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ABSTRACT

This is a curriculum guide for the preliminary edition of Volume III-B of Science For Georgia Schools, Junior High Earth Science. The course of study is designed for the eighth grade and includes selected topics from astronomy, meteorology, geology, oceanography, physical geography, and space travel. Topics are grouped under five units called (1) lithosphere, (2) hydrosphere, (3) atmosphere, (4) astronomy, and (5) space. In this teacher's guide, outlines for teaching the topics are presented. Each outline contains a list of (1) concepts to be learned, (2) activities, experiments, and demonstrations to illustrate the concepts, (3) films, and (4) references. The guide also lists supplementary activities, the sources of earth science materials, bibliographies of student and teacher references, and equipment. (LC)

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SCIENCE FOR GEORGIA SCHOOLS

JUNIOR HIGH EARTH SCIENCE
Volume III–B

Preliminary Edition

Division of Curriculum Development
Office of Instructional Services
Georgia Department of Education
Atlanta, Georgia 30334

Jack P. Nix, State Superintendent of Schools
1970

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PLEASE NOTE

This preliminary edition of Volume III-B of Science For Georgia Schools, Junior High Earth Science, is being issued in very limited numbers. Much care has been taken in selecting the people who receive copies of it. It is expected that these people will offer a written critical review of this publication which will be used in determining the form of the guide to be used for general distribution.

A record has been kept of your having received this guide. It is hoped that you will voluntarily submit your review during the 1969-1970 academic year. This is not to imply that any coercion will be used to require you to make this criticism, but hopefully you will see our need to share your expertise.

The original writing team put forth considerable effort to make this science guide accurate, both scientifically and pedagogically. But the writing team will be the first to admit that many errors have occurred in both categories.

Please use your interest, ability and time to find these errors, report them on the attached form to the Department of Education, and help make this publication as effective and useful as possible.

SUGGESTED FORMAT FOR REPORTING CRITICISM

I. Errata (page and line numbers)

II. Scientific inaccuracies

III. Pedagogical errors

IV. Suggestions for additional sections or chapters

V. Other criticism

VI. Name and title of reviewer

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CONTENTS

FOREWORD

Earlier volumes of this series, "Science For Georgia Schools," were concerned with curriculum guidance for the elementary grades. They attempted to put into an orderly sequence the multitude of activities appropriate for these years. In addition, they attempted to show the inseparable interrelationships between matter and energy as they affect the broad areas of living matter; rocks, soils, and minerals; earth and space; electricity and magnetism; heat; sound; light; properites of matter; and air and water. These earlier guides were characterized by consistent internal themes which led the elementary students to broadened insight in the realm of scientific knowledge and increased skill in the process of science.

As the years passed by, new kinds of needs developed for science in the intermediate or junior high school years. Possibly the most fundamental of these needs arose from the advent of the junior high school itself in Georgia. As school populations increased, the logical curriculum reorganization pattern for many Georgia communities was toward the junior high school arrangement. It was felt that if special intermediate schools developed, then special science curricula should be made available for them.

Curriculum developments in the senior high schools also changed the requirements for science in the junior high school years. National curriculum studies such as PSSC Physics, CEMS Chemistry and BSCS Biology, with their quantitative, laboratory centrality, called for students with different kinds of skills. Students who were successful in these courses were successful, at least in part, because they understood how to function in open-ended laboratory experiences. The implication is then, that prerequisite coursework for these new curricula should be developed.

Our emerging society also demands special materials for the junior high school. As the population becomes more urban, students are farther removed from their natural environment and more closely associated with a complex technological environment. Concomitantly, mankind's need for efficient utilization of the earth's resources increases. So there arises in the schools the desirability for instruction in earth and environmental sciences. If citizens are to make wise choices concerning the use of this planet's natural wealth, then they all must understand the nature of the work of the earth scientist, his successes and his limitations.

Similarly, the combination of factors make special attention to the life sciences in the junior high school desirable. These factors include the nature of new biology curriculum materials for the senior high school, the fact that some students still do not attend senior high school, and the fact that increased population density has had attendant increases in certain diseases and health problems.

Traditional concepts of physiological structures and processes have been deemphasized in new biology curriculum materials for the senior high school. There should be some time during the public school years for all students to learn something about the construction and operation of the human organism, to learn basic ideas of human reproduction and genetics and to learn fundamental ideas about the mechanism of disease vectors which affect human welfare. The junior high school is an appropriate time for this effort.

The real world of today's citizen is the technological world, and the basis for this technology is the physical sciences. Therefore, all citizens should know the basic principles and laws which govern technological phenomena. Besides knowing these principles and laws, today's citizens should have appropriate skills enabling them to bring these principles and laws to bear on problems which they encounter in day-to-day existence. This, then, is part of the rationale for emphasizing in the junior high school years coursework in introductory physical science. A second, but more limited, reason for teaching the physical sciences is the new curriculum materials in science for the senior high school. Effective instruction in the Biological Sciences Curriculum Study laboratory materials demands that students have background in fundamental laws of physical science. The laboratory experience in physical science in the junior high school permits the development of familiarization with laboratory procedure characteristic of the high school years.

Three volumes of this curriculum guide for science in the junior high school are being written then, to provide learning experiences in life science (Volume III-A), earth science (Volume III-B), and physical science (Volume III-C). Volume III-A has been published and Volume III-C will be made available to schools as quickly as the mechanics of editing and printing can be accomplished.

The writers have prepared these materials so that they can be used in sequence, with life science being presented in the first of the junior-high years, earth science in the second and physical science in the third. The writers recognize that this sequence may not be the most desirable one for every school using these materials. It will be possible, therefore, to divide each course so that a portion of each may be presented during each year of the junior high school sequence. The essential consideration is that all these materials be presented during the junior high years.

During the summer of 1967, a writing team under the direction of Dr. Johnathan Westfall of the University of Georgia assembled to write this guide. The team was composed of Louis Hornsby, Albany High School; Mrs. Gladys Atkinson, Dykes High School, Atlanta; Mrs. Nannelle Bacon and Mrs. Bobbie Gamble, Bacon County Junior High School; Mrs. Linda Chapman and Mrs. Rosemary Strother, Clarke County Junior High School; Mrs. Dorothy Evans, DeKalb Junior College; Barney Purvis, Irwin County High School and Henry Weissinger, Muscogee County Schools.

Gratitude must be expressed in advance for those who will offer critical review of this preliminary version of Volume III-B, "Science For Georgia Schools." The work done by the writing team cannot be judged without the thoughtful criticism of both professional scientists and science teachers. Only after this first effort is modified by the expertise of scientists and the experience of teachers will it be possible to publish this guide in a final form for general distribution to all people in Georgia concerned with the development of the science curriculum in the junior high school grades.

Introductory Material

Introduction to Earth Science

The Earth Science course of study as presented in this curriculum guide is concerned primarily with a combination of subject areas that deal with the scientific phenomena of the earth and its environs, including the lithosphere, hydrosphere and atmosphere. Specific topics include fundamental elements of physical geography, astronomy, meteorology, oceanography, geology and space travel.

Instruction in Earth Science at the eighth grade level contributes greatly to the objectives of science education. The study of the earth and its environs affords excellent opportunities for eighth grade students to understand and appreciate the world in which they live. Such a study provides the student with an understanding of the physical earth and the space that surrounds it, and provides opportunities for the pupil to see the scientific method of solving problems. The study also provides the basis for an appreciation of the natural resources of our state and nation, and it has an aesthetic value in that travel becomes meaningful through an understanding of the physical features of the earth.

Earth Science for the eighth grade has been developed to present a variety of ideas and activities. The teacher may use the activities to lead students in discovering relationships and in understanding a number of the emerging concepts. Some of the ideas are for teacher demonstrations, but most are designed for student participation. Good science instruction involves active participation by students in laboratory activities. The order of the topics may be varied or altered at the discretion of the teacher. However, it is suggested that opportunities for stressing relationships of the various topics be an integral part of the year's course.

The course outline as developed here suggests many concepts of Earth Science. The supporting activities, which include field trips, can be developed in and out of the classroom.

The topics considered are:

Lithosphere treats the structure and composition of the earth and earth processes are studied in the physical geology unit. Attention is given to maps and map making as a tool used in studying landforms.

The origin of the earth is presented as a series of theories on the creation of the planet earth. Reading history from earth, land and sea formations gives attention to geologic time measurements and the historical development of life.

Hydrosphere includes oceanography, and allows for study of the physical geography of the oceans, the chemical properties of sea water and the effects of the oceans' currents on the earth's surface.

Atmosphere gives attention to the makeup of the air the hydrologic cycle, and includes meteorology, with activities on weather and climate. A study of the basic physical principles of weather prediction is included.

Astronomy is limited to the study of the solar system and the place of the earth in the sun's family, with space study being considered as a related topic.

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Using The Guide

It is unlikely that all the material in the earth science guide can be covered thoroughly in a school year of approximately 180 days, although a suggested allotted time has been given. Therefore, it is wise for the teacher to plan the school year carefully so that the available time may be budgeted among those topics which will be of the greatest interest and value to the students.

The choice of topics should be based on the capabilities of the teacher and the needs of the students. Some teachers may wish to build most of their course around the geological aspects of earth science by expanding Unit I or by weaving together Units III, IV and V. Many valid combinations of unit areas are possible.

The units may be taught as they appear in the guide or may be varied in sequence as it seems best for the particular school and teacher. One unit is not necessarily a prerequisite to another. Neigher is it obligatory that the following time schedule be followed rigidly. Should the teacher elect to explore all of these areas within the school year, the following suggested time table may be helpful:

Unit I.	Lithosphere	12 weeks
Unit II.	Hydrosphere	4 weeks
Unit III.	Atmosphere	8 weeks
Unit IV.	Astronomy	6 weeks
Unit V.	Space	6 weeks

The way science is taught in the junior high school is more important than the selection of material to be presented. Science is a "doing" subject; young people learn by doing. A planned program of concepts to be learned, and activities, experiments and demonstrations to illustrate certain concepts make up the organization of the course of study. Merely reading about science and talking about science is little better than no science at all.

The activities given are only a few suggestions. Each teacher needs to develop his own techniques for presenting the many concepts.

If instruction in science is to be effective, all activities, lab experiences, materials, concepts and investigations must be organized around those things which have significance for students in terms of interests or needs.

The junior high school science teacher should have some knowledge of what should be taught, and he must know something of current happenings in fields such as electricity, satellites, nuclear energy and space travel. A most important asset is the willingness to give students time to solve problems rather than "giving" them the answers. Teachers must take time to guide students in discussing, setting up problems, planning, reading, observing, experimenting and arriving at conclusions.

Much leeway has been allowed in the guide by the inclusion of a wide variety of references, activities and films. The guide is not designed as a prescribed course of study, but it is hoped that it can provide teachers with a resource for curriculum planning appropriate for local needs.

Objectives For Teaching Earth Science

1. To develop an understanding of the role of the earth in space as a basis for an appreciation and comprehension of the many natural phenomena that vitally affect life upon the earth.

2. To develop in the pupil the ability to record data and write reports in an accurate and concise manner.

3. To provide experiences which will develop skills and understanding and appreciation of the earth.

4. To develop an ability to read with understanding the material in the popular press on this area of study.

5. To arouse curiosity concerning natural phenomena by concept development, inquiry and investigation.

6. To develop the habit of checking evidence before forming a conclusion.

7. To develop in the student a desire to be inquisitive about the unknown.

Philosophy and Rationale For Teaching Earth Science

Earth Science is a part of everyday living.

Perhaps the most important reason for teaching earth science is that it offers experience in a wide range of science disciplines to all students. A number of students drop out of school at the end of junior high school. These students who do not continue in school have developed in earth science some knowledge of mathematics in dealing with and solving problems. These dropouts have acquired some concepts about the earth which will make them useful citizens. They should be able to vote intelligently in the future on issues related to water and air pollution, exploration of space, desalting of the oceans' waters, conservation and use of natural resources.

Earth Science is not a defined, discreet branch of science. Rather it is a number of sciences with a common thread of continuity binding these disciplines together. The binding agent in this case is the earth.

Earth Science is of strong current interest. The impact of the IGY is only beginning to be felt. Topics of vital concern are: space, travel, the oceans' mineral resources, conservation of natural resources and the search for new materials.

It is hoped that the Earth Science course in the eighth grade can break down traditional barriers between the science disciplines and contribute greatly to the relationships among astronomy, geology, meteorology, oceanography, physical geography, chemistry, physics and biology.

The student of earth science can develop greater understanding of and appreciation for his natural surroundings. Local field trips can yield important information about the geological history of an era and man's use and misuse of his natural resources. Brief trips to the schoolyard itself can reveal weathering and erosion at work. Students can see that natural forces are changing the earth today as in the past.

Interest in the principles of light and optics can be aroused when they lead into a study of the heavens by means of a telescope.

Depending upon the location of the school, certain ecological projects can be undertaken. For example, the relationship of ancient as well as modern marine life to the physical environment may be studied in fossils or marine forms found on the beach.

In an introduction to minerals and rocks, many important chemical concepts can be emphasized. Students learn the value of determining physical and chemical properties with accuracy in identifying minerals. By growing and studying crystals similar to those found in rocks, students can learn far more about the behavior of atoms, molecules and ions than a mere discussion could impart.

There are excellent opportunities for integration with other courses. The tie to geography is obvious. Natural resources, the effects of climate upon the world's inhabitants, the dangers of atomic radiation, and the impact of new earth science discoveries upon society are topics which are treated in social studies, as well as in science classes. Various types of models and visual aid material may be constructed in art and shop classes.

There are many activities in the guide which give excellent opportunities for club and hobby work. Students can build their own weather instruments to record data on changes in the atmosphere. Mineral, rock and fossil collecting are hobbies that can be enjoyed throughout life. Earth science draws heavily upon biology, chemistry and physics. An excellent medium is provided for demonstrating the interdependence of science fields. There is hardly a principle of physics that cannot be applied to the dynamic earth and other bodies of the universe. Virtually every substance used by man comes from the earth. The theory of evolution is based upon fossil evidence. It is interesting to note that most geology majors are required in college to take at least one year each of chemistry, biology and physics in addition to their geology training.

Laboratory experiences are particularly important. Students can develop skills in handling basic equipment needed also in biology, chemistry and physics. The course provides excellent training for students who will take other science courses.

With increasing emphasis upon laboratory experiences, the earth sciences have a great deal to offer. In addition to the outdoor laboratory, much can be accomplished in the classroom. A few subjects which have been investigated and listed in the guide are:

1. Theories about the earth's formation
2. Soil chemistry
3. Mapping
4. Principles of crystal growth
5. Identification of minerals by means of specific gravity
6. Determination of chemical and physical properties in minerals.
7. Evidence of evolution in fossils
8. Refraction and reflection of light
9. Construction of weather maps and instruments
10. Reading history from the earth
11. Forces that have changed the earth's surface
12. Oceanography
13. Climate
14. Astronomy
15. Space travel

In the earth science course, it is possible to relate the earth to its atmosphere and the universe. With this unity earth science offers a distinct advantage over the usually conglomerate "general" science. In earth science, a small number of science areas are explored so that students have a better opportunity of finding out what science is really about. Repetition and duplication are avoided.

