Unit 2
Historical Geology
Suggested Time: 14 Hours

Unit Overview

Introduction

This unit is intended to give students an opportunity to explore the concepts of relative and absolute time using historically important geologic principles and modern applications of radioactive decay.

In addition, this unit highlights the history of Earth's time through the geologic time scale and the importance fossils played in the compilation of this scale

Focus and Context

The focus here is to develop an understanding of how people measure time on a significantly large scale. Students will have an opportunity to apply skills and knowledge through the two core labs and an STSE module. Exploration of the geologic time scale places this in the appropriate context.

Science Curriculum Links

Students have previously studied the major divisions of the geologic time scale in grade 7 and fossils formation at the elementary level. Students build on this knowledge in Earth Systems 3209 by exploring the evolution of life and Earth's surface features through absolute and relative dating techniques.

Curriculum Outcomes

STSE	Skills	Knowledge
Students will be expected to **Nature of Science and Technology** 114-9 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions 115-1 distinguish between scientific questions and technological problems 115-7 explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced **Relationships Between Science and Technology** 116-2 analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology 116-4 analyse and describe examples where technologies were developed based on scientific understanding 116-7 analyse natural and technological systems to interpret and explain their structure and dynamics **Social and Environmental Contexts of Science and Technology** 117-7 identify and describe science- and technology-based careers related to the science they are studying 117-9 analyse the knowledge and skills acquired in their study of science to identify areas of further study related to science and technology	*Students will be expected to* **Performing and Recording** 213-3 use instruments effectively and accurately for collecting data 213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data **Analyzing and Interpreting** 214-2 identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies 214-10 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty **Communication and Teamwork** 215-1 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others 215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results 215-6 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise	*Students will be expected to* 330-1 describe theories and evaluate the limits of our understanding of Earth's internal structure 332-4 illustrate the geologic time scale and compare to human time scales 332-5 compare and contrast the principles of uniformitarianism and of catastrophism in historical geology 332-6 explain the appropriate applications of absolute and relative dating 332-7 describe geological evidence that suggests life forms, climate, continental positions, and Earth's crust have changed over time

Historical Developments and Geologic Time

Outcomes

Students will be expected to

- recognize that uniformitarianism is a fundamental principle of geology and contrast this principle with catastrophism (332-5)
  - define uniformitarianism

Elaborations—Strategies for Learning and Teaching

It is reasonable to assume that processes occurring today occurred in the past. Thus, uniformitarianism, as proposed by James Hutton, plays an important role in understanding current and past geologic events. Inherent in this concept is the idea that time plays an important role in the effects these processes play and that these processes have explainable causes. Alternatively, catastrophism, as purposed by James Ussher, describes Earth processes as sudden events with unknown causes. As a result, there is a tendency sometimes to reject the concept of catastrophism as an antiquated and preposterous notion. Be careful of this. There are many good reasons to suggest that catastrophism may have some ability to account for certain events. Mass extinctions such as the one that removed the dinosaurs, for example, can be accounted for with catastrophic models. Teachers could reference Topic 6 - Unit 1 in the Edukit available from the Johnson GEO CENTRE.

- explain the appropriate applications of absolute and relative dating (332-6)
  - distinguish between absolute and relative time

Students' ages should be used as an analogy. They can compare their ages to one another saying, for example, "I am younger than you, but older than John" to demonstrate relative time or they can state their ages in absolute terms such as "I am 17.5 years old".

Students should know that relative time does not involve numbers, but rather a sequencing of events, whereas absolute time involves numbers to count or calculate from a known event.

Absolute dating refers to an exact date or time known for an event. For example, a birth date. In the text on page 218, there is a reference to numerical dating. This is the same as absolute dating.

Teachers could reference Topic 7 - Unit 1 in Edukit.

Historical Developments and Geologic Time

Suggested Assessment Strategies

Performance

- Complete the Edukit activity “A Geo TV Special – Uniformitarianism vs Catastrophism” (Topic 6 - Unit 1).
- Create a time line poster using relative time techniques to order a series of events without using specific dates. For example, grades in school K-12 or a series of historical events.

