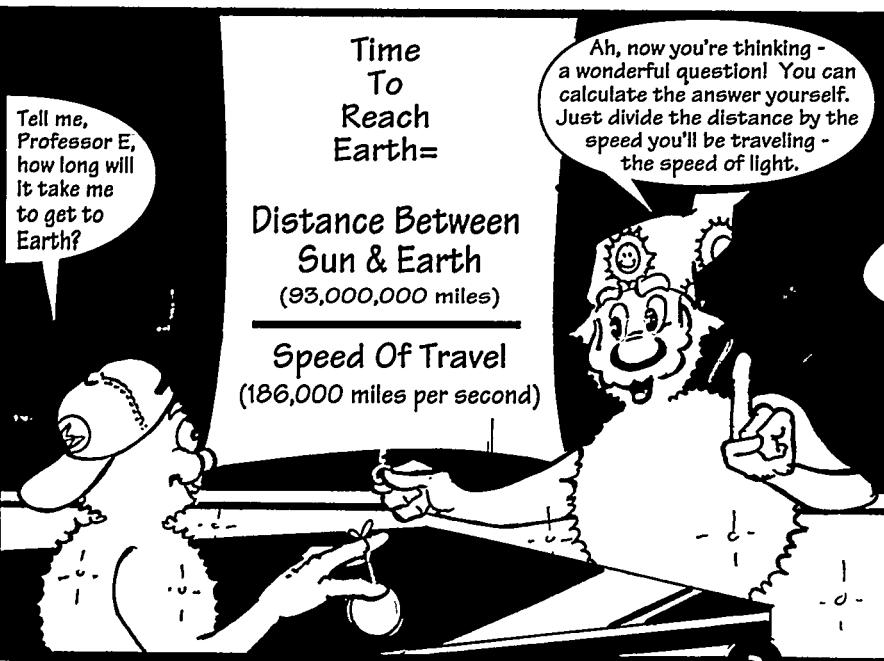
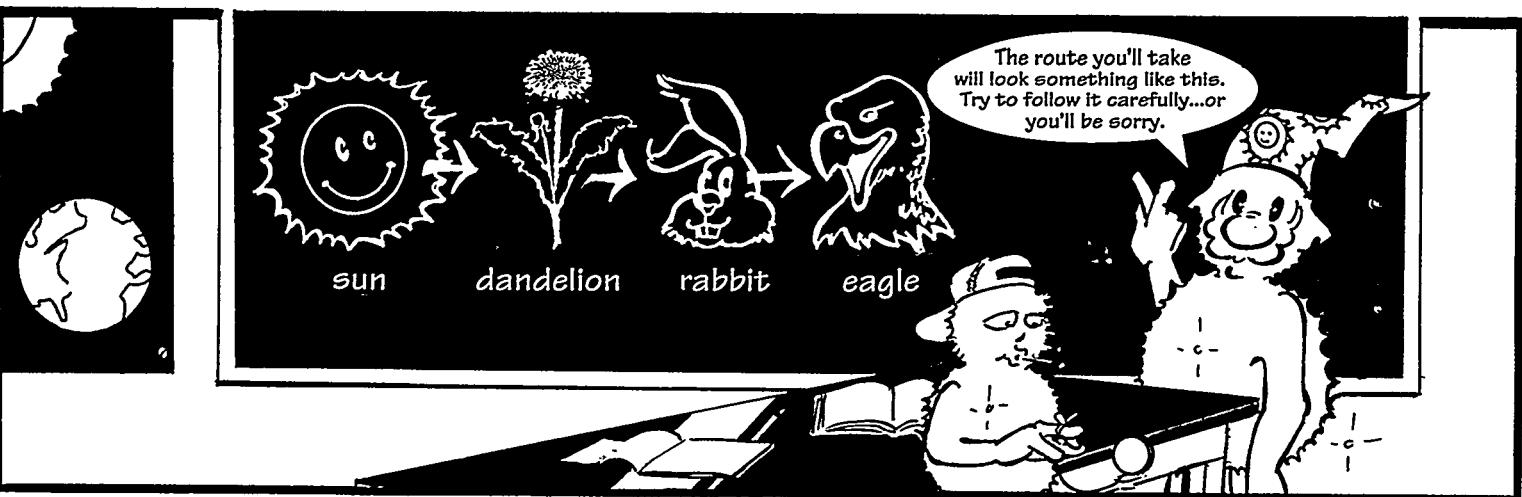
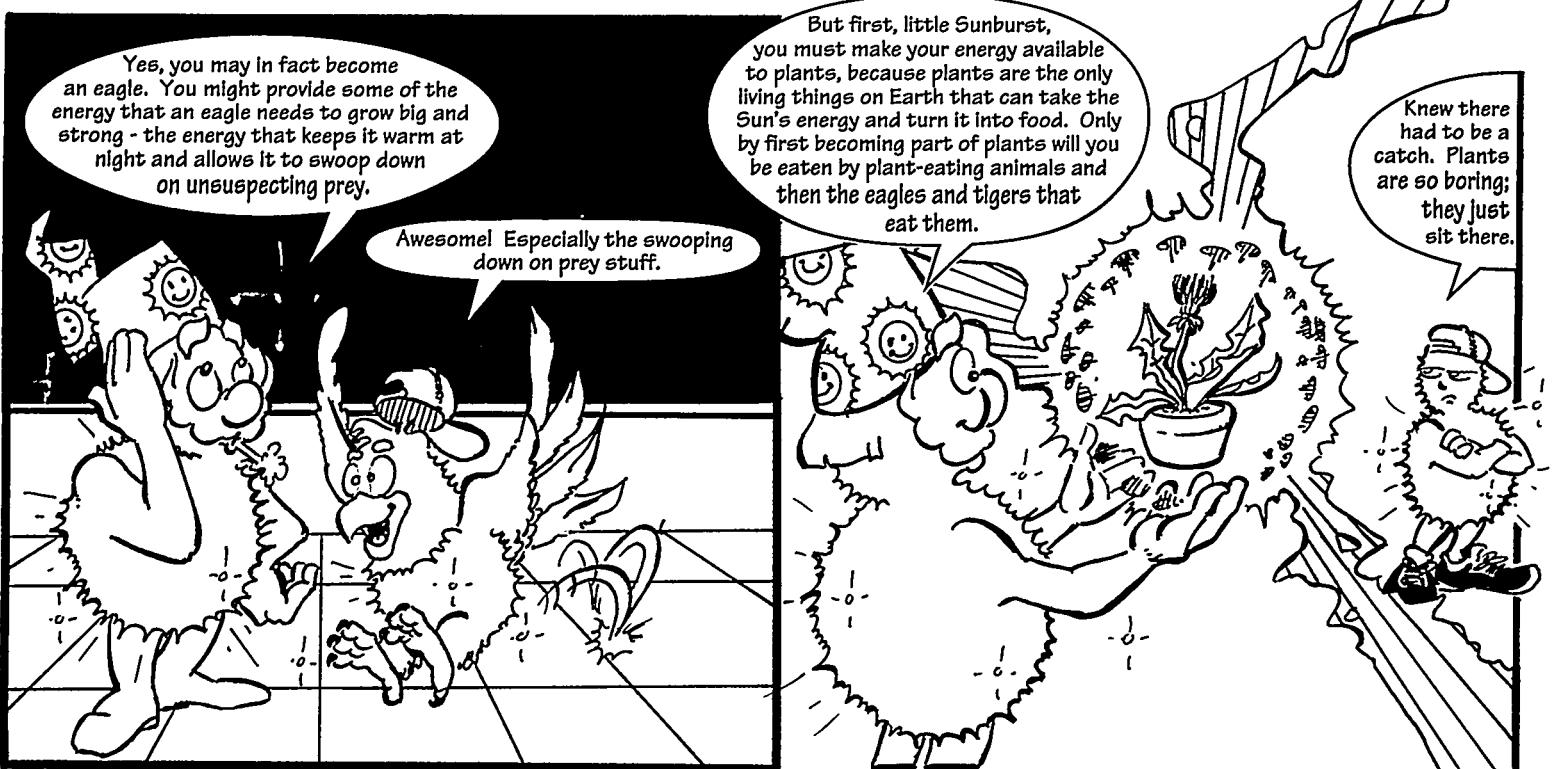
Grampa Ray

Sunburst, Sunbeam
Mom and Pop

No,
Sunburst,
I have to stay
and teach other
students. But let's
start over from the
beginning. Just about
all of the Earth's energy
originally comes from
the place we're in right
now - the Sun. After
it leaves here, it can
take many different
forms. You should
be able to tell me
some of them
by now.

It's always so hot in
here; it's hard to think.





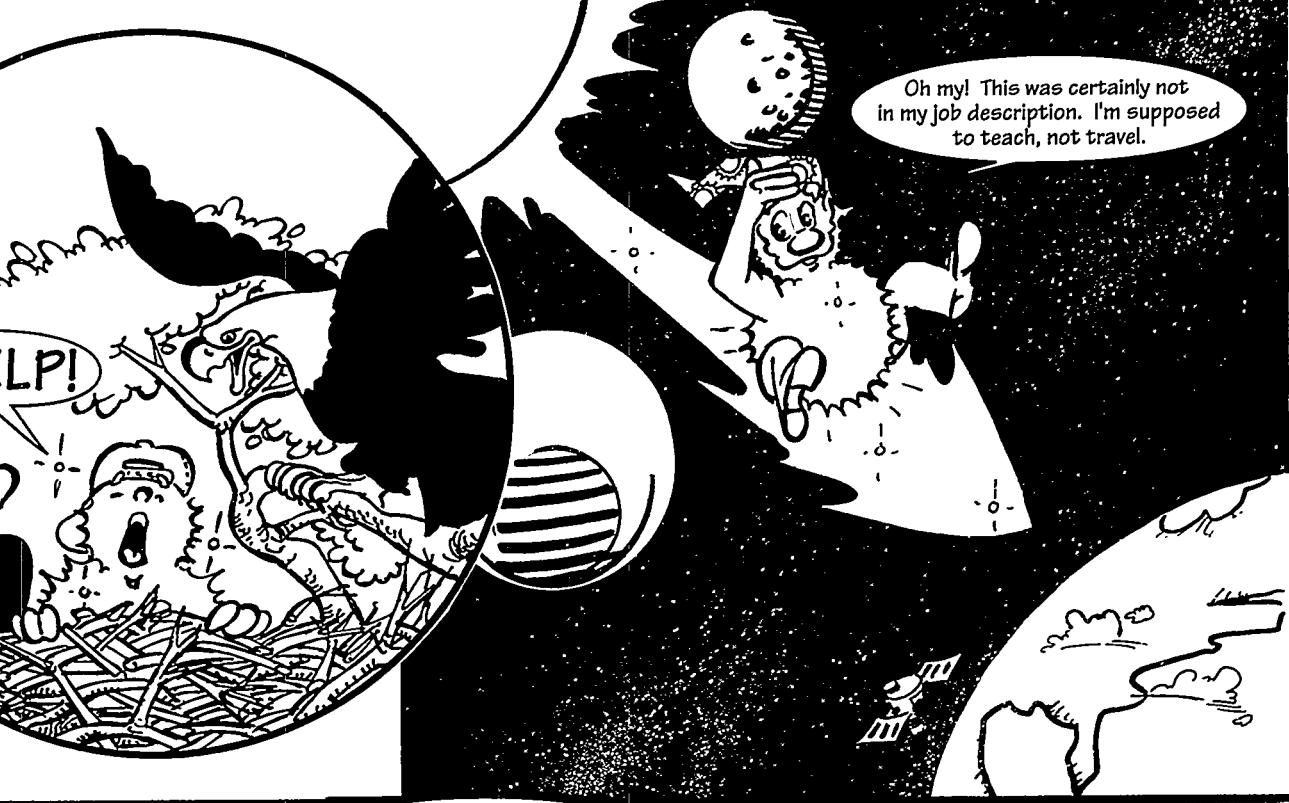
CHAPTER 2

The Professor, relieved that Sunburst is finally on his way...

That little Sunburst. He's so smart, but just can't seem to apply himself. I never thought I'd say this about one of my pupils, but he seems to have too much energy. Sunburst was right, it is hot in here.

Whoops, time to check on Sunburst's progress towards Earth. So much to do and only a few billion years to do it.

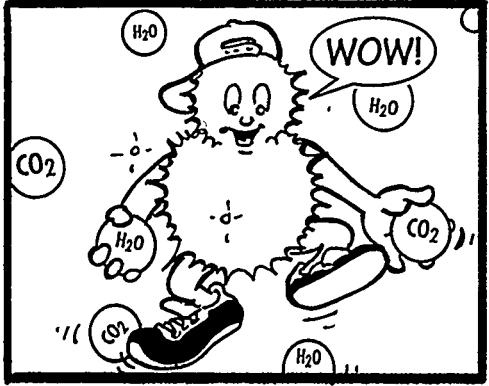
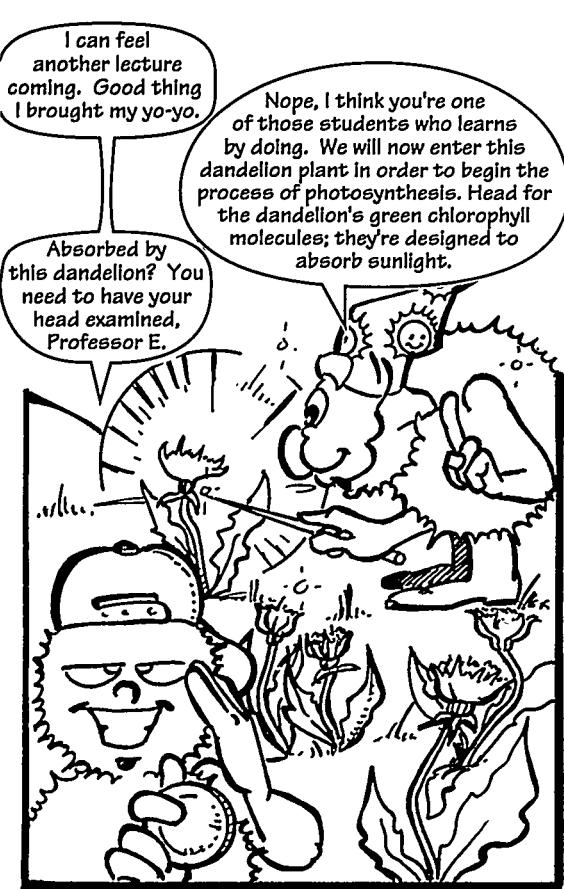
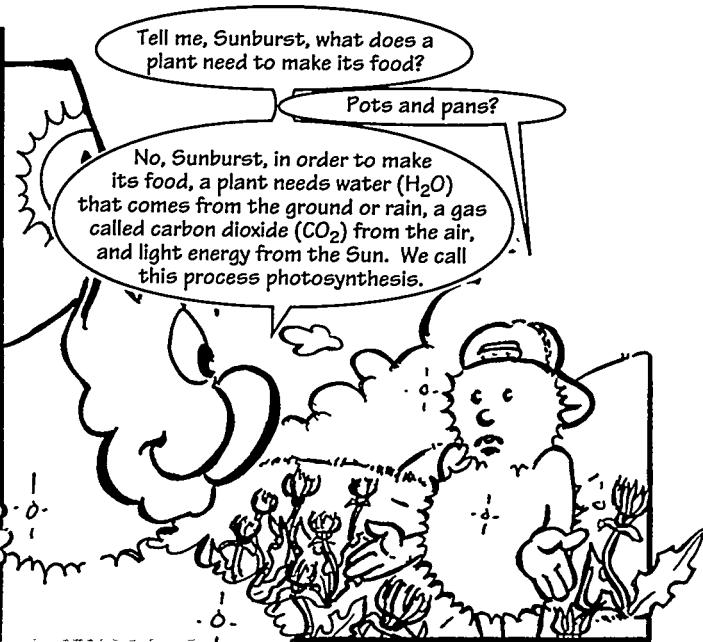
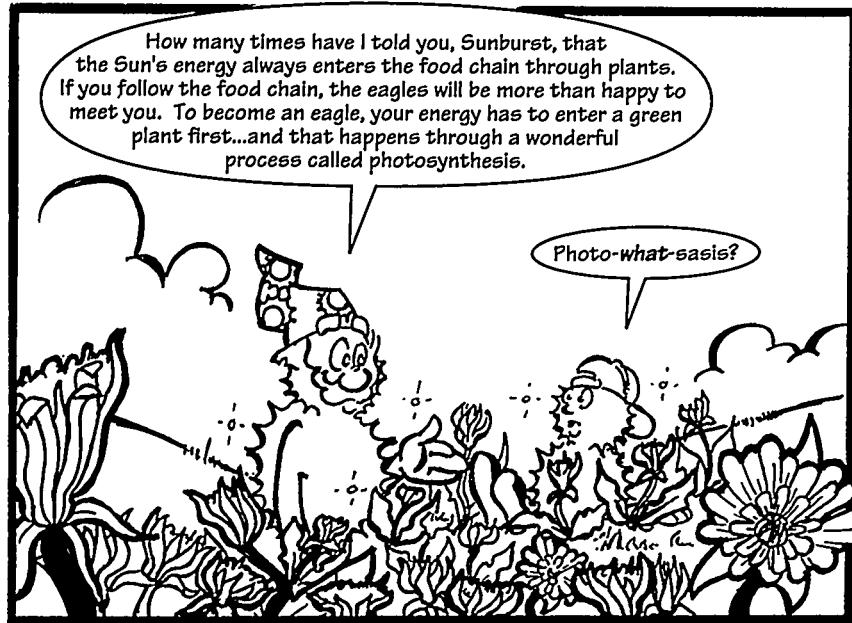
Ohmigosh! What on Earth is Sunburst doing?



Sunburst, what's going on?

Well, I saw these great eagles and I decided I'd skip all that other stuff. I thought they'd be happy to see me, but one looked ready to tear my head off.

No time to talk, better get us out of here. Cabradabra. Or is that Abracadabra? I can never remember.



CHAPTER 3

A short while later, still in the dandelion...

Now that you've mastered photosynthesis, Sunburst, do you still think plants are boring?

Well, photosynthesis is pretty neat, I guess. It's great to be able to make food from just water, air, and sunlight. But I still like animals - there are so many different kinds.

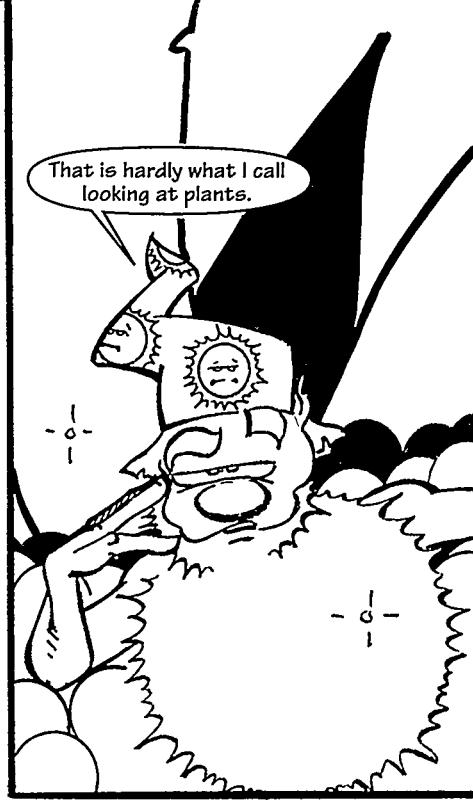
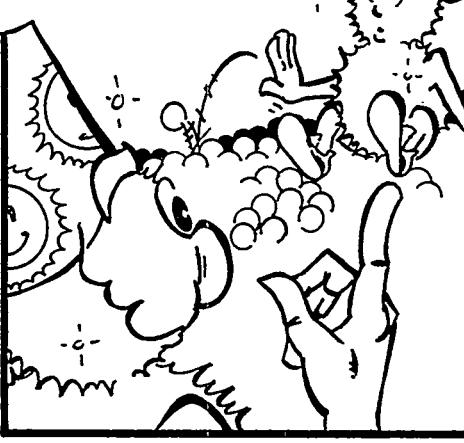
Plants all look the same to me.

Oh my, oh my. This is a problem. This bad attitude of his is certain to set us behind schedule.

Sunburst, there are even more kinds of plants than animals - and they are just as amazing. Have you ever really looked at plants?

Well, not really; I mean, through my telescope I've seen kids playing baseball on the grass and people eating lettuce in salads...

That is hardly what I call looking at plants.



Do you realize, Sunburst, that plants are found almost everywhere on Earth: on land and in the ocean, in some of the coldest places and the hottest, in the wettest and the driest?



Good Conditions For Plant Growth

Tell me, Sunburst, what conditions make it easiest for plants to grow?

Well, if I think back to the things that were used in photosynthesis, I guess you could say plants need water, carbon dioxide gas, and lots of sunlight.

Now you're talking. And do you think that all places on Earth have the same amounts of these things?

Well, I know that not all places have the same amount of water. There's a big difference between deserts and rainforests. I guess they have different amounts of sunlight, too, 'cause most of my friends got sent down to the equator. Only Starbright and a few others went to the North Pole.

Exactly right! Different places on Earth receive different amounts of the Sun's energy - and that's a major reason why different habitats are found in different places. Let's focus on tundra and rainforest, two habitats that are quite different.