Detailed Outline Of The Guide

UNIT I. LITHOSPHERE

A. PLANET EARTH

1. Formation

a. Theories

(1) Ancient

(2) Modern

2. Layers

a. Crust

(1) Past condition or state

(2) Present condition

(3) Future condition (prediction)

b. Mantle -- Moho Project

c. Core

(1) Composition

(2) Earth's Magnetic Field

B. MINERALS

1. Basic chemistry

a. Structure of matter

b. Chemical reactions

2. Identification of minerals

a. Visible characteristics

(1) Color

(2) Streak

(3) Luster

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(4) Crystal form

(5) Hardness

(6) Specific gravity

b. Special properties

(1) Magnetic

(2) Electrical

(3) Fluorescent

(4) Radioactive

(5) Optical

c. Chemical tests

3. Classification

a. Metallic

b. Non-metallic

c. Gem

4. Uses

a. Commercial

b. Decorative

C. ROCKS

1. Formation and identification

a. Igneous

b. Sedimentary

c. Metamorphic

2. Uses

D. READING HISTORY FROM THE EARTH

1. Records in rocks

a. Stratigraphy

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b. Paleontology

2. Geological time table

E. MAPPING

1. Measurement of the earth

a. Shape of the earth

b. Determining direction

(1) Latitude

(2) Longitude and time

2. Map design and reading of maps

a. Projections

b. Topographic maps

F. GEOMORPHOLOGY

1. Changing the ea.ths surface

a. Diastrophism

(1) Folds

(2) Faults

(3) Earthquakes

b. Mountains and vulcanism

c. Plains and plateaus

2. Surface forces that change the landscape of the earth (destructional, mechanical)

a. Running water (stream cutting)

b. Wind

c. Glacial ice

d. Gravity

e. Waves

UNIT II. HYDROSPHERE

A. TOPOGRAPHY OF THE OCEAN FLOOR

1. Zones

   a. Basins

   b. Shelf

   c. Slope

   d. island arcs

   e. Sea mounts

   f. Trench

2. Sediments

B. CHEMICAL PROPERTIES OF SEA WATER

1. Organic

2. Inorganic (desalting)

C. MOTIONS OF THE OCEANS' WATERS

1. Waves

2. Tides

3. Currents

UNIT III. ATMOSPHERE

A. MAKEUP OF THE AIR

1. Gases

2. Pollution

3. Layers

   a. Temperature

   b. Pressure

4. Greenhouse effect

   a. Reflection

   b. Refraction

   c. Mirage

B. AIR MOVEMENTS

   1. Planetary winds

      a. Pressure belts

      b. Wind belts

      c. Coriolis effect

      d. Circumpolar whirl

      e. Jet stream

   2. Local breezes

C. WATER IN THE ATMOSPHERE

   1. Hydrologic Cycle

      a. Water pollution (causes and effects)

      b. Evaporation

         (1) Temperature

         (2) Humidity

         (3) Pressure

      c. Condensation

         (1) Cloud types

         (2) Forms of precipitation

D. WEATHER CHANGES

   1. Air masses and weather fronts

   2. Storms

      a. Hurricanes

      b. Tornadoes

      c. Thunderstorms

E. WEATHER PREDICTION

1. Application of instruments

a. Radar

b. Satellites

2. Weather maps

F. CLIMATE

1. Determinants of climate

a. Average weather conditions

b. Topography of the earth

2. Geological changes affect climate

UNIT IV. ASTRONOMY

A. COMPOSITION OF MATTER IN SPACE

1. The spectra

a. Continuous spectrum

b. Bright line spectrum

c. Absorption spectrum

B. PHYSICAL LAWS OF SPACE

1. Orbital motions

a. Early theories

b. Modern theories

2. Time

a. As related to earth's rotation

b. As related to earth's revolution

3. Seasons

4. The nature of light

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C. TOOLS OF THE ASTRONOMER

1. The telescope

   a. Optical

   b. Radio

2. The spectroscope

3. Other miscellaneous tools

D. CHARTING THE SKY

1. The star chart

2. The constellations

E. THE MOON-OUR NEAREST NEIGHBOR

1. Physical characteristics and surface features

2. Its motions in space

3. Its effects on the earth

F. THE SUN

1. Physical characteristics

   a. Surface features

   b. Mass, temperature, distance, etc.

2. Motions of the sun

   a. Surface rotation

   b. Position and movement in the milky way

3. Surface activity

   a. Sun spots and prominences

   b. The sun's source of energy

G. THE SOLAR SYSTEM

1. Organization and members of the system

2. Theories of origin

3. Orbital motions

H. THE STARS

1. Distance and size
2. Stellar units for distance
3. Classification of stars color and brightness
4. Motions in space
5. Stars of special interest
    a. Variable stars
    b. Double stars
    c. Star clusters
6. Life cycle of a star; theory of star evolution

I. GALAXIES

1. Physical characteristics
    a. Spiral
    b. Elliptical
    c. Irregular
2. Distribution, distances, size, and motions
3. Our galaxy; the milky way
4. Other objects in the milky way (star fields, nebulae, dust clouds)

UNIT V. SPACE OBJECTS, FORCES AND EXPLORATION

A. ASTRONAUTICS-THE SCIENCE OF SPACE FLIGHT

1. Definition of outer space
2. Problems and hazards

B. AIR FLIGHT

1. Early efforts and history
2. Principles involved
    a. Bernoulli's principle and the kite effect

b. Engines for air flight

C. FLIGHT BEYOND THE ATMOSPHERE

1. History and early work

2. Principles and problems; the rocket engine

D. SATELLITES-INSTRUMENT BEARING

1. Their contribution to meteorology, navigation and communication

E. MANNED SATELLITES

1. The astronaut

2. History of manned flights

3. The goal: man on the moon

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UNIT I. THE LITHOSPHERE

Introducing the Unit

The surface of the earth has undergone many changes in its history. Most of these changes are still going on and can be observed in the vicinity of any school campus. Students should become aware, through first-hand experiences, of some of the processes that bring about changes in the earth's surface. An understanding of these processes can serve as a foundation for future work in conserving water, soil, plants and wildlife.

This study begins with the origins and features of the earth itself, with emphasis on the characteristics of the planet as a foundation to the better known processes occurring in and on the crust.

The teacher may wish to begin the lesson with a film. (Listings are given in this guide.) The National Academy of Sciences has produced an excellent series of thirteen films called the "Planet Earth" series. Principal fields of geophysical research, including the work of the IGY are stressed. The "Hidden Earth" film is especially appropriate. Many of these films are listed in this guide and can be found in the Georgia Department of Education film catalog.

Teachers should evaluate their students' backgrounds in this area. Do not bore your classes by reviewing familiar concepts, but be prepared to clarify any misunderstandings. This is a challenging study. Keep it alive the whole year.

A. PLANET EARTH

1. Formation

   a. Theories

      (1) Ancient

      (2) Modern

Suggested Activities

1. Panel discussion may come after research on both ancient and modern theories.
2. Discuss age of the earth. Some students may want to investigate the exact methods by which radioactive decay can be used to date the earth.
3. See Foundations of Physical Science, pp. 315-319 (theories of earth's formation)
4. See Science Today for the Elementary School Teacher, part 3 on "Space, Time, Earth" (suggestions are given for experiments and demonstrations).

Emerging Concepts

1. There are several theories of how the earth was formed.

2. Available data allow scientists to evaluate these theories which have been advanced to explain the orgin of the earth.

Equipment

Slate globe

Films*

1. "The Hidden Earth," j-s, 27 mins., 7158

2. "The Shape of the Earth," j-s, 27 mins., 7382

*Numbers listed with film titles indicate Georgia Department of Education film catalog number.

References

1. Today's Basic Science: The Atom and the Earth, Ch. 12.

2. Modern Earth Science, pp. 86-87.

2. Layers

   a. Crust
      (1) Past condition or state
      (2) Present condition
      (3) Future condition (by predition)

   b. Mantle -- Moho Project

   c. Core
      (1) Composition
      (2) Earth's magnetic field

Suggested Activities

(Note: If a melon were used to represent the earth, the crust would be a mere pencil line on the outside.)

1. See activity 1, The Earth, Investigating Science with Children, Vol. 2, on discovering the meaning of density, p. 6.

2. See activity 2, (above reference) on mixing substances of differing densities, p. 7.

Suggested Activities (continued)

3. Place iron filings over a bar magnet. Explain that the earth acts as a huge magnet. (Caution: Do not place filings directly on magnet. Place paper over the magnet.)

4. See Foundations of Physical Science, pp. 320-324, on the study of layers of the earth.

5. Our Planet in Space, see pp. 482-483, on a discussion and demonstration on isostasy.

6. The Earth, Investigating Science with Children, see activity 4, p. 8 making a clay model of the earth. (Note: This should be a teacher demonstration or a small-group activity.)

Emerging Concepts

1. The age of the earth and the nature of its interior have been investigated with the help of specialized tools which extend man's senses.

2. The outer layer of the earth is very thin compared with the other rock layers of the earth.

3. The Moho project is an attempt to drill through the earth's crust to reach the mantle.

Equipment

Activity 1: Cotton ball, cork, cork stopper, wood block, small piece of iron, piece of glass, small stone, piece of aluminum

Activity 2: Olive jar with cap, water, pebbles

Films

1. "What's Inside the Earth," e-j, 15 mins., 4886

2. "Project Mohole," j-s, 19 mins., 4904

3. "Earth: Its Structure," e-j, 11 mins., 1779

4. "Birth of the Soil," j-s, 10 mins., 415

References

1. Modern Earth Science, pp. 89, 94.

2. Earth Science: The World We Live In, pp. 3-5.

3. Investigating the Earth, pp. 52.

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B. MINERALS

1. Basic chemistry

    a. Structure of matter

    b. Chemical reactions

Suggested Activities

1. See Modern Earth Science, p. T-26 (Teacher's edition).

2. See Geology and Earth Science Sourcebook, pp. 1-40, an ideal sourcebook for the entire unit on minerals.

3. Introduce laboratory work. Students can become familiar with some simple pieces of equipment as they observe and investigate chemical reactions.

Emerging Concepts

1. The formation of the substances of the earth's crust can be explained by developing an understanding of some of the basic principles of chemistry.

Equipment

Iron filings, sulfur, litmus paper, copper sulfate, acids and bases, scales, bar magnets, periodic chart

Films

1. "Chemical Change," e-j, 12 mins., 4395

References

1. Modern Earth Science, Ch. 10.

2. Earth Science: The World We Live In, pp. 6-15.

3. Earth and Space Sciences, pp. 29-35.

4. Investigating the Earth, pp. 35-50.

2. Identification of minerals

   a. Visible characteristics

      (1) Color
      (2) Streak
      (3) Luster
      (4) Crystal form
      (5) Hardness
      (6) Specific gravity

   b. Special properties

      (1) Magnetic
      (2) Electrical
      (3) Fluorescent
      (4) Radioactive
      (5) Optical

   c. Chemical tests

Suggested Activities

1. Discovery Problems in Earth Science, pp. 3-21, study guide, activities, and tests for the study of mineral classification.

2. Field trip on or off campus to collect samples.

3. Demonstrate visible characteristics of minerals, such as color, hardness, luster and streak.

4. Have small collections of unidentified minerals in boxes; divide class into small groups. Have students use visible characteristics to identify minerals with the aid of mineral identification chart. Modern Earth Science, pp. 631-642.

5. Introduction to Physical Geology, pp. 27-37, 468.

6. Encourage students to collect and identify minerals from surrounding local areas; this could lead to a large display of collections or other laboratory studies of minerals.

7. Lab exercise on crystal growing. Crystals and Crystal Growing. (paperback)

8. Activities using Bell Telephone kits on crystal growing.

9. Laboratory Manual for Earth and Space Science, pp. 1-26. Lab exercises on crystal forms, visible characteristics, density and specific gravity.

Emerging Concepts

1. Minerals can be identified by physical and chemical properties.

Equipment and Supplies

1. Unglazed tile (enough for entire class), glass squares, penny, knife, Bunsen burners, diluted hydrochloric acid, mortar and pestle

2. Collection of common minerals

3. Fluorescent minerals kit

4. Scale of hardness

5. Superior mineral collection

6. Spring balances

7. Jolly balance

Films

1. "Crystal Clear," Bell Telephone Co.

Slides

1. "Ward's Color Slides for Mineralogy"

References

1. Modern Earth Science, Ch. 11.

2. Earth Science: The World We Live In, Ch. 2.

3. Basic Earth Science, pp. 101-119

4. Modern Science: Earth, Space and Environment, pp. 194-199.

5. Earth and Space Science, pp. 38-47.

6. Investigating the Earth, pp. 51-57.

3. Classification

    a. Metallic

    b. Non-metallic

    c. Gem

Suggested Activities

1. Continue group work on identifying minerals, but now have students classify the minerals.

Suggested Activities (continued)

2. Another field trip may be taken. Have students identify minerals as they collect them. This activity can be used as a means of evaluation. Use field methods of identification.

Emerging Concepts

1. Minerals can be classified into three basic groups.

Equipment and Supplies

1. Mineral samples from each group

Films

1. "The Earth: Resources In Its Crust," e-j, 11 mins., 1778

References

1. Earth Science: The World We Live In, Ch. 3.

2. Modern Earth Science, pp. 176-192.

4. Uses

   a. Commercial

   b. Decorative

Suggested Activities

1. Student research in the library. The information gained can be presented to the class in the form of reports and discussion. (This activity can open up an interest in possible careers).

2. Use a resource person to give the class information about careers.

Emerging Concepts

1. The properties of minerals determine their uses and economic value.

Equipment and Supplies

1. Products made from minerals

2. Minerals used in chemical industries (collection).

Films

1. "Mining," e-j-s, 20 mins., 4683

References

1. Earth and Space Science, pp. 47-50.

2. Earth Science: The World We Live In, Ch. 3.

3. Modern Earth Science, pp. 176-192.

C. ROCKS

1. Formation and identification

   a. Igneous

   b. Sedimentary

   c. Metamorphic

2. Uses

Suggested Activities

1. Introduce unit by field trip to road cuts and weathered areas. Find an area of granite which is being weathered. Use granite as an example of how minerals make rocks.

2. Geology and Earth Sciences Sourcebook, pp. 41-61. This section may be used through the entire study of rocks.

3. Discovery Problems in Earth Science, pp. 23-40, study guides, investigations and tests.

4. Work-a-Text in Earth Science, pp. 13-25, study guides, investigations, and tests.

5. Exercises and Investigations for Modern Earth Science, pp. 55-62, lab exercises.

6. Laboratory Manual, Earth and Space Science, pp. 39-44, classification of rocks.

7. Introduction to Physical Geology, Ch. 17 and 19, study of sedimentary rocks and metamorphism.

8. Elements of Geology, pp. 37-49, classification of rocks.

Emerging Concepts

1. Rocks of the earth's surface are formed from minerals which have been metamorphosed.

2. The rocks of the earth contain valuable products for the use of man.

Equipment and Supplies

1. Picks, sacks, hand lenses, and hammers; diluted hydrochloric acid
2. Collections of at least six specimens from each group of rocks
3. Earth Science rock collection

Films

1. "Rocks for Beginners," e-j, 16 mins., 4794 (good introductory film)
2. "Rocks That Form on the Earth's Surface," e-j-s, 17 mins., 4880
3. "Rocks that Originate Underground," e-j-s, 22 mins., 5432

References

1. Modern Earth Science, Ch. 12.
2. Investigating the Earth, Ch. 15.
3. Modern Science: Earth, Space, and Environment. See index, p. 456.
4. Earth Science: The World We Live In, Ch. 4.
5. Earth and Space Science, Ch. 6, 9, and 10.

D. READING HISTORY FROM THE EARTH

1. Records in Rocks
   a. Stratigraphy
   b. Paleontology

Suggested Activities

1. Geology and Earth Sciences Sourcebook, Unit 16. A sourcebook for the study of stratigraphy.

   Note: Students can begin to make a collection of fossils. Small fossils may be found in layers of limestone, shale or sandstone. They may also be found in coal and gravel pits. Have students classify them as much as possible and keep for further use in geological time unit.

2. Exercises and Investigations, Modern Earth Sciences, pp. 131-134. Lab exercises on investigations and classification of fossils.
3. Investigating Science with Children, Vol. 2, activity 107, making a fossil (ideal introduction to fossils).

Suggested Activities (continued)

4. Investigating Science with Children, activity 108, making a cast from a fossil imprint.

5. Geology and Earth Science Sourcebook, Unit 15. A sourcebook for study of paleontology.

6. Laboratory Manual for Earth and Space Science, pp. 81-86, study and identification of fossils.

Emerging Concepts

1. Rock layers are studied so that earth history can be reconstructed in detail as much as possible.

2. Fossils are used by geologists to determine the changes that have occurred since the earth was first formed.

Equipment and Supplies

Fossils lab; clay, fern or animal shell, fossil imprint, clay, tempera, talcum powder, brush, paleogeographic relief map

Films

1. "Fossils: Clues to Prehistoric Times," e-j, 11 mins., 1879

2. "Prehistoric Animals of the Tar Pits," e-j-s, 15 mins., 4692

3. "Prehistoric Times: The World Before Man," e-j-s, 11 mins., 1600

References

1. Earth Science, The World We Live In, Ch. 21.

2. Modern Earth Science, Ch. 21, pp. 388-397.

3. Exploring Earth Science, pp. 337-371.

4. Investigating the Earth, pp. 414-420.

5. Earth and Space Science, pp. 556-563.

6. Our Planet in Space, pp. 509-515.

2. Geological time table

Suggested Activities

Note: Have students examine two or three historical geology textbooks and explain how certain species of animals might have become extinct.

1. Exercises and Investigations for Modern Earth Science, Exercise 55, Geologic time table

   Visit the nearest museum or college geology department where you can study an exhibit of fossils of different types and of different geological ages.

2. Science Today for the Elementary School Teacher, Ch. 8, sourcebook for the geological calendar.

Emerging Concepts

1. The fossil remains of living things represent specific eras of geologic time

2. The geological timetable shows a series of changes in the fauna and flora throughout the span of geologic time, with the simplest being found in the lowest (oldest) rock layers and gradual changes toward higher forms of life in the highest (youngest) layers.