Journal

- Surmise future Earth shaping events based on the concepts of Uniformitarianism and Catastrophism. One possible topic could be the impact of a large meteor on Earth’s surface.
- Create personal examples to distinguish between relative and absolute time.

Paper and Pencil

- Complete the Edukit activity “Relative and Absolute Time Worksheet” (Topic 7 - Unit 1)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST p. 6

Edukit

ST p. 218

Edukit

Conventions used in Resources Column

ST = Student Text

Historical Developments and Geologic Time (continued)

Outcomes

Students will be expected to

- explain the appropriate applications of absolute and relative dating (332-6)

(continued)

- demonstrate an understanding of the principles and laws used to establish relative time. Include:
  (i) superposition
  (ii) cross-cutting relations
  (iii) horizontality
  (iv) inclusions
  (v) fossil succession (index fossils)
  (vi) unconformities

- construct and interpret cross-sectional diagrams of Earth using geological concepts. Include:
  (i) horizontality
  (ii) superposition
  (iii) correlation
  (iv) cross-cutting relationships
  (v) unconformities
  (vi) inclusions
  (vii) folding and faulting
  (viii) metamorphism

Elaborations—Strategies for Learning and Teaching

There are several simple ways to demonstrate these principles and laws. A stack of books on a desk, for example, functions as a suitable set-up for superposition. The students can easily observe and understand that the bottom most book was the first one placed there and so on. A slightly more flexible prop might be a graduated cylinder into which different types of clay and sand have been placed. Once again, the students can see the rationality of assuming that the bottom most layer was the first one deposited and so on. Teachers might find this way preferable to using the books as it more closely resembles sedimentary layers. Using a meter stick angled across the front of the stack of books could be used to show cross-cutting relations. Students could observe and understand that the position of the meter stick indicates a later event in the relative sequencing of events.

Teachers should indicate the three types of unconformities, which include: angular unconformity; nonconformity; and disconformity.

Teachers should also introduce index fossils and their use in fossil correlation (e.g. Olenellus trilobites indicate the Cambrian period of the Paleozoic era).

It would be beneficial to define each principle or law and to illustrate their use in relative dating using cross-sectional diagrams of sedimentary rock units.

Students should know that cross-sections are simply vertical profiles of Earth's subsurface along a particular line in map view. Treatment of some of these geological concepts should be brief as they will have been previously addressed.

Students should know that rock layers can be correlated using various criteria including: fossils; rock types; texture; and colour. Students should know that there are three types of unconformities, which include: angular unconformity; disconformity; and nonconformity.

Students should be able to draw well-labelled diagrams demonstrating each geological concept.

Students should be able to interpret well-labelled diagrams that demonstrate each geological concept. Additionally, students should be able to use their understanding of the different geological concepts to determine the history of formation of the rock sequence.

Historical Developments and Geologic Time (continued)

Suggested Assessment Strategies

Paper and Pencil

- Complete an analysis of a geologic outcropping to determine ordering of events using the principles and laws appropriate to relative dating techniques.
- Complete the Edukit “Relative Time Principles Worksheet” (Topic 7 - Unit 1).
- Complete the Edukit “Relative Time Principles and Newfoundland and Labrador Worksheet” (Topic 7 - Unit 1).

Performance

- Create Quiz-Quiz-Trade question cards (Appendix C) related to the principles and laws used in relative dating.
- Create varve models using large beakers, sand, and silt. Alternate the layers of sand and silt to represent varve deposition in a glacial lake.

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 218-226

Edukit

Historical Developments and Geologic Time (continued)

Outcomes

Students will be expected to

- explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced (115-7)
- analyse natural and technological systems to interpret and explain their structure and dynamics (116-7)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others (215-1)
- select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results (215-2)
- work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)
- describe theories and evaluate the limits of our understanding of Earth's internal structure (330-1)

Elaborations—Strategies for Learning and Teaching

Core Laboratory Activity: Interpreting Historical Geological Events

The laboratory outcomes 115-7, 116-7, 213-5, 215-1, 215-2, 215-6, 330-1, and 332-6 are addressed, in whole or in part, by completing **CORE LAB #1** "Interpreting Historical Geologic Events".