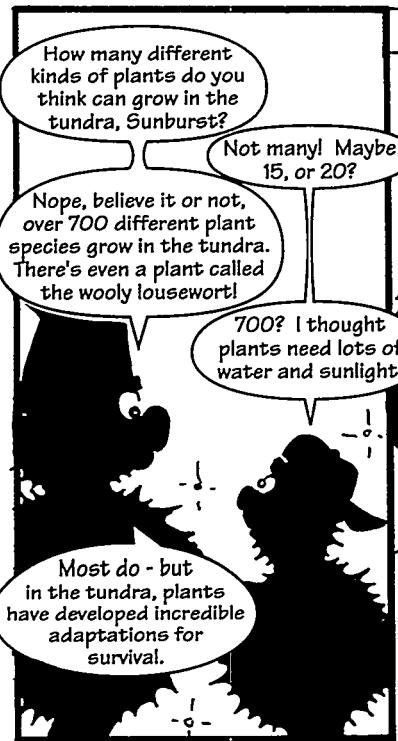
Tundra
Rainforest



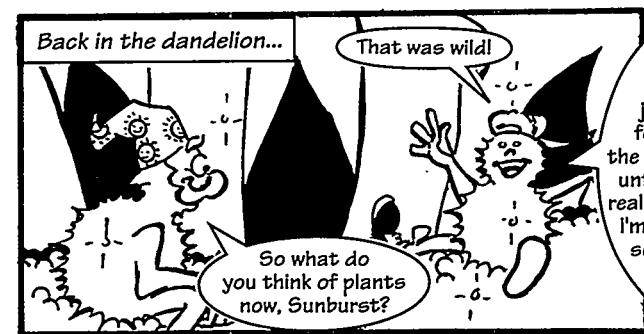
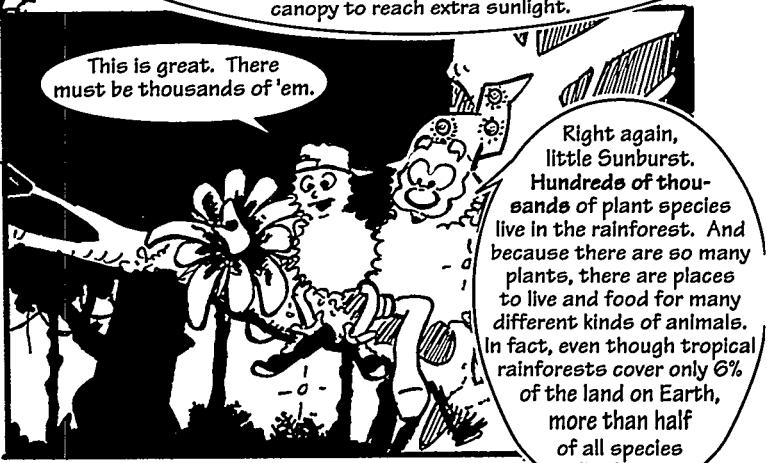
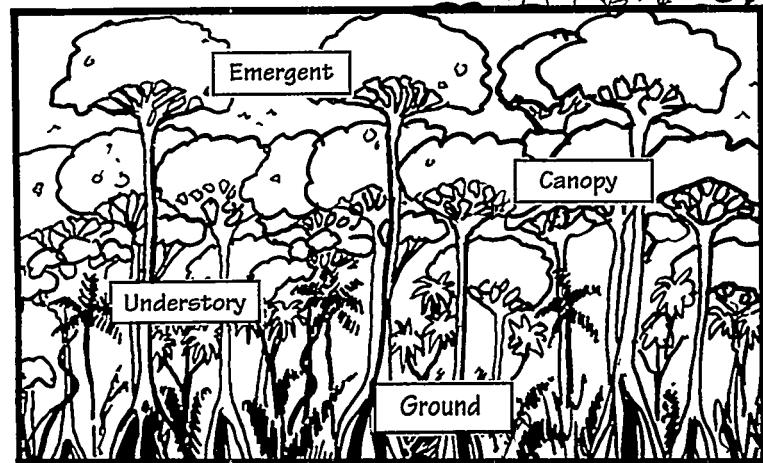
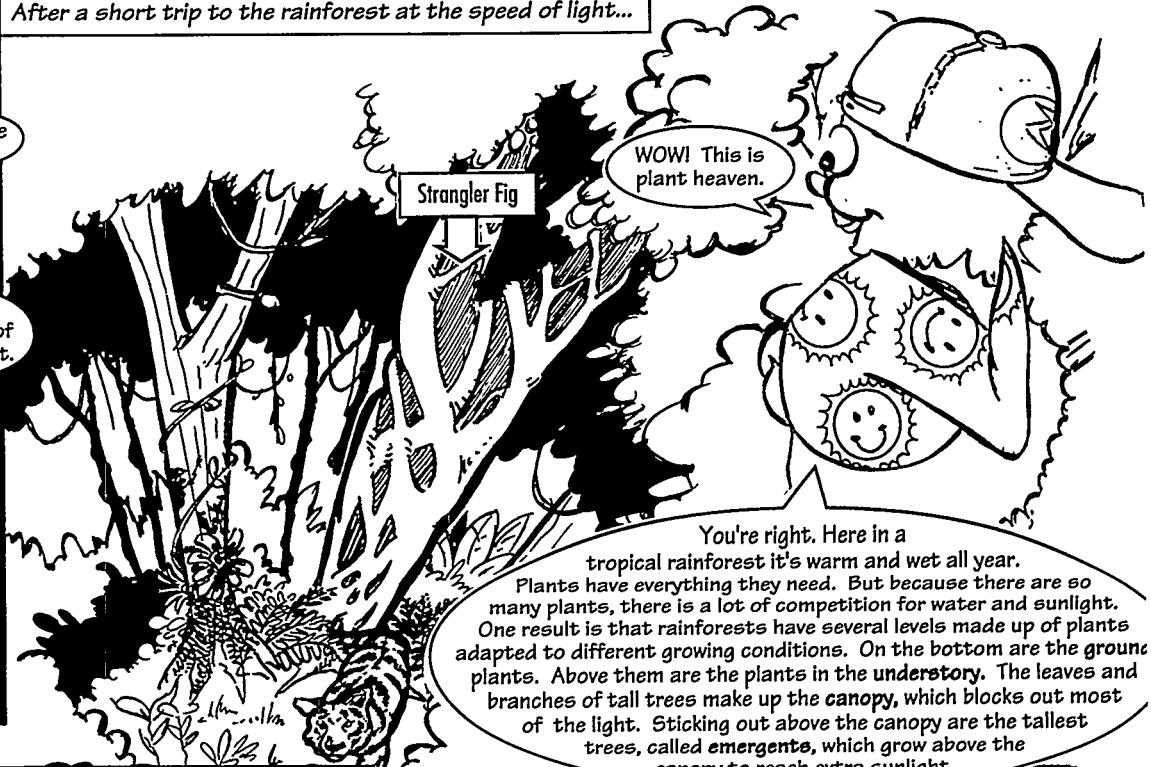
The tundra is a very difficult place for plants to grow. Winters are long, cold, and windy. In some places the Sun doesn't rise for months, and the temperature can drop to -50°C (-58°F), way below freezing. The ground is frozen most of the year, so there's hardly any water available for plants. Tundra plants look small because they keep a lot of themselves underground to avoid harsh weather. That's why you don't see any trees.



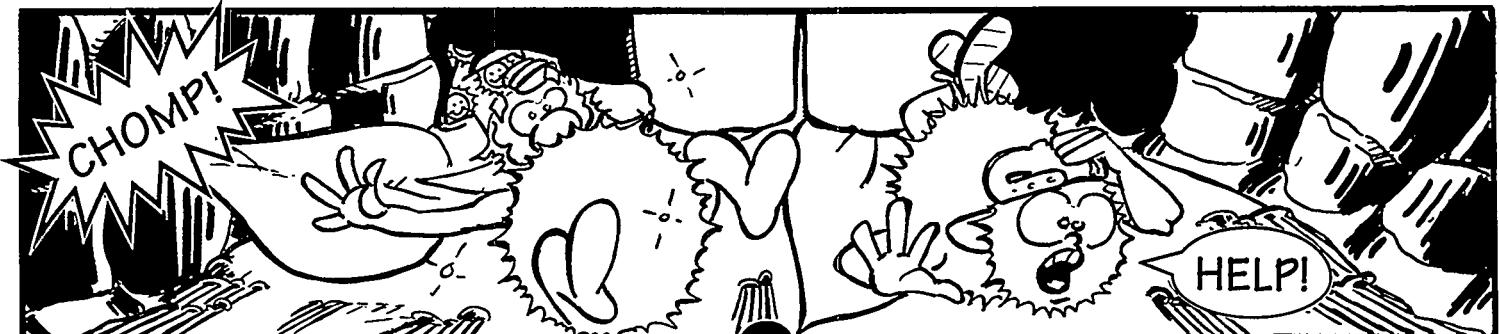
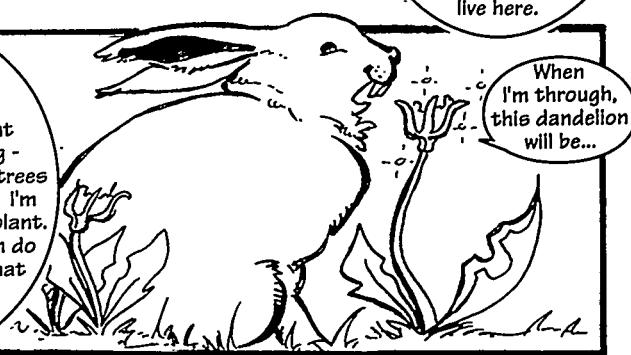
Brrr, they sure could use more sunlight up here.



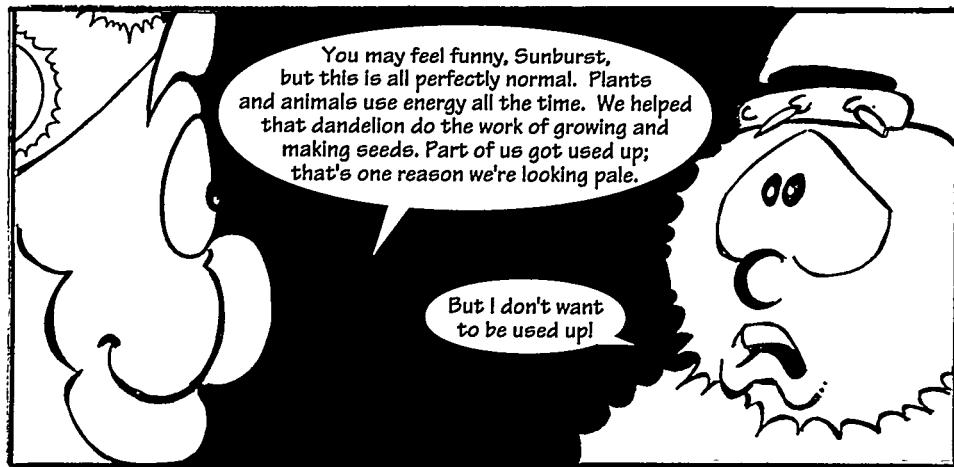
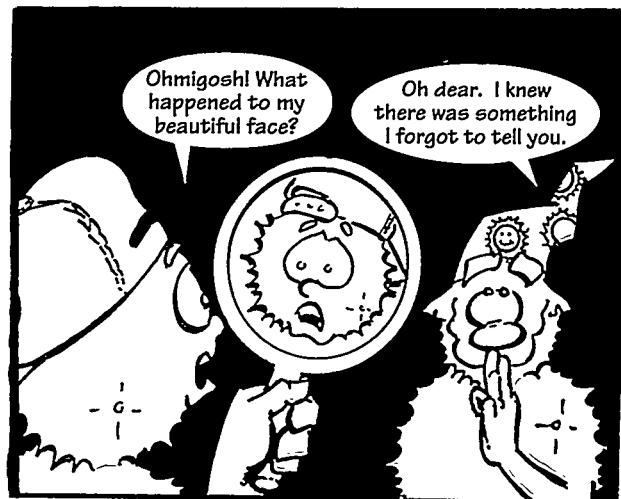
After a short trip to the rainforest at the speed of light...

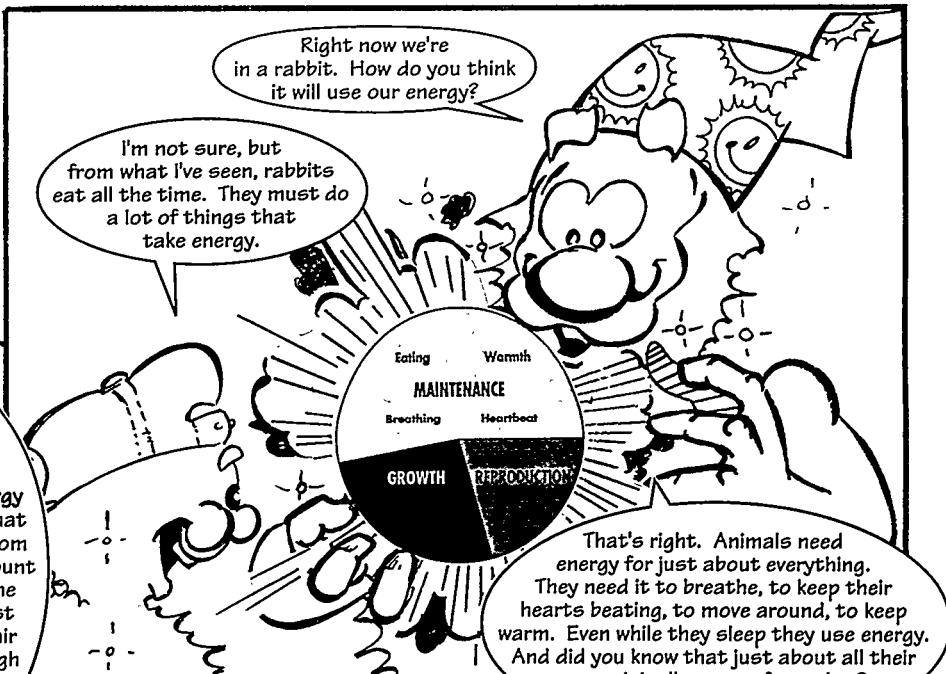
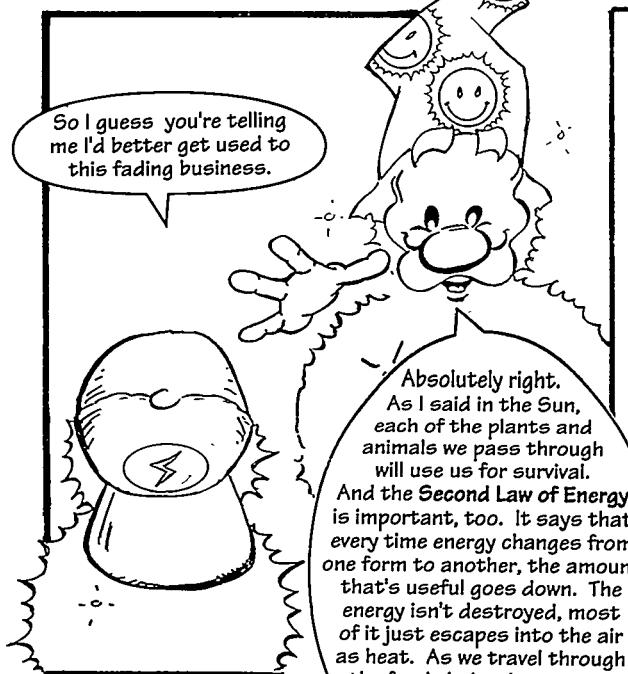
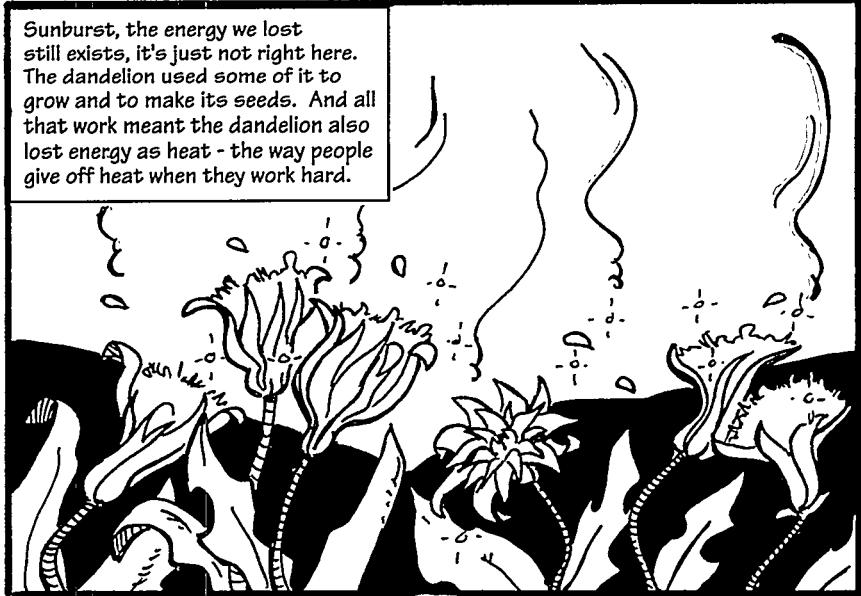
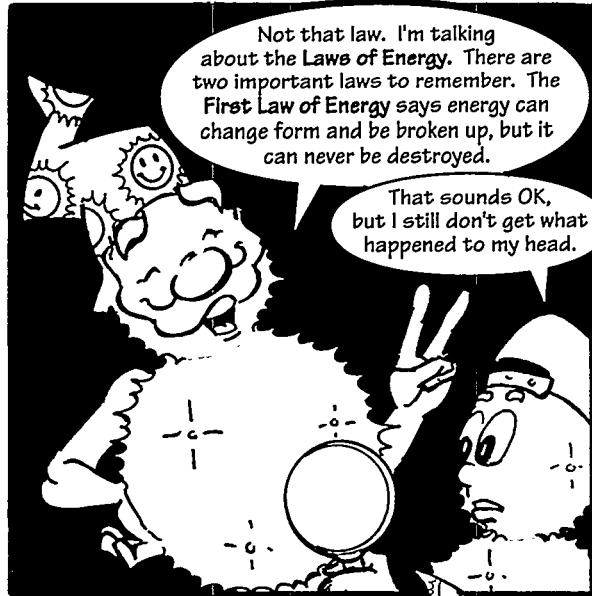


Awesome! I had no idea what plants could do - how they fight for sunlight just like some animals fight for food. That strangler fig - the one that curls all around trees until they die - was amazing! I'm really gonna get into being a plant. I'm gonna help this dandelion do so much photosynthesis that it becomes the biggest and the greenest one on earth!



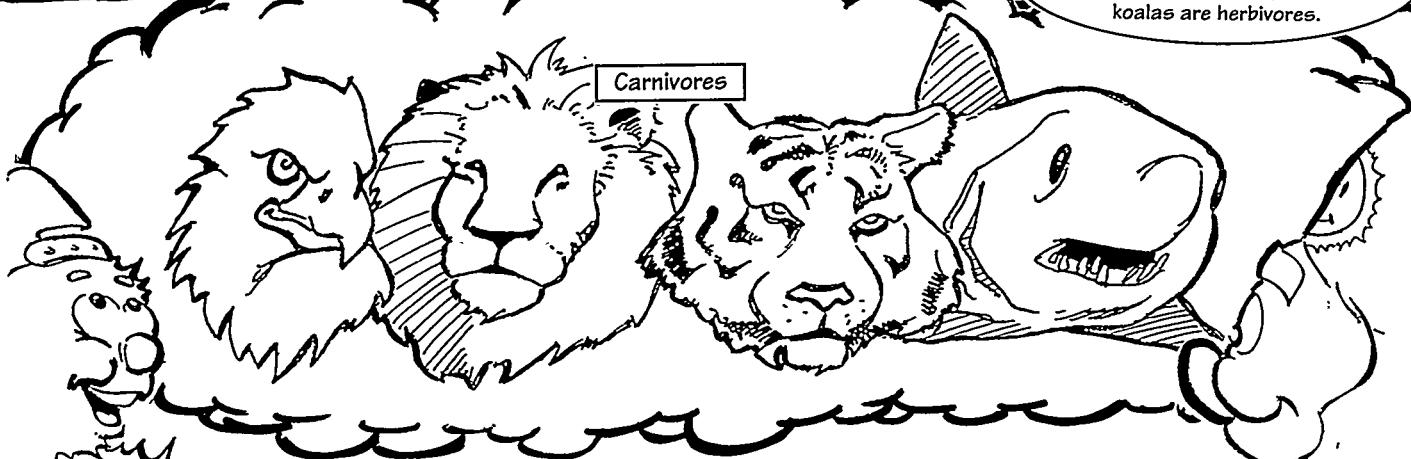
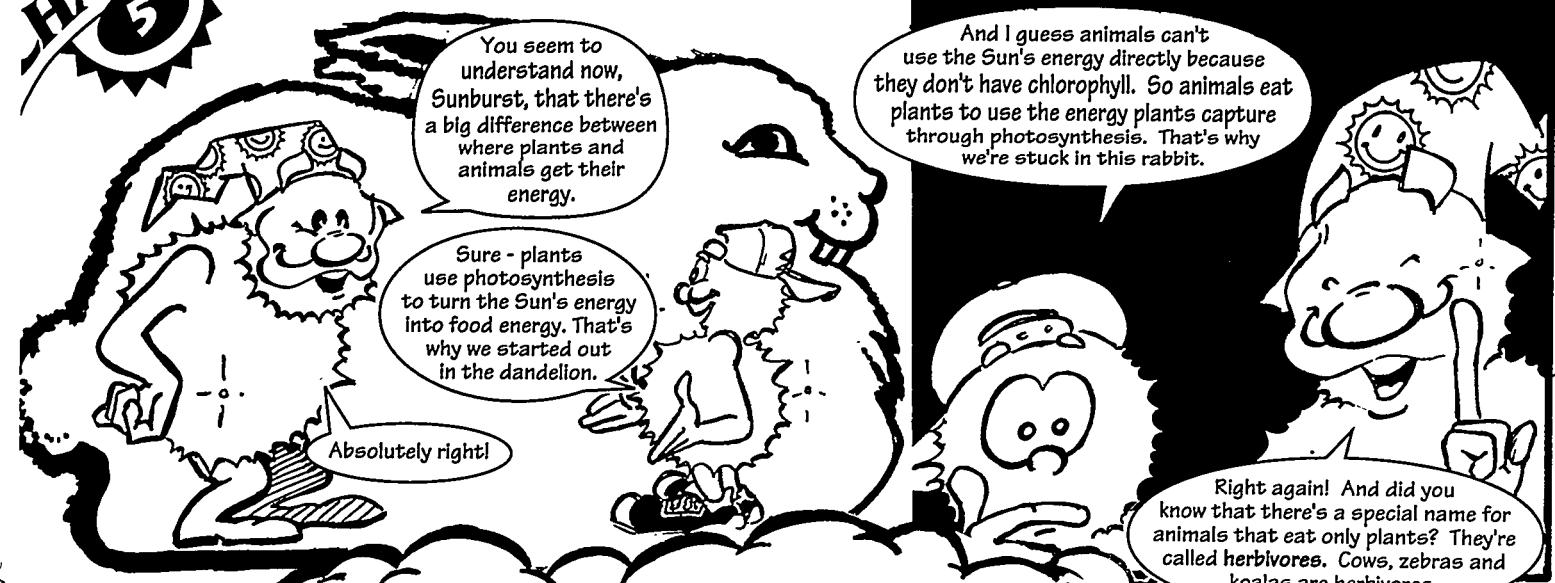
CHAPTER 4





CHAPTER 5

The Professor is pleased at his pupil's progress.





