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ABSTRACT

A variety of in-class assignments are included in this guide designed to accompany SPACES, a series of six, half-hour television programs designed to introduce students in the fourth through eighth grades to people and careers in science and technology. Targeted toward Black, Hispanic, Asian, and Native American minority children, the series demonstrates how science and technology are inextricably tied to everyday life. Each individual chapter corresponds to a program in the series: Space, the Body, Computers, Ecology, Energy, and Communications. Each chapter contains the program objectives, a program synopsis, pre- and post-viewing activities for students, subject background information for teachers, and a resource list of books and visual aids. Student viewing sheets, student activity sheets, and teacher directions for activities for each program are appended. (LMM)

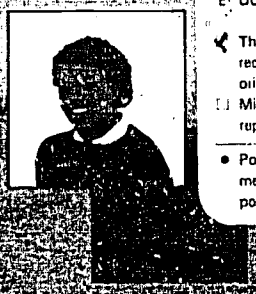
SPACES

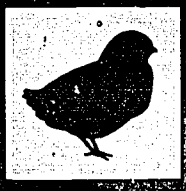
A Teacher's Guide

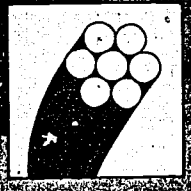
SPACES is a series of six 30-minute television programs introducing young people ages 9 - 13 to people and careers in science and technology.

It was produced for [illegible] by WETA, Washington, D.C. in association with InterAmerica Research Associates.

Funds were provided by the U.S. Department of Education Office of Educational Research and Improvement with additional support from the Alcoa Foundation.







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A Teacher's Guide to

SPACES

"Every inch of space is a miracle"
Walt Whitman
Leaves of Grass

Science fills the SPACES of our lives,
from the vastness of outer space to
the mysteries of inner space

dedicated to the
ACES of our
ren's futures.

2 Acknowledgements

The SPACES series and teacher's guide represent the efforts of adults and children who offered their advice and assistance during the development of the project. We are particularly grateful to the following individuals and groups:

The SPACES Advisory Board.

The scientists and students who gave freely of their time to participate in the SPACES programs.

The 700 children and their teachers who participated in the pilot testing and evaluation of the series. In Chelsea, Massachusetts—Shurtleff Elementary, Williams Junior High. In Oakland, California—Hawthorne Elementary, Lincoln Elementary, Westlake Junior High. In Penablanca, New Mexico—Cochiti Elementary. In Washington, D.C.—Fletcher-Johnson School, Oyster Elementary, and Hine Junior High.

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The SPACES series and this publication were developed in accordance with contract #300810309 with the U.S. Department of Education, Office of Educational Research and Improvement, Office of Libraries and Learning Technology. It is the intention of the Department of Education that these materials be used in as many classrooms as possible. They may be reproduced according to local needs.

May 1983

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Table of Contents

Introduction to the Series 4

Program One: Space 6
- Synopsis 6
- Objectives 6
- Suggested Activities 6
- Background Notes 8
- Research List 9

Program Two: The Body 10
- Synopsis 10
- Objectives 10
- Activities 10
- Background Notes 11
- Resource List 13

Program Three: Computers 14
- Synopsis 14
- Objectives 14
- Activities 14
- Background Notes 15
- Resource List 17

Program Four: Ecology 18
- Synopsis 18
- Objectives 18
- Activities 18
- Background Notes 20
- Resource List 21

Program Five: Energy 22
- Synopsis 22
- Objectives 22
- Activities 22
- Background notes 24
- Resource List 25

Program Six: Communications 26
- Synopsis 26
- Objectives 26
- Activities 26
- Background Notes 27
- Resource List 29

Career Index 31

Appendix 45

Introduction to the Series

SPACES is a series of six, 30-minute television programs introducing students to people and careers in science and technology. The programs, SPACE, THE BODY, COMPUTERS, ECOLOGY, ENERGY, and COMMUNICATIONS, are designed for students in the fourth through eighth grades. Each program features successful Asian, Black, Hispanic, or Native American scientists, engineers, and students.

The programs, together with this guide, give educators a tool with which to encourage children, especially minority children, to pursue careers in science and technology.

The SPACES programs present men and women who are in astronaut training and extracting DNA from cells; adults at the peak of their achievements and a young woman who is starting her first job as an industrial engineer; high school students planning to send ants into space; and the high technology world of communication satellites and computers.

In SPACES, minority women and men are presented in a television magazine format that combines mini-documentaries of their lives with science information on their subject area. Each program has regular features.

ADULT PROFILES. Showing successful minority scientists in their work, home, and community environment.

STUDENT PROFILES. Introducing minority teenagers involved in science-related projects.

CONEXIONES or **CONNECTIONS.** Demonstrating how science is tied to everyday activities such as sports, dance, and the arts.

NAMEDROPPERS. Presenting the historical contributions of minority scientists.

MINDBLOWERS. Animated science facts and science futures to excite the imagination.

To the Teacher and Counselor:

This guide has been designed to assist you in integrating the SPACES series into your classroom. We hope the activities and ideas presented in it will serve as a springboard to classroom discussions and students' exploration of the many challenging and different careers in science and technology. While the series is targeted to minority children, the programs and classroom exercises can be effective vehicles for science motivation in all children.

In recent years, many parents, teachers, scientists, engineers, and other concerned citizens have become increasingly disturbed by the small number of minority students expressing an interest, and subsequently preparing for careers, in science and technology. This limited interest and participation can be traced to a number of factors, including language difficulties, lack of minority role models, poor math and science backgrounds, fear of failure, inadequate counseling, and lack of advocacy within many schools and communities.

The SPACES series provides role models and information about the contributions of minorities to science and technology. It is hoped that after viewing the six programs in the series, and performing the classroom exercises in this guide, a student will be able to:

1. Recognize that there has been in the past, and will be in the future, a growing need for minority representation in sciences and technology.
2. Develop strategies to overcome barriers to advancement in science and mathematics during school years.
3. Recognize science as an activity relevant to everyday life and the immediate community.
4. Discuss qualities which mark a scientist as logical, careful thinking and reflective, interested in problem-solving, and having a sense of discovery and wonder.
5. Recognize that some science and technology careers require graduate-level study, and that many others are available to individuals with associate (two year) or bachelor degrees.
6. Plan a high school program which facilitates entry into science and technology careers (7th and 8th grade students).
7. Judge his/her own interests, abilities, and dispositions with respect to science, mathematics, and technology.
8. Propose science activities related to, but not necessarily demonstrated in, the SPACES programs.

The SPACES series is replete with opportunities for student discussions of obstacles which confront minority students seeking a career in science and technology. We suggest that you make such discussions an on-going part of your classroom instruction.

Using Your Guide

The SPACES guide is divided into chapters which correspond to each program in the series: SPACE, THE BODY, COMPUTERS, ECOLOGY, ENERGY, and COMMUNICATIONS. Each chapter contains the program objectives, a program synopsis, pre- and post-viewing activities for students, subject background information for teachers, and a resource list of books and audiovisual aids. Student Viewing Sheets, Student Activity Sheets, and teacher directions for activities for each program are in the Appendix. The chapters are in order of the intended viewing; however, each program stands alone and may be placed in any order that is convenient for you.

Begin by reviewing the information in the chapter. Try to screen the program before your class. If you are not able to view the program in advance, the synopsis will brief you on the information that you and your students will see in the program. You may wish to use the suggested classroom previewing activities or create activities specifically targeted to your class.

Each chapter contains a variety of in-class assignments, often more than can be accomplished in a class period. Select activities which best meet your classroom needs.

Before presenting a lesson, check the before viewing and after viewing sections. Special materials, worksheets, or additional class time may be needed for some exercises.

Duplicate and distribute the student viewing sheet. Student viewing sheets should be completed at the end of each show. If students will be viewing some shows at home, they may need to be reminded at the end of the class session to complete the student viewing sheet.

SUGGESTIONS

1. Have each student keep a Careers Folder or notebook in which may be kept all information relating to careers in general, and those specifically in science and technology. Suggested items which may be included in this folder are completed viewing sheets from each of the SPACES programs, all other SPACES assignments, news articles relating to science and technology, and any plans the student might have regarding future course selections in junior and senior high schools.

2. Establish a Career Center within the classroom and designate it as the area in which all on-going activities will take place. You may want to create a science and technology bulletin board within the Career Center, displaying relevant career information. The career index of this guide will be an excellent support for career center activities. Having this information prominently displayed will enable students to refer to it when completing several of the activities suggested in this guide.

Your Career Center should also include a dictionary; career books on loan from local libraries; pamphlets, brochures and other resource materials sent from professional associations and organizations; pictures; and the employment section from various newspapers.

3. You will certainly want to explore your local associations and organizations for minority specialists. Generate a list of potential guest speakers. Your list will be continuously growing as you add the names of new resource persons and helpful contacts.

Your lessons for the SPACES programs will be greatly enhanced by a local speaker from the career area presented in each program. Students may review the suggested interview questions presented in the Appendix, page 46, expanding or modifying each as appropriate.

An invaluable resource often close at hand is the parent. Including parents in the students' learning experiences can often be mutually rewarding. Encourage parents to watch the SPACES series with their children as well as to participate in other science-related activities. Parents may encourage scientific attitudes by taking field trips with their children and exploring parks, zoos, museums, science centers; encouraging their children to explore on their own and to try different activities at home; providing their children with the space to explore and "mess around."

Program One: Space

Synopsis

PROFILES: In this program, students are introduced to Dr. Patricia Cowings, a Black psychophysiologist, and Dr. Franklin Chang, an Hispanic astronaut.

Dr. Patricia Cowings is a psychophysiologist at the Ames Research Center in Moffitt Field, California. Working in the Biomedical Research Division, Dr. Cowings studies the relationship between the mind and the body, what we think and how well we feel. Dr. Cowings specializes in motion sickness, conducting tests that produce symptoms similar to those observed in space motion sickness. She also trains human subjects to voluntarily control their symptoms of nausea and dizziness through biofeedback techniques. Dr. Cowings hopes this research will lead to the prevention of space motion sickness sometimes suffered by space travelers.

Dr. Cowings received a Ph.D. in psychology from the University of California at Davis in 1973. She works with her husband, who is also a psychologist.

Dr. Franklin Chang is an astronaut at the Lyndon B. Johnson Space Center in Houston, Texas. He is a mission specialist who will one day be the in-flight scientist aboard a space shuttle mission. In his two year training to become an astronaut, Dr. Chang learned about the mechanical systems of the shuttle spacecraft, and was trained to fly, navigate, and dock the spacecraft through simulations.

Dr. Chang received a Ph.D. in applied plasma physics from the Massachusetts Institute of Technology in 1977. He continues his research in applied plasma physics and fusion technology at NASA, trying to develop a means for high speed space travel.

Dr. Chang grew up in Costa Rica, and lists as his hobbies swimming, gliding, and playing the guitar.

STUDENT PROFILES: The Student Profiles feature high school students from Camden, New Jersey who worked together to design and build an experiment that will be carried on a space shuttle flight. The experiment tests the effects of weightlessness on an ant colony.

CONEXIONES: Artistic interpretations of space and space travel are seen through the work of children, ages nine to thirteen.

NAMEDROPPERS: The contributions of the Anasazi Indians in developing a solar calendar are explored.

MINDBLOWERS: Orbiting communities in space, called SPACEHABS, that will house future space workers and scientists, are seen in this animated segment.

Objectives:

1. To identify at least three aerospace-related careers.
2. To describe one problem which aerospace scientists and engineers are trying to solve.

Suggested Activities:

Before Viewing

1. Ask students what they remember about the most recent space mission.

   A space shuttle test mission, "space walk" or SPACELAB launching.

What was the purpose of the mission? What problems were encountered? What kinds of jobs were involved? List the jobs on the board. The list can be expanded during the post-viewing discussions.

2. Inform the students about the SPACES television series. Distribute copies of the Student Viewing Sheet for the Space show, Appendix, page 47. If the Space show is to be viewed at home, have students fill in the viewing date, time, and channel in advance.

After Viewing

1. DISCUSS the persons and careers profiled in the show. (See Synopsis, Background Notes, and the Career Index Table of Contents, page 31). Students should refer to their viewing sheet notes for this discussion. The discussion should bring out the educational requirements and problems encountered by these minority professionals in pursuing their careers. See page 4.

2. "AEROSPACE JOB SEARCH"—(page 48). Copies of this word search puzzle can be distributed to students for classroom or home assignments. When completed, go over the list of careers hidden in the puzzle. (Refer to the Career Index, page 31.)

3. READ each of the following hypothetical problems to the class. Using their aerospace job search career list, students will select the most appropriate persons to solve each problem.

(a) A shuttle astronaut is showing symptoms of space sickness: dizziness and nausea. Who can suggest remedies?

Physician, psychologist, biomedical engineer

(b) An orbiting space telescope is sending back new information about hot young stars in a distant galaxy. Who will explain or interpret this information?

Astronomer, physicist

(c) A faster and longer lasting rocket must be designed for launching certain spacecraft. Who would be on a team to do the research and development?

Physicist, engineer, technologist, technician

(d) An experiment must be set up to find out how green plants react to the zero-gravity environment of space. Who should be consulted on this?

Biologist, perhaps an engineer to design the equipment

4. JOB ON A SPACE STATION (creative writing). The "Mindblowers" segment of this show describes Spacehab, a space station which will orbit thousands of miles above the earth's surface. Among its two human transient residents will be the command crew, medical staff, galley workers, scientists, technicians, engineers, and satellite assembly workers.

After a review of the film's coverage of Spacehab, present students with the following situation:

You have just graduated from college and have been offered a job on Spacehab. In two paragraphs, describe the job and tell how it will change your life. Use imagination!!

5. PLANETS, a cooperative logic problem. Much of NASA's unmanned space exploration has focused on our planetary neighbors in the solar system. Working in groups of 4 to 6, students will organize given information, utilize models and logical reasoning to arrange the nine planets of the solar system in order, based on their relative distance from the sun. See Appendix pages 63, 64 for directions and the Student Activity Sheet on PLANETS.

6. DESIGNING A SPACE SHUTTLE, paper airplane models.

(a) Read over the Student Activity Sheet found on page 68 of the Appendix. Students not familiar with the metric units may be given English substitutions for the NASA Requirements:

minimum wing span = 10 cm or 4 inches
maximum wing span = 15 cm or 6 inches
minimum length = 15 cm or 6 inches
maximum length = 30 cm or 12 inches

(b) If a balance is not available, eliminate the weight requirement, but have all teams start with identical sheets of paper.

(c) A "test site" should be designated and marked on the classroom floor with masking tape.

(d) Group students into teams of three, and issue name tags identifying career and role function. The teacher should wear the "NASA Representative" identification tag.

(e) The teacher should stress the role of each designated individual in the groups.

- Aerospace Engineer—Designs the model(s) within the requirements and corrects any problems found in the model(s).
- Aeronautical Technician—Aids the engineer with construction of the model and tests the model to see if it meets all the requirements.
- Quality Control Inspector—Makes sure the model(s) meet all the requirements through ongoing and final inspections of the model before it is presented to the NASA Representative.

(f) Students should be given a "free hand" with the design and encouraged to experiment. The only criterion is that the students stay within the specified requirements of the project.

7. AEROSPACE CAREER INFORMATION. A student committee can write a letter to the Educational Programs Officer at the NASA Center serving your state.

NASA Ames Research Center
Moffett Field, CA 94035
Serving: Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming

NASA Goddard Space Flight Center
Greenbelt, MD 20771
Serving: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont

NASA Johnson Space Center
Houston, TX 77058
Serving: Colorado, Kansas, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, and Texas

NASA Kennedy Space Center
Kennedy Space Center, FL 32809
Serving: Florida, Georgia, Puerto Rico, and the Virgin Islands

NASA Langley Research Center
Hampton, VA 23665
Serving: Kentucky, North Carolina, South Carolina, Virginia, and West Virginia

NASA Lewis Research Center
2100 Brookpark Road, Cleveland, OH 44135
Serving: Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin

NASA Marshall Space Flight Center
Marshall Space Flight Center, AL 35812
Serving: Alabama, Arkansas, Iowa, Louisiana, Mississippi, Missouri, and Tennessee

Background Notes

Both aerospace scientists, Dr. Patricia Cowings and Dr. Franklin Chang, spotlighted in the Space Show, are employed by the National Aeronautics and Space Administration (NASA). The term aerospace (aeronautics and space) embraces activities related to flight within and beyond the earth's atmosphere. Because of the breadth and complexities of NASA's programs, the work is divided among the thirteen subgroups which comprise NASA's Aerospace Technology System. The research and development tasks of each subgroup are performed by teams of scientists, engineers, technicians, and support staff assigned to that subgroup. Dr. Chang's laboratory work with nuclear fusion fuels for rockets is a function of the Propulsion Systems Subgroup. Dr. Cowings, on the other hand, is a psychophysiologist whose research activities in zero-gravity sickness syndrome and biofeedback are a function of the Biomedical Research Program, a division of NASA's Life Sciences Subgroup.

A project such as the development of the Space Shuttle and its support systems required the interaction of NASA subgroups and private industry. Hundreds of aerospace-related occupations were involved in the successful completion of this project. Extensive feasibility studies and experiments were conducted; designs were submitted by aerospace engineers; scale models were constructed and tested by engineers and technicians in facilities such as wind tunnels which simulate the actual environmental conditions in which the shuttle would operate; full-sized experimental models were developed, tested, and modified before the final production of this reusable space transport vehicle.

Astronauts and Their Training

Most shuttle astronauts are not pilots, but professional scientist-physicists like Dr. Chang, biologists, geologists, astronomers, etc. The "scientist-astronaut" is called the mission specialist and he or she is responsible for seeing that the scientific objectives of the flight are met. Other members of a basic flight crew are: 1) the commander, a trained pilot whose responsibilities include flight execution and general crew safety; 2) the pilot who assists the commander; and often 3) a physician or biomedical engineer who serves as a payload specialist.

The payload consists of equipment and experimental activities related directly to the purpose of that particular space mission, as opposed to equipment essential for all spacecraft operations. Commercial organizations interested in having satellites launched or conducting experiments requiring a space environment are now able to purchase space in a spacecraft's cargo bay. The cannister containing the ant colony experiment of Camden high school students is an example of shuttle payload, and the purchase of space by RCA Laboratories.

Every astronaut, whether qualified to fly a specific spacecraft or not, is required to undergo a technical training program which includes:

(a) Several four-hour sessions in the Shuttle Mission Simulator, a model cockpit situated on a moving platform less than 25 feet (7.6 meters) above the ground. Computer-generated images of real-life scenes pass by the windows of this rolling cockpit. Ship to ground communications, as in the real shuttle, are maintained by the five built-in computers with their CRTs (screens).

The computer programming for this machine enables it to simulate the shuttle launching, moving away from earth, separating from its boosters, cruising, and landing.

The computer programmers "on the ground" can, at any point in the flight, interject changes which force the trainee to handle crises such as unexpected turbulence, cabin pressure changes, or cockpit computer malfunctions.

(b) Half-hour sessions in a space shuttle model which is submerged in a 25 foot (7.6 meters) tank of water.

(c) Assigned periods in the "Weightless Environment" training tank, and in a water tank which simulates zero-gravity.

(d) A ride on a KC-135 transport jet which, after traveling straight up for 35,000 feet (10,675 meters), suddenly plunges downward for thousands of feet. This parabolic flight ride creates the motion sickness type symptoms associated with weightlessness and has earned the nickname "vomit comet" for the jet. This experience was designed to help NASA physicians determine the appropriate amount of medication for each astronaut in preparation for launching.

Weightlessness

Physicians or biomedical engineers have been added to shuttle crews to gather additional data on the body system (physiological) changes associated with weightlessness. In prolonged periods of weightlessness almost half of the astronauts on previous shuttle missions have experienced some symptoms of zero-gravity sickness syndrome or space adaptation syndrome: vomiting, dizziness, nausea, and malaise. The launching of the spacecraft abruptly separates the astronaut from his or her natural earth environment and its gravitational field. Because of the earth's great mass, it has a tendency to pull on all bodies and all matter located in, on, or near it. (This includes the moon 240,000 miles or 384,000 km away).

Weight, simply put, is the amount of force being exerted on an object by a planet's gravity. A person's weight is directly related to the mass of the planet on which he or she is located. The greater the planetary mass, the greater the gravitational force, and that means greater weight. A 120 pound (54 kg) astronaut from earth will weigh less than 20 pounds (9 kg) on the moon because the moon's mass is 1/6 the mass of the earth. When the astronaut moves away from a planet, its gravitational pull on her mass (the amount of material making up her body) diminishes to the point where no gravitational force is present, and therefore, she has no apparent weight. This is designated as zero gravity (0 g) in contrast to the designation of 1 g on the earth's surface.

Dr. Cowings is engaged in research to identify those zero gravity induced body system changes which can be altered, or possibly avoided, by self regulation. Her computerized laboratory equipment includes eight digital meters which permit her to monitor a subject's involuntary or autonomic body activities (e.g., heartbeat, bloodflow, breathing, muscular activity, etc.). The subject is taught techniques for controlling breathing and other autonomic functions. Successful application of this biofeedback technique would reduce considerably the discomfort of the astronauts and would increase the efficiency of mission operations.

Resource List

CURRENT PUBLICATIONS:

HEAVENS ABOVE! A BEGINNER'S GUIDE TO OUR UNIVERSE by Heather Couper and Terence Murtagh. (Illus.) NY: Franklin Watts, 1981. 64pp. $8.90. (Grades 5-12, Teacher.)

THE PLANETS: EXPLORING THE SOLAR SYSTEM by Roy A. Gallant. (Illus.) NY: Four Winds, 1982. 176pp. $12.95. (Grades 6-12.)

SPACESHIP EARTH by Adam Ford. NY: Lothrop, 1981. 41pp. $11.95. (Grades 5-12.)

STARS: DECODING THEIR MESSAGES by Irving Adler. NY: Crowell, 1980. (Illus.) 152pp. $7.95. (Grades 5-8).

THE HISTORY OF MANNED SPACE FLIGHT by David Baker. (Illus.) NY: Crown, 1982. 544pp. $35.00. (Grades 7-12, Teacher.)

SPACE COLONY: FRONTIER OF THE 21ST CENTURY by Franklyn M. Branley. (Illus.) NY: Elseview/Nelson, 1982. 103pp. $10.95. (Grades 5 & up, Teacher.)

THE SPACE SHUTTLE by George S. Fichter. (Illus.: A First Hand Book.) NY: Watts, 1981. 65pp. $7.40. (Grades 5-12.)

VOYAGER: THE STORY OF A SPACE MISSION by Margaret Poynter and Arthur L. Lane. (Illus.) NY: Atheneum, 1981. 152pp. $9.95. (Grades 4-8.)

ACTIVITIES/CAREERS:

AVIATION/SPACE CAREERS lists materials from professional, government, industry, and commercial sources. $5.00 per copy. Write: American Society for Aerospace Education, 1750 Pennsylvania Avenue, NW, Suite 1303, Washington, DC 20006.

DRAWING SPACESHIPS AND OTHER SPACECRAFT by Don Bolognese. (Illus.) NY: Watts, 1982. 61pp. $8.90. (Grades 4-8.)

THE SPACE SHUTTLE OPERATOR'S MANUAL by Kerry Mark Joels and Gregory P. Kennedy. (Designed by David Larkin.) NY: Ballantine, 1982. 160pp. $22.50; $9.95 (paper). (Grades 7-12.)

PEOPLE:

BENJAMIN BANNEKER, GENIUS OF EARLY AMERICA by Lillie Patterson. (Illus. by David S. Brown.) Nashville: Abingdon, 1978. 142pp. $6.95. (Grades 3-7.)

SKYWATCHERS OF THE PAST by Malcolm E. Weiss. (Illus. by Eliza McFadden.) Boston: Houghton Mifflin, 1982. 84pp. (Grades 5-8.)

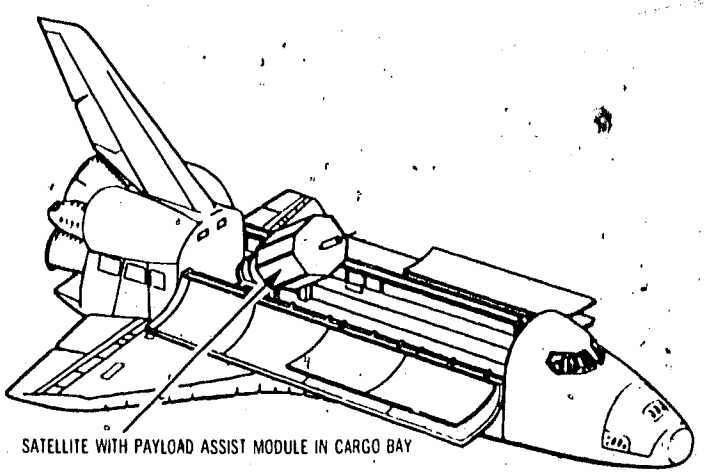
FILMS:

REFLECTING ON THE MOON. Well-illustrated introduction to how the features of the moon are studied. 15 minutes. 1982. $20 rental with accompanying teacher's guide. Write: National Geographic Society, Educational Services, 17th and M Streets, NW, Washington, DC 20036. (Grades 4-8.)

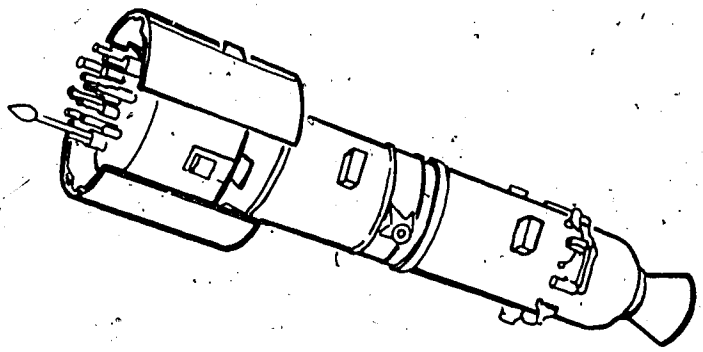
SPACE FOR WOMEN. Interviews seven outstanding NASA women about their careers. 27 and 1/2 minutes. 1981. Free loan from NASA. For additional information on NASA film(s) write: NASA Headquarters, Publications Office, CODE: LFC-9, Washington, DC 20546.

THE VOYAGE OF S.S. COLUMBIA: JUST SHORT OF A MIRACLE. Reviews the premiere flight of the space shuttle Columbia. 22 minutes. 1981. $70 rental. Write: MTI Teleprograms, Inc., 3710 Commercial Avenue, North Brook, IL 60062.

WHERE DREAMS COME TRUE. A look at career opportunities within NASA for minorities and women. 28 minutes. 1979. Free loan from NASA. For additional information on NASA film(s) write: NASA Headquarters, Publications Office, CODE: LFC-9, Washington, DC 20546.



SATELLITE WITH PAYLOAD ASSIST MODULE IN CARGO BAY



Program Two: The Body

Synopsis

PROFILES: In this program, students are introduced to Dr. Lidia Villa-Kamaroff, a Mexican American molecular biologist, and Dr. Allen Counter, a Black neurobiologist.

Dr. Villa-Kamaroff is a molecular biologist and a faculty member at the University of Massachusetts medical school. She grew up in Santa Fe, New Mexico, and received her Ph.D. in cell biology from the Massachusetts Institute of Technology.

As a molecular biologist, Dr. Villa-Kamaroff researches the structure and function of genes and studies how genes determine such characteristics as the color of hair, eye color, and height. In this program, Dr. Villa-Kamaroff demonstrates to a group of students how to extract DNA from a cell.

Dr. Allen Counter is a research neurobiologist at Harvard University in Cambridge, Massachusetts. His special area of interest is the brain and how it controls our ability to hear, see, taste, and smell. Through his work, Dr. Counter tries to understand why some people can hear and others are not able to hear. He examines the hearing mechanisms of many animals and humans in his experiments, including in this program, a cricket, a chicken, and a child.

Dr. Counter received his Ph.D. from Case Western Reserve University in biological science. He spends some of his summers in South America where he lives with a tribe who emigrated from Africa to settle near the Amazon River many years ago.

STUDENT PROFILE: Jeannie Lo, a student at Stuyvesant High School in New York City and winner in the Westinghouse Science Talent Search, is featured. Jeannie explains her project in protein chemistry, which tests whether antigens will seek out proteins they normally bond with if the proteins are in an altered state.

CONEXIONES: An animated approach to the link between the mind and body as parcticed by masters and students of the martial arts.

NAMEDROPPERS: The achievements of Hideyo Noguchi, a Japanese immigrant who discovered the parasite that causes yellow fever, are described in this program.

MINDBLOWERS: This animated segment shows the medical advances that are possible using polymers to imitate living tissue. Polymers may someday be used to create artificial muscles and skin.

Objectives

1. To distinguish between careers related to the practice of medicine and careers related to biomedical research.
2. To describe at least four careers involved in the understanding and care of the human body.

Activities

Before Viewing

*1. Contact a local physician, preferably a minority person. Invite him or her to visit your class to talk with students about his or her training and work. Prepare students by announcing the upcoming SPACES program on the body. Have students draft a list of good interview questions. Refer to Appendix, page 46. Ask the physician to include in the classroom presentation a discussion of the role of medical research in the physician's work with patients.

