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ABSTRACT

This syllabus outlines a year earth science program designed to be activity oriented, investigatory in approach, and interdisciplinary in content. Each topic section contains a topic abstract and topic outline, major understandings, and information to teachers. The topic abstract lists behavioral objectives and general information about the topic and its relationship to other topics. There are fourteen topics which occur in these five major subject areas: Investigating Processes of Change, The Earth Model, The Earth's Energy Budget, The Rock Cycle, and The History of The Earth. Student and teacher laboratory guide sheets and reference tables are presented in two separate publications. (PR)

1970 EDITION

EARTH SCIENCE SYLLABUS

The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Bureau of Secondary Curriculum Development
Albany, New York 12224

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THE UNIVERSITY OF THE STATE OF NEW YORK

FOREWORD

Between December 1966 and June 1967, the State Education Department convened several meetings of an Earth Science Syllabus Revision Committee. The purpose of this committee was to develop guidelines that could be used as a basis for revising the New York State earth science program.

The guidelines that were developed by the committee described a philosophy and approach for a new course of study in earth science that would be:

1. student activity oriented - Students should be exposed to a learning environment in which they would be active participants. Laboratory and field experience should be the focal point of this program;
2. investigatory in approach - The learning activities should be oriented toward an inquiry approach, placing the student in the role of investigator;
3. interdisciplinary in content - The course content organization should integrate the traditional earth science subject areas. Emphasis should be placed on the analysis of the environment, and the processes affecting it.

Under the direction of Roger W. Ming, then Associate in the Bureau of Science Education now Supervisor, Education for the Gifted, and through the efforts of a writing team, a format, an outline, and implemental materials evolved which were consistent with the Revision's Committee's initial guidelines.

During the summer of 1967, a first edition of the experimental syllabus was written. A supplement containing suggested learning activities and separate test items for a terminal examination were developed concurrently. During the 1967-68 school year, 75 teachers used the first edition. These teachers were organized into regional centers which held frequent meetings to assemble feedback on the course of study. The centers also provided training for their members and prepared inservice programs for teachers who were not yet using the experimental materials.

During the summer of 1968, second editions of the experimental syllabus and supplement were developed incorporating changes suggested in the feedback from the participating teachers. A second terminal examination was also prepared. During the 1968-69 school year, 110 teachers used the second edition of the syllabus. The regional centers were expanded in number and more specific functions and responsibilities were assumed by the center teachers.

A third edition of the refined syllabus materials and an examination were prepared during the summer of 1969. This edition was tested by 110 teachers in the 1969-70 school year.

The final editions of the new earth science syllabus and supplement were prepared during the summer of 1970.

A total of 155 teachers representing 96 school districts throughout New York State were directly involved in the process of developing and evaluating the new course of study. These, along with others who contributed, are listed on page vi.

The overall project was developed under the general direction of Hugh B. Templeton, Chief, Bureau of Science Education. During the 1967-69 period of development and field-testing, Mr. Ming was mainly responsible for the steps taken that resulted in the extensive involvement of teachers across the State. Robert F. Zimmerman, Associate in Secondary Curriculum, was the curriculum liaison person during the total period.

The final edition of this syllabus was prepared under the direction of Douglas S. Reynolds, Associate in Science Education. A special acknowledgment is made to the leadership role on the writing teams played by W. John Higham, Vestal Central School, and to the special services that his school performed in publishing experimental editions of the syllabus and supplement.

Gordon E. Van Hooft
Chief, Bureau of Secondary Curriculum Development

William E. Young
Director, Curriculum Development Center

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INTRODUCTION TO TEACHERS

Student Scheduling

Earth science is most frequently offered to selected and able ninth grade students who display an interest in science.

Some schools have found that success in earth science can be achieved by very high ability students in the eighth grade, and by Regents caliber senior high school students. In the 11th or 12th year some students with a strong science interest and high ability that did not have this course in junior high school may elect to enroll in two sciences simultaneously.

Time Requirement

The *minimum* time required for this course is six 45-minute periods per week, although seven periods are recommended. The time allotment should include at least one double period for laboratory work each week.

Laboratory

One of the requirements of this course is that the pupil shall have successfully completed at least 30 periods performing laboratory work, and shall have prepared a written record verifying this work.

State Diploma Credit

This course may be used as one unit of the group II major science sequence or for group III credit as an elective toward a State Diploma.

Changes in Syllabus

Corrections or changes in the syllabus that become necessary will be brought to the attention of school principals by means of supervisory letters from the Department.

Topic Sequence

Recommendations from the participating teachers in the experimental program have resulted in the development of the sequence of topics presented in this syllabus that leads to a successful completion of the course objectives.

INSTRUCTIONAL OBJECTIVES

If the objectives of any course of study are not clearly defined, it will be difficult to evaluate what has been learned. Without such clearly defined objectives, there can be no sound basis for selecting appropriate course content or instructional methods and materials. Clearly defined objectives should provide the student with a means to evaluate his own progress at any time and to help him organize his efforts into relevant activities.

In this syllabus, the focus is upon the identification and formulation of appropriate objectives which have been *behavioralized.* These are classified into two groups: those related to the process of inquiry (PIO's), and those related to subject matter or course content (CCO's). Both groups of objectives have been specifically related to the understandings in each topic.

Process-of-Inquiry Objectives (PIO)

At the completion of the course, the student should be able to:

1. demonstrate the following skills in mathematics:
   a. determine relative error in percent,
   b. use scientific notation correctly,
   c. solve for unknowns in simple algebraic equations (e.g., $D = \frac{M}{V}$)
   d. use proportions in establishing scale,
   e. measure dimensions using metric system and convert from one metric unit to another metric unit;
2. a) read the scales on standard measuring apparatus, such as rulers, protractors, balances, graduated cylinders, barometers, or compasses, to an accuracy of 1/2 of the smallest scale calibration of the apparatus;
   b) demonstrate a degree of precision with standard measuring apparatus by collecting 3 trial measurements that vary no more than $\pm 1/2$ of the smallest scale calibrations of the apparatus;
   c) demonstrate an ability to determine map measurements, such as directions, locations, distances, and other quantities designated on special maps, which are appropriate to the limitations of the map;
3. a) devise a classification system that can be used to interpret natural phenomena;
   b) create models that can be used to interpret natural phenomena;
4. list possible sources of error in an investigation when given a description of the data, procedure, and instrumentation;
5. a) collect and organize data;
   b) construct graphs using scales which are appropriate for the data;
   c) extrapolate from and interpolate within a set of data;
   d) interpret models which have been created to represent natural phenomena.

Course-Content Objectives (CCO)

At the completion of the course, the student should be able to identify examples from observations of his environment which illustrate that:

1. Change is universal and results from energy flow across an interface.
2. Mass-energy is conserved as change occurs.
3. The sun is the major source of energy which drives earth systems.
4. Natural systems tend to move toward a state of dynamic equilibrium.
5. Many earth processes reflect cyclical changes.
6. Changes or events reflect interactions between physical, chemical, and biological aspects of an environment, and are described within the frames of reference of space and time.
7. The properties of the environment and the materials of which it is composed indicate how they were formed and how they may change.
8. The study of present environments may be used to predict the future and to explain the past.
9. Data derived from a microenvironment may be used as a guide to the interpretation of a macroenvironment.
10. Observations occur when one or more of the senses are focused on an aspect of the environment.
11. Powers of observation are limited by the senses, and can be extended by the use of instruments.
12. There is a difference between information based on sensory perception and inferences made from these observations

*Mager, R.F. *Preparing Instructional Objectives.* Palo Alto, California. Fearon, 1962, pp. 3-4.

THE EARTH SCIENCE SYLLABUS FORMAT

The format has been designed to facilitate teaching by the investigative method. The materials consist of three publications:

The Syllabus

The main body of the syllabus consists of three columns:

column 1: Topic Outline
column 2: Major Understandings
column 3: Information to Teachers

The Topic Abstract of each topic lists the *Major Behavioral Objectives* that are to be attained as a result of the experiences gained during the topic and provides, in the *Approach*, general information about the topic and its relationship to other topics.

The Topic Outline (column 1) is a statement of the course content in outline form. Each section of a topic begins with the significant *Section Question* which initiates the learning experience. It is intended that the investigations, activities, and discussions for the section will provide the student with the major understandings listed in the section.

The Major Understandings (column 2) consist of concepts related to the section question. It includes concepts that can be derived directly from the suggested activities as well as ideas which would be derived indirectly. It is *not* intended that this column list *all* the understandings which can be related to the question.

The Information to Teachers column contains suggestions for approaching the material within a topic, appropriate cross references to understandings appearing in other topics, and the listing of process-of-inquiry and course-content objectives which relate to the understandings.

The Supplement

The supplement contains the investigations indexed by topic and section, and contains lists of multimedia and other reference materials.

Each set of topic investigations is preceded by the Investigations-Understandings Matrix which is designed to illustrate the relationship of the investigation to the major understandings. It can also be used to relate multimedia materials to the topic.

The descriptions of the student laboratory investigations are presented in two forms:

1. Teacher Laboratory Guide Sheet - provides orientation and approach for teacher use.

2. Student Laboratory Guide Sheet - provides a structured procedure for the student. The sheet can be easily duplicated at the discretion of the teacher.

Some investigations require special maps, charts, diagrams, or other items not readily available elsewhere. These appear on separate pages to facilitate duplication.

Long-Term Investigations (L.T.I.) and Field Experiences (F.E.), have been grouped together in topic II of the supplement even though many of these are used in other topics. The individual activities are listed in a special matrix sheet which shows the topics to which they apply. In addition, each activity is listed in the matrix sheet for the specific topics where the activity applies.

Both types of investigations may be conducted by individual students or with an entire class.

The two categories of investigations are not mutually exclusive. Many of the long-term investigations are intended to be performed in the field, and many of the procedures described in the field experiences may be treated as long-term investigations.

Additional suggestions for the long-term investigations and field experiences appear in topic II of the supplement.

While the investigations have been placed in a "supplement," it should be clearly understood that they are *not* supplementary — *they are essential, and comprise the core of the course.*

The supplement also contains a glossary of some terms which are used throughout the syllabus. It is *not* intended that these terms be memorized by the student. Vocabulary testing *is not* an appropriate activity for this course. The glossary should be used by the student as another reference source. Thus, the teacher can include terminology in discussions or laboratory activities and not feel obligated to "teach" definitions.

The Reference Tables

The reference tables, which are available in quantity, contain useful information such as charts, scales, tables of constants, and graphs, which can be used by the student at any time throughout the year.

It is *not* intended that the information in the table be memorized.

The tables are provided for use on the state-prepared examination and may be used during classroom testing at teacher discretion.

A N N O T A T E D   F O R M A T   E X A M P L E

Syllabus Pages

The topic question is an indication of the inquiry theme of the entire topic.

Topic title from outline

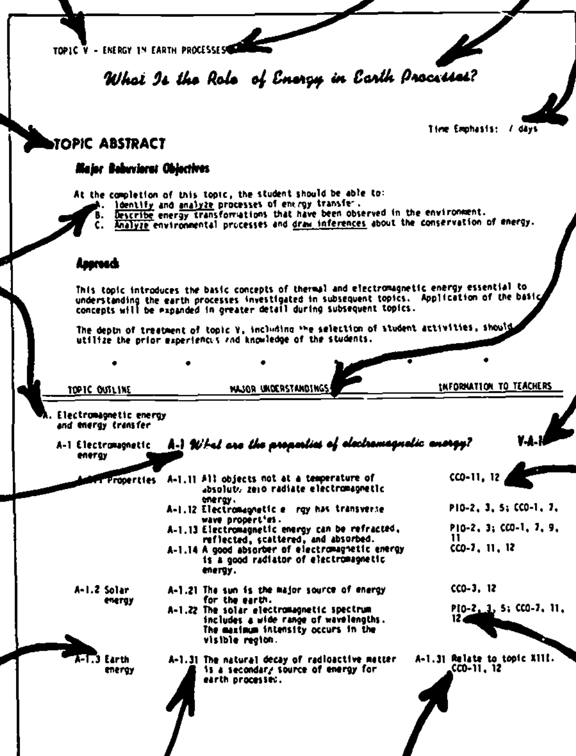
Topic number

Digest of -
1. *Major Behavioral Objectives for students.*
2. *Suggested Approach for the teacher with emphasis on what precedes or follows.*

The letter designation indicates the Major Behavioral Objective which is related to a specific section of the topic.

Whole number integers designate section questions. The understandings will develop from the investigation of the question, enabling the student to accomplish the appropriate Major Behavioral Objective.

A number in tenths (A-1.3) designates a subtopic required to develop an answer to the section question.



TOPIC V - ENERGY IN EARTH PROCESSES

What Is the Role of Energy in Earth Processes?

Time Emphasis: 7 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:
A. Identify and analyze processes of energy transfer.
B. Describe energy transformations that have been observed in the environment.
C. Analyze environmental processes and draw inferences about the conservation of energy.

Approach

This topic introduces the basic concepts of thermal and electromagnetic energy essential to understanding the earth processes investigated in subsequent topics. Application of the basic concepts will be expanded in greater detail during subsequent topics.

The depth of treatment of topic V, including the selection of student activities, should utilize the prior experiences and knowledge of the students.

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Electromagnetic energy and energy transfer		
A-1 Electromagnetic energy	*A-1 What are the properties of electromagnetic energy?*	V-A-1
A-1.1 Properties	A-1.11 All objects not at a temperature of absolute zero radiate electromagnetic energy.	CCO-11, 12
	A-1.12 Electromagnetic energy has transverse wave properties.	PIO-2, 3, 5; CCO-1, 7.
	A-1.13 Electromagnetic energy can be refracted, reflected, scattered, and absorbed.	PIO-2, 3; CCO-1, 7, 9, 11
	A-1.14 A good absorber of electromagnetic energy is a good radiator of electromagnetic energy.	CCO-7, 11, 12
A-1.2 Solar energy	A-1.21 The sun is the major source of energy for the earth.	CCO-3, 12
	A-1.22 The solar electromagnetic spectrum includes a wide range of wavelengths. The maximum intensity occurs in the visible region.	PIO-2, 3, 5; CCO-7, 11, 12
A-1.3 Earth energy	A-1.31 The natural decay of radioactive matter is a secondary source of energy for earth processes.	A-1.31 Relate to topic XIII. CCO-11, 12

This time estimate suggests the extent of depth of treatment. It is exclusive of time required for testing.

This column represents statements of student understandings which should be derived primarily from investigations.

V-A-1 refers to the specific section of the supplement.