Historical Developments and Geologic Time (continued)

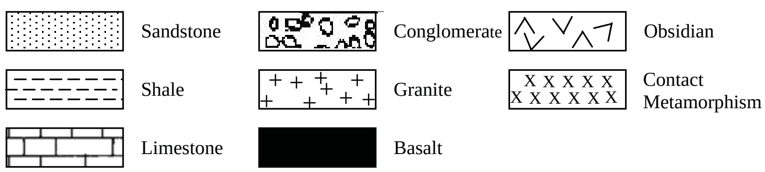
Suggested Assessment Strategies

Interview

- Using an assessment rubric, interview students to determine their knowledge and understanding of geological concepts used in interpreting cross-sectional diagrams.

Paper and Pencil

- Construct a fictitious geologic cross-section on a blank index card. On the opposite side explain the historical geologic events. Exchange cards with classmates to practice interpretation of cross-sections. A rubric could be used for self, peer or teacher assessment.



- Using an example, explain how science knowledge evolves over time.

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

Core Lab #1: “Interpreting Historical Geologic Events”, Appendix B

Historical Developments and Geologic Time (continued)

Outcomes

Students will be expected to

- explain the appropriate applications of absolute and relative dating (332-6)
  - demonstrate an understanding of the processes and features used to establish absolute time. Include:
    (i) varves
    (ii) growth rings
    (iii) radioactive dating

Elaborations—Strategies for Learning and Teaching

Varves and growth rings are two common examples of features used to establish absolute time. The amount of detail required here is minimal. Demonstrations work well for these concepts. The same apparatus used to demonstrate relative time can be used to demonstrate how varves can be used to establish absolute time. Prepare a display sample in advance. Obtain a graduated cylinder and place some water in it. Alternate layers of sand with clay until a clear pattern of sand/clay/sand/clay is visible. Display this pattern for the students to observe and indicate that similar patterns are seen in nature. Challenge students to date the display sample and to construct a plausible explanation for its origin. Inform them that a layer of sand with a layer of clay represents one year, which represents one varve. Alternatively, a cross-section of a tree could be used. Students could count the rings to calculate age. The number of growth rings equals the age of the sample.

A varve is a pair of sedimentary layers that are deposited in one year in a glacial lake in an area that experiences strong seasonal contrast. Geologists count the pairs of sedimentary layers (varves) to determine the number of years of deposition. For example, 308 sedimentary layers means that there are 154 glacial varves, which represents 154 years of sediment deposition. Each varve contains a dark, fine-grained sedimentary layer and a light, coarse-grained sedimentary layer. The dark, fine-grained layer forms in the fall and winter when water is most likely frozen and very little sediment deposition is occurring. The dark colour is due to the abundance of humus material that settles out of the water body during these seasons. The light, coarse-grained layer forms in the spring and summer when meltwater is abundant and is flowing and eroding large quantities of sediment. The light colour is attributed to the abundance of sediment and the relatively small amount of humus material.

Radioactive dating will require greater depth of treatment as illustrated in the following outcomes.

Historical Developments and Geologic Time (continued)

Suggested Assessment Strategies

Presentation

- Create a presentation explaining the formation of varves.
- Using a cross-section of a tree, model the process of determining the absolute age of a rock using varves.
- Research and create a presentation highlighting features of human skeletons that are used to establish absolute age.

Performance

- Calculate the absolute age of trees from trunk cross sections.

Paper and Pencil

- Infer why coarse sediments are deposited in the spring and summer while fine sediments are deposited in the fall and winter.