2. Distribute copies of the student viewing sheet for The Body Show. Have students fill in the correct viewing date, time, and channel.

*This contact should be made well in advance of the desired visit date.

After Viewing

1. (a) DISCUSS the featured medical and biomedical research scientists, Dr. S. Allen Counter, the neurobiologist, and Dr. Lydia Villa-Kamaroff, the molecular biologist. The class should use the viewing sheet notes to help identify the scientific problems these two scientists and the student, Jeannie Lo, are trying to solve. Point out that Dr. Counter uses the inner ear of birds as a model to help him better understand the human hearing system. Much biomedical lab research relies on animals as models. See notes on scientific model building, page 24.

(b) What personal difficulties might these three scientists have encountered in pursuing their work? See discussion of common obstacles faced by minorities on page 4.

2. WHO "WORKS ON" THE HUMAN BODY? (page 50)

(a) Distribute copies of this worksheet which can be done as a class or home assignment. Read the introductory information with the class. If a Career Learning Center has been set up in the classroom, students can work in groups, using resources such as dictionaries, encyclopedias, pamphlets, career books on library loan, and copies of appropriate pages from the Career Index.

(b) Discussion—On the chalkboard make two columns, one headed *Biomedical and Medical Research Careers,* the other *Health Care Careers.* Have students contribute from their completed worksheets to fill in careers for each column.

(c) Assist the class in making a tally of the four careers most frequently named in each of the two career circles.

3. VISIT A HOSPITAL LABORATORY and/or UNIVERSITY BIOMEDICAL RESEARCH LABORATORY. This field trip requires prior arrangements, and many facilities are cooperative if you inform them a) of the purpose of the SPACES series, b) that the students have indicated interest in specific careers related to that facility (from worksheet tally), and c) that the students have a respect for the purpose of the facility. Each student may prepare for the trip by writing a question on an index card to carry along. This can be used for note-taking during the visit. Encourage questions about the jobs they will see being performed, education and training required, and equipment being used. Follow up the trip with a general discussion of what was learned and how it all relates to the human body.

4. THE HUMAN INNER EAR and SENSE OF BALANCE (related to the neurobiologist's work). The inner ear contains tiny, curved, liquid filled tubes called semicircular canals. Body movement causes the liquid to move and this is communicated to the brain by nerves which are located in these tubes. The brain then sends messages, by nerves, to the appropriate muscles, resulting in bodily adjustments to restore balance. Spinning stirs up the inner ear's liquid causing it to send messages faster than the brain can process them.

(a) Pair students. Taking turns, have one student stand on one foot, with eyes closed, while the other student observes all movements made to correct or reestablish balance.

(b) Place a blindfolded student on a stool with a revolving seat. Spin him or her in a clockwise direction. Stop the motion and ask him or her to immediately point to the direction in which he or she was spinning. (Student will probably point in the opposite direction.)

5. PROTEIN (life building substance being studied by Jeannie Lo, molecular biologists, and biochemists). Instructions for this activity may be written on the chalkboard and students may do the activity at home. Students can observe the protein material in egg white. Place about 5 cc or 4 teaspoons of egg white in a clear glass or a graduated cylinder. Shine a flashlight through the egg white, describe what you see. Students should see tiny particles, like dust, held in suspension.

6. THIS IS YOUR LIFELINE. Each student will make a plan for his or her life and then graph it on a timeline. See Appendix pages 69-70 for direction and student instructions sheet.

7. COMMITTEES OF STUDENTS may be appointed to contact several of the following local resources for additional information and/or to arrange interviews: high school biology teachers, local college biology departments, a medical school, county medical society, Red Cross Blood Bank, Public Health Department, clinic, medical laboratory, dentist, pharmacist, visiting nurses association. Your local yellow pages can be helpful for this activity.

Background Notes

Neurobiologists like Dr. Allen Counter, who was profiled in this show, focus their research activities on some aspect of the development and function of the nervous system. They may choose to investigate at the molecular level; the cellular, multicellular or systems level; or the total behavior level. At each level, each of these scientists is trying to contribute information on some basic questions: What molecular activity is involved in the formation and development of nerve cells? How do nerve cells behave? How do nerve networks store and retrieve information? What is the genetic involvement in the acquisition (learning) and retention (memory) of new information? What kinds of cellular changes are involved in learning? The work of neurobiologists, neurochemists, psychologists, and others is intensifying the quest for an understanding of this complex coordinating system that enables the human being to adapt to changes in the environment. The brain, nerves, sense organs, and spinal cord are vital components in the reception and transmission of and adaptation to environmental stimulation.

Much of the current investigative work has evolved from discoveries about the electro-chemical nature of the basic functional unit of the nervous system—the neuron or nerve cell. Humans have several billion of these distinctive message carriers, comprising the peripheral nervous system, and linking all parts of the body to the spinal cord and brain, the body's central nervous system. A typical neuron consists of a cell body and one or more processes extending from it. The longest extending process, a single axon, ranges from .04 inches to many feet in length. The shorter branched processes are called dendrites. An axon transmits an impulse to the dendrite, or cell body of another neuron, to glands, or to muscles. Dendrites receive impulses from neighboring axons or the sense organs which have specialized nerve endings.

A commonly accepted theory of how nerves function involves the polarized (+, −) membrane which encases neurons and their extending fibers, axons, and dendrites. Outside this membrane are positively-charged chemical particles, called ions, and inside the membrane are negative ions. When an environmental stimulus initiates an impulse, the membrane allows certain positively charged ions to enter, temporarily depolarizing the membrane. Membrane polarization returns immediately with the flow of certain other positive ions from inside to out. This impulse, now traveling as an electric current, continues through the nerve cell body and on through the extending axon fiber to a synaptic gap. Here the fiberous tips of the axon are very close to, but not touching, a neighboring dentrite or cell body. The membrane around the axon tip converts the electric signals into chemical neurotransmitters which move through the axon membrane and into the synaptic space. There, the membrane of the receiving dendrite or cell body is stimulated to convert the chemical message back into electric signals for passage through the nerve cell body. It may require several synaptic crossings before a message reaches the spinal cord and brain. This sequence, bearing different signals, is repeated as messages are directed from the brain and spinal cord to muscles and glands.

At present, much significant research, related to neuron activity at the synaptic juncture, is underway. Of high interest are the fluid-filled synaptic spaces between the billions of neurons in the brain. Over forty neurotransmitters have been identified so far, and scientists speculate that there are hundreds more. Irregularities in the chemical composition of the neurotransmitters are now being linked to memory loss, anxiety, intelligence deficiencies, depressive moods, schizophrenia, and other forms of mental illness. The expanding field of psychopharmacology is a response to the need for safe, effective therapeutic mind drugs.

Genetic Engineering

The human body, and in particular the living cell, also holds fascination for the molecular biologists and the geneticists. Dr. Villa-Kamaroff is a molecular biologist studying the composition of genes and how they work in the human body ro determine a person's hair and eye color, height, etc.

The cell, the microscopic, basic unit of structure of all living organisms, can duplicate itself by: a) sexual means in which nuclear material is contributed by two parents, resulting in new cells with hereditary material from both parent cells or b) asexual means involving only one parent, resulting in new cells which are identical to the parent's cell genetically. In either case, a new organism can grow from the resulting cells, assuming a conducive environment.

In the nucleus of each cell are tiny thread-like structures, chromosomes, on which are located the genes. Genes, the structures carrying heredity information, are composed of a complex molecule, deoxyribonucleic acid, DNA for short. This DNA molecule consists of groups of atoms such as phosphates, sugars, and the four nitrogen bases, gadenine, thymine, cytosine, and guanine arranged in a manner similar to that of two twisted threads, a double helix. The DNA composition of every cell in a particular organism's body is identical. For cell division DNA strands split lengthwise down the twisted thread-like molecule, resulting in the formation of two identical strands for every original one. Each new cell then bears a copy of the original DNA, or genetic, material. Since this DNA material carries in it the heredity information from the parent, continuity of a particular species is insured.

DNA also carries the instructional program for every cell in the organism's body. This information tells each cell what its specialization is, and what kinds of materials it must manufacture to enable it to meet its specific function. DNA sends this information out of the cell's nucleus and into the cell's ribosomes where protein manufacturing is done. The messenger carrying this vital information is another nucleic acid, ribonucleic acid or RNA. Its molecular structure is similar to that of DNA except that in RNA, one of the four nitrogen bases has been replaced by uridine.

Through observation and experimentation with viruses and bacteria, biochemists learned that when viruses invade bacteria, DNA material can be exchanged between these two very different species of organisms. Viruses are the simplest of living organisms, neither plant nor animal, consisting of a DNA or RNA molecule in a protein covering. They are obligate parasites since they cannot reproduce outside a living cell. Subsequent experiments led to the development of techniques for combining DNA material from one species with the DNA of another species, thereby creating a new organism with a unique genetic structure, quite unlike its parents. Molecular biologists are using a tiny bacterium commonly found in the human intestine, *E. coli* or *Escherichia coli*, for their experiments with new combinations of DNA. DNA material from animals, plants, or other bacteria can be introduced into the plasmid, a part of the *E. coli* bacterium cell. Geneticists hope to use this technique, RECOMBINANT DNA, gene splicing, to determine the exact location and function of each human gene. Some birth defects might well be averted someday by knowledge of the exact location of the responsible gene.

RECOMBINANT DNA experiments have generated heated debates over the whole issue of genetic engineering because scientists cannot accurately predict the behavior of the newly created organism. Many molecular biologists, however, feel that if approached with caution and effective safety procedures, this rapidly expanding field will be extremely beneficial to humans. Although gene splicing is a relatively new field, the possibilities for problem solving using *E. coli* bacterium with an appropriate bit of DNA introduced into it, seem vast. *E. coli* can now be spliced to produce a bacterium that consumes petroleum in marine life-threatening oil spills. Interferon, insulin, and growth hormones for humans are all being produced through recombinant DNA technology.

Body Resource List

CURRENT PUBLICATIONS:

THE BRAIN AND NERVOUS SYSTEM by Brian R. Ward. (Illus.) NY: Watts, 1981. 48pp. $7.90. (Grades 5-12.)

THE BRAIN: MAGNIFICENT MIND MACHINE by Margery and Howard Facklam. (Illus. by Paul Facklam.) NY: Harcourt, 1982. 118pp. (Grades 7 & up.)

THE HUMAN BODY by Ruth Dowling Bruun and Bertel Bruun. (Illus. by Patricia J. Wynne.) NY: Random House, 1982. 96pp. (Grades 4-8.)

THE LAST 100 YEARS: MEDICINE by Daniel Cohen. (Illus.) NY: Evans, 1981. 192pp. $8.95. (Grades 6 & up.)

THE STORY OF YOUR EAR by Alvin and Virginia B. Silverstein. (Illus. by Susan Gaber.) NY: Coward, 1981. 64pp. $6.99. (Grades 5 & up.)

TEST-TUBE MYSTERIES by Gail Kay Haines. (Illus.) NY: Dodd, 1982. 175pp. (Grades 6 & up.)

YOUR IMMUNE SYSTEM by Alan E. Nourse. (Illus.) NY: Watts, 1982. 66pp. $7.90. (Grades 5-8.)

THE WORLD OF BIONICS by Alvin and Virginia Silverstein. NY: Metheun, 1979. $7.95.

CAREERS:

CAREERS IN MEDICINE FOR THE NEW WOMAN by Carol Jochnowetz. NY: Watts, 1978. (Grades 5-9.)

MEDICINE: THE CAREER FOR ME? A free service bulletin. $.20 per copy for orders of more than three. Enclose self-addressed, stamped envelope. Write: Dept. MED, Office of University Communications, University of Rochester, Rochester, NY 14627.

THE PHYSICIAN'S ASSOCIATE: A NEW CAREER IN HEALTH CARE by Ann Cavallaro. Nashville: Thomas Nelson, 1978. 160pp. $6.95. (Teacher.)

YOUR CAREER IN THE DRUG INDUSTRY AND IN PHARMACY by David Graulich. NY: Arco, 1982. $6.95. (Grades 7 & up.)

PEOPLE:

HOMEWARD THE ARROW'S FLIGHT by Marion March Brown. Nashville: Abingdon, 1980. $7.95. (Grades 7 & up.)

SURE HANDS, STRONG HEART: THE LIFE OF DANIEL HALE WILLIAMS. (Illus. by David Scott Brown.) Nashville: Abingdon, 1981. 159pp. $7.95. (Grades 7-12.)

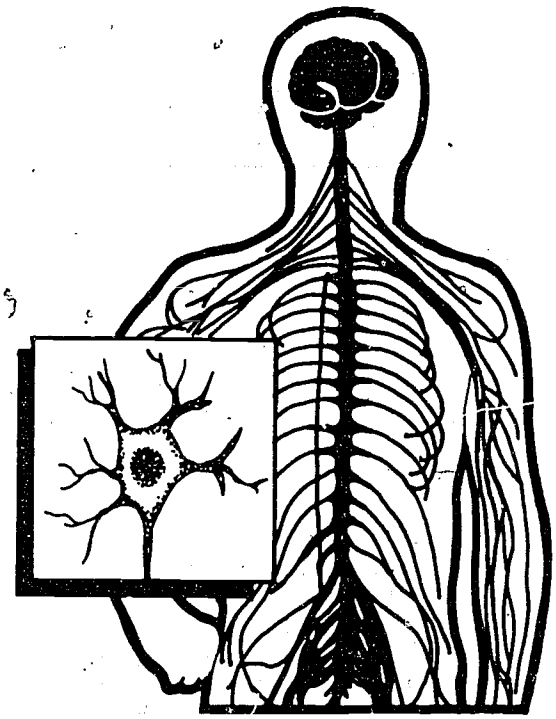
TRAILBLAZER: FIRST NEGRO NURSE IN THE AMERICAN RED CROSS by Jean Pitrone. NY: Harcourt, 1969. (Grades 6 & up.)

FILMS:

EARS: HAVE YOU HEARD THE LATEST? A short film on the anatomy and function of the ear. 10½ minutes. 1981. $23.50 rental. Write: Centron Films, 1621 W. 9th Street, Lawrence, KS 66044. (Grades 7 & up.)

LESS STRESS: An introduction to the causes and effects of stress. 14 minutes. $13 rental. Write: Boston University School of Education, Film Library, 565 Commonwealth Avenue, Boston, MA 02215. (Grades 3-8.)

MITOSIS. 2nd ed. Cell growth, maintenance, duplication, division and cloning are illustrated through animation and time-lapse photography. 14 minutes. 1980. $16 rental. Write: Encyclopedia Britannica Educational Corp., 425 N. Michigan Avenue, Chicago, IL 60611. (Grades 7 & up.)



Program Three: Computers

Synopsis

PROFILES: In this program, students are introduced to Nancy Wallace, a Native American industrial engineer, and Lee Ray, a Korean American computer specialist.

Nancy Wallace is beginning her career as an industrial engineer at Digital Electronics in Phoenix, Arizona. At 24, she is the youngest professional featured in the series. Her career as an industrial engineer is an example for students of one type of career that can be entered with a bachelor's degree. Ms. Wallace uses computers to solve materials handling problems within the company, including a computer-controlled carousel conveyance system to move materials and driverless vehicle robots. Ms. Wallace, who grew up on a farm in Oklahoma, is a descendant of the Creek and Comanche tribes. She received her BS in industrial engineering from the University of Oklahoma.

Lee Ray uses computers to create new sounds and to compose music. He is working at the Center for Music Experiment in San Diego, California. Mr. Ray uses the computer as a composing partner, writing programs that give a computer the parameters of how a composition should sound. In this program, we see and hear the process he follows in creating a composition.

Lee Ray is a Ph.D. candidate in theory and experimental studies at the University of California, San Diego. He grew up in California and is proud to be the first member of his family to attend college.

STUDENT PROFILES: High school students Charles Phillips and Dwayne Feester, who participate in computer courses at the University of the District of Columbia, create their own computer programs and games.

CONEXIONES: A mixture of live action and animation shows students one way that computers are tied to the arts, using the computer to record and create dancer's movements.

NAMEDROPPERS: The Mayan Indians of Central America had a mathematical system based on zero hundreds of years before Europeans began using a similar system.

MINDBLOWERS: A real industrial robot that delivers mail and an animated robot programmed to perform household tasks are shown in this segment.

Objectives

1. To identify at least three careers associated with computers.
2. To recognize the significance of mathematics in the computer field.

Activities

Before Viewing

1. BRAINSTORM: Ask the class: What jobs or what businesses use computers? Record all answers. Allow no one to make a judgement on any answer. A sunburst is a fun way to display the answers.

Students may want to begin this activity by recalling the ways they have seen the computer used in various "SPACES" shows.

2. Introduce the computer show. Distribute copies of the Student Viewing Sheet (Appendix, page 51). Have students fill in the correct viewing time, date and channel.

After Viewing:

1. DISCUSSION:

(a) Was either of the professionals featured in this show a scientist? (No, neither was engaged in research to discover new information on which to build scientific principles. Both were involved in application of knowledge and technology). Have students share their notes about the engineer from their viewing sheets. Ask them if they can think of any problems Ms. Wallace may have had in school or may have had in her job. Discuss possible solutions.

(b) Students will probably enjoy sharing their reactions to Lee Ray's computerized music.

(c) Robotics (see Background Notes) emphasize the relationship between a working robot and its computer.

(d) Can we make additions to our "computer sunburst?"

2. COMPUTER CAREERS MATCH (Appendix, page 52). Class or home assignment—Students will match job descriptions with jobs. Follow-up discussion of the correct answers should help prepare students for the field trip. (Activity #7)

3. The COMPUTER—Our Electronic Counting Machine—Student Information Sheets #1 and #2 (Appendix pages 53-54) can be read as a class or home assignment.

Suggestion: Have students read sections I and II together. Then you may wish to introduce or review the concept of base two numeration and the binary system. After reading and discussing section III, students can do IV and V on their own.

4. COMPUTER COLLAGE—Many students will enjoy collecting pictures of computers from magazines and newspapers. They can create a collage which might include a description of one job with computers. This can be a home assignment which will provide illustrations for activity #5.

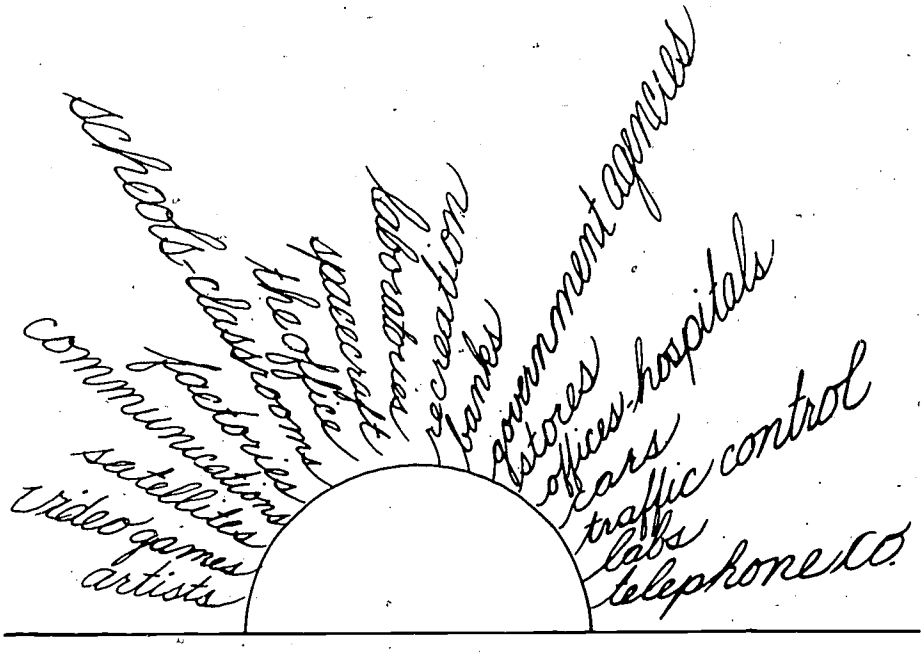
5. The COMPUTER—HOW DOES IT WORK? Student Information Sheet #3 (Appendix page 55). Class or home assignment—Students will read a brief description of the basic components of a computer system and begin to develop a "computer vocabulary."

6. WHAT IS A COMPUTER LANGUAGE? Student Information Sheet #4 (Appendix page 56). Class or home assignment—Students will be introduced to the reasons for computer programming and be given the names of a few computer languages.

Extension: Have students start a classroom list of computer languages and applications. Keep the list posted so that it can be added to as they find new languages.

7. FIELD TRIP—Arrange for the class to visit a local computer facility. Possibilities: data processing department of a large company, local telephone company, local college, government agencies, large insurance company, bank, computer store, computer training school or public utilities company. When making the arrangements, find out if students can question a few of the people whom they will see working with computers.

8. SALARY SCRAMBLE (cooperative logic problem)—Working in groups of 4 to 6, students will organize given information, utilize computation skills and work cooperatively to determine the average yearly salary for six given occupations. (Appendix pages 63-65.)



An example of a sunburst

Background Notes

Featured in the computer show are Lee Ray and Nancy Wallace, who are each investigating techniques for utilizing computers in different ways—one in music and the other in industrial engineering. The versatility of the computer seems to be limited only by the programmer's imagination and skills, and the availability of the most appropriate computer for one specific job.

Computers and Music

In the music industry, computers are being combined with oscillators to assist musicians and composers. To generate electronic music, oscillators are used to produce electric signals that result in sounds when amplified and channeled through loudspeakers. Several oscillators and filters may be combined to produce a

certain desired sound. Pitch, quality, and loudness can be controlled by linking the oscillators and filters to a computer. Another way to adjust musical notes is to translate the notes into a computer language which can then be converted into electrical signals representing sounds. Although the quality of the musical sounds is not perfect, the computer can give the composer a simulated orchestra so that, as he or she works, compositions may be reviewed and altered.

Robotics

Robby the robot, featured in the "Mindblowers" segment of this program, is an example of what robotic enthusiasts call "The Robotics Age." Robots are being used in industry to perform a variety of tasks, from placing candy in boxes to delivering mail or packages to destinations within a factory. One responsibility of industrial engineers, like Nancy Wallace, is planning the best use of robots and other computer-operated equipment in materials handling and problem solving in the workplace. We see two examples of this in the computer program: the use of driverless vehicles to transport fragile parts, and a computer-programmed conveyor system that delivers equipment to employees assembling products.

Robots, however, are not a modern phenomenon. The ancient Egyptians, Greeks, Ethiopians, and Chinese all constructed moving figures powered by water or steam; and the eighteenth and nineteenth centuries witnessed the invention of machines to play musical instruments, write, draw, weave, and lathe. However, the true Robotics Age did not get under way until 1946, when a general purpose robot, to control machines, was developed. It is now generally agreed by most roboticists that the term robot can be applied to mechanisms meeting the following criteria:

1. It should be a machine capable of performing certain tasks.

2. It should have artifical intelligence (thanks to its computer programming).

3. It can be reprogrammed.

The term robot came from the Czech word robota which means serf or worker. These computer-controlled workers are designed and programmed for very specific and, often, tedious tasks. They never become tired or bored, and hazardous conditions rarely pose a problem for them, which probably accounts for the 17,000 industrial robots now in use around the world.

The robot may be controlled by a minicomputer located inside the mechanism. A radio may also be used to link a robot to a nearby external computer. In other cases, the external linkage is accomplished with wires. A physical examination of these electrically powered workers reveals that the standard internal equipment includes gears and motors for motion, and electronic circuits for computer communication and control. Recently developed tactile and vision sensors are increasing the capabilities of industrial and home robots. However, robots still have great limitations when it comes to adapting to new situations—a characteristic of "real" intelligence.

Until R2D2 and C3PO of "Star Wars," probably the most widely known robots were those used in the Surveyor, Viking, and Voyager space missions. Surveyor made a soft landing on the moon in 1966, and robots from two Viking missions landed on Mars in 1976. The terrain was explored, samples were collected, tests performed, and the information was relayed back to scientists on earth. Robots are a significant part of the plans for future construction activities in space.

There is a rapidly growing movement among commercial automators and hobbyists to design and build home robots capable of performing household chores, home security assignments, speech identification, and various other sophisticated tasks. Regardless of the specific task performance desired, higher technology robotics requires the roboticist to utilize and integrate knowledge of electronics, mechanical engineering, and advanced computer programming.

Computer Graphics

Computer graphics is another interesting and challenging area of computer technology. It offers a wide range of possibilities to businesspersons, scientists, engineers, architects, cartographers, hobbyists, video game enthusiasts as well as creative artists. From charts, tables and graphs, to the complex images of artistic works, the visual arts are being expanded by this component of computer technology.

Computer drawings can be produced by utilizing either a plotter or a CRT (Cathode Ray Tube) display. For plotter graphics the computer is programmed to send instructions to the attached plotter mechanism which then produces a point by point pen and ink drawing. Drawings for complex maps and engineering projects are produced in this way. The CRT is really a television picture tube, often referred to as the monitor or the screen. The computer uses an electron beam to produce a spot of light on the screen. The picture is created as the electron beam moves light, point by point, across the video grid as instructed by the programming. Computer drawings can also be created by moving a pen containing a light sensitive cell, across the screen. The computer responds to the energy emissions of the light pen by tracking the pen's movements on the screen with lines. Special drawing tablets which can be stored by the computer are another alternative. With appropriate programming, computers can improve and enlarge line drawings, rotate figures, move figures, and present three dimensional drawings in perspective. The graphic product can be repeated endlessly, stored for future use, or delivered as a print-out.

Computer Resource List

CURRENT PUBLICATIONS:

BITS 'N BYTES ABOUT COMPUTING: A COMPUTER LITERACY PRIMER by Rachelle S. Heller and C. Dianne Martin. (Illus.) Rockville, MD: Computer Science, 1982. 174pp. $17.95. (Grades 7-12. Teacher.)

COMPUTERS FOR KIDS by Sally G. Larrsen. Creative Computing, 1980. $3.95. (Grades 4-8).

COMPUTERS (Illus.) Chicago: Childrens Press, 1982. 48pp. $6.95. (Grades 1-4. Teacher.)

IT'S BASIC: THE ABCs OF COMPUTER PROGRAMMING by Shelley Lipson. (Illus. by Janice Stapleton.) NY: Holt, 1982. 46pp. (Grades 4 & up.)

MINDSTORMS: CHILDREN, COMPUTERS, AND POWERFUL IDEAS by Seymour Papert. NY: Basic, 1980. 230pp. $12.95. (Teacher.)

PRACTICAL GUIDE TO COMPUTERS IN EDUCATION by Peter Coburn. (Illus.) Reading, MA: Addison-Wesley, 1982. 266pp. $9.95 (paper). (Teacher.)

SILICON CHIPS AND YOU: THE MAGICAL MINERAL IN YOUR TELEPHONE, CALCULATOR, TOYS, AUTOMOBILE, HOSPITAL, AIR CONDITIONING, FACTORY, FURNACE, SEWING MACHINE, AND COUNTLESS OTHER FUTURE INVENTIONS by C. D. Remore. NY: Beaufort, 1980. 144pp. $8.95. (Teacher.)

SMALL COMPUTERS: EXPLORING THEIR TECHNOLOGY AND FUTURE by Fred D'Ignazio. (Illus.) NY: Watts, 1981. 146pp. $9.95. (Grades 5 & up. Teacher.)

HERE COME THE ROBOTS by Joyce Milton. (Illus. by Peter Stern.) NY: Hastings, 1981. 120pp. $8.95. (Grades 4-8.)

ROBOTS by Hilary Henson. (Illus.) NY: Warwick, 1982. 77pp. $9.90. (Grades 7-12. Teacher.)

WORKING ROBOTS by Fred D'Ignazio. (Illus.) NY: Elseview/Nelson, 1982. 149pp. $11.50. (Grades 7-12. Teacher.)

ACTIVITIES/CAREERS:

COMPUTER TUTOR by Sandra Markel. Learning Works, 1981. $4.95. (Grades 4-6. Teacher.)

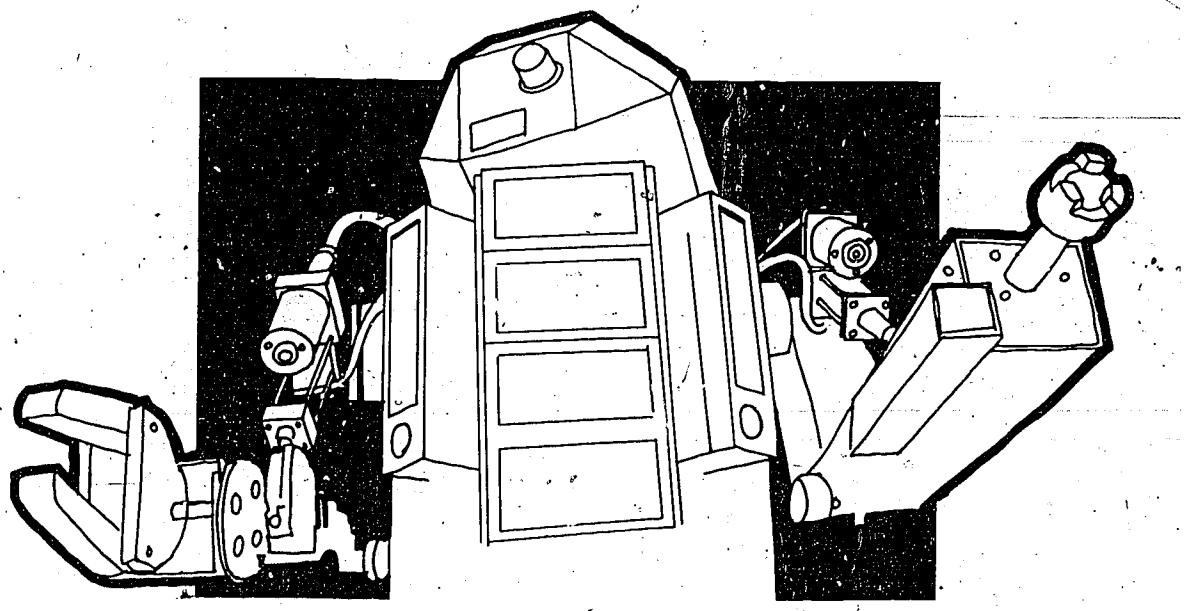
CREATIVE KID'S GUIDE TO HOME COMPUTERS by Fred D'Ignazio. Garden City, NY: Doubleday, 1981. $9.95. (Grades 4-8.)