CHAPTER 6

Still inside the rabbit, our heroes' voyage has hit some rough spots.

Ah, how lucky we are, Sunburst! There's nothing like being part of great events! The food chain in action!

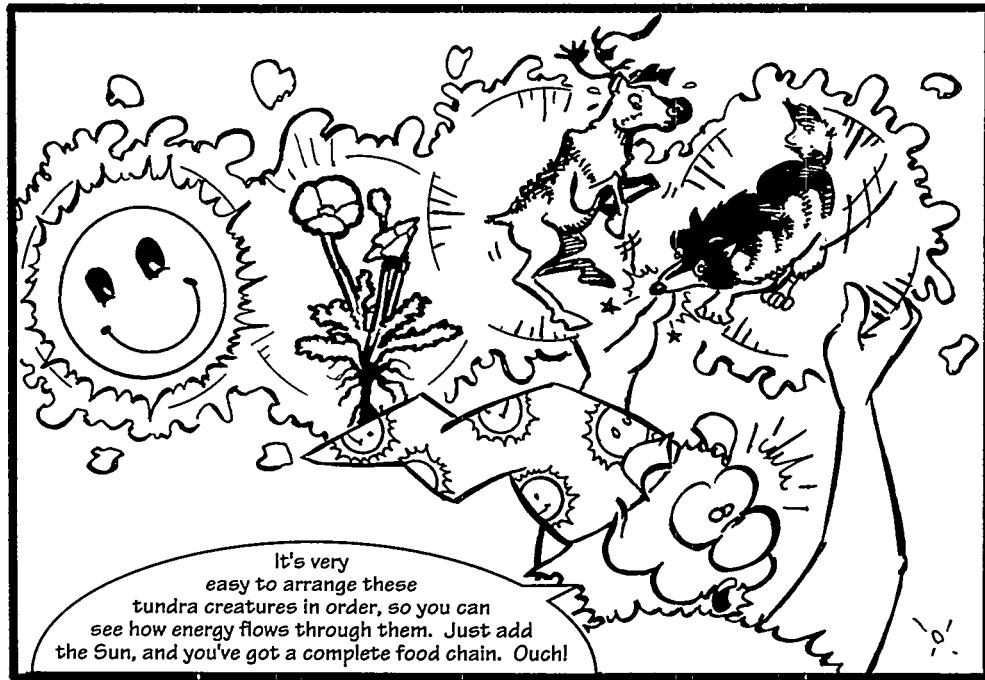
Just great! I'm getting excited about flying off into the wild blue yonder on wings of eagles, and this rabbit's about to be gobbled up by a weasel! A weasel of all things! What bum luck! And look at my hands! Since this rabbit started running it's been using us up even faster.

Now, now, Sunburst. You have to be flexible. I know there wasn't a weasel on the food chain I showed you up in the Sun. But there are many different chains that can be made in any given habitat. It's sometimes hard to predict who will eat whom.

You mean an animal can be part of more than one food chain?

You bet. Let's look at some examples.

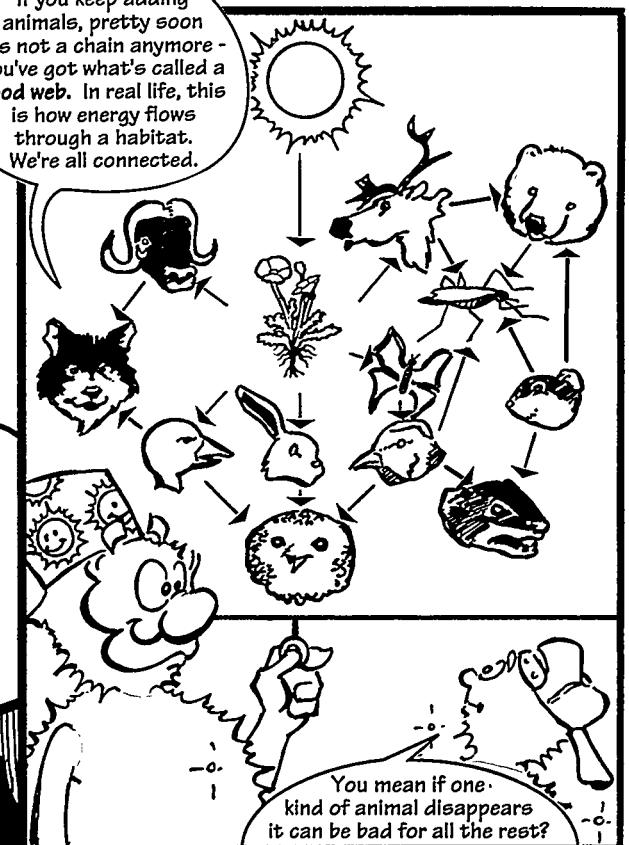
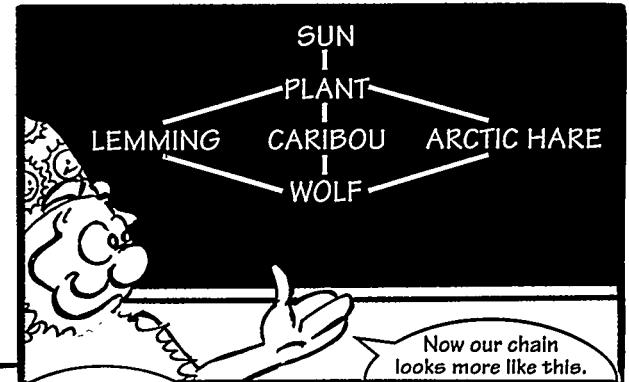
Here, Sunburst, are some of my favorite creatures that live in the tundra. Abracadabra!



I have a question. Wolves don't always eat caribou, do they? Don't they also eat rabbits and moose?



Look what happens when we add more animals to the wolf's dinner menu.





CHAPTER 11

Sunburst Has a Question...

Gee, Professor, it's fun flying around and looking at habitats. But there's one thing I don't understand. Up on the tundra we saw hundreds of caribou, but only twenty or thirty wolves. It would be more fun if there were more wolves. How come there are usually fewer carnivores in a habitat than herbivores?

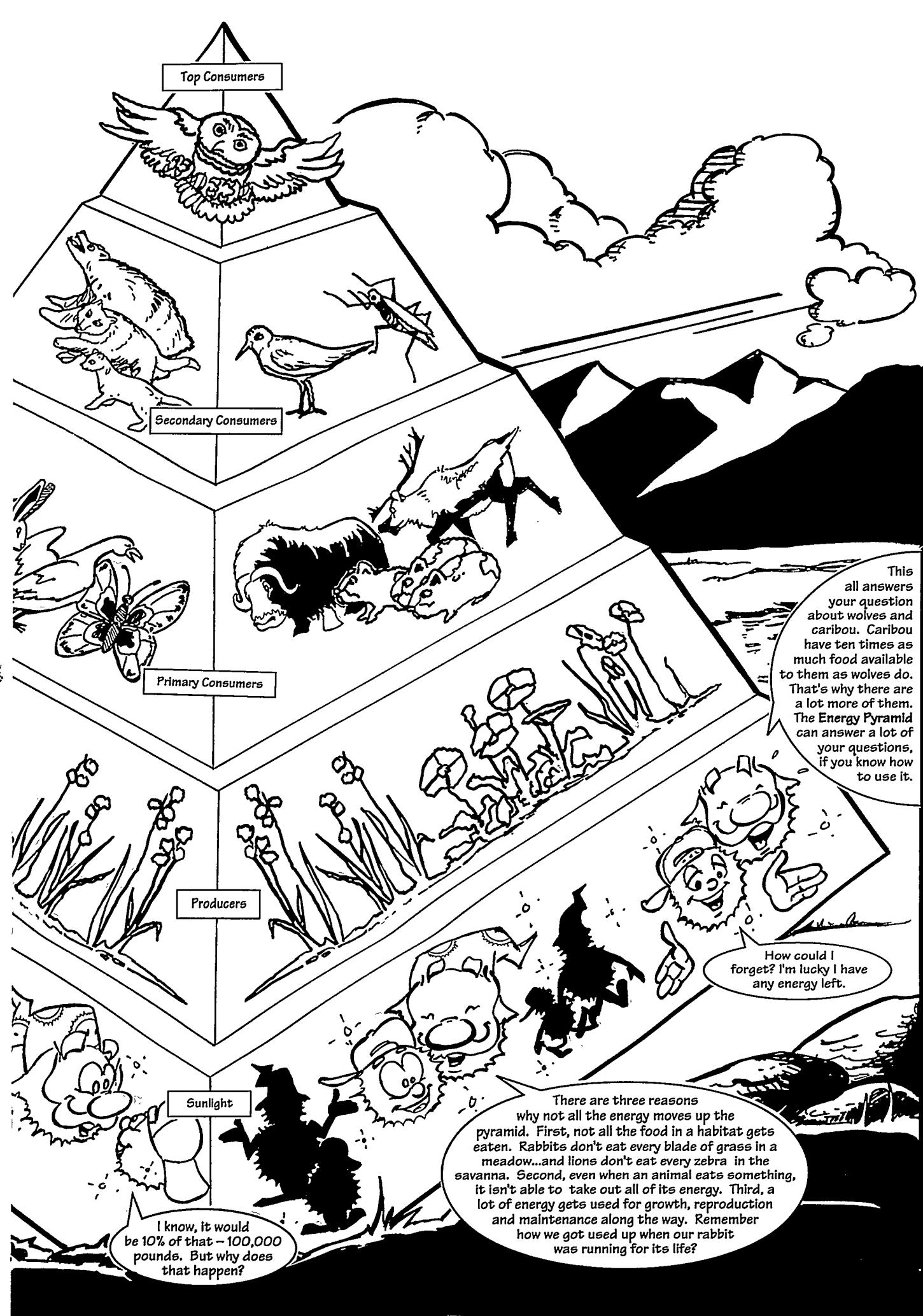
Good point, Sunburst! You're making me proud. Let me introduce you to some terms that will help me answer your question. Living things can be broken up into two groups based on where they get their food. Plants are **producers**. They make, or produce, their own food. The other group is called the **consumers**. Who do you think they are?

Well, consuming means eating, right? So animals must be **consumers**, because they have to eat.

You're right on target. Take a look at my Energy Pyramid. I didn't think you were ready for it before, but now you're becoming one of my best students ever. An Energy Pyramid shows how energy flows through a habitat. On the bottom level is sunlight, the source of just about all the energy in living things. The next level is made up of the **producers**, which use photosynthesis to turn the Sun's energy into food. Above that are the **herbivores**, which we also call **primary consumers**, because they're the first level of consumers. The next level is made up of **carnivores** and **omnivores**, which we call **secondary consumers** because they get their energy from eating primary consumers. And at the top are the **top consumers**, which eat carnivores and omnivores.

In the pyramid, each level is a different size. Does that mean there is less energy on the higher levels than on the ones below them?

Exactly! Each level has only about 10% of the energy of the level below it. If you weighed all the plants and animals on the pyramid, you'd see the same thing. The total weight of living things in a habitat is called the **biomass**. If you put all the plants on a scale and found that they weigh 1,000,000 pounds, guess what the **biomass** of primary consumers would be.



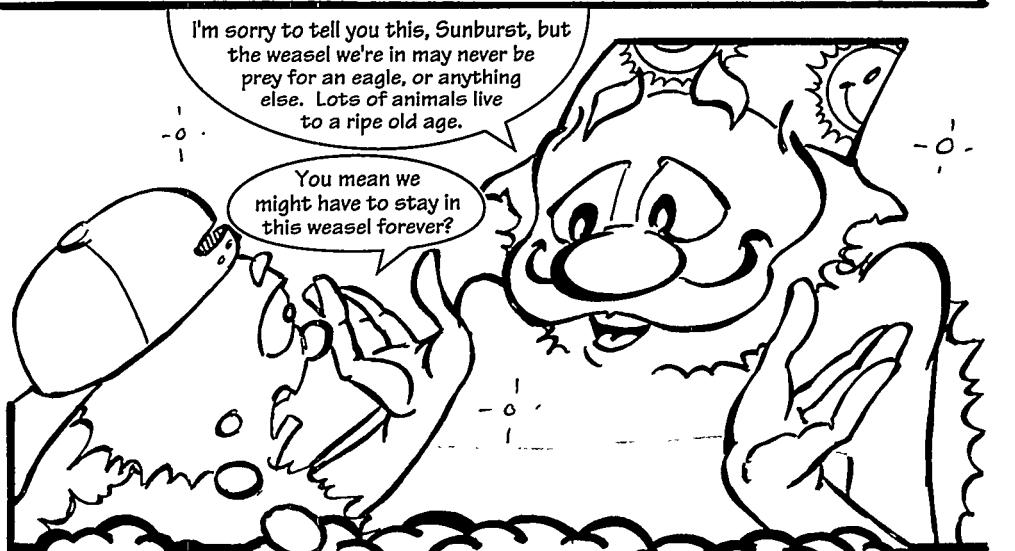
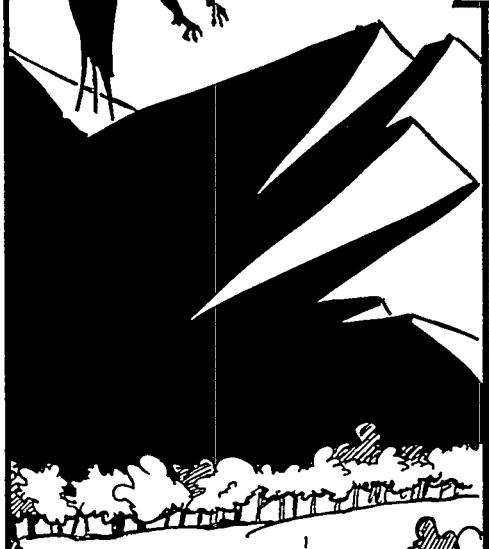
I know, it would be 10% of that - 100,000 pounds. But why does that happen?

There are three reasons why not all the energy moves up the pyramid. First, not all the food in a habitat gets eaten. Rabbits don't eat every blade of grass in a meadow...and lions don't eat every zebra in the savanna. Second, even when an animal eats something, it isn't able to take out all of its energy. Third, a lot of energy gets used for growth, reproduction and maintenance along the way. Remember how we got used up when our rabbit was running for its life?

This all answers your question about wolves and caribou. Caribou have ten times as much food available to them as wolves do. That's why there are a lot more of them. The Energy Pyramid can answer a lot of your questions, if you know how to use it.

CHAPTER 8

Still inside the weasel, Sunburst makes an exciting discovery...





CHAPTER 9

By the power vested in me by the Sun, I hereby certify you Energy 1st Class. You have graduated with high honors. I was worried at first, but you've proven yourself sun-sational. Do you have anything to say?

I have to admit, Professor, it turned out to be a lot more fun than I expected. But even though we've left Earth, I'm still worried about what's going on there. I keep thinking about that man with the gun.

I'm glad to see you're thinking about these things, Sunburst. There are a lot of problems down there.

A long time ago, humans were part of a natural energy flow on Earth.

But today, people are using more than their share of the Earth's energy supply.

That doesn't sound very fair.

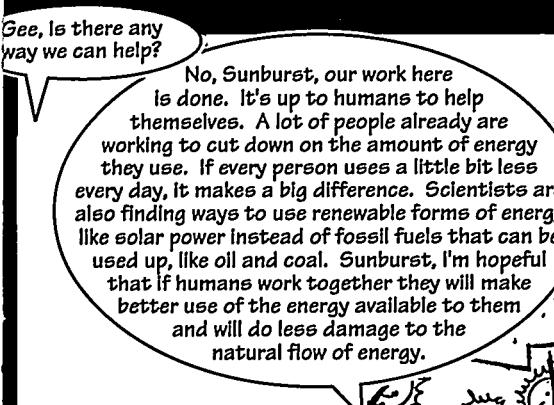
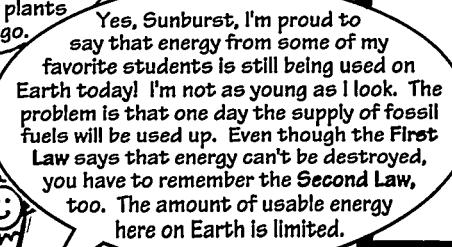
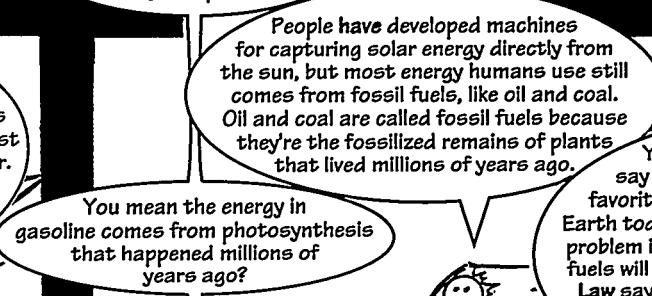
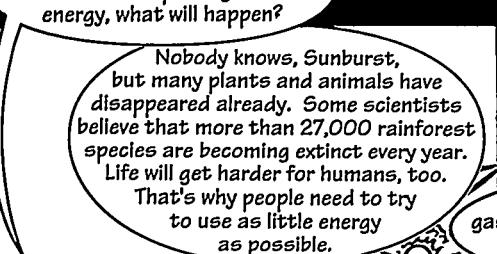
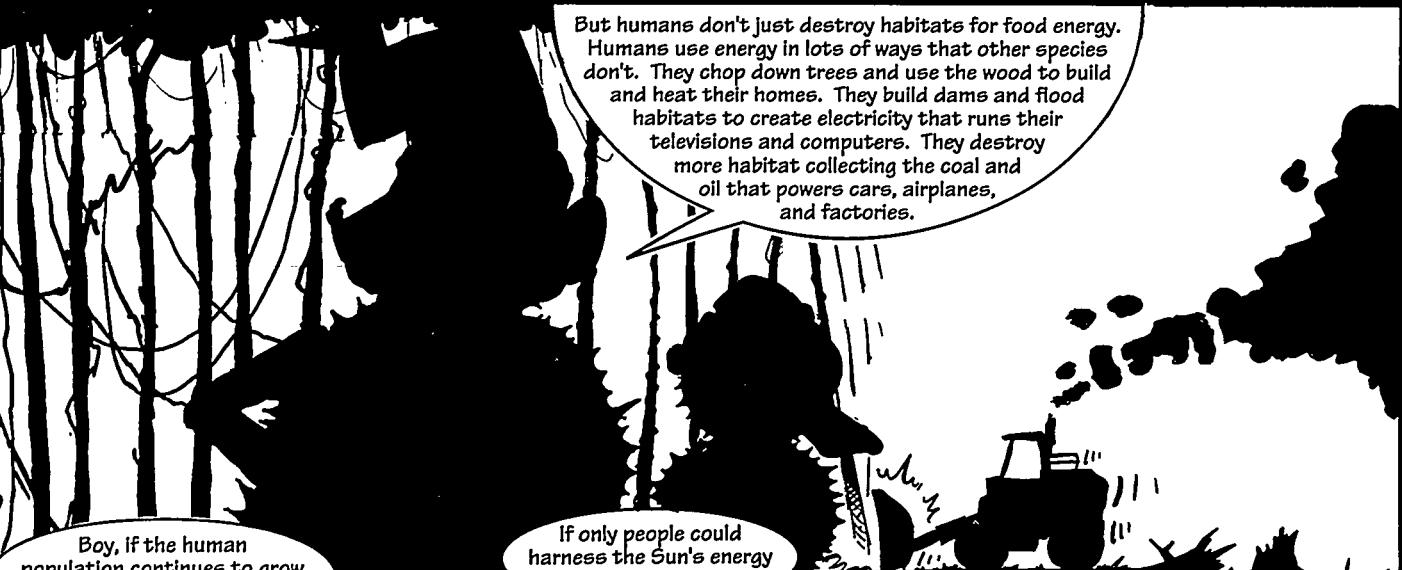
It's not, Sunburst. Throughout most of the time humans have been on Earth, their population was small - probably less than a million people. But now population growth is a huge problem. Do you know how many people there are today?

Five million?
(5,000,000)

No, Sunburst, it would probably be OK if there were only five million people. Unfortunately, there are over five billion (5,000,000,000) people. That's 5,000 million.

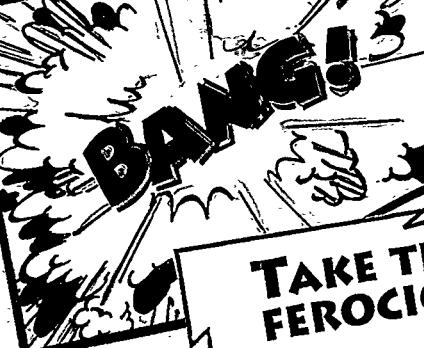
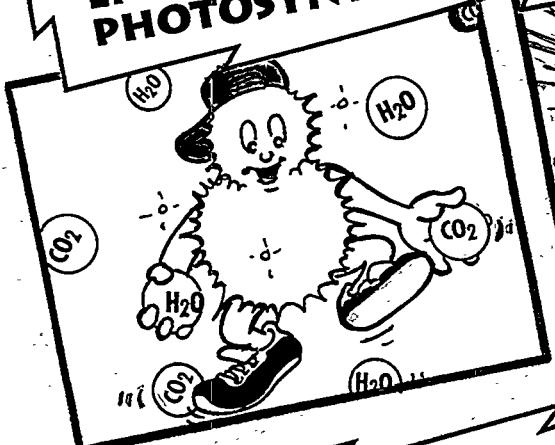
WOW! They must eat a lot!

That's one problem. People take large areas of forest and turn them into fields to grow their own food. That takes habitat from the plants and animals that live there. In the process, they destroy the plants that collected the energy on which so many animals depend. One hundred years ago there were almost 7,000,000 square miles of rainforest on Earth. Today, half of that is gone.



JOIN
PROFESSOR
ENERGY
AND HIS STUDENT
SUNBURST
IN THEIR
ROUND-THE-WORLD
ADVENTURE!

WHERE THEY HAVE A CLOSE
ENCOUNTER OF THE
PHOTOSYNTHETIC KIND...