3. Advanced forms of plants and animals have lived in three major divisions of geologic time.

Films

1. "The Dinosaur Age," e-j-s, 15 mins., 4730

2. "Geological Work of Ice," j-s, 11 mins., 264

References

1. Our Planet in Space, pp. 516-521.

2. Earth and Space Science, Ch. 41.

3. Investigating the Earth, pp. 423-430.

4. Modern Earth Science, Ch. 22.

5. Earth Science, The World We Live In, Ch. 22 and 23.

ERIC

E. MAPPING

1. Measurement of the earth

    a. Shape of the earth

    b. Determining direction

        (1) Latitude

        (2) Longitude and time

Suggested Activities

1. Introduce the topic by asking students to give their location; then, with the aid of your city, county, state, U. S., North America, Northern Hemisphere, and world maps, show the complexity of problems involved in giving one's location.

2. This is an excellent time to introduce magnetism.

3. Laboratory Manual, Basic Earth Science, pp. 63-64, study of earth's magnetic field.

4. Exercises and Investigations for Modern Earth Science, exercises 9, 10, 11 and 12, deal with the globe, latitude, longitude and time.

5. Demonstrate meridians and parallels (refer to book in activity 4, p. 34).

6. Discovery Problems in Earth Science, pp. 249, 262. Study guides and investigations about latitude and longitude.

7. Work-a-Text in Earth Science, pp. 41-50. Exercises 3, 5, 6 and 7 are on measurement of the earth and determining location.

8. Man's Physical World, pp. 11-28, locations, scale and maps.

Emerging Concepts

1. The size and shape of the earth play an important part in accurately determining one's location.

Equipment and Supplies

1. Maps: city, county, state, U. S., North America, Northern Hemisphere, world
2. Relief globe
3. Slate globe
4. Small set of colored pencils
5. Transparencies
6. Magnetic compasses and bar magnets, for entire class, and iron filings
7. Magnetic globe and dipping needle
8. World Atlas
9. World globe

Films

1. "Magnetic, Electrical, and Gravitational Fields," e-j, 11 mins., 354

2. "Magnetic Force," s, 29 mins., 7383

3. "Latitude and Longitude," j-s, 9 mins., 1555

4. "Which Way is North," e, 14 mins., 5423

5. "The Shape of the Earth: Geodesy," j-s, 27 mins., 7382

References

1. Investigating the Earth, pp. 60-70; 120-124.

2. Modern Earth Science, pp. 94-95; 98-108

3. Earth Science; The World We Live In, Ch. 29.

4. Earth and Space Science, pp. 236, 239-240; 246-247.

5. Foundations of Physical Science, pp. 199-201.

2. Map design and reading of map

a. Projections

Suggested Activities

1. With the aid of a globe and transparent plastic sheets, introduce the various ways in which flat maps are made of a curved surface.

2. Refer to maps made from different projections so that students can recognize the various types. Be sure to emphasize the distortions which are made by the various projections.

3. Work-a-Text in Earth Science, pp. 51-53, gives exercises to aid in teaching projections.

4. Introduction to Physical [illegible]ology, pp. 483-484, gives uses of maps.

5. Man's Physical World, pp. 29-38, map projections.

Emerging Concepts

1. A curved surface cannot be reproduced accurately on a flat plane.

Equipment and Supplies

1. A selection of maps based on each projection

2. Sheets of transparent plastic

3. Map projection model

4. Trigraphic contour relief maps, set of 7

Films

1. "Global Concept in Maps," j-s, 11 mins., 470

2. "Introduction to Map Projection," j-s, 20 mins., 4335

References

1. Modern Earth Science, pp. 126-131.

2. Earth Science, The World We Live In, pp. 59-62.

b. Topographic Maps

Suggested Activities

1. The complete understanding of how to interpret topographic maps is necessary to prepare for the following unit on geomorphology.

2. The following books contain laboratory exercises relating to topographic maps:

   Work-a-Text in Earth Science, pp. 53-60

   Discovery Problems in Earth Science, pp. 41-52

   Exercises and Investigations for Modern Earth Science, pp. 27-34

3. Geology and Earth Sciences Sourcebook, pp. 365-375, activities on topographic mapping.

4. Modern Earth Science, pp. T-23, T-24.

5. Man's Physical World, pp. 39-42, deals with contour mapping.

6. Introduction to Physical Geology, pp. 485-487, on contour mapping.

Emerging Concepts

1. The elevation and contour of the earth's surface can be represented by and studied with the aid of topographic maps.

Equipment and Supplies

1. Purchase a series of topographic maps of your area or purchase the ones which are listed with the suggested exercises. Orders may be placed with the Map Information Office, U. S. Geological Survey, Washington 25, D. C.

2. Map reading model

3. Rulers and compasses

4. World globe

5. Transparencies

Films

1. "Maps and Their Uses," e-j, 10 mins., 1247

2. "Language of Maps," e-j, 11 mins., 108

References

1. *Modern Earth Science*, pp. 131-139.

2. *Earth Science, The World We Live In*, Ch. 5.

3. *Exploring Earth Science*, pp. 401-421.

4. *Earth and Space Science*, pp. 21-23.

F. GEOMORPHOLOGY

1. Changing the earth surface

   a. Diastrophism

      (1) Folds
      (2) Faults
      (3) Earthquakes

   b. Mountains and vulcanism

   c. Plains and plateaus

Introductory Material

A special feature of the junior high level is investigation. In addition, there is a need for a conservation theme to run through the whole year of study. This is particularly true of this unit. If processes include the entire general realm of inquiry, students can observe the results of erosion and inquire about its causes and methods of prevention. The science program at this level should instill

Introductory Material (continued)

in boys and girls an appreciation of the scientific approach to conservation. Many resource people and materials are available in the community in this field. Teachers should participate in an overall instructional program to establish objectives for the purpose of conserving soil, forests and wildlife.

Students should be made aware of the following points:

1. Soil is conserved primarily by contour plowing, strip cropping, terracing and crop rotation.

2. The conservation of soil while it is being used is a continuous struggle that requires increasing knowledge and skill.

Suggested Activities

1. Introduction to Physical Geology, Ch. 20 and 21. Execellent source of information for this unit.

2. Elements of Geology, Ch. 4. Geologic forces.

3. Discovery Problems in Earth Science, 4th ed., Unit 3, pp. 133-170. Study guide and activities on constructional forces.

4. Modern Earth Science, T-37 to T-40.

5. Geology and Earth Sciences Sourcebook, pp. 97-110, gives information and activities on earthquakes.

6. Science Today for the Elementary School Teacher, pp. 175-181, observations and experiments pertaining to changes in the earth's surface features.

7. Exercises and Investigations for Modern Earth Science, exercises 29, 30, 31, 34 and 35, on mountains and volcanoes.

8. Geology and Earth Sciences Sourcebook, pp. 113-124. Information and investigations on mountain building.

9. Modern Earth Science, T-42 to T-44.

10. Exercises and Investigation for Modern Earth Science, exercises 32, 33. Deal with plateaus.

11. Geology and Earth Sciences Sourcebook, pp. 66-84. Information and activities on volcanoes.

12. Study the Appalachian system of mountains, the physiographic regions of Georgia. Allow time for discussion about Stone Mountain, Fall Line, Okefenokee Swamp, and islands off the coast of Georgia.

Emerging Concepts

1. Earthquakes and volcanoes furnish evidence that forces are operating today which tend to change the earth's crust.

2. Mountain systems, folds and fractures in rock strata show that such forces have worked in the past.

Equipment and Supplies

1. Geology demonstration kit

2. Physiographic relief globe

3. Geology models (land form)

4. Collection of color slides on land forms.

Films

1. "Earthquakes and Volcanoes," j-s, 13 mins., 4645

2. "The Face of the Earth," e-j-s, 12 mins., 763

3. "Lava and the River," j-s, 20 mins., 5133

4. "Secrets of a Volcano," j-s, 25 mins., 7116

5. "Volcano," e-j, 18 mins., 5071

6. "Mountains on the Move," e-j, 11 mins., 2010

7. "Why Do We Still Have Mountains?," e-j-s, 20 mins., 5517

References

1. Modern Earth Science, Ch. 13.

2. Earth and Space Science, Ch. 11.

3. Earth Science, The World We Live In, Ch. 11 and 14.

4. Modern Science: Earth, Space, and Environment, pp. 235-240.

5. Modern Earth Science, Ch. 14, 16.

6. Earth and Space Science, Ch. 5

7. Investigating the Earth, Ch. 14, 15.

8. Earth Science, The World We Live In, Ch. 12, 13.

9. Modern Earth Science, Ch. 15.

ERIC

2. Forces that change the landscape of the earth (destructional-mechanical)

   a. Running water (stream cutting)

   b. Wind

   c. Glacial ice

   d. Gravity

   e. Waves

Suggested Activities

Note: Find rocks that show signs of weathering. What kinds of weathering are illustrated? Point out evidence of erosion and weathering on the school grounds and buildings.

1. Elements of Geology, pp. 174-180, geological work on glaciers.

2. Exercises and Investigations for Modern Earth Science, investigations 26, 29, p. 123, on mechanical and chemical weathering erosion.

   Use a stream table to show the result of changing stream velocity and gravity.

3. Elements of Geology, Ch. 11, pp. 183-194, describes wave action and shorelines.

4. Exercises and Investigations for Modern Earth Science, investigation 28, p. 123. Demonstration on ice.

5. Laboratory Manual: Earth and Space Science, pp. 67-70. Exercises concerning the work of glaciers.

6. Exercises and Investigations for Modern Earth Science, exercises 44, 49, 50, 51 and 52, deal with work of streams and shore line features.

7. Modern Earth Science, T-52 to T-63.

Emerging Concepts

1. Erosion is basically a leveling process.

2. Destructional forces that change the surface of the earth are: wind, ice, abrasion, water and weathering.

3. The crust of the earth is worn down in some areas and is built up in other areas.

Equipment and Supplies

1. Stream table

ERIC

Films

1. "Soil and Water Conservation," j-s, 10 mins., 324

2. "Evidence for the Ice Age," e-j, 19 mins., 4875

3. "Conserving Our Soil Today," e-j, 11 mins., 1782

4. "Erosion: Leveling the Land," e-j-s, 13 mins., 4831

References

1. Investigating the Earth, Ch. 21.

2. Earth Science, The World We Live In, Ch. 15.

3. Modern Earth Science, Ch. 17-20.

UNIT II. THE HYDROSPHERE

Introducing the Unit

An investigation of the oceans can be an inviting study for the junior high school student. Help the boys and girls develop a true picture of the oceans as part of the earth. It should be kept in mind that the study has now shifted from the lithosphere to the hydrosphere. This can be an interesting experience, a probing into the unknown. The oceans are mysterious domains which present challenges to scientists, explorers and adventurers.

Be prepared to answer any questions which may arise; at least listen to students' inquiries. Consider the personal backgrounds of these students. Their experiences are varied. Children who live in the coastal areas will be aware of phenomena which children in inland areas have not seen. The ocean, with all of its mysteries, is really an invitation to inquiry.

Use as many of the teacher references as possible. They will be of tremendous help in planning your activities, investigations and field trips. The student references listed with given page numbers are to be used with the entire unit on the Hydrosphere. A rather extensive list of films is given, with the hope that at least some of them will be available when they are needed.

A. TOPOGRAPHY OF THE OCEAN FLOOR

1. Zones
   a. Basins
   b. Shelf
   c. Slope
   d. Island arcs
   e. Sea mounts
   f. Trench

2. Sediments

B. CHEMICAL PROPERTIES OF SEA WATER

1. Organic

2. Inorganic (desalting)

C. MOTIONS OF THE OCEAN'S WATERS

1. Waves

2. Tides

3. Currents

Suggested Activities

1. The Harper Encyclopedia of Science. See Ocean, Oceanography, Ocean Currents, Deeps and Rises, Submarine Canyons, Mid-Oceanic Ridge, and Continental Shelf, Slope, and Rise; illustrations and maps.

2. Investigating Science with Children, Vol. 2, Unit 3, investigating the hydrosphere, pp. 38-61.

3. Man's Physical World, Ch. 15, pp. 527-568. Realm of the sea

4. Periodicals: Scientific American
   "Beaches," #845, Aug., 1960.
   "Ocean Waves," #828, Aug., 1959.
   "Tsunamis," #829, Aug., 1954.
   "The Changing Levels of the Sea," #805, May, 1960.
   "The Circulation of the Oceans," #813, Sept., 1955.
   "The Anatomy of the Atlantic," #810, Jan., 1955.

5. Exercises and Investigations for Modern Earth Science, ex. 58, p. 137; ex. 59, p. 141, investigation 40, p. 143. Study guide for ocean profile, currents and density.

6. Geology and Earth Sciences Sourcebook, presentation, pp. 158-166. Demonstrations, projects, and experiments, pp. 168-175, numbers 4, 5, 6 and 7. Unsolved geological problems, p. 167, numbers 5, 7 and 8. This information concerns mainly ocean floor, currents and waves.

7. Elements of Geology, Ch. 11, pp. 183-194. Information deals with wave action and shorelines.

8. Introduction to Physical Geology, Ch. 15 and 16, pp. 281-321. Submarine geology. Waves, currents and the sculpture of coasts.

Emerging Concepts

1. The ocean floor is irregular in form; it is made of a mass of plains, valleys and mountains.

2. The main subdivisions of the ocean floor are continental shelves, continental slopes and deep basins.

3. Oceanography is the branch of science that deals with the study of the ocean.

4. Great currents of water move from the equator to the poles and back again.

5. The oceans of the earth are vast sources of food and minerals.

6. Ocean waves over the years have changed the earth's surface.

7. Ocean currents and distribution of marine life are affected by the contour of the ocean floor.

Emerging Concepts (continued)

8. Ocean currents are affected by temperature, wind, salinity and earth rotation.

9. Winds produce waves as a result of friction between air and water.

10. Gravitational attraction between the earth, moon and the sun produces tides.

Equipment and Supplies

1. Hydrographic relief globe

2. Charts of the topography of the ocean floor--Atlantic Ocean Charts. Geological Society of America, 231 E. 46th St., New York 17, New York

3. Relief maps of ocean floor

Films

1. "Challenge of the Oceans," s, 29 mins., 7156

2. "Plankton and the Open Sea," s, 19 mins., 5400

3. "Science of the Sea," s, 19 mins., 4699

4. "What's Under the Ocean," e-j-s, 14 mins., 4909

5. "The Restless Sea," Bell Telephone Co.

6. "Ocean Tides--Bay of Fundy," e-j-s, 14 mins., 5283

7. "Ocean Currents," j-s, 17 mins., 5100

8. "Earth, Its Oceans," e-j, 12 mins., 4241

9. "Exploring the Ocean," e-j, 10 mins., 784

10. "Life in the Ocean," e-j-s, 17 mins., 4731

11. "Life in the Sea," e-j-s, 11 mins., 303

12. "Marine Animals of the Open Coast," j-s, 22 mins., 5137

13. "Marine Life," e-j, 11 mins., 584

14. "Waves on Water," e-j-s, 16 mins., 5289

Slides

1. Selection of slides on oceanography, Wards Scientific Co.

References

1. Today's Basic Science: The Atom and the Earth, Ch. 15.
2. Investigating the Earth, Ch. 10, pp. 227-245.
3. Earth Science, The World We Live In, Unit 4, pp. 232-276.
4. Earth and Space Science, Unit 4, pp. 434-553.
5. Modern Science: Earth, Space, and Environment, Ch. 8, pp. 203-224.
6. Modern Earth Science, Ch. 25, 26, pp. 492-522.
7. Basic Earth Science, pp. 141-156.
8. Our Planet in Space, Ch. 15, pp. 299-319.

UNIT III. THE ATMOSPHERE

Introducing the Unit

Meteorology is a growing science, and its importance increases daily as information is obtained about the behavior of the gases and substances of the atmosphere. At this point, conservation of our air should be introduced. The makeup of the atmosphere is being changed due to air pollution. A knowledge of this problem is important as pollution may possibly change both weather and climate, and eventually man's way of life.

Students may have some knowledge of certain phases of weather, such as clouds and forms of precipitation. You may wish to use this knowledge as a basis for planning the extent to which you need to develop your outline of study.

The study of meteorology is an area of science which lends itself to student activity and participation. To be meaningful and effective, observations should be made and data collected daily. With the aid of instruments which have been purchased or made by the students, class weather predictions can be made. When technically constructed instruments are used, the conversion of the English and metric systems should be included in the work. Visits to local airports or other places having weather stations can prove valuable.

As the area of climatology is approached the teacher must be cautious not to make this a "dead" study. It is not necessary that students be held responsible for learning the Koeppen-Geiger system of identifying climatic regions. It is more important that they learn what determines a climate and the resulting effects on the land and the people.

A. MAKEUP OF THE AIR

1. Gases
2. Pollution
3. Layers
    a. Temperature
    b. Pressure
4. Greenhouse effect
    a. Reflection
    b. Refraction
    c. Mirage

Suggested Activities

1. Geology and Earth Science Sourcebook, pp. 127-140. This section applies to the entire unit on the atmosphere and will be valuable for suggestions of activities and problems.