EXPLORING WITH COMPUTERS by Gary G. Bitter. (Illus.) NY: Messner, 1981. 64pp. $7.59. (Grades 4-8.)

THE FUTURE FILE: A GUIDE FOR PEOPLE WITH ONE FOOT IN THE 21ST CENTURY by Paul Dickson. NY: Rawson, 1977. 252pp. $9.95. (Teacher.)

FILMS:

ROBOTS: INTELLIGENT MACHINES SERVING MANKIND. A brief introduction to industrial robots. 13 minutes. 1981. Available for free preview in 16mm, 3/4" videotape (Beta or VHS). Write: Science Screen Report, PO Box 691, NY 10003.



Program Four: Ecology

Synopsis

PROFILES: In the Ecology program students will meet Dr. Margaret Collins, a Black entomologist, and Dr. Eloy Rodriguez, a Mexican American plant chemist.

Dr. Margaret Collins is an entomologist at Howard University in Washington, D.C. Dr. Collins specializes in termite behavior, with much of her time spent observing termite and ant colonies in the tropical rain forests of northern South America. Dr. Collins travels extensively, collecting insects used in her research. She also donates insects to places such as the Insect Zoo at the Smithsonian Institution so that visitors to the museum can learn more about the lives of insects.

Dr. Collins grew up in West Virginia, where her father taught agriculture classes. Scholarships and outside work helped her through the University of Chicago, where she received her Ph.D. in zoology.

Dr. Eloy Rodriguez is an associate professor in the School of Biological Sciences at the University of California at Irvine. He investigates the chemical ecology and medicinal chemistry of natural chemicals of desert plants. Dr. Rodriquez is also active in the Saturday College Program at UCI where he designs laboratory experiments and field trips for junior high and high school students.

Dr. Rodriguez grew up in Texas, and received his Ph.D. in botany, specializing in phytochemistry, at the University of Texas at Austin.

STUDENT PROFILE: Indian teenagers at the Summer Science Institute in Boulder, Colorado, increase their knwledge of the ecosystem and ecological problems.

CONEXIONES: Students see how the camera can be used as a scientific tool, a key to observing insect and animal life, through the lens of a professional photographer.

NAMEDROPPERS: The contributions of Ah Bing, Lue Gim Gong, and Guey Jones in the development of special varieties of cherries, oranges, and rice are illustrated.

MINDBLOWERS: This animated feature gives examples of cloning through cutting, growth, and development of a ficticious Supertree.

Objectives

1. To identify at least three ecology-related careers.
2. To become familiar with the academic preparation required for careers in the life sciences.

Activities

Before Viewing

1. Write the word BIOLOGY on the chalkboard. Ask students to define it. Discuss the definition; then ask everyone to write one career in biology on a small piece of paper. Collect the slips of paper and have a student read them to the class. Another student can list them on the board, preferably listing those careers re-

lated to plants under botany, those related to animals under zoology, and those involving both under ecology.

2. Introduce the upcoming SPACES show on ecology. Distribute the Student Viewing Sheets (Appendix page 57) and have students fill in the correct viewing time, date and channel.

After Viewing

1. DISCUSSION of the two ecologists, Dr. Collins and Dr. Rodriguez and their work. What are the similarities and differences in their work? Can Dr. Collins be called a zoologist? Can Dr. Rodriguez be called a zoologist? Discuss the notes taken by the students on their viewing sheets, paying special attention to Question 4. Responses, though varied, should include:

(a) Take all the math courses possible in high school

(b) Take all the science courses possible in high school

(c) Participate in any available science fairs and science programs

(d) Be curious, be interested in nature

(e) Study hard

2. ECOSYSTEMS. (See ECOLOGY show Background Notes) Discuss the concept of the earth as a closed ecosystem in contrast to the nearly complete ecosystems of the garden, the desert, a pond, an ocean, grasslands, etc. Focus on the two ecosystems featured in the ecology show—the garden and the desert.

What is required for living organisms to survive on this planet? Does this planet supply those things? In the smaller, less complete ecosystems, what do the living organisms require to survive? Do these systems have to rely on external means for any of these necessities?

Rain for water, atmospheric changes, temperature

Identify examples of these components of a garden food chain:

Producers, consumers-herbivores, consumers-carnivores, decomposers

How do these organisms interact with each other and with their environment? How are materials of life recycled?

3. *OUTDOOR OBSERVATIONS:* Students will act as ecologists by observing the plants and animals living in a particular environment.

(a) They can, in teams, study the interaction of living organisms and their environment in any one of the following places, within walking distance of the school: the school grounds, a vacant lot, playground areas, steep slopes, lawns, and woods. Select a convenient place which is safe and can be easily revisited. Discuss the purpose of the activity.

Be sure students take notebooks or index cards and pencils with which to record all observations. Study the area selected as a model of an open ecosystem. How many different plants are present? Draw the dominant plant. How many different animals? Examine and describe the soil. Can you find any evidence of human activity in this ecosystem?

Classroom Followup:

(b) After reporting their findings to each other, students should discuss the interaction of the components of the ecosystem observed.

(c) List 3 questions they would ask an ecologist about this ecosystem. Save these questions for an interview with an ecologist or biologist.

4. ECOLOGY FAIR (a cooperative logic problem). Working in groups, students will use logical reasoning, data organization and cooperation to find out whose science project won which prize at an ecology fair. (Appendix pages 63-66)

5. HOME ASSIGNMENT. Observe one organism from a selected ecosystem (e.g., pond: dragonfly, garden: spider or sowbug). Study and record its activities, habitat, light preferences, life cycle, feeding habits, dangers, etc. Give a general description of its ecosystem.

6. INVITE A LOCAL SCIENTIST, preferably a minority person, working in the area of ecology, botany, zoology, or environmental science to visit the classroom. Local resources to contact for assistance may include Public Health Department, local college biology professors and graduate students, Bureau of Water and Air Quality, county extension agent, local Environmental Protection Agency, zoo.

(a) Students will interview him/her about his or her work, educational background, etc. Refer to page 46 of Appendix.

(b) Students will seek the answers to questions generated by their outdoor activities.

7. ENVIRONMENTAL ENGINEERING (designing an environmental park for humans). In teams of 3 or 4, students will create an environmental park out of a vacant block which has as its main features a hill and two trees. Refer to Appendix pages 71-74 for directions and worksheets for grades 4-6 and 7-8.

Background Notes

The field of biology is so vast and the problems to be studied so specialized that a life scientist must necessarily focus on developing an understanding of one particular aspect of the biosphere (all earth's living organisms and their planetary environment). For example, the molecular biologist might concentrate on the chemical molecules which form the living matter of the cell. Many highly specialized zoologists and botanists concern themselves with the structure, behavior, or functioning of a specific plant or animal, while others study entire groups.

Ecologists are biologists who specialize in the interrelationships between living organisms and their environment. Because of the immensity of earth's biosphere, most ecologists elect to study one particular set of interrelated organisms in their natural environment. Even then, the ecologist may choose to investigate an entire ecosystem, or he or she may focus on several components of an ecological system. The work of Dr. Eloy Rodriguez and Dr. Margaret Collins, the two ecologists featured in this program, demonstrates merely two approaches to the study of living organisms in their environment. Dr. Rodriguez investigates the unique chemical and physical characteristics of desert plants. Dr. Collins, an entomologist, has an on-going project involving the behavior of two natural enemies in the insect world: termites and ants.

Ecosystems

An ecosystem (or ecological system) is a nearly self-contained, complex unit of plants and animals interacting with each other and with their physical environment. Most of the materials and energy required to sustain life in a particular ecosystem are provided by environmental components of that system. An Arizona desert, a tropical forest, an urban garden, the Arctic ice cap, a lake, the ocean are all examples of relatively self-contained units. While these ecosystems may vary in size, geographical location, and types of plant and animal inhabitants, there are some outstanding common elements:

1. The living organisms, both plants and animals, exchange materials with their environment in cyclical patterns, which include the oxygen cycle, the carbon cycle, the nitrogen cycle, and recycling such minerals as calcium, phosphorus, sodium, and iron.
2. A steady flow of energy within the ecosystem is necessary to provide the living organisms with the chemical energy essential for carrying on their life sustaining activities.
3. The food energy available to an ecosystem's inhabitants is dependent upon the number of types of species present, as well as the components from the non-living environment.

The major participants in the food energy flow of an ecosystem can be classified generally as:

1. Food Producers: Green plants utilize the minerals and water from the soil, carbon dioxide from the atmosphere and sunlight to manufacture carbohydrates, fats, proteins, vitamins, and other materials. This food-making process, photosynthesis, enables the plant to transform and store energy from the sun.
2. Food Consumers: These organisms feed on plants or other animals, and thus the stored solar energy is passed on to them. This group includes:
   - **(a)** Herbivores—the plant eaters
   - **(b)** Carnivores—animals who feed on herbivores and other carnivores
   - **(c)** Parasites—organisms which feed off other living organisms without killing them (e.g. lice)
   - **(d)** Scavengers—animals that feed on dead plants and animals (e.g. termites)

   (Animals like ants, wasps and cockroaches are omnivorous, eating both plant and animal tissue)
3. Decomposers: The life building materials would be unavailable for recycling if there were no decomposers in the ecosystem. These organisms, usually microorganisms such as bacteria, yeasts, fungi and molds, break down the plant and animal bodies, releasing such simple substances as carbon dioxide and phosphates, which can be used again by plants in the food-making process.

An uncorrected "malfunction" at any level of the ecological system can upset the balance. If that balance is not restored, the food energy flow is broken and certain species of organisms can no longer survive in that environment. Fortunately, nature is frequently self-adjusting.

Cloning

Humans not only alter the non-living components of their ecosystem, they also seek to control certain living components. Those organisms which are deemed hazardous or undesirable are usually eliminated. Those with useful or desirable characteristics are nurtured, preserved, and protected. The Supertree from the "Mindblowers" segment illustrates a relatively recent development in our efforts to propagate organisms with useful characteristics: propagation from a few cells in the laboratory.

Now this process has been made more efficient by the science of tissue culture in which cells of the desired plants are nurtured in nutrient solutions in sterile test tubes. Thousands of plants can be grown at one time in very little space. Plants may be selected for tissue culture cloning because of their resistance to disease and insects, size and quality of fruit, suitability for a particular environment, flower characteristics, and so on. Certain lower animals, such as flatworms, can reproduce asexually, thus producing clones naturally. A technique for cloning frogs was developed in the 1950s and later adapted to salamanders.

In 1981 this technique was successfully applied, for the first time, to mammals, and mice were cloned. While our imaginations can run away with the possibilities and implications for cloning humans, emerging techniques for animal cloning will probably enable cytologists to study human cells in a way that could impact on our understanding and control of certain cell-based diseases, including cancer.

Resource List

CURRENT PUBLICATIONS:

DREAMS OF A PERFECT EARTH by Lorus J. Milne and Margery Milne. NY: Atheneum, 1982. 120pp. $9.95. (Grades 4 & up.)

WATER FOR THE WORLD by Franklyn M. Branley. (Illus. by Trude Kelley.) NY: Crowell, 1982. 95pp. $9.95. (Grades 5-12.)

THE WILDERNESS WAR: THE STRUGGLE TO PRESERVE AMERICA'S WILDLANDS by Edward B. Weinstock. (Ilus.) NY: Messner, 1982. 191pp. $9.29. (Grades 7 & up. Teacher.)

ALLIGATORS, RACCOONS, AND OTHER SURVIVORS: THE WILDLIFE FUTURE by Barbara Ford. NY: Morrow, 1981. 160pp. $8.95. (Grades 4-8.)

ANTS by Cynthia Overveck. (Illus. by Satoshi Kuribayashi.) Minneapolis, MN: Lerner, 1983. 48pp. $8.95. (Grades 4-8.)

CACTUS: THE ALL-AMERICAN PLANT by Anita Holmes. (Illus. by Joyce Ann Powzyk.) NY: Four Winds, 1982. 178pp. $14.95. (Grades 5 & up. Teacher.)

THE CHANGING DESERT by Ada and Frank Graham. (Illus. by Robert Shetterly.) NY: Scribner, 1981. 90pp. $11.95. (Grades 5 & up. Teacher.)

ACTIVITIES:

BIOTIC COMMUNITIES, CITY PLANNING, ECO-KIDS EXPERIMENT WITH AIR ON SPACESHIP EARTH, ECO-KIDS FLY OFF TO THE FORESTS, GAMES CITIES PLAY, SUNLIGHT ON THE INSIDE, YOUR STATE'S ENVIRONMENT. Environmental Career-Oriented Learning Packets. $3.00 each. Write: Ecology, Highline Public Schools, Box 66100, Seattle, WA 98166. (Grades 4-6.)

BIRDS OF PREY ($4), *KNOW YOUR INSECTS* ($1.50), *LABELLING AND STORING AN INSECT COLLECTION* ($1.25), *UNDERSTANDING BIRDS OF PREY* ($3), Illustrated Booklets. Quantity discounts available. Write: Media Services Distribution Center, 7 Research Park, Ithaca, NY 14850.

CAMPING AND ECOLOGY by Paul Neimark. (Illus. by Tom Dunnington.) Chicago: Children's Press, 1981. 64pp. $6.95.

FREE Ecology Related Materials. For free catalog and materials write: United Communications, PO Box 320, Woodmere, NY 11598.

CAREERS:

CAREERS IN CONSERVATION by Ada and Frank Graham. (Illus. by Drake Bordan.) NY: Scribner, 1980. $9.95. (Grades 5-8.)

A DAY IN THE LIFE OF A MARINE BIOLOGIST by William Jaspesohn. (Illus.) Boston: Little Brown, 1982. 96pp. $10.95. (Grades 5 & up.)

EXPLORING ANIMAL CARE CAREERS by Charlotte Lobb. (Illus.) NY: Richard Rosen Press, 1981. 112pp. $5.97. (Grades 5-8.)

HOW TO BE A WILDLIFE PHOTOGRAPHER by Joe Van Wormer. NY: Dutton, 1982. $10.95. (Grades 7 & up.)

OPPORTUNITIES IN ENVIRONMENTAL CAREERS by Odom Fanning. (Illus.) Skokie, IL: Vocational Guidance Manuals, 1981. 150pp. $7.95; $5.95 (paper). (Grades 7 & up.)

SAFEGUARDING THE LAND: WOMEN AT WORK IN PARKS, FORESTS, AND RANGELANDS by Gloria Skurzynski. NY: Harcourt, 1981. 162pp. $9.95; $3.95 (paper). (Grades 7 & up.)

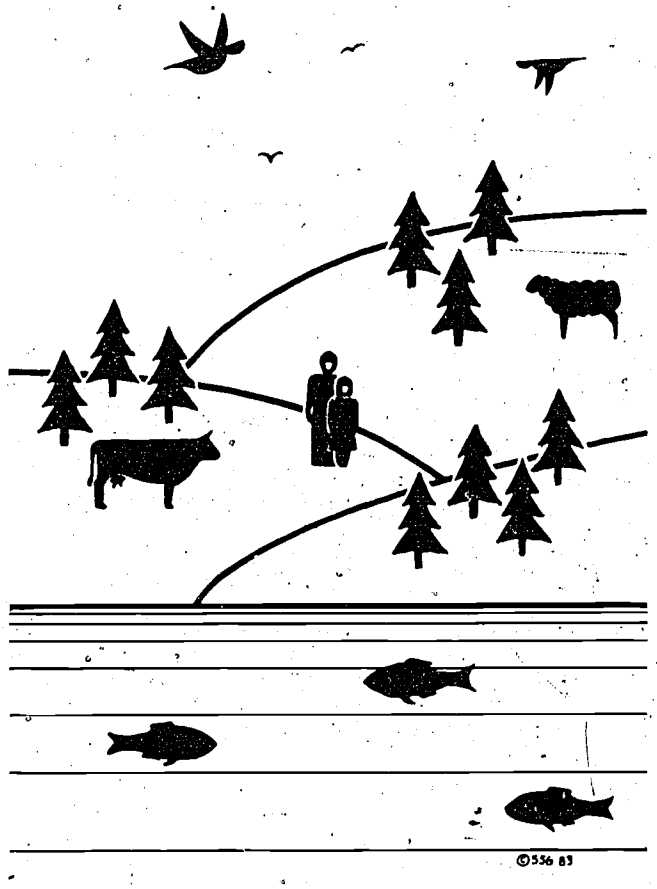
PEOPLE:

GEORGE WASHINGTON CARVER: SCIENTIST AND SYMBOL by Linda D. McMurry. (Illus.) NY: Oxford University Press, 1981. 367pp. $25.00. (Grades 7 & up.)

SHARK LADY by Ann McGovern. NY: Four Winds, 1979. 84pp. $6.95. (Grades 3-5.)

FILMS:

CASTLES OF CLAY. Explores life in a termite colony. 55 minutes (2 parts). 1980. $87 for 2 day rental. Write: Benchmark Films Inc., 145 Scarborough Road, Briarcliff Manor, NY 10510. Accompanying teacher's guide.



Program Five: Energy

Synopsis

PROFILES: In this program, students are introduced to Virginia Sweeney, a Native American geological engineer, and Dr. Miguel Rios, a Mexican American solar scientist.

Ms. Virginia Sweeney is a twenty-six year old geological engineer with the Amoco Production Company. She oversees ninety oil and natural gas wells in West Central Oklahoma and monitors their monthly output of oil and gas production. Ms. Sweeney says the work she does is similar to that of a detective: she investigates problems and finds a way to solve them, with each case a challenge because each oil well is different. Ms. Sweeney says that in high school she was a pom-pom girl and that many of her friends would be surprised to see her today, wearing a hardhat and supervising the drilling of an oil well.

Ms. Sweeney, a descendant of the Chickasaw and Cherokee tribes, received her BS in geological engineering at the University of Oklahoma.

Dr. Miguel Rios is a solar energy specialist at Sandia National Laboratories, a field center for the U.S. Department of Energy, in Albuquerque, New Mexico. Dr. Rios is researching a form of solar energy, photovoltaics, which converts the sun's energy into electricity using solar cells. In this program Dr. Rios explains photovoltaic technology, and its potential for an alternative energy source.

Dr. Rios received his Ph.D. in experimental nuclear physics at the University of Maryland. He grew up in El Paso, Texas and is active in SACNAS, the Society for the Advancement of Chicanos and Native Americans in Science.

STUDENT PROFILE: Three students from the Southwest Regional Center for Science who are participating in a regional science fair explain their projects: using salts as a heat source, extracting petroleum from shale, and measuring the air pollution caused by auto emissions.

CONEXIONES: The energy needed for the growing of grain, transportation of pickles, lettuce, mustard, and ketchup are illustrated in an animated segment of what it takes to make a hamburger.

NAMEDROPPERS: Students are told of the work of Louis Latimer, a co-worker and contemporary of Thomas Edison, who invented the incandescent filament.

MINDBLOWERS: An animated treatment of the earth's history, squeezed into a calendar year, shows students the millions of years required to produce fossil fuels and the advent of man on the planet.

Objectives

1. To recognize the personal qualities and academic qaulifications required for successful careers in engineering.

2. To make a distinction between the role of the scientist and the role of the engineer.

3. To identify at least three energy-related careers.

Activities

Before Viewing

1. Demonstration to initiate discussion of the relationship between energy sources, steam, electrical power plants and electricity for homes.

*Fill an aluminum can half full of water. Cover with a small cardboard square and boil within viewing range of the class. What has supplied the energy to move the cardboard? How is this system like a sim-

plified model of a section of electronic power plant? In large furnaces, the burning of fossil fuels converts stored energy into heat energy which raises the temperature of water in the boiler to produce steam. The steam turns a large wheel, the turbine, which rives the generator, and the generator produces electrical power. The turbines of other kinds of electric powerplants are driven by water, gas, or nuclear energy.

2. Introduce the energy show. Distribute copies of the Student Viewing Sheet (page 59) and have students fill in the correct viewing time, date and channel.

After Viewing

1. DISCUSSION:

(a) THE WORK—Ms. Sweeney and Dr. Rios are both problem solvers in the energy field. Students should use their viewing sheets to help them remember the kinds of problems they try to solve. (See (Background Notes.) Point out to students that when physicists have found the solutions to the scientific problems involved in converting solar energy to electric energy, civil, mechanical and electrical engineers will probably work with technicians to design and produce equipment and facilities that utilize the solar conversion principles. They will develop the technology for wide-spread use.

(b) EDUCATION AND TRAINING—focus on the last question in Number 1 of the viewing sheet. Discuss the problems involved in not being properly prepared for a college program in engineering or science. Student responses may include *additional time and money, often lower grades and lower class rank, summer school, even changing majors and relinquishing original career goals.* Reinforce the idea of taking as many math and science courses as possible in high school.

2. DO YOU WANT TO BE AN ENGINEER? An activity designed to help students understand the relationship between personal interests and future careers. This can be read to students or copied and assigned for homework. (See Appendix pages 75-77.)

3. CAREER RESEARCH and SIMULATED INTERVIEWS: Divide class into seven groups. Assign each group one of the following occupations to research: mechanical engineer, electrical engineer, civil engineer, nuclear engineer, architect, physicist, and chemist. Encourage the groups to visit the library and to make inquiries in the community. Students can share the information in a series of simulated interviews to be presented to the class. One member of the group should serve as the interviewer while the other group members assume the role of the professional scientists or engineers. Encourage use of props, etc. for imaginative presentations.

4. FIELD TRIP to an electric power plant or the public utilities company. Make arrangements well in advance. Students should be able, later, to compile a list of the kinds of jobs they observed at the site.

5. THE SUN AS A SOURCE OF HEAT ENERGY (an experiment for "physicists").

Materials: cold water, 2 saucers, 2 thermometers.

Procedure: Have students fill two saucers with the same quantity of cold water from the same source. Place one saucer in the direct rays of the sun and the other in a well shaded area—perhaps under the porch or stairs. After one hour students should check the temperature in both saucers, and discuss their findings. Based on these findings what location would these "physicists" suggest for a stove which used only the sun's energy to cook food?

**6. CONSTRUCT A SOLAR OVEN (a task for a team of 3 or 4 "engineers").

Materials: Shovels, yard stick or meter stick, aluminum foil, rigid metal mesh with small holes, several bricks or large rocks, unshaded outdoor ground area at least 6' x 6' (1.8 x 1.8 m).

Procedures: The students assigned to this task should either do library research or be told about parabolic curves. Try to find a picture of one (the large disk-shaped antenna used by satellite ground stations and astronomers is an example).

(a) Dig a round, parabolic hole in the ground 4 feet (1.2 m) across and 18 inches 45 cm) deep at the center;

(b) When the walls of the hole are smooth and hard, students should line it completely with heavy duty aluminum foil, keeping it as flat as possible;

(c) the hole should be covered with the mesh which can be held in place by bricks or other heavy objects;

(d) paper clip a piece of paper to the mesh exactly over the center of the hole. When the sun is directly over the hole, the paper should burn. The shiny parabolic surface of this oven reflects the sun's rays at an angle so that they are all concentrated at one point over the center of the oven. Students can heat water or soup in a small pan placed over the center of the oven as long as the sun is directly overhead.

7. DESIGN A SOLAR HOUSE (an architect's project). Invite a local architect to talk with the class about the basic structural features of houses designed to utilize solar energy. You may wish to allow time for library research after assigning students the task of drawing their own solar houses. Some may choose to construct scale models from their drawings.

*Adapted from the Competency-Based Curriculum Guide–Science Intermediate. Public Schools of the District of Columbia.

**Adapted from SUNPOWER EXPERIMENTS: Solar Energy Explained—Maggie Spooner, Sterling Publishing Co., Inc., New York, 1980.

Background Notes

Profiled in this show are two specialists who are working on very different approaches to the same basic problem: efficient energy supply systems. Geological engineer Virginia Sweeney applies her knowledge of the earth's crust and engineering physics to efficient management of two conventional energy sources, oil and natural gas. On the other hand, Dr. Miguel Rios, solar energy engineer, is developing an alternative system from solar energy: photovoltaics.

Petroleum Engineering

One of the problems Virginia Sweeney addresses is discovering the best ways to get oil and gas out of layers of rock. Geological engineers need to maintain oil and natural gas wells at top production efficiency in order to produce the most energy at a minimum of cost. When locating a new well, geological engineers have to decide what stimulation should be used to obtain the oil and natural gas from the earth. Oil or gas is concentrated in pools held by certain kinds of permeable or porous rock. To locate an oil pool, geologists look for traps, places where the porous rock is surrounded by impermeable rock. By studying the initial stages of drilling, geologists are better able to make predictions about the depths to which the drilling must continue before oil or gas is reached.

Photovoltaics and Solar Energy

Both photovoltaics and the more commonly used roof solar collector boxes rely on direct conversion of sunlight into another, immediately useful energy form. Photovoltaics utilizes special solar energy collectors called solar cells to transform sunlight into electricity. Solar cells have no moving parts and have been used to provide continuous power generating devices for equipment in space.

Some solar cells are small (4" x 4", or 10 cm x 10 cm), thin, glasslike wafers made of purified silicon, an element found in common sand. This cell has two layers of silicon separated by a barrier layer. The silicon surface absorbs light which excites the silicon molecules, displacing electrons. These electrons, carrying their negative charges, pass through the barrier sandwiched in the middle of the cell, leaving their positively charged parent molecules behind. This creates a positively charged zone and a negatively charged zone in the photovoltaic cell, similar to the situation in a dry cell battery. The photovoltaic cell, when connected to a circuit, will provide a flow of electrical current as the displaced electrons stream in search of their positively charged counterparts. In strong sunlight, a photovoltaic cell may produce about .5 volt of electricity (a size D flashlight battery produces 1.5 volts). For higher voltages, the photovoltaic cells are connected together in series with the negative surface of one connected to the positive surface of the next one.

In a solar array, or panel, the numerous photovoltaic cells needed to supply power for a specific task, are usually anchored in a strong base material. If the equipment powered by the solar array during daylight is to operate at night, the surplus electrical output of that array may be stored, until dark, in rechargable batteries. The biggest problem, however, is not backup power sources, but the large areas of land required for the photovoltaic arrays. For example, a third of an acre is used for the 33,600 solar cell array that powers a radio station in Bryan, Ohio.

At present, experimental sites operating with photovoltaic systems include:

- Airport power systems in Phoenix, Arizona, and Dallas, Texas
- Hospital in Kauai, Hawaii
- Science and art center in Oklahoma City, Oklahoma
- Shopping center in Albuquerque, New Mexico
- Sea World Park in Orlando, Florida

Until the technology exists to make efficient, safe, clean, cost effective, renewable alternative energy systems available for widespread use, our society will probably continue to rely on fossil fuels (coal, petroleum, and natural gas) and nuclear fission. Aside from the problem of fossil fuels being non-renewable and in limited supply, there are environmental problems associated with their large scale use. Every energy conversion has an impact on the environment, and these carbon based fuels are no exception. Oil spills and the ravages of strip mining are two problems with high visibility. The burning of fossil fuels in power plants, heating systems, and motor vehicles contributes to atmospheric pollution. Some coal, when burned, releases sulfur dioxide (SO_2) into the atmosphere; this chemical combines with atmospheric water to make a weak sulfuric acid, better known as acid rain.

Scientific Model Building and Simulations

When confronted with macroscopic problems like those involving changes in the earth's atmosphere, scientists and engineers often use simulations and graphic or mathematical models of the actual phenomenon being studied. Models enable the scientist to manipulate variables which cannot be controlled in the actual situation, thus allowing for a better understanding of the problem. Frequently the scientist, or engineer, is able to use the model to test various hypotheses. If the results correspond to what has been observed in the real world, the model is probably an accurate representation and can be used to make predictions.

Computers are excellent tools for the development and utilization of mathematical models for scientific problem solving. Climatologists, for example, are using computers to build mathematical models of global climatic changes. One problem being studied through computer simulation is the effect of rising carbon dioxide levels in the atmosphere. The burning of fossil fuels since the Industrial Revolution has contributed to a fifteen percent increase in atmospheric carbon dioxide. This concerns climatologists because the carbon dioxide allows most visible sunlight to reach the earth's surface, but blocks the reflection of infrared radiation (heat rays) from earth back into space. Consequently, the earth's atmosphere becomes warmer. Using information learned from computer models, climatologists have predicted that if the present level of carbon dioxide in the atmosphere doubles, the earth will be four to five degrees Fahrenheit warmer than it is now. Such a warming would break and melt the polar ice caps, causing sea levels to rise.