This designates the Course-Content Objectives. The CCO(s) represent broad themes which permeate the syllabus, and should be stressed accordingly at this point.

This designates the Process-of-Inquiry Objectives. The PIO(s) should be employed in helping the student achieve the understanding.

A number in hundredths (A-1.31) designates the specific major understandings.

This information refers only to the single understanding if it is coded in hundredths (A-1.31). It refers to the entire section of the topic if it is coded in tenths only.

ANNOTATED FORMAT EXAMPLE

Investigations-Understandings Matrix

Investigation number (topic omitted) found at top of both teacher and student laboratory guide sheet.

The blocks in a horizontal column designate which investigations will support and explain a single understanding. For C-1.12, (The amount of energy lost....) any or all of the investigations (A-2a, B-1a, C-1a) might be used.

Estimated time in 45-minute class periods.

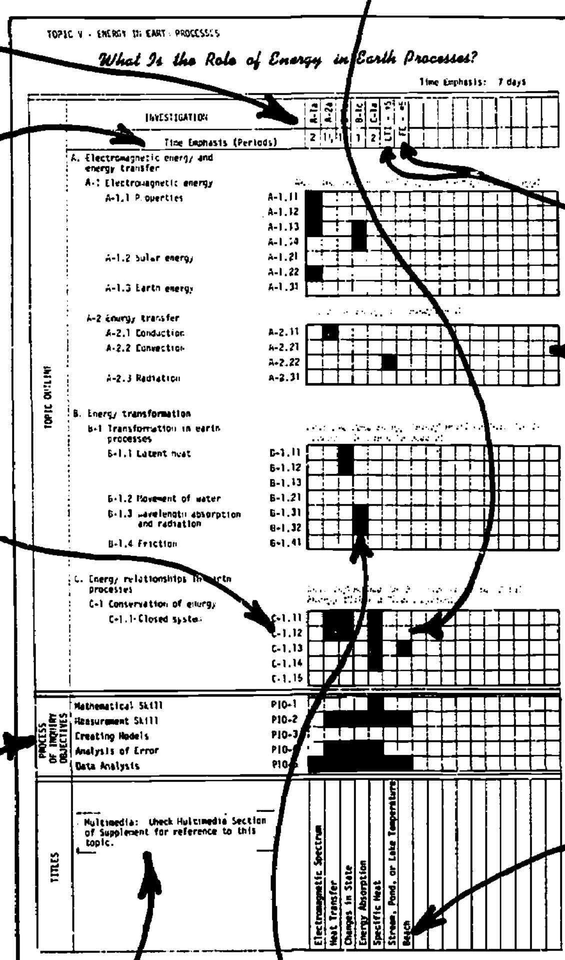
Long Term Investigations and Field Experiences

The understandings are coded directly to the syllabus, Major Understandings column. (i.e., C-1.12, The amount of energy lost by a source equals....)

Space left for teachers to place resources of their school into matrix (i.e., films, filmstrips, slides, videotapes, off-prints, library books, etc.)

Those Process Objectives used in an investigation.

Name of investigation

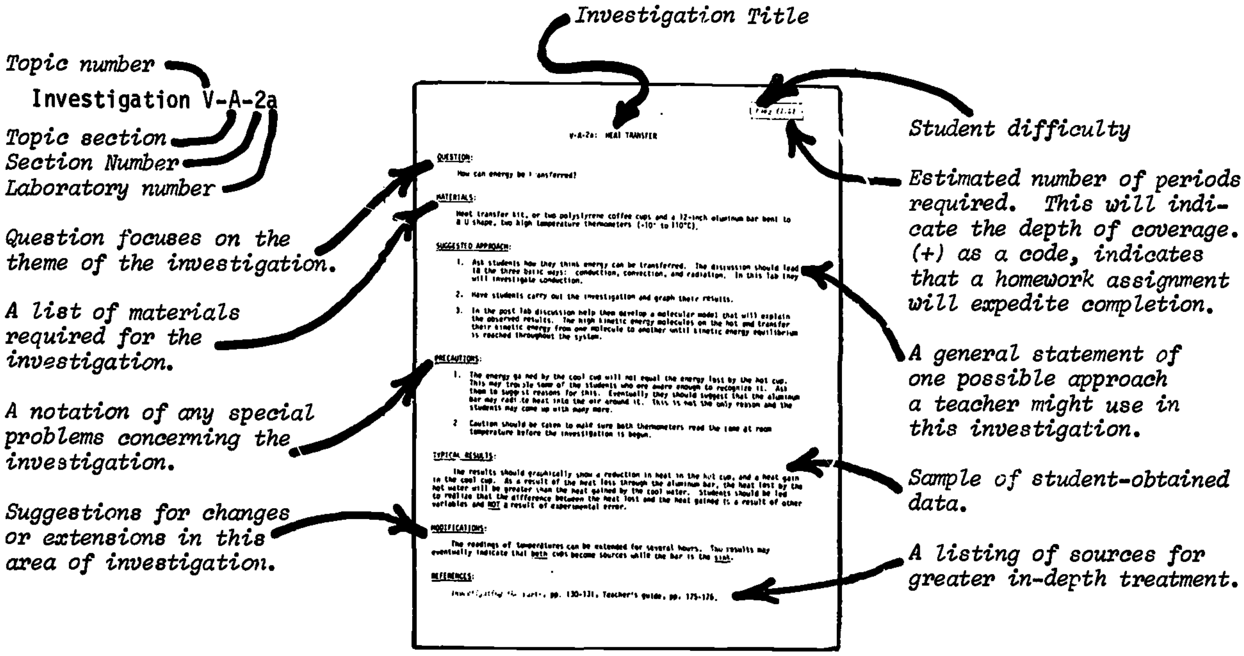


All multimedia are located in front of supplement by topic.

The blocks in a vertical column designate which understandings are included in a single investigation. Investigation B-1a: Energy Absorption, includes understandings: A-1.13, A-1.14, B-1.31, B-1.12.

A N N O T A T E D   F O R M A T   E X A M P L E S

Teacher Laboratory Guide Sheet



V-A-2a: HEAT TRANSFER

QUESTION:

How can energy be transferred?

MATERIALS:

Heat transfer kit, or two polystyrene coffee cups and a 12-inch aluminum bar bent to a U shape, two high temperature thermometers (-10° to 110°C).

SUGGESTED APPROACH:

1. Ask students how they think energy can be transferred. The discussion should lead to the three basic ways: conduction, convection, and radiation. In this lab they will investigate conduction.
2. Have students carry out the investigation and graph their results.
3. In the post lab discussion help them develop a molecular model that will explain the observed results. The high kinetic energy molecules on the hot end transfer their kinetic energy from one molecule to another until kinetic energy equilibrium is reached throughout the system.

PRECAUTIONS:

1. The energy gained by the cool cup will not equal the energy lost by the hot cup. This may trouble some of the students who are aware enough to recognize it. Ask them to suggest reasons for this. Eventually they should suggest that the aluminum bar may radiate heat into the air around it. This is not the only reason and the students may come up with many more.
2. Caution should be taken to make sure both thermometers read the same at room temperature before the investigation is begun.

TYPICAL RESULTS:

The results should graphically show a reduction in heat in the hot cup, and a heat gain in the cool cup. As a result of the heat loss through the aluminum bar, the heat lost by the hot water will be greater than the heat gained by the cool water. Students should be led to realize that the difference between the heat lost and the heat gained is a result of other variables and NOT a result of experimental error.

MODIFICATIONS:

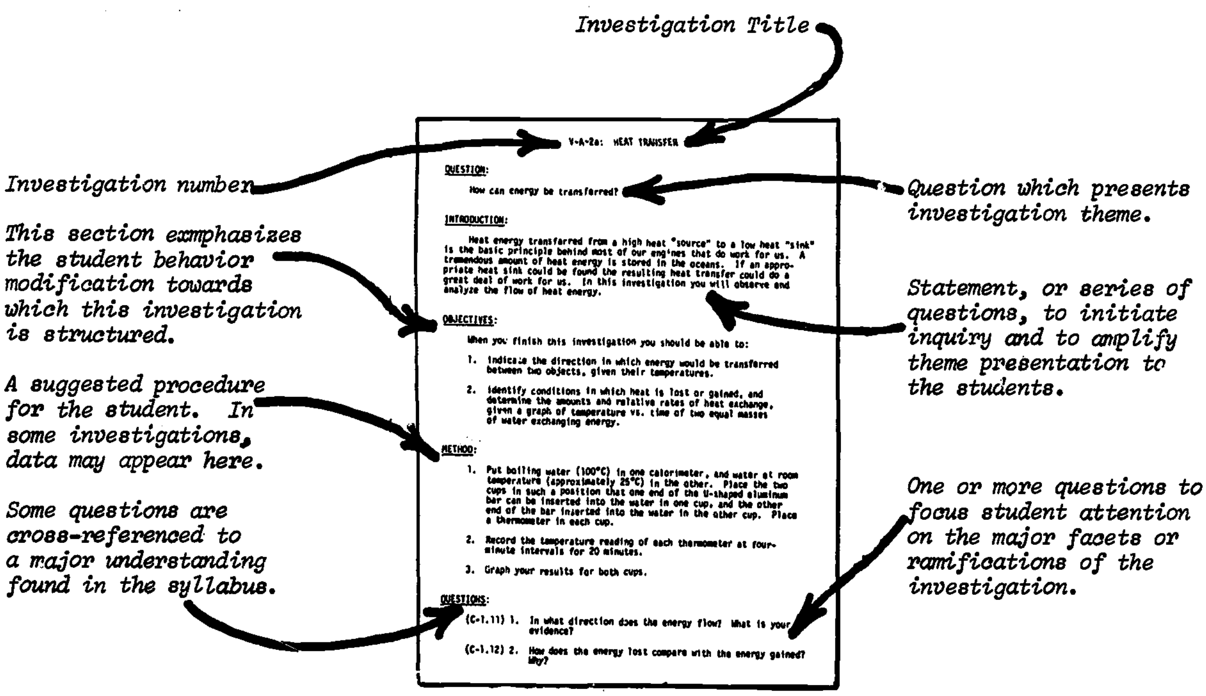
The readings of temperatures can be extended for several hours. The results may eventually indicate that both cups become sources while the bar is the sink.

REFERENCES:

Investigating the Earth, pp. 130-131, Teacher's guide, pp. 175-176.

Student Laboratory Guide Sheet

This will be available for each investigation for duplication and distribution to students if the teacher chooses.



V-A-2a: HEAT TRANSFER

QUESTION:

How can energy be transferred?

INTRODUCTION:

Heat energy transferred from a high heat "source" to a low heat "sink" is the basic principle behind most of our engines that do work for us. A tremendous amount of heat energy is stored in the oceans. If an appropriate heat sink could be found the resulting heat transfer could do a great deal of work for us. In this investigation you will observe and analyze the flow of heat energy.

OBJECTIVES:

When you finish this investigation you should be able to:

1. Indicate the direction in which energy would be transferred between two objects, given their temperatures.
2. Identify conditions in which heat is lost or gained, and determine the amounts and relative rates of heat exchange, given a graph of temperature vs. time of two equal masses of water exchanging energy.

METHOD:

1. Put boiling water (100°C) in one calorimeter, and water at room temperature (approximately 25°C) in the other. Place the two cups in such a position that one end of the U-shaped aluminum bar can be inserted into the water in one cup, and the other end of the bar inserted into the water in the other cup. Place a thermometer in each cup.
2. Record the temperature reading of each thermometer at four-minute intervals for 20 minutes.
3. Graph your results for both cups.

QUESTIONS:

(C-1.11) 1. In what direction does the energy flow? What is your evidence?

(C-1.12) 2. How does the energy lost compare with the energy gained? Why?

A R E A   T I M E   E M P H A S I S   C H A R T

				Time Emphasis
AREA 1	INVESTIGATING PROCESSES OF CHANGE			10 days
	Topic I	Observation and Environment	5 days	
	Topic II	The Changing Environment	5 days	
AREA 2	THE EARTH MODEL			20 days
	Topic III	Measuring the Earth	10 days	
	Topic IV	Earth Motions	10 days	
AREA 3	THE EARTH'S ENERGY BUDGET			38 days
	Topic V	Energy in Earth Processes	7 days	
	Topic VI	Insolation and the Earth's Surface	5 days	
	Topic VII	Energy Exchanges in the Atmosphere	16 days	
	Topic VIII	Moisture and Energy Budgets and Environment Change	10 days	
AREA 4	THE ROCK CYCLE			37 days
	Topic IX	The Erosional Process	6 days	
	Topic X	The Depositional Process	6 days	
	Topic XI	The Formation of Rocks	12 days	
	Topic XII	The Dynamic Crust	13 days	
AREA 5	THE HISTORY OF THE EARTH			30 days
	Topic XIII	Interpreting Geologic History	15 days	
	Topic XIV	Landscape Development and Environmental Change	15 days	
		Total Instructional Time		135 days

TOPIC OUTLINE

AREA 1 INVESTIGATING PROCESSES OF CHANGE

TOPIC I - OBSERVATION AND MEASUREMENT OF THE ENVIRONMENT

A. The local environment

- A-1 Observation
  - A-1.1 Sensory perception
  - A-1.2 Sensory limitations
  - A-1.3 Inferences
- A-2 Classification
  - A-2.1 A system of classification
  - A-2.2 Purpose

B. Properties of the environment

- B-1 Measurement
  - B-1.1 Dimensional quantities
  - B-1.2 Comparison
  - B-1.3 Error
- B-2 Density
  - B-2.1 Variations

TOPIC II - THE CHANGING ENVIRONMENT

A. The nature of change

- A-1 Characteristics of change
  - A-1.1 Occurrence of events
  - A-1.2 Frames of reference
  - A-1.3 Rate of change
  - A-1.4 Cycles — noncycles
  - A-1.5 Predictability of change
  - A-1.6 Occurrence of change

B. Energy and change

- B-1 Relationship between energy and change
  - B-1.1 Energy flow and exchange

C. Environmental change

- C-1 Man's influence on the environment
  - C-1.1 Environmental balance
  - C-1.2 Environmental pollution

AREA 2 THE EARTH MODEL

TOPIC III - MEASURING THE EARTH

A. Earth dimensions

- A-1 Shape
  - A-1.1 Evidence
- A-2 Size
  - A-2.1 Measurement techniques
  - A-2.2 Measurement determination
- A-3 Extent of the atmosphere, hydrosphere, and lithosphere
  - A-3.1 Atmosphere
  - A-3.2 Hydrosphere
  - A-3.3 Lithosphere