2. Exercises and Investigations for Modern Earth Science, p. 145. The atmosphere

3. Work-a-Text in Earth Science. Characteristics of the atmosphere, p. 177; air temperature, p. 183.

4. Discovery Problems in Earth Science. Includes study guides and activities on the composition of the atmosphere, pp. 263-285.

5. Laboratory Manual: Basic Earth Science. Exercises on angle of radiant energy, p. 11, convection, p. 44. Lab sheets are given in the back of the book.

6. 700 Science Experiments for Everyone. Wide selection of brief experiments on air and air pressure, weather and light, plus instructions for making a model weather station.

7. Weather Elements. Excellent resource book for use in Unit III.

Emerging Concepts

1. The composition of the atmosphere and the effects of the sun's radiation on the earth determine the various weather phenomena.

2. Weather phenomena involve vast energy changes in terms of heat, moisture content and air.

3. The atmosphere maintains its balance as a life supporting gas system as a result of natural processes such as the carbon dioxide and nitrogen cycles.

Equipment and Supplies

1. Thermometers, one for every 2 students in class

2. Ring stands and clamps, one for every 2 students in class

3. Reflectors or aluminum foil

4. 200 watt bulbs

Films

1. "Unchained Goddess," Bell Telephone, excellent introductory film for this unit

2. "Ocean of Air," e-j, 14 mins., 4889

3. "Inconstant Air," s, 29 mins., 7134

4. "Earth and the Sun's Rays," j-s, 5 mins., 342

5. "Refraction," j-s, 8 mins., 362

References

1. Earth Science, The World We Live In, Ch. 31, 38.

2. Modern Earth Science, Ch. 27.

3. Exploring Earth Science, pp. 17-23; 38-43; 50-59.

4. Basic Earth Science, pp. 200-209

5. Investigating the Earth, pp. 156-163.

6. Earth and Space Science, pp. 344-354.

7. Modern Science, Earth, Space, and Environment, Unit 4 refers to A, C, of Unit III.

8. Current Science and Science and Math Weekly, Our Polluted World, Unit Book, 1956.

B. AIR MOVEMENTS

1. Planetary Winds

   a. Pressure belts
   b. Wind belts
   c. Coriolis effect
   d. Circumpolar whirl
   e. Jet stream

2. Local breezes

Suggested Activities

1. Exercises and Investigation for Modern Earth Science, exercise 61. The study of planetary and local winds

2. Discovery Problems in Earth Science. Study guides and exercises on the winds pp. 297-306.

3. Work-a-Text in Earth Science. Explanations, experiments, review questions on winds and weather, pp. 209-220.

Emerging Concepts

1. Once the mobile gases of the atmosphere are set in motion, they develop complex wind circulation patterns over the earth.

2. Three major elements responsible for circulation of the earth's atmosphere are: (1) heat from the sun, (2) rotation of the earth, (3) friction between the earth's irregular surface and the air itself.

3. Local conditions determine the extent of local breezes.

Equipment and Supplies

1. Slate globe
2. Convection box

Films

1. "Atmosphere and Its Circulation," j-s, 10 mins., 237

2. "What Makes the Wind Blow?," e-j-s, 16 mins., 5331

References

1. Earth Science, The World We Live In, pp. 456-461, Ch. 33.

2. Modern Earth Science, Ch. 29.

3. Investigating the Earth, pp. 164-175.

4. Earth and Space Science, pp. 380-390.

C. WATER IN THE ATMOSPHERE

1. Hydrologic cycle

a. Water pollution (causes and effects)

b. Evaporation

(1) Temperature
(2) Humidity
(3) Pressure

c. Condensation

(1) Cloud types
(2) Forms of precipitation

Suggested Activities

Note: Information on pollution problems may be found in recent newspapers, magazines and other references available in most libraries. Be sure to check the Reader's Guide for help in finding magazine articles. Your local and state health departments and weather bureaus, local industries, as well as the tuberculosis and health associations, may be able to help you.

1. Current Science and Science and Math Weekly, unit book, "Our Polluted World," Applied ecology of air and water.

2. Exercises and Investigations for Modern Earth Science, exercise 62, p. 149 and exercise 63, p. 151, investigation 50, p. 158. Activities on evaporation and condensation.

Suggested Activities (continued)

3. Geology and Earth Sciences Sourcebook, Presentation, pp. 133-134, suggested problems and questions, p. 138, nos. 8, 10. Unsolved problems, p. 139, no. 11. Information dealing with condensation and precipitation.

4. Work-a-Text in Earth Science, Ch. 3, pp. 199-208. Exercises dealing with moisture in the air.

Emerging Concepts

1. Water in the atmosphere is mostly in the form of water vapor, the gaseous state; the vapor condenses and becomes liquid water. Water freezes and becomes ice.

2. Water evaporates from the oceans and moves into the atmosphere as water vapor.

3. "Relative humidity" expresses the amount of water the air holds in comparison to the maximum it can hold at a given temperature.

4. The volume of a gas increases with a rise in temperature.

5. The volume of a gas decreases as the pressure on it increases.

6. Atmospheric capacity for absorbing and retaining moisture is regulated by temperature and pressure.

7. Meteorologists measure the amount of water vapor in the air; they express the amounts in terms of vapor pressure, relative humidity and absolute humidity.

8. Three basic types of clouds are Cumulus, Stratus and Cirrus.

9. The forms of precipitation are rain, hail, snow and sleet.

10. Cooling air below its saturation point results in condensation, clouds and precipitation.

Equipment and Supplies

1. Current Science, a weekly science news periodical for junior high school classes

2. Sling psychrometer, wet and dry bulb thermometers, barometer, air guide hygrometer, rain gauge, wind vane

3. Charts and pamphlets which include photographs and descriptions of principal cloud types can be obtained from the U. S. Weather Bureau. Commercial charts showing cloud levels and types are also available from map publishers. Slides may be purchased from museums and commerical suppliers.

4. U. S. slate or chalk (washable material) weather map, to be used for drawing in storms, fronts, etc.

Films

1. "Water Cycle," e-j, 9 mins., 366

2. "Water for the Community," e-j, 11 mins., 1805

3. "Water, Water, Everywhere," p, 11 mins., 640

4. "Weather, Understanding Precipitation," e-j, 11 mins., 1731

5. "Clouds Above," e-j, 10 mins., 1283

6. "Clouds," j-s, 11 mins., 2014

7. "What Makes Rain," p-e, 8 mins., 632

8. "What Makes Clouds," e-j, 19 mins., 5330

References

1. Investigating the Earth, Ch. 8, pp. 179-203.

2. Basic Earth Science, Ch. 9, pp. 200-229.

3. Modern Earth Science, Ch. 29, pp. 551-566.

4. Earth Science, The World We Live In, Ch. 34 and 35, pp. 475-499.

5. Today's Basic Science, the Atom and the Earth, pp. 364-366.

6. Exploring Earth Science, pp. 24-34.

7. Earth and Space Science, Ch. 27, pp. 360-374, Ch. 31, pp. 416-431.

8. Our Planet in Space, Ch. 13, pp. 259-281.

D. WEATHER CHANGES

1. Air masses and weather fronts

2. Storms

   a. Hurricanes

   b. Tornadoes

   c. Thunderstorms

E. WEATHER PREDICTION

1. Application of instruments

   a. Radar

   b. Satellites

2. Weather maps

Suggested Activities

Note: Beginning with this unit, the classroom work should be closely related with existing weather conditions. Build on what your students know from previous studies of weather. Develop your study through a process approach by considering heat, wind, moisture and air pressure, their causes and effects. Newspapers and weather bureau maps will describe the location and type of air masses producing current weather conditions. This information should be displayed in the classroom, preferably in the form of large, easily visible maps that may have the air masses and fronts drawn in from day to day. Much of the classroom discussion will be built around this type of display and will make the study of weather origins much more meaningful.

Encourage students to watch weather reports on television and compare television readings with readings from classroom instruments.

A field trip to the nearest weather bureau office is a highly desirable activity. A preparatory discussion between the teacher and the meteorologist at the weather station is essential in order to arrange the details for the trip and to acquaint the teacher with the operation of the station so that the students may be properly prepared.

Review the new balloons, satellites and elaborate instrumentation that now provide valuable data about air and weather.

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Suggested Activities (continued)

1. Earth Science, Work-a-Text, pp. 221-226. These activities show how the U. S. Weather Bureau obtains, analyzes, reports, and predicts weather information.

2. Discovery Problems in Earth Science, pp. 320-336. Study guides and activities for study of fronts, air masses and storms.

3. Weather Elements, Thomas Authur Blair, Ch. 10, 11 and 12, pp. 191-277. An excellent sourcebook for teachers; describes circulation and movement of air masses.

4. Meteorology, Albert Miller, brief, logical discussion of fundamental meteorological concepts.

5. Exercises and Investigations for Modern Earth Science, exercise 64, p. 153, exercise 65, p. 155, investigation 45, p. 147, investigation 48, p. 158. Activity: air masses and weather stations; homemade instruments; weather forecasting.

6. Geology and Earth Science Sourcebook, presentation, p. 132, suggested problems and questions, p. 138, nos. 8, 11. Unsolved problems, p. 139, nos. 2, 5, 9, 10 and 12. Study of weather disturbances.

Emerging Concepts

1. Air masses form when air becomes stagnant over an area; fronts form when two different air masses meet near a low pressure area.

2. Four conditions of the atmosphere give rise to weather: heat, wind, moisture and air pressure.

3. The general circulation of the atmosphere influences weather.

4. Air masses move across the earth in low-pressure systems and high-pressure systems.

5. Certain factors cause changes in weather which can be measured by special instruments.

6. Weather forecasts are possible as a result of collections of weather data. These data are plotted on weather maps which are used by meteorologists.

Equipment and Supplies

1. U. S. or North American continent map

2. Weather forecasting labs (Six labs for a class of 30 are recommended)

Films

1. "Weather," p-e, 10 mins., 1343
2. "Story of Hurricanes," j-s, 11 mins., 823
3. "Weather: Understanding Storms," e-j, 11 mins., 1730
4. "Weather," e-j-s, 10 mins., 1489
5. "Weather: Why It Changes," e-j, 11 mins., 1729
6. "Our Weather," e-j, 11 mins., 883
7. "Inside the Weather," e-j-s, 14 mins., 4998
8. "Eyes in Outer Space," j-s, 26 mins., 7096
9. "Reading Weather Maps," e-j, 14 mins., 4321

References

1. Investigating the Earth, pp. 193-203.
2. Today's Basic Science, The Atom and the Earth, pp. 369-375.
3. Earth Science, The World We Live In, Ch. 36 and 37, pp. 502-531.
4. Our Planet in Space, Ch. 14, pp. 283-297.
5. Earth and Space Science, Ch. 29 and 30, pp. 391-415.
6. Exploring Earth Science, pp. 68-80.
7. Modern Earth Science, Ch. 30 and 31, pp. 567-598.

F. CLIMATE

1. Determinants of climate
   a. Average weather conditions
   b. Topography of the earth
2. How geological changes affect climate

Suggested Activities

1. Discovery Problems in Earth Science, exercises, questions, and tests for climate, pp. 337-348.

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Suggested Activities (continued)

2. Exercises and Investigations for Modern Earth Science, pp. 159-163. Activities dealing with elements of climate in the United States.

3. Man's Physical World, pp. 245-284. Global climatic patterns.

4. Albert Miller, Meteorology. Teacher sourcebook for the unit on climate.

5. Earth and Space Science; Laboratory Manual, p. 161. Maritime and continental climates.

Emerging Concepts

1. Climate is defined as the average weather in a locality over a period of extended time.

2. Despite the fluctuations in weather conditions over the earth, certain comparable characteristics enable climates to be grouped regionally.

3. Warm equatorial air mixes with cold polar air at high altitudes to form systems of high speed winds. These systems appear to have a great effect on the patterns of weather which determine climate.

Equipment and Supplies

1. World Relations maps of temperature, rainfall, climatic conditions

2. Abundant supply of photographs of typical climatic regions, from National Geographic, Look, Life, travel brochures, etc.

Films

1. "Climate and the World We Live In," e-j, 13 mins., 4142

2. "Climates of North America, From the North Pole to the Tropic of Cancer," e-j, 17 mins., 5399

3. "Climates of the United States," e-j, 11 mins., 1706

4. "High Arctic Biome," j-s, 22 mins., 5360

5. "The Amazon," e-j-s, 22 mins., 5290

6. "African Continent: Tropical Region," e-j, 16 mins., 4300

7. "Australia: The Land and the People," e-j-s, 18 mins., 4116

8. "Chile," e-j-s, 15 mins., 5092

Films (continued)

9. "Tropical Rain Forest," j-s, 16 mins., 5391

10. "Argentina," e-j-s, 15 mins., 5092

11. "Physical Regions of Canada," e-j-s, 23 mins., 4690

References

1. Earth Science, The World We Live In, Ch. 39, 40.

2. Modern Earth Science, Ch. 32, 33.

3. Investigating the Earth, Ch. 11.

4. Exploring Earth Science, pp. 81-112.

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UNIT IV. ASTRONOMY

Introducing the Unit

The unit on astronomy shares most objectives recognized as goals of general science. In addition, there are some unique purposes which will be identified.

The exploration of space depends heavily on knowledge acquired through astronomy. Many principles at work on earth and in space were discovered by astronomers. In nature's great laboratory in space, we find many conditions impossible to duplicate here on earth.

Astronomy can be an exciting and satisfying hobby. This unit will give many young people their first glimpse of the vast mysteries and beauties of the universe.

The teacher has a serious responsibility to the student in this unit. A tiresome and dreary routine of statistics and fact memorization is almost surely calculated to destroy the natural curiosity all young people have about the wonders of space. There are available many excellent astronomical manuals, charts and handbooks which place all such data at the student's finger tips, thus making memorization unnecessary.

One of the primary objectives of this unit is to stimulate an interest in space. Hopefully, this interest will lead the student to a study of much greater depth and a lifetime of interest in the heavens.

A word of warning to the teacher: Most of the material in this unit can quickly reach a level of difficulty above which this age group is not prepared to go. It is the teacher's responsibility to keep the material at an introductory, descriptive level and to leave the depth study to physical science and physics.

If a telescope is not available at the school, or if the teacher does not feel competent to handle the instrument, an enthusiastic amateur astronomer can usually be found who will take great delight in sponsoring a nighttime field trip for the class. The excitement and pleasure of such an adventure has been responsible for the creation of many amateur astronomy clubs.

During this unit of work, it is strongly recommended that the following items be made available for class use:

1. A world globe
2. A celestial globe
3. An American Ephemeris and Nautical Almanac
4. Several copies of Mallan's Exploring Space With Astronomy, Fawcett-Haynes, Louisville, Kentucky, 1967
5. A small telescope with tripod

If this material is not available from the science supply room it may be possible to borrow some items from other school departments. The almanac and Sky and Telescope

Introducing the Unit (continued)

can be supplied by the school library. A little effort on the part of the teacher will turn up these and other useful items as the unit proceeds.

A. COMPOSITION OF MATTER IN SPACE

1. The Spectra

a. Continuous spectrum

b. Bright line spectrum

c. Absorption spectrum

Note:

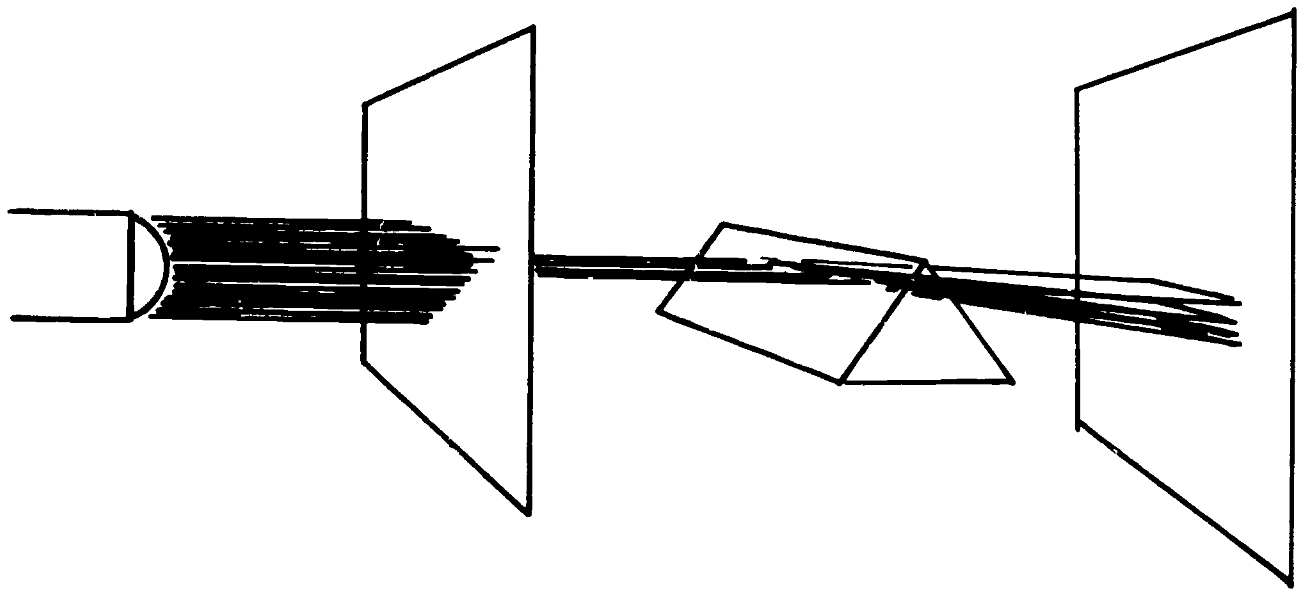
In Unit I-B (Earth and Space Science), the earth's structure is studied in relation to rocks and minerals. At this time, the structure of matter as it is found in space is to be considered. Matter in outer space often under physical conditions of pressure and temperature far different from those found on earth. The earth scientist has access to samples of material to use in his studies, but the astronomer does not. He must analyze the structure of matter observed far out in space, and in doing so, must often use techniques and tools different from those used in other laboratories. What are some of these instruments? How can matter, located countless miles out in space, possibly be analyzed by earth-bound man?