The use of simulations and models in the search for solutions is by no means limited to climatology; in fact, they are integral components of most scientific problem solving processes.

Resource List

CURRENT PUBLICATIONS:

ENERGY AT WORK by John Satchwell. (Illus.) NY: Lothrop, 1981. 41pp. $11.47; $7.95 (paper). Grades 5 & up.)

GEOTHERMAL ENERGY: A HOT PROSPECT by Augusta Goldin. (Illus.) NY: Harcourt, 1981. 128pp. (Grades 6-8.)

HOW DID WE FIND OUT ABOUT SOLAR ENERGY? by Isaac Asimov. NY: Walker, 1981. 62pp. $7.95. (Grades 4 & up.)

OFFSHORE! OIL AND GAS PLATFORMS IN THE OCEAN by Ross R. Olney. NY: Dutton, 1981. 88pp. $11.50. (Grades 5-8.)

WINDMILLS: AN OLD-NEW ENERGY SOURCE by Lucile McDonald. (Illus. by Helen Hawkes Battey.) NY: Dutton, 1981. 120pp. $10.95. (Grades 6-8.)

WIRE & WATTS: UNDERSTANDING AND USING ELECTRICITY by Irwin Math. (Illus. by Hal Keith.) NY: Scribner, 1981. 80pp. $8.95. (Grades 6 & up.)

ACTIVITIES/CAREERS:

AMOCO TEACHING AIDS. A 7-page folder describing free and low cost energy teaching pamphlets, kits, and resources. Individual teacher's copies free. Write: Amoco Educational Services, Public Affairs—MC 3705, PO Box 5910-A, Chicago, IL 60680.

CAREERS IN THE ENERGY INDUSTRY by Betsy Harvey Kraft. NY: Watts, 1977. $4.90. (Grades 6 & up.)

QUESTIONS KIDS ASK ABOUT ENERGY. Free classroom and playground reproducible activities on wind energy. Write: Science Activities in Energy, P.O. Box 117, Oak Ridge, TN 37830.

SOLAR PROJECTS. a 122-page paperback on simple instructions for solar projects. $7.95 plus postage. Write: Edmund Scientific, 7082 Edscorp Building, 101 E. Gloucester Pike, Barrington, NY 08007.

STUDENT ENERGY PROJECT BOOKS. 25 books and teacher's guide. $4.75. Write: The Campbell Soup Company, Box 881, Young America, MN 55399. (Grades 4-9.)

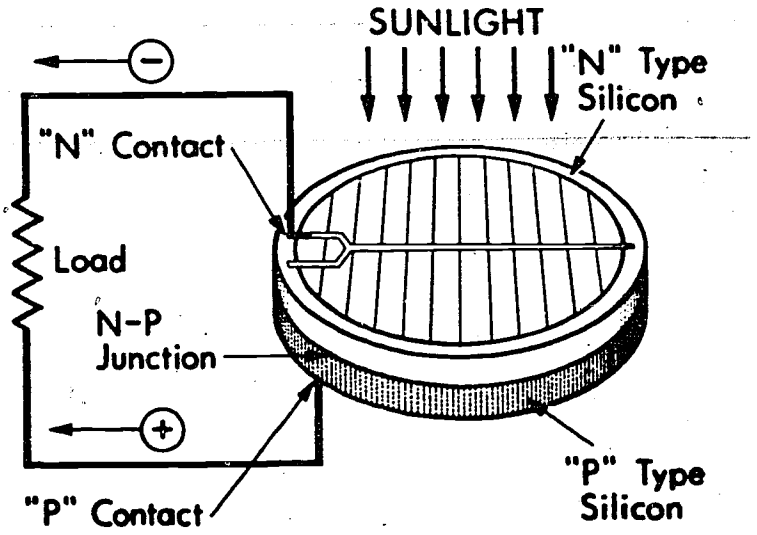
FILMS:

ODYSSEY: A QUEST FOR ENERGY. Free loan film with accompanying teacher's guide. 28 minutes. Write: Modern Talking Picture Service, Inc., Film Scheduling Center, 5000 Park Street North, St. Petersburg, FL 33709. (Grades 3-6.)

ENERGY MONSTERS: HOW TO STARVE THEM. A short film illustrating ways of conserving energy. 13 minutes. 1978. $23.00 rental. Write: MFA Education Media, PO Box 1795, 2211 Michigan Avenue, Santa Monica, CA. (Grades 3-9.)

ENERGY: THE PROBLEMS AND THE FUTURE. A comprehensive review of alternative energy sources. 27 minutes. 1978. $25.00 rental. Write: National Geographic Society, 17th & M Streets, NW, Washington, DC 20036. (Grades 7 & up.)

THE SOLAR FILM. A short review of the sun's energy with teacher's guide. 9 minutes. 1980. $30.00 rental. Write: Pyramid Films, Box 1048, Santa Monica, CA. (Grades 7 & up.)



Photovoltaic Cell.

Program Six: Communications

Synopsis

PROFILES: In this program, students are introduced to Raquel White, a Cuban American telecommunications engineer, and Dr. George Campbell, a Black physicist.

Raquel White is Assistant Vice-president of Lourdes Industries of Hauppauge, New York. Trained as an engineer, she assists in the development of new telecommunications products, supervising other engineers in the Research and Development Department. Ms. White feels that telecommunications is the nation's fastest growing industry, and encourages students to pursue engineering careers. In this show, she explains the technology of fiber optic cables used in telephone transmission.

Ms. White was born in Cuba, emigrating to New York City with her family when she was twelve years old. She received her B.S. degree in aerospace engineering from the Polytechnic Institute of Brooklyn. As with many engineers, Ms. White's training in aerospace engineering had applications in another high technology field, telecommunications.

Dr. George Campbell is a physicist at the Bell Telephone Laboratories in Holmdell, New Jersey, specializing in communications satellites. Dr. Campbell is developing new digital communication services for satellites. Students will see him use satellite simulators to evaluate the new services over a satellite channel. In this segment Dr. Campbell also describes how communications satellites transmit television pictures, phone calls, and computer data.

After receiving a B.S. degree in physics, Dr. Campbell and his wife spent two years in Zambia, where he taught physics and math. Returning to the United States in 1971, Dr. Campbell completed his Ph.D. in theoretical high energy physics at Syracuse University.

STUDENT PROFILE: Students in a communications program at the Arlington Career Center learn the basics of television production from a former student, Pam Phelps, who substitute teaches at the Center and works as an assistant director at a local television station.

CONEXIONES: An animated fantasy shows two friends expressing their feelings for one another through American Sign Language.

NAMEDROPPERS: Students are introduced to Granville T. Woods who developed a telegraph system for railroads.

MINDBLOWERS: An animated look at one aspect of the future of communications, elevators that talk and use voice print identification to screen riders.

Objectives

1. To identify two careers in the field of technological communications.
2. To become aware of the relationship between science and technology.

Activities

Before Viewing

1. Have the students bring to class a list of all the methods of communication they have used in the past twenty-four hours. Discuss technology as the collection of processes, tools, instruments, and machines which have developed from the application of scientific knowledge to practical purposes.

Early physicists such as Isaac Newton, Robert Boyle, and Von Guericke of the 17th century; Benjamin Franklin, Volta, and Galvani of the 18th century; and Faraday and Ampére of the 19th century all contributed to the scientific understanding of the principles of electricity. Inventor Thomas Edison and his assistant, Lewis Latimer, applied these principles in developing the lightbulb.

As students share their lists, classify each communication method on the chalkboard as technological or non-technological. Encourage the inclusion of radios, casettes, phonograph records, etc.

2. Introduce the communications show as an opportunity to find out about new and growing areas of technological communication. Distribute copies of the Student Viewing Sheet (Appendix page 61) and have students fill in the appropriate viewing time, date and channel. Read the introductory paragraph with students.

After Viewing

1. DISCUSSION: How does Ms. White's work as an engineer differ from Dr. Campbell's work as a physicist? (Refer to Synopsis, Profiles, and Background Notes.) Students should use viewing sheet notes to discuss the work of each of these persons. Share information about their backgrounds and education from the Profiles.

2. COMMUNICATIONS SATELLITES: Student demonstration.

Materials: Large globe, at least three flashlights, a darkened room

Procedure: Read Background Notes for this show. This demonstration is intended to model a communications satellite system which uses three geosynchronous satellites to provide global communications.

Position the students so that one flashlight is focused directly over the equator, above the Atlantic Ocean, another is over the Indian Ocean, and the third is over the Pacific Ocean. Have each student adjust his or her distance until the range of light from the flashlights covers about 1/3 of the globe. Point out that the light represents the global surface range within which each satellite can receive and transmit information signals. Discussion should include suggestions for areas which are not within range of these three "satellites."

One solution: *Additional satellites over polar regions.*

3. BUILD THE HIGHEST TOWER: In groups of 2 to 4, students will explore creative problem-solving by using non-traditional materials to build a structure. The brainstorming, problem solving skills, and cooperation required by this activity will simulate the experiences of a team of engineers when given a new problem to solve. See page 78 of Appendix.

4. INVITE AN ELECTRICAL ENGINEER and/or physicist to visit the class. Or arrange for a small group of students to interview someone in the field of technological communications. Local resources to check include the telephone company, radio stations, television stations, colleges, high school physics teachers, cable TV company, newspaper plants, commercial satellite companies, amateur radio operators clubs.

*5. OSCILLOSCOPE: A student project or teacher demonstration activity. Real oscilloscopes are used by physicists and electrical engineers to indicate changes in the shape, frequency, or strength of sound waves.

Materials needed: A balloon with the mouth cut off; a cardboard mailing tube (2" diameter, 5" length); rubber cement; glitter or small piece of mirror (a reflector); flashlight or sunlight.

Procedure: Stretch balloon tightly over the end of the mailing tube. Cement in place. Cement mirror piece, or glitter, to outside of the balloon. Hold tube so that the light is focused on the reflector (glitter or mirror) and is projected onto a dark wall as a spot. When a student speaks vowel sounds into the open end of the tube, different light patterns will be produced on the wall.

6. WHO WILL BE ACCEPTED (cooperative logic problem): Students, working in groups of 4 to 6, will organize data and logical reasoning to solve the hypothetical problem of which student is most qualified for admission to engineering school. (See pages 63, 67.)

*Adapted from *TELEZONIA: Communicating by Telephone*, Teacher's Book, American Telephone and Telegraph Company, Copyright 1975.

*7. PARABOLIC (curved surface) REFLECTORS: Outdoor student demonstration. Earth stations which receive and transmit communication satellite signals are easily recognized by their large dish-like parabolic antennas which collect and focus microwaves. (See Background Notes.) This simulation using sound waves can be set up by a group of 3 or 4 students.

Materials: Two umbrellas (for parabolic surfaces), transistor radio, 4 forked sticks (at least 36 in. (90 cm.) long).*

Procedure:

(a) Post 2 forked sticks in the ground in such a way that they will support the shaft of one open umbrella.

(b) Position the other forked sticks in the same manner some distance away. Make sure the umbrella handles are pointing directly at each other. One student should hang the transistor radio on the handle of an umbrella and another student should stand beside the other umbrella. The radio volume should be turned down so that the student at the opposite umbrella cannot hear it.

(c) Focus the beam of sound waves by moving the radio back and forth along the handle of the sending umbrella. The student at the opposite umbrella will hear the sound when the sound waves from the radio are concentrated at the focus point on the handle of the receiving umbrella.

**Adapted from SCIENCE MAGIC with PHYSICS by Kay Richards, Arco 1975.*

Background Notes:

This show presents an opportunity to meet two professionals whose careers in communications may provide insight into the often overlooked distinction between natural and applied science. The featured physicist, Dr. George Campbell, conducts research experiments to help him create theoretical models which will lead to the development of satellites that can operate at maximum capacity, even under adverse conditions. Raquel White, an engineer, uses her technological expertise to develop new products in electronic communications for Lourdes Industries. She applies the information and theories developed by research scientists in a way in which society can make practical use of them.

Communications Satellites

The common "ancestor" for most of our modern technological communication systems is the telegraph, invented in the 1830s. Marconi's success with the wireless telegraph, near the end of the nineteenth century, led to the development of radio communication. However, the term radio refers to more than the device we use for entertainment.

Radio, as a major area of telecommunications, includes all communication forms which rely on the radiation and detection of signals sent over distances as electromagnetic waves. Radio, television, telephone, and communications satellites all use radio waves of various lengths or frequencies. AM radio broadcasting uses the lower frequency, longer radio waves, while communications satellites use microwaves. These microwaves are short radio waves which enable communications satellite systems to handle high volume traffic for widely separated places.

Until the 1957 launching of Sputnik I, the moon was the earth's only satellite. The first successful American satellite, Explorer I, launched January 31, 1958, transmitted scientific information which revealed the existence of earth's radiation belts. Within 5 years, a number of other scientific (Vanguards, Explorer, Pioneers), meteorological (TIROS, Nimbus) and communications (Echo, Telstar, Relay) satellites were in service.

The earliest communications satellites were low orbiting. With the launching of the first synchronous communications satellite, Syncom, in 1963, the wider range advantage of high altitude orbiting was demonstrated. Synchronous communications satellites are launched by booster rockets with various upper stages, one of which contains a guidance system to facilitate tracking. The booster motors project the satellite into an elliptical (oval) orbit 22,300 miles (35,900 km) above the earth's surface. Spinning, the satellite may make as many as twelve orbits before the final booster motor is fired, placing it in a circular orbit 23,000 miles (35,000 km) over the earth's equator. These satellites move in orbit at a velocity of 1 mile per hour (1.6 km/hr). Orbiting at that speed 22,300 miles above the equator causes the satellite's movements to synchronize with the earth's rotation on its axis. Consequently, these satellites appear to be fixed or stationary. Although they are powered by solar energy, they carry nickel-cadmium storage batteries for emergencies.

Today's commercial communications satellites contain the electronic equipment necessary for receiving, amplifying and recording or transmitting ground signals. Their receiving and transmitting antennas must always point toward the earth. Antennas are also a vital part of the satellite ground tracking and earth stations which transmit and receive satellite signals. The large parabolic (dish-shaped) antennas pick up the microwave signals from satellites and pass them through electronic control boards for sorting and amplifying. These signals are then relayed to communication centers such as television stations, telegraph offices, telephone installations, and computer or data processing departments.

Communications Satellite Technology is being applied to:

1. Telephone communications—20,000 transatlantic calls can presently be handled by a satellite at one time.

2. Third World countries—Satellites have provided instant communications systems.

3. Education—Vital information and new techniques can now be taught to those in isolated areas.

4. Television—At least two-thirds of cable programming in the U.S. is beamed in by satellite. Cable offers expanded channel capacity and can be combined with newspapers, radio, films, books, computers, etc.

Two-way cable systems allow for viewer participation.

Direct broadcasting to homes—Valuable in areas without television, but each home must be equipped as a modified earth station.

5. Business—Teleconferencing allows participants, in various geographical locations, to see and speak with each other via satellite. Banks use satellite technology to transfer funds.

Satellite-linked computers enable industries and research institutions to communicate efficiently. Speech mail systems open, scan, and transmit contents of letters by satellites.

6. Transportation—Ships "sight" satellites for navigation and airplanes "sight" satellites for establishing location. Satellites are used to locate and direct spacecraft.

7. Information—World-wide news coverage is now possible as well as a global library system.

Fiber optical communications

NASA has developed an argon gas laser to beam messages to the Explorer XXXVI satellite which orbits the earth in an ellipse, ranging between 671 miles (1079.6 km) and 976 miles (1570.4 km). This science satellite is equipped to receive laser signals, convert them into radio signals, and transmit them back to earth. Their pure color and narrow light beams make lasers well-suited for long distance communications, especially in interplanetary space. However, near the earth's surface, the earth's atmospheric gases and poor weather conditions interfere with laser light communications. This problem led to the development of special, ultrapure, very fine glass fibers to act as channels for light traveling over long distances on the earth's surface. Each fiber, thinner than a human hair, has a glass core surrounded by a layer of a slightly different kind of glass. As many as 140 or more of these glass (optical) fibers may be encased in a polyethylene and steel wire sheath, forming a fiber optic communication cable.

At one end of the optical fiber is a tiny semiconductor laser, a light-emitting diode-LED, which emits laser light in a signal pattern when stimulated by a signal-carrying electric current. The signal patterns may originate from voice or data sources. These signal-carrying light beams are bounced along the glass fiber's inner walls until they reach the next semiconductor laser. This repeater station amplifies and relays the information through the next section of fiber. At present, most fiber optical communication systems place a repeater unit every 12.5 miles (20 km). Once the signal-carrying light reaches its destination at the system terminal, the light signals are converted back into electrical signals, which are then converted into sounds or data.

Several advantages of fiber optical systems are significant:

Many more channels for communication can pass through a much thinner conductor. Less space is required for fiber optical cables than for copper electrical wire cables.

Fiber-optic communication is not subject to the electromagnetic interference which causes hum, static, and weakened signals in copper wires.

The ultrapure glass fibers are made of silica, a component of sand which exists in great abundance.

Fiber optic system linkups are currently being planned for the major cities of the Northeast and the major cities of California. In addition to increasing the capacities of telephone systems, fiber optic systems are being used to link computers, to transmit data at high speeds, to transmit video signals, and to guide and monitor urban transit systems.

Resource List

CURRENT PUBLICATIONS:

MERCURY'S WEB: THE STORY OF TELECOMMUNICATTIONS by James Jespersen and Jane Fitz-Randolph. (Illus. by Judith Fast.) NY: Atheneum, 1981. 226pp. $10.00. (Grades 7-12.)

TELEMATIC SOCIETY: A CHALLENGE FOR TOMORROW by James Martin. Englewood Cliffs, NJ: Prentice-Hall, 1981. 224pp. (2nd Edition of THE WIRED SOCIETY.) (Teacher.)

LASERS: LIGHT WAVES OF THE FUTURE by Allen Maurer. (Illus.; from the How-It-Works Series.) NY: Arco, 1982. 174pp. $12.85. (Grades 7-12.)

A LOOK INSIDE LASERS by Jim Johnson. (Illus. by Jay Blair and Mark Mille.) Milwaukee, WI: Raintree, 1981. 48pp. $10.25.

HIDDEN WORLDS by National Geographic Society. (Illus.; Books for World Explorers.) Washington, DC: National Geographic Society, 1981. 104pp. $6.95. (Grades 5-8.)

SENDING MESSAGES by John Warren Stewig. (Illus. by Richard D. Badley.) Boston: Houghton Mifflin, 1978. 64pp. $6.95. (Grades 3-6.)

SNAP! PHOTOGRAPHY by Miriam Cooper. NY: Julian Messner, 1981. 63pp. $7.95. (Grades 5-9.)

ACTIVITIES/CAREERS:

BELL SYSTEM AIDS TO EDUCATION. Communication materials: activities, careers, films, and teaching manuals. Free. For information contact your local Bell Telephone Company.

HOW TO MAKE AND USE A PINHOLE CAMERA. Instructions for making a working camera. Free. Write: Eastman Kodak Company, Rochester, NY 14650.

FILMS:

LANDSTAT, A SATELLITE FOR ALL SEASONS. A loan film series with accompanying teacher's guide. Each of the six films in the series runs 14 and 1/2 minutes. 1976. Free. For additional information write: NASA Headquarters, Publications Office, CODE: LFC-9, Washington, DC 20546.

THE LIGHT OF THE 21ST CENTURY. Reviews present day application as well as future uses of laser technology. 57 minutes, 1978. $65. rental. (Grades 7 & up.)

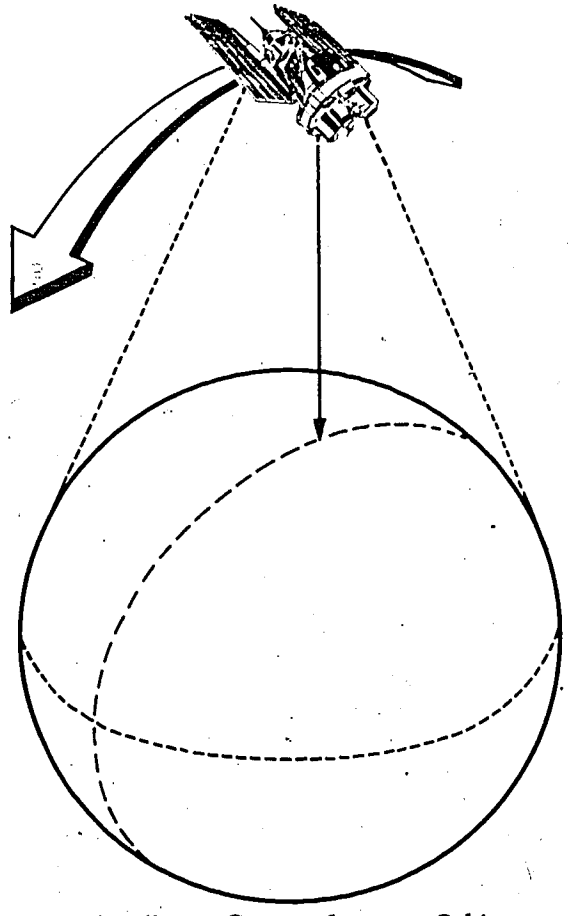
The Resource Lists for the six programs were compiled primarily from the following periodicals:

Children's Science Books 1981-82—Museum of Science and Industry, Chicago, Illinois

"Outstanding Science Trade Books For Children" (1978-82)—National Science Teachers Association/Children's Book Council Book Review Committee

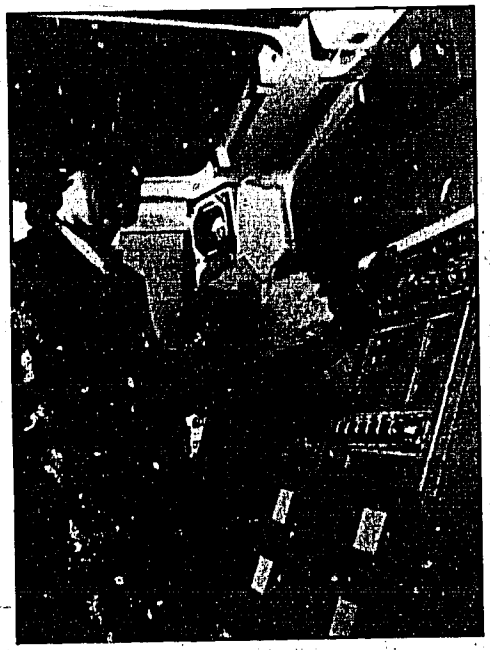
Science and Children—National Science Teachers Association (NSTA)

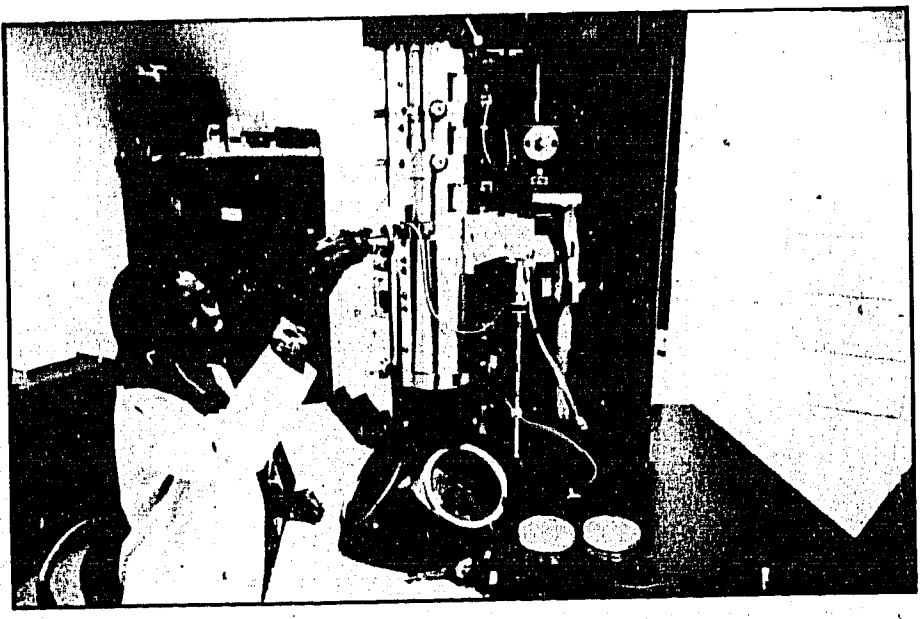
Science Books & Films—American Association for the Advancement of Science (AAAS)



Satellite in Geosynchronous Orbit

(Right) **Dr. Betty Jones** specializes in medical parasitology, tropical medicine, and electron microscopy. She also teaches biology at the college level.
(Below) **Mr. Jerry Elliott** is an aerospace engineer working in the Space Shuttle Program at NASA's Johnson Space Center.





(Below) **Dr. Robert Williamson** is a wildlife biologist conducting research on the relationships between wildlife and their environment.

(Right) **Dr. Tacheeni Scott** is the only full-blooded Native American microbiologist is the U.S. with a doctorate. He is involved in intracellular parasite research.

(Left) **Ms. Kathleen Chin** supervises computer software developers at Bell Laboratories, Piscataway, N.J.

(Above) **Dr. Dan Snedecor** monitors and develops computer graphics systems for Ford Motor Co. He also participates in pre-college programs and career day workshops.

Career Index

Introduction . . . . . **Page 32**

Individual Career Descriptions—Life Sciences . . . . . **Page 34**

- Biologist
- Biochemist
- Space Biologist
- Botanist
- Ecologist
- Agronomist
- Forester
- Horticulturist
- Entomologist
- Parasitologist
- Microbiologist
- Embryologist
- Pathologist
- Pharmacologist
- Physiologist
- Marine Biologist
- Aquaculturist
- Physician
- Experimental Psychologist
- Pharmacist
- Space Biomedical Researcher

Individual Career Descriptions—Physical Sciences . . . . . **Page 37**

- Astronomer
- Astronaut
- Astrogeologist
- Astrophysicist
- Chemist
- Chemical Engineer
- Physicist
- Atomic Physicist
- Optical Physicist
- Plasma Physicist
- Solar Energy Physicist
- Meteorologist
- Climatologist
- Geologist
- Petroleum Geologist
- Soil Conservationist
- Oceanographer
- Chemical Oceanographer
- Oceanographic Engineer

Individual Career Descriptions—Engineering . . . . . **Page 40**

- Engineer
- Aerospace Engineer
- Agricultural Engineer
- Civil Engineer
- Electrical Engineer
- Industrial Engineer
- Mechanical Engineer
- Petroleum Engineer

Individual Career Descriptions—Mathematical Sciences . . . . . **Page 41**

- Mathematician
- Operations Research Analyst
- Statistician

Individual Career Descriptions—Computer Science . . . . . **Page 42**

- Systems Analyst
- Programmer

Individual Career Descriptions—Technical Support . . . . . **Page 42**

- Technician
- Aerospace Engineering Technician
- Forestry Technician
- Medical Technologists
- Chemical Technician

Bibliography . . . . . **Page 44**

List of Organizations . . . . . **Page 44**

Career Index

This career index is designed for use by teachers, parents, students, and counselors and can be reproduced for distribution to all. It includes a discussion of the distinction between scientists, engineers, and technicians; a description of the main branches of science and engineering; and a list of careers in the life sciences, physical sciences, and mathematics.

Students who are considering careers as scientists, engineers, and technicians should enroll in high school college preparatory courses. A typical program would include:

ENGLISH Four Years

MATHEMATICS Four Years
(Algebra, Geometry, Trigonometry, Calculus)

NATURAL SCIENCES Four Years

SOCIAL SCIENCES Three Years
(History, Economics, Sociology, Psychology, Political Science)

FOREIGN LANGUAGES Two or more Years

ELECTIVES
(Computer courses if available, and others of interest to student)

In addition to these courses, science activities such as science fairs and clubs will provide valuable background experience.

Organizations concerned with the advancement of minorities in science and engineering, and professional organizations in each field, are listed for students who wish to obtain more information on training requirements, scholarships, and possible internships. Students should be encouraged to write to these organizations for more information about their particular career field.

A bibliography of books, pamphlets, and reference guides used to compile the information in this section appears on page 44. Students and teachers who wish to further investigate specific occupations should consult these materials, most of which are available in your school or public library.

What do Scientists Do?

Scientists investigate the unknown. They study the universe around us to learn why it behaves as it does. They investigate every aspect of our natural surroundings, from the center of the earth to the farthest star.

Scientists use a variety of methods in the course of their work. Some key words relevant to these methods include:

- Hypothesis
- Experiment
- Research
- Theory

As the first step, scientists begin their work with an *hypothesis* which is an unproved idea or plan to explain how something works or functions. An hypothesis that has considerable information or evidence in support of the explanation or idea, that is tentatively inferred, is called a *theory*. The second step is to learn what is already known about the scientific problem. This is called *research*. Research is necessary so the scientist does not have to spend time 'reinventing the wheel'.

After learning everything possible from the work of others, the scientist considers how to solve the problem at hand. Often moving towards the solution will involve some sort of *experiment*. Experiments must obey certain rules to be considered reliable. A reliable experiment results in solid conclusions drawn from experiment observations. An experiment is the process or action taken (sometimes referred to as tests) to discover something not yet known or to find whether or not something is effective, valid or workable. As such, scientists use the information they gather from experiments to either confirm or deny the *hypothesis* they started out with.