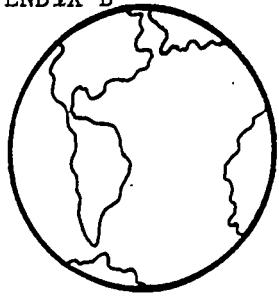


TAKE THE HEAT FROM
FEROCIOUS EAGLES...

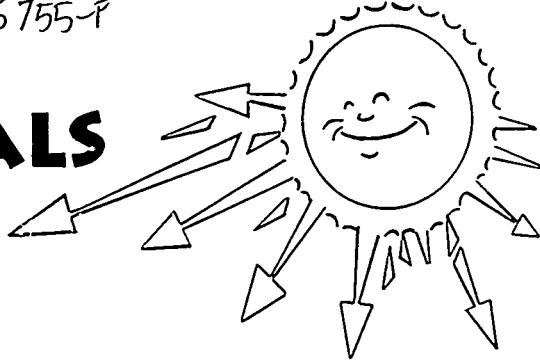
TRAVEL THROUGH TIME
AND SPACE TO EXOTIC,
ENERGETIC PLACES!



LOOK
INSIDE!



MATERIALS



Comic Book

The comic book, *Voyage From The Sun*, is designed to be the guide that leads students through the activities, explaining abstract and difficult concepts in a student-friendly context. Each kit has 35 copies. Depending on the reading ability of your class, we suggest having students read panels aloud while the rest of the class reads along. Directions on when each chapter should be read appear in the lesson plans.

Energy For Survival Poster

The Energy For Survival Poster illustrates a wide array of ways in which people and other animals are using energy. It also illustrates consequences of human energy use on the environment. The poster has more than 140 animals and more than 190 people. It is intended to be colored by students during the course of the unit and serves as a motivator and visual guide for activities that follow.

Energy Pyramid

The lesson plans that follow contain instructions on when, and how, the Energy Pyramid should be used. The Energy Pyramid has five levels, four sides, and is approximately three and a half feet tall. The large packing box in which the materials arrived makes a good stand for the pyramid. The pyramid is designed to represent the flow of energy through a habitat. The bottom level is devoted to the sun, the source of virtually all terrestrial energy. The second level is devoted to plants (producers), which use the process of photosynthesis to convert solar energy into chemical energy, or food. The third level is devoted to the plant-eating animals (also called herbivores or primary consumers) which derive their energy from the chemical energy "produced" by plants. The fourth level is made up of the omnivores and carnivores (secondary consumers) which get all or part of their energy by eating primary consumers. And the top level is devoted to top carnivores (tertiary consumers) which have a diet made up almost entirely of meat. The model is shaped like a pyramid because in most ecosystems, only about 10% of the energy in each level passes up to the next. For further explanation, see Chapter 7 of the comic book and Appendix 4 of this Teachers' Guide.

Two sides of the pyramid are devoted to habitats. One is a high energy system (Asian tropical rainforest) and the other relatively low energy (North American tundra). A third side of the pyramid is devoted to a map that provides the game board for the human-impact game, "Race For The Rainforest." The pyramid's final side is devoted to questions, answers and issues relating to the central role energy plays in biology and in our daily lives. When completed, the Energy Pyramid becomes a classroom exhibit. By having your class explain the pyramid to others, you will find the Energy Pyramid an ideal subject for development of your students' presentation skills.

Plant, Animal, and Wild Cards

Your kit contains:

35 Animal Cards (23 rainforest, 12 tundra);

18 Plant Cards (12 rainforest, 6 tundra);

7 Wild Cards

A set of triangular card guides to be placed in marked areas on the pyramid.

A set of blue dots for tundra cards (use optional – see Lesson 8)



Activity Sheets

Your kit contains activity sheets which must be copied for distribution to your students. The following activity sheets are included:

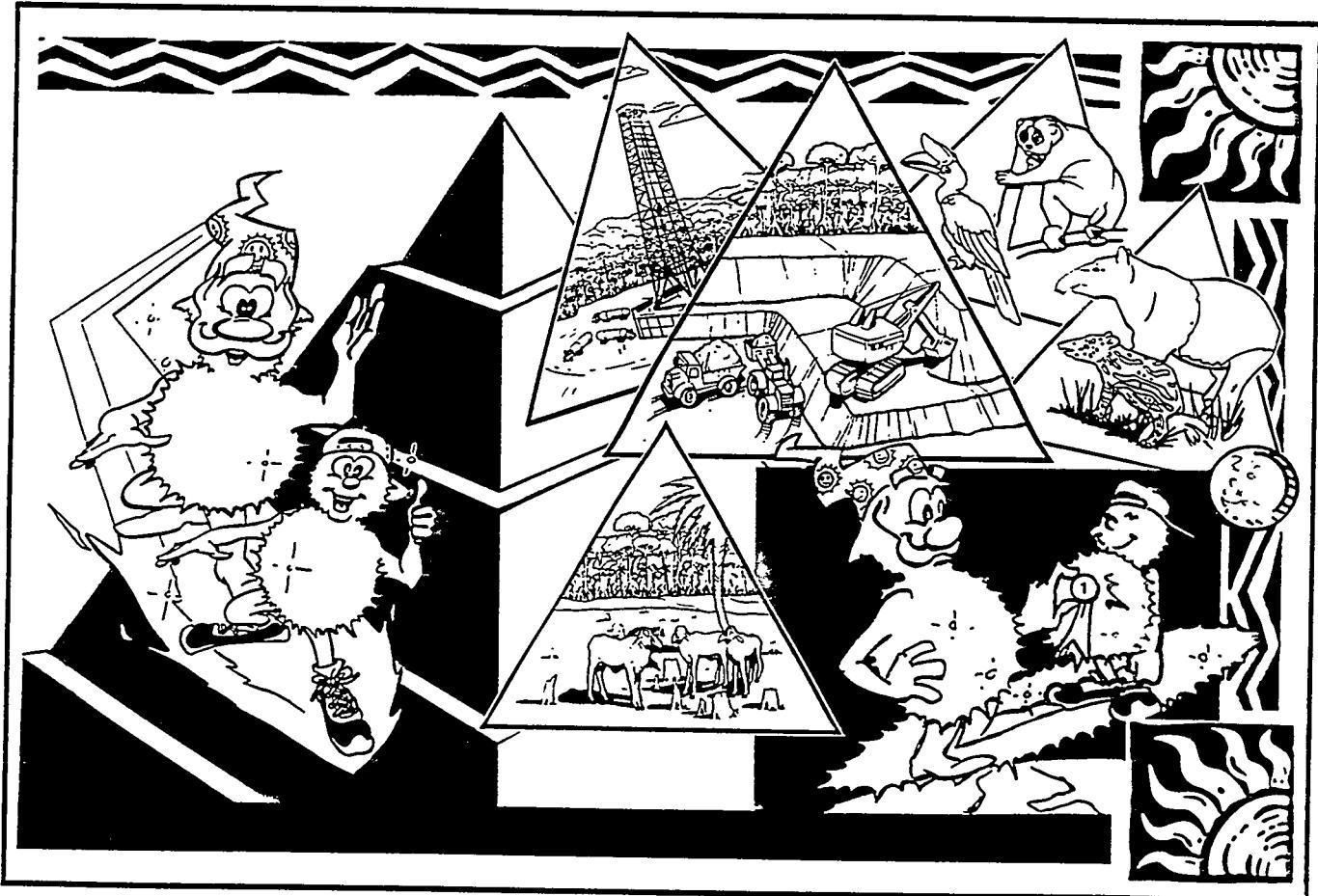
- Solar Detective- 1 sheet
- Photosynthesis Scramble- 4 sheets
- Photosynthesis Bingo- 1 sheet
- Habitat Hypothesis- 1 sheet
- Energy, Calories and Food- 1 sheet
- Conserving Energy- 1 sheet
- Scientific Method- 1 sheet
- Energy Puzzler- 1 sheet
- Energy Watch - 3 sheets
- Build-A-Plant - 2 sheets

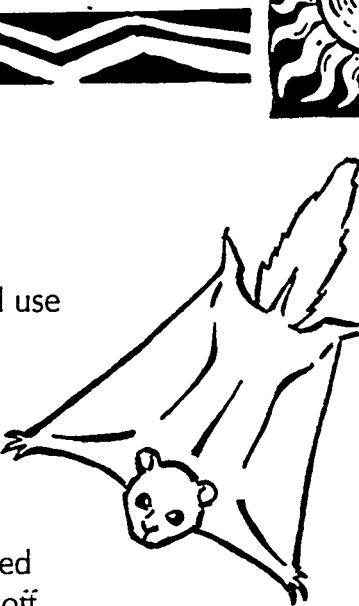
Race For The Rainforest Game Materials

Your kit contains 4 sheets associated with the game: Population Possibilities (one sheet); Bidding Groups (2 sheets); Sites For Sale (1 sheet). The kit includes 10 Human Impact cards (2 each of 5 topics): Cattle, Coal, Hydroelectricity, Logging, Oil and 4 "Saved!" cards. Also included is a set of Race For The Rainforest play money.

Teachers' Guide

A guide to the program, containing lesson plans, background information, activity sheet answers, and pronunciation guide.





ENERGY WATCH

DATA ANALYSIS

Depending on their needs, different kinds of animals acquire and use energy in different ways. One of the first steps in understanding "animal energetics" is to look at the relationship between an animal's diet and the amount of energy it uses. As you will see, not all animals have the same energy needs.

You have had a chance to watch animal behavior. Now is the time to figure out how much energy the animals you watched used up, and how much they will need to eat to make up for it. Start off by completing your Energy Watch Data Collection Sheets. Then answer the questions below.



- 1** What is the Grand Total of energy (Calories) used during the observation period for each animal?

Species #1 _____ Energy Used _____

Species #2 _____ Energy Used _____

Species #3 _____ Energy Used _____

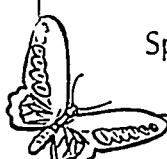
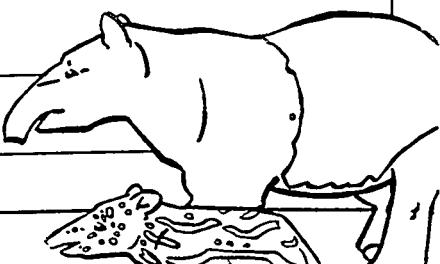
- 2** What foods does each of your animals eat?

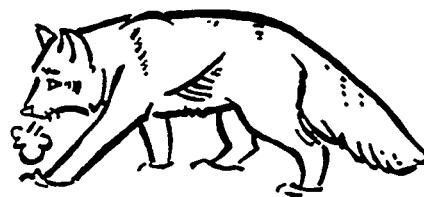
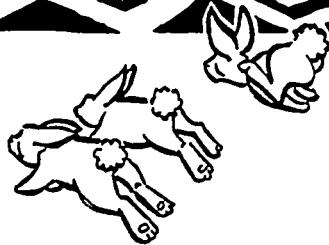
Leaves	Fruits/Vegetables	Nectar/Sap	Seeds	Meat	Insects
1.5 Cal/gram	.75 Cal/gram	0.5 Cal/gram	5.6 Cal/gram	2.5 Cal/gram	1.2 Cal/gram

Species #1 _____

Species #2 _____

Species #3 _____





- 3** For each animal, divide the Grand Total of energy used (Calories) by the energy content (Cal/g) of the animal's food. (In your calculations, use only the food you think your animal eats most.)

$$\text{Calories} \div \text{Cal/g} = \text{grams of food}$$

The result is the amount of food (by weight) that the animal would need to eat in order to replace the energy used during the time you observed its behavior.

Species #1 _____

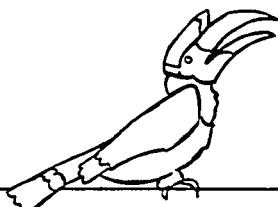
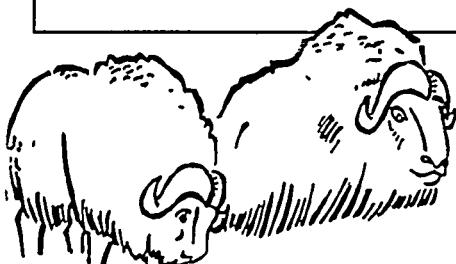
Food Necessary _____

Species #2 _____

Food Necessary _____

Species #3 _____

Food Necessary _____



Questions for Discussion

- A** Which animal used up the most energy? Which used the least?
- B** Which animal used up the most energy compared to its body weight (Calories per kilogram)? Which used up the least?
- $\text{Energy Used} \div \text{Body Weight} = \text{Calories per kilogram}$
- C** For questions A and B, were there big differences in the results for the animals you observed?
- D** How would you explain the similarities or differences in the amount of energy used by the different animals? Were the animals doing different things, or did some animals use more energy than others in the same activities?
- E** Which animal has to eat the most to recover all the energy it used?
- F** Which has to eat the most compared to its body weight?

$$\text{grams of food} \div \text{body weight} = \text{grams of food per kg body weight}$$

Is the answer to this question different from the answer to Question E? If it is, try to explain why.



ENERGY WATCH

CALORIE CHART

Use the Calorie figures in this chart to fill in the Calorie per minute (Cal/Min) column on your Energy Watch Data Collection Sheet. Make sure to use only the figures that apply to the animal's approximate body weight.

Animal	Weight	Resting (Cal/min)	Standing (Cal/min)	Walking (Cal/min)	Running (Cal/min)	Swimming (Cal/min)	Flying (Cal/min)	Brachiating (Cal/min)	Eating (Cal/min)	Eating (Herbivore) (Cal/min)	Eating (Carn/Omn) (Cal/min)
Mammal	.1 kg	0.015	0.018	0.027	0.144	0.030	0.144		0.024	0.022	
Mammal	1 kg	0.078	0.094	0.137	0.696	0.156	0.851	0.206	0.128	0.113	
Mammal	10 kg	0.402	0.482	0.689	3.380	0.804		1.034		0.656	0.578
Mammal	100 kg	2.085	2.502	3.502	16.502	4.170		5.253		3.403	3.002
Mammal	1000 kg	10.840	13.008	17.841	80.668	21.680				17.691	15.610
Bird	.1 kg	0.023	0.028	0.037	0.154	0.046	0.144		0.031		
Bird	1 kg	0.122	0.146	0.189	0.748	0.244	0.851		0.162		
Bird	10 kg	0.658	0.790	0.997	3.688	1.316	5.009		0.877		
Bird	100 kg	3.521	4.225	5.225	18.225	7.042			4.690		
Reptile	.1 kg	0.002	0.002	0.011	0.111	0.004				0.002	
Reptile	1 kg	0.012	0.014	0.057	0.616	0.024				0.017	
Reptile	10 kg	0.060	0.072	0.279	2.970	0.120				0.086	
Reptile	100 kg	0.313	0.376	1.376	14.376	0.616				0.451	

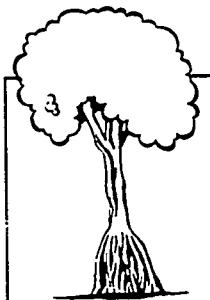
BUILD-A-PLANT

RAINFOREST

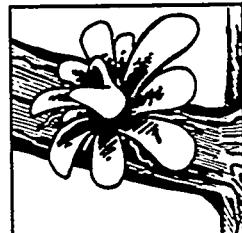
Type of Plant



Climbing Vine

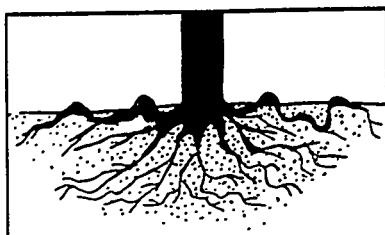


Tree

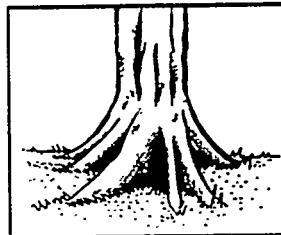


Epiphyte

Type of Roots



Long, Shallow Roots

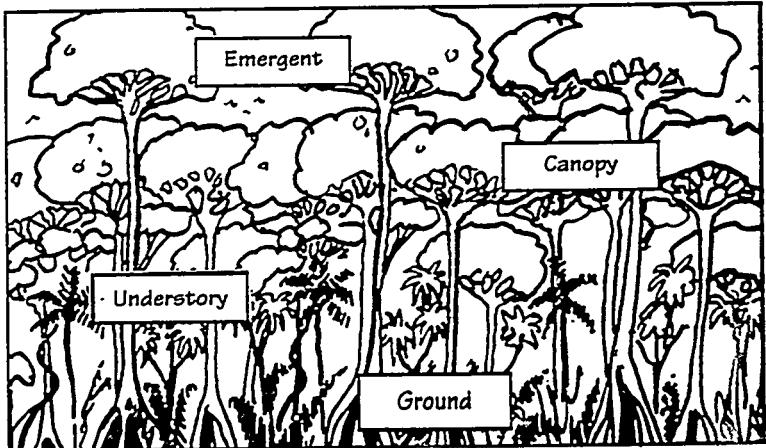


Large Buttress Roots

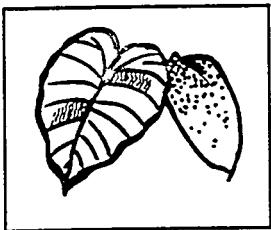


Clinging Roots

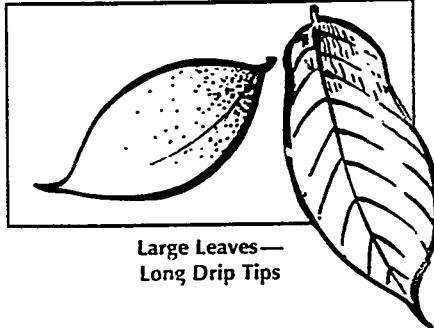
Where It Grows



Type of Leaves



Small Leaves—
Short Drip Tips



Large Leaves—
Long Drip Tips

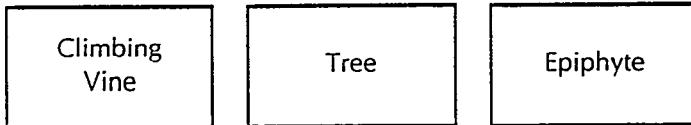


BUILD-A-PLANT

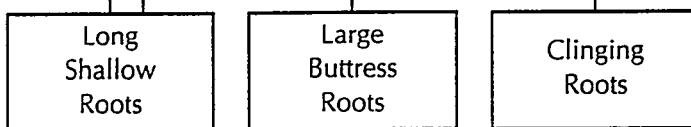
RAINFOREST



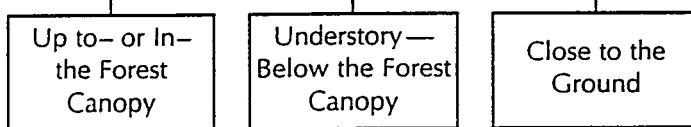
Type of Plant



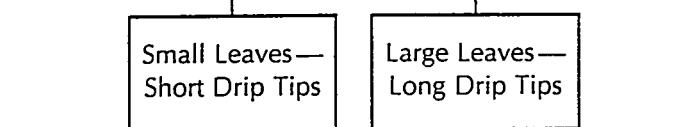
Type of Roots



Where It Grows



Type of Leaves



Life Cycle



- Climbing vines use hooks or tendrils to climb up trees.
- Trees have hard wood trunks anchored in the ground by roots.
- Epiphytes are plants that grow on the branches and trunks of trees.

- Roots take in water. They are also a plant's form of support.
- Because rainforest soil is often thin, many rainforest plants have long, shallow roots.
- Tall rainforest trees often have large buttress roots for support.
- Epiphytes have short roots which cling to the trees on which they grow.

- Rainforest plants are often described according to the level in which they grow: ground, understory, canopy, and emergent
- Trees, vines, and epiphytes may grow at more than one level.
- Different levels receive different amounts of sunlight.

- Leaves are a plant's tools for trapping sunlight and storing energy.
- Below the forest canopy—where there is little sunlight—leaves are large, thin, and often have long “drip tips,” which allow water to run off easily.
- Canopy and emergent trees often have smaller, thicker, and more rounded leaves.
- Plants in the dim understory may have leaves with a reddish or purplish tint to collect more light.

- Because temperature and rainfall are fairly constant in a tropical rainforest, the leaves of most plants stay green all year long.

POPULATION POSSIBILITIES

RACE FOR THE RAINFOREST

Site # _____

Plant Biomass = _____ lb.

(1)
Species
Name

TERTIARY
(2)
Species
Biomass

CONSUMERS

(3)
Biomass per
Individual

(4)
Individuals
Column 2 ÷ Column 3

TERTIARY CONSUMERS: TOTAL BIOMASS

(1)
Species Name

SECONDARY
(2)
Species
Biomass

CONSUMERS

(3)
Biomass per Individual
(from Animal Card)

(4)
Individuals
Column 2 ÷ Column 3

SECONDARY CONSUMERS: TOTAL BIOMASS

(1)
Species Name

PRIMARY
(2)
Species
Biomass

CONSUMERS

(3)
Biomass per Individual
(from Animal Card)

(4)
Individuals
Column 2 ÷ Column 3

PRIMARY CONSUMERS: TOTAL BIOMASS

lb (10% PLANT BIOMASS)

lb (10% SECONDARY CONSUMER BIOMASS)

lb (10% PRIMARY CONSUMER BIOMASS)



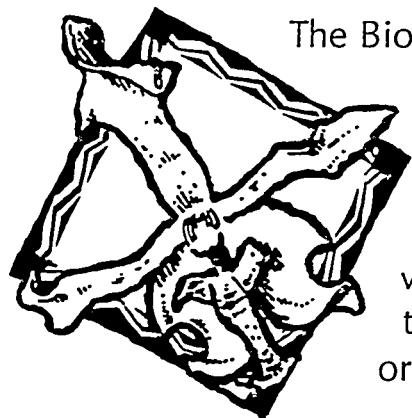
BIDDING GROUPS

RACE FOR THE RAINFOREST



Wildlife Conservation Society

The Wildlife Conservation Society is based at the Bronx Zoo in New York City. Its motto is "Working to Save Wildlife" and its main goal is to save disappearing species and habitats. In addition to breeding endangered species at the Bronx Zoo, the Wildlife Conservation Society supports conservation and education programs around the world. The Society encourages governments to protect natural habitats and supports the work of field scientists. The Society often chooses to focus upon areas known to have populations of highly endangered species, or on regions rich in wildlife that have not been well studied.