The purpose of this unit is to guide an examination of the knowledge the astronomer has gained about matter and of some of the tools and techniques he uses in his work.

Suggested Activities

1. Continuous spectrum: Use a classroom-size spectrum chart and discuss the continuous, bright line and absorption spectra.

   For class observation, form a continuous spectrum from white light. Use set-up similar to this sketch:



Suggested Activities (continued)

2. Bright-line spectrum: Refer again to large spectrum chart and discuss bright lines that appear in spectrum.

3. Set up spectroscope and have students observe the spectra of several elements and compounds. A physics teacher or capable physics student may assist with this experiment.

4. Have students construct a simple spectroscope and examine the spectra of several light sources. (Kits are available for about $6.00). For instructions, see Ramsey, et al., Foundations of Physical Science, pp. 312-314.

Emerging Concepts

1. Throughout all space, the fundamental structure of matter is found to be the same.

Equipment and Supplies

Classroom-size spectrum chart ($5.00)
Spectrum kit ($6.00)
Triangular prism

Spectroscope kit (about $6.00)
Gas flame
Sample materials (iron, copper wire, table salt, etc.) to produce spectra and fluorescent and tungsten light sources

References

1. Basic Earth Science, pp. 267-268.

2. Modern Space Science, pp. 201-202.

3. Investigating the Earth, pp. 526-527.

4. Modern Earth Science, pp. 6-7.

5. Astronomy, pp. 37-40.

To form continuous spectrum see:

6. Exercises and Investigations for Modern Earth Science, p. 16.

7. Earth Science, The World We Live In, pp. 327-329.

8. Investigating the Earth, p. 533 (see Fig. 24-11).

9. Earth and Space Science, Lab manual, pp. 133-135. Exercise on the spectroscope.

B. PHYSICAL LAWS OF SPACE

1. Orbital movements

    a. Early theories of celestial motions

    b. Modern theories

2. Time

    a. As measured in relation to earth's rotation

    b. As measured in relation to earth's revolution

Note:

Before recorded history man had surely observed the movements of the heavenly bodies. These he had noted with interest, fear and wonder. He must have wondered if the same physical laws controlling the movement of heavenly bodies also controlled the movements of the earth.

Efforts to define and explain these movements have engaged the best minds of the ages. It has been the goal of science to find some sort of simple relationships among celestial movements. Many theories have been developed to account for the observed events. Continued observation and newly discovered knowledge have made necessary a constant reevaluation of existing theories and laws.

As new knowledge is gained, old theories and cherished beliefs often have to be dropped. This is not always easy to do!

Some of the physical laws of space will be examined at this point. The evolution of some of the early theories to their presently accepted forms will be traced.

Suggested Activities

1. Orbital motions. Dramatic evidence of the earth's rotation is provided by a photo of a star trail. Students can photograph a star trail in this way: Use fast film, mount camera on tripod and point toward the North Star. Open shutter (time exposure) and leave camera undisturbed for two or more hours. The processed picture will show effect of the earth's rotation.

Emerging Concepts

1. The earth is a moving platform in space, from which we observe the universe.

Equipment and Supplies

Camera and tripod

Films

1. "Exploring Space," e-j-s, 27 mins., 7062

For pictures of star trails see:

1. Investigating the Earth, p. 86.

2. Modern Earth Science, p. 9.

3. Earth and Space Science, Lab manual, pp. 107-109, The Ecliptic.

Suggested Activities

a. Early theories of celestial motions. Discuss the early theories that accounted for celestial motions. Have students sketch charts to compare the Ptolemic and Copernican systems.

This is a good place to emphasize the danger that may result from a false assumption. However, many theories that are not entirely true have helped to advance knowledge. They may clarify some aspects of a problem and later be dropped in favor of a better theory.

The class should understand the great difficulty man faced in achieving a true understanding of celestial motions.

Emerging Concepts

1. Early False Concept: The earth is the center of the universe, around which all celestial bodies revolve.

2. When new knowledge is obtained, existing laws may have to be revised.

Equipment and Supplies

Sketching paper, compass, scales (or rulers)

References

1. Modern Space Science, pp. 104-105.

2. Investigating the Earth, pp. 496-498.

3. Modern Earth Science, pp. 2-3.

4. Astronomy, pp. 2-7.

5. Basic Earth Science, pp. 260-261.

6. Our Planet in Space, pp. 97-109.

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Suggested Activities

b. Modern theories. Discuss with the class how modern theory evolved from the work of many great men, such as Brahe, Kepler, Galileo, Newton and others.

Trace the work of these great men and show how their work led to knowledge of the solar system as we know it today.

Have students construct an ellipse, identify its component parts and graphically relate Kepler's laws on the drawings. See Modern Space Science, pp. 107-109.

Emerging Concepts

1. Artificial satellites behave according to the same laws that govern the movement of natural space objects.

2. The solar system is a matter-energy system bound together by the universal force of gravity.

Equipment and Supplies

Borrow from the physics department a law-of-motion apparatus and a falling body apparatus.

Sketching paper, thumbtacks, string, ruler

Films

1. "Planets in Orbit," j-s, 10 mins., 309

References

1. Modern Space Science, pp. 100-123.

2. Astronomy, pp. 1-13.

3. Earth and Space Science, pp. 268-270 and 322-324.

Also see Astronomy, pp. 9-10, Earth and Space Science, p. 269, Earth Science, The World We Live In, pp. 352-353, and Our Planet in Space, pp. 90-91.

Suggested Activities

2. Time

   a. As related to earth's rotation. Have the class arrive at a definition of time.

   Man has always found it desirable to mark the passage of time.

   In our present complicated culture, we could not manage without our time-keeping practice.

   Interesting projects and reports can be developed around early time-keeping techniques. Projects can include construction of an hour candle, water clock, sand glass, sun dial, etc. See Modern Space Science, p. 127 and Modern Science: Earth, Space and Environment, p. 29 for details.

   See Investigating the Earth, p. 378 (Chinese rope clock).

   Modern techniques: Modern time-keeping devices began with Galileo's discovery of the laws of the pendulum. See Modern Science: Earth, Space, and Environment, p. 30 (Experiment with pendulum).

   Examine a clock movement. (A large unit may be borrowed from a clock repairman). See Modern Space Science, p. 128, Fig. 7-3.

   Discuss why modern society requires time keeping of far greater accuracy than is possible by mechanical means.

   Discuss the use of synchronous electric clocks and how they made possible uniform and accurate nationwide time.

   An oscillator and oscilloscope can demonstrate a highly accurate technique of timing. This experiment would require the assistance of a physics teacher.

Equipment

A simple pendulum with accessories (may be assembled from nylon string, weights, a meter stick and a stand). Also large clockworks

Films

1. "Story of Time," s, 10 mins., 1259

2. "How to Measure Time," e-j, 11 mins., 337

3. "About Time," 60 mins., Bell Telephone

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References

1. Earth Science, The World We Live In, pp. 422-429.

2. Our Planet in Space, pp. 98-99.

3. Astronomy, p. 19 (Astronomer's view of time).

For teacher reference

1. Modern Physics, Dull, Williams and Metcalf. (It is recommended that 8th grade students not be given assignments in this text.)

2. Modern Space Science, p. 142, Fig. 7-13. (An atomic clock).

3. Modern Science: Earth, Space, and Environment, p. 33, Fig. 1-30. (An atomic clock).

General text references

1. Modern Space Science, pp. 125-148.

2. Modern Science: Earth, Space and Environment, pp. 28-37.

3. Foundations of Physical Science, pp. 19-25.

4. Investigating the Earth, pp. 374-378.

Suggested Activities

b. Time as related to earth's revolution: Use diagram to show that since the earth's rotation and its yearly revolution do not form an even ratio, a simple calendar is not possible.

Class discussions and reports can center around problems involved in inaccuracies of early calendars.

Have students construct the newly proposed "universal" calendar and "world" calendar. Their relative merits should be explained and discussed.

Thought question: Why is it so difficult to get an obviously better calendar universally adopted?

With a globe and spotlight, the need for time zones and an international dateline can be demonstrated.

Emerging Concepts

1. The combination of the earth's rotation and its revolution form the basis for the calendar design.

Equipment

Sketching paper, rulers, globe, spotlight

References

1. Modern Space Science, pp. 133-139.

2. Modern Earth Science, pp. 120-121.

3. Earth Science, The World We Live In, pp. 427-428.

4. Earth and Space Science, pp. 244-245.

5. Discovery Problems in Earth Science, study guide on earth's revolution, p. 241.

3. Seasons

The earth follows the path of an ellipse in its flight around the sun, and actually is closest to the sun in December. Why is it winter at this time in the Northern Hemisphere? The earth's tilt has the effect of causing the seasons.

Suggested Activities

1. Use a globe and flashlight to demonstrate how angle light reaches the globe at each season. See activity suggested in ESCP, Investigating the Earth, p. 94.

2. See activity suggested in Earth and Space Science, p. 246.

3. Use diagram to show thickness of atmosphere solar energy must penetrate in reaching the earth's surface from high and low angles.

Emerging Concepts

1. The seasons depend mainly on the angle of the sun above the horizon.

2. The tilt of the earth's axis is responsible for the seasons.

Films

1. "Earth and the Seasons, e-j-s, 10 mins., 1508

References

1. Earth and Space Science, p. 246.

2. Modern Space Science, p. 143.

References (continued)

3. Investigating the Earth, p. 93-95 (Fig. 4-14).

4. Work-a-Text in Earth Science, pp. 155-165.

5. Discovery Problems in Earth Science, pp. 239-246.

4. Nature of Light

Note to Teacher:

Light is such an essential and basic tool of the astronomer that some study of the nature of light must be undertaken at this time. Care must be taken to keep the following suggested topics at a level easily understood by students. Further study of light, in more depth, will come in physical science and later in physics.

Suggested Activities

1. Explain the wave and particle theories of light. Show how each theory was useful in early studies of light, and how it finally became necessary to combine the two concepts as a result of new knowledge.

   The velocity of light has been determined with great accuracy and is now an essential tool of the astronomer.

2. Discussion and reports on efforts of early scientists to measure the speed of light form an interesting activity. Their crude techniques led to the false concept that the speed of light was instantaneous.

3. Diagram for the class the method used by Roemer to time the speed of light.

   Use diagrams to explain later techniques used by Fizeau and, later, by Michelson.

4. Discuss how the constancy of light speed enables the astronomer to use light to determine distance and time. (see definition of "light year")

   Explain how light intensity is an important tool in astronomy.

   The eye is a poor judge of intensity and other tools must be used for accurate measurement.

5. Demonstrate a light meter, an accurate tool for measuring intensity.

6. Use a diagram to explain the concept of the foot-candle (or lumen) as a quantitative unit of light intensity.

Suggested Activities (continued)

7. Experiment for class: Set lighted candle in center of dark room. Holding a foot-square-card one foot away will show approximately the intensity of 1 lumen (foot-candle). Note how the eyes gradually adjust to seeing in dim light.

   Discuss and explain how this concept (See Emerging Concepts no. 1) with refined techniques has given the astronomer one tool to determine the size and distance of stars.

8. Explain the concept of the light year and how it has become a convenient "yard stick" to measure the vast distances in space.

Emerging Concepts

1. The intensity of light reaching us from a distant object results partly from its distance and size.

2. Light travels a constant distance in any given unit of time.

3. The light year is a distance that light travels in a year.

Equipment

Light meter (or photographic exposure meter); candle, one-foot-square white card.

Films

1. "Light: Wave and Quantum Theories," j-s, 14 mins., 4293

2. "Speed of Light, j-s, 14 mins., 4964

3. "Infinite Univer e," j-s, 11 mins., 1429

4. "Mystery of Time," j-s, 40 mins., 9001

References

1. Modern Space Science, pp. 149-178.

   Reference for teacher: Section on light in any high school physics text will provide information on theories of light. It will be the teacher's responsibility to explain this material at a level the students can understand.

2. Modern Space Science, pp. 149-153.

3. Modern Space Science, p. 151, fig. 8-1.

4. Modern Space Science, p. 198.

References (continued)

5. Earth and Space Science, p. 299.

6. Modern Earth Science, p. 4.

7. Investigating the Earth, p. 522.

8. Earth and Space Science, p. 310.

C. TOOLS OF THE ASTRONOMER

   1. The telescope

      a. Optical

      b. Radio

   2. The Spectroscope

   3. Other miscellaneous tools (photometer, camera, etc.)

Introductory Material

The astronomer would be extremely handicapped if he depended only on the unaided eye in his work. The truth is, very little of his work is done today by direct viewing. Serious astronomical work began only after the invention of the telescope about 1608. Since then, telescopes have been greatly improved, and many other instruments have been perfected to aid the natural senses. In this section, some of these instruments and techniques will be introduced to the class.

Suggested Activities

1. The telescope: Discuss with the class the early history of the telescope. Use diagrams to explain the principle of the refractor and reflector instruments. Note: Only a descriptive treatment should be presented here. Study in greater depth will come in physical science and physics. For a student investigation, see Exercises and Investigations for Modern Earth Science, p. 15.

2. Display of telescopes of each type in class.

   Exercises and Investigations for Modern Earth Science, pp. 1-2, telescopes; Investigation 3, p. 15.

   Work-a-Text in Earth Science, pp. 116-118. Study guides, activity, test on the tools of the astronomer.

   Lab Manual [illegible] and Space Science. Lenses and telescope, exercise 32, pp. 111-11[illegible]

Suggested Activities (continued)

3. The radio telescope was discovered in the early 1930's.

   Discuss this instrument with the class and explain why it will gather information not carried by light. Explain that the instrument is useful in both daylight and darkness.

   Student activity: Tune a radio set between stations and listen for natural static (not interference generated by electrical equipment). This static is largely produced by the sun. The stars also generate static, and can be "tuned in" with a highly directional antenna.

   Discuss how static signals carry information useful to the astronomer.

4. The spectroscope used in conjunction with the telescope makes a powerful tool for the astronomer. Earlier in this unit, the underlying principle of the spectroscope was considered in connection with its ability to determine the structure of matter. Explain how this feature of the spectroscope helps determine the physical composition of the sun and the stars.

   The spectroscope is used to detect the movements of the stars. Explain the Doppler effect, as it reveals motion.

   Demonstration: Securely tie a three-foot length of strong cord to a tuning fork. Set the fork in vibration, then swing it around in a circle. The variation in sound pitch will demonstrate the Doppler effect with sound. Many other examples of the effect of motion on sound pitch can be cited.

5. The photoelectric cell is used as an accurate means of measuring light intensity. See B, 4. Nature of Light.

   Most serious work in astronomy is done with the camera in combination with the telescope and other instruments.

   Discuss the potential of the camera that results from its ability to take advantage of the cumulative effect of light energy.

   Astrophotography, certainly a most important tool of the astronomer, can be enjoyed by the amateur. Capable and interested students should be encouraged to try this fascinating hobby.

Emerging Concepts

1. In his search for knowledge, the astronomer has depended heavily on tools to extend his senses.

2. Visible light is not the only kind of radiation being emitted by celestial objects.

Emerging Concepts (continued)

3. There is no such thing as a body at rest, except as one chooses a particular frame of reference.

Equipment

Several small lenses of short and long focal length; refractor telescopes (may be borrowed from high school physics department); portable radio, with directional loop antenna; tuning forks (may be borrowed from the physics dept.)