What do Engineers do?

Most discoveries of modern science would have remained in the laboratory if not for the work of engineers. Engineers are responsible for a variety of objects and products in our everyday environment: plastic, automobiles, radio and television, skyscrapers, bridges, airplanes, satellites. Engineers produced all these things by applying scientific knowledge to everyday problems. Most discoveries of modern science would have remained in the laboratory if not for the work of engineers. Engineers begin with a 'how to' problem—how to build a computer system, how to turn sunlight into electricity, etc. Like scientists, they do research to find a solution.

But finding solutions that work represents only the beginning. Engineers often must calculate the cost and difficulty of implementing their solutions. Engineers have to make sure that solutions are both economical and practical as well as technically sound.

Engineers solve problems by using a variety of tools, the most important being analytical tools. Analytical tools permit engineers to reshape their problems into manageable forms, and this helps in a search for a solution. Mathematical models are one such analytical tool. The model that an engineer builds is nothing more than a set of equations that describes the problem mathematically. By building a model, an engineer can examine the effects of change on different parts of the final product.

Engineers employ equipment of all sizes and shapes for measuring, calculating, and testing. Some tools remain in the lab while others are used outside. The computer is very important. It can perform calculations which are too long or too involved to do by hand. It can handle hundreds of equations at once, so that the engineer can build longer, more complex mathematical models.

What do Technicians do?

Scientists and engineers often work as part of a team. Another member of the team might be the *technician*. Technicians perform the day-to-day tasks necessary in creating a new project or running an operation. They operate testing and measuring equipment in a laboratory. They make drawings of new designs. They build physical models of new projects. They may inspect a manufacturing plant to see that a product's quality remains high, repair machines that break down, or act as sales representatives, selling products such as airplanes or computers.

Training for Scientific and Technical Occupations

Students interested in a career as a scientist, engineer, or technician, might be encouraged to begin thinking about. . . .

- *Hobbies*—Some leisure activities can teach skills that could be useful in science or engineering occupations. Examples are: using a chemistry set, building radios, fixing bicycles, observing the phases of the moon, making an ant colony.

- *Aquariums, Zoos, and Museums*—Visits to these places can provide valuable information on animals, the stars, the oceans, fish, and natural history.

- *Clubs and Science Fairs*—Churches, schools, community centers, and local colleges sponsor science clubs and science fairs, which are activities that can teach you more about science through experiments, projects and field trips. Ask your teacher or guidance counselor for advice on these opportunities.

- *Classes*—Formal training in science begins in high school. You should take as much *math* as possible, as well as *basic science courses—biology, chemistry, phsyics, earth science. Drafting* and *electronics* would also be useful for some career fields. *English* courses are important, too. Scientists, engineers, and technicians must be able to communicate clearly (orally as well as in writing) with their co-workers.

- *College*—Scientists and engineers generally earn a college degree after 4 or 5 years of study and if necessary, they go on to graduate school. Some science occupations require a Ph.D. Most engineers, however, find work with a bachelor's or master's degree. Technicians usually spend 2 or 4 years in special training programs after high school.

- *Reading*—In order to keep up with new discoveries, theories, and applications, scientists, engineers, and technicians read books and magazines, and attend conferences and seminars. You can learn more about science by reading, too. Ask your teacher or librarian for suggestions for books and magazines which are tailored to your special interests.

What Characteristics Indicate Potential Scientific Aptitude in Students?

A list of some important characteristics which may indicate a student's interest and/or aptitude for science includes:

- Enjoyment of science and math classes or subjects;
- Curiosity and inquisitiveness about many things; frequent pondering of why and how certain events occur;
- Enjoyment of abstract thinking, deductive reasoning, and mental exercise;
- Satisfaction in working with instruments;
- Pride in performing tasks well;
- Innovative approach to doing or making things;
- Confidence in one's ability to succeed;
- Capacity to work diligently;
- Persistence;
- Enjoyment of reading;
- Ability to reach decisions independently.

Careers in Science

The numerous branches of science all grow out of three basic fields:

LIFE SCIENCES, PHYSICAL SCIENCES,
and *MATHEMATICS*

Life Sciences

Life scientists study living organisms, especially the relationship of animals and plants to their environment. Many life scientists work in laboratories where they conduct basic research, adding to our knowledge of living organisms. Research can also take place in locations other than the laboratory. A *marine biologist*, for example, may spend days, weeks, even months aboard a vessel conducting research on marine life.

People working in the life sciences generally fit into two major categories: The *biological scientist* or the *medical scientist. The biological scientist* wants to know about life on earth, how plants and animals function and reproduce. Biologists usually specialize in one type of living thing such as *entomology* (the study of insects), *zoology* (the study of animals), or *botany* (the study of plants), etc. *The medical scientist* studies the human and specifically human diseases and how to control them. These scientists seek cures through research and differ from *health practitioners* who work directly with people.

Physical Sciences

Physical scientists expand our knowledge of the characteristics of matter and energy. Some do research, both applied and basic, while others develop new products or methods. There are two basic groups of physical scientists. The first group is made up of *physicists, chemists,* and *astronomers.*

Physicists investigate the behavior of light, electricity, magnetism, and gravity. They see how objects behave at very high speeds or very low temperatures. Past research in physics has provided knowledge for products and accomplishments such as: radio and television, nuclear energy, refrigeration, and space travel.

Chemists study the 103 known elements. Occasionally they discover new ones. They examine the chemical composition and properties of all substances and the reactions between substances. One job of the chemist is to observe and try to understand the physical processes going on around us. Another is to rearrange the atoms of known substances in order to produce new substance. *Astronomers* seek answers to questions about the nature of the universe such as its origin and history and the evolution of our solar system. They use the principles of physics and mathematics to study and determine the behavior of matter and energy in distant galaxies. They use telescopes, cameras, and other devices in order to answer age-old questions about the universe: How large is the universe? How were the stars and planets formed? How do they move? What are they made of? And is there intelligent life elsewhere in the universe?

The second group of physical scientists are referred to as *earth scientists* or *environmental scientists.* These scientists help to increase our knowledge of the earth's physical environment. They play an important part in solving environmental problems such as pollution. Scientists in these fields are concerned with the history, composition, and characteristics of the earth's surface, interior, and atmosphere. The earth or environmental scientists include *geologists, oceanographers, and meteorologists.*

Geologists explore new sources of oil and other fuels. They study the history and composition of our planet. Some also study movements such as earthquakes and volcanoes. *Meteorologists,* on the other hand, study the air surrounding the earth. They determine the effects of the motions

of the atmosphere on our physical environment. This knowledge is applied to forecasting weather and studying the climate and in solving problems relating to agriculture, transportation, communications, health, and national defense. *Oceanographers* focus on the oceans. By using laws and techniques of natural science, math and engineering, they examine the movements, properties, and plant and animal life of the oceans. Their research helps to expand our basic scientific knowledge. It also helps develop methods for determining weather, developing fisheries, mining ocean resources, and improving national defense.

Mathematics

The last branch of science, the mathematical sciences, is a science in its own right as well as being the language of other sciences. Biological and physical scientists could not have achieved as much as they have without discoveries in the field of mathematical sciences. Mathematics is the group of sciences (including algebra, geometry, calculus, trigonometry, etc.) dealing with quantities, magnitudes, and forms and relationships by use of numbers and symbols.

Mathematicians study the science of abstract numbers. Most mathematicians develop their theories to solve a specific problem. Many, however, produce theories that find practical use only much later.

Statisticians develop and use theories that allow scientists to make general statements about a group of people or objects without studying every member of the group.

An offshoot of the mathematical sciences is *Computer Sciences*. Computer sciences have become increasingly important and sophisticated as our society relies more heavily on advanced technology.

Life Science/Biological Scientists

Occupation: Biologist

Description:

Biologists study the origin, development, anatomy, function, distribution, and other basic principles of plants and animals. Most biologists specialize in research on a particular plant or animal, or on the relationship between plant and animal life. Many industries and fields (medicine, pharmacy, agriculture, forestry, wildlife management, and pest control) depend upon the biologist for basic scientific knowledge.

Training:

Young people seeking careers in the life sciences should obtain the broadest possible background in biology and other sciences. Useful high school courses include English, biology, physics, chemistry, geometry, algebra and typing.

Further Information:

American Institute of Biological Sciences
1401 Wilson Boulevard
Arlington, VA 22209

Federation of American Societies for Experimental Biology
9650 Rockville Pike
Bethesda, MD 20014

Related Specialties:

Biochemist

Biochemists study the chemical composition of living organisms, identifying and analyzing the chemical processes related to such biological functions as muscular contraction, reproduction, and metabolism. Their studies often lead to the discovery of the effects of substances such as food, hormones or drugs on various organisms. They sometimes seek cures for diseases or identify nutrients necessary to maintain good health.

Further Information:

American Society of Biological Chemists
9650 Rockville Pike
Bethesda, MD 20014

Ecologist

Some life scientists apply their specialized knowledge to a number of areas. Ecologists study the mutual relationships between organisms and their environments. They are interested in the effects on organisms of environmental influences such as pollution, rainfall, temperature, and altitude. For example, ecologists may take samples of plankton from bodies of water to determine the effects of pollution and to measure the radioactive content of fish.

Space Biologist

Space biologists study the role of gravity in evolution and normal life processes of living things on earth. These scientists use phenomena like zero gravity and cosmic radiation as research to explore the adaptive responses of plants and animals to the unfamiliar conditions of space. Understanding how terrestrial plants will grow in zero gravity as well as the effects of weightlessness on the developmental stages of animals is also important to these scientists.

Further Information:

Office of Educational Programs and Services
National Aeronautics and Space Administration
400 Maryland Avenue
Washington, DC 20005

Occupation: Botanist

Description:

Life scientists who work primarily with plants are called botanists. Some study all aspects of plant life, while others work in specific areas such as identifying and classifying plants or studying the structure of plants and plant cells. Some botanists concentrate on the cause and cure of plant diseases.

Training:
Like any of the life scientists, botanists should obtain the broadest background in biology and other sciences. Useful high school courses include English, biology, physics, chemistry, Latin, geometry, algebra, and typing. Computer experience is also helpful.

Related Specialties:

Agronomist
These scientists are concerned with the mass development of plants. They look to improve the quality and yield of crops by developing new growth methods or by controlling disease, pests, and weeds. They analyze soils to determine ways of increasing acreage yields and decreasing soil erosion.

Further Information:
American Society of Agronomy
677 S. Segoe Road
Madison, WI 53711

Forester
Foresters manage, develop, and protect forest resources including timber, water, wildlife, forage, and recreational areas. They plan and supervise the cutting and planting of trees and have other duties ranging from wildlife protection and watershed management to the development and supervision of camps, parks, and grazing lands. They often specialize in one area of work, such as timber management, outdoor recreation, or forest economics.

Further Information:
American Forest Institute
1619 Massachusetts Avenue, NW
Washington, DC 20036

American Forestry Association
1319 18th Street, NW
Washington, DC 20036

Society of American Foresters
5400 Grosvenor Lane
Washington, DC 20014

Horticulturist
Horticulturists work with orchards and garden plants such as fruit and nut trees, vegetables, and flowers. They seek to improve plant culture methods for beautification of communities, homes, parks, and other areas as well as for increasing crop quality and yield.

Further Information:
American Society for Horticultural Science
701 St. Asaph Street
Alexandria, VA 22314

Occupation: Zoologist

Description:
Zoologists focus on animal life—it's origin, behavior, and life processes. Some conduct experimental studies with live animals and some examine dissected animals in labs. Zoologists are usually identified by the animal group studied.

Training:
Some biological scientists such as zoologists, botanists, or ecologists may take field trips which involve strenuous physical activity and primitive living conditions. Recommended high school courses include: English, biology, physics, chemistry, Latin, geometry, algebra and typing.

Further Information:
American Society of Zoologists
Box 2739 California Lutheran College
Thousand Oaks, CA 91360

Related Specialties:

Entomologist
Entomologists study insects and their relation to plant and animal life. They may also examine insect habits to determine effective methods of pest control.

Further Information:
Entomological Society of America
4603 Calvert Road
College Park, MD 20770

Parasitologist
Parasitologists are concerned with animal parasites and their effect upon human beings and animals.

Further Information:
American Society of Parasitologists
1041 New Hampshire Street
Lawrence, KS 66044

Occupation: Microbiologist

Description:
Microbiologists investigate the growth and characteristics of microscopic organisms such as bacteria, viruses, and molds. They isolate the organisms and examine them under a microscope. Medical microbiologists are concerned with the relationship between bacteria and disease or the effect of antibiotics on bacteria. Other microbiologists specialize in soil bacteriology (the effect of microorganisms on soil fertility), virology (viruses), or immunology (mechanisms that fight infections).

Training:
The Ph.D. is generally required for college teaching, for independent research jobs, and other management positions. A master's degree is sufficient for some jobs in applied research. New graduates with a bachelor's degree can start their career as advanced technicians, particularly in medical research. Useful high school courses include: biology, English, physics, chemistry, Latin, geometry, algebra, typing, and computer experience.

Further Information:
American Institute of Biological Sciences
1401 Wilson Boulevard
Arlington, VA 22209

Pathologist
Pathologists specialize in the effects of diseases, parasites, and

insects on human cells, tissues, and organs. They may study genetic variations caused by drugs.

Further Information:
American Society of Clinical Pathologists
2100 W. Harrison
Chicago, IL 60612

Pharmacologist

Pharmacologists conduct tests on animals such as rats, guinea pigs, and monkeys to determine the effects of drugs, gases, poisons, dusts, and other substances on the functioning of tissues and organs. They may develop new or improved drugs and medicines.

Further Information:
American Society for Pharmacology and Experimental Therapeutics
9650 Rockville Pike
Bethesda, MD 20014

Physiologist

Physiologists study life functions of plants and animals under normal and abnormal conditions. They may specialize in functions such as growth, movement, or in the physiology of a certain body area or system.

Further Information:
American Physiological Society
Education Officer
9650 Rockville Pike
Bethesda, MD 20014

Occupation: Marine Biologist

Description:
Marine biologists study plant and animal life in the ocean. They search for ways to extract drugs from marine plants or animals, investigate life processes of marine animals, and determine the effects of radioactivity and pollution on marine life.

Training:
The chief requirement for employment as a marine biologist is a suitable educational background—either a bachelor's or master's degree for a junior level position—coursework in biology, especially laboratory assignments can give valuable experience. Field trips to federal and private laboratories and research centers are useful. Useful high school courses include: English, biology, physics, chemistry, Latin, geometry, algebra, and typing. Computer experience is also valuable.

Further Information:
Marine Technology Society
1730 M Street, NW
Washington, DC 20036

Related Specialty:

Aquaculturist

Aquaculturists raise fish for food. They work mainly in fish hatcheries and are responsible for providing a suitable environment for the type of fish being raised. To do this, they adjust the volume, depth, velocity, and temperature of the water. They also plan feeding programs and check fish for signs of disease.

Further Information:
American Fisheries Society
5410 Grosvenor Lane
Bethesda, MD 20014

Life Science/Medical Scientists/Health Practitioners

Occupation: Physician

Description:
A physician is a person of recognized experience, educational and legal qualifications who diagnoses, prescribes medicine for, and otherwise treats disorders of the human body.

Training:
The physician is required to spend many years of study before being able to practice. A high school student should enroll in a program which will prepare him or her for college. Prospective physicians are encouraged to take courses in English, foreign languages (especially Latin), the humanities, social studies, and mathematics, in addition to courses in biology, chemistry, and physics.

Career/Education Information:
American Medical Association Careers
535 N. Dearborn Street
Chicago, IL 60610

Association of American Indian Physicians
6801 S. Western, Suite 206
Oklahoma City, OK 73139

National Medical Association
1301 Pennsylvania Avenue, Suite 310
Washington, DC 20004

Student National Medical Association, Inc.
1133 15th Street, NW
Suite 1100
Washington, DC 20005

Related Specialties:

Experimental Psychologist

Experimental psychologists conduct scientific experiments on some particular aspect of behavior, either animal or human. Much experimental study is done in physiological psychology (the relationship of behavior to physiological processes) or comparative psychology (animal psychology). However, these are not the only areas in which psychologists work. Many psychological studies are carried out with animals because their environment can be carefully controlled. Some experimental psychologists are concerned with the effects of space travel on human behavior.

Further Information:
American Psychological Association
1200 17th Street, NW
Washington, DC 20036

Association of Psychologists for La Raza
4 Linden Drive
Boulder, CO 80302

Asian-American Psychological Association
Dr. Albert H. Yee
Dean, School of Education
University of Montana
Missoula, MT 59812

Society of Indian Psychologists
3181 SW Sam Jackson Road
White Cloud Center
VOHSCA—Gaines Hall, Rm. 255
Portland, OR 97201

The Association of Black Psychologists
P.O. Box 2929
Washington, DC 20013

Pharmacist

Pharmacists may be called druggists, registered pharmacists, or apothecaries. Pharmacists compound and dispense medicines and preparations as directed by prescription orders written by licensed physicians and dentists. Pharmacists often serve as consultants to health practitioners and the general public.

Further Information:
American Council on Pharmaceutical Education
One E. Wacker Drive
Chicago, IL 60601

National Pharmaceutical Association
Howard University College of Pharmacy
2300 4th Street, NW
Washington, DC 20059

Space Biomedical Researcher

These researchers investigate the major physiological (bodily) and psychological (mental and behavioral) problems experienced by humans traveling and working in space. Some issues they study are: motion sickness, radiation, human behavior, motivation, and relationships.

Further Information:
Office of Educational Programs and Services
National Aeronautics & Space Administration
400 Maryland Avenue
Washington, DC 20025

Physical Science

Occupation: Astronomer

Description:
Astronomers study the nature and properties of the universe and its heavenly bodies. They attempt to understand the origin of the universe. Astronomers also investigate planetary environments and compare them with the environment of the Earth. Instruments they use may include optical telescopes, spectrometers, photometers, and computers. They work with and interpret complex data made available as a result of America's space exploration efforts. Astronomers usually specialize in one brand of the science such as instruments and techniques, the sun, the solar system, or the evolution of stars and galaxies.

Training:
An astronomer must have a bachelor's degree in astronomy, mathematics, or physics to begin work in the field, and a doctorate is usually necessary for specialization and advancement. Interested high school students should enroll in a college preparatory program which includes courses in advanced mathematics, physics, chemistry, earth science, and foreign language.

Resource Information:
Education Office
The American Astronomical Society
University of Delaware
Newark, DE 19711

Related Specialties

Astronaut

Astronauts attempt to extend our knowledge of both outer space and our physiological and psychological adaptation to that environment. To this end they conduct experiments and gather information while in actual space flight and on the moon. They also conduct experiments with the spacecraft itself to develop new concepts in design, engineering, and the navigation of vehicles outside the earth's atmosphere.

Pilot astronauts concern themselves with conducting the space vehicle while mission specialist astronauts act as on-board scientists who conduct scientific experiments while in flight.

Further Information:

American Institute of Aeronautics and Astronautics, Inc.
1290 Avenue of the Americas
New York, NY 10019

Astrogeologist

Astrogeologists apply their knowledge of geology to interpretations of data in order to study surface conditions on the moon and other planets.

Further Information:
Office of Educational Programs and Services
National Aeronautics and Space Administration
300 Maryland Avenue
Washington, DC 20005

Astrophysicist

An astrophysicist is both an astronomer and a physicist who studies the composition of the planets and the stars. When the spectroscope (an instrument that analyzes light) was invented by

a physicist, a science called spectroscopy arose, which led to the analysis of the chemical elements of the stars. Today astrophysicists are studying the internal structure of the stars to learn how the planets of our solar system and the chemical elements found there, were formed.

Further Information:
American Astronomical Society
1816 Jefferson Place, NW
Washington, DC 20036

Occupation: Chemist

Description:
Chemistry is the science that studies the composition and properties of all substances and the reactions between substances. One job of the chemist is to observe and try to understand the physical processes going on around us. Another job is to rearrange the atoms of known substances in order to produce new substances. In this way, chemists can make new materials and improve or modify natural products. Chemists and chemical engineers also use their knowledge of chemical principles to help solve problems in agriculture, industry, health, and the environment.

Training:
The Bachelor's degree is the route to laboratory jobs in analysis research and development, or other technical areas which include much independent work. Jobs such as production supervision process, design and evaluation, are available to chemical engineering graduates. A bachelor's degree can also be used to advance in administration, sales, and other business areas in the chemical and related industries. In order to teach college classes or to conduct research programs, a master's degree or doctorate are required. People with Ph.D.s often supervise other chemists or technicians and determine the direction of a research project. Useful high school courses include: English, mathematics, including algebra and geometry, biology, chemistry, physics, social studies and foreign languages.

Further Information:
American Chemical Society
1155 16th Street, NW
Washington, DC 20036

American Institute of Chemists
60 E. 42nd Street
New York, NY 10017

Manufacturing Chemists Association
1825 Connecticut Avenue, NW
Washington, DC 20009

National Organization for the Professional Advancement of Black Chemists and Chemical Engineers
8 Longmeadow Road
Westboro, MA 01581

Related Specialties:

Chemical Engineer

Chemical engineers are concerned with chemicals which are produced and used by industry in large quantities. Problems they deal with are heat transfer, movement of materials, large scale mixing and separation, as well as the socio-economic factors involved in plant design, location, and production.

Further Information:
American Institute of Chemical Engineers
345 E. 47th Street
New York, NY 10017

Chemical Industry Minorities Engineering
P.O. Box 1931
Midland, MI 48640

Occupation: Physicist

Description:
Physicists study and analyze various forms of energy, the structure of matter, and the relationship between matter and energy. Their work leads to greater scientific knowledge and the scientific development of useful technological tools and materials.

Physicists are engaged in research and development. Some conduct basic research to increase our body of scientific knowledge. Theoretical physicists work primarily with mathematical concepts and formulas. Experimental physicists employ systematic observation and measurement, often designing new instruments for these purposes. Engineering oriented physicists work in research designing new or improved scientific products.

Training:
A bachelor's degree with a major in physics is the minimum requirement for a career as a physicist. In a number of settings, advanced degrees are necessary—prospective physicists will study a variety of mathematic and science subjects as a base for their specialization in physics. Recommended high school courses include following a college preparatory curriculum which includes a combination of courses in language arts, social studies, mathematics, and science.

Career/Education Information:
American Institute of Physics
335 East 45th Street
New York, NY 10017

National Society of Black Physicists
Bell Laboratories
600 Mountain Avenue
Murray Hill, NJ 07974

Related Specialties:

Atomic Physicists

Scientists working in this field try to improve methods of producing power. They may plan power plants which produce electricity. They do research in the structure and behavior of atoms.

Optical Physicists

Research physicists have created lasers, devices which amplify light and emit electromagnetic waves in a narrow, intense beam of light. Lasers are used in surgery, industry, defense, and space communications. Light beams can be used instead of radio waves for transmitting television and other communications. One beam can carry over one hundred separate television programs.

Plasma Physicists

Plasma physicists work with gases to produce energy. Plasma study is important to space exploration; scientists are investigating the possibility of plasma-propelled space vehicles.

Solar Energy Physicists

Some physicists work in industry using principles of physics to improve an old product or develop a new one. One example is scientists working in solar energy who attempt to convert solar power to electricity to be stored in batteries. Their knowledge of the behavior of electrons and how materials react to the sun helps in the development of products. This work may lead to the determination of how space stations will be powered.

Occupation: Meteorologist

Description:
Meteorologists study the gases that surround the earth and other planetary bodies. They investigate the interactions between the atmosphere, the sun, and planetary surfaces. Most familiar are the synoptic meteorologists (weather forecasters) who chart and interpret weather information reported by observers and use it to predict conditions and make weather forecasts.

Training:
The normal minimal requirement for work in the field is a bachelor's degree in meteorology or a degree in a related field with 20 semester hours of work in meteorology plus study in physics and mathematics. Advanced degrees are required for research and teaching positions. Recommended high school courses include: as much coursework as possible in mathematics, physics, chemistry, and if possible—French or German. The ability to draw accurately and neatly is also important.

Further Information:
American Meteorological Society
45 Beacon Street
Boston, MA 02108

U.S. Weather Bureau Environment
Services Division
Department of Commerce
Washington Science Center
Building 5
Rockville, MD 20850

Related Specialties:

Climatologists

Climatologists study past records to discover weather patterns for a given region. The climatologist compiles, makes statistical analyses of, and interprets data on temperature, sunlight, rainfall, humidity, and wind for a particular area over a long period of time for use in weather forecasting aviation, agriculture, commerce, and public health.

Further Information:
NOAA National Weather Service
National Oceanic and Atmospheric Administration
6010 Executive Boulevard
Rockville, MD 20852

Occupation: Geologist

Description:
Geologists study the physical aspects of the Earth, including its origin, history, composition, and structuring. Geologists may, through the use of theoretical knowledge and research data, locate oil, minerals and other raw materials, or aid in compiling architectural safety reports, maps, and diagrams. The geologist's tools include hammers, chisels, levels, compasses, seismographies, and gravity meters. They may work with photographs taken from aircraft, spacecraft, and satellites, and use computers to record and analyze data.

Training:
A bachelor's degree is the minimum education requirement. An advanced degree is required for research or teaching. Prospective geologists must study in a variety of fields including: physics, history, geography, minerology, math, and the arts and humanities. Useful high school courses include: college preparatory curriculum including science, mathematics, language arts, social studies, foreign languages.

Further Information:
American Geological Institute
5205 Leesburg Pike
Falls Church, VA 22041

Related Specialists:

Petroleum Geologists

These geologists comprise the vast majority of geologists. They attempt to locate natural gas and oil deposits through exploration and study the data they obtain. They recommend the acquisition, retention, or release of company owned and leased properties. They also estimate oil reserves and assist petroleum engineers in determining production procedures.

Further Information:
American Petroleum Institute
Box 957
Golden, CO 80401

Soil Conservationist

Soil conservationists study the physical, chemical, and biological traits of soils. They examine soils in the field and the lab and classify them according to a national system of soil classification. This helps determine the soil capability for crops, grasses, and tree production and its suitability for foundations of buildings and other structures.

Further Information:
Soil Conservation Society of America
7515 N.E. Ankeny Road
Anekeny, Iowa 50021

Occupation: Oceanographer

Description:
Oceanographers use the principles and techniques of natural science, mathematics, and engineering to study the oceans—their movements, physical properties, and plant and animal life. Their research extends basic scientific knowledge and also helps develop practical methods for forecasting weather, developing fisheries, mining ocean resources, and improving national defense.

Training:
A bachelor's degree is required for beginning positions in oceanography. Graduate work is required for most positions in research and teaching. Useful high school courses should include as many basic and advanced courses in mathematics and science as are available.

Further Information:
International Oceanographic Foundation
3979 Rickenbacker Causeway
Virginia Key
Miami, FL 33149

Woods Hole Oceanographic Institution
Woods Hole, MA 02543
(also see Marine Biologist and Limnologist)

Related Specialties:

Chemical Oceanographers
Chemical oceanographers investigate the chemical composition of the ocean water and sediments as well as chemical reactions in the sea.

Oceanographic Engineers
Oceanographic engineers design and build instruments for oceanographic research and operations. They may lay cables and supervise underwater construction.

Applied Science—Engineering

Occupation: Engineer

Description:
Engineers find practical applications for abstract scientific principles. The emphasis is not on the discovery of scientific principles, but on their application. The role of the engineer is to find a practical use for what the scientist discovers. Through the application of mathematics, science, experience, and practical judgment, the engineer creates new products, processes, procedures, or systems. An engineer may conduct experiments, design a device, calculate the time and money needed to produce an item, or investigate the durability of an item.

Training:
A bachelor's degree in engineering is the minimum educational requirement for beginning engineers. Many engineering schools now offer 5-year programs. Related summer work experience is also helpful.

Interested high school students should follow a college preparatory program of courses and should strive for good grades in English, social studies, algebra, geometry, economics, physics, chemistry, biology, and trigonometry. Other useful courses include foreign languages, graphics and art, and computer programming.

Junior engineering societies and science enrichment after-school programs are usually available in a student's region. These are good sources of information and experience.

Further Information:
American Indian Council of Architects and Engineers
P.O. Box 111
Edmond, OK 73034

American Society for Engineering Education
One Dupont Circle
Washington, DC 20036

Junior Engineering Technical Society
345 E. 47th Street
New York, NY 10017

Minority Introduction to Engineering
345 E. 47th Street
New York, NY 10017

National Action Council for Minorities
in Engineering, Inc.
3 W. 35th Street
New York, NY 10001

National Society of Black Engineers
317 Clermont Avenue
Brooklyn, NY 11205

Related Specialties:

Aerospace Engineer
Aerospace engineers work in the development of space exploration, including a variety of missiles, rockets, spacecraft and satellites, and are concerned with the entire development of aerospace products, from conception through the testing and production. They generally specialize in a particular phase of aerospace engineering, such as structural design, or testing.

Further Information:
American Institute of Aeronautics and Astronautics, Inc.
1290 Avenue of the Americas
New York, NY 10019

National Society of Professional Engineers
2029 K Street, NW
Washington, DC 20006

Agricultural Engineer
Agricultural engineers now work in many phases of agriculture and the food industry to produce better breeds of animals, better strains of plants, and design machines that plant and harvest more efficiently.