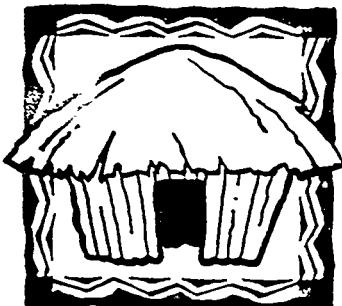


Biodiversity Preservation Trust

The Biodiversity Preservation Trust's main goal is to protect areas with high biodiversity (many different species of plants and animals). The Biodiversity Preservation Trust focuses on areas that have been well studied and that are known to be natural habitats for many different kinds of plants and animals. The Trust is particularly concerned with places that are in immediate danger of human impact: forests that are about to be cut, areas that are about to be flooded by a dam, or places about to be mined for coal or oil.

The Traditional Peoples Survival Fund

The Traditional Peoples Survival Fund protects the ways of life of people who have lived in the rainforest and relied on the forest for food and other products for centuries. The Fund's main goal is to buy and protect land around existing villages. The Fund provides money to help purchase land on which rainforest people can continue to fish, hunt and harvest rainforest products. In general, the traditional peoples helped by the Fund do not destroy the forest, but try to make use of its plants and animals at a rate that is sustainable (naturally replaceable).



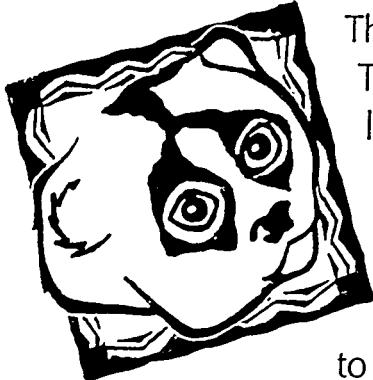


BIDDING GROUPS

RACE FOR THE RAINFOREST



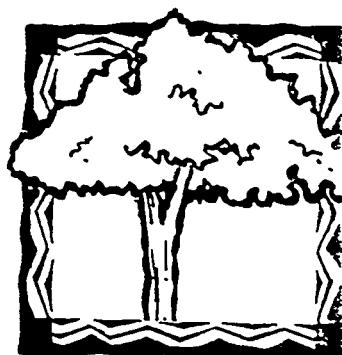
Primate Protection Society



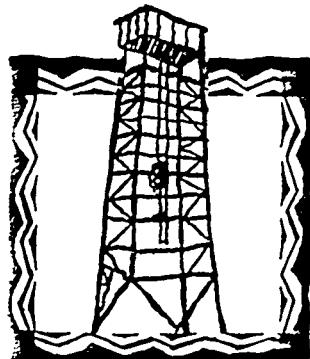
The Primate Protection Society is based at a university in Southeast Asia. The Society's main goal is to protect natural habitats that are home to large numbers of monkeys, apes (such as gibbons), and other non-human primates (such as lorises). The Society is also devoted to educating people about the need to protect habitats where primates are still found. To encourage people to protect primate habitats, the Society organizes trips to areas where primates can be observed. Places close to towns, or to rivers that can be reached by boat, are preferred.

Hearty Hardwoods

Hearty Hardwoods is a large timber company that earns money through the harvest and sale of wood. It ships wood to countries in Southeast Asia, the United States, and other parts of the world. The most profitable trees are tall hardwoods, such as teak. When possible, Hearty Hardwoods cuts trees selectively, which does not destroy habitats. Sometimes, however, the company cuts down all the trees in an area—completely destroying the habitat. Hearty Hardwoods is most interested in buying areas that can be reached by road or boat, which make it easier to remove the cut trees from the forest. Places near towns or villages are also preferred, because they provide a source of workers.



Easy Flow Oil Company



Easy Flow Oil is a large international oil company. It owns thousands of gas stations in the United States and around the world. The Company's goal is to purchase areas known to be rich in oil. It sometimes also buys areas in which oil exploration has not yet taken place. Easy Flow Oil is most interested in regions that can be reached by road or boat—making it easier to bring in equipment for oil wells and to ship oil out of the forest. Places near existing towns or villages are also preferred, because many workers are needed. The roads built and the hunting by the Company's workers cause the greatest harm to wildlife.



BIDDING GROUPS

RACE FOR THE RAINFOREST



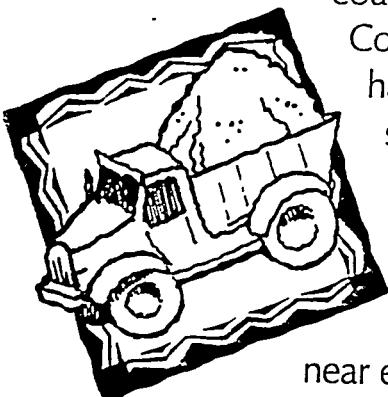
High Energy Hydroelectricity Company

The High Energy Hydroelectricity Company builds hydroelectric dams on large rivers. The energy in moving water is converted to electricity, which is sold to several countries in the area. The hydroelectric dams flood hundreds of square miles upriver of the dams, completely covering the existing forest. People who live in the flooded areas are forced to move to other places. Often, the dams prevent important nutrients from flowing down the river. This can have a harmful impact on plants and animals that live downstream. The Company buys sites on rivers, preferably in areas where the flooding will not force villages to be moved.



Fossil Fuels Mining

The Fossil Fuels Mining Corporation runs coal mines around the world. The coal is taken out of mines and sold for use as fuel in many countries. The Corporation buys areas known to be rich in coal, or in which coal exploration has not yet taken place. In some places, the Corporation mines coal near the surface of the Earth, completely destroying the habitat. In other places it digs deep mines which are not as harmful to plants and animals. The Corporation is most interested in buying areas that can be reached by road or boat, which make it easier to bring in the equipment needed for mining and easier to ship the coal out of the forest. Places near existing towns or villages are also preferred, because many workers are needed.



Colossal Cattle

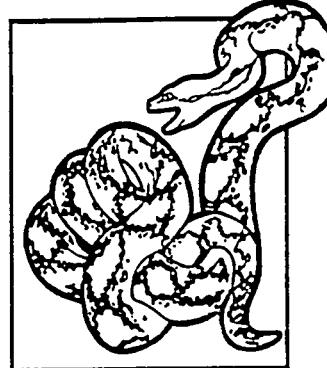
The Colossal Cattle company owns cattle ranches in many parts of the world. It buys rainforest areas and then rents the area to timber companies, allowing them to cut down and remove all the trees. Once the trees are gone, Colossal Cattle uses the cleared land for grazing large herds of cattle. The beef from cows raised by Colossal Cattle is sold in large quantities to restaurant and fast food chains in the United States and other parts of the world. Colossal Cattle tries to buy sites with large hardwood trees (preferred by timber companies) near rivers or roads.





Site One

This is an area of rainforest that is almost untouched. It is far from any roads or villages, and far from the Lankong River. Few expeditions have been to this area. Those which have been here saw a wide variety of plant and animal species. Their field notes include mention of leopards, pythons, muntjacs, tapirs, tortoises, butterflies, pangolins, termites, flower mantises, sunbirds and binturongs. The area has many tall hardwood trees and would be a good place for grazing cattle. It has never been explored for oil or coal. No people live on the site. [8,000,000 lb of plant biomass]



Site Two

This site lies along the banks of the Lankong River, one of the largest rivers that has not yet been dammed in Southeast Asia. The river and the surrounding forest draw an extremely large variety of animals, which come to the river to drink. These include tigers, leopards, tapirs, leaf monkeys, gibbons, tarantulas, flying frogs, sunbirds, walking sticks, butterflies, flower mantises, hornbills and binturongs. The river is large enough for large boats to travel to and from the area. The surrounding forest has large stands of teak and other hardwood trees. There are large reserves of oil, and coal deposits just below the Earth's surface. The site is a perfect spot for a dam, which would flood the entire site. However, a small traditional village is located in the area. The people would be forced to move if a dam is built. The site is a good area for grazing cattle. [10,000,000 lb of plant biomass]



Site Three

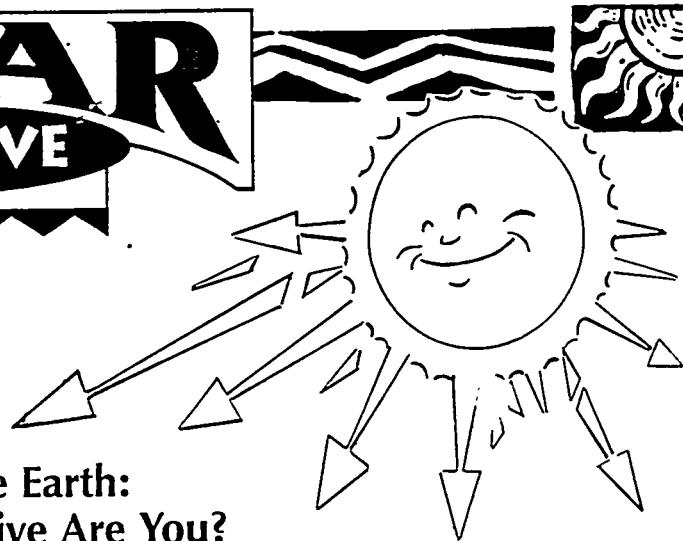
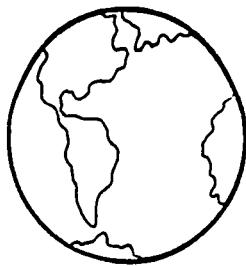
This is an area in which logging took place many years ago. Some of the roads built at that time still remain. The site is on the banks of the river, eight miles from the nearest town. There are still large areas of hardwood trees remaining that could be logged if roads are extended. There are also many areas that would be good for grazing cattle. Although many kinds of animals disappeared when the area was first logged, some species have returned to the forest. These are known to include lorises, binturongs, sunbirds, leopards, leaf monkeys, gibbons, squirrels, walking sticks and butterflies. There are known to be some oil reserves on the site, but no coal has been found. The site is a fairly good place for a dam. No people live on the site. [900,000 lb of plant biomass]







SOLAR DETECTIVE



The Sun and the Earth: How Good A Detective Are You?

On the back of this page are a number of clues about the sun and the Earth. Some of the clues are in words, some of them are in pictures. Use one or more of the clues to answer each of the questions on this page. Be sure to say which clues you used for each answer. Get more than half of the answers right and you qualify as a Solar Detective, First Class.

Solar Detective Exam: Use Only Sunlight

- 1 If the sun suddenly turned bright blue, how long would it be before the first ray of blue light reached your eye? (All light travels at the same speed.)
- 2 On December 21, what part of the world is dark all day and night? What part of the world has 24 hours of daylight? (Remember, the Earth spins around its axis.)
- 3 On June 21, what part of the world is dark all day and night? What part of the world has 24 hours of daylight? (Remember, the Earth spins around its axis.)
- 4 Does the Tasmanian Devil celebrate New Year's Day in the middle of the winter or the middle of the summer?
- 5 Which get more solar energy, the tropics or the areas near the poles?
- 6 Why does it get colder as you move from the Equator to the North or South Pole?
- 7 Where do you think you would find more plants, in the tropics or at the poles? Why?
- 8 Why is it *winter* in the United States when the Earth is *closer* to the Sun and *summer* when it's *farther* away? Is that crazy, or what?
- 9 Now for the question that separates the Solar Detectives, First Class from mere human beings: Why are there seasons? Study the clues carefully and talk this one over. Draw your own diagram if it makes it easier to explain.



Clue #1: About the Sun

The Earth is an average of 93 million miles from the sun. During part of the year, it's a little closer. During part of the year, it's a little farther away.

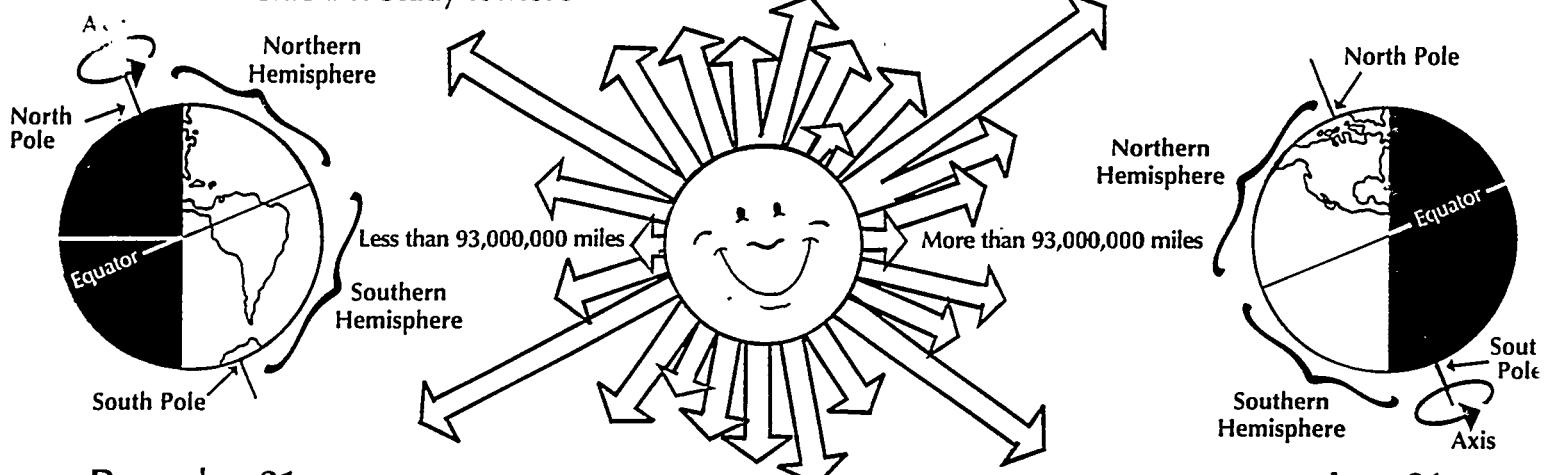
Clue #2: Just for You!

Tasmania is in Australia, in the Southern Hemisphere.

Clue #3: Holds the Key

Plants like light.

Clue #4: Study It More



December 21

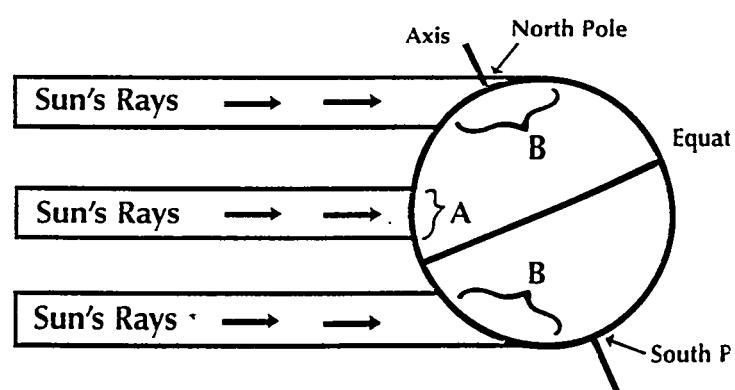
June 21

Clue #5: How Long to Arrive?

Light travels at a speed of 186,000 miles per second.

Clue #6: Just for Kicks

When the sun's rays hit the Earth directly (A), they provide strong heat and light. When the sun's rays are more spread out over the Earth's surface (B), their heat and light are weaker.



Clue #7: Tropical Heaven

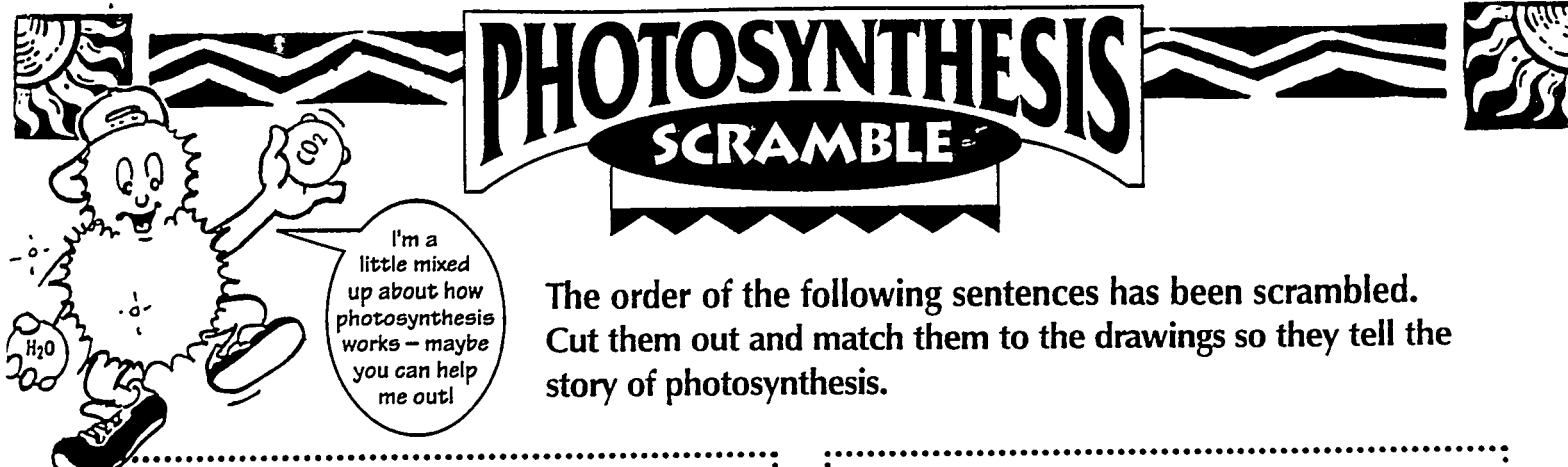
The tropics are the areas just north and south of the Equator.

Clue #8: Check That Date

It's not the Earth's distance from the sun that makes seasons—it's the angle to the sun. When the Northern Hemisphere is tipped toward the sun, it's summer in the United States. When the Southern Hemisphere is tipped toward the sun, it's summer in Australia.

Clue #9: The Famous Line

The Equator is an imaginary line running around the middle of the Earth, dividing it into the Northern and Southern Hemispheres.



PHOTOSYNTHESIS SCRAMBLE

The order of the following sentences has been scrambled. Cut them out and match them to the drawings so they tell the story of photosynthesis.

A

The **carbon dioxide** gas (CO_2) travels through the air and enters a leaf through microscopic holes called *stomata*.

B

The process of photosynthesis can be described in word or symbol equations. Whichever equation you prefer, **sunlight** is always the **energy** that makes photosynthesis possible.

C The **sugars** made by photosynthesis provide the **energy** in fruits, vegetables, and all other plant foods we eat. They are passed up the food chain to become the **energy** in all the animal foods (such as beef, chicken, fish) in the rest of our diet.

D

The leaf has now made **oxygen** gas and **sugar**, which the plant uses to feed itself.

E

Every time we take a breath, we inhale **oxygen** gas (O_2) produced by plants through photosynthesis. The **oxygen** is essential to our survival.

F

Sunlight travels to the Earth and strikes a tree, which is absorbing **water** (H_2O) through its roots.

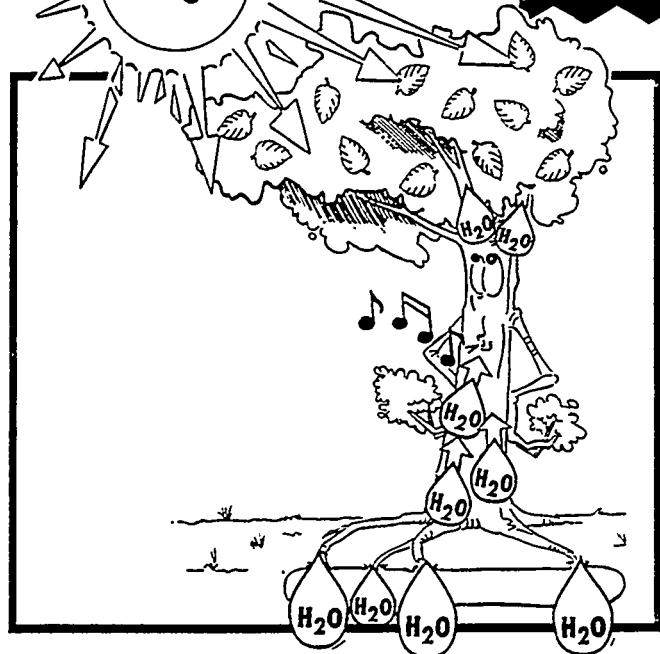
G

Nearby, people and other animals exhale a gas called **carbon dioxide** (CO_2).

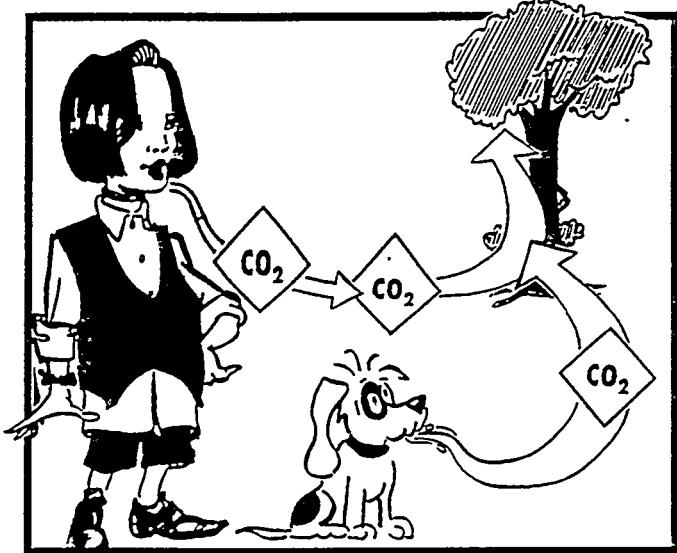
H

Sunlight striking a leaf is absorbed by the green pigment **chlorophyll**. The **energy** in **sunlight** is used to power a reaction between **carbon dioxide** (CO_2) and **water** (H_2O).