Films

1. "How We Explore Space," j-s, 19 mins., 4664 (good introductory film)

2. "Lenses," s, 10 mins., 365

3. "Exploring the Universe," e-j-s, 11 mins., 161

4. "Inquisitive Giant," j-s, 29 mins., 7098

5. "Doppler Effect," s, 8 mins., 1035

6. "What Are Stars Made Of," j-s, 16 mins., 4927

References

1. Modern Space Science, pp. 179-207.

2. Earth Science, The World We Live In, pp. 322-325. (Good schematic diagrams of each type telescope).

3. Modern Space Science, pp. 192-194.

4. Basic Earth Science, pp. 269-272 (see diagram on p. 269).

5. Earth Science, The World We Live In, p. 326.

6. Basic Earth Science, pp. 269-271.

7. Modern Space Science, pp. 293-296.

8. Basic Earth Science, pp. 267-268.

9. Modern Space Science, p. 202.

10. Investigating the Earth, pp. 91 and 557.

11. Modern Earth Science, pp. 6-7.

12. Earth and Space Science, p. 316.

References (continued)

13. Foundations of Physical Science, pp. 198-199.

14. Modern Space Science, p. 198.

15. Exploring Space with Astronomy, pp. 96-105.

16. Modern Space Science, p. 196.

17. Exploring Space with Astronomy, p. 96.

D. CHARTING THE SKY

1. The star chart

2. The constellations

Suggested Activities

1. Use large star chart of the northern hemisphere. Show how the constellations are used to locate galaxies, nebulae, star clusters and individual stars.

   After gaining some familiarity with the constellations, the students should be encouraged to observe the sky on a clear night. Under good conditions, the unaided eye can see about 5,000 stars. A pair of binoculars can multiply this number by several thousand. Of course, a wide-field telescope is best for this purpose, and it will bring the mysteries of outer space into dramatic view.

2. Individual reports on myths and legends after which the constellations and planets were named will always create interest in astronomy.

3. Students can use black paper to make charts depicting constellations. Position of each star is represented by hole pricked in paper.

   Exercises and Investigations for Modern Earth Science, Ex. 2, pp. 3-4 on the stars. Discovery Problems in Earth Science, study guide and test on stars.

Emerging Concepts

1. All stars in the Northern Hemisphere appear to move in circles around the North Star.

2. Constellations are apparent groupings of stars that serve as guideposts in locating celestial bodies.

Equipment

Large star chart of northern sky (about $6.00); celestial globe; notebook-size star maps for student use

Films

1. "Exploring the Night Sky," e-j, 11 mins., 879

2. "Beyond Our Solar System," e-j, 11 mins., 1819

3. "Constellations: Guides to the Night Sky," j-s, 10 mins., 728

References

1. Modern Space Science, pp. 238-260 and 222-237.

2. Our Planet in Space, pp. 200-201.

3. Earth and Space Science, pp. 295-298.

4. Exploring Space with Astronomy, pp. 20-25.

E. THE MOON -- OUR NEAREST NEIGHBOR

   1. Physical characteristics and surface features

   2. Its motions in space

   3. Its effects on the earth

Introductory Material

There is a considerable current interest in the moon because of the NASA Apollo space program. NASA has given the moon priority attention, and a tremendous amount of new knowledge has been gained. Not only have the steps on the moon been giant steps technologically for all mankind, but man's safe return with samples of moon material have provided space scientists with a unique new tool for space study. Knowledge gained in this way will be considered in more detail in the unit on space. This particular topic deals with knowledge of the moon as learned in traditional astronomy.

Suggested Activities

1. Some time should be spent in studying the physical characteristics of the moon, such as its distance from the earth, its size, gravity and surface features. How it will appear and feel to man on the surface of the moon can be discussed here.

2. A night-time field trip to observe the moon could be arranged at this time. Observation with binoculars will reveal much detail. Students could individually be encouraged to make such observations and class reports if a field trip is not practical.

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Suggested Activities (continued)

3. Discuss the moon's rotation and revolution. An earth globe and smaller sphere can be used to demonstrate why only one moon face can be seen from earth. This demonstration can also be used during discussion of the tides caused by earth-moon gravity.

   Exercises and Investigations for Modern Earth Science, exercise 5, pp. 9-10. Characteristics of the moon

   Laboratory manual for Earth and Space Science, exercise 33, pp. 115-117. Eclipses

   Discovery Problems in Earth Science. Study guide, activity and tests on the moon and its movements.

   Work-a-Text in Earth Science, pp. 145-154. Movements of the moon, surface of phases and eclipses, activities and tests

Equipment

A room-size map of the moon is available from: Griffith Observatory, Los Angeles, California (about $1.00)

Films

1. "The Moon," j-s, 11 mins., 1278
2. "Trip to the Moon," e-j-s, 16 mins., 5320
3. "Moon," j-s, 11 mins., 148
4. "Moon and How it Affects Us," e-j, 10 mins., 1851
5. "This is the Moon," e, 11 mins., 579
6. "Tides of the Ocean," j-s, 16 mins., 5152

References

1. Modern Space Science, pp. 261-285.
2. Investigating the Earth, pp. 482-493.
3. Modern Earth Science, pp. 53-67.
4. Earth and Space Science, pp. 249-266.
5. Exploring Space with Astronomy, pp. 30-39.

References (continued)

6. Modern Space Science, p. 271.

7. Modern Space Science, pp. 281-283.

8. Investigating the Earth, pp. 99-101.

9. Modern Earth Science, pp. 516-519.

F. THE SUN

1. Physical characteristics

   a. Surface features

   b. Data (mass, temperature, distance from earth)

2. Its motions

   a. Surface rotation

   b. Position and movement in the Milky Way

3. Surface activity

   a. Sun spots and prominences

   b. The sun's source of energy

Suggested Activities

1. A discussion of the composition of the sun is a good beginning point. Refer again to the spectroscope (A-1 and C-2 of this unit).

2. Refer to spectral lines that identify elements in sun's makeup. See Modern Space Science, p. 294, fig. 14-5.

3. Surface features of the sun are constantly changing. Sunspots can be observed through dark glass from a welder's hood.

   Note: Students should be firmly warned never to look at the sun without approved protection. Unless special equipment or methods are used, an observer looking even momentarily at the sun through an optical instrument will permanently damage his eyes. The dangers of solar observation cannot be over emphasized. Adequate protection must be provided for the eyes.

Suggested Activities (continued)

4. Discuss and diagram the parallax method of determining the distance of the sun from the earth. See Modern Space Science, p. 288.

5. Observation of sun spots and studies with the spectroscope indicate rotation of the sun. This is an interesting topic for class discussion or reports. See Astronomy, p. 78.

6. For sun's position in the galaxy (Milky), see diagrams in Modern Space Science, p. 395.

7. Diagrams, pictures and other information found in text material should be used in the study of the sun's changing surface. Granules, sunspots, corona visible during eclipses, and other phenomena indicate continuous activity on the sun's surface.

   Surface activities are best studied in the sun's corona. See Modern Space Science, pp. 305-315.

   Sunspot activity affects weather and communications; student reports could could investigate how this takes place.

   Laboratory Manual for Earth and Space Science. Exercise on the sun's rotation, pp. 99-102.

   Exercises and Investigations for Modern Earth Science, Exercise 3, pp. 5-6. Characteristics of the sun

Emerging Concepts

1. Our sun is a typical star in respect to size, brightness, surface temperature and other characteristics.

2. The sun is the ultimate source of all energy (and life) on earth.

3. The earth receives energy from the sun in the form of radiant energy.

4. Radiant energy travels out through space with the speed of light.

Equipment

Dark filter glass. Use only glass approved for electric welding or that recommended by a reputable firm. See Exploring Space With Astronomy, pp. 30-39.

Films

1. "Our Mr. Sun," Bell Telephone, 68 min., color

2. "Nearest Star," s, 29 mins., 7162

3. "The Flaming Sky," e-j-s, 27 mins., 7136

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References

1. Modern Space Science, pp. 86-304.

2. Modern Earth Science, pp. 21-32.

3. Basic Earth Science, pp. 285-286.

4. Investigating the Earth, p. 545.

5. Earth and Space Science, p. 309.

6. Modern Space Science, pp. 297-303.

7. Investigating the Earth, pp. 142-144.

8. Earth and Space Science, pp. 255-257 and 288-289.

9. Earth and Space Science, pp. 317 and 354.

G. THE SOLAR SYSTEM

1. Organization and members of the system
2. Theories of origin
3. Orbital motions

Introductory Material

The sun with its planets and other bodies in solar orbit form a family of objects in space known as the solar system. During the study of this section, attention will be called to certain things that have been covered previously in this unit. Repeated detailed consideration is not intended. It is only necessary to put this information in context.

Suggested Activities

1. The existing organization of the solar system is a result of the interaction of gravity among the members and their velocities. Since the sun is most massive, all bodies tend to be drawn toward it and fall into orbits determined by their masses and velocities.

2. In discussing the theories of the origin of the solar system, it should be emphasized that they are all highly speculative and are constantly being discarded and revised. They serve as a basis for interesting discussions and can motivate students to do further reading.

3. Orbital movements are considered in some detail in B-1 of this unit. At this time, they can be considered as related to the solar system.

   New knowledge of the planets is being constantly acquired by NASA projects. Information is available from this source.

Suggested Activities (continued)

4. Discovery Problems in Earth Science. Study guides, activities and tests on the solar system, pp. 211-222

Emerging Concepts

1. The position of the members of the solar system is determined by their masses and velocities in relation to gravity.

Films

1. "Asteroids, Comets, and Meteorites," e-j-s, 11 mins., 852

2. "The Solar System," j-s, 10 mins., 1277

3. "Planets Around Our Sun," e-j-s, 14 mins., 5114

4. "Solar System," e-j, 10 mins., 1274

5. "Planets in Orbit - The Laws of Kepler," j-s, 10 mins., 309

6. "Earth in Motion," j-s, 12 mins., 109

References

1. Modern Space Science, pp. 319-350.

2. Investigating the Earth, pp. 494-514.

3. Modern Earth Science, pp. 33-52.

4. Earth and Space Science, pp. 267-285.

5. Investigating the Earth, pp. 508-510.

6. Modern Earth Science, pp. 34-37.

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H. T'; STARS

1. Size and distance from the earth
2. Stellar units for distance
3. Classification -- color and brightness
4. Motions in space
5. Stars of special interest
    a. Variable stars
    b. Double stars
    c. Star clusters
6. Life cycle of a star -- theory of star evolution

Introductory Material

We see the stars as tiny, fixed points of light. Not too long ago, many scientists believed we would never learn much more than this about them. Today we know of what the stars are made. We are able to determine their size and distance from the earth and their motions in space. No one has ever visited a star. How has this information been obtained? During the study of this topic, the students will learn the answer to this question.

Suggested Activities

1. The size of stars and their vast distances from the earth are fascinating subjects for discussion.

   Explain the parallax technique for measuring the distance of stars; see Investigating the Earth, p. 522. Use diagrams and small scale examples. Explain the concept of the radian, the radian formula, and how it is used to find size and distance. Care must be taken to present this at a level the class can handle. Eighth grade students should not be expected to master this concept. (see Modern Space Science, pp. 351-353.)

   Note to teacher: The importance of presenting this material is to impress on the student that the astronomer does not depend entirely on guess or speculation, but most of his knowledge has been obtained by careful observation and sound reasoning supported by mathematics.

2. For convenience, the astronomer must use special units when considering stellar distances. Some important units to explain and discuss are: (1) the astronomical unit (A.U.) (2) the parsec, and (3) the light year. Teacher reference, see Modern Space Science, pp. 351-353.

Suggested Activities (continued)

3. Discovery Problems in Earth Science, pp. 203-210. Study guide and tests.

4. Work-a-Text in Earth Science, Ch. 2, pp. 119-128. Stars, constellations and galaxies.

5. Stars are classified by color and brightness. The class should carefully examine and discuss the Hertzsprung-Russell (H-R) diagram. See Earth and Space Science, p. 299-301.

   Discuss magnitude. See chart in Investigating the Earth, p. 519. (Suggested activity for students is also listed here).

6. Stars appear fixed, but we have learned that they move. What techniques do astronomers use to determine the motions of stars? Explain motion as detected by parallax. (see above).

   Astronomers also use the Doppler effect to detect motion of the stars (see C-2 above). Review the spectroscope and discuss the spectral shift that indicates motion.

7. Many unique stars have been observed. The class should discuss variable stars, double stars and star clusters. Much information is revealed when these special stars are compared with average stars.

8. Several theories have been suggested to account for the origin and evolution of a star. The life of a star is thought to be about 10 billion years; thus no star has ever been observed throughout its life cycle.

Emerging Concepts

1. All stars visible to the eye are members of the Milky Way.

2. The apparent brightness of a star is known as its magnitude.

3. The actual brightness of a star is a function of its size and temperature.

4. The radiant energy from a star gives astronomers information about the stars.

Films

1. "What are Stars Made Of?" j-s, 16 mins., 4927

References

1. Modern Space Science, pp. 319-350.

2. Investigating the Earth, pp. 516-533.

3. Modern Earth Science, pp. 6-13.

References

4. Earth and Space Science, pp. 295-308.

5. Modern Space Science, pp. 261-266.

6. See investigation for students (measuring the diameter of the sun) in Investigating the Earth, p. 530.

I. GALAXIES

1. Physical characteristics

   a. Spiral

   b. Elliptical

   c. Irregualr

2. Distribution, distances, size, and motions

3. Our galaxy -- the Milky Way

4. Other objects in the Milky Way -- star fields, nebulae and dust clouds

Introductory Material

When thinking of the universe as including everything in existence, one is confronted with a size so vast that it defies imagination. Under this topic the total organization of matter and the manner in which the earth fits into this pattern will be considered.

Suggested Activities

1. Discuss the Milky Way as a spiral galaxy. Explain that we view the Milky Way through its edge. Pictures of the three types of galaxies should be studied and discussed by the class. For pictures, see Investigating the Earth, pp. 535, 544, 546; Modern Earth Science, pp. 14-15; Basic Earth Science, p. 314; Earth and Space Science, pp. 309-313.

2. If a telescope is available, the three types of galaxies can be seen first hand. See Exploring Space with Astronomy, pp. 56-89. Assistance of an amateur astronomer, if available, is recommended.

3. A general view of the universe should be presented to the class. See Investigating the Earth, pp. 554-558; Modern Earth Science, pp. 11-13; Basic Earth Science pp. 312-313; Earth and Space Science, pp. 312-316.

4. Students should be made aware of objects in the Milky Way other than typical stars. See Exploring Space with Astronomy, pp. 92-95. Once the constellations can be located, many interesting objects can be found. See a Messier Catalog (location of more than 100 objects).

Emerging Concepts

1. The Milky Way is a spiral galaxy containing an estimated 100 billion stars.

2. Our sun is located in the Milky Way.

3. Observations with powerful telescopes lead scientists to believe there are billions of galaxies.

4. Evidence indicates that galaxies are composed of the same chemical elements found on earth.

5. Evidence indicates that the universe is expanding all around us.

6. The theory of the expanding universe implies that it has no center.

7. The universe is everything that exists -- empty space, galaxies, stars, our solar system, the earth.

Films

1. "How Many Stars," j-s, 10 mins., 1393

2. "Stars and Star Systems," j-s, 16 mins., 5340

References

1. Investigating the Earth, pp. 535-569.

2. Earth and Space Science, pp. 309-321.

UNIT V. ROCKETS, SATELLITES AND THE EXPLORATION OF SPACE

Introducing the Unit

Probably the most important event that has occured in our generation is the beginning of the space age. Space, a great unknown, is our last frontier.

Every facet of the human mind is seeking answers to such questions as: What is in space? How can earthbound man survive in space? What benefits will man accrue from the space effort?

All organized science is being used in the search for the answers to questions of this kind. Bio-astronautics, bio-dynamics and bio-avionics are new sciences through which answers are sought.

Money, manpower, mineral resources and industry are all involved in a mighty effort for space leadership. The greatest need today is for human imagination. What may seem today to be a foolish idea or a wild dream may tomorrow hold the key to success and world leadership in the space race.

A. ASTRONAUTICS--THE SCIENCE OF SPACE FLIGHT

1. Introduction--definition of terms and goals
2. Problems and hazards of space flight

Note to Teacher: A folder, NASA Educational Publications, is available to teachers and may be ordered from: Educational Publications, National Aeronautics and Space Administration, Washington, D.C. 20546

Publications listed in this folder cover practically every aspect of the space program, and are written for the nontechnical person. It is strongly recommended that a teacher of this space unit become acquainted with NASA material before beginning the unit.

Suggested Activities

1. As an introduction to this unit, discuss the term astronautics. Define the term and list the type of things this science is concerned with. Definition from Modern Physical Science, p. 592: "Astronautics is a new science concerned with the art or science of designing, building and operating space vehicles."