B. Positions on the earth

- B-1 Position determination
  - B-1.1 Coordinate systems
- B-2 Position description
  - B-2.1 Vector-scalar properties
  - B-2.2 Fields

TOPIC IV - EARTH MOTIONS

A. Celestial observations

- A-1 Motion of objects in the sky
  - A-1.1 Star paths
  - A-1.2 Planetary motions
  - A-1.3 Satellite motion
  - A-1.4 Sun motion

B. Terrestrial observations

- B-1 Motion at the earth's surface
  - B-1.1 Foucault pendulum
  - B-1.2 Coriolis effect

C. Time

- C-1 Frames of reference for time
  - C-1.1 Earth motions

D. Solar system models

- D-1 Geocentric and heliocentric models
  - D-1.1 Geocentric model
  - D-1.2 Heliocentric model
- D-2 Simple celestial model
  - D-2.1 Geometry of orbits
  - D-2.2 Force and energy transformations

AREA 3 THE EARTH'S ENERGY BUDGETS

TOPIC V - ENERGY IN EARTH PROCESSES

A. Electromagnetic energy and energy transfer

- A-1 Electromagnetic energy
  - A-1.1 Properties
  - A-1.2 Solar energy
  - A-1.3 Earth energy
- A-2 Energy transfer
  - A-2.1 Conduction
  - A-2.2 Convection
  - A-2.3 Radiation

B. Energy transformation

B-1 Transformation in earth processes
B-1.1 Latent heat
B-1.2 Movement of matter
B-1.3 Wavelength absorption and radiation
B-1.4 Friction

C. Energy relationships in earth processes

C-1 Conservation of energy
C-1.1 Closed system

TOPIC VI - INSOLATION AND THE EARTH'S SURFACE

A. Insolation at the earth's surface

A-1 Insolation factors
A-1.1 Angle
A-1.2 Duration
A-1.3 Absorption
A-1.4 Reflection
A-1.5 Scattering
A-1.6 Energy conversion

B. Terrestrial radiation

B-1 Radiation factors
B-1.1 Material radiation
B-1.2 Gases
B-1.3 Balance

TOPIC VII - ENERGY EXCHANGES IN THE ATMOSPHERE

A. Atmospheric variables

A-1 Local atmospheric variables
A-1.1 Probability of occurrence
A-1.2 Temperature variations
A-1.3 Pressure variations
A-1.4 Moisture variations
A-1.5 Air movement
A-1.6 Atmospheric transparency
A-1.7 Other variables

B. Synoptic weather data

B-1 Synoptic analysis
B-1.1 Airmass characteristics
B-1.2 Airmass source regions
B-1.3 Airmass tracks

C. Atmospheric energy exchanges

C-1 Input of moisture and energy
C-1.1 Evaporation and transpiration
C-1.2 Vapor pressure
C-1.3 Saturation vapor pressure
C-1.4 Other input energy

C-2 Moisture and energy transfer
C-2.1 Density differences
C-2.2 Wind speed and direction
C-2.3 Adiabatic changes
C-3 Release of moisture and energy within the atmosphere
C-3.1 Condensation and sublimation
C-3.2 Cloud formation
C-4 Release of moisture and energy from the atmosphere
C-4.1 Precipitation
C-4.2 Wind-water interaction

TOPIC VIII - MOISTURE AND ENERGY BUDGETS AND ENVIRONMENT CHANGE

A. Earth's water

A-1 Ground water
A-1.1 Infiltration
A-1.2 Permeability
A-1.3 Porosity
A-1.4 Capillarity
A-2 Surface water
A-2.1 Runoff
A-3 Pollution of the earth's water
A-3.1 Sources of pollutants
A-3.2 Types of pollutants
A-3.3 Concentration of pollutants
A-3.4 Long-range effects

B. The local water budget

B-1 Water budget variables
B-1.1 Precipitation (P)
B-1.2 Potential evapotranspiration (E_p)
B-1.3 Moisture storage
B-1.4 Moisture utilization
B-1.5 Moisture deficit
B-1.6 Moisture recharge
B-1.7 Moisture surplus
B-2 Streams
B-2.1 Stream discharge and the water budget
B-3 Climates and the local water budget
B-3.1 Climatic regions

C. Climate pattern factors

C-1 Factors
C-1.1 Latitude
C-1.2 Elevation
C-1.3 Large bodies of water and ocean currents
C-1.4 Mountain barriers
C-1.5 Wind belts
C-1.6 Storm tracks

AREA 4 THE ROCK CYCLE

TOPIC IX - THE EROSIONAL PROCESS

A. Weathering

- A-1 Evidence of weathering
  - A-1.1 Weathering processes
  - A-1.2 Weathering rates
  - A-1.3 Soil formation
  - A-1.4 Soil solution

B. Erosion

- B-1 Evidence of erosion
  - B-1.1 Displaced sediments
  - B-1.2 Properties of transported materials
- B-2 Factors affecting transportation
  - B-2.1 Gravity
  - B-2.2 Water erosion
  - B-2.3 Wind and ice erosion
  - B-2.4 Effect of erosional agents
  - B-2.5 Effect of man
  - B-2.6 Predominant agent

TOPIC X - THE DEPOSITIONAL PROCESS

A. Deposition

- A-1 Factors
  - A-1.1 Size
  - A-1.2 Shape
  - A-1.3 Density
  - A-1.4 Velocity

B. Erosional-depositional system

- B-1 Characteristics
  - B-1.1 Erosional-depositional change
  - B-1.2 Dominant process
  - B-1.3 Erosional-depositional interface
  - B-1.4 Dynamic equilibrium
  - B-1.5 Energy relationships

TOPIX XI - THE FORMATION OF ROCKS

A. Rocks and sediments

- A-1 Comparative properties
  - A-1.1 Similarities
  - A-1.2 Differences

B. Minerals

- B-1 Relation to rocks
  - B-1.1 Composition
- B-2 Characteristics
  - B-2.1 Physical, chemical properties
  - B-2.2 Chemical composition
  - B-2.3 Structure

C. Rock formation

- C-1 Sedimentary rocks
  - C-1.1 Compression cementation
  - C-1.2 Chemical processes
  - C-1.3 Biological processes
- C-2 Nonsedimentary rocks
  - C-2.1 Solidification process
  - C-2.2 Recrystallization process
- C-3 Environment of formation
  - C-3.1 Inferred characteristics
  - C-3.2 Distribution

D. Rock cycle

- D-1 Evidence
  - D-1.1 Transition zones
  - D-1.2 Rock composition

TOPIC XII - THE DYNAMIC CRUST

A. Evidence for crustal movement

- A-1 Minor crustal changes
  - A-1.1 Deformed rock strata
  - A-1.2 Displaced fossils
  - A-1.3 Displaced strata
- A-2 Major crustal changes
  - A-2.1 Zones of crustal activity
  - A-2.2 Geosynclines
  - A-2.3 Vertical movements
  - A-2.4 Ocean floor spreading
  - A-2.5 Continental drift
  - A-2.6 Magnetic poles

B. Earthquakes

- B-1 Wave properties
  - B-1.1 Types of waves
  - B-1.2 Velocities
  - B-1.3 Transmission
- B-2 Location of an epicenter
  - B-2.1 Epicenter
  - B-2.2 Origin time

C. Model of the earth's crust and interior

- C-1 Properties
  - C-1.1 Solid and liquid zones
  - C-1.2 Crustal thickness
  - C-1.3 Crustal composition
  - C-1.4 Density, temperature, and pressure
  - C-1.5 Interior composition

D. Theories of crustal change

- D-1 Inferred processes
  - D-1.1 Mantle convection cells
  - D-1.2 Geosynclinal development
  - D-1.3 Isostasy
  - D-1.4 Process relationships

AREA 5 THE HISTORY OF THE EARTH

TOPIC XIII - INTERPRETING GEOLOGIC HISTORY

A. Geologic events

A-1 Sequence of geologic events
A-1.1 Chronology of layers
A-1.2 Igneous intrusions and extrusions
A-1.3 Faults, joints, and folds
A-1.4 Internal characteristics

B. Correlation techniques

B-1 Correlation
B-1.1 Continuity
B-1.2 Similarity of rock
B-1.3 Fossil evidence
B-1.4 Volcanic time markers
B-1.5 Anomalies to correlation

C. Determining geologic ages

C-1 Rock record
C-1.1 Fossil evidence
C-1.2 Scale of geologic time
C-1.3 Erosional record
C-1.4 Geologic history of an area
C-2 Radioactive decay
C-2.1 Decay rates
C-2.2 Half-lives
C-2.3 Decay product ratios

D. The fossil record

D-1 Ancient life
D-1.1 Variety of life forms
D-1.2 Evolutionary development

TOPIC XIV - LANDSCAPE DEVELOPMENT AND ENVIRONMENTAL CHANGE

A. Landscape characteristics

A-1 Quantitative observations
A-1.1 Hillslopes
A-1.2 Stream patterns
A-1.3 Soil associations
A-2 Relationship of characteristics
A-2.1 Landscape regions

B. Landscape development

B-1 Environmental factors
B-1.1 Uplifting and leveling force
B-1.2 Climate
B-1.3 Bedrock
B-1.4 Time
B-1.5 Dynamic equilibrium
B-1.6 Man

AREA 1

INVESTIGATING PROCESSES OF CHANGE

AREA TIME EMPHASIS	TOPIC	TITLE	TIME
10 DAYS	I	Observation and Measurement of the Environment	5 days
	II	The Changing Environment	5 days

How Can the Environment Be Investigated?

TOPIC ABSTRACT

Time Emphasis: 5 days

MAJOR BEHAVIORAL OBJECTIVES

At the completion of this topic, the student should be able to:

A. Describe and classify his own observations of the local environment.

B. Measure some of the properties of his environment at a level of performance described in the "Process of Inquiry Objectives."

Approach

Treatment of topic I should be brief. The amount of time spent will depend upon previous student experience with observation and measurement. The student should be made aware that casual observations must be standardized and classified in order to form a basis for scientific investigation. He should also become aware of the problems which accompany any type of scientific measurement.

An important aspect of the study of density should be to provide the vehicle for an examination of the skills of scientific measurement.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. The local environment		
A-1 Observation	**A-1 *How can the local environment be observed?***	**I-A-1**
A-1.1 Sensory perception	A-1.11 Observations involve the interaction of the senses with the environment.	CCO-10
A-1.2 Sensory limitations	A-1.21 Powers of observation are limited by the senses.	CCO-11
	A-1.22 Powers of observation can be extended by the use of instruments.	PIO-1; CCO-11
A-1.3 Inferences	A-1.31 Inferences are interpretations based upon observations.	CCO-12
A-2 Classification	**A-2 *How can observations of the environment be classified?***	**I-A-2**
A-2.1 A system of classification	A-2.11 A classification system is based on observable properties.	PIO-5; CCO-10, 12
A-2.2 Purpose	A-2.21 A classification system enables an investigator to organize observations in a meaningful way.	PIO-3

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
B. Properties of the environment		
B-1 Measurement	**B-1 *How can properties of the environment be measured?***	**I-B-1**
B-1.1 Dimensional quantities	B-1.11 All measurements contain at least one basic dimensional quantity (time, length, or mass).	PIO-1
	B-1.12 Some properties of matter are described by the mathematical combination of the basic dimensional quantities (e.g., density, pressure, volume, or acceleration).	PIO-1
B-1.2 Comparison	B-1.21 Measurements of some properties of matter are made by a direct comparison with standards (e.g., length, mass, volume).	PIO-1, 2
B-1.3 Error	B-1.31 Any measurement is an approximation of an absolute value and must be considered to contain some error.	PIO-1, 2, 3
B-2 Density	**B-2 *What are some characteristics of the properties of the environment?***	**I-B-2**
B-2.1 Variations	B-2.11 The density of a uniform material is independent of the size and shape of the material.	PIO-1, 2, 4, 5; CCO-10, 11
	B-2.12 The density of a gas varies with pressure and temperature.	CCO-10, 11
	B-2.13 The maximum density of most materials occurs in the solid phase.	PIO-1, 2, 5; CCO-7, 10, 11
	B-2.14 The maximum density of water occurs in the liquid phase.	PIO-1, 2, 5; CCO-7, 10, 11

How Changeable Is Our Environment?

Time Emphasis: 5 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Describe the nature of changes occurring in his environment from observations of the environment.
B. Draw inferences about the relationship of energy to change from direct observations.
C. Draw inferences about man's ability to modify his environment from direct observations.

Approach

Throughout this topic the student's attention should be focused on changes in his environment. The student should develop an awareness that the phenomenon of change is the prevailing condition in nature.

In this topic it is desirable to start some long-term investigations of the "watch" type which will be concluded and summarized at various points in later topics. Specific suggestions for these investigations are included in the supplementary materials.

Long-term watches should be initiated with enthusiasm and students should be frequently encouraged so that they will feel the necessity for continuing their work. Specific end points for these investigations should be determined in advance, and plans should be established for the incorporation of the accumulated data into the appropriate topics.

The relationship between energy and change should be introduced in this topic. Further development will occur in topic V.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. The nature of change		
A-1 Characteristics of change	**A-1 *How can changes be described?***	**II-A-1**
A-1.1 Occurrence of events	A-1.11 Change can be described as the occurrence of an event.	CCO-1, 2, 4, 6, 7
	A-1.12 An event occurs if the properties of matter are altered.	PIO-4, 5; CCO-1, 2, 4, 6, 7
	A-1.13 An event occurs if the properties of a system are altered.	PIO-4, 5; CCO-1, 2, 4, 6, 7
A-1.2 Frames of reference	A-1.21 Time and space are frames of reference through which change can be described.	PIO-3, 4, 5; CCO-1, 2, 10, 11, 12
A-1.3 Rate of change	A-1.31 A change can be described by measuring the rate at which it occurs.	PIO-2, 4; CCO-1, 2, 6, 7
	A-1.32 The rates of change of some earth processes are difficult to measure.	PIO-2; CCO-10, 11

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A-1.4 Cycles-noncycles	A-1.41 Cyclic change is an orderly manner of events in time and space which repeats.	CCO-6
	A-1.42 Most changes in the environment are cyclic.	CCO-5
A-1.5 Predictability of change	A-1.51 The scope and direction of change is often predictable when evidence of the nature of the change is available.	CCO-1, 2, 4, 5, 6, 7, 10, 12
A-1.6 Occurrence of change	A-1.61 Change is a natural state of the environment.	
B. Energy and change		
B-1 Relationship between energy and change	***B-1 What is the relationship of energy to change?***	**II-B-1**
B-1.1 Energy flow and exchange	B-1.11 Change occurs simultaneously in the part of the environment which loses energy and in the part of the environment which gains energy.	CCO-1, 4
	B-1.12 The exchange of energy in processes of change occurs at the interface between parts of the environment.	CCO-1, 2, 4
C. Environmental Change		
C-1 Man's influence on the environment	***C-1 How does man modify the environment?***	**II-C-1**
C-1.1 Environmental balance	C-1.11 The environment is in a state of equilibrium which can be altered easily on a small scale.	CCO-4
	C-1.12 Man's technology has enabled him to disrupt the equilibrium of large portions of his environment.	CCO-6
C-1.2 Environmental pollution	C-1.21 The environment is considered to be polluted when the concentration of any substance or form of energy reaches a proportion that adversely affects man, his property, or the plant and animal life on which he depends.	PIO-2, 5; CCO-8, 9
	C-1.22 Environmental pollutants include such diverse materials as solid , liquids, gases, biologic organisms, and forms of energy such as heat, sound, and nuclear radiation.	CCO-7
	C-1.23 Pollutants are being added to the environment by natural processes, the activities of individuals, communities, and industrial processes.	CCO-1
	C-1.24 The addition of some pollutants to the environment varies with such factors as the seasons or the time of day.	PIO-2; CCO-1, 2, 4, 5

AREA 2

THE EARTH MODEL

AREA TIME EMPHASIS	TOPIC	TITLE	TIME
20 DAYS	III	Measuring the Earth	10 days
	IV	Earth Motions	10 days

What Is Our Model of the Earth?