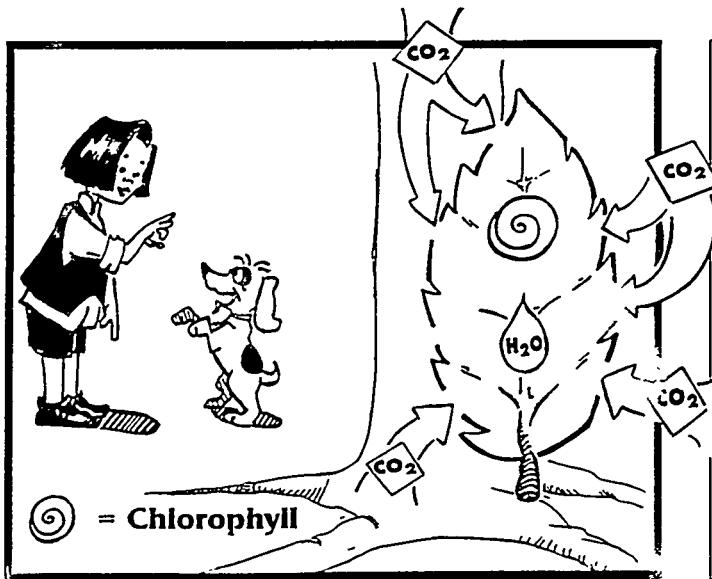
PHOTOSYNTHESIS SCRAMBLE



1

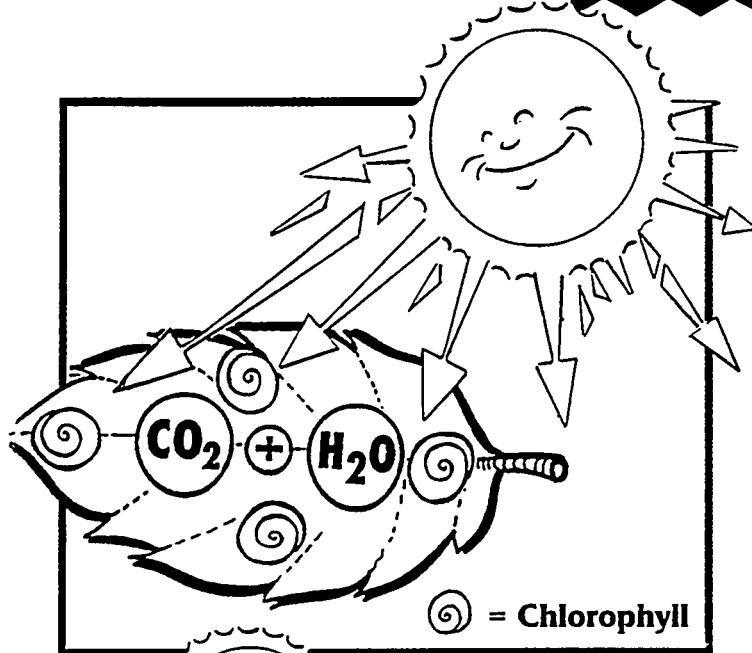


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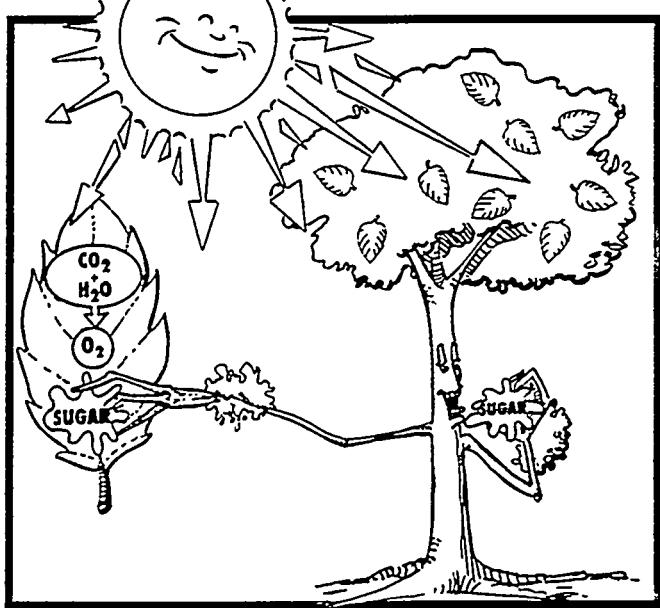


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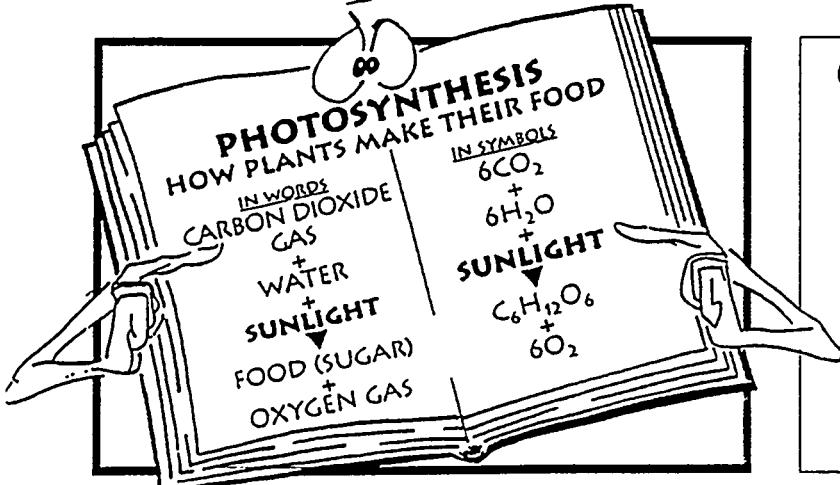
PHOTOSYNTHESIS SCRAMBLE



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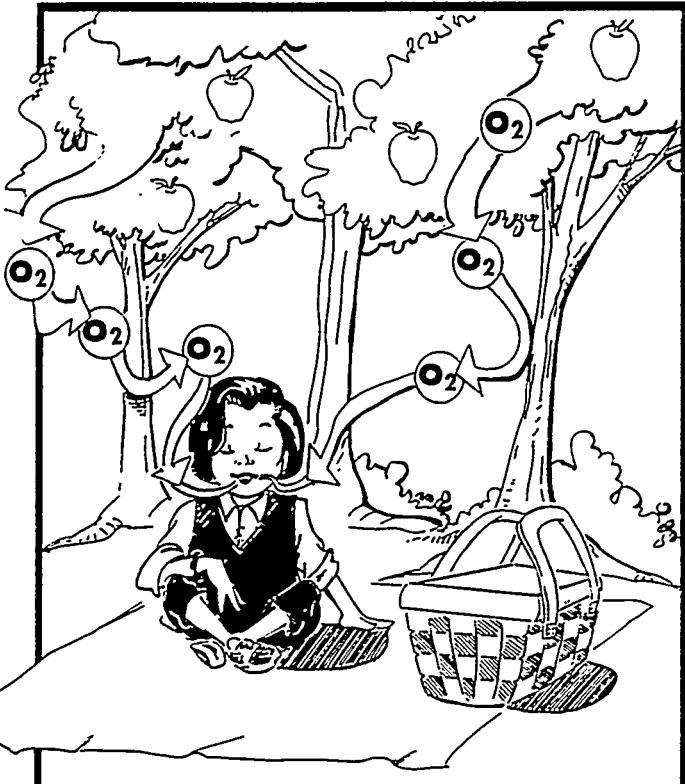


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6

PHOTOSYNTHESIS SCRAMBLE



7



8

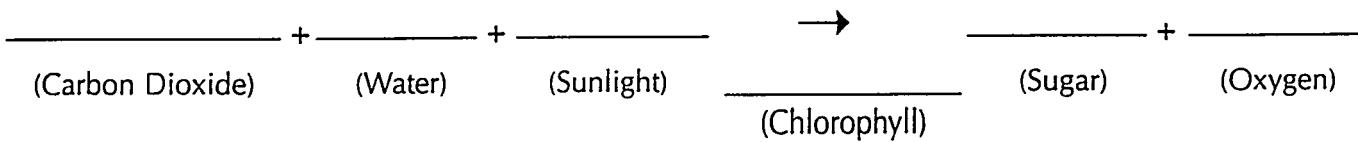


PHOTOSYNTHESIS BINGO



Now is your chance to help us make photosynthesis happen. Fill in the words or symbols at right anywhere on your leaf shaped grid. Put one complete symbol in each square. When all your squares are filled in, you're ready to play. As your teacher calls out a square, cross it off. Then write the word or symbol you crossed off into its proper place on the blank equation. When all the blanks in your equation are filled in, jump up and yell "Photosynthesis!"

CARBON DIOXIDE	CO_2	(6 squares)
WATER	H_2O	(6 squares)
OXYGEN	O_2	(6 squares)
SUGAR (glucose)	$C_6H_{12}O_6$	(1 square)
CHLOROPHYLL		(11 squares)
SUNLIGHT		(4 squares)



	A	B	C	D	E	F
1						
2						
3						
4						
5						
6						

HABITAT HYPOTHESIS



Average Daylight Hours

	Rainforest (S. E. Asia)	Tundra (Alaska)
--	----------------------------	--------------------

Jan.	12	1
Feb.	12	7
Mar.	12	12
Apr.	12	16
May	12	23
Jun.	12	24
July	12	24
Aug.	12	19
Sept.	12	14
Oct.	12	9
Nov.	12	3

Which habitat has more species of plants and animals, the rainforest or the tundra? If you know the answer, can you explain why? This activity should help you figure out the answer and explain it to other people.

But let's start by creating a **hypothesis**. A **hypothesis** is a prediction or assumption that can be tested through observation. For example, the following statement is one example of a **hypothesis**:

Classical music concerts are louder than rock music concerts.

This is a **hypothesis** that can be tested through observation. How would you test it?

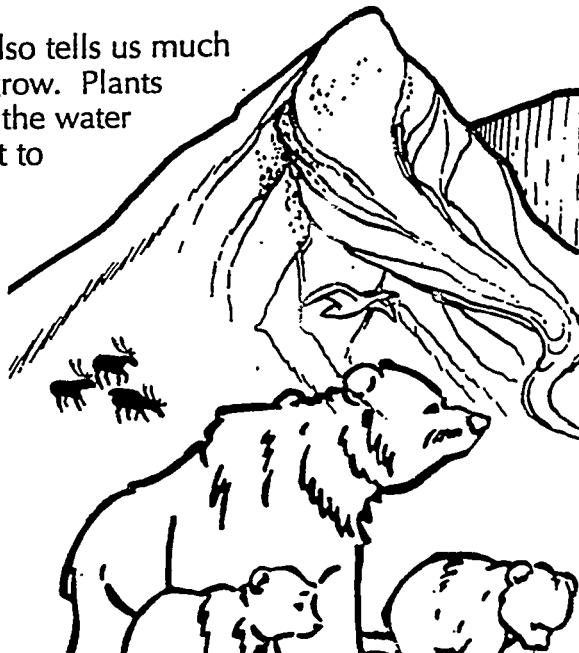
You can create a **habitat hypothesis** by filling in the blanks in the statement below:

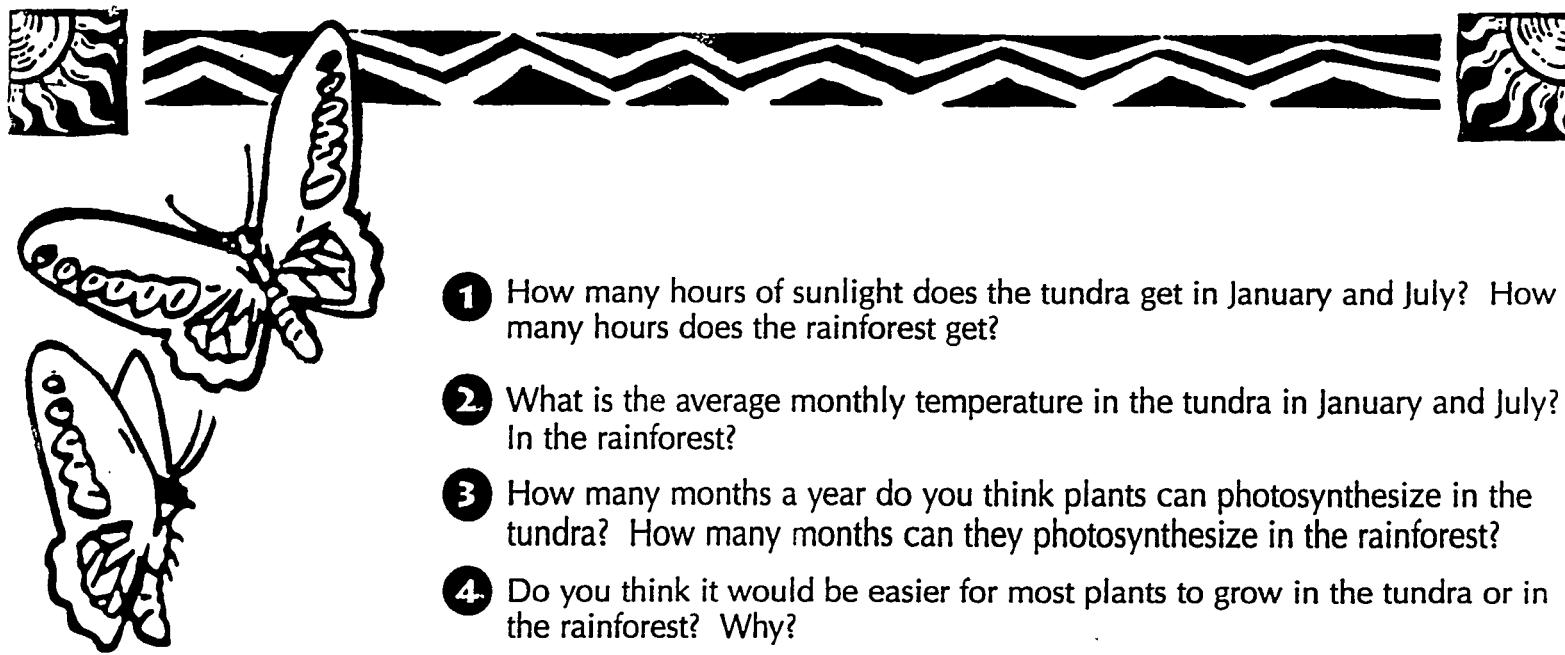
The _____ has more kinds of plants and animals than the _____ because _____.

Now let's look at some information that will help you test your hypothesis. You already know that the Arctic tundra gets less direct sunlight than the rainforest regions near the Equator. Another important factor for plants and animals is the amount of time when the energy is available. Do you think most plants can survive several months in almost total darkness?

The average monthly temperature also tells us much about how easy it is for plants to grow. Plants need water for photosynthesis. If the water is frozen, then plants cannot use it to convert the energy in sunlight into the sugars they use for food.

Look at the two tables on this sheet—showing Average Daylight Hours and Average Monthly Temperature. Use the information in the tables to make two graphs comparing the conditions of the rainforest and the tundra. Then use both graphs to help you answer the questions below.



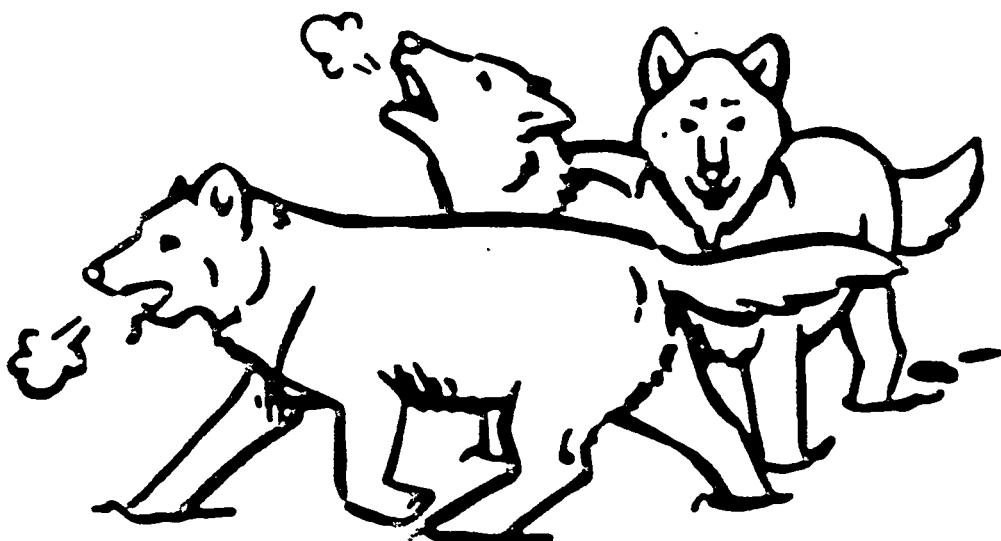


Average Monthly Temperature: °F

	Rainforest (S. E. Asia)	Tundra (Alaska)
Jan.	81	-14
Feb.	81	-20
Mar.	82	-16
Apr.	32	-2
May	84	19
Jun.	82	33
July	82	39
Aug.	82	38
Sept.	82	31
Oct.	81	14
Nov.	81	-1
Dec.	81	-13

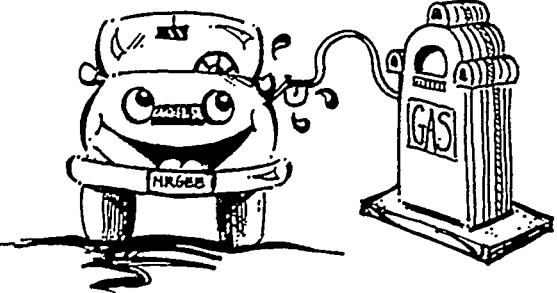
- 1 How many hours of sunlight does the tundra get in January and July? How many hours does the rainforest get?
- 2 What is the average monthly temperature in the tundra in January and July? In the rainforest?
- 3 How many months a year do you think plants can photosynthesize in the tundra? How many months can they photosynthesize in the rainforest?
- 4 Do you think it would be easier for most plants to grow in the tundra or in the rainforest? Why?
- 5 Scientists have a word that describes the total weight of all the plants and animals in an area. They call it **biomass**. Would you expect the tundra or the rainforest to have more biomass? Explain why in terms of energy.
- 6 You've already thought about some of the problems plants face in the tundra. What are the problems faced by animals? Explain in terms of energy.
- 7 A rainforest is a very high energy habitat. In human terms, it's like living in a big city—there is a lot of opportunity, but a lot of competition too. What kinds of problems do you think plants and animals might face in a rainforest? How do you think they might go about solving them?

Now imagine you are a field biologist interested in comparing the tundra to the rainforest. Your first task is to come up with a **testable hypothesis**. Use your answers to the questions above, and your graphs, to revise your original hypothesis. Do you still agree with the way it is written? Are there things you might like to add based on the questions above and the graphs you have made? After your hypothesis is complete, write a paragraph describing how, as a field biologist, you will go about testing it.



ENERGY, CALORIES AND FOOD

Calories! At some point in our lives, we all think about how many Calories we're eating. But what is a Calorie? How are the Calories in our food related to our energy needs and body weight? This activity will help you to understand the relationship between energy, Calories, and food.

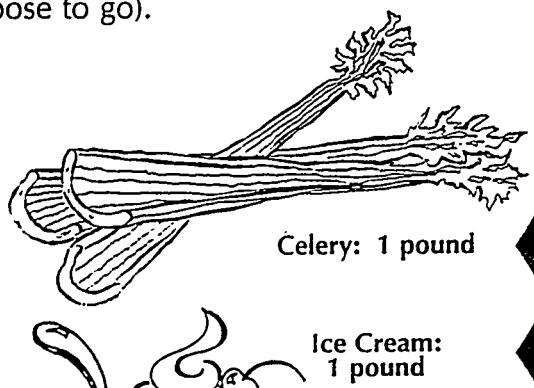


The engine of a car needs fuel in order to make the wheels turn. The fuel it is designed to use is gasoline.

Your body also needs fuel to work properly. The fuel it is designed to use is food.



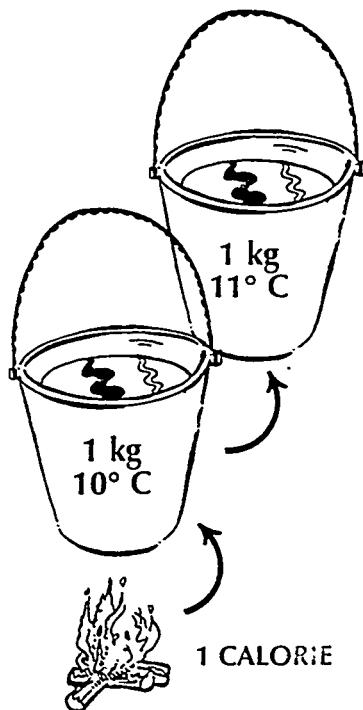
The energy in gasoline is what allows a car to do the **work** of transporting you from place to place. The energy in food is what allows your muscles and bones to do the **work** of moving **yourself** from place to place (by walking, running, hopping, jumping, skipping, dancing, or however else you choose to go).



Some foods contain more energy than others.

Which has more energy, a pound of ice cream or a pound of celery?

The energy in food can be measured in Calories. To a scientist, a Calorie is the amount of energy it takes to raise the temperature of a kilogram (2.2 pounds) of water by one degree Celsius (about 1.8 degrees Fahrenheit).

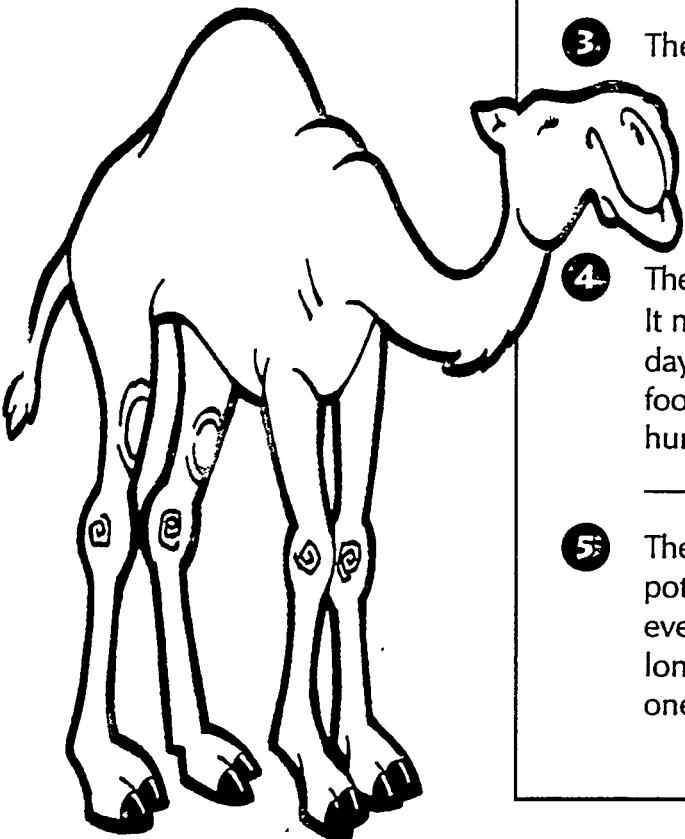


Throughout most of human history, we haven't usually had three meals a day, spaced out to keep a constant supply of energy in our bodies. So our bodies evolved ways to save energy for times when it isn't available. We do this by taking the extra Calories in food and storing them in fat. Fat is like a bank account that you use only in emergencies. If your body doesn't have enough food, it can then use the stored fat for energy.