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 231-234

Historical Developments and Geologic Time (continued)

Outcomes

Students will be expected to

- explain how the half-lives of radioactive elements are used in estimating ages of materials (332-4)
  - define half-life
  - define isotope
  - identify parent and daughter elements

Elaborations—Strategies for Learning and Teaching

Teachers should briefly review atomic structure, sub-atomic particles (i.e., protons, neutrons, and electrons), atomic number and atomic mass. Isotopes should be defined as variations of an element that have different mass numbers. Their atoms contain the same number of protons in the nucleus but differ in the number of neutrons. Students should recognize that some isotopes are energetically unstable and will emit particles and/or energy to achieve stability. This emission is called radioactivity. Depth of treatment should not include the types of particles emitted from a nucleus (i.e., alpha, beta, gamma). Examples of parent and daughter elements should include: carbon-14 to nitrogen-14; uranium-235 to lead-207; uranium-238 to lead-206; potassium-40 to argon-40, and rubidium-87 to strontium-87 with their associated half-life values. For example, the half-life of carbon-14 is 5730 years. Memorizing accepted half life values for these elements is not necessary.

A more detailed treatment of radiometric dating can be found in the Core STSE “Labrador Zircons and their Link to Radiometric Dating and Absolute Time”.

- determine the age of a sample using radiometric data

Teachers should limit treatment to scenarios with straight forward calculations as some students find the application of half-life difficult. Teachers should clearly distinguish between the half-life values for an isotope and the number of half-lives involved in a scenario, as this is often a point of confusion. Scenarios should include calculations to determine the fraction or percent of parent and daughter material, the number of half-lives, the ratios of parent to daughter material, and changing mass. Teachers should also demonstrate the use of radioactive decay curves.

- evaluate the sources of error and limitations in estimating radiometric age (214-10)

Sources of error and limitations of radioactive dating include: metamorphism resetting the radioactive clock; addition (e.g. hydrothermal fluids)/loss (e.g. leaching) of parent or daughter isotopes, applicability with sedimentary rock (due to their formational nature of being composed of sediment that was weathered and eroded from various sources), appropriateness of certain parent-daughter pairs in their application (e.g. carbon-14 can only be used to date living or once-living things). The idea here is to illustrate that while this type of dating is useful, it is not without errors.

Historical Developments and Geologic Time (continued)

Suggested Assessment Strategies

Paper and Pencil

- Complete sample calculations using radioactive decay.
- Explain how flipping a coin could be used to demonstrate radioactive decay.
- Complete the Edukit "Radiometric Dating Problems Worksheet" (Topic 8 - Unit 1)

Presentation

- Create a presentation illustrating the potential sources of error in radioactive dating and the limitations of its use.

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 228-235

Lab-Aids - Introduction to Radioactivity and Half-life Experiment

Edukit

ST p. 231

Historical Developments and Geologic Time (continued)

Outcomes

Students will be expected to

- explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions (114-9)
- distinguish between scientific questions and technological problems (115-1)
- analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-2)
- analyse and describe examples where technologies were developed based on scientific understanding (116-4)
- analyse the knowledge and skills acquired in their study of science to identify areas of further study related to science and technology (117-9)
- identify limitations of a given classification system and identify alternative ways to classify to accommodate anomalies (214-2)
- identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty (214-10)

Elaborations—Strategies for Learning and Teaching

The Core STSE component of this unit incorporates a broad range of outcomes. More specifically, it addresses, in whole or in part, outcomes 114-9, 115-1, 116-2, 116-4, 117-9, 214-2, 214-10, 332-4, and 332-6. The STSE component, “Labrador Zircons and their Link to Radiometric Dating and Absolute Time”, can be found in Appendix A.

Teachers could consider showing the CBC learning episode “Geologic Journey - Canadian Shield ”.

Teachers could also use a radioactive decay activity, using pennies or candy, and link it to the STSE.

Historical Developments and Geologic Time (continued)

Suggested Assessment Strategies

Interview

- Ask students to explain the process of radiometric dating in their own words. Using a rubric, assess their usage of appropriate scientific language. This could be conducted as a peer assessment.

Paper and Pencil

- Using examples from the STSE, distinguish between a scientific question and a technological problem.
- What impact has radiometric technology had on our understanding of historical geologic events?
- Infer why the two parent-daughter pairs of the U-Pb system are superior to other radiometric systems.

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

Appendix A

Lab-Aids - Introduction to Radioactivity and Half-life Experiment

CBC learning “Geologic Journey - The Canadian Shield”

Fossils and