TOPIC ABSTRACT

Time Emphasis: 10 days

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Develop models to illustrate the earth's size and shape and the extent of the earth's spheres.

B. Determine a method for locating a point on the earth's surface, measure the physical properties at this point, and develop models of some of the fields that exist at that point.

Approach

Students will very likely have preconceived ideas concerning earth dimensions and relative scale. Care should be taken to place the magnitude of the various dimensions in proper perspective. This topic should be developed from a "how-do-we-know-it" approach employing a questioning, analytic technique.

The measurement of a physical characteristic at many points should be used to develop the field concept. The field can then be used to infer the characteristics of points that have not been measured.

Students should be provided with enough experience with fields so that the concept can be easily applied in later topics.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Earth dimensions		
A-1 Shape	**A-1 *How can the earth's shape be determined?***	**III-A-1**
A-1.1 Evidence	A-1.11 Observations of the altitude of Polaris measured as a function of latitudinal distance leads to an interpretation of the earth's shape.	PIO-1, 2, 3, 4, 5; CCO-11, 12
	A-1.12 Other evidences that indicate the earth's shape include: a. photographs of the earth from space b. gravimetric measurements	PIO-1, 2, 3, 4, 5; CCO-11, 12
A-2 Size	**A-2 *How can the earth's size be determined?***	**III-A-2**
A-2.1 Measurement techniques	A-2.11 The dimensions of the earth can be determined from observations of the earth from space.	PIO-1, 5; CCO-11
	A-2.12 The circumference of the earth can be determined from observations of the sun's altitude measured at the same time in two different locations.	A-2.12 An actual determination of the circumference of the earth can be made by measuring the sun's

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
		position and exchanging the data with another school. PIO-1, 2, 3, 4, 5; CCO-11, 12
	A-2.13 The earth's diameter, volume, and surface area can be calculated once the circumference is known.	PIO-1, 5; CCO-11
A-2.2 Measurement determination	A-2.21 The earth's circumference through the poles is less than the measurement along the equator.	PIO-1, 2, 3, 4, 5; CCO-11
	A-2.22 The earth is nearly spherical, being only slightly oblate.	A-2.22 The objective in this understanding is to put the earth's shape in proper perspective regarding scale. The "out of roundness" should not be overemphasized. Otherwise, students may develop an exaggerated mental model of the earth's shape. PIO-1, 3; CCO-11, 12
A-3 Extent of the atmosphere, hydrosphere, and lithosphere	***A-3 What is the extent of the atmosphere, hydrosphere, and lithosphere?***	**III-A-3**
A-3.1 Atmosphere	A-3.11 Nearly all of the atmosphere is confined to a thin shell surrounding the earth. However, the atmosphere extends several hundred kilometers into space.	A-3.11 The objective in this understanding is to put the extent of the atmosphere in proper perspective regarding scale. PIO-1, 3; CCO-7, 11
	A-3.12 The atmosphere is stratified, with each layer possessing distinct characteristics.	PIO-5; CCO-7, 9, 11
A-3.2 Hydrosphere	A-3.21 The majority of the earth's surface is covered with water that is largely confined to a relatively thin film.	PIO-1, 3; CCO-7, 11
A-3.3 Lithosphere	A-3.31 The rock near the earth's surface forms a continuous solid shell around the earth.	A-3.31 Relate to topic XII. PIO-1, 3; CCO-7, 11
B. Positions on the earth		
B-1 Position determination	***B-1 How can a position on the earth's surface be determined?***	**III-B-1**
B-1.1 Coordinate systems	B-1.11 A coordinate system of imaginary lines, an earth grid, can be developed to determine a position on the earth's surface.	B-1.11 The students should become aware that many reference systems can be used to determine positions on the earth. PIO-2, 3, 5
	B-1.12 The latitude-longitude system is based on celestial observations.	PIO-2, 3, 5; CCO-11

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
B-2 Position description	***B-2 How can the characteristics of a position be measured and described?***	**III-B-2**
B-2.1 Vector-scalar properties	B-2.11 The physical characteristics of a point may be either vector or scalar quantities.	PIO-3, 5
B-2.2 Fields	B-2.21 A field is a region of space which contains a measurable quantity at every point.	PIO-3, 5
	B-2.22 Isolines are models representing field characteristics in two dimensions.	PIO-3, 5
	B-2.23 Iso-surfaces are models representing field characteristics in three dimensions (e.g., contour map or magnetic field)	PIO-3, 5
	B-2.24 The characteristics of a field frequently change with the passage of time.	B-2.24 A field should be studied in which change can be noted. Do not create the impression that fields are static or unchanging. PIO-2, 3, 5; CCO-1, 7, 10, 11
	B-2.25 Gradients within the field express the degree of change of the field quantity from place to place.	PIO-5; CCO-7

What Are the Motions of the Earth?

Time Emphasis: 10 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Collect data on the motions of objects in the sky.
B. Draw inferences about earth motions from evidence such as the Coriolis effect and the Foucault pendulum.
C. Draw inferences from celestial and terrestrial observations relating frames of reference for time and earth motion.
D. Analyze models of the solar system using locally obtained data to synthesize a simple model, and evaluate the model for its applicability.

Approach

Topic IV continues the development of a general model of the planet earth by the examination of terrestrial, lunar, and planetary observations. These observations should be used to construct a model for earth motions.

The geocentric and heliocentric models should be introduced and the observations used to support or refute these models.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Celestial observations		
A-1 Motions of objects in the sky	**A-1 *What observations can be made of celestial objects?***	**IV-A-1**
A-1.1 Star paths	A-1.11 The apparent daily motion of stars is a circular path.	PIO-5; CCO-4, 6, 8
	A-1.12 The daily rate of motion of stars is constant.	PIO-5; CCO-6, 8
A-1.2 Planetary motions	A-1.21 The movement of planets through the star field is not uniform.	PIO-5; CCO-4, 6, 8
	A-1.22 The apparent diameter of each planet varies in a cyclic manner.	PIO-5; CCO-5, 6, 8
	A-1.23 The observation of planets indicates that many rotate.	PIO-5; CCO-4, 6, 8
A-1.3 Satellite motion	A-1.31 The moon's motion creates a cycle of phases.	PIO-5; CCO-4, 5, 6, 8
	A-1.32 The moon's apparent diameter varies in a cyclic manner.	PIO-5; CCO-4, 5, 6, 8
A-1.4 Sun motion	A-1.41 The sun's apparent daily path through the sky is an arc.	PIO-5; CCO-4, 6, 8
	A-1.42 The sun's apparent path varies with the seasons.	CCO-5, 6, 8

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
	A-1.43 The high noon position is never directly overhead farther north than 23½° N. latitude.	CCO-5, 6, 8
	A-1.44 The points of sunrise and sunset vary with the seasons.	CCO-5, 6, 8
	A-1.45 The length of day varies with the seasons.	CCO-5, 6, 8
	A-1.46 The apparent solar diameter varies in a cyclic manner during the year.	PIO-5; CCO-4, 5, 6, 8
B. Terrestrial observations		
B-1 Motion at the earth's surface	***B-1 What terrestrial evidence suggests earth motions?***	**IV-B-1**
B-1.1 Foucault pendulum	B-1.11 The plane of vibration of a freely swinging pendulum appears to change direction in a manner that is predictable.	PIO-5; CCO-6, 9
B-1.2 Coriolis effect	B-1.12 The path of a fluid at the surface of the earth appears to undergo a predictable horizontal deflection.	PIO-5; CCO-6, 9
C. Time		
C-1 Frames of reference for time	***C-1 How are frames of reference determined for time?***	**IV-C-1**
C-1.1 Earth motions	C-1.11 The frames of reference for time are based upon the motions of the earth.	CCO-5, 6
	C-1.12 Mean time differs from apparent solar time by an amount which varies with the seasons.	CCO-5, 6
D. Solar system models		
D-1 Geocentric and heliocentric models	***D-1 What models explain the observations of celestial and terrestrial motions?***	**IV-D-1**
D-1.1 Geocentric model	D-1.11 The apparent motions of celestial objects are explained by a geocentric model.	PIO-3, 4; CCO-5, 11, 12
	D-1.12 The apparent terrestrial motions of objects are not explained by a geocentric model.	PIO-3, 4; CCO-11
D-1.2 Heliocentric model	D-1.21 The apparent motions of celestial objects are explained by a heliocentric model.	PIO-3; CCO-6, 12
	D-1.22 The apparent terrestrial motions of objects are explained by a heliocentric model.	PIO-3; CCO-6, 12
	D-1.23 Compared to the geocentric model, the heliocentric model of celestial motion is less complex.	PIO-3, 4; CCO-5, 6, 8

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
D-2 Simple celestial model	***D-2 What simple celestial model can be synthesized from observations?***	**IV-D-2**
D-2.1 Geometry of orbits	D-2.11 The earth's orbit around the sun is an ellipse with the sun at one of the foci.	PIO-3; CCO-3, 5, 6, 12
	D-2.12 The orbits of the other planets also describe ellipses with the sun at a focus.	PIO-3; CCO-5, 6, 12
	D-2.13 The areas swept out by an imaginary line connecting the sun and a planet are equal for equal intervals of time.	PIO-3; CCO-5, 8
	D-2.14 The period of any given planet is related to the mean radius of its orbit. $[T^2 \propto \bar{R}^3]$	PIC-3; CCO-5, 8
D-2.2 Force and energy transformations	D-2.21 The gravitational force between objects is attractive.	PIO-3; CCO-2, 6, 9
	D-2.22 The gravitational force is proportional to the product of the masses of the objects and inversely proportional to the distance between their centers squared. $\left[F \propto \frac{M_1M_2}{R^2}\right]$	
	D-2.23 A cyclic energy transformation between kinetic and potential energy takes place as the earth moves, resulting in a change in the earth's speed.	PIO-3; CCO-1, 2, 3, 4, 5, 6, 8
	D-2.24 The length of the day varies because of the change in speed of the earth in its orbit.	CCC-5, 6, 9

AREA 3

THE EARTH'S ENERGY BUDGETS

AREA TIME EMPHASIS	TOPIC	TITLE	TIME
38 DAYS	V	Energy in Earth Processes	7 days
	VI	Insolation and the Earth's Surface	5 days
	VII	Energy Exchanges in the Atmosphere	16 days
	VIII	Moisture and Energy Budgets and Environmental Change	10 days

What Is the Role of Energy in Earth Processes?

Time Emphasis: 7 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Identify and analyze processes of energy transfer.
B. Describe energy transformations that have been observed in the environment.
C. Analyze environmental processes, and draw inferences about the conservation of energy.

Approach

This topic introduces the basic concepts of thermal and electromagnetic energy essential to understanding the earth processes investigated in subsequent topics. Application of the basic concepts will be expanded in greater detail during subsequent topics.

The depth of treatment of topic V, including the selection of student activities, should utilize the prior experiences and knowledge of the students.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Electromagnetic energy and energy transfer		
A-1 Electromagnetic energy	***A-1 What are the properties of electromagnetic energy?***	**V-A-1**
A-1.1 Properties	A-1.11 All objects not at a temperature of absolute zero radiate electromagnetic energy.	CCO-11, 12
	A-1.12 Electromagnetic energy has transverse wave properties.	PIO-2, 3, 5; CCO-1, 7,
	A-1.13 Electromagnetic energy can be refracted, reflected, scattered, and absorbed.	PIO-2, 3; CCO-1, 7, 9, 11
	A-1.14 A good absorber of electromagnetic energy is a good radiator of electromagnetic energy.	CCO-7, 11, 12
A-1.2 Solar energy	A-1.21 The sun is the major source of energy for the earth.	CCO-3, 12
	A-1.22 The solar electromagnetic spectrum includes a wide range of wavelengths. The maximum intensity occurs in the visible region.	PIO-2, 3, 5; CCO-7, 11, 12
A-1.3 Earth energy	A-1.31 The natural decay of radioactive matter is a secondary source of energy for earth processes.	A-1.31 Relate to topic XIII. CCO-11, 12