Today, most people in this country can eat much more food than they actually need, and many of those foods are very high in Calories. But adaptation takes a long time to adjust to change—our bodies still think we're living in times when food sometimes was not available. **When we eat more than we need, our bodies take the extra Calories and tuck them away for a rainy day in the form of fat.** Too much fat can be unhealthy. That's why you see many people watching their diets and counting Calories.

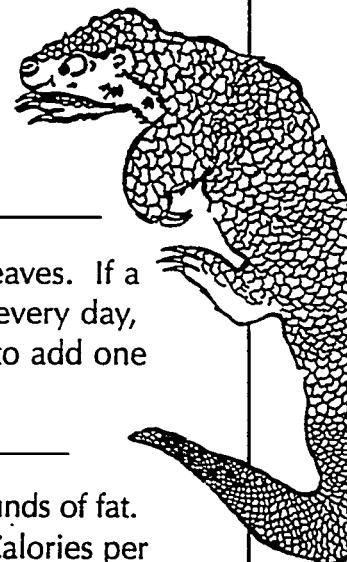
Although it doesn't always seem like it, there is a direct relationship between how many Calories we eat and how much fat we store in our bodies. **In fact, 3,600 Calories is about equal to a pound of fat.** These Calorie problems will show you how it works.



Calorie Conundrum

1 3,600 Calories = one pound of fat. There are 180 Calories in a typical soft drink. If you drank one extra can of soft drink every day, how many days would it take to add an extra pound to your body weight? _____

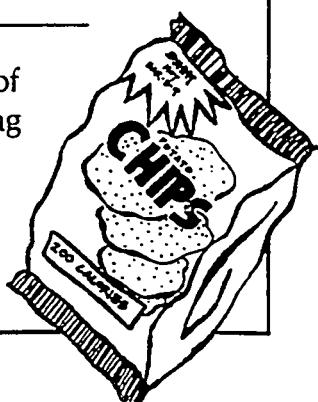
2 There are 60 Calories in a batch of 200 termites. If a pangolin ate one extra batch of termites per day, how long would it take the pangolin to add a pound of fat to its body? How many extra termites would it have eaten? _____



3 There are 600 Calories in a pound of leaves. If a camel ate 2 extra pounds of leaves every day, how long would it take the camel to add one pound of fat to its hump? _____

4 The camel has a hump that stores 60 pounds of fat. It normally eats food containing 7,200 Calories per day. If it needed to cross a wide desert without food, how long would it be before the energy in its hump was totally used up? _____

5 There are 200 Calories in a small bag of potato chips. If a person eating one bag every day stopped eating them, how long would it take that person to lose one pound? _____



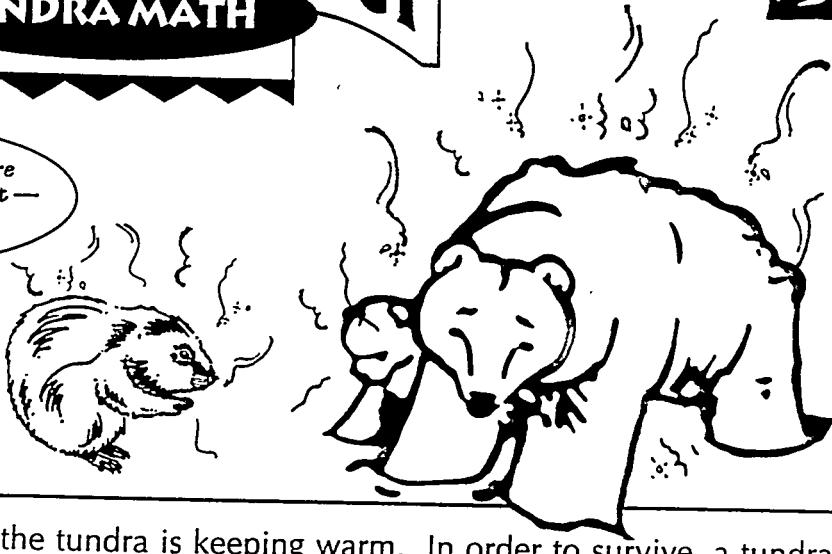


CONSERVING ENERGY

TUNDRA MATH

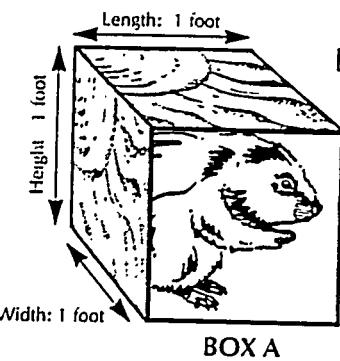


Which has to worry more about losing its body heat — a lemming or a bear?



One of the most difficult things about life on the tundra is keeping warm. In order to survive, a tundra animal has to make enough heat to keep itself warm—and make sure it doesn't lose too much of that heat to the outside world.

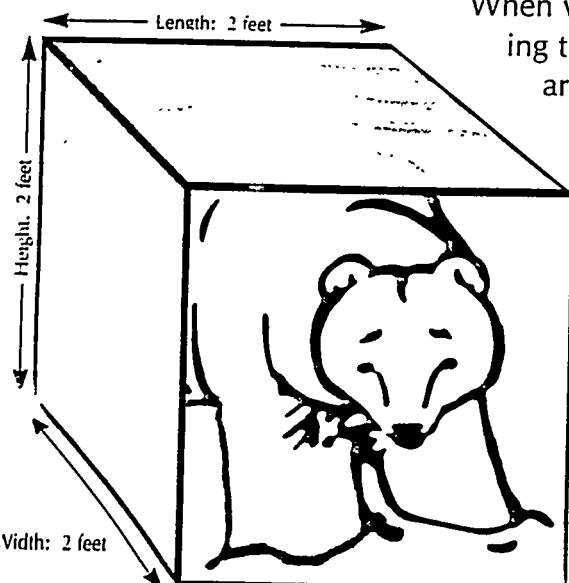
If you were to design an animal for life on the tundra, would you want it to be big or small? A tough question. An animal produces heat inside its body and loses heat through its skin. So to answer the question, you need to think about the amount of skin an animal has compared to its body size. The more skin an animal has for its body size, the more heat it usually loses to the outside world.



Do all animals, no matter how big they are, have the same amount of skin for their body size? Look at the pictures above and fill in the Tundra Math hypothesis below:

A lemming has _____ skin for its body size than/as a bear.
less/more/the same amount of

Through millions of years of adaptation, tundra animals have found solutions to problems related to body size and heat loss. But you can explore that relationship through an invention animals don't have: mathematics.



When we compare an animal's amount of skin to its body size, we are comparing the animal's surface area to its volume. It's hard to measure the surface area and volume of animals. But we can figure out what we need to know by comparing the animals to objects that we can measure easily like the two boxes shown on the left. Pretend that the small box above is the lemming, and the large box is the bear. Now rewrite your hypothesis:

Box A has _____ surface area (skin) for its
less/more/the same amount of
volume (body size) than/as Box B.

Now let's test whether your hypothesis is correct.

Box A is 1 foot on each side. Box B is two feet on each side.



- 1 What is the area of each side of Box A (length x width)? _____ square feet
- 2 What is the area of each side of Box B (length x width)? _____ square feet

An object's surface area is the total area of all its different sides. So, multiply the area of each side by the number of sides on a box to get the total surface area of each box. (How many sides does a box have? If you're not sure, look for one around you and count.)

- 3 What is the total surface area of Box A? _____ square feet
- 4 What is the total surface area of Box B? _____ square feet

The total **surface area** of the large and small boxes is like the total **amount of skin** of the large and small animals. Which is bigger? _____

- 5 What is the volume of Box A (length x width x height)? _____ cubic feet
- 6 What is the volume of Box B (length x width x height)? _____ cubic feet

The **volume** of the two boxes is like the overall **body size** of the two animals. Which is bigger? _____

Now comes the hard part. But remember what a ratio is and you won't have any problems.

- 7 Compute the ratio of the total surface area of Box A to the total volume of Box A (divide answer 3 by answer 5). This is the area of the small box compared to the box's size.
Ratio: _____
- 8 Compute the ratio of the total surface area of Box B to the total volume of Box B (divide answer 4 by answer 6 and reduce the fraction until the denominator is 1). This is the area of the large box compared to the box's size. Ratio: _____
- 9 Do the two boxes have the same amount of surface area for their volumes? _____
- 10 Which one has more? _____
- 11 So which animal has more surface area for its volume? _____
- 12 Does this information support your original hypothesis? _____
- 13 So for its body size, will a lemming or a bear lose more heat to the outside world? _____

Would you design an animal to be large or small in a cold climate? Explain. _____

This is one way in which scientists use mathematics to find out about the world around us.



THE SCIENTIFIC METHOD

Elephants, Shrews, and YOU

Earlier in this program, you created a Habitat Hypothesis. You learned that a hypothesis is a prediction or assumption that can be tested through observation. Creating a hypothesis and testing it are two of the most important parts of the way scientists work. The process by which scientists figure out answers to questions is called The Scientific Method. It can be shown in six steps.

The Scientific Method

- 1 Identifying A Question
- 2 Gathering All The Information Available
- 3 Creating a Hypothesis
- 4 Performing Experiments or Making Observations To Test The Hypothesis
- 5 Figuring Out If Results Support The Hypothesis
- 6 Drawing A Conclusion

Now we'll look at how the Scientific Method can be applied to a situation in the real world. Imagine you are a biologist interested in exploring how an animal's body size is related to how much food it needs to eat.

Identifying A Question

The question you identify is:

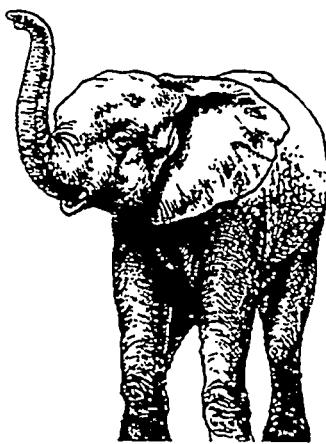
Which eats more food per kilogram of its body weight, an elephant or a shrew?

Gathering Information

After identifying your question, you gather the following information from studies other scientists have done. Shrews are the smallest mammals in North America. They eat insects and other small animals. Elephants eat hay, leaves, twigs and other plant food. In one article, you find the following chart:



Calories in Food	
Shrew	2.0 Calories per gram
Elephant	1.5 Calories per gram



Which animal's food has more energy (Calories per gram)? _____



Creating A Hypothesis

Now is the time to create a hypothesis. Obviously, an elephant eats much more than a shrew, because it's so much bigger. But imagine that an elephant and a shrew are the same size. The shrew still eats animals and the elephant still eats hay and other plant foods. Based on the information above, which do you think needs to eat more food? In other words, which one has to eat the most for its size? (Hint: Look at the Calories in each one's food?)

Write your answer as a hypothesis:

A/an _____ needs to eat more food for its size than a/an _____.

elephant/shrew)

elephant/shrew)

Performing Experiments or Making Observations

Next comes the time to test your hypothesis. You will need to use experiments or observations to find out the following:

- 1 the weight of an elephant;
- 2 the weight of a shrew;
- 3 the weight of food an elephant eats in a day;
- 4 the weight of food a shrew eats in a day.

These figures are not so easy to find. (It's hard to get an elephant to climb onto your bathroom scale.) On another sheet of paper write a paragraph describing the observations or experiments you will use in order to find the information (or "data") you need.

Figuring Out If Your Results Support Your Hypothesis

Now that you've completed the experimental part of your project, the time has come to interpret the results (data) you have found. Your results are shown in the table below.

	<u>Body Weight</u>	<u>Food Eaten/Day</u>
Shrew	0.13 oz (3.7 gm)	0.39 oz (11.1 gm)
Elephant	11,000 lb (4994 kg)	220 lb (100 kg)

Use the information in the table to figure out how much food each one eats relative to its body weight.

Do this by dividing the amount of food eaten by the animal's body weight. Now multiply the total by 100. This is the percentage of its body weight that each animal eats in a day.

Shrew: _____ % Elephant: _____ %

Does the shrew or the elephant eat more food for its size? _____

Respond to your hypothesis. Is it true or false? _____

Drawing A Conclusion

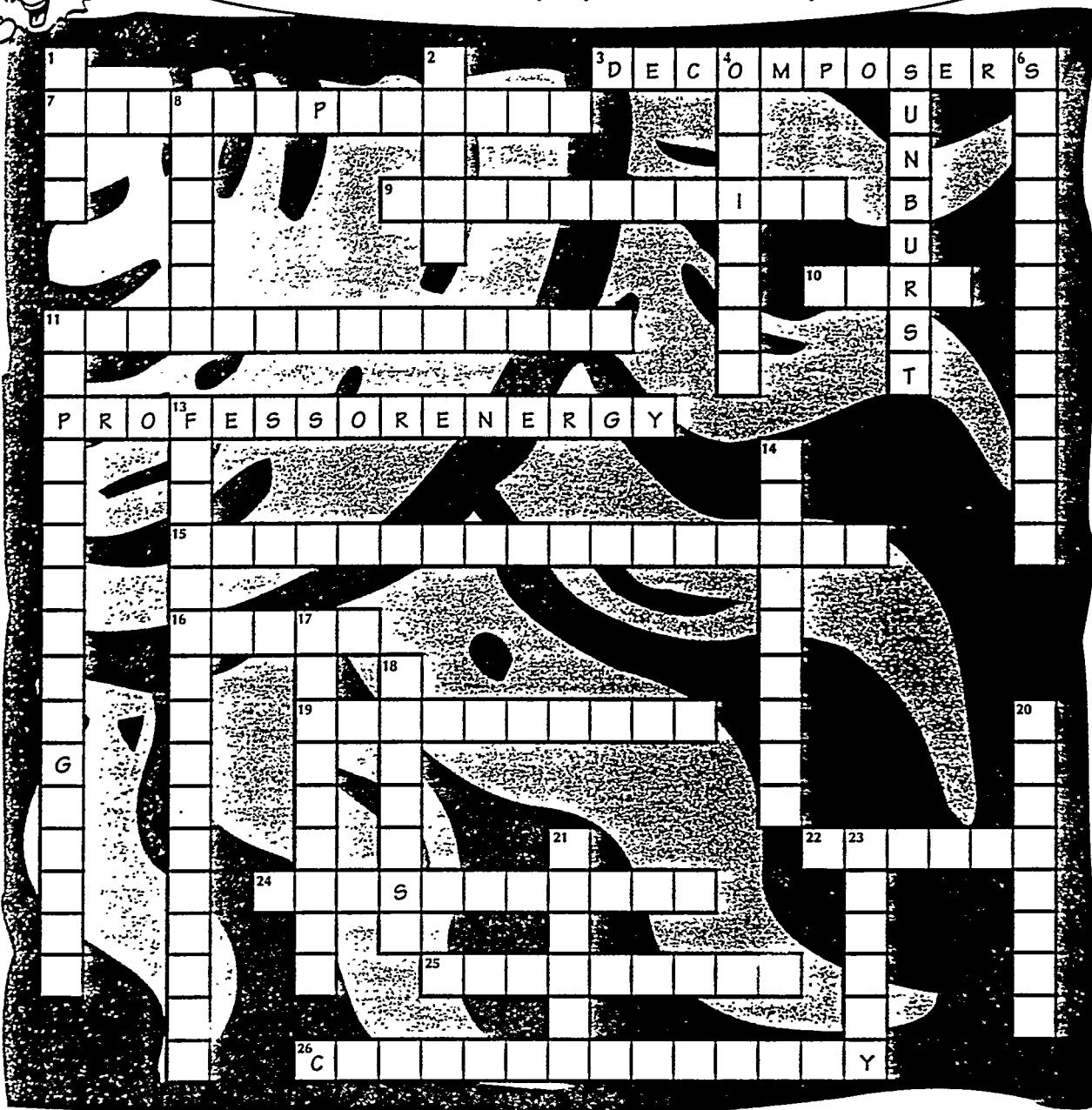
In another paragraph, explain your results. Was your hypothesis supported? Why or why not?



ENERGY PUZZLER



You've read the story of my voyage; now you can help me fill in this Energy Puzzler. See how much you can fill in based on everything you've learned already. If there are clues you can't answer, take another look at my story. It has all the information you need.



CROSS

3. Creatures that break down dead plants and animals and return their nutrients to the soil.
7. A design that shows how energy decreases as you follow it from the Sun to green plants, herbivores, first level carnivores, and finally top carnivores.
9. A form of energy found in lightning and a socket in your wall.
10. The heat that cooks food and the light that illuminates your room are both examples of energy's ability to do this.
11. The process in which plants absorb the Sun's energy and

- changes form, the amount of useful energy goes down.
16. A form of energy that allows you to read this page.
 19. A warm and wet habitat that is home to more than half of the species known on Earth.
 22. The first carnivore that Sunburst and the Professor travel through on their voyage.
 24. The fossilized remains of plants and animals that lived millions of years ago; oil and coal are two examples.
 25. The green plant, or producer, in which Sunburst and the Professor

Down

1. A form of energy that cooks food or raises the body temperature of a lizard lying in the sun.
2. The top carnivore that Sunburst and the Professor meet on their voyage.
4. An animal that eats plants and animals.
6. 186,000 miles per second.
8. The herbivore that eats Sunburst's dandelion.
11. A major cause of the destruction of habitats, this concept describes the increase in the number of people on Earth.
13. This states that energy can change
14. Animals that eat only meat.
17. Animals that eat only plants.
18. The total weight of all the plants or animals found in a habitat.
20. One of the ingredients in photosynthesis, and the source of the energy in all the living things on Earth. Sunburst and the Professor start out in this form.
21. A habitat that is cold and dark much of the year, it is still populated by an amazing variety of plants and animals.
23. The ability to do work, it comes in many different forms.

APPENDIX C

VOYAGE FROM THE SUN

Teacher Evaluation Form

Please fill out the form below in as much detail as possible. Your responses will be extremely valuable as we evaluate the program and make plans for its future. In addition to this form, we would greatly appreciate receiving examples of your students' work, videotapes, slides- anything that will provide information on how the program was received by you and your students. Please mail this form, and any other materials, to the following address:

Voyage From The Sun
Education Department
Bronx Zoo/Wildlife Conservation Park
Bronx, New York 10460-1099

Your Name _____

School Name _____

School Address _____

School Telephone _____

Home Address _____

Home Telephone _____

1. At what grade level(s) did you test the program? (please circle grade)

4

5

6

7

8

9

Other _____

2. How would you describe the majority of your students?

above average academically

special education
(please explain below)

average academically

below average academically

3. What percentage of your students are eligible for participation in the school lunch program?

4. Please describe the demographics of the class with which you used the program.

5. What was your overall response to the program? Please circle and explain.

highly effective

effective

ineffective

6. How did the program's difficulty relate to your students' ability and maturity?

too difficult

about right

too easy

7. In your opinion, how clear were the aims of the program?

very clear

clear

unclear

very unclear

8. In your opinion, did the instructional activities address the stated aims?

yes

no

9. Please rate the program's effectiveness in stimulating your students' interest in science.

excellent

good

fair

poor

10. How interesting was the program to your students?

very interesting

interesting

uninteresting

very uninteresting

11. In how many class periods did you use the program with your students? _____

12. How many of the program's 20 lessons did you complete? _____

13. How many class periods would it take to implement the program in its entirety with students of similar academic background?

sessions of approximately _____; # minutes per session _____

14. Did the program provide enough opportunity for student involvement and discovery?

high student involvement moderate student involvement low student involvement

15. What were your, and/or your students', favorite activities in the program? Why?

16. What were your, and/or your students', least favorite activities in the program? Why?

17. Did the program duplicate other curricular programs or did it provide new materials and approaches? (please circle)

Many New
Approaches/Materials

Some New
Approaches/Materials

Duplicates
Other Programs

18. If the program contains new approaches, please check off all of the following that were included.

Holistic Approach To Energy/Ecology_____

Integration Of Physical And Biological Sciences_____

Use of Experiments And Research_____

Application Of Physical And Biological Concepts To Real-Life Situations_____

Hands-On Activities_____

Use Of Zoos And/Or Animals To Enhance Classroom Learning_____

Use Of Games And Simulations_____

Other (Please Explain Below)_____

19. How well does this program fit into your current curriculum? Please explain and tell us where in your curriculum you integrated this program.

20. Were there any unexpected learning outcomes that resulted from the program? If so, please explain.

21. What assessment tools did you use? What results did they show? Please explain.

22. Did you attend a training session with a member of the Bronx Zoo staff?

23. If you attended a training session, did you find it to be:

Very Effective

Effective

Not Effective

24. Would you like to use this program again? Yes No

Why or why not?

Part 2

Please provide specific ratings and information on the following program elements.

25. Teachers' Guide

a. How clear were the instructions provided?

very clear clear unclear very unclear

b. How useful was the background information?

very useful useful not very useful useless

c. Overall, how would you rate the Teachers' Guide?

very effective effective not effective

26. Voyage From The Sun Comic Book

a. How effective was the comic book in providing science content and motivating students?

very effective effective not effective

b. How would you rank the comic book in terms of your students' abilities?

too easy easy about right difficult very difficult

27. Energy Pyramid

a. How effective was the pyramid in providing science content and motivating students?

very effective effective not effective

28. Plant and Animal Cards

- a. How effective were the plant and animal cards in providing science content and motivating students?

very effective

effective

not effective

29. Activity Sheets

- a. How effective were the activity sheets in providing science content and motivating students?

very effective

effective

not effective

- b. Which activity sheets were most effective?

- c. Are there any activity sheets you chose not to use? If so, which ones and why?

30. Energy For Survival Poster

a. How effective was the poster in motivating students?

very effective

effective

not effective

31. Race For The Rainforest Game

a. How effective was the game in providing science content and motivating students?

very effective

effective

not effective

Thank you very much for your comments! Please use the reverse of this page for any additional remarks.