2. What are some major reasons for the existence of the space program: Discuss the following possibilities:

    1. To retain preeminence in science and technology

Suggested Activities (continued)

2. For national security

3. Potential economic benefits

4. Anticipated new scientific knowledge

5. The stimulating effects of this challenging enterprise. See NASA, Space--The New Frontier

Discuss (in general, at this time) some of the problems involved in the space effort -- escape velocity to leave earth, the alien environment of outer space, the high cost of the program. See Modern Science: Earth, Space and Environment, pp. 72-74; NASA, Space -- The New Frontier, pp. 10-13; Illustrated Space Encyclopedia, p. 116, and Modern Physical Science, pp. 579-603.

Emerging Concepts

1. The exploration of space requires the teamwork of scientists and technicians in many fields of knowledge.

2. Outer space presents an environment completely alien to earthbound life.

3. Outer space is considered to begin at that point above the earth at which satellites can safely orbit.

4. Rockets and satellites are adding to man's understanding of his home planet and of the universe as well.

Films

1. "Challenge of Outer Space," (pt. 1), j-s-t, 30 mins., 7464

2. "Challenge of Outer Space," (pt.2), j-s-t, 30 mins., 7465

3. "Exploring by Satellite," j-s, 28 mins., 7095

4. "Science in Space," j-s, 27 mins., 7385

5. "Magnetic Force," s, 29 mins., 7383

6. "Van Allen Radiation Belts: Exploring in Space," j-s, 17 mins., 4815

References

1. Modern Earth Science, pp. 68-82.

2. Basic Earth Science, pp. 318-345.

3. Earth and Space Science, pp. 322-341.

References (continued)

4. Modern Science: Earth, Space and Environment, pp. 64-80.

5. Spacecraft.

6. Space -- The New Frontier.

7. Illustrated Space Encyclopedia.

   For glossary of frequently used space terms, see NASA, Space--The New Frontier, pp. 63-71.

Teacher References:

1. Modern Physical Science, pp. 579-603.

   The following books may be used throughout the entire unit on space travel:

2. Exercises and Investigations for Modern Earth Science, pp. 13 and 14. Study of the problems of space travel.

3. Work-A-Text in Earth Science, pp. 165-176. Study of the exploration of space, exercises, investigations and tests.

4. Lab Manual:Earth and Space Science, exercises on parallax,(p. 91), and on the orbit of Mars (p. 95).

B. AERONAUTICS

   1. History of air flight

   2. Principles involved in air flight

Suggested Activities

1. Man's first successful efforts to fly depended on air lift. Success inevitably led to space flight.

   Special student reports and class discussions should cover a brief history of air flight. Abundant resource material should be available in the school library.

2. Demonstrate Bernoulli's Principle and the "kite effect". See Modern Physical Science, p. 581. (Also see any available physics text).

3. Have class reports on principles of operation of conventional and jet engines used on aircraft. Discuss why these engines will not work for spacecraft. See Modern Earth Science, pp. 68-69

Emerging Concepts

1. Physical principles involved in aeronautics are quite different from those involved in astronautics.

2. The top possible speed of air flight is limited by atmospheric friction.

Films

1. "The Day Man Flew," e-j-s, 17 mins., 5034

2. "Early Days," s, 28 mins., 7053

3. "Airplanes and How The.' Fly," e-j, 14 mins., 5516

References

1. Aeronautics and Space Bibliography, Second edition, Washington: 1963, available from Superintendent of Documents, U.S. Government, Printing Office, Washington, D.C. 20402 (35¢).

C. THE ROCKET ENGINE AND LAUNCH VEHICLES

Suggested Activities

1. Demonstrate the rocket principle to the class. (See NASA, Space -- The New Frontier, p. 58.) Use an inflated ballon or a carbon dioxide type fire extinguisher in this demonstration.

2. Discuss the principle of the rocket engine. (See NASA, Space -- The New Frontier, pp. 53-56.)

   The device which propels and guides a spacecraft is called a Launch Vehicle. The United States has several such vehicles which are now operational and several more larger vehicles under development. (See Modern Physical Science, pp. 30-41.)

   Students' reports on each type of vehicle should be made to the class. Complete data is available in NASA Facts, Vol. II, No. 5 supplement.

Emerging Concepts

1. Rockets are the only engines capable of propulsion in space.

2. Newton's three laws of motion are fundamental to operational theory of the rocket engine.

3. An oxidizer must be provided along with fuel for a rocket engine.

Films

1. "Rockets: Principles and Safety," e-j, 10 mins., 952

2. "Rockets: How They Work," e-j-s, 18 mins. 5329

3. "Exploring Space," e-j-s, 27 mins., 7062

D. UNMANNED SATELLITES AND SPACE PROBES -- INSTRUMENT BEARING

Introductory Material

Through the use of the instrument bearing, unmanned satellites and space probes (sounding rockets), man has very greatly increased his knowledge of the earth and its cosmic environment. At this time the class should investigate and discuss some of the discoveries man has made about the cosmos.

No ones knows what will be revealed by further explorations with instrument rockets and satellites but surely our knowledge will continue to be extended at an increasing rate.

Suggested Activities

1. For detailed information on early unmanned space explorations, see: NASA Space -- The New Frontier, pp. 20-33. This source is authentic and current.

2. For student assignments for class reports and discussions, see NASA Facts. These bulletins are prepared for educational use, and are available free to schools. Bulletins cover each of the unmanned satellite projects, and provide complete authentic information. They are designed for bulletin board display or for insertion in looseleaf notebooks.

Emerging Concepts

1. Artificial satellites and space probes move in accordance with the laws that govern the movement of celestial bodies.

2. All bodies in a given orbit must have the same velocity.

3. A body must attain a speed of approximately 7 miles per second in order to escape from the gravitational field of the earth.

4. Much useful data has been gathered by unmanned spacecraft.

Films

1. "Centripetal Force and Satellite Orbits," s, 11 mins., 1684

2. "Earth Satellites: Explorers of Outer Space," j-s, 17 mins., 5328

Films (continued)

3. "The Story of the Earth Satellite," j-s, 5 mins., 820

4. "Satellites: Stepping Stones to Space," j-s, 18 mins., 4732

5. "Eyes in Outer Space," j-s, 26 mins., 7096

6. "Rocket Instrumentation," j-s, 15 mins., 4490

References

1. If you request NASA Facts, you will be placed on the mailing list for all future issues. For a complete list of available bulletins and other material, request: NASA Educational Publications, National Aeronautics and Space Administration, Washington, D.C., 20546

E. MANNED SATELLITES

   1. The astronaut

   2. Review of manned flights

   3. Man on the moon-goal of the near future

Introductoy Material

The conquest of space demands that man explore the void beyond our earth's atmosphere. Much has been learned, and much more will be learned, with unmanned, instrument-bearing satellites. For the sake of human safety and reduced costs, this technique will be exploited to the limit of its value. However, man brings to space exploration certain attributes no one has ever succeeded in building into a machine. Attributes such as intelligence, judgement, determination, courage and creativity. Thus, by adding man and his capabilities to a machine, the success of a space mission is enormously increased.

Project Mercury placed the first American in space. Beginning with the sub-orbital flight of Alan Shepard in 1961, progress has been rapid toward the goal of landing a man on the moon and lunar exploration.

Suggested Activities

1. In order to survive and fulfill the missions assigned to him in the alien and unfriendly environment of outer space, the astronaut must have very special abilities and qualities.

   How are the astronauts selected? Special reports and class discussions should consider this problem. See NASA, Space--The New Frontier, pp. 51-52; illustrated Space Encyclopedia, pp. 117-178; "The Astronaut: Photographs and Brief Biographies," (NASA Booklet), and Manned Space Flight Team, publication EP-11, available from NASA.

Suggested Activities (continued)

Manned flights are covered effectively in NASA material. See NASA FACTS: Manned Space Flights (Mercury-Gemini), Vol. II, no. 8; Manned Space Flights (Apollo), Vol. III, no. 1; See NASA, Space--The New Frontier, pp. 34-42; and Modern Physical Science, pp. 59-85.

All the above material will furnish information suitable for student reports and class discussion.

NASA's decision to accomplish a manned lunar landing was announced at a news conference in 1962. See: bulletin Lunar Orbit Rendezvous. The landing was scheduled to occur before or during 1970. Students' research projects should bring the class reports of the current status of the program. See NASA, Space--The New Frontier, pp. 38-42, and Modern Physical Science, pp. 102-119.

Emerging Concepts

1. No instrument can ever fully replace the human mind.

2. The manned satellites are advantageous because of the possibilities of the human mind plus the instruments aboard, which are used to extend the astronauts' natural senses.

3. Man's ability to survive in space requires that he be provided with an environment that stimulates conditions on earth.

4. Conditions on earth which support life are not found on other planets in the solar system.

Films

Georgia schools may borrow NASA films from:

Photographic Operations Section, NASA

John F. Kennedy Space Center Code SOP323

Kennedy Space Center, Florida 32809

For full instructions and current film list, request the latest film catalog.

1. "Manned Space Flights, 1964," 14 min., color (NASA)

2. NASA: "A Walk in Space" (Gemini 4-Extra-vehicular activity)

Georgia Department of Education films:

1. "First Man Into Space," e-j-s, 16 min., 5428

2. "All About Weightlessness: The Astronaut's Dilema," e-j-c, 11 min., 1513

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Films (continued)

3. "Missio¬: 22 Orbits," e-j-s, 10 min., 155

4. "Algae," s-c, 16 min., 4457

5. "Man and the Moon," e-j-s-c, 20 min., 4309

6. "Rocket Instrumentation," j-s, 15 min., 4490

References

1. Bulletin entitled Lunar Orbin Rendezvous, U.S. Government Printing Office, 1962, No. 0-654534.

SUPPLEMENTARY ACTIVITIES

The following list of supplementary activities is offered as samples of the type thing which will help make the study of earth science a more meaningful experience. It is not offered as a complete, comprehensive list, nor will the teacher find it desirable to use all of the suggested activities. Many additional activities are available from the publishers of earth and space science material.

Lithosphere

1. Determine the latitude and longitude to the nearest degree for several major cities of the United states.

2. Make a report on the procedure followed by the Geological Survey in making topographic maps.

3. Make clay models to show some of the major features shown on topographic maps.

4. From a topographic map of your community, make a plywood or cardboard model. Indicate the topography by varying the thickness of the material according to the contour interval.

5. From a topographic map of your community determine the exact latitude and longitude of important buildings such as banks, churches, shopping centers and schools.

6. Determine great circle routes from some of the major United States seaports to points in Asia and Europe. In each case calculate the length of the trip. Do the same for air trips over the North Pole.

7. Set up a display of sediments and the rocks that they form.

8. Obtain or draw a map of the continental United States and label the location of important mineral deposits.

9. Make a collection of metal ores and exhibit them with an example of the extracted metal.

10. Refer to a high school chemistry book and do several borax bead tests, flame tests or blowpipe tests.

11. Make a circle graph to show the relative quantities of major elements in the earth's crust.

12. Try to arrange a talk by a local lapidary or "rock hound."

13. Make a report on the importance of conservation of our mineral resources.

14. Prepare a bulletin board display of pictures illustrating earthquakes.

15. Make models in clay, plaster, plywood or papier mache to illustrate folding and faulting. Paint the various rock layers.

Lithosphere (continued)

16. Draw a map of the world and print the names and dates of disastrous earthquakes in the proper places.

17. On a map of the United States, locate and outline the major physiographic provinces.

18. Collect photographs of typical topography, scenery, industry, etc., in the physiographic provinces of the United States. Most state tourist bureaus are glad to supply these pictures.

19. Make a model to illustrate the theory of isostasy.

20. On an outline map of the world locate and label 12 important mountain systems.

21. Make models to illustrate mountains in the different stages of their life cycles. Include such characteristics as ruggedness, streams, snow line and glaciers, timberline, etc.

22. Make models to illustrate a batholith, laccolith, sill and dike.

23. Prepare a display of photographs that show local weathering and erosion. Under each photograph give the location, probable agent of weathering or erosion, some possible preventative, conservation procedure.

24. Prepare a report to show how landforms have influenced the history or development of some particular geographic area.

25. Prepare a report on the "dust bowl" of the 1930's.

26. Determine the speed of a local river or stream every day for a month. This can be done by recording the time that a floating object takes to travel a known distance. Each day collect samples of the water. Record the clearness of the water; then allow the water to settle and measure and record the level of the sediment and the type of sediment. Draw graphs to show the relationship between the speed of flow and the amount of sediment carried by the stream.

27. Set up a display of models of dinosaurs. Models may be constructed or purchased from dime stores, scientific supply houses or the Museums of Natural History in New York and Chicago.

Hydrosphere

1. Prepare a bulletin-board diagram to illustrate the hydrologic cycle.

2. Make a model to show a cross-section of an ocean basin. See the Life Magazine series "The World We Live In" for sketches and diagrams.

3. Determine the density of water by punching two holes in a tin can and suspending it by a wire from a spring scale. Weigh the can and the wire and record the weight. Measure out 100 cc. of water in a graduated cylinder and pour the water and record the weight. The weight of the water is equal to the difference between the second weight recorded and the first weight recorded.

ERIC

Hydrosphere (continued)

4. Demonstrate the process of distillation.

Meteorology

1. Write a report on the possibilities of using satellites for weather forcasting.

2. Construct models from such materials as plastic, glass, cotton and cardboard to illustrate the different "fronts."

3. On an outline map of the United States, use a color code to show the distribution of climatic regions.

4. Have your class keep a record of the clouds they observe over a period of one month. Spend some time discussing the subtypes, the nimbo-stratus, strato-cumulus, alto-cumulus, and alto-stratus clouds.

5. Prepare a world map of typical tracks of tropical cyclones over the oceans.

6. Make an air thermometer.

7. Make a hygrometer using a human hair.

8. Construct a vane-type anemometer.

Astronomy

1. To show the change of seasons: This project will produce a good piece of permanent equipment to demonstrate that the tilt of the earth causes the change of seasons.

   See Ideas for Teaching Science in the Junior High School, p. 88. Needed materials include 3/8" x 3' x 2' plywood; 4 red and blue ribber balls; 4 knitting needles; pasteboard, 1" x 7"; 1/2" mesh hardware cloth, 6" x 10"; 1/4" fiber board; protractor; light bulb, socket and cord.

2. Building a device to demonstrate the relationship between longitude, time and date. A student will gain a clearer understanding of these concepts with a few minutes practice with this device.

   See Ideas for Teaching Science in the Junior High School, p. 89. Needed materials include two circular plywood discs, one approximately 2' in diameter, and the second about 4" smaller in diameter.

3. Building a tin can planetarium: Complete instructions are given for construction of a simple device for projecting star images.

   See Ideas for Teaching Science in the Junior High School, pp. 92-95. Material: (not critical) No. 2 can (or larger); board for base; nails, white paint, black paint, flashlight bulb with socket, battery for above bulb, and other easily obtained items.

4. A laboratory activity to help students acquire an understanding of certain concepts, such as changes in the apparent position of the sun (through the hours, days and seasons), clock time and calendar time, the coordinate system using latitude and longitude and a method of determing the latitude and longitude of any point.

   See Ideas for Teaching Science in the Junior High School, p. 101. Materials needed include an old drawing board, strips of 1/2 x 1" wood, small shelf bracket, plumb bob (or other suitable weight) string, thumbtacks, drawing paper, and other simple items.

5. Several activities in astronomy are described by Arthur G. Suhr. Detailed information is given for construction of a Foucault pendulum and a spectroscope. Suggested activities with these devices are also given.

   See Ideas for Teaching Science in the Junior High School, pp. 105-107. For the spectroscope a plastic replica grating is needed. All other materials for the projects are simple and easily obtained.

6. Activity 17-B "Orbital Velocity of an Earth Satellite" is a student exercise to help develop an understanding of how an earth satellite stays in orbit.

   See Discovery Problems in Earth Science, pp. 219-220. Only pencil, paper and ruler are needed for this activity.

7. Activity 17-A, "The Phases of the Moon," is a student activity in which the detailed phases of the moon and the reasons for their occurrence is studied.

   See Discovery Problems in Earth Science, pp. 233-234. Only pencil, paper, and ruler are needed for this activity.

8. Activity 19-B, "Eclipses of Moon and Sun". Lunar and solar eclipses are studied in this activity.

   See Discovery Problems in Earth Science, pp. 235-236. Only pencil, paper and ruler are needed for this activity.

9. Activity 20-A, "The Seasons." In this activity students study and account for the changes of the seasons.

   See Discovery Problems in Earth Science, pp. 245-246. Only pencil, paper and ruler are needed for this activity.

10. "Measuring latitude by Polaris" is an activity that involves making a simple star sighter (a sextant) and learning to use it to determine latitude.

    See Lab Manual, Basic Earth Science, pp. 60-62. A soda straw, tape, protractor, thread and weight are all that are needed to make the "star sighter."