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A-2 Energy transfer	***A-2 How can energy be transferred?***	**V-A-2**
A-2.1 Conduction	A-2.11 Conduction of thermal energy occurs as an interaction of matter at the molecular or atomic level.	CCO-11, 12
A-2.2 Convection	A-2.21 Density differences influence the transfer of energy in fluids.	A-2.21 Relate to topic VII. PIO-3, 5; CCO-1, 4, 5, 6, 11
	A-2.22 In a fluid, convection cells develop which transfer energy.	A-2.22 Relate to topic VII and topic XII. PIO-2, 3, 5; CCO-1, 4, 5, 6, 7, 8, 9, 11, 12
A-2.3 Radiation	A-2.31 Electromagnetic energy requires no medium for transfer.	CCO-11, 12
B. Energy transformation		
B-1 Transformation in earth processes	***B-1 What are some energy transformations that can be observed in earth processes?***	**V-B-1**
B-1.1 Latent heat	B-1.11 Changes of phase are contingent upon the loss or gain of energy	PIO-3, 5; CCO-1, 2, 4, 11, 12
	B-1.12 As energy is added to matter, causing a change of phase while the temperature remains constant, this energy is transformed into potential energy.	PIO-3, 5; CCO-1, 2, 4, 11, 12
	B-1.13 A significantly greater amount of energy is required to change a given mass of water from liquid to vapor than is required to change ice to liquid.	B-1.13 Relate to topic VII and topic VIII. PIO-1, 2, 3, 5; CCO-1, 2, 11
B-1.2 Movement of matter	B-1.21 The movement of matter toward or away from the earth's center of mass results in an energy transformation from kinetic to potential or vice versa.	B-1.21 Relate to topics,IX, X, and XIV. CCO-1, 2, 12
B-1.3 Wavelength absorption and radiation	B-1.31 The characteristics of the surface of a material determine the quantity and type of electromagnetic energy absorbed.	PIO-2, 3, 5; CCO-1, 6, 7, 11, 12
	B-1.32 Absorbed short wavelengths of electromagnetic energy can be subsequently radiated as long wavelengths.	PIO-3, 5; CCO-1, 2, 7, 10
B-1.4 Friction	B-1.41 Energy is transformed at interfaces where friction occurs.	B-1.41 Relate to topic IX. PIO-3, 5; CCO-1, 2, 7, 10
C. Energy relationships in earth processes		
C-1 Conservation of energy	***C-1 What inferences can be drawn about the total energy within a closed system?***	**V-C-1**
C-1.1 Closed system	C-1.11 Energy flows from sources to sinks.	PIO-2, 3, 5; CCO-1, 2, 4, 7, 9, 11, 12
	C-1.12 The amount of energy lost by a source equals the amount of energy gained by a sink.	PIO-2, 3, 5; CCO-1, 2, 4

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
	C-1.13 The amount of energy needed to produce an equal temperature change in equal masses of different materials varies with the materials.	C-1.13 Relate to topic VIII. PIO-2, 3, 5; CCO-1, 6, 7, 11
	C-1.14 Water has the highest specific heat capacity among naturally occurring materials.	C-1.14 Relate to topic VIII. PIO-2, 3, 5; CCO-1, 2, 7, 11
	C-1.15 Heat lost (or gained) is proportional to the product of the mass and the temperature change.	PIO-1, 2, 3, 5; CCO-1 11,11
	C-1.16 The heat lost (or gained) in a phase change is equal to the product of the mass times the change in potential energy per unit mass.	C-1.16 Relate to topic VII. PIO-2, 3, 5; CCO-1, 2, 7, 11

What Happens to Solar Energy That Reaches the Earth?

Time Emphasis: 5 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Analyze factors which influence the amount of insolation reaching the earth's surface.
B. Measure the effect of factors which influence the amount of terrestrial radiation.

Approach

In this topic the student has the opportunity to investigate the absorption, reflection, radiation, and energy conversions involved in the earth-sun energy system.

In topic VII the radiative budget becomes the basis for the investigation of weather.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Insolation at the earth's surface		
A-1 Insolation factors	**A-1 *What are some factors which affect insolation?***	**VI-A-1**
A-1.1 Angle	A-1.11 The intensity of insolation per unit area increases as the angle of insolation approaches perpendicular.	PIO-2, 3, 5; CCO-1, 11
	A-1.12 The intensity of insolation per unit area decreases with an increase in latitude.	PIO-3, 5; CCO-1
	A-1.13 The angle of insolation at any location varies with the time of day.	PIO-3, 5; CCO-1
A-1.2 Duration	A-1.21 The temperature at a given location varies directly with the duration of insolation.	PIO-3, 5; CCO-1, 3, 6
	A-1.22 The duration of insolation varies with latitude and season.	PIO-3, 5; CCO-1, 5
	A-1.23 Maximum insolation in northern mid-latitudes occurs about June 21.	PIO-3, 5; CCO-1, 5
	A-1.24 Maximum surface temperature occurs sometime after the maximum duration of insolation.	PIO-3, 5; CCO-1, 3
A-1.3 Absorption	A-1.31 The atmosphere is largely transparent to visible radiation, but it selectively absorbs quantities of ultraviolet and infrared radiation.	A-1.31 Relate to topic VII. PIO-3; CCO-2, 6
	A-1.32 Land surface temperatures change more rapidly than water surface temperatures.	PIO-3; CCO-1, 3, 6

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A-1.4 Reflection	A-1.41 Clouds may reflect approximately 25 percent of the incident insolation.	PIO-3; CCO-6
	A-1.42 The reflectivity of the earth depends upon the angle of insolation.	PIO-3; CCO-6
	A-1.43 Ice and snow reflect almost all of the incident insolation.	PIO-3; CCO-6
A-1.5 Scattering	A-1.51 Aerosols (such as water droplets and dust) in the atmosphere cause a random reflection of insolation.	PIO-3; CCO-6
	A-1.52 The amount of insolation reaching the earth's surface decreases as the amount of random reflection increases.	PIO-3; CCO-6
A-1.6 Energy conversion	A-1.61 Some insolation is converted into potential energy by evaporation of water and melting of ice.	PIO-3; CCO-1, 2, 6

B. Terrestrial radiation

B-1 Radiation factors	***B-1 What are some factors which affect terrestrial radiation?***	**VI-B-1**
B-1.1 Material radiation	B-1.11 The maximum intensity of outgoing radiation from the earth's surface is in the infrared region of the electromagnetic spectrum.	PIO-3, 5; CCO-3, 6
B-1.2 Gases	B-1.21 Water vapor and carbon dioxide are good absorbers of infrared radiation.	PIO-3, 5; CCO-1, 6
B-1.3 Balance	B-1.31 Long-term measurements (thousands of years) of worldwide surface temperatures indicate that the earth *is not* in radiative balance.	PIO-3, 5; CCO-8
	B-1.32 Intermediate term measurement (decades) of worldwide surface temperatures indicates that the earth *is* in radiative balance.	PIO-3, 5; CCO-8
	B-1.33 Annual measurement of worldwide surface temperatures indicates that the earth *is not* in radiative balance.	PIO-3, 5; CCO-4

What Causes the Weather?

Time Emphasis: 16 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Compare locally observed atmospheric variables, and derive interrelationships.
B. Determine characteristics of airmasses from synoptic weather data.
C. Describe energy exchanges in atmospheric processes.

Approach

It is assumed that the student has observed, measured, and recorded local atmospheric variables in a weather watch-type investigation prior to this topic. The data collection which may have been started earlier in topic I or topic II can be used in this topic for analysis.

An analytical approach should be used in this topic. Students should be encouraged to hypothesize relationships based on the evidence *they* have collected.

The prediction of atmospheric changes is an activity which can stimulate the interest of all students.

The moisture-energy relationships in the water cycle should be carefully considered in this topic. The latent heat factor that was introduced in topic V should be reinforced at this point.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Atmospheric variables		
A-1 Local atmospheric variables	**A-1** *What are some relationships between atmosphere variables that can be observed locally?*	**VII-A-1**
A-1.1 Probability of occurrence	A-1.11 Relationships between atmospheric variables can be expressed as the probability of occurrence.	A-1.11 The use of probabilities is desirable to establish an understanding of the complex and dynamic relationships that exist between the variables. PIO-3, 5; CCO-10, 11
A-1.2 Temperature variations	A-1.21 Temperature is greatly affected by the amount and duration of insolation.	A-1.21 Relate to topic VI. PIO-2, 5; CCO-11, 12
A-1.3 Pressure variations	A-1.31 Air pressure changes are closely associated with temperature changes.	PIO-2, 5; CCO-11, 12

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A-1.4 Moisture variations	A-1.41 Variations in the dew point temperature are indicators of changes in atmospheric moisture.	PIO-2, 5; CCO-4, 6, 11
	A-1.42 The probability of precipitation increases as the difference between dew point temperature and air temperature decreases.	PIO-5; CCO-11
A-1.5 Air movement	A-1.51 Wind speeds are directly related to pressure field gradients.	PIO-5; CCO-11
A-1.6 Atmospheric transparency	A-1.61 Atmospheric transparency varies inversely with the amount of input of materials produced by natural processes and the activities of man.	PIO-2, 5; CCO-6, 8, 11
	A-1.62 The atmosphere tends to clean itself periodically through natural processes such as cloud formation and precipitation.	A-1.62 This understanding can be related to a pollution part of a continuing weather watch. PIO-4, 5, 6, 8, 10
A-1.7 Other variables	A-1.71 Other weather variables seem to be associated in a more complex manner than simply a direct or inverse relationship.	A-1.71 Visibility depends on temperature, humidity, pollution, etc. PIO-2, 5; CCO-10, 11

B. Synoptic weather data

B-1 Synoptic analysis

B-1 *What airmass characteristics can be determined from synoptic observations?* **VII-B-1**

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
B-1.1 Airmass characteristics	B-1.11 Airmasses are identified on the basis of pressure, moisture, and temperature characteristics.	PIO-2, 3, 5; CCO-7, 10, 11
	B-1.12 Within an airmass, at any given altitude, the air temperature field and the humidity field are nearly uniform.	PIO-2, 3, 5; CCO-7, 11
	B-1.13 In a low pressure airmass (cyclone) circulation is counterclockwise and toward the center in the northern hemisphere.	PIO-3, 5; CCO-11, 12
	B-1.14 In a high pressure airmass (anticyclone), circulation is clockwise and away from the center in the northern hemisphere.	PIO-3, 5; CCO-11, 12
	B-1.15 Precipitation is most probable near the interface (frontal surface) between airmasses of different temperatures.	PIO-2, 3, 5; CCO-4, 6, 8, 11, 12
	B-1.16 Atmospheric conditions are usually unstable in the vicinity of the interfaces.	PIO-2, 3, 5; CCO-4, 6, 8, 11, 12
B-1.2 Airmass source regions	B-1.21 Airmasses have definite characteristics which depend upon the geographic region of origin.	PIO-5
B-1.3 Airmass tracks	B-1.31 Airmass tracks and rates of movement can be determined and usually predicted.	PIO-1, 2, 5; CCO-8, 11, 12

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
C. Atmospheric energy exchanges		
C-1 Input of moisture and energy	**C-1 *How does the atmosphere acquire moisture and energy?***	**VII-C-1**
C-1.1 Evaporation and transpiration	C-1.11 Moisture enters the air by means of transpiration and by evaporation.	PIO-2, 5; CCO-1, 4, 9, 11
	C-1.12 The ocean is the primary source of moisture for the atmosphere.	CCO-1, 6
	C-1.13 Energy is required to cause evaporation and transpiration.	PIO-1, 2, 5; CCO-1, 4, 9, 11
	C-1.14 Evaporation and transpiration constitute an energy input to the atmosphere in the form of more energetic water molecules.	C-1.14 Refer to topic V and topic VI. CCO-1, 4, 5, 6, 9, 11, 12
C-1.2 Vapor pressure	C-1.21 The vapor pressure (moisture content) of the air increases at the air-water interface.	PIO-2, 5; CCO-1, 4, 8, 9, 11'
	C-1.22 The rate of evaporation decreases as the vapor pressure of the air at the interface increases.	PIO-2, 5; CCO-1, 4
	C-1.23 The rate of evaporation at a given location depends on surface area, the energy available, and the moisture content of the atmosphere.	C-1.23 Relate to topic VI. PIO-5; CCO-1, 4, 6, 8, 9, 11, 12
C-1.3 Saturation vapor pressure	C-1.31 A state of dynamic equilibrium exists when saturation vapor pressure is reached.	PIO-2, 5; CCO-1, 4, 9, 11, 12
	C-1.32 Saturation vapor pressure varies directly with air temperature.	PIO-5; CCO-1, 4, 9, 11, 12
C-1.4 Other input energy	C-1.41 The atmosphere acquires energy by radiation and conduction from the earth's surface, and radiation from the sun.	C-1.41 Relate to topic V and topic VI. PIO-3, 5; CCO-1, 3, 11, 12
	C-1.42 The rate of energy input is related to variables such as moisture and carbon dioxide content.	CCO-1, 4, 6, 8, 11, 12
	C-1.43 The atmosphere acquires energy by mechanical means such as frictional drag.	CCO-1, 4, 6, 9, 11, 12
C-2 Moisture and energy transfer	**C-2 *How are moisture and energy transferred in the atmosphere?***	**VII-C-2**
C-2.1 Density differences	C-2.11 The density of air decreases with increased moisture content.	PIO-2, 5; CCO-6, 9, 11, 12
	C-2.12 The density of air decreases with increased air temperature.	PIO-2, 5; CCO-6, 9, 11, 12
	C-2.13 Convection cells are caused by density differences and the effect of the gravity field.	C-2.13 This concept can be related to convection in the atmosphere, ocean, and mantle. PIO-5; CCO-1, 5, 6, 9, 12
	C-2.14 Atmospheric convection is affected by variations in insolation.	C-2.14 Refer to topic V and topic IV. PIO-5; CCO-1, 3, 4, 5, 6, 11, 12
	C-2.15 The movement of air is from regions of divergence to regions of convergence.	PIO-5; CCO-1, 4, 5, 9, 11

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
C-2.2 Wind speed and direction	C-2.21 Air moves from high pressure to low pressure.	PIO-5; CCO-1, 4, 6, 8, 9, 11
	C-2.22 Wind direction is modified by the earth's rotation.	PIO-5; CCO-1, 4
	C-2.23 Wind speed is directly related to the pressure field gradient.	PIO-5; CCO-1, 4
C-2.3 Adiabatic changes	C-2.31 Rising or descending air changes temperature by an adiabatic process.	PIO-5; CCO-1, 4, 5, 9, 11
C-3 Release of moisture and energy within the atmosphere	***C-3 How are moisture and energy released within the atmosphere?***	**VII-C-3**
C-3.1 Condensation and sublimation	C-3.11 Condensation can occur when air is saturated and a condensation surface is available.	PIO-2, 5; CCO-1, 8, 9, 11
	C-3.12 When water vapor condenses, a significant amount of heat energy is released.	C-3.12 Refer to topic V. PIO-2, 5; CCO-1, 8, 9, 11
	C-3.13 At temperatures below 0°C.,water vapor changes directly to ice.	CCO-1, 8, 9, 11
C-3.2 Cloud formation	C-3.21 Clouds are formed from condensed moisture or from ice crystals.	PIO-5; CCO-1, 6, 7, 8, 9, 11, 12
C-4 Release of moisture and energy from the atmosphere	***C-4 How are moisture and energy released from the atmosphere?***	**VII-C-4**
C-4.1 Precipitation	C-4.11 Precipitation results when condensation droplets form that are large enough to fall.	PIO-5; CCO-1, 4, 6, 7, 8, 9, 11, 12
C-4.2 Wind-water interaction	C-4.21 Surface ocean currents are an effect of a transfer of energy from the atmosphere by winds.	C-4.21 The erosion aspect of winds is treated in topic IX. PIO-3, 5; CCO-1, 6, 11, 12

TOPIC VIII - MOISTURE AND ENERGY BUDGETS
AND ENVIRONMENT CHANGE

What Happens to Water and Energy Released From the Atmosphere?