Appendix D**Voyage From the Sun Program Evaluation****Summary for All Grade Levels (31 evaluations)****Background information:**

Academic level of students:

Average = 19
 Below average = 13
 Special Education (emotionally disturbed) = 1
 Above average = 2

% of students eligible for
 School Lunch Program:

Ranged from 2 to 100%

Class Demographics include:

Multicultural
 Middle class suburban mix
 White middle class
 Black/Hispanic
 Rural (lower to middle class,

Overall response to the program:

Highly effective = 11
 Effective = 19
 Ineffective = 0

Rate the program's difficulty in relationship to the students' ability and maturity:

About right = 26
 Too difficult = 6
 Too easy = 0

How clear were the program's aims?:

Very clear = 16
 Clear = 15
 Unclear = 0
 Very unclear = 0

Did the instructional activities address stated aim?:

Yes = 31
 No = 0

Rate program's effectiveness in stimulating students' interest in science:

Excellent = 17

Good = 14

Fair = 0

Poor = 0

How interesting was program to your students?:

Very interesting = 18

Interesting = 14

Uninteresting = 0

Very uninteresting = 0

Average number of periods the program was used:

13 periods

Average # of lessons completed:

10 lessons

Average # of periods it would take to implement entire program for students same ability:

25 periods @ 45 minutes

Rate the student involvement that the program involves:

High involvement = 25

Moderate involvement = 10

Low student involvement = 0

Does the program provide new materials/approaches?:

Many new = 22

Some new = 9

Which were new approaches?:

Use of games/simulations (28)

Holistic approach to energy/
ecology (25)

Integration of physical science/
biology (24)

Hands-on activities (22)

Application of concepts to
real-life (20)

Use of zoos to enhance
learning (20)

Use of experiments/research (15)

Does the program duplicate other programs?	2 (Duplicates school districts' ecology program, but <i>Voyage</i> is more detailed)
# of teachers who attended training:	30
Rate the training session:	Very effective = 24 Effective = 6 Not effective = 0
Would you like to use this program again?:	Yes = 31 No = 0
Reasons why all teachers would use the program again : (most frequently cited comments)	Served as a high motivation for learning Enhanced learning Effective teaching tool Fun/fabulous way to integrate subjects Interesting and part of existing curriculum Integrates concepts
Teachers' guide instructions are:	Very clear = 17 Clear = 13 Unclear = 1 Very unclear = 0
Teachers' guide background info is:	Very useful = 23 Useful = 7 Not very useful = 0 Useless = 0
Rate teachers' guide:	Very effective = 19 Effective = 10 Not effective = 0
How effective was the comic book in providing science content and motivating students?:	Very effective = 23 Effective = 7

Not effective = 0

Rank comic book in relationship to
students' abilities:

About right = 26

Difficult = 9

Easy = 2

Too easy = 0

Very difficult = 0

How effective was the pyramid
in providing science content and
motivating students?:

Very effective = 21

Effective = 6

Not effective = 1

How effective were the plant/animal
cards in providing science content and
motivating students?:

Very effective = 24

Effective = 6

Not effective = 0

How effective were the activity sheets
in providing science content and
motivating students?:

Very effective = 18

Effective = 10

Not effective = 1

How effective was the poster
in motivating students?:

Very effective = 12

Effective = 12

Not effective = 5

How effective was the "Race for the
Rainforest" game in providing science
content and motivating students?:

Very effective = 13

Effective = 6

Not effective = 0

Favorite Activities (summary of all grade levels)

Activity	# of Responses
Photosynthesis Bingo	15
Comic Book	12
Pyramid	10
Food chains/Webs	7
Coloring Poster	6
Rainforest Race	2
Photosynthesis Scramble	2

Least Favorite Activities (summary of all grade levels)

Activity	# of Responses
Activity sheets with math	6
Habitat Survival Bag	2

Voyage From the Sun Program Evaluation by Grade

4th Grade (9 evaluations received)

Background information:

Academic level of students:	Average = 5 Below average = 4 Special Education (emotionally disturbed) = 1
% of students eligible for School Lunch Program:	Ranged from 5 to 99%
Class Demographics include:	Multicultural Middle class suburban mix White middle class Black/Hispanic

Overall response to the program:

Highly effective = 6
Effective = 2
Ineffective = 0

Rate the program's difficulty in relationship to the students' ability and maturity:

About right = 7
Too difficult = 3
Too easy = 0

How clear were the program's aims?:

Very clear = 6
Clear = 3
Unclear = 0
Very unclear = 0

Did the instructional activities address stated aim?:

Yes = 9
No = 0

Rate program's effectiveness in stimulating students' interest in science:

Excellent = 8
Good = 1
Fair = 0
Poor = 0

How interesting was program to your students?:

Very interesting = 9
Interesting = 0
Uninteresting = 0
Very uninteresting = 0

Average number of periods the program was used:

19 periods

Average # of lessons completed:

12 lessons

Average # of periods it would take to implement entire program for students of same ability:

30 periods @ 40 minutes

Rate the student involvement that the program involves:

High involvement = 9
Moderate involvement = 0
Low involvement = 0

The five most favorite activities are:

The pyramid
The comic book
Photosynthesis Scramble
Researching habitats and animals
Webbing

The least favorite activity was:

Any activity involving complex mathematics calculations, i.e., Energy Calories/Tundra Math

Does the program provide new materials/approaches?:

Many new = 7
Some new = 2
Duplicates other programs = 0

Which were new approaches?: (most frequently cited comments)	Use of games/simulations (8) Hands-on activities (8) Holistic approach to energy/ecology (7) Integration of physical science/biology (6) Use of experiments/research (5) Application of concepts to real-life (4) Use of zoos to enhance learning (4)
Reasons why program fits curriculum: (most frequently cited comments)	Use of critical thinking skills Use of hands-on activities Includes food chains/webs/photosynthesis and ecology topics Bolsters student's self-esteem Matches science curriculum
Unexpected learning outcomes: (most frequently cited comments)	Students learned and retained more information Students paid closer attention to how environment effects people and animals Program includes a high level of student involvement Students developed awareness of their responsibility in world
What assessment tools were used?: (most frequently cited comments)	Discussion and debate which demonstrated students' vocal concerns about the environment Pretest/Posttest which revealed that students were learning Webbing, research and art projects which demonstrated the students' progress

of teachers who attended training:

9

Rate the training session:

Very effective = 7

Effective = 2

Not Effective = 0

Would you like to use this program again?:

Yes = 9

No = 0

Reasons why all teachers would use the program again:
(most frequently cited comments)

Served as a high motivation for learning

Enhanced learning

Effective teaching tool

Fun/fabulous way to integrate subjects

Interesting and part of existing curriculum

Integrates concepts

Teachers' guide instructions are:

Very clear = 5

Clear = 4

Unclear = 1

Very unclear = 0

Teachers' guide background info is:

Very useful = 8

Useful = 1

Not useful = 0

Useless = 0

Rate teachers' guide:

Very effective = 7

Effective = 2

Not effective

How effective was the comic book in providing science content and motivating students?:

Very effective = 8

Effective = 1

Not effective = 0

Rank comic book in relationship to students' abilities:

About right = 7

Difficult = 5

Very difficult = 0

Easy = 0

Too easy = 0

How effective was pyramid in providing science content and motivating students?:

Very effective = 9
Effective = 0
Not effective = 0

How effective were the plant/animal cards in providing science content and motivating students?:

Very effective = 7
Effective = 2
Not effective = 0

How effective were the activity sheets in providing science content and motivating students?:

Very effective = 4
Effective = 5
Not effective = 0

Most effective activity sheets are:

Photosynthesis Bingo
Photosynthesis Scramble
Energy Watch
Sites for Sale
Build a Plant
Population Possibilities
Solar Detective

Least effective activity sheet:

Habitat Hypothesis (hard to understand w/out ex.)

How effective was the poster in motivating students?:

Very effective = 4
Effective = 2
Not effective = 1

How effective was the "Race for the Rainforest" game in providing science content and motivating students?:

Very effective = 4
Effective = 2
Not effective = 0

5th Grade (13 evaluations received)

Background information:

Academic level of students:

Average = 8

Below average = 5

Above average = 1

% of students eligible for
School Lunch Program:

Ranged from 2 to 100%

Class Demographics include:

Multicultural

Middle to upper middle class

Hispanic

Black

Rural (lower to middle class)

Overall response to the program:

Highly effective = 4

Effective = 9

Ineffective = 0

Rate the program's difficulty in relationship
to the students' ability and maturity:

About right = 11

Too difficult = 2

Too easy = 0

How clear were the program's aims?:

Very clear = 7

Clear = 6

Unclear = 0

Very unclear = 0

Did the instructional activities address
stated aim?:

Yes = 13

No = 0

Rate program's effectiveness in stimulating
students' interest in science:

Excellent = 4

Good = 9

Fair = 0

Poor = 0

How interesting was program to your students?:	Very interesting = 5 Interesting = 9 Uninteresting = 0 Very uninteresting = 0
Average number of periods the program was used:	13 periods
Average # of lessons completed:	9 lessons
Average # of periods it would take to implement entire program for students of same ability:	25 periods @ 45 minutes
Rate the student involvement that the program involves:	High involvement = 8 Moderate involvement = 5 Low student involvement = 0
The five most favorite activities are:	The pyramid The comic book Photosynthesis Bingo Food chains/webs Coloring the poster
The least favorite activity was:	Any activity involving complex mathematics calculations Webbing(had already done a lot) Habitat Survival Bag Game
Does the program provide new materials/approaches?:	Many new = 10 Some new = 3
Does program duplicate other programs?:	District ecology program = 1
Which were new approaches?:	Use of games/simulations (12) Use of zoos to enhance learning (11) Holistic approach to energy/ ecology (11)

	<p>Hands-on activities (10) Integration of physical science/ biology (9) Application of concepts to real-life (9) Use of experiments/research (5) Other: students role-playing comic book characters (1)</p>
Reasons why program fits curriculum: (most frequently cited comments)	<p>Includes energy and ecology Good source of integration (esp. ecology and rain forest) Integrated with reading/writing Good link to ecology, environment and marine biology units Pulled together concepts of photosynthesis and habitats and clarified them</p>
Unexpected learning outcomes: (most frequently cited comments)	<p>Students looking forward to science and learning about ecology Students who were difficult to motivate were enthusiastic Students became more aware of true life applications of sun's energy Photosynthesis activities enhanced students' learning</p>
What assessment tools were used?: (most frequently cited comments)	<p>Discussion with adults demonstrated students' understanding Pretest/Posttest which revealed that students were learning Students teaching younger children demonstrated their understanding of material</p>
# of teachers who attended training:	13
Rate the training session:	<p>Very effective = 12 Effective = 1 Not effective = 0</p>

Would you like to use the program again?:	Yes = 13 No = 0
Reasons why all teachers would use the program again: (most frequently cited comments)	Served as a high motivation for learning Perfect match of science units Effective teaching tool Fun way to learn Keeps the kids' interest Addresses the need to discover importance of energy and its use
Teachers' guide instructions are:	Very clear = 5 Clear = 7 Unclear = 0 Very unclear = 0
Teachers' guide background info is:	Very useful = 7 Useful = 5 Not very useful = 0 Useless = 0
Rate teachers' guide:	Very effective = 5 Effective = 7 Not effective = 0
How effective was the comic book in providing science content and motivating students?:	Very effective = 9 Effective = 3 Not effective = 0
Rank comic book in relationship to students' abilities:	About right = 11 Difficult = 2 Easy = 1 Too easy = 0 Very difficult = 0
How effective was the pyramid in providing science content and motivating students?:	Very effective = 8 Effective = 3 Not effective = 0

How effective were the plant/animal cards in providing science content and motivating students?:

Very effective = 12
Effective = 1
Not effective = 0

How effective were the activity sheets in providing science content and motivating students?:

Very effective = 10
Effective = 2
Not Effective = 1

Most effective activity sheets are:

Photosynthesis Bingo
Photosynthesis Scramble
Solar Detective
Build a Plant
Habitat Hypothesis

Least effective activity sheet:

Solar Detective (hard for students without geography knowledge)
Calorie Count (math confusing)

How effective was the poster in motivating students?:

Very effective = 5
Effective = 6
Not effective = 2

How effective was the "Race for the Rainforest" game in providing science content and motivating students?:

Very effective = 6
Effective = 3
Not effective = 0

6th Grade (9 evaluations received)

Background information:

Academic level of students:	Average = 6 Below average = 4 Above average = 1
% of students eligible for School Lunch Program:	Ranged from 10 to 100%
Class Demographics include:	Multicultural Lower to middle class Hispanic Black

Overall response to the program:

Highly effective = 1
Effective = 8
Not effective = 0

Rate the program's difficulty in relationship to the students' ability and maturity:

About right = 8
Too difficult = 1
Too easy = 0

How clear were the program's aims?:

Very clear = 3
Clear = 6
Unclear = 0
Very unclear = 0

Did the instructional activities address stated aim?:

Yes = 9
No = 0

Rate program's effectiveness in stimulating students' interest in science:

Excellent = 5
Good = 4
Fair = 0
Poor = 0

How interesting was program to your students?:

Very interesting = 4
Interesting = 5
Uninteresting = 0
Very uninteresting = 0

Average number of periods the program was used:	8 periods
Average # of lessons completed:	9 lessons
Average # of periods it would take to implement entire program for students of same ability:	25 periods @ 45 minutes
Rate the student involvement that the program involves:	High involvement = 8 Moderate involvement = 5 Low students involvement = 0
The five most favorite activities are:	The pyramid The comic book Photosynthesis Bingo Food chains/webs Rainforest Race
The least favorite activity was:	Habitat Survival Bag Game
Does the program provide new materials/approaches?:	Many new = 5 Some new = 4
Does program duplicate other programs?:	Ecology program = 1 (but "Voyage is more detailed)
Which were new approaches?:	Integration of physical science/biology (9) Use of games/simulations (8) Holistic approach to energy/ecology (7) Application of concepts to real-life (7) Use of zoos to enhance learning (5) Use of experiments/research (5) Hands-on activities (4) Other: students role-playing comic book characters (1)

Reasons why program fits curriculum: (most frequently cited comments)	Matches science cluster and environment unit Serves both instructional and enrichment purposes Easy to integrate with social studies Can be used to meet energy, experimental and research objectives
Unexpected learning outcomes: (most frequently cited comments)	Information can be integrated with literature High level of sophistication achieved in application of math skills in zoo activity Students able to explain seasonal change
What assessment tools were used?: (most frequently cited comments)	Discussion with adults demonstrated students' understanding Pretest/Posttest which revealed that students were learning Students' notebooks
# of teachers who attended training:	8
Rate the training session:	Very effective = 5 Effective = 3 Not effective = 0
Would you like to use the program again?:	Yes = 9 No = 0
Reasons why all teachers would use the program again: (most frequently cited comments)	Served as a high motivation for learning Keeps the kids' interest
Teachers' guide instructions are:	Very clear = 7

Clear = 2
Unclear = 0
Very unclear = 0

Teachers' guide background info is:

Very useful = 8
Useful = 1
Not useful = 0
Useless = 0

Rate teachers' guide:

Very effective = 7
Effective = 1
Not effective = 0

How effective was the comic book in providing science content and motivating students?:

Very effective = 6
Effective = 3
Not effective

Rank comic book in relationship to students' abilities:

About right = 8
Difficult = 2
Easy = 1
Too easy = 0
Very difficult = 0

How effective was the pyramid in providing science content and motivating students?:

Very effective = 4
Effective = 3
Not effective = 1

How effective were the plant/animal cards in providing science content and motivating students?:

Very effective = 5
Effective = 3
Not effective = 0

How effective were the activity sheets in providing science content and motivating students?:

Very effective = 4
Effective = 3
Not effective

Most effective activity sheets are:

Photosynthesis Bingo
Photosynthesis Scramble
Zoo Calories
Build a Plant
Habitat Hypothesis

Least effective activity sheet:

Solar Detective (hard for students
without geography knowledge
Calorie Count (math difficult)

How effective was the poster
in motivating students?:

Very effective = 3
Effective = 4
Not effective = 2

How effective was the "Race for the
Rainforest" game in providing science
content and motivating students?:

Very effective = 3
Effective = 1
Not effective = 0

VOYAGE FROM THE SUN

Name: _____ Grade: _____ Teacher: _____

Instructions: There are 30 multiple choice questions below. Please choose the answers you think are best. Circle **only one** letter (a, b, c or d) for each question.

- 1) Which of the following is a form of energy?
 - a. Light.
 - b. Heat.
 - c. Electricity.
 - d. Light, heat, and electricity are all forms of energy.

- 2) Which is the best definition of energy?
 - a. Energy is a force field around the Earth.
 - b. Energy is the ability to do work.
 - c. Energy is found only in living things.
 - d. Energy is impossible to see or feel.

- 3) Just about all of the energy in living things on Earth starts
 - a. In the sun.
 - b. In the ground.
 - c. In water.
 - d. None of the above.

- 4) Which is the best explanation of why we have seasons.
 - a. In summer the Earth is closer to the sun than in winter.
 - b. The Earth is tilted at an angle to the sun. During part of the year sunlight hits places on Earth more directly than at other times.
 - c. The Earth spins faster during some parts of the year.
 - d. The sun gives off less energy during part of the year.

- 5) Photosynthesis is a process in which
- Animals use sunlight to warm up their bodies.
 - Water is heated to its boiling point.
 - Plants use sunlight to make their own food.
 - Plants spread their seeds.
- 6) Which of the following is needed for photosynthesis?
- Water (H_2O).
 - Sunlight.
 - Carbon dioxide gas (CO_2).
 - All of the above.
- 7) In most rainforests
- Plants are found at different levels.
 - There are only tall trees.
 - All plants are the same height.
 - There is a cold season.
- 8) In the tundra
- It is too cold for plants to live.
 - For months the sun doesn't rise.
 - There are forests of tall trees.
 - There is very little wind.
- 9) When would you have the biggest need for a flashlight?
- Stranded in the rainforest in summer.
 - Stranded in the rainforest in winter.
 - Stranded in the tundra in summer.
 - Stranded in the tundra in winter.

10) Leaves help a plant by

- a. Absorbing sunlight.
- b. Keeping out the rain.
- c. Shading its roots.
- d. None of the above.

11) A buttress root helps a tree

- a. Support itself.
- b. Protect itself.
- c. Move from place to place.
- d. Spread its seeds.

12) Herbivores are

- a. Animals that live in the trees.
- b. Plants that make their own food.
- c. Animals that eat only animals.
- d. Animals that eat only plants.

13) Which of the following is the best example of an omnivore?

- a. Leopard.
- b. Caribou
- c. Human.
- d. Tiger.

14) Which energy chain is in the right order?

- a. plant -- sun -- wolf -- caribou
- b. wolf -- plant -- sun-- caribou
- c. sun -- plant -- caribou -- wolf
- d. caribou -- wolf -- plant -- sun

- 15) When an animal becomes extinct
- It will never be seen again.
 - All of the animals in its food web can be harmed.
 - The "balance of nature" is upset.
 - All of the above.
- 16) Which of the following would be found on the top level of an Energy Pyramid?
- A herbivore.
 - A carnivore.
 - The sun.
 - All of the above.
- 17) Which of the following statements best describes the tundra?
- There are usually more caribou than wolves.
 - There are usually more wolves than caribou.
 - There are the same number of wolves and caribou.
 - There are no wolves or caribou.
- 18) Which of the following is a "Producer"?
- A dandelion.
 - A caribou.
 - A wolf.
 - A weasel.
- 19) A Calorie is
- A sweet-tasting ingredient in many foods.
 - Equal to one pound.
 - A measure of the energy contained in food.
 - None of the above.

- 20) You can demonstrate one Calorie by
- Jumping up and down for 10 minutes in hot weather.
 - Cooling water until it freezes.
 - Running the length of a football field against the wind.
 - Heating a kilogram of water to raise its temperature 1 degree Centigrade.
- 21) An animal needs extra Calories when it is
- Old and sick.
 - Growing or pregnant.
 - Hibernating or sleeping.
 - None of the above.
- 22) In general, a reptile needs
- More Calories than a mammal, but fewer than a bird.
 - The same number of Calories as a bird or a mammal.
 - Fewer Calories than a bird or a mammal.
 - More Calories than a bird, but fewer than a mammal.
- 23) Fossil fuels are
- The remains of plants that lived millions of years ago.
 - Fuels that were used by humans thousands of years ago.
 - Of little use to humans.
 - None of the above.
- 24) Which of the following are fossil fuels?
- Oil.
 - Coal.
 - Gas.
 - All of the above.

- 25) Fossil fuels
- a. Will be around forever.
 - b. Will run out some day.
 - c. Do not harm the environment.
 - d. Are not used in the United States.
- 26) Which of the following doesn't destroy natural habitats and harm wildlife?
- a. Mining.
 - b. Logging.
 - c. Hiking.
 - d. Cattle grazing.
- 27) To save energy, it makes sense to develop clean and renewable sources of energy such as
- a. Horse power.
 - b. Insulation.
 - c. Wind power.
 - d. Wood stoves.
- 28) The First Law of Energy states that
- a. Energy is always running out.
 - b. Energy can change form and be broken up, but it can never be destroyed.
 - c. Energy always flows from a cold object to a hot object.
 - d. Energy never changes form and can easily be destroyed.
- 29) The most important reason why humans today are using more energy than ever is because
- a. There is less energy to go around.
 - b. The human population is larger than ever.
 - c. Humans spend more time indoors than they used to.
 - d. None of the above.

- 30) Which of the following is the **least useful** way for a family to cut down on the amount of energy it uses.
- a. Drive less.
 - b. Use less heat indoors.
 - c. Become vegetarians.
 - d. Turn off lights when leaving a room.

Voyage From The Sun

Student Test: Correct Answers

1. d
2. b
3. a
4. b
5. c
6. d
7. a
8. b
9. d
10. a
11. a
12. d
13. c
14. c
15. d
16. b
17. a
18. a
19. c
20. d
21. b
22. c
23. a
24. d
25. b
26. c
27. c
28. b
29. b
30. c

Appendix F

Student Test Results

Comparison of Pretest and Posttest Scores

Grade	# of Classes	# of Students	Pre-Unit Test Mean Score	Post-Unit Test Mean Score	t	t Critical one-tail	Significant Difference? (p=.05)
4	4	112	15.1	19.6	-17.1	11.7	Yes
5	12	328	14.4	20.0	-22.9	11.6	Yes
6	4	104	11.4	16.0	-11.8	11.7	Yes
All Grades	20	544	13.9	19.1	-29.6	11.6	Yes