Astronomy (continued)

11. In this activity a laboratory telescope is made with simple lenses of various focal length.

    See Exercises and Investigations for Modern Earth Science, p. 15. Materials needed include a meter stick, lens mounts, several simple lenses and a cardboard tube.

12. This experiment demonstrates the principle of the thermocouple. A highly sensitive thermocouple used with a telescope will measure the temperature of the planets.

    See Exercises and Investigations for Modern Earth Science, p. 15. Copper wire, iron wire, a source of heat and a sensitive galvanometer are needed in this activity.

13. This activity is an investigation of the principles involved in the orbital motion of planets and satellites.

    See Exercises and Investigations for Modern Earth Science, p. 16. Materials needed include heavy iron ball, steel wire, strong magnet, clamp and clamp stand.

14. Forming a continuous spectrum.

    See Exercises and Investigations for Modern Earth Science, p. 16. Equipment and materials needed include a slide projector, screen, triangular prism, opaque card, knife, and a dark room.

15. Photographing a star trail.

    See Exercises and Investigations for Modern Earth Science, p. 16. A camera with shutter that will set to "time" and a tripod or other solid support are needed.

16. Gaining understanding of the following concepts: latitude, longitude, prime meridian, International Date Line and other concepts related to time and date keeping.

    See Work-a-Text in Earth Science, pp. 41-46.

17. An activity to gain an understanding of parallax.

    See Lab Manual: Earth and Space Science, pp. 91-94. Materials: cardboard, paper, thumbtacks, pins, meter stick and other simple materials.

ERIC

Astronomy (continued)

18. Measuring the diameter of the earth using the technique discovered by Erastosthenes.

    See Lab Manual: Earth and Space Science, pp. 103-106.

19. An investigation of an eclipse of the moon.

    See Lab Manual: Earth and Space Science, pp. 115-118. Graph paper, pencil, ruler and compass are needed.

Sources Of Earth Science Materials

Astronomy slides, photos, charts

Division of Photography, American Museum of Natural History, New York 24, New York

Astronomy Charted, 35 Winfield Street, Worcester 10, Massachusetts

International Screen Organization, 1445 18th Avenue, North St. Petersburg 4, Florida

Lick Observatory, Mount Hamilton, California

Mount Wilson and Palomar Observatories, 1201 East California Street, Pasadena 4, California

Sky Publishing Corporation, Harvard Observatory, Cambridge 38, Massachusetts.

Yerkes Observatory, Photographic Service Department, Williams Bay, Wisconsin

Wall maps, charts, globes

Denoyer-Geppert Company, 5235 Ravenswood Avenue, Chicago 40, Illinois

C. S. Hammond and Company, Maplewood, New Jersey

Rand McNally Company, P. O. Box 7600, Chicago 80, Illinois

A. J. Nystrom Company, 3332 Elstron Avenue, Chicago, Illinois

Weher Costella Company, Chicago Heights, Illinois

Meterorological and astronomical instruments and supplies

Cambosco Scientific Company, 37 Antwerp Street, Boston 35, Massachusetts

Central Scientific Company, 79 Amherst Street, Boston 42, Massachusetts

Chicago Apparatus Company, 1735 North Ashland Avenue, Chicago 22, Illinois

Edmund Scientific Company, Barrington, New Jersey

National Biological Labs, P. O. Box 511, Vienna, Virginia

Science Associates, 401 North Broad Street, Philadelphia 8, Pennsylvania

Taylor Instrument Companies, 95 Ames Street, Rochester 1, New York

W. M. Welch Manufacturing Company, 1515 Sedgwick Street, Chicago 10, Illinois

Will Corporation, 39-51 Russell Street, Rochester 3, New York

Hammetts School Supply, 290 Main Street, Cambridge, Massachusetts, 02142

Hubbard Scientific, Earth Space Science, T. N. Hubbard Scientific Company, Northbrook, Illinois

Lapine Science Catalog, 6001 South Knox Avenue, Chicago, Illinois, 60629

Macalaster Scientific Corporation, Waltham Research and Development Park, 186 Third Avenue, Waltham, Massachusetts, 02154

Nasco Science Materials, Fort Atkinson, Wisconsin, 53538

Transparencies

United Transparencies, Inc., P. O. Box 888, Binghampton, New York

Geology slides

Ward's (See listings under films)

Rocks and minerals

Boodle Lane Minerals, Galena, Kansas

Eckert Minerals, 110 East Main Street, Florence, Colorado

Minerals Unlimited, 1724 University Avenue, Berkeley, California

National Biological Labs, P. O. Box 511, Vienna, Virginia

Schartmann's Minerals, 6 McKinley Avenue, Easthampton, Masschusetts

Scott Williams Mineral Company, 440 North Scottsdale Road, Scottsdale, Arizona

Southern Gem and Mineral Company, 2307 North Mesa, El Paso, Texas

Swanson Mineral Company, 639 B North Osage Drive, Tulsa, Oklahoma

Tom Roberts Rock Shop, 1006 South Michigan Avenue, Chicago 5, Illinois

V. D. Hill, Route 7, Box 188, Salem, Oregon

Ward's, P. O. Box 1712, Rochester 3, New York

U. S. Geological Survey Topographic Maps

A monthly circular entitled "New Publications of the Geological Survey" is sent free to teachers on application to the Geological Survey, Washington 25, D. C. The circular lists books, bulletins, maps and charts newly published, revised or reprinted, and gives prices and ordering instructions.

State of Georgia topographic map index circulars are also free on request from:

Dr. A. F. Furcron
Department of Mines and Minerals
Capitol Square
Atlanta, Georgia

U. S. Weather Bureau weather maps

A subscription to the daily weather map is $9.60 a year or $2.40 for three months (the minimum), payable to Superintendent of Documents, Government Printing Office, Washington 25, D. C. Free booklet of weather bureau publications on request. Ask for Price List No. 48.

ources of films and filmstrips

Local and regional film libraries and audiovisual centers at colleges and universities should be consulted. Many systems have local materials centers where these films, filmstrips and transparencies are available.

BIBLIOGRAPHY OF STUDENT REFERENCES

1. Blanc, Sam, Abraham Fischler and Olcott Gardner, Modern Science: Earth, Space, and Environment, New York, Holt, Rinehart and Winston, 1967.

2. Earth Science Curriculum Project, Investigating the Earth, Atlanta, Houghton Mifflin Company, 1967.

3. Ebbighausen, E. G., Astronomy, Columbus, Ohio, Charles E. Merrill, 1966.

4. MacCracken, Helen, Donald Decker, John Read, and Alton Yanian, Earth Science, Chicago, L. W. Singer Company, 1968.

5. Namowitz, Samuel and Donald Stone, Earth Science: The World We Live In, New Jersey, American Book Company, 1969.

6. Navarra, John and Arthur Strahler, Our Planet in Space, New York, Harper Row Company, 1967.

7. Navarra, John and John Garone, Today's Basic Science: The Atom and the Earth, New York, Harper Row Company, 1965.

8. Ramsey, W. L., R. A. Burckley, C. R. Phillips and F. M. Watenpaugh, Modern Earth Science, New York, Holt, Rinehart, and Winston, 1965.

9. Thurber, Walter and Robert Kilburn, Exploring Earth Science, Atlanta, Allyn and Bacon, 1965.

10. Trinklein, Frederick and Charles Huffer, Modern Space Science, New York, Holt, Rinehart and Winston, 1961.

11. Wolfe, Caleb, et al, Earth and Space Science, Boston, D. C. Heath, 1966.

BIBLIOGRAPHY OF TEACHER REFERENCES

1. American Geological Institute, Geology and Earth Sciences Sourcebook, New York, Holt, Rinehart and Winston, 1962.

2. Blair, T. A., Weather Elements, 4th edition, Englewood Cliffs, New Jersey, Prentice Hall, 1957.

3. Decker, Donald, et al, Laboratory Manual: Basic Earth Science, Atlanta, Georgia, L. W. Singer Company, 1964.

4. Flock, Henri J., Exercises and Investigations for Modern Earth Science, New York, Holt, Rinehart and Winston, 1965.

5. Holden Alan and Phylis Singer, Crystals and Crystal Growing, Garden City, New York, Anchor Books, 1960.

6. Joseph, Benjamin, Paul Brandwein, et al, A Sourcebook for the Physical Sciences, New York, Harcourt, Brace and World, Inc., 1964.

7. Longwell, C. R. and R. F. Flint, Introduction to Physical Geology, 2nd edition, New York, John Wiley and Sons, 1962.

8. National Science Teachers Association, The Earth: Investigating Science With Children, Volume 2, Darien, Connecticut, Teachers Publishing Corporation, 1964.

9. National Science Teachers Association, Ideas for Teaching Science in the Junior High, Washington, D. C., 1963.

10. Navarra, John and Arthur Strahler, Our Planet in Space, New York, Harper and Row, 1967.

11. Navarra, John and Joseph Zafforoni, Science Today for the Elementary School Teacher, Evanston, Illinois, Harper and Row, 1960.

12. Ramsey, William, Clifford Phillips, and Frank Watenpaugh, Foundations of Physical Science, New York, Holt, Rinehart and Winston, 1967.

13. Stafnger, Robert L., Work-A-Text in Earth Science, New York, Cambridge Book Company, 1967.

14. Stone, Donald, Discovery Problems in Earth Science, 5th edition, New York, College Entrance Book Company, 1966.

15. UNESCO, 700 Science Experiments for Everyone, New York, Doubleday, 1958.

16. Van Riper, Joseph, Man's Physical World, New York, McGraw Hill, 1962.

17. Wolfe, C. W., L. J. Battan, et al, Teacher's Laboratory Manual, Earth and Space Science, Atlanta, Georgia, D. C. Heath and Company, 1966.

18. Zumberge, James, Elements of Geology, New York, John Wiley and Sons, 1958.

ADDITIONAL REFERENCES FOR THE LIBRARY

1. Berger, J. Joel and Howard Baumel, Enriching the Science Program, Englewood Cliffs, New York, Prentice Hall, 1964.

2. Boenning, Eileen and Marilyn J. Monson, Steps Into Space, New York, Lyons and Carnahan, 1965.

3. Coker, R. E., This Great and Wide Sea: An Introduction to Oceanography and Marine Biology (Paperback).

4. Deason, Hilary J., A Guide to Science Reading, New York, New American Library, (Signet), 1964.

5. Earth Science Curriculum Project Reference Series, Englewood Cliffs, New Jersey, Prentice Hall.

   RS-1, Sources of Earth Science Information, 1964.
   RS-2, Selected References for Earth Science Courses, 1964.
   RS-3, Selected Earth Science Films, 1964.
   RS-4, Maps and Earth Science Publications: For the States and Provinces of North America, 1964.
   RS-5, Free Materials for Earth Science Teachers, 1964.
   RS-6, Properties of Rocks and Minerals, 1964.
   RS-7, Planetariums, Observatories and Earth Science Exhibits -- Where to See Them, 1965.
   RS-8, Fossils: Their Classification and Identification, 1965.
   RS-9, Selected Topographic Maps: Their Use and Interpretation, 1965.

6. Heller, Robert L., editor, Geology and Earth Sciences Sourcebook, New York, Holt, Rinehart and Winston, 1962.

7. Hug, John and Phyllis Wilson, Curriculum Enrichment -- Outdoors, New York, Harper and Row, 1965.

8. Lesser, Milton, Successful Science Teaching, Englewood Cliffs, New Jersey, Prentice Hall, 1961.

9. Strahler, Arthur N., The Earth Sciences, Washington, The Teachers Library, (National Education Association).

10. Strickland, Warren L., Investigations in Physical Science, Minnesota, Burgess Publishing Company, 1964.

11. Water Intake by Soil Experiments for High School Students, Washington, D. C., Government Printing Office, 1963.

12. White, John Francis, Study of the Earth: Readings in Geological Science, Englewood Cliffs, New Jersey, Prentice Hall, 1962.

U. S. GOVERNMENT PUBLICATIONS
(Available from U. S. Government Printing Office)

1. Aeronautics and Space Bibliography for Secondary Grades, First Edition, 1961, 41 pp., Second Edition, 1963, 50 pp.

2. Aids for Teaching Science, (Suggested checklist fro assessing a science program), Revised, 1964, 20 pp.

3. Facilities and Equipment for Science and Mathematics, (Requirements and Recommendations of State Departments of Education), 1960, 130 pp.

4. Science as a Way of Life, 1961, 27 pp.

5. Science Course Improvement Projects, College and University, Secondary, Elementary, 1964, 77 pp.

6. Science Equipment and Materials, Science Kits, 1963, 26 pp.

7. Space Resources For Teachers: Space Science, 1969, (EP-64), 144 pp.

8. Steps to Excellence: A Program to Improve Science Teaching, 1962, 12 pp.

MISCELLANEOUS PUBLICATIONS

1. Bergaust, E., Editor, Illustrated Space Encyclopedia, New York, G. P. Putnam's Sons, 1966.

2. New York (State) Bureau of Secondary Curriculum Development Earth Science Handbook, Bureau of Secondary Curriculum Development, The New York State Education Department, Albany, 1961. (Gives experiments, demonstrations and other activities suggested for earth science).

3. Scientific American Offprints, San Francisco, California, W. H. Freeman and Company, 660 Market Street, 94104.

MAJOR ITEMS OF EQUIPMENT

Item	Available from
1. Slate globe	Denoyer-Geppert
2. Physiographic relief globe	Hubbard
3. Scales	Welch
4. Bar magnets	Welch (15 sets of two)
5. Periodic chart	Welch (on roller)
6. Fluorescent minerals kit	Welch
7. Selection of 25 slides of minerals	Ward's
8. Scale of hardness	Welch
9. Selection of 37 slides of rocks	Ward's
10. Collection of minerals used in chemical industries	Welch
11. Superior mineral collection	Welch
12. Spring balance	Ward's (6 for class)
13. Simple jolly balance, beginner's type, and accessories	Ward's
14. Lenses (tripod)	Hammetts (30 ea)
15. Lenses (hand), 4" dia.	Hammetts (15 ea)
16. Earth science rock collection	Hubbard
17. Fossils lab	Nasco (6 sets for class)
18. Paleogeographic relief maps	Hubbard
19. World relief globe	Macalaster (Denoyer-Geppert)
20. Magnetic compases	Welch (set of 12)
21. Terrella magnetic globe and dripping needle	Welch

ERIC

Item	Available from
22. Map projection model	Hubbard
23. Trigraphic contour relief maps (set of 7)	Hammetts
24. Map reading model	Hubbard
25. Color slide selections (landforms), LWI-A or LWI-B, or LWI-C set	Ward's
26. Geology landform models	Hubbard
27. Geology demonstration kit	Hubbard
28. Selection of slides on oceanography (from LWI-F 1.1 to LWI-F 7.8)	Ward's
29. Earth science stream table	Hubbard
30. Thermometers, (for class of 30)	Macalaster (15 ea)
31. Convection box	Welch (tough paper .20)
32. Sling psychrometer	Welch
33. Wet and dry bulb thermometers	Ward's
34. Barometer	Nasco
35. Thermometer-hygrometer, wall type	Welch
36. Rain gauge	Welch
37. Wind vane	Nasco
38. Weather map, U.S. Slate	Hubbard
39. Anemometer	Welch
40. Weather forecast labs	Nasco (6 for class of 30)
41. World relations maps of: temperature, rainfall, and climatic conditions	Denoyer-Geppert
42. World Atlas, Rand-McNally	Central Scientific

Item	Available from
43. Magdeburg Hemispheres	Welch
44. Gyroscopes	Welch
45. Density ball	Welch
46. Transparent celestial globe	LaPine
47. Spectrum chart	Welch
48. Spectrum kit	Macalaster
49. Prism	Macalaster
50. Light source, socket and cord	Nasco
51. Light meter	Welch
52. Demonstration lenses	Welch
53. Universal star chart	Ward's
54. Desk outline star charts	Ward's (pkg. of 50)
55. Illuminated planetarium	Hubbard
56. Set of 100 transparencies for Modern Earth Science	United Transparencies, Inc.
57. Microscope	Welch

Note: The laboratory manuals and the teacher's edition of the student reference books also contain lists of suggested equipment. Equipment included in such lists has not been listed above.

ERIC

MATERIALS AND MINOR ITEMS OF EQUIPMENT

Items in the following list which are not already available from the physics and/or chemistry labs in the school should be ordered before school begins:

Beakers
Ring stands (clamps and rings)
Test tubes (racks, and clamps)
Small amounts of chemicals
Tripods
Busen burners
Beaker tongs
Funnels (and funnel racks)
Filter paper
Litmus paper
Asbestoes wire
Crucible tongs
Mortars and pestles
Graduated cylinders
Flasks
Battery jars
Watch glasses
Stirring rods
Alcohol
Glass and rubber tubing
Splints