Time Emphasis: 11 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Measure and describe the nature and movement of water in and on various earth materials.
B. Analyze and relate aspects of the water budget to the environment.
C. Determine, from his analysis of the factors which affect climate, the climate patterns for a continental land mass.

Approach

This topic is essentially a transition from the water cycle and energy budgets, treated earlier, to the rock cycle processes, which will be treated later. Relationships between water movement and aspects of water pollution should be reinforced within this topic.

An analytical approach to climates should be used. The means of identification of climate regions should evolve from water budget analysis. The point should be stressed that climate zones are the results of the combined effect of the environmental factors identified in earlier topics.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Earth's water		
A-1 Ground water	**A-1 *How does water move into the earth?***	**VIII-A-1**
A-1.1 Infiltration	A-1.11 Precipitation may infiltrate the earth's surface, run off, or evaporate.	CCO-5
	A-1.12 Infiltration can occur if the surface is permeable and unsaturated.	PIO-1, 2, 3, 4, 5
A-1.2 Permeability	A-1.21 The permeability of loose material increases with increased particle size.	PIO-1, 2, 3, 4, 5; CCO-11
	A-1.22 Water that has infiltrated loose material continues downward to the saturated zone or water table.	CCO-4
A-1.3 Porosity	A-1.31 The porosity of loose material is largely dependent upon shape, packing, and the mixture of sizes of the particles.	PIO-1, 2, 3, 4, 5; CCO-11
A-1.4 Capillarity	A-1.41 Capillarity in loose materials increases with decreased particle size.	PIO-1, 2, 3, 4, 5; CCO-11

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A-2 Surface water	***A-2 How does water move on the surface of the earth?***	**VIII-A-2**
A-2.1 Runoff	A-2.11 Surface runoff can occur when rainfall exceeds the permeability rate, when the pore space is filled, or when the slope of the surface is too great to allow infiltration to occur.	A-2.11 Relate to topic IX. PIO-3; CCO-2, 4
A-3 Pollution of the earth's water	***A-3 What is man's effect on the earth's water?***	**VIII-A-3**
A-3.1 Sources of pollutants	A-3.11 Pollutants are often added to the hydrosphere through the activities of individuals, communities, and industrial processes.	A-3.11 Analyze local conditions. Local conditions that may be considered include pollution of the oceans, rivers, and the ground water supply. Relate to topic VII, A-1.6; CCO-6, 8, 9
A-3.2 Types of pollutants	A-3.21 Hydrospheric pollutants include dissolved and suspended materials such as organic and inorganic wastes, thermal energy effluent from industrial processes, radioactive substances, and the abnormal concentration of various organisms.	A-3.21 Relate to local area. CCO-8, 9
	A-3.22 The excessive heating of water, or the increased activity of aerobic bacteria, can cause a loss of dissolved oxygen from the water. This may lead to an increase in the concentration of anaerobic bacteria, a biologic pollutant.	CCO-8, 9
A-3.3 Concentration of pollutants	A-3.31 The concentration of water pollutants in rivers increases in the vicinity of population centers.	A-3.31 Relate to stream discharge. CCO-6
	A-3.32 Lake pollution tends to vary with the population density near the lake.	CCO-6
	A-3.33 Ground water pollution within a community tends to vary directly with the population density.	CCO-6
A-3.4 Long-range effects	A-3.41 The uncontrolled increase of pollution in the hydrosphere may eventually render the sources of water unfit for human use.	CCO-6, 8
	A-3.42 The purification of water for human use is complex and costly.	CCO-6
B. The local water budget		
B-1 Water budget variables	***B-1 How is the water budget influenced by the environment?***	**VIII-B-1**
B-1.1 Precipitation (P)	B-1.11 The moisture source for the local water budget is precipitation (P).	PIO-3, 5

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
B-1.2 Potential evapotranspiration (E_p)	B-1.21 The potential evapotranspiration (E_p) of an area is directly proportional to the energy available or the amount of evaporation surface.	CCO-3, 4, 8
B-1.3 Moisture storage	B-1.31 A specific maximum quantity of moisture can be stored in a soil under optimum conditions.	PIO-2; CCO-9, 10
B-1.4 Moisture utilization	B-1.41 Available moisture is taken from soil storage if precipitation is less than potential evapotranspiration ($P<E_p$).	CCO-1, 3
B-1.5 Moisture deficit	B-1.51 Moisture deficit exists when soil moisture is depleted and P is less than E_p.	CCO-3, 5, 9
B-1.6 Moisture recharge	B-1.61 Soil moisture is recharged when precipitation exceeds potential evapotranspiration, $P>E_p$.	CCO-3, 5, 9
B-1.7 Moisture surplus	B-1.71 Surplus moisture exists when soil moisture storage is maximum and precipitation is greater than potential evapotranspiration.	CCO-3, 5, 9
B-2 Streams	***B-2 How is the local water budget related to stream discharge?***	**VIII-B-2**
B-2.1 Stream discharge and the water budget	B-2.11 Stream discharge is a measure of the loss of available surface water through runoff. B-2.12 The stream discharge during a dry season is related to ground water depletion.	B-2.11 Stream characteristics relative to erosion are treated in topic IX. PIO-5; CCO-6 PIO-5; CCO-6
B-3 Climates and the local water budget	***B-3 How is the local water budget related to climate?***	**VIII-B-3**
B-3.1 Climatic regions	B-3.11 Climatic regions can be distinguished quantitatively by factors such as P/E_p or $P - E_p$.	CCO-7
C. Climate pattern factors		
C-1 Factors	***C-1 What factors affect climate patterns?***	**VIII-C-1**
C-1.1 Latitude	C-1.11 Latitude is a factor which influences temperature patterns.	C-1.11 Relate to topic VI. CCO-3, 5
C-1.2 Elevation	C-1.21 The elevation (height above sea level) influences temperature and moisture patterns.	CCO-6

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
C-1.3 Large bodies of water and ocean currents	C-1.31 Large bodies of water modify the latitudinal climate patterns of their shoreline areas. C-1.32 Ocean currents modify the coastal climate patterns.	C-1.31 Relate to topic VI and topic VII. CCO-1, 4 CCO-1, 4
C-1.4 Mountain barriers	C-1.41 Mountains, acting as barriers to circulation, modify the latitudinal climate pattern.	CCO-1, 4
C-1.5 Wind belts	C-1.51 Moisture and temperature patterns are affected by planetary wind and pressure belts.	C-1.51 Relate to topic VI. CCO-4, 5
C-1.6 Storm tracks	C-1.61 Low pressure systems, which affect temperature and moisture patterns, seem to follow statistically predictable paths.	CCO-4, 5

AREA 4

THE ROCK CYCLE

AREA TIME EMPHASIS	TOPIC	TITLE	TIME
37 DAYS	IX	The Erosional Process	6 days
	X	The Depositional Process	6 days
	XI	The Formation of Rocks	12 days
	XII	The Dynamic Crust	13 days

TOPIC IX - THE EROSIONAL PROCESS

How Is the Earth's Crust Affected by Its Environment?

Time Emphasis: 6 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Analyze and measure earth materials to obtain evidence of weathering.
B. Analyze and measure earth materials to obtain evidence of erosion, and draw inferences from observations about the factors which affect erosion.

Approach

Consideration of the weathering process should provide a bridge from climate and climate factors, which were dealt with in topic VIII, to the effects of the environment on the earth's crust, which will be dealt with in this topic and in topic X.

Erosion of rock materials should be approached through the concept of a transporting *system* to dramatize the complex nature of the erosion process in nature. It should be stressed that a "system" includes the agent or agents, the "driving" forces, and the material transported. The interrelationships between erosion and deposition are treated at the end of topic X after the basic factors affecting them have been developed.

It may be desirable to have students investigate the characteristics of a local stream (erosion system) if one is readily accessible.

Landscape features produced by erosional systems are considered in topic XIV.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Weathering		
A-1 Evidence of weathering	**A-1 *What is some evidence that earth materials weather?***	**IX-A-1**
A-1.1 Weathering processes	A-1.11 Weathering occurs when rocks are exposed to the hydrosphere and the atmosphere.	CCO-1, 4, 6, 7, 12
	A-1.12 The weathering process involves the physical and chemical breakdown of material.	PIO-3, CCO-1, 2, 4, 6, 7
	A-1.13 The weathering process is affected by climatic conditions.	CCO-3, 4, 6, 7
A-1.2 Weathering rates	A-1.21 The weathering rate of rock material varies inversely with the particle size.	PIO-1, 3; CCO-1, 2, 4, 6, 7
	A-1.22 Rock particles weather at different rates depending on mineral composition.	CCO-1, 2, 4, 6, 7

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A-1.3 Soil formation	A-1.31 Soil horizons develop as a result of weathering processes and biologic activity.	A-1.31 Emphasis should be placed on how soils develop rather than on types of soils and their names. PIO-3; CCO-4, 6, 7, 9, 12
	A-1.32 The complex interrelationships of living organisms are significant factors in soil formation.	CCO-6, 7
A-1.4 Soil solution	A-1.41 The end product of weathering is a solution of ionic material, the minerals present in all surface and ground water.	A-1.41 Relate to topic VIII; CCO-1, 2, 4, 6, 7
B. Erosion		
B-1 Evidence of erosion	***B-1 What evidence suggests that rock materials are transported?***	***IX-B-1***
B-1.1 Displaced sediments		B-1.1 A field trip, or observation from a previous field trip, can be used to examine evidences of erosion. Slides or aerial photographs may also be used.
	B-1.11 Sediments displaced from their source are evidence of erosion.	PIO-2; CCO-4, 10, 11, 12
	B-1.12 Transported material is far more common than residual material.	CCO-12
B-1.2 Properties of transported materials	B-1.21 Transported materials may possess distinctive properties indicative of the transporting medium.	CCO-1, 2, 4, 7, 12
B-2 Factors affecting transportation	***B-2 How does the transportation of rock materials take place?***	***IX-B-2***
B-2.1 Gravity	B-2.11 Gravity is the primary force which motivates all transporting systems.	CCO-4
	B-2.12 Gravity may act alone in transporting earth materials.	CCO-4
B-2.2 Water erosion		B-2.2 Comparisons between model streams and streams in nature should be treated cautiously. Usually more than one factor is changing and they are not of equal importance.
	B-2.21 For a given portion of a stream channel, an increase in the discharge increases the average velocity of water.	PIO-1, 2, 3, 4; CCO-1 2, 4, 6

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
	B-2.22 For a given stream channel shape, an increase in slope tends to increase the velocity of the water.	PIO-1, 2, 3, 5; CCO-1, 2, 4, 6
	B-2.23 The size of the particle that can be transported increases as water velocity increases.	CCO-4, 6
	B-2.24 The position of maximum velocity in a stream cross section varies with changes in the direction of the stream flow.	CCO-1, 2, 4, 6, 7
	B-2.25 Streams carry material by solution, by suspension, and by rolling materials along their beds.	CCO-1, 2, 4, 6, 7
B-2.3 Wind and ice erosion	B-2.31 Wind and ice may act as transporting agents of rock materials.	CCO-1, 2, 4, 6
	B-2.32 The factors affecting wind erosion and ice erosion are similar to the factors affecting erosion by running water.	CCO-1, 2, 4, 6, 11, 12
B-2.4 Effect of erosional agents	B-2.41 Each agent of erosion produces distinctive changes in the material that it transports.	B-2.41 Students should be given the opportunity to examine and compare materials transported by wind, water, and ice. CCO-1, 2, 7, 11, 12
B-2.5 Effect of man	B-2.51 Man adds to the erosion of the land through activities of the individual and his societies.	B-2.51 Relate to topic XIV. CCO-7
B-2.6 Predominant agent	B-2.61 Running water is the predominant agent of erosion on the earth.	PIO-3; CCO-7, 12

How Does Sedimentation Occur?

Time Emphasis: 6 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Analyze and measure the deposition of particles in a medium, and draw inferences about the process.

B. Analyze patterns of erosion and deposition by a medium, and draw inferences about the characteristics of the system.

Approach

The basic factors affecting deposition of particles are considered here. Deposition of materials from solution will be treated in topic XI. The final section of this topic involves the analysis of an erosion-deposition system.

In later topics, the student will examine past evidence of erosion and deposition. From this evidence, he will be expected to draw inferences about the environment at the time erosion and deposition were taking place.

In topic XIV, the erosion-deposition system will be considered in connection with landscape development.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Deposition		
A-1 Factors	**A-1 *What factors affect the deposition of particles in a medium?***	**X-A-1**
A-1.1 Size	A-1.11 Other factors being equal, smaller particles settle more slowly than larger particles.	A-1.11 Develop a simplified model of deposition which can be related to the more common and more complex case of deposition in a moving medium. PIO-2, 3, 5; CCO-9, 11
	A-1.12 Particles of colloidal size and smaller may remain suspended indefinitely.	PIO-2, 3, 5; CCO-9, 11
	A-1.13 When a mixture of sediment sizes settles in a quiet medium (water or air), sorting into horizontal layers takes place.	PIO-3, 5; CCO-8, 9, 11
A-1.2 Shape	A-1.21 Other factors being equal, the shape of a particle may determine its settling rate.	PIO-2, 3, 5; CCO-9, 11

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A-1.3 Density	A-1.31 Other factors being equal, high density particles settle faster than low density particles.	PIO-2, 3, 5; CCO-9, 11
A-1.4 Velocity	A-1.41 As the velocity of a sediment laden flow decreases, the particles of greater weight and density settle out first.	A-1.41 PIO-2, 3, 5; CCO-9, 11
	A-1.42 Decreasing velocity produces horizontal sorting. Smaller particles are usually carried farther.	A-1.42 Relate to topic XIII. PIO-2, 3, 5; CCO-9, 11
	A-1.43 The velocity of particles in a moving medium is not necessarily the same as the velocity of the fluid.	A-1.43 PIO-2, 3, 5; CCO-9, 11
	A-1.44 Sorting in a quiet, solid medium, such as ice, is more complex than in a fluid medium.	PIO-3, 5; CCO-0, 11, 12
B. Erosional-depositional system		
B-1 Characteristics	***B-1 What are some characteristics of an erosional-depositional system?***	**X-B-1**
B-1.1 Erosional-depositional change	B-1.11 The erosional and depositional processes produce characteristic changes which can be observed.	B-1.11 Relate to topic XIV PIO-3, 5, CCO-4, 7, 8, 9, 11
B-1.2 Dominant process	B-1.21 Either erosion or deposition may be dominant depending on the condition at a particular location.	
B-1.3 Erosional-depositional interface	B-1.31 An interface between erosion and deposition can often be located.	B-1.31 Relate to topic XIV PIO-3, 5; CCO-1, 4, 8, 9, 11
B-1.4 Dynamic equilibrium	B-1.41 A state of dynamic equilibrium exists within the system in which the erosional and depositional rates are equal.	PIO-3, 5; CCO-1, 4, 9
B-1.5 Energy relationships	B-1.51 The erosion phase of the erosional-depositional system results from a transfer from potential to kinetic energy.	PIO-3, 5; CCO-1, 2, 4, 6
	B-1.52 The depositional phase of the erosional-depositional system results from a loss of energy.	PIO-3, 5; CCO-1, 2, 4 6
	B-1.53 Energy transformations between potential and kinetic energy may occur in an erosional-depositional system.	PIO-3, 5; CCO-1, 2, 4
	B-1.54 In an erosional-depositional system, the total energy within the system is decreasing.	PIO-3, 5; CCO-1, 2, 4

TOPIC XI - THE FORMATION OF ROCKS

How Are Rocks Formed?