Further Information:
American Society of Agricultural Engineers
2950 Niles Road
St. Joseph, MI 49085

Civil Engineer
Civil engineers design and supervise the construction of bridges, highways, dams, water-supply and sewage systems, power plants, factories, parks, and sanitation facilities. They also develop public transportation programs and the control networks that link the nation's highways and transit systems.

Further Information:
American Society of Civil Engineers
345 E. 47th Street
New York, NY 10017

Electrical Engineer

Electrical engineers design, develop and supervise construction of everything which uses electricity—from huge power-generating systems to miniature circuits for computers and transistor radios.

In the communications industry, electrical engineers design and oversee the production of TV and radio broadcasting equipment, and telephone and communications satellite systems. They also work in the operation and maintenance of these systems. Electrical engineers have been responsible for advances in the development of products such as lasers, fiber optics, robotics, radar, remote sensing, and holography.

Industrial Engineer

Industrial engineers are concerned with production processes and seek the most efficient way to utilize materials, machines, and employees. They are often responsible for the plant layout—the arrangement of machinery and equipment. They plan the work flow and work areas. Their supervisory functions often include the selection of tools, machines, and other equipment, as well as the manufacturing processes and procedures to be employed. They analyze various production jobs and devise systems for controlling inventory of materials and accounting procedures and study the quality and cost of materials.

Further Information:
American Institute of Industrial Engineers
25 Technology Park
Atlanta, GA 30092

Mechanical Engineer

Mechanical engineers are concerned with the design, manufacture, and operation of a wide range of components, devices and systems. All forms of energy—solar, nuclear, wind, water, oil, and gas—are used by these engineers to produce and use power. Some design machines that produce power such as steam and gas turbines, jet and rocket engines, and nuclear reactors. others design systems that use power such as elevators, air conditioning equipment, and printing presses.

Further Information:
American Society of Mechanical Engineers
345 E. 47th Street
New York, NY 10017

Petroleum Engineer

The work of the petroleum engineer mainly involves drilling and and producing oil and gas with the best and most efficient drilling methods. Petroleum engineering research and development aims to increase the amount of oil recovered. This is an important contribution to increasing our available energy resources. Most petroleum engineers are employed by oil companies and by drilling equipment manufacturers.

Further Information:
American Institute of Mining, Metallurgical, and Petroleum Engineers
345 E. 47th Street
New York, NY 10017

Mathematical Sciences

Occupation: Mathematician

Description:
Mathematicians are engaged in a number of activities ranging from creating new theories to translating scientific and managerial problems into mathematical terms. The work of the mathematician falls into two categories: theoretical and applied mathematics. Theoretical mathematicians develop new principles and new relationships between existing principles of mathematics. Applied mathematicians use mathematics to develop theories, techniques, and approaches used to solve practical problems in many different fields of science, engineering, business, and government. Their work has a variety of applications—from the mathematical analysis of launching Earth satellites to the effects of new drugs on disease.

Training:
The minimum requirement for mathematicians is a bachelor's degree with course work in analytical geometry, calculus, differential equations, probability, and statistics and mathematical analysis. Many colleges are also requiring mathematics students to take coursework in allied fields such as computer science, operations research, economics, or physical science.

Useful high school courses include all the mathematics and science courses available. Introductory computer courses are also recommended.

Further Information:
American Mathematical Society
P.O. Box 6248
Providence, RI 20940

Mathematical Association of America
1529 18th Street, NW
Washington, DC 20036

Society for Industrial and Applied Mathematics
33 S. 17th Street
Philadelphia, PA 19103

Related Specialties:

Operations Research Analyst

Operations research is the mathematics of decision-making. This analyst constructs simple mathematical models of complex business and economic structures. These models are used to help in predicting future needs.

Statistician

Statisticians use numbers to help describe the characteristics of the world and its inhabitants. They devise, carry out, and interpret the numerical results of surveys and experiments. They usually apply their knowledge of statistical methods to a particular field such as economics, human behavior, natural science, and engineering. Statisticians use statistical techniques to perform a variety of activities. Examples are: predicting population growth or economic conditions, developing quality control tests for products, or helping business managers and government officials to make decisions and evaluate the results of new programs.

Further Information:
American Statistical Association
806 15th Street, NW
Washington, DC 20005

Institute of Mathematical Statistics
3401 Investment Blvd., No. 6
Hayward, CA 94545

Computer Science

Occupation: Systems Analyst

Description:
Many essential technical functions and scientific research projects depend on systems analysts to plan efficient methods of processing data and handling the results. Analysts begin an assignment by discussing the information processing problem with managers or specialists, to determine the exact nature of the problem and to break it down into its component parts. If a new inventory system is desired, for example, systems analysts must determine what new data must be collected, the equipment needed to make computations, and the steps to be followed in processing the information.

Training:
Generally, college graduates are sought for positions in systems analysis, with emphasis on different majors, depending on the specific kind of work. For complex jobs, persons with graduate degrees are preferred. A growing number of employers seek applicants who have a degree in computer science, information systems, or data processing. In many industries, systems analysts begin as programmers and are promoted to analyst positions after gaining experience. Useful high school courses include: mathematics including algebra, calculus, trigonometry, and any computer science courses available.

Further Information:
American Federation of Information Processing Societies
1815 North Lynn Street
Arlington, VA 22209

Association for Systems Management
24587 Bagley Road
Cleveland, OH 44138

Related Specialties:

Programmer

Programmers work in the field of electronic data processing. Because machines cannot think for themselves, it is the job of the programmer to write detailed instructions called programs that list in a logical order the steps the machine must follow to organize data, solve a problem, or do some other task.

Further Information:
Association for Computing Machinery
1133 Avenue of the Americas
New York, NY 10036

Data Processing Management Association
505 Busse Highway
Park Ridge, IL 60068

Technicians/Technologists

Occupation: Technician

Description:
The technician often serves as a technical assistant to an engineer or scientist. After knowing the basic ideas, the technician carries out the detailed work necessary for the project. An electronics technician, for example, may make the standard calculations for estimating the cost of electronic equipment or prepare service manuals for it. They may check, test, or maintain equipment according to standards set by an engineer.

Training:
Useful high school courses include college preparatory courses, which are essential. Most positions require technical training in a particular specialty. A 2-year program of training at a community college, technical institute, university extension service, or a vocational high school can provide the necessary training. On-the-job experience and apprenticeship programs may also provide necessary training.

Related Specialties:

Aerospace Engineering Technician:

These technicians help engineers and other scientists convert space age theories into practical realities. They work as part of a team in all phases of the aerospace industry, from theory through construction, testing, and operation. They check or prepare drawings, diagrams, tests on materials, parts, and systems to measure reliability. Specific duties vary with the area of specialization and kind of project. Aerospace engineering technicians use wind tunnels, acoustical lab equipment, fatigue test machines, vacuum chambers, and similar complex instruments and testing apparatus in their work.

Further Information:
American Society of Certified Engineering Technicians
2029 K Street, NW
Washington, DC 20006

Forestry Technician

These workers help foresters care for and manage forest lands and their resources. They may help estimate timber production; inspect trees for disease and other problems; help prevent and control fires; and maintain forest areas for hunting, camping, and other activities.

Further Information:
Society of American Foresters
5400 Grosvenor Ln.
Washington, DC 20014

Medical Technologists

The medical technologist works in a laboratory and is usually trained in a highly specialized curriculum and certified by one of several laboratory technologist societies. In the laboratory, the technologist is supported by technicians and assistants in analyzing blood or tissue specimens using precision instruments, and reporting results to medical staff.

Further Information:
American Medical Technologists
710 Higgins Road
Park Ridge, IL 60068

Chemical Technician

Chemical technicians work in government agencies, or research labs and in manufacturing industries where chemistry is important. In industry, they work in labs where they perform a number of chemical tests and procedures. In research and development they carry out procedures which have been set up by research chemists. They are also employed in industry to perform tests during large-scale factory production of chemical products. These tests tell whether the manufacturing process is going along smoothly.

Further Information:
American Institute of Chemists
60 E. 42nd St.
New York, NY

Bibliography

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Mary H. Lewis, Academic Affairs Division,
National Aeronautics and Space Administration
Washington, DC, 1980

Physical Sciences Jobs Handbook
Ronald B. Vleck, Ph.D.,
Editor in Chief
Prospect Press
Gaithersburg, MD, 1981

Exploring Careers
U.S. Department of Labor Statistics,
Bulletin 2001, 1979

Jobs in Science/Job Family Series/Number 1
Science Research Associates, Inc.
Chicago, IL, 1970

Careers in Chemistry
Opportunities for Minorities
Project SEED
American Chemical Society
Washington, DC, 1976

Engineering A Future
A Guide to Engineering for Parents
and Counselors of Minority Students
Richard T. Mullins, *Executive Director*
Minority Engineering Education Effort
New York, NY, 1977

Encyclopedia of Careers and Vocational Guidance
Fifth Edition, Vols. I and II
William E. Hopke, *Editor in Chief*
J.G. Ferguson Publishing Company
Chicago, IL, 1981

Occupational Outlook Handbook
U.S. Bureau of Labor Statistics, 81-82

Organization List

The following is a list of some organizations which are concerned with the Professional Advancement of Minorities in Science and Engineering. Students may be interested in contacting them for information on scholarships, internships, and career information.

American Association for the Advancement of Science
Office of Opportunities in Science
1776 Massachusetts Ave., NW
Washington, DC 20036

American Chemical Society
Project SEED
1155 Sixteenth Street, NW
Washington, DC 20036

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c/o A. T. Anderson, Executive Director
Anderson Research Consultants, Inc.
35 Porter Avenue
Naugatuck, CT 06770

Association for Puerto Ricans in Science and Engineering (APRSE)
Box 1725
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Mathematical Association of America
1529 Eighteenth Street, NW
Washington, DC 20036

Minority Introduction to Engineering
345 E. 47th Street
New York, NY 10017

National Action Council for Minorities in Engineering, Inc.
3 West 35th Street
New York, NY 10001

National Technical Association, Inc.
1425 H Street, NW
Suite 701
Washington, DC 20005

Organization of Black Scientists, Inc.
c/o Dr. Franklin Hamilton
Department of Chemistry
Atlanta University
223 Chestnut Street, SW
Atlanta, GA 30314

Society for the Advancement of Chicanos and Native Americans in Science (SACNAS)
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Appendix

Interview Guidelines 46

Student Viewing Sheets
- Space 47
- The Body 49
- Computers 51
- Ecology 57
- Energy 59
- Communications 61

Student Information Sheets
- Space—Aerospace Job Search 48
- The Body—Who Works On The Human Body 50
- Computers—Computer Careers Match 52
- Computers—Our Electronic Counting Machine 53
- Computers—Our Electronic Counting Machine (Continued) 54
- Computers—How Does It Work? 55
- Computers—What Is Its Language? 56
- Ecology—Ants and Termites 58
- Energy—Help Wanted 60
- Communications—How The Telephone Works . . . 62

Student Activities and Teacher Information Sheets
- Cooperative Logic Problems—Directions 63
- Space—Planets 64
- Computers—Salary Scramble 65
- Ecology—Ecology Fair 66
- Communications—Who Will Be Accepted 67
- Space—Designing A Space Shuttle 68
- The Body—This Is Your Lifeline 69
- Ecology—Environmental Engineering 71
- Energy—Do You Want To Be An Engineer? 75
- Communications—Build The Highest Tower 78

Career Skits—Evaluational Activity 79

Answer Key 80

Interview Guidelines—Teacher Information Sheet

This format, with some modifications, can be followed with each person invited to visit your class.

I. Preparation

A. Inform your guest of the SPACES television series and the kinds of activities that will precede and follow his or her visit.

B. Discuss the interview questions with students, encouraging them to change or add questions.

C. Assign special tasks such as a host or hostess, someone to introduce speaker to class, discussion leader.

II. Interview Questions*

A. Background

1. How did you become a _____?
2. Where did you study?
3. What courses did you study?
4. What was your most difficult course?
5. What degrees do you have?
6. Do you have training other than school?
7. Are any major tests or licenses required?

B. Work

1. What is your workplace like?
2. What skills do you need to be a _____?
3. Do all _____ do the same things?
4. What tools do you use?
5. Do you use a computer?
6. Do you work with technicians, other scientists or engineers?
7. What is the hardest part of your job?

C. Professional Life

1. What journals and magazines are related to your field?
2. What is a professional society? Do you belong to one?
3. What is the advantage of belonging to a professional society?
4. Do _____ continue their education after graduation? Why or why not?
5. How have things changed since you graduated from school?

D. The Field

Students should generate questions based on the things that interest them in that particular field.

Adapted from Yellow Pages of Learning Resources *edited by Richard Saul Wurman, 1972. Group for Environmental Education, Inc.*

Space—Student Viewing Sheet

Name _____ Date _____

This SPACES show will be aired at _____ A.M./P.M. on _____

Channel _____ .

In this show you will meet two aerospace scientists. Listen carefully as they describe their work. Observe their workplaces and notice the equipment they use. The notes you record on this sheet will help you remember what you have seen and heard.

1. Dr. Franklin Chang has completed training as an _____

but he is also a _____ and does research on

_____

What are some of the things he had to do while in training?

_____

_____

_____

2. Dr. Patricia Cowings works for _____ as a psychologist. She is interested in how your mind can cause changes in your body.

What space-related problem is she working on? _____

_____

How will this help the astronauts? _____

_____

3. The high school students from Camden, NJ used _____ in their space shuttle experiment. Why did they send these insects into space?

_____

_____

_____

Name _____ Date _____

Astronomer, Dr. Yoji Kondo is in charge of all science activities related to NASA's satellite telescope. This telescope is orbiting 36,000 kilometers(22,356) miles above the earth.

Dr. Kondo teaches Judo and Aikido in his spare time.

AEROSPACE JOB SEARCH

The twenty aerospace careers listed are also hidden in this puzzle. Some are written across, some down, and a few are written on a diagonal (slant). Find and circle them. Check each one off on the list as you find it in the puzzle.

B	I	O	L	O	G	I	S	T	P	H	Y	S	I	C	I	S	T
I	A	P	S	T	R	M	O	E	N	G	I	N	E	E	R	A	C
O	T	I	P	S	O	P	Y	C	X	C	A	S	B	Y	T	R	R
M	L	O	A	O	U	N	P	H	Y	S	I	C	I	A	N	P	E
E	S	T	Y	N	N	V	B	N	F	K	I	R	X	O	P	N	Z
D	A	C	L	E	D	M	U	I	M	D	C	I	R	C	A	K	T
I	M	X	O	F	C	S	T	C	O	M	M	A	N	D	E	R	X
C	B	D	A	R	R	O	C	I	H	J	R	U	T	I	P	E	F
A	O	S	D	R	E	B	L	A	X	E	P	P	M	A	M	R	Z
L	D	M	S	V	W	Q	S	N	T	A	M	C	I	F	A	K	F
E	F	E	P	S	Y	C	H	O	L	O	G	I	S	T	T	G	L
N	P	K	E	U	J	T	R	U	B	W	P	H	S	N	H	A	I
G	I	G	C	O	T	Z	V	I	D	K	R	O	I	T	E	S	G
I	W	T	I	B	W	E	T	T	A	H	M	R	O	Q	M	B	H
N	E	X	A	I	X	H	R	F	T	P	B	F	N	E	A	O	T
E	M	P	L	S	S	B	C	P	I	L	O	T	S	X	T	E	C
E	S	T	I	A	T	R	D	D	R	M	A	A	P	S	I	U	O
R	O	A	S	Z	K	R	J	B	H	O	I	L	E	N	C	V	N
C	I	M	T	D	H	N	O	R	U	S	G	Q	C	L	I	G	T
A	S	R	A	S	T	R	O	N	O	M	E	R	I	O	A	E	R
H	A	B	D	R	I	S	B	E	A	P	O	L	A	N	N	E	O
O	S	T	E	S	A	L	K	E	T	U	X	T	L	M	F	G	L
T	E	C	H	N	O	L	O	G	I	S	T	G	I	H	M	I	L
S	I	C	G	E	Q	U	I	B	X	D	J	O	S	P	A	E	E
G	A	S	U	P	G	E	O	L	O	G	I	S	T	I	G	A	R

ASTRONOMER
ASTRONAUT
BIOLOGIST
BIOMEDICAL ENGINEER
CHEMIST
COMMANDER
COMPUTER PROGRAMMER
ENGINEER
FLIGHT CONTROLLER
GEOLOGIST
GROUND CREW
MATHEMATICIAN
MISSION SPECIALIST
PAYLOAD SPECIALIST
PHYSICIAN
PHYSICIST
PILOT
PSYCHOLOGIST
TECHNICIAN
TECHNOLOGIST

The Body—Student Viewing Sheet

Name _____ Date _____

This SPACES show will be aired at _____ A.M./P.M. on _____

Channel _____ .

Both of the adult scientists featured in this show are conducting research experiments to learn more about the human body. Observe their workplaces and notice the equipment they use. Do they talk about their educational training? Take notes.

1. Dr. Allen Counter is a *neurobiologist.* In his research he studies _____

_____

From listening to him I learned:

_____

_____

2. Dr. Lydia Villa-Kamaroff is a *molecular biologist.* Describe her workplace. _____

_____

What special equipment does she use?

_____

What is she trying to find out through her research experiments? _____

_____

3. Student scientist Jeannie Lo is working on a science problem which involves

_____

_____

How is she like you? _____

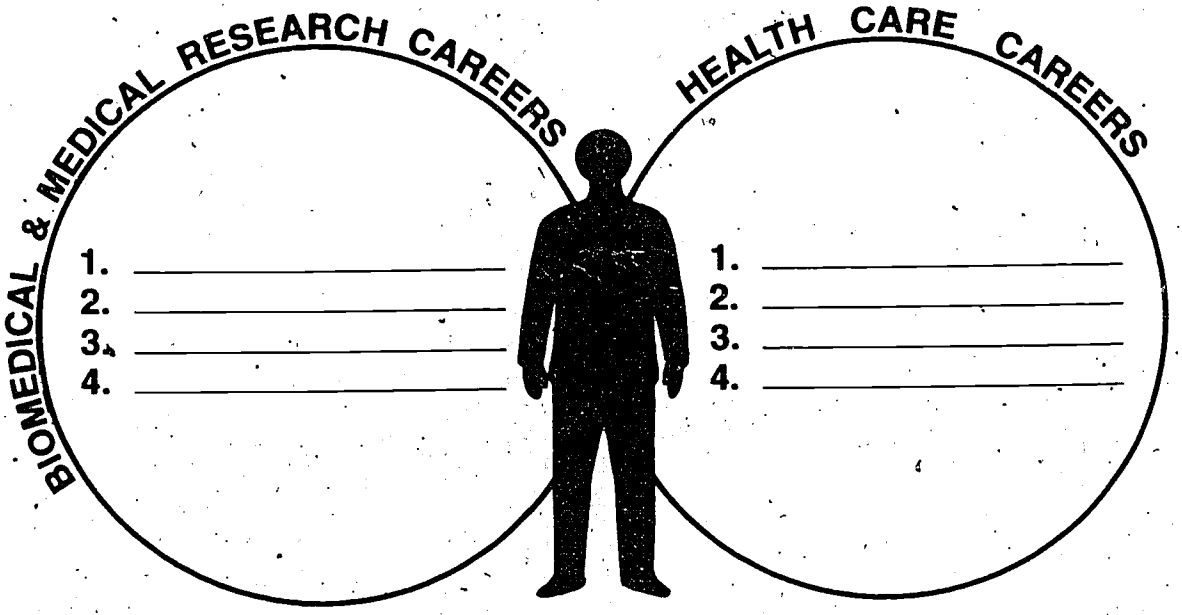
How is she different from you? _____

_____

50 The Body—Student Information Sheet

Name _____ Date _____

WHO "WORKS ON" THE HUMAN BODY?



Select the four most interesting for each circle and fill them in.

molecular biologist
physical therapist
dentist
parasitologist
medical technologist
nurse
X-ray technician
geneticist
physician
laboratory technician
neurobiologist
pathologist
pharmacist
biochemist
microbiologist
space biomedical researcher

a. People with careers in HEALTH CARE FIELDS diagnose and treat illnesses. They also help people to learn better ways of taking care of their bodies. Put HC in front of these people in this list. They usually work in hospitals, medical offices, and clinics.

b. People with careers in MEDICAL and BIOMEDICAL RESEARCH conduct experiments in laboratories. Their experiments and studies are set up to help them learn more about the things that no one, including physicians, fully understands about the human body. Their discoveries lead to new and better health care practices. Put MR in front of these people in this list. Use a dictionary or encyclopedia to help you.

GENETICIST, Dr. Frank Dukepoo has done research on how certain traits are passed from parents to children through the tiny genes in the cells. He was the first Hopi Indian to receive a Ph.D. degree.

BIOMEDICAL RESEARCHER and college teacher, Dr. Betty Jones, is shown here in her laboratory with an electron microscope. This instrument is necessary for her research work on parasites and tropical diseases.

Computers—Student Viewing Sheet

Name _____ Date _____

This SPACES show will be aired at _____ A.M./P.M. on _____

Channel _____.

The Computer Show will take you behind the scenes into a musician's studio and to a factory where computers provide workers with supplies. Notice the various ways the musician and the engineer use the computer to help them in their work. Ecology is a special area of biology, the study of living things. Ecology is the study of the way living things live together and how they live in their environment.

1. Ms. Nancy Wallace's occupation is manufacturing engineer. In her job she must _____

_____

_____

What are robots used for on her job? _____

_____

_____

_____

2. Musician Lee Ray uses the computer to _____

_____

_____

_____

_____

3. Why were robots included in this show on computers? _____

_____

_____

52 Computers—Student Information Sheet

Name _____ Date _____

COMPUTER CAREERS MATCH

Here are nine computer-related jobs. Match the correct description with its job. Write the letter for it on the line in front of the job.

_____1. Computer Programmer*	a. Sells computers and related services.
_____2. Data Processing Manager	b. Uses a keyboard-like machine to punch holes in cards which will carry data into the computer.
_____3. Key Punch Operator	c. Supervises storage systems for and keeps records of a computer's tapes and disks.
_____4. Computer Sales Representative	d. Supervises the people who program and operate a computer.
	e. Controls and schedules jobs for the computer
_____5. Computer Service Technician	f. Develops new and improved computers.
_____6. Computer Design Engineer*	g. Repairs computers.
_____7. Computer Programmer*	h. Writes instructions for the computer.
_____8. Systems Analyst*	i. Studies the way a company operates. Decides which jobs should be done by a computer.
_____9. Tape and Disk Librarian*	

*Although a college degree is desirable for most of these jobs, it is required for those with a *.

Mr. Dan Snednecor develops computer graphics systems for Ford Motor Company. These computer programs use data to create line drawings on a video screen. He majored in math in college and went on to earn a Master of Science degree in mathematics.

Name the jobs that require a college degree:

_____

_____

_____

_____

Name _____ Date _____

The Computer—Our Electronic Counting Machine

I. The earliest counting machines were probably sticks and stones. About 5,000 years ago, in Asia, the abacus was developed. An *abacus* has groups of movable beads on rods. The position of the bead on the rod lets you know what number the bead represents. In some parts of the world many people, especially storekeepers still use the abacus for computations.

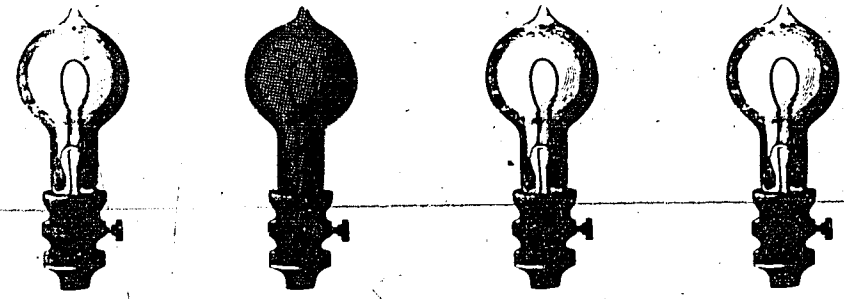
II. Our modern electronic computers are also based on the idea of using a certain position to represent a certain number.

You already know that in our decimal number system, 20 means that there are 2 tens and 0 ones. The 2 in the tens position tells us its value. In the decimal system we count by 10's, using our ten numerals.

III The computer uses a different number system, the binary system (bi means 2). The computer's number system uses only two numerals: 0 and 1. Using just two numerals makes it possible for electricity to be quickly switched on or off in the tiny storage units of the computer's memory.

To the computer 1 means the switch is on and the electricity flows.

This changing back and forth from off to on or 0 to 1 creates an electrical pulse.



1 0 1 1 = 11

Binary Decimal

Name _____ Date _____

The Computer—Our Electronic Counting Machine

IV. A computer must change our number symbols into the two numerals it can use.

These two numerals are _____ and _____ .

YOUR OUTPUT:

Look at this chart showing computer numbers from zero to twenty. Fill in the decimal system numbers.

Computer	Decimal
0	0
1	
10	
11	
100	
101	5
110	

Computer	Decimal
111	
1000	
1001	
1010	10
1011	
1100	
1101	

Computer	Decimal
1110	
1111	
10000	16
10001	
10010	
10011	
10100	20

V. MORE OUTPUT: (Review your computer careers match sheet.)

By now you have probably concluded that math is very important for those who work with computers. You are right, but some jobs require the higher math skills learned in courses that come after high school algebra, geometry, trigonometry and calculus.

Name two of these jobs: _____

_____

At least two computer occupations require knowledge of electricity and electronics.

Can you name them? _____

_____

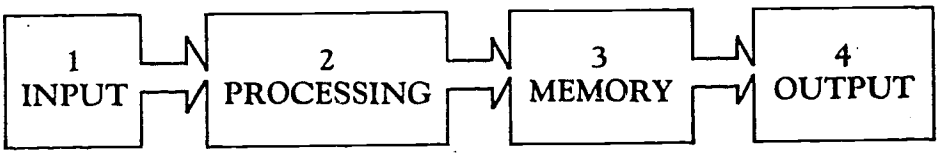
Computers—Student Information Sheet

Name _____ Date _____

The Computer—How does it work?

The information put into a computer is called *data.* Data is the plural of the word datum. Data is often used with a singular verb. We use the plural because we must give the computer more than one piece of information when we want a job done.

A computer goes through four basic steps with data is it performs a given job. Those steps are:



Step 1 INPUT: Data is usually put into the computer by typing on a typewriter-like keyboard.

The computer changes each letter of our alphabet and each decimal system number into a binary number which uses only 0's and 1's. This is done when the words and numbers are typed on the keyboard.

The information, called a *BIT,* then travels as an electrical pulse to the processing unit of Step 2.

Step 2 PROCESSING: The Central Processing Unit performs arithmetic or arranges the data.

Step 3 MEMORY: The memory is made up of millions of very tiny units. These store the bits of input and output information.

Step 4 OUTPUT: The information or data is changed from bits to words, numbers, or lines. This information may be given to the computer operator in the form of printed material or video screen pictures.

This output information can also be on a magnetic tape or disc which can be fed into another computer.

YOUR INPUT:

Pretend that you are a computer operator, a computer service technician or a computer sales representative. There are certain words that you must use in your work.

List six words important to your work with computers.

_____ _____ _____

_____ _____ _____

Name _____ Date _____

The Computer—What is its language?

Although computers can do many things faster and more efficiently than we can, they can only do these things because of human beings. A person must give the computer the instructions to do a certain task. These instructions are called a program and the person who writes them is called a computer programmer.

A computer programmer must first study a problem. Then he or she must list the most logical steps for solving the problem. This information must be written as instructions in a special language which the computer understands. The language used depends on the kind of job to be done. The following chart gives some examples of computer languages and their uses.

LANGUAGE	USE
BASIC (Beginning All Purpose Symbolic Instruction Code)	education and business
FORTRAN (Formula Translation)	math and science
COBOL (Common Business Oriented Language)	business
LISP	artificial intelligence (robots)
SIMSCRIPT	creating models of real situations
PASCAL	general purpose language (especially useful in education and microprocessing)

COMPUTER SCIENTIST, Ms. Kathleen Chin supervises a group of people who develop computer *software* for Bell Telephone Laboratories. *Software* is another term for computer programs. The programs are used on computer equipment known as *hardware.*

Ms. Chin majored in math and computer science in college. She has a master's degree in Computer Science.

YOUR INPUT:

Select the best computer language for the following situations:

Robotics Inc. needs its new robot programmed. _____

Provential Insurance wants all its charts of figures computerized.

_____

Ms. Verbal wants a program written to teach English grammar.

_____

The telephone company is computerizing customer billing records.

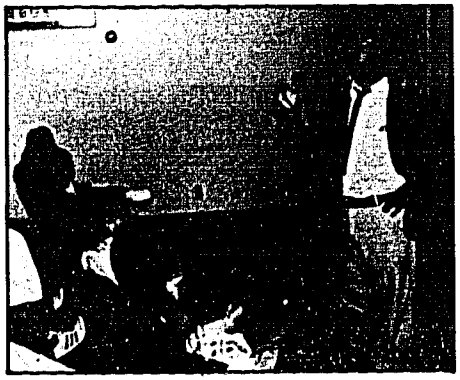
_____

Ecology—Student Viewing Sheet

Name _____ Date _____

This SPACES show will be aired at _____ A.M./P.M. on _____

Channel _____ .



The people, places, and actions featured in this show are all related to the study of the world around us—our environment. The two ecologists you will meet study certain kinds of plants or animals and their environments. Ecology is a special area of biology, the study of living things. Ecology is the study of the way living things live together and how they live in their environment.

1. Dr. Eloy Rodriguez is a plant ecologist. Where does he do much of his work? _____

_____

What is he trying to find out about plants?

_____

Why was it a good idea for Dr. Rodriguez, as a student, to take a job cleaning up a lab?

_____

_____

2 Dr. Margaret Collins, an entomologist, studies the relationship between ants and

_____

Describe her workplaces: _____

3. Define ecosystem: _____

_____

_____

Name one ecosystem discussed in this show: _____

4. To become a scientist like Dr. Rodriguez and Dr. Collins, you must _____

_____

_____

Name _____ Date _____

ANTS AND TERMITES

Ants and Termites

If you were fascinated by the ant-termite battle in the ecology show, you will be interested in some of the following facts about these two natural enemies:

1. Ants descended from wasps and have inhabited the earth for at least 100 million years. In terms of survival and adaptation, ants are perhaps the most successful of all the insect groups.

2. Ant colonies vary in size from a few hundred ants to millions. Ants usually live in the ground or in rotting wood.

3. Ants function in their specific roles because of inherited instincts.

4. The queen is the largest ant of a species. After one mating, she may lay over 20,000 eggs a year during her 10-15 year lifetime.

5. The males hatch from unfertilized eggs, fertilize the young queens, and die soon after.

6. The workers are sterile, wingless females that do not lay eggs. They build and repair the nest, collect food, feed, guard and care for the queen and lavae.

7. Soldiers are specialized workers. Some have large heads with powerful jaws for defending the colony.

8. Some ants make slaves of other species of ants.

9. Ants communicate through body secretions which leave a trail as they move along.

10. Ants may be carnivorous or herbivorous.

WILDLIFE BIOLOGIST, Dr. Robert Williamson is conducting research on the relationship between wildlife and the environment. In addition to research, he works with students in a preforestry program in Alabama.

1. All termites are scavengers; they digest decaying wood with the assistance of the bacteria living in their intestinal tracts.

2. Termites descended from roaches, have a life cycle somewhat similar to that of ants, and also function by inherited behavior.

3. After mating, the young winged king and queen termites may stay together a lifetime, anywhere from 15 to 20 years.

4. The king and queen, together, establish a new colony which may, eventually, consist of several million termites.

5. The enlarged queen in some termite species can lay up to 8,000 eggs a day for many years.

6. The workers, living from 2 to 4 years, are male and female, wingless, and usually lacking eyes.

7. The soldiers, using powerful jaws and/or chemical secretions, direct their attacks at the termites' main predators: ants.

8. Advanced species of soldier termites can repel up to 15 ants with one squirt of a sticky liquid ejected from a structure in their heads.

9. Termite nests are fortresses which offer protection against climate and other insects. Ground mound nests, made of chewed vegetable material and clay, may be as tall as 19.5 feet (6 meters).

10. Food is stored in the upper level of the nest while underground tunnels enable the workers to come and go.

11. Some types of termites grow fungus gardens in their nests. These gardens serve as food for the colony.

Energy—Student Viewing Sheet

Name _____ Date _____

This SPACES show will be aired at _____ A.M./P.M. on _____

Channel _____ .

Turn the thermostat down! Buy smaller cars! Insulate! We have all heard about "The Energy Problem." Our fossil fuel energy supplies, like natural gas and petroleum (oil), are dwindling. They cannot be replaced with freshly made fossil fuels. Many scientists and engineers are working to find new or better ways to supply the fuel and power needed to run our homes, factories, and transportation. In this show you will meet several people who are trying to help solve the "Energy Problem."

1. Virginia Sweeney is a petroleum engineer who works for _____ .

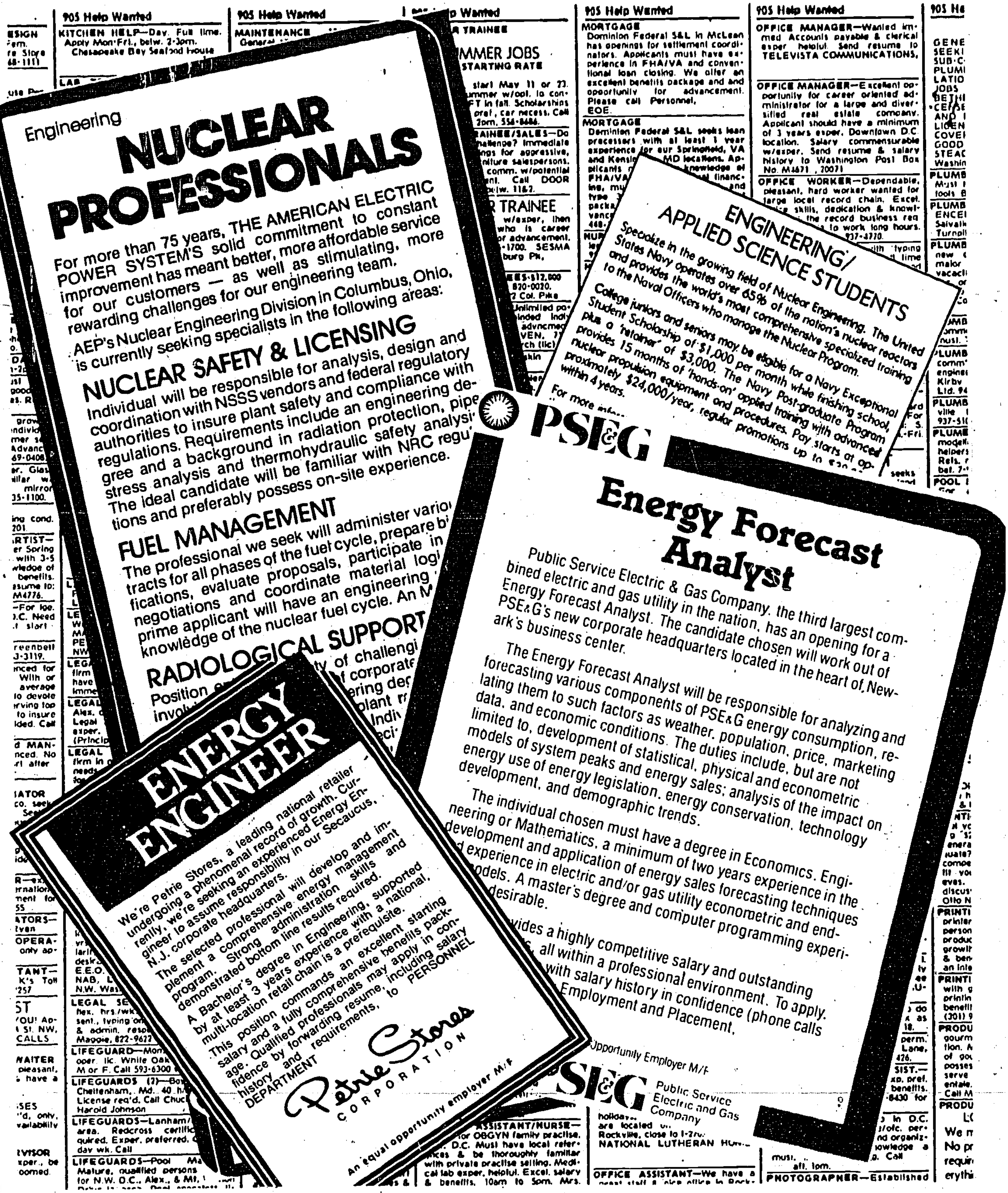
Describe her work place: _____

She says she did not take enough science classes in high school. What did she have to do because of that? _____

2. Dr. Miguel Rios is a physicist at Sandia Research Labs in _____ . This scientist experiments with _____

3. Can you name the sources of energy mentioned in this show? _____

Name ____ Date __________


Engineering
NUCLEAR PROFESSIONALS
For more than 75 years, THE AMERICAN ELECTRIC POWER SYSTEM'S solid commitment to constant improvement has meant better, more affordable service for our customers — as well as stimulating, more rewarding challenges for our engineering team.
AEP's Nuclear Engineering Division in Columbus, Ohio, is currently seeking specialists in the following areas:
NUCLEAR SAFETY & LICENSING
Individual will be responsible for analysis, design and coordination with NSSS vendors and federal regulatory authorities to insure plant safety and compliance with regulations. Requirements include an engineering degree and a background in radiation protection, pipe stress analysis and thermohydraulic safety analysis. The ideal candidate will be familiar with NRC regulations and preferably possess on-site experience.
FUEL MANAGEMENT
The professional we seek will administer various contracts for all phases of the fuel cycle, prepare bid specifications, evaluate proposals, participate in negotiations and coordinate material logistics. The prime applicant will have an engineering degree and knowledge of the nuclear fuel cycle.
RADIOLOGICAL SUPPORT
ENGINEERING/
APPLIED SCIENCE STUDENTS
Specialize in the growing field of Nuclear Engineering. The United States Navy operates over 65% of the nation's nuclear reactors and provides the world's most comprehensive specialized training to the Naval Officers who manage the Nuclear Program.
College juniors and seniors may be eligible for a Navy Exceptional Student Scholarship of $1,000 per month while finishing school, plus a 'retainer' of $3,000. The Navy Post-graduate Program provides 15 months of 'hands-on' applied training with advanced nuclear propulsion equipment and procedures. Pay starts at approximately $24,000/year, regular promotions up to
within 4 years.
PSE&G
Energy Forecast Analyst
Public Service Electric & Gas Company, the third largest combined electric and gas utility in the nation, has an opening for a Energy Forecast Analyst. The candidate chosen will work out of PSE&G's new corporate headquarters located in the heart of Newark's business center.
The Energy Forecast Analyst will be responsible for analyzing and forecasting various components of PSE&G energy consumption, relating them to such factors as weather, population, price, marketing data, and economic conditions. The duties include, but are not limited to, development of statistical, physical and econometric models of system peaks and energy sales; analysis of the impact on energy use of energy legislation, energy conservation, technology development, and demographic trends.
The individual chosen must have a degree in Economics, Engineering or Mathematics, a minimum of two years experience in the development and application of energy sales forecasting techniques experience in electric and/or gas utility econometric and end-models. A master's degree and computer programming experience desirable.
vides a highly competitive salary and outstanding all within a professional environment. To apply, with salary history in confidence (phone calls Employment and Placement,
Opportunity Employer M/F
PSE&G Public Service Electric and Gas Company
ENERGY ENGINEER
We're Petrie Stores, a leading national retailer undergoing a phenomenal record of growth. Currently, we're seeking an experienced Energy Engineer to assume responsibility in our Secaucus, N.J. corporate headquarters.
The selected professional will develop and implement a comprehensive energy management program. Strong administration skills and demonstrated bottom line results required.
A Bachelor's degree in Engineering, supported by at least 3 years experience with a national, multi-location retail chain is a prerequisite.
This position commands an excellent starting salary and a fully comprehensive benefits package. Qualified professionals may apply in confidence by forwarding resume, including salary history and requirements, to PERSONNEL DEPARTMENT
Petrie Stores CORPORATION
An equal opportunity employer M/F

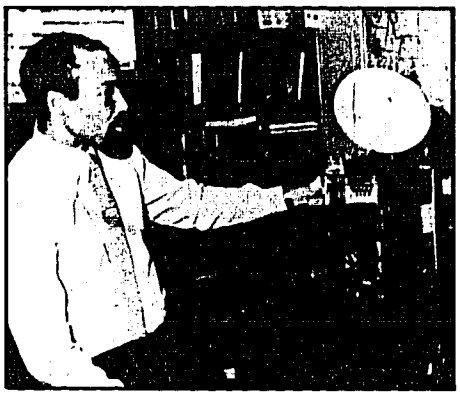
Communications—Student Viewing Sheet

Name _____ Date _____

This SPACES show will be aired at _____ A.M./P.M. on _____

Channel _____ .

Imagine being able to participate in a world-wide science fair without leaving your hometown. You could talk with other participants as well as see students' projects in such far away places as London, New Delhi, Lagos. The new communications technology is making this, and many other exciting things, possible. In the Communications Show you will meet a scientist and an engineer who are working in this fast growing field. What do they do? Take notes!



1. Dr. George Campbell is a physicist at Bell Labs. What does he do? _____

Describe his workplace. _____

From him I learned _____

2. Raquel White was trained as an aerospace engineer but is now working in telecommunications. Describe her workplace. _____

What did you learn about her work? _____

3. What did you like best about this show? _____

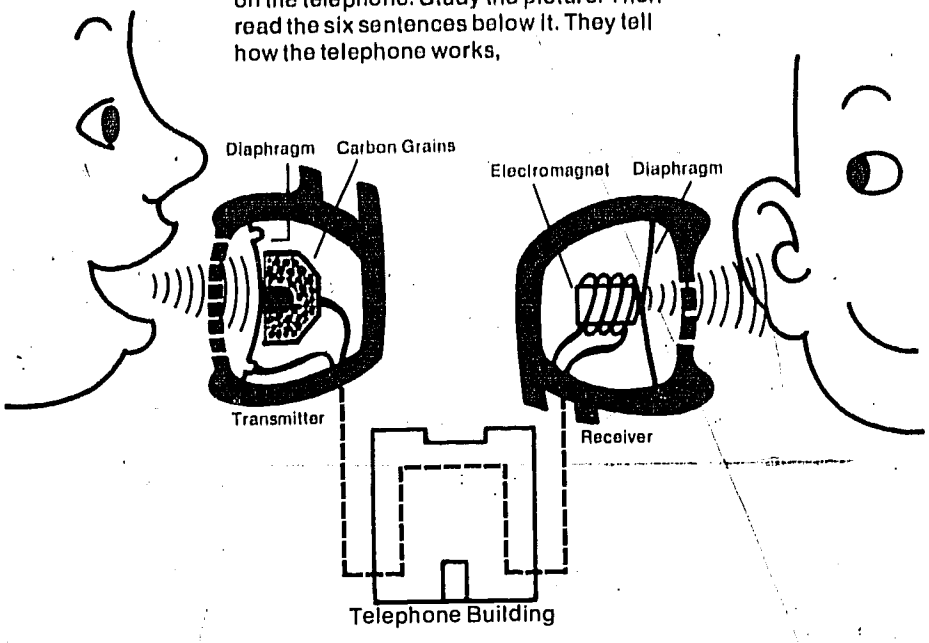
Why? _____

Name _____ Date _____

How the Telephone Works

AEROSPACE ENGINEER, Jerry Elliott is a project engineer for the Space Shuttle Program. He used his engineering skills to help bring the first satellite telecommunication system to Crow and Pueblo Indian reservations.

The picture below shows two people talking on the telephone. Study the picture. Then read the six sentences below it. They tell how the telephone works.



- ☐ The sound waves of your voice go into your telephone's transmitter.
- ☐ These waves cause a diaphragm in the transmitter to vibrate and press on the tiny carbon grains.
- ☐ The harder the diaphragm presses the carbon, the more electricity goes through the telephone wire. The electricity flows in short, irregular impulses.
- ☐ The electrical impulses flow through wires that are connected to a telephone company building. There they are linked up with wires connected to the phone you are talking to.
- ☐ The receiver of the phone you are talking to contains an electromagnet. The impulses of electricity cause the electricity to vibrate a diaphragm in the receiver.
- ☐ The vibrations of this diaphragm reproduce the sounds of your voice.

To see how well you understand how the telephone works, try to explain it to someone else. Cut out the picture above and show it to a parent, brother, sister or friend. In your own words tell them how the telephone operates.

Reprinted from Telezonia Communicating by Telephone

Cooperative Logic Programs*—Teacher Information Sheet

Planets (Space) — **Ecology Fair** (Ecology) — **Who will be accepted** (Communications) — **Salary Scramble** (Computers)

These logic problems encourage students to work cooperatively. Each student has a clue important to the solution. Some of the problems use manipulative pieces that can be moved to check solutions.

PREPARATION:
Make one copy of each problem for each group of 4-6 students. Cut each sheet into the 6 separate clue pieces. An envelope makes good storage space for each problem and its parts.

DIRECTIONS:
Explain to the students that they will be working on logic problems. One way to introduce the idea of logic problems is to draw the analogy with detective stories. First you meet the characters involved and find out the problem. Typically, you want to discover who committed a crime. As the story progressees and clues are presented, the list of suspects is narrowed until only one remains and the mystery is solved. This process of elimination, based on clues, is similar to the reasoning used by doctors and mechanics when diagnosing medical or mechanical ailments.

Each problem is to be solved cooperatively. Students need to work together to find an answer. Emphasize that each person will have different clues, so it is important to listen as each clue is read.

Give each student within the group one clue to the logic problem. If there are more than four students in a group, use the extra pieces that are starred (*). All problems can be solved with the four unstarred clues. Clues given on the starred pieces may be helpful, but are not necessary for solving the problem. Students may read their clues to each other, but may not show each other the written clues.

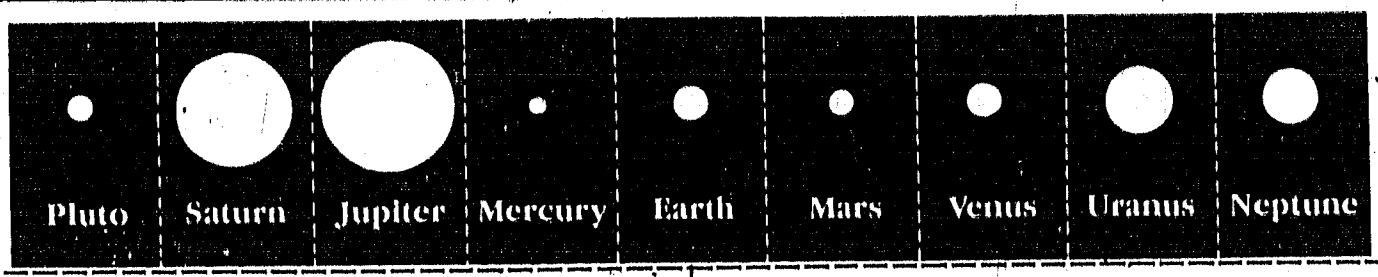
Hands-on Logic
Two of the problems have movable parts which can be organized and reorganized by anyone in the group to try out possible solutions. The statement of the problem is on all clue cards in these two problems. You may want to discuss the content, wording, or some of the logic problems before doing them.

Planets: This will be an interesting problem for students who do not yet know the order of the planets. The actual distances of the planets from the sun vary as each planet travels its orbit. Numerical values for the distances are not needed to determine the order of the planets from the sun.

Other Logic Problems
The other two cooperative logic problems have the problem statement on just one of the clue cards. Remind students to listen for the problem statement. These are more suitable for 6th, 7th, and 8th grade students.

For ECOLOGY FAIR and WHO WILL BE ACCEPTED, many students may find grids useful for keeping track of the clues. Grids for these problems are found on the answer key page. Copy them on the chalkboard omitting the answers.

*The four Cooperative Logic Problems and general directions for them were reprinted from SPACES by permission of EQUALS, Lawrence Hall of Science, Berkeley, CA Copyright 1982, Regents, University of California. SPACES—Solving Problems of Access to Careers in Engineering and Science by the EQUALS PROJECT is not related to the SPACES Television Series and Teachers Guide.



Planets

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Arrange the nine planets in order based on their relative distance from the sun.

- The five planets nearest the sun are Earth, Jupiter, Mercury, Venus, and Mars, not necessarily in that order.

Planets

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Arrange the nine planets in order based on their relative distance from the sun.

- Early astronomers knew that Venus and Mercury were the only two planets closer to the sun than our planet Earth.
- Saturn is nearer Earth than Neptune.

Planets

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Arrange the nine planets in order based on their relative distance from the sun.

- The five planets furthest from the sun are Uranus, Neptune, Jupiter, Pluto, and Saturn, not necessarily in that order.
- Four of the planets are much larger than the other five planets, but have a lower density.

Planets

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Arrange the nine planets in order based on their relative distance from the sun.

- Mercury and Pluto have seven planets between them.
- There is just one planet between Uranus and Pluto.

Planets*

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Arrange the nine planets in order based on their relative distance from the sun.

- Uranus is between Saturn and Neptune.
- The five terrestrial or earthlike planets are Earth, Pluto, Venus, Mars, and Mercury.

Planets*

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Arrange the nine planets in order based on their relative distance from the sun.

- Copernicus in the 16th century knew of six planets: Earth, Mars, Mercury, Jupiter, Saturn, and Venus. These are the six planets closest to the sun.
- Earth is 93 million miles from the sun.

Salary Scramble

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

- A computer systems operator earns $5,130 more than a secretary.
- A school teacher averages $17,447 a year.

Salary Scramble

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

- A computer systems operator averages $43,670 less than a pilot.
- A teacher averages $1,297 less than a carpenter.

Salary Scramble

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

- A teacher earns almost as much as a computer systems operator, only $883 a year less.
- An engineer averages $10,086 a year more than a carpenter.

Salary Scramble

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: What is the average yearly salary of each profession?

- An engineer earns $30,170 less than a pilot.
- A secretary earns $2,247 less than a teacher.

Salary Scramble*

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

- A pilot earns more than 3 times as much as a teacher.
- There is a difference of $46,800 between the highest and lowest salary.

Salary Scramble*

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

- The salaries of the pilot and the secretary together total $77,200.
- An engineer earns over twice as much as a secretary.

Ecology—Cooperative Logic Problem

April	Sharon	Gloria
SUN CAR	SOLAR STOVE	PLANT/PEST CHART
3rd prize	2nd prize	1st prize

Ecology Fair
These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Find out who did which project and who won which prize.

- The first prize went to the SUN CAR, a model of a solar powered car.
- Gloria would like to become a biologist.

Ecology Fair
These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Find out who did which project and who won which prize.

- The finalists were April, Sharon, and Gloria, not necessarily in that order.
- The second prize winner made soup on her SOLAR STOVE for all her friends.

Ecology Fair
These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Find out who did which project and who won which prize.

- The following projects won the top three prizes in the Ecology Fair: SOLAR STOVE, PLANT/PEST CHART, and SUN CAR.
- Gloria won third prize.

Ecology Fair
These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Find out who did which project and who won which prize.

- The SOLAR STOVE used reflectors angled to intensify the sun's heat.
- April had never seen a sun-powered car before the Ecology Fair.

Ecology Fair*
These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Find out who did which project and who won which prize.

- All the prize winners in the Ecology Fair were 14 years old.
- April bought a copy of the PLANT/PEST CHART from the third prize winner.

Ecology Fair
These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Find out who did which project and who won which prize.

- Several years of study and gardening were summarized in the PLANT/PEST CHART, a guide to plants that repel garden pests.
- Sharon enjoyed the soup April made.

Who Will Be Accepted?

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

- Lawrence, Amy, Steven, and Betty are competing for entrance into the College of Engineering.
- Amy has taken more math than Steven.

Who Will Be Accepted?

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

- Betty has taken more math than Steven.
- The academic math classes at their high school are: Algebra I, Geometry, Algebra II, and Calculus. They must be taken in this order.

Who Will Be Accepted?

These are your clues to help solve the group's problem..
Read them to the group, but do not show them to anyone.

- These four students are equally qualified except for the number of math courses taken. Each has taken at least one academic math class.
- Lawrence has taken more math than Betty.

Who Will Be Accepted?

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

Problem: Find the most advanced math course taken by each student. Who will be accepted into the College of Engineering?

- Lawrence has taken one year less math than Amy.
- One of these students will be accepted to the College of Engineering.

Who Will Be Accepted?*

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

- Lawrence enjoyed Geometry the most of all his math classes.
- Steven did not take Geometry.

Who Will Be Accepted?*

These are your clues to help solve the group's problem.
Read them to the group, but do not show them to anyone.

- Amy has taken more math than Betty.
- Steven wishes he had taken more math in high school.

Designing a SPACE SHUTTLE*

A New Project

Zoom Aircraft and Design, Inc. has been given a new project from NASA. NASA wants them to design a space shuttle (paper airplane) for exploration. The shuttle must meet the special requirements given by physicists, or it can not be launched by a rocket. Your team assignment is to build a model of the space shuttle according to NASA's requirements.

NASA's Requirements

Flight—Your model must fly in a straight path for at least four meters or more.

Landing—Your model must land gently (not crash).

Wing span—The wings cannot be less than 10 centimeters wide nor greater than 15 centimeters wide.

Length—The length cannot be less than 15 centimeters nor greater than 30 centimeters.

Mass—The model cannot have a mass greater than 5 grams. (Your teacher may direct your class to omit this requirement. In that case you will not need the triple-beam balance listed under Inspection Equipment.)

Construction Materials—Paper, tape, paper clips

Inspection Equipment—Triple-beam balance, meter stick

Teams—Each three person team is composed of an Aerospace Engineer, Aeronautical Technician, and a Quality Control Inspector.

Each person in the group should have a tag telling which career is represented. The Aerospace Engineer and Aeronautical Technician should work closely in building the model according to NASA's requirements. The Quality Control Inspector has to make sure that the model that has been designed and built is perfect and meets the requirements of NASA.

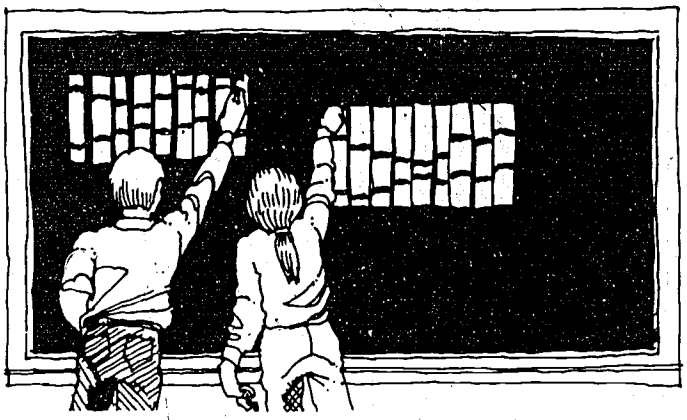
The team must be able to explain to the "NASA Representative," the teacher, why the model(s) they developed does or does not work. The team may build as many as two models to achieve the requirements set by NASA. Only one model may be presented to the NASA Representative. Remember, time is money on such a project.

Steps to build the Space Shuttle model:

1. Discuss in the team, or as a class, the NASA Requirements.
2. Research—(think about) the different ways you could build your model(s).
3. Design—Build your model(s).
4. Test your model(s) at the test site in the class room.
5. Pass inspection by the Quality Control Inspector.
6. Present your best model to the NASA Representative.

Reprinted from SCIENCE in CAREERS: Satellite Research and Space Travel Teacher's Guide Module IX by National Center for the Development of Bilingual Curriculum—Dallas, Dallas Independent School District.

This is Your Lifeline



Skills
- *Graphing*
- *Metric measuring*
- *Sequencing*
- *Decision making*
- *Planning*
- *Estimating*

Time
- *1 class period*

Participants
- *Individual*

Materials
- *1 copy of Student Instructions for each student*
- *Strips of adding machine tape 30 cm long, 1 for each student*
- *Crayons or marking pens: the same 2 colors should be available for each student. For example, education may be marked in red and employment may be marked in blue. All students should use the same colors in order to create the graphic effect. Sharing of crayons or pens will help.*
- *Scotch tape*
- *Metric rulers*

Each student is asked to make a plan for his or her life and to graph it on a time line. This process can increase a student's awareness of the relationship between education and employment options.

Directions:

Tell the students that they are going to imagine what will happen to them during their lives. Ask them to take a minute to list several things they think might occur.

When they have made their individual lists, put a few of the items on the chalkboard to help other students think of things they might have missed.

Give each student a strip of tape, along with the sheet of instructions. (See Student Instructions.) Give the students 15 minutes to complete their own lifelines.

As the lifelines are completed, have the students tape them into position on the chalkboard. The graph may be more significant if lifelines for girls are put together in one column and boys in another column.

The most important part of this activity is the open-ended discussion. Some of the students will have made unrealistic life plans. The discussion ties in the relationship between high school courses and employment options.

Discussion:

Question: Which is greater, the time spent in education or in working? (Read from graph.)

Question: How does education time compare with time after retirement? (Read from graph.)

Question: Did many people choose to stay home with small children? (Read from graph.)

Question: How long did most people work? (Read from graph.)

Question: Was there a difference in the graphs for boys and girls? Who worked longer? Who attended more school? Who retired earlier?

Fact: On an average, an American man works 45 years and retires at age 65. About one-half of his life is spent in the workforce.

Fact: On an average, a married American woman works 25 years outside the home. The average unmarried woman works 43 years. Considering a woman's life expectancy today, this is at least one-third of her life. There is a rapid increase in the number of women working each year and a trend toward working more years.

Question: What education is necessary for the career choices on the students' lifelines?

Fact: A student planning his or her life might keep in mind the definite relationship between jobs that pay higher salaries and jobs that require a math background. Math skills allow maximum flexibility and opportunity in this technological world.

Fact: Math courses are sequential. Important decisions regarding high school courses are made in junior high school. To complete the precalculus sequence in most high schools, a student must acquire the basic skills in 7th and 8th grades, take Algebra I in 9th, Geometry in 10th, Algebra II in 11th, and Math Analysis and Trigonometry in 12th.

Fact: Calculus is considered elementary mathematics. We need to recognize it as a starting place, not an ending place. Without high school preparation, many students will eliminate themselves from the majority of college majors.

Question: Which careers probably bring the highest salaries?

Fact: Many fields that previously required no math are becoming technologically oriented. Technology is used in such diverse occupations as food processing, milking cows, and running libraries. Advancement opportunities often depend on math and science backgrounds. Students will open many options by taking as much math and science as possible in high school.

Name _____ Date _____

Student Instructions

You should have a strip of paper 30 cm long for your lifeline.

You should also have made a list of the things you think will happen to you during your life.

Directions:

1) On one end, write whether you are a male or female.

2) Write the year you were born on the same end.

3) Assume that you will live 100 years. Along one edge of the paper, make a mark for each 10-year period. (Let 3 cm represent 10 years.)

4) Mark the year you started school.

5) Mark the year you plan to finish school. Do you plan to finish high school? College? Get an advanced degree?

6) Mark the year you plan to first begin working full-time.

7) Mark the year you plan to retire from work or stop working. Are there times in your life when you stop working and then begin again after a few years? Mark those times.

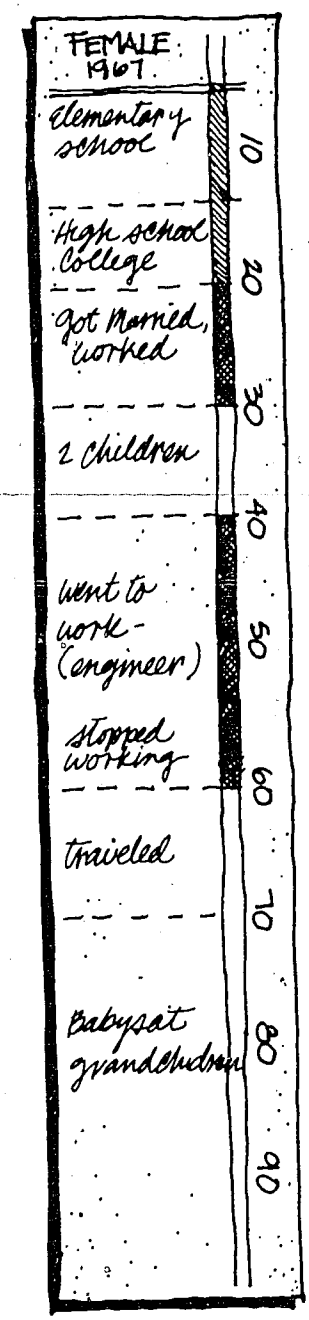
8) Color all the Education Years with the color your teacher tells you.

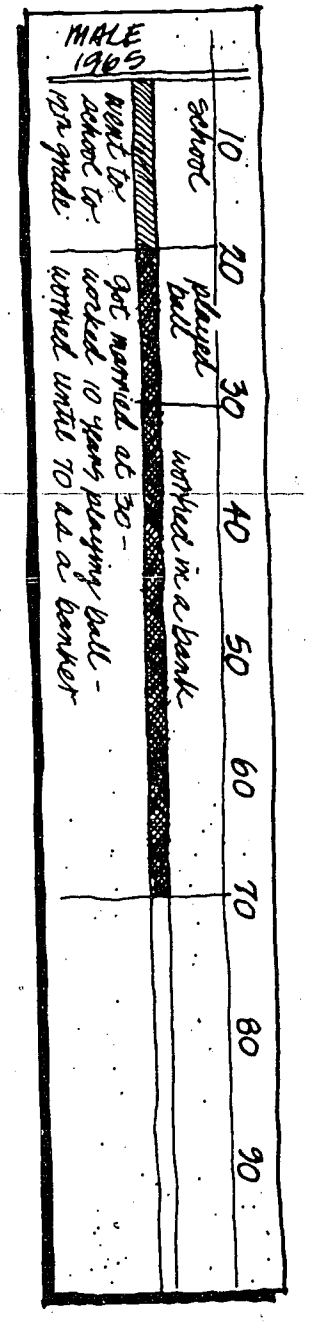
9) Color all the Employment Years with the color your teacher tells you.

10) Fill in any other important dates on your lifeline.

11) Write in other information: What kind of job do you have? Do you marry? Do you have children?

12) Tape your lifeline onto the class graph.





Environmental Engineering

Planning ahead, considering use of space, working in groups, and making models are essential career skills. In this activity, the students explore architecture, engineering, and city planning through designing an environmental park in small groups.

Preparation:

1) Plan for student groups of three to four.

2) Cut one sheet of butcher paper for each group.

3) Duplicate student worksheets—one copy for each group.

Directions:

With the whole class, brainstorm a list of features they like in parks. You may want to talk about features other groups of people like—for example, what is needed for very small children? What about older people?

Present the problem. The size of the proposed park is 300 ft. by 200 ft. Compare this to some known landmark such as the school yard or a football field. Emphasize the difference between the required features (i.e. natural features: a hill and trees) and the optional features.

Put students in groups. Tables are helpful, but students may also work on the floor.

Distribute worksheets and materials.

Set a time limit for the students to come up with a plan they like and to draw these plans on paper. They may need to modify the designs to keep the total budget below the $5,000 limit. Allow each team 3–5 minutes to present their design and budget to the class at the end of the activity.

Skills
- *Organizing information*
- *Visualizing*
- *Group decision making*
- *Using models*
- *Estimating*
- *Computing*
- *Scale drawing*

Time
- *2–3 class periods*

Participants
- *Groups of 3 or 4 students*

Materials
- *Butcher paper cut to 3′ × 2′*
- *Rulers*
- *Paper—plain or colored*
- *Crayons and felt pens*
- *Scissors*
- *Tape or glue*
- *Copies of student worksheets I and II for younger students*
- *Copies of student worksheets II and III for older students (7th grade and above)*

Extensions:

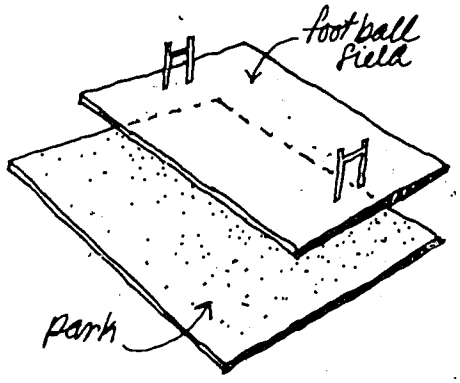
1) Take a field trip to a nearby park and sketch its layout.

2) Redesign the school playground.

3) Have students draw a park exactly to scale.

4) Make a three-dimensional model of the park.

5) Research the actual cost of materials and equipment to build your environmental park.



72 Ecology—Environmental Engineering Worksheet I

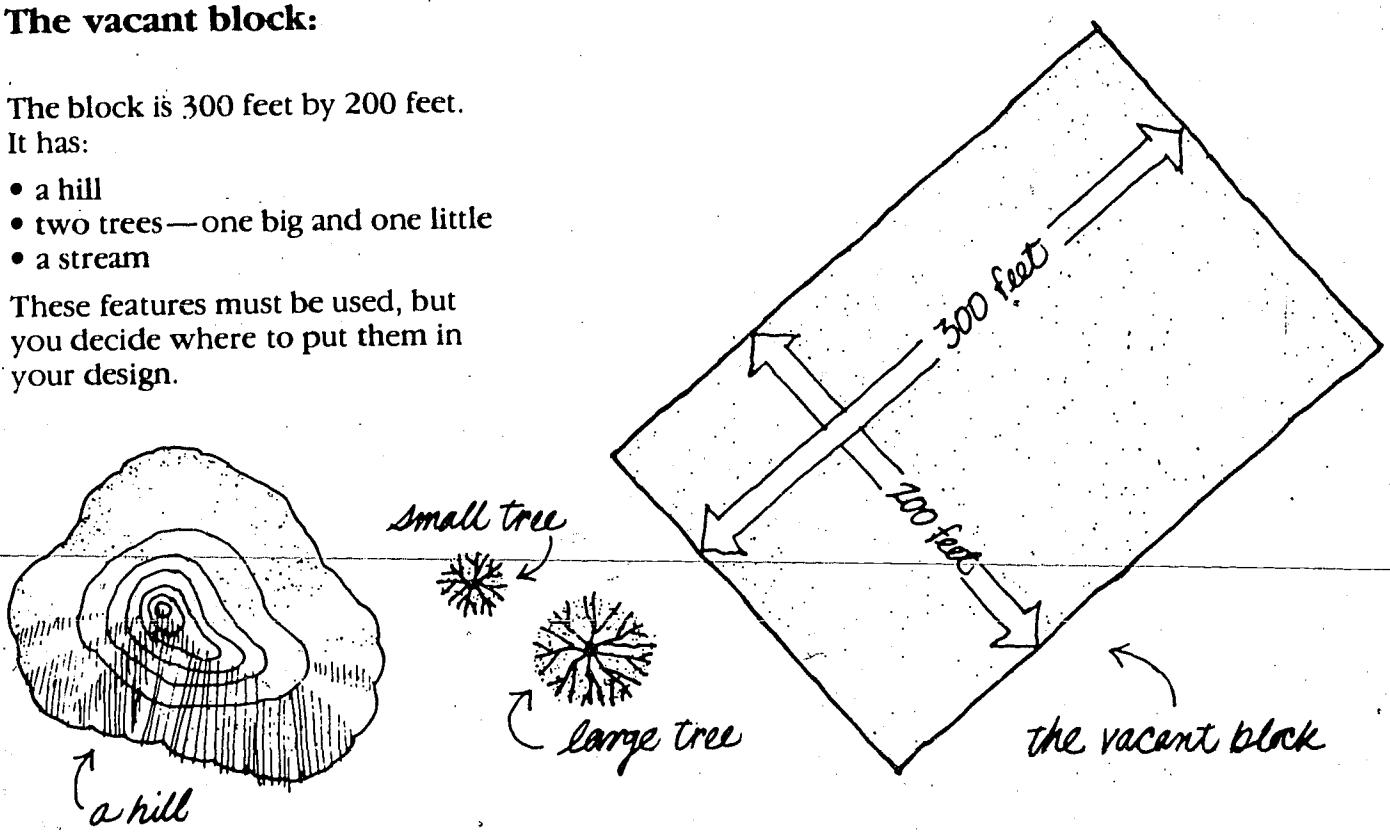
Let's assume that your town is going to change a vacant block into an environmental park and $5,000 has been set aside to develop it. The people of the town will do the work. Your class has been asked to design the park. Since the park will be for the whole community, you will need to include features that will be enjoyed by young children and adults, as well as by people your own age.

The vacant block:

The block is 300 feet by 200 feet.
It has:

- a hill
- two trees—one big and one little
- a stream

These features must be used, but you decide where to put them in your design.



Your park:

Follow the steps listed below in making your design on butcher paper.

1. Write down materials and equipment (such as picnic tables) you want in your park.
2. Star (*) your favorite features on the list.
3. Look up prices for your materials. (See Worksheet II.) Remember that you get a hill and two trees free. If any items are not on the list, ask your teacher a way to find out the cost.
4. Draw in the natural hill, two trees, and the stream.
5. On a separate piece of paper, draw a picture of each feature and piece of equipment; cut out your pictures.
6. Experiment on the butcher paper with ways to arrange the features and equipment you want.
7. Find a layout or design you like that fits on the paper and costs no more than $5,000. Glue it down.
8. Present your design to the class.

COST OF MATERIALS AND EQUIPMENT

	Cost	Unit	Quantity	Total Cost
Rope	$1	per 10′		
Bricks	$1	each		
Sand	$1	cubic foot		
Stepping stones	$5	each		
Plants and shrubs	$10	each		
Trash barrels	$10	each		
Benches (6′ long)	$15	each		
Old telephone poles (10′ long)	$25	each		
Wire fencing (6′ high)	$30	per 10 running feet		
Asphalt pavement (4′ wide)	$40	per 10 running feet		
Picnic tables with two benches	$50	each		
Community garden plot and seedlings	$50	10′ × 10′		
Animals Small Large	$20 $100	each each		
Drinking fountains	$75	each		
Pond	$100	each		
Playground equipment	$100	per item		
Bike racks	$150	each		
Barbeques	$150	each		
Street lights	$250	each		
Public telescope	$300	each		
Stage (20′ square)	$300	each		
Bathrooms (one each, men and women)	$350	pair		
Bleachers (grandstand)	$750	each		
Bridge	$1000	each		
Other (list)	$			
	$			

74 Ecology—Environmental Engineering Worksheet III

Spring Valley School District has decided to develop some of its land as an environmental park. Your engineering team has been asked to submit a proposal for the development of this land. Consider the following criteria when developing your plan:

Versatility:
- Is the park suitable for people of all ages?
- Can the park be used at night as well as during the day?
- Is the park useful in all seasons?
- Is there a wide range of activities available within the park?

Safety:
- How safe is the design for young and old users?
- Are there any possible hazards?

Aesthetics:
- Is the design pleasing?
- Would people of all ages enjoy the park?

Cost Effectiveness:
- Was the money well spent?
- Is energy used efficiently in the park?

Innovation:
- Is the design unusual?
- Are materials used in new and interesting ways?

Your team will choose a draftsperson, a finance officer, an engineer, and a public relations person. The major responsibilities will be:

Draftsperson: Draws design to scale and displays the finished design.

Engineer: Responsibile for design and safety.

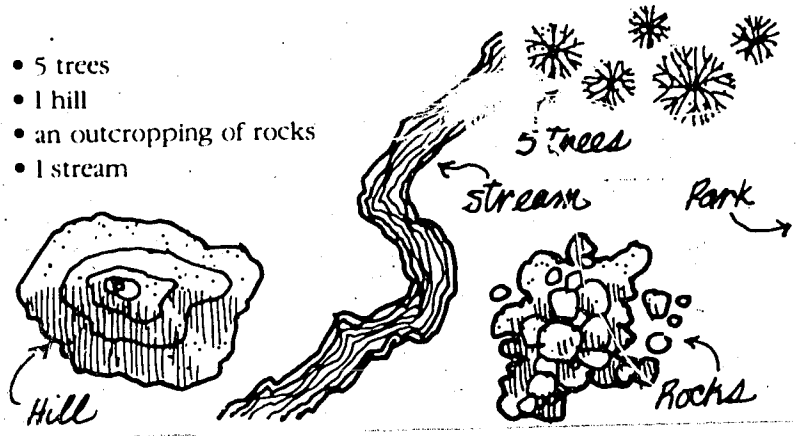
Finance Officer: Keeps track of and presents the budget.

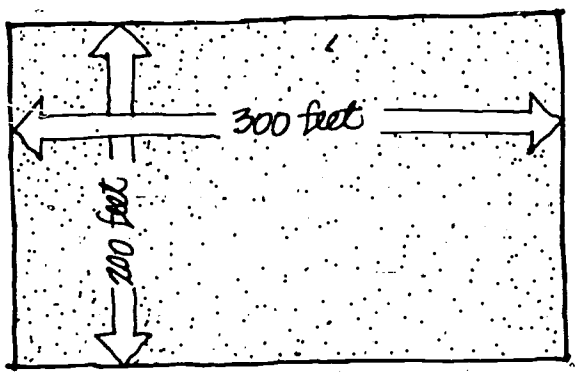
Public Relations Person: Keeps track of special features of the design and presents the team proposal. Prepares a five-sentence written summary of the proposal pointing out why this plan should be chosen over others.

The Problem

The area is 300 feet long and 200 feet wide (approximately the length of a football field and 1½ times as wide). The size of paper that you will use for your design is approximately 3′ by 2′. The area has the following natural features which must be included:

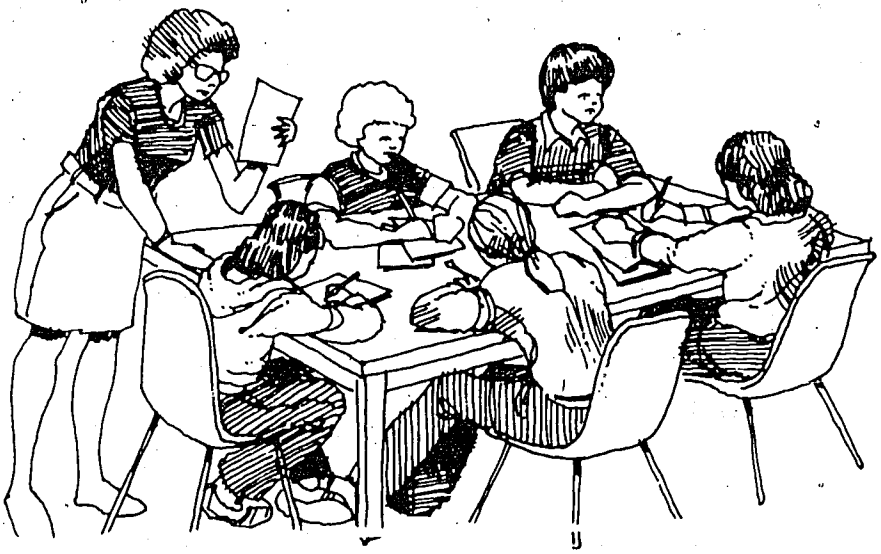
- 5 trees
- 1 hill
- an outcropping of rocks
- 1 stream





Your team decides where to put these natural features in your design. Worksheet II lists some possible materials and costs for the development of the land. You are free to use as much or as little of these as you wish. If you wish to use something that is not on the materials and equipment list, check with your teacher on whether the item is appropriate for an environmental park and what is the approximate cost. You have a budget of $5,000.

Do You Want To Be an Engineer?



Skills
- *Understanding the relationship between personal interests and future careers*
- *Understanding the relationship between personal interests and future careers*

Time
- *1 class period*

Participants
- *Individual*

Materials
- *A sheet of paper and a pencil for each student*

This questionnaire activity is designed to inform students about the characteristics that lead to success in engineering occupations, as well as in many other careers.

Directions:

Have the students number a sheet of paper from 1 to 20, as if for a true-false test or a spelling test.

Read each question aloud, with students writing down "yes" or "no" beside the number of the question.

After completing the questionnaire, read aloud each portion of the scoring directions. Discuss the questions for each section, or go back and read each question and discuss it individually.

This activity provides a unique opportunity for students to ask questions about the relationship between their own interests and possible future careers.

Please note that the intent of this activity is to inform and motivate students. The questions and the scoring are not scientifically designed.

Extensions:

1) If paper is not a problem, and you prefer each student to have a copy, this activity may be done as a written questionnaire, followed by discussion of the scoring and the questions.

2) The activity may also be used for homework or put into a learning center, since students can complete it without assistance.

3) Students may be interested in doing further research about a particular engineering field.

76 Energy—Student Questionnaire: Do You Want To Be An Engineer?

Name _____ Date _____

	Answer Yes	Answer No
1) When you were little, did you like taking things apart?	☐	☐
2) Do you hate to do jigsaw puzzles?	☐	☐
3) Do you feel that making an outline for a report is really important?	☐	☐
4) Do you like working outdoors?	☐	☐
5) Do you like working with a team of people?	☐	☐
6) Is it hard for you to sketch a picture of something that others can recognize?	☐	☐
7) Do you avoid playing strategy games, such as checkers or chess?	☐	☐
8) Can you follow complicated directions?	☐	☐
9) Do you like to travel to places that are not famous for scenery?	☐	☐
10) Do you like to do projects with your hands, such as carving, macrame, or building models?	☐	☐
11) Do you groan when you have to do the word problems in math?	☐	☐
12) Can you write out detailed instructions for doing something?	☐	☐
13) Do you think you would like using computers?	☐	☐
14) When you look at a plan for something (like a model or a sewing pattern) do you have trouble imagining what it will look like?	☐	☐
15) Do you like to have somebody tell you the answer to a problem before you have had a chance to figure it out?	☐	☐
16) Would you rather study alone than with friends?	☐	☐
17) Do you often think there must be a better way to build something?	☐	☐
18) Do you have trouble reading a map?	☐	☐
19) When you have a question about something, do you usually try to look it up in a dictionary or an encyclopedia?	☐	☐
20) Do you like to give talks in front of the class?	☐	☐

Energy—Scoring Instructions for Do You Want To Be An Engineer?

To find out the different skills that engineers use, look at each of the topics below and find out how you scored.

Technology and Mechanical Aptitude. See questions 1, 10, 13, and 17.
A majority of these questions answered with a yes shows mechanical aptitude. An engineer is sure to have a need for computers. It's also helpful to have confidence when it comes to taking things apart or putting them together. And, of course, thinking of better ways to build things might be part of your job. To develop these skills, practice working with puzzles, tools, and mechanical objects.

Spatial Visualization. See questions 2, 6, 14, and 18.
If you answered a majority of these questions with a no, you have good spatial skills. Jigsaw puzzles, drawing accurate pictures, visualizing rooms or models, and reading maps are indications of good spatial abilities. Your skills can be sharpened with practice.

Organization and Carefulness. See questions 3, 8, 12, and 19.
Do you work with care, plan ahead, and organize? For these questions, a majority answered with a yes shows good organization skills. An engineer is usually the basic organizer of a project and has to direct people, see that every detail is correctly done, and stay with the job until it is done to see that things go right. To practice writing out clear instructions, try using outlines or flow charts.

Problem Solving. See questions 2, 7, 11, and 15.
Engineers need to develop strategies and techniques for problem solving and the ability to keep trying until the problem is solved in the best way possible. If you answered these questions with a no, you are a good problem solver. To develop problem-solving skills, try all sorts of games, puzzles and "thinking" activities. Concentrate on *how* you are solving the problem or playing the game, so you can do it better next time.

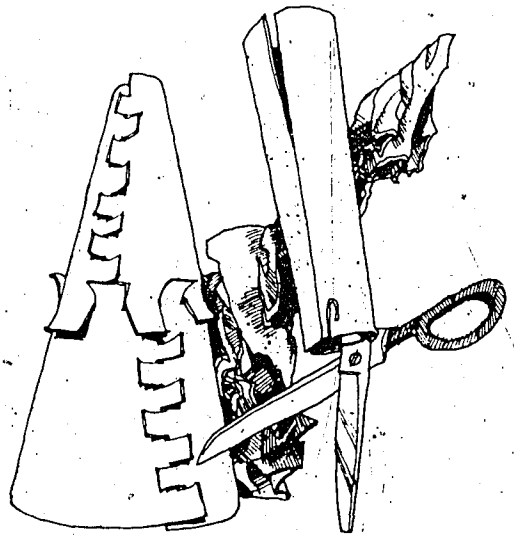
Your Working Environment. See questions 4, 5, 9, 16, and 20.
These questions ask how you feel about your working environment. There are no right or wrong answers for an engineer, who may work alone or with others, indoors or outdoors, may travel or stay in one place, may have to appear in public or work out in the field or in an office. You might want to read about different kinds of engineers to find the one you like best.

Build the Highest Tower

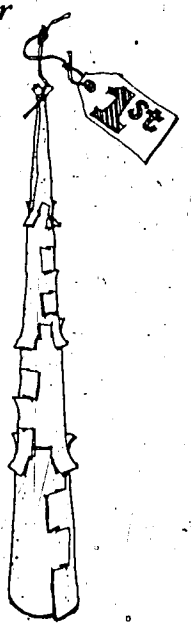
Skills
- *Brainstorming*
- *Cooperating*

Time
- *1 class period*

Participants
- *Groups of 2–4 students*



Materials
- *8½" × 11" paper*
- *Paper clips*
- *Scissors*
- *Masking tape*
- *Marking pen*



Students explore creative problem solving by using non-traditional materials to build a structure. The challenge is to build the highest tower using these materials.

Preparation:

1) Divide the materials into sets consisting of:

2 pieces of paper

10 paper clips

1 pair of scissors

You will need a set for each group of students.

2) Apply a strip of masking tape to a wall or door jamb starting at the floor and extending up about 5 feet. This will be used to compare the heights of the towers.

Directions:

Give these directions to the students:
- Only the materials provided may be used in building your tower.
- The towers must be free-standing. They may not lean against the wall or be held up.
- Towers must be brought to the tape on the wall for measuring. This means they will have to be transportable or easy to rebuild at the measuring site.

Divide the students into groups and assign a working area for each group of students. Distribute sets of materials and let the students start building.

Some questions may arise, such as, "Can we tear the paper?" or "Can the scissors be part of the structure?" The best response is to repeat the beginning instructions, without giving further information. The intent is to minimize instructions so students will be encouraged to invent innovative ways to build the tower.

As pairs of students finish their structures, have them bring the towers to the measuring site. Write the initials or names of students beside their tower's mark on the tape.

When all towers have been measured, announce the winners. You may want to discuss with the class some of the successful or not-so-successful strategies used to hold the towers together and upright.

Extensions:

Allow time for experimentation. Give the students 15 minutes to experiment with scratch paper before they actually begin building their tower.

Evaluation Activity—Teacher Information Sheet

Career Skits

One of the objectives of the SPACES series is to increase awareness and understanding of scientific and technological occupations. This activity will enable students to demonstrate what they have learned about the careers explored in the programs and in the activities from this guide. Other occupations are included in this list to encourage greater versatility and creativity in the students' skits. However, you may wish to limit this activity to those occupations explored in your classroom activities.

Preparation:

Make cards with job titles on them (see below for suggested occupations). Arrange students in groups of 3.

Directions:

In groups of three, students will pick three cards with job titles. Each group will prepare a skit involving the three occupations (approximately three minutes long). The occupations may not be named in the skit. As each skit is presented, the class will try to identify the occupations of that group.

Photographer
Biologist
Plant Chemist
Ecologist
Zoologist
Botanist
Molecular Biologist
Oceanographer
Mathematician
Astronomer
Ballplayer
Secretary
Computer Programmer
Police Officer
Teacher
Librarian
Pilot
Flight Attendant
Busdriver
Architect
Engineer
Telecommunications Engineer
Computer Design Engineer
Industrial Engineer
Solar Energy Engineer
Aerospace Engineer
Petroleum Engineer
Firefighter
Physicist
Chemist
Pharmacist
Technician
Carpenter
Electrician
Plumber
Locksmith
Auto Mechanic
Astronaut
Psychologist
Mission Specialist
Computer Operator
Geologist
Meteorologist
Dentist
Physician
Veterinarian
Nurse
Bank Teller
Lawyer
Judge
College professor

Cooperative Logic Problems

PLANETS (SPACE)

The planets in order from the sun are:

Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto

(The orbits of Neptune and Pluto actually cross one another periodically, which would switch the positions of these two outermost planets on this list).

SALARY SCRAMBLE (COMPUTERS)

The teacher's salary is the reference point.

Pilot	$62,000
Engineer	31,830
Carpenter	21,744
Computer Systems Operator	18,330
Teacher	17,447
Secretary	15,200

ECOLOGY FAIR (ECOLOGY)

	Sun Car	Solar Stove	Plant/Pest Control
Sharon	(1st prize)		
Gloria			(3rd prize)
April		(2nd prize)	

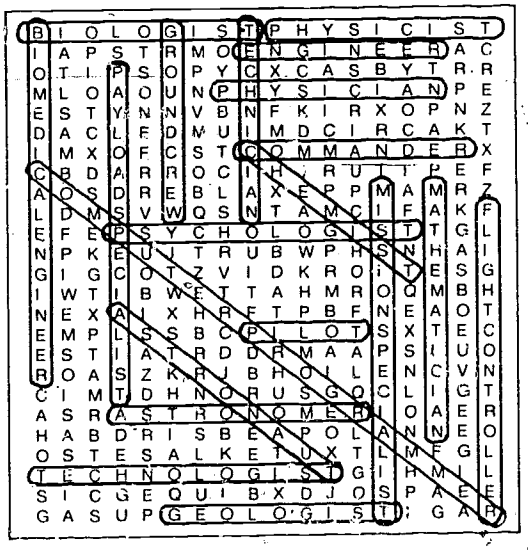
WHO WILL BE ACCEPTED? (COMMUNICATIONS)

	Algebra I	Geometry	Algebra II	Calculus
Betty	(✓)	(✓)		
Lawrence	(✓)	(✓)	(✓)	
Amy	(✓)	(✓)	(✓)	(✓)
Steven	(✓)			

✓ = academic math course taken. Amy will be accepted.

Space

Aerospace Job Search



The Body

Who "Works On" The Human Body?

Medical Research Careers	Health Care Careers
molecular biologist	physical therapist
parasitologist	dentist
geneticist	medical technologist
laboratory technician	nurse
neurobiologist	X-ray technician
biochemist	laboratory technician
microbiologist	pathologist
space biomedical researcher	physician
	pharmacist

For career descriptions—See Career Index.

Computers

Computer Careers Match

1. e	4. a	7. h
2. d	5. g	8. i
3. b	6. f	9. c

Student Information Sheet #2

IV. 0 and 1

Computer	Decimal
0	0
1	1
10	2
11	3
100	4
101	5
110	6
111	7
1000	8
1001	9
1010	10

Computer	Decimal
1011	11
1100	12
1101	13
1110	14
1111	15
10000	16
10001	17
10010	18
10011	19
10100	20

V. Higher math: Computer design engineer, systems analyst, computer programmer
Electronics: computer service technician, computer design engineer.

Computers

Student Information Sheet #3

Important terms:

data	keyboard
input	disc
processing	magnetic tape
memory	bit
output	
Central Processing Unit	

Student Information Sheet #4

Robotics, Inc.—LISP
Provential Insurance—COBOL, BASIC, PASCAL
Teaching Grammer—BASIC, PASCAL
Telephone Co.—COBOL, PASCAL
(BASIC is improbable here)