Time Emphasis: 12 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Analyze rocks and sediments, and compare their characteristics to determine the degree of similarity.
B. Analyze rocks to determine their composition, and identify the characteristics of minerals.
C. Devise models for the formation of sedimentary and nonsedimentary rocks.
D. Construct a model from available evidence that illustrates the cyclic nature of rock-forming processes.

Approach

Previous topics have dealt with the processes of weathering, erosion, and deposition. In this topic, rock-forming processes should be considered in detail.

Students should investigate the characteristics of rocks which should enable them to infer a model for rock formation. Minerals should be studied as indicators of the rock-forming processes.

Rock properties will be used as indicators of large scale change in Topic XII. With the assumption made that most changes are cyclic, the attention in this topic should be directed toward the evidence that suggests cyclic processes of rock formation.

Care should be taken to develop understanding of the relationships between the inferred rock-forming processes that leads to the concept of the rock cycle.

When considering the rock-forming processes, it is important that the student distinguish inferences from facts.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Rocks and sediments		
A-1 Comparative properties	**A-1 *What similarities do rocks have with sediments?***	**XI-A-1**
A-1.1 Similarities	A-1.11 Some rocks have properties such as discrete layers, fragmental particles, organic composition, a range of particle size, or a predominance of one particle size which strongly resembles sediments.	Relate to topic X PIO-5; CCO-4, 6, 7, 9, 10
A-1.2 Differences	A-1.21 Some rocks have properties such as crystalline structure, banding, distortion of structure, and crystal alignment. These do not resemble sediments.	PIO-5; CCO-4, 6, 7, 9, 10

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
B. Minerals		
B-1 Relation to rocks	***B-1 What is the composition of rock?***	**XI-B-1**
B-1.1 Composition	B-1.11 Rocks are composed of minerals.	CCO-10, 11
	B-1.12 Some rocks are monomineralllic; others are polymineralllic.	CCO-10, 11
	B-1.13 Most rocks have a number of minerals in common.	CCO-10, 11
B-2 Characteristics	***B-2 What are some characteristics of minerals ?***	**XI-B-2**
B-2.1 Physical, hemical properties	B-2.11 Minerals are identified on the basis of well-defined physical and chemical properties.	CCO-10
B-2.2 Chemical composition	B-2.21 Of the many naturally occurring elements, only a few comprise most minerals.	PIO-3; CCO-4,6, 7
	B-2.22 Of the elements comprising most minerals, oxygen is the most abundant by weight and volume. Silicon is the second most abundant by weight.	CCO-10, 11, 12
B-2.3 Structure	B-2.31 The elements oxygen and silicon unite to form a tetrahedral unit.	PIO-3; CCO-11, 12
	B-2.32 The physical properties of minerals can be described as a function of the arrangements of their constituents' units.	PIO-3; CCO-7, 12
C. Rock formation		
C-1 Sedimentary rocks	***C-1 How are sedimentary rocks formed?***	**XI-C-1**
C-1.1 Compression cementation	C-1.11 Some sedimentary rocks form as a result of sediments undergoing compression and/or cementation.	PIO-3, 5; CCO-9
C-1.2 Chemical processes	C-1.21 Some sedimentary rocks form as a result of chemical processes such as evaporation and precipitation.	PIO-3, 5; CCO-9
C-1.3 Biological processes	C-1.31 Some sedimentary rocks form as a result of biologic processes.	PIO-3, 5; CCO-9
C-2 Nonsedimentary rocks	***C-2 How are nonsedimentary rocks formed?***	**XI-C-2**
C-2.1 Solidification process	C-2.11 Some nonsedimentary rocks form as a result of solidification of molten material.	PIO-3, 5; CCO-9
	C-2.12 Crystal sizes seem to vary as a function of time, temperature, and pressure.	PIO-3, 5; CCO-9
C-2.2 Recrystallization process	C-2.21 Some nonsedimentary rocks form as a result of the recrystallization of unmelted material under high temperature and pressure.	PIO-3, 5; CCO-9

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
C-3 Environment of formation	***C-3 What is the environment in which a rock forms?***	**XI-C-3**
C-3.1 Inferred characteristics	C-3.11 The environment in which a rock formed is often inferred from compositional, structural, and textural characteristics.	PIO-5; CCO-7, 9, 12
C-3.2 Distribution	C-3.21 Sedimentary rocks are usually found as a thin veneer over large areas of continents. C-3.22 Nonsedimentary rocks, at or near the surface, are most frequently found in regions of volcanoes or mountains.	PIO-1, 3, 5
D. Rock cycle		
D-1 Evidence	***D-1 What evidence suggests a cyclic model of rock formation?***	**XI-D-1**
D-1.1 Transition zones	D-1.11 Transition zones from unaltered to altered rock can be found where molten material has come in contact with the local rock.	PIO-5; CCO-6, 7, 8, 9, 12
D-1.2 Rock composition	D-1.21 The composition of some sedimentary rock suggests that the components had varied origins. D-1.22 The composition of some rocks suggests that the materials have undergone multiple transformations.	Relate to topic X. PIO-5; CCO-6, 7, 8, 9, 12

How Are Changes in the Earth's Crust Produced?

TOPIC ABSTRACT

Time Emphasis: 13 days

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Identify evidence of crustal changes from his observations of the earth's crust.
B. Describe the properties of earthquake waves;and from an analysis of seismic data, locate the epicenter and determine time of occurrence of an earthquake.
C. Construct inferences about the structure and composition of the earth's crust and interior from available evidence.
D. Construct inferences about the processes which may cause crustal change from the available evidence.

Approach

In this topic, the student should be provided with an opportunity to examine evidence that suggests a dynamic lithosphere. Much of the evidence examined is indirect and incomplete. *Care should be taken so that students do not mistake inferences for facts.*

While topic XII focuses on large scale crustal changes, the interpretations of local changes, past and present, are considered in later topics.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Evidence for crustal movement		
A-1 Minor crustal changes	***A 1 What evidence suggests minor changes in the earth's crust?***	**XII-A-1**
A-1.1 Deformed rock strata	A-1.11 Folded and tilted rock strata and faults suggest past crustal movements.	A-1.1 A series of slides or photographs may be used to illustrate deformed crustal material. PIO-3, 5; CCO-1, 4, 6, 8
A-1.2 Displaced fossils	A-1.21 Marine fossils found at high elevations above sea level suggest past uplift.	PIO-3, 5; CCO-1, 4, 6, 8, 12
	A-1.22 Shallow water fossils found at great ocean depths suggest past subsidence.	PIO-3, 5; CCO-1, 4, 6, 8, 12
A-1.3 Displaced strata	A-1.31 Displacement of strata, which may accompany earthquakes, provides direct evidence of crustal movement.	PIO-3, 5; CCO-1, 4, 6, 8, 12

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A-2 Major crustal changes	***A-2 What evidence suggests major changes in the earth's crust?***	**XII-A-2**
A-2.1 Zones of crustal activity	A-2.11 Zones of frequent crustal activity can be located on the earth's surface.	A-2.11 Relate to D-1.11. PIO-3, 5; CCO-1, 4, 5, 6, 8, 12
A-2.2 Geosynclines	A-2.21 Great thicknesses of sediment that were deposited in shallow water are observed in some areas.	A-2.21 Relate to D-1.31. PIO-3, 5; CCO-1, 4, 5, 6, 8, 12
	A-2.22 Shallow basins of large (regional) area which may be slowly subsiding can be observed in some areas.	A-2.22 Relate to D-1.31. CCO-1, 4, 5, 6, 8, 12
A-2.3 Vertical movements	A-2.31 Tilted shorelines, changed bench mark elevations, and other related phenomena can be observed in some areas.	A-2.31 Relate to D-1.41. PIO-3, 5; CCO-1, 4, 5, 6, 8, 11, 12
A-2.4 Ocean floor spreading	A-2.41 Igneous material along the oceanic ridges is younger than the igneous material farther from the ridges.	A-2.41 Relate to D-1.21. PIO-3, 5; CCO-1, 4, 5, 6, 8, 11, 12
	A-2.42 Strips of igneous rock parallel to the ocean ridges show reversal of magnetic orientation.	A-2.42 Relate to D-1.21. PIO-3, 5; CCO-1, 4, 5, 6, 8, 11, 12
A-2.5 Continental drift	A-2.51 The present continents appear to fit together as fragments of an originally larger land mass.	A-2.51 Relate to D-1.21. PIO-3, 5; CCO-1, 4, 6, 8, 11, 12
	A-2.52 Correlation of rock, mineral, and fossil evidence between continents suggests that the land masses were joined at some time in the past.	A-2.52 Relate to D-1.21. PIO-3, 5; CCO-1, 4, 6, 8, 11, 12
A-2.6 Magnetic poles	A-2.61 Rocks have recorded the position of the earth's magnetic poles in vastly different locations.	A-2.61 Relate to D-1.21. PIO-3, 5; CCO-1, 5, 6, 8, 11, 12
Earthquakes		
B-1 Wave properties	***B-1 What are some properties of earthquake waves?***	**XII-B-1**
B-1.1 Types of waves	B-1.11 Earthquakes generate compressional and shear waves.	PIO-1, 5; CCO-1, 6, 11
B-1.2 Velocities	B-1.21 In the same medium, compressional waves travel at a velocity greater than shear waves.	PIO-1, 5; CCO-1, 11
	B-1.22 The velocities of seismic waves depend upon the physical properties of the materials through which the waves travel.	PIO-1, 5; CCO-1, 6, 11, 12
B-1.3 Transmission	B-1.31 Compressional waves are transmitted through solids and fluids.	PIO-5; CCO-1, 6, 11, 12
	B-1.32 Shear waves are transmitted only through solids.	PIO-5; CCO-1, 6, 11, 12

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
B-2 Location of an epicenter	***B-2 How can the epicenter of an earthquake be located?***	**XII-B-2**
B-2.1 Epicenter	B-2.11 Differences in travel times of seismic waves can be used to determine the distance to the epicenter.	PIO-1, 2, 4, 5; CCO-6, 11, 12
B-2.2 Origin time	B-2.21 The origin time can be inferred from the evidence of epicenter distance and travel time.	PIO-1, 2, 4, 5; CCO-6, 11, 12
C. Model of the earth's crust and interior		
C-1 Properties	***C-1 What are some properties of the earth's crust and interior?***	**XII-C-1**
C-1.1 Solid and liquid zones	C-1.11 Analysis of seismic data leads to the inference that solid zones (crust, mantle, inner core) and a liquid zone (outer core) exist within the earth.	C-1.11 The characteristics of seismic waves developed in the previous section may be used to construct a more detailed model of the earth's interior than is required. PIO-1, 5; CCO-6, 7, 11, 12
C-1.2 Crustal thickness	C-1.21 The average thickness of the continental crust is greater than the average thickness of the oceanic crust.	PIO-1, 5; CCO-11, 12
C-1.3 Crustal composition	C-1.31 The oceanic and continental crusts have different compositions.	C-1.31 Relate to topic XI. PIO-1, 5; CCO-11, 12
C-1.4 Density, temperature, and pressure	C-1.41 The density, temperature, and pressure of the earth's interior increase with depth.	C-1.41 Relate to topic III. PIO-1, 5; CCO-6, 7, 11, 12
C-1.5 Interior composition	C-1.51 The composition of some meteorites suggests an earth core composed of iron and nickel.	PIO-5; CCO-6, 7, 11, 12
	C-1.52 The compositions of the crust and core suggest a different composition for the mantle.	PIO-5; CCO-6, 7, 11, 12
D. Theories of crustal change		
D-1 Inferred processes	***D-1 What inferences can be drawn about the processes which may cause crustal changes?***	**XII-D-1**
D-1.1 Mantle convection cells	D-1.11 The occurrence of heat flow highs in areas of current mountain building, and heat flow lows in areas of shallow subsiding basins, suggests the existence of mantle convection cells.	PIO-3, 5; CCO-1, 4, 5, 6, 8, 12

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
D-1.2 Geosynclinal development	D-1.21 Continental growth and mountain building may be related to geosynclinal development.	PIO-3, 5; CCO-1, 4, 5, 6, 8, 12
D-1.3 Isostasy	D-1.31 Mountains of geosynclinal origin may in part be caused by isostatic adjustments of materials of different density.	PIO-3, 5; CCO-1, 4, 5, 6, 8, 12
D-1.4 Process relationships	D-1.41 The close correlation among zones of earthquake activity, volcanic activity, and mountain building suggests that these processes of crustal change are related.	PIO-3, 5; CCO-1, 4, 5, 6, 8, 12

AREA 5

THE HISTORY OF THE EARTH

AREA TIME EMPHASIS	TOPIC		TIME
30 DAYS	XIII	Interpreting Geologic History	15 days
	XIV	Landscape Development and Environmental Change	15 days

TOPIC XIII - INTERPRETING GEOLOGIC HISTORY

How Can Geologic History Be Interpreted?

Time Emphasis: 15 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Collect and analyze evidence of several geologic events in a field situation, and establish a chronological order.
B. Establish a correlation between different locations using rock and fossil evidence.
C. Determine the relative and/or absolute ages of rocks or geologic events from data such as fossil evidence, radioactive decay evidence, erosion, and deposition.
D. Draw inferences concerning ancient life from a study of the fossil record.

Approach

This topic explores some of the techniques that geologists use to interpret the geologic history recorded in the rocks. Most of the processes considered in topics IX, X, XI, and XII play an important role in the interpretation and should be reconsidered where appropriate.

The analysis, synthesis, and interpretation of geologic events is a form of puzzle solving, and the student can play the role of chief investigator or puzzle solver. Once some of the techniques are learned, he can enjoy working out a geologic history for a specific area.

Investigation of local geological features is strongly suggested during this topic. The use of specific field experiences can help make the interpretation of geologic history more realistic to the student. Seeing at firsthand is far superior to reading and talking about things in far-away places. Where field trips are impossible, slides, samples, and maps of the local geology can be substituted for the actual field trip experience.

The focus of this topic should be upon the process of making interpretations rather than upon the actual record. Particular events from the geologic past of New York State and other areas should be used as illustrations of interpretations that have been made.

In considering the geologic record, students should be left with the impression that the interpretations constitute probable events rather than indisputable facts.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Geologic events		
A-1 Sequence of geologic events	**A-1 *How can the order in which geologic events occurred be determined?***	**XIII-A-1**
A-1.1 Chronology of layers	A-1.11 The bottom layer of a series of sedimentary layers is the oldest, unless the series has been overturned or has had older rock thrust over it.	PIO-5; CCO-8, 12

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A-1.2 Igneous intrusions and extrusions	A-1.21 Rock layers are older than igneous intrusions which cut through them or igneous extrusions which are above them.	PIO-5; CCO-8, 12
A-1.3 Faults, joints, and folds	A-1.31 Rocks are older than faults, joints, or folds that appear in them.	PIO-5; CCO-8, 12
A-1.4 Internal characteristics	A-1.41 Fragments which occur within a rock are older than the rock.	PIO-5; CCO-5, 8, 12
	A-1.42 Cracks, veins, and mineral cement are younger than the rocks in which they occur.	PIO-5; CCO-8, 12
B. Correlation techniques		
B-1 Correlation	**B-1** ***How can rocks and geologic events in one place be matched to another?***	**XIII-B-1**
B-1.1 Continuity	B-1.11 Rock layers can often be traced from one location to another directly by "walking the outcrop."	CCO-10, 12
B-1.2 Similarity of rock	B-1.21 Rocks can often be tentatively matched on the basis of similarity in appearance, color, and composition.	B-1.21 It is important in this section to carefully distinguish *evidence* from *inference*. PIO-5; CCO-6, 8, 10, 12
B-1.3 Fossil evidence	B-1.31 Fossils are found almost exclusively in sedimentary rocks.	CCO-6, 7, 8
	B-1.32 Fossils provide clues to the environments in which the organisms lived.	CCO-6, 7, 8, 12
	B-1.33 Fossils which occurred widely but only within a particular formation can be used to correlate sedimentary rocks.	PIO-5; CCO-6, 8, 10, 12
B-1.4 Volcanic time markers	B-1.41 Because of their rapid deposition over a large area, layers of volcanic ash occurring between other layers may serve as time markers.	PIO-5; CCO-6, 7, 9, 10, 12
B-1.5 Anomalies to correlation	B-1.51 Careful study may show that two similar rock formations may be of different ages. A single formation may actually be older in some places than in others.	B-1.5 The interpretation of geologic history can be *oversimplified*, leading to misconception. Cautious interpretation can minimize this problem.

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
C. Determining geologic ages		
C-1 Rock record	***C-1 What does the rock record suggest about geologic history?***	**XIII-C-1**
C-1.1 Fossil evidence	C-1.11 Events in geologic history can often be placed in order according to relative age by using evidence provided by certain fossils.	PIO-3, 5; CCO-8, 12
C-1.2 Scale of geologic time	C-1.21 Geologists have subdivided geologic time into units, based on fossil evidence.	C-1.21 For further subdivisions see the geologic time scale in the Reference Tables. PIO-5
	C-1.22 Most of the geologic past is devoid of a fossil record.	PIO-5; CCO-6, 8, 10
	C-1.23 Man's existence is infinitesimal in comparison with geologic time.	C-1.23 A major intent in this section is to help the student develop a model through which he can gain some comprehension of the scale of geologic time. PIO-1, 3
C-1.3 Erosional record	C-1.31 Buried erosion surfaces indicate gaps in the time record. The gaps represent periods of destruction of the geologic record.	PIO-5; CCO-7, 8, 12
C-1.4 Geologic history of an area	C-1.41 The geologic history of an area can be inferred from the evidence of former influence by a variety of processes.	C-1.41 The geologic map of New York State and the geologic time scale that appear in the reference tables may be used to illustrate the various portions of the rock record that have been preserved in New York State. PIO-1, 2, 3, 5; CCO-5, 6, 7, 8, 9, 10, 11, 12
C-2 Radioactive decay	***C-2 How can geologic ages be measured by using radioactive decay?***	**XIII-C-2**
C-2.1 Decay rates		C-2.1 Models are used extensively to implement this section. Students should be cautioned to interpret the models with care so that misapplication of the concept is avoided.
	C-2.11 Some rocks contain atoms whose nuclei undergo radioactive decay.	PIO-3, 4, 5; CCO-1, 2, 4, 7, 11
	C-2.12 The disintegration of an individual atom occurs as a random event.	PIO-3, 5; CCO-7, 10, 11, 12

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
	C-2.13 The disintegration of a radioactive substance occurs at a predictable rate.	CCO-7, 11, 12
	C-2.14 The disintegration rate is unaffected by external factors.	CCO-6
C-2.2 Half-lives	C-2.21 The half-lives are different for different radioactive substances.	CCO-7, 12
	C-2.22 Radioactive substances with short half-lives, such as C^{14}, are good for dating recent organic remains. Those with longer half-lives, such as U^{238}, are useful for dating older remains.	
C-2.3 Decay product ratios	C-2.31 The age of a rock can often be inferred from the relative amounts of the undecayed substance and the decay product.	PIO-1, 3, 4; CCO-2, 6, 7, 11, 12
D. The fossil record		
D-1 Ancient life	**D-1 *What does the fossil record suggest about ancient life?***	**XIII-D-1**
D-1.1 Variety of life forms	D-1.11 Fossils give evidence that a great many kinds of animals and plants have lived on earth in the past under a great variety of environmental conditions and that most of them have become extinct.	CCO-6, 8, 9, 12
	D-1.12 In addition to the fossil types which have been found, it is highly probable that an even greater number have left no traces in the rocks.	CCO-6, 8, 9, 12
D-1.2 Evolutionary development	D-1.21 Variations within a species can be observed, measured, and described.	PIO-1, 2, 4, 5
	D-1.22 It has been theorized that the variations within a species may provide some members with a higher probability of survival.	PIO-5; CCO-6, 8, 9, 12
	D-1.23 The similarity among some fossil forms of various time periods suggests a transition which may be a result of evolutionary development.	PIO-1, 2, 4, 5; CCO-6, 11

What Causes Landscapes?

Time Emphasis: 15 days

TOPIC ABSTRACT

Major Behavioral Objectives

At the completion of this topic, the student should be able to:

A. Identify and measure various local landscape characteristics.
B. Develop inferences from observations of various landscapes, local and remote, about the influence of the environment on landscape development.

Approach

Environmental analysis should be stressed in this topic. The concept of landscapes as indicators of the interaction of crustal forces, climate, and man should be carefully developed and extensively explored. Students should become *actively* involved in the interpretation of landscapes and environmental changes from firsthand field experiences.

The use of a specific field experience with field trips to appropriate locations is very desirable. Slides, maps, or photographs may be used to provide secondhand experiences in situations where the firsthand experience is not possible or needs supplementation.

The interdisciplinary nature of man's influence in producing environmental change may suggest a coordinated approach by the social studies and science departments.

The student should complete this topic, and the course, with a questioning attitude and some plausible ideas about the formation of *any* landscape and the influence of various factors on *his* environment.

The material in this topic may be related to several other topics as indicated in the Information to Teachers column.

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TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
A. Landscape characteristics		
A-1 Quantitative observations	**A-1 *What are some landscape characteristics that can be observed and measured?***	**XIV-A-1**
A-1.1 Hillslopes	A-1.11 Hillslopes with distinctive shapes can be identified and measured.	PIO-1, 2, 5; CCO-11
A-1.2 Stream patterns	A-1.21 Stream patterns which have measurable characteristics can be identified.	A-1.21 Relate to topic IX. PIO-1, 2, 5; CCO-11
A-1.3 Soil associations	A-1.31 Various soil associations can be identified and some of their characteristics can be measured.	A-1.31 Relate to topic IX. PIO-1, 2, 5; CCO-11

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
	B-1.34 Structural features in bedrock, such as faults, folds, and joints, frequently affect the development of hillslopes.	Relate to topic XII. PIO-5; CCO-7, 11, 12
	B-1.35 Stream characteristics are controlled by bedrock characteristics.	B-1.35 Relate to topic IX. PIO-2, 5; CCO-4, 6, 7, 11, 12
	B-1.36 Soil associations may differ in composition and are dependent upon the bedrock composition.	B-1.36 Relate to topic IX. PIO-5; CCO-4, 6, 7, 11, 12
B-1.4 Time	B-1.41 The duration of time during which environmental factors have been active will determine the stage of development or condition of a landscape region.	B-1.41 Relate to topics VIII, IX, X, and XIII. PIO-3, 5; CCO-6, 10, 11, 12
B-1.5 Dynamic equilibrium	B-1.51 A delicate balance of multiple environmental factors exists in all landscapes. A change in any of the factors results in a modification of the landscape and the establishment of a new equilibrium.	PIO-3, 5; CCO-1, 4, 5, 6, 7, 9, 11, 11, 12
B-1.6 Man		B-1.6 Activities or watches begun earlier on pollution may be summarized at this point.
	B-1.61 The activities of man have altered the landscapes in many areas.	PIO-5; CCO-6, 7, 8, 9, 11, 12
	B-1.62 The human population on the earth is increasing at an exponential rate.	B-1.62 The present doubling time is approximately 37 years. PIO-3, 5.
	B-1.63 Landscape pollution or misuse of the landscape is more critical to man in areas of high population density.	PIO-5; CCO-6, 8, 9, 12
	B-1.64 Man, with advanced technology, can inflict rapid changes on his environment that may produce catastrophic events as the environment adjusts to the stress.	CCO-6.
	B-1.65 Man's addition of pollutants to the atmosphere alters the rate of energy absorption and radiation which may result in a landscape-modifying climate change.	B-1.65 Relate to topics II, VII, and VIII. PIO-1, 2, 3, 5; CCO-4, 6, 7, 8, 9, 11, 12
	B-1.66 Resources, such as soil for agriculture, land for homesites, pure water for consumption and recreation, and clean air for biologic survival, can be conserved by careful planning and by the control of environmental pollutants.	B-1.66 Relate to topic II, VIII, and IX PIO-3, 5; CCO-1, 2, 4, 5, 6, 7
	B-1.67 Environmental conservation and planning programs may result in: a) elimination of landscape pollution and denudation b) reclamation of landscapes that have been misused	CCO-8
	B-1.68 Development of environmental conservation programs depends upon the awareness, attitudes, and action of the people.	CCO-12

TOPIC OUTLINE	MAJOR UNDERSTANDINGS	INFORMATION TO TEACHERS
Relationship of characteristics	**A-2** ***How are landscape characteristics related?***	**XIV-A-2**
A-2.1 Landscape regions	A-2.11 Sets of landscape characteristics seem to occur together, identifying distinctive landscape regions.	PIO-5; CCO-11, 12
	A-2.12 The boundaries between landscape regions are usually well defined.	PIO-5; CCO-12
	A-2.13 Any continental land mass has several distinctive types of landscape regions which can be identified.	PIO-5; CCO-12
	A-2.14 The surface of New York State has several distinctive landscape regions.	PIO-5; CCO-12
B. Landscape development		
B-1 Environmental factors	**B-1** ***How is landscape development influenced by environmental factors?***	**XIV-B-1**
B-1.1 Uplifting and leveling forces	B-1.11 Landscapes seem to result from the interaction of uplifting and leveling forces.	B-1.11 Relate to topic IX and topic XIII. PIO-3, 5; CCO-1, 4, 5, 6, 7, 8, 10, 11, 12
	B-1.12 In a particular landscape, one of the forces, uplifting or leveling, may be dominant.	PIO-3, 5
	B-1.13 The rate of crustal uplift or subsidence may result in a modification of landscape by altering hillslopes, drainage patterns, or orographic wind patterns.	B-1.13 Relate to topic VIII and XII. PIO-3, 5; CCO-4, 5, 6, 7, 8, 9, 10, 11, 12
B-1.2 Climate	B-1.21 A change in the climate would result in a modification of the landscape.	B-1.21 Relate to topic VIII. PIO-3, 5; CCO-4, 6, 7, 8, 9, 11, 12
	B-1.22 Some landscapes contain evidence of having developed under conditions of climatic extremes such as arid and glaciated regions.	B-1.22 Relate to topic VIII. PIO-3, 5; CCO-4, 6, 7, 8, 9, 11, 12
	B-1.23 The rate at which landscape development occurs may be influenced by the climate.	B-1.23 Relate to topic VIII. PIO-5; CCO-4, 6, 7
	B-1.24 The steepness of hillslopes in an area is affected by the balance between weathering and removal of materials.	PIO-1, 2, 5; CCO-6, 7, 8, 11, 12
	B-1.25 Other factors being equal, hillslopes which have evolved in a dry climate tend to differ in appearance from hillslopes which have evolved in a humid climate.	B-1.25 Relate to topic VIII and topic IX. PIO-5; CCO-4, 6, 7, 8, 11, 12
	B-1.26 Stream characteristics are affected by the climate.	B-1.26 Relate to topic VIII and topic IX. PIO-1, 5; CCO-4, 7, 8, 11, 12
	B-1.27 Soil associations differ in composition depending on the climate.	B-1.27 Relate to topic IX. PIO-5; CCO-4, 6, 7, 11, 12
B-1.3 Bedrock	B-1.31 The rate at which landscape development occurs may be influenced by the bedrock.	PIO-2, 5; CCO-6, 7, 11, 12
	B-1.32 The shape and steepness of hills are affected by the local bedrock composition.	PIO-2, 5; CCO-6, 7, 11, 12
	B-1.33 Competent rocks are responsible for plateaus, mountains, and escarpments, whereas weak rocks usually underlie valleys and other low-level areas.	B-1.33 Relate to topic IX. PIO-5; CCO-7, 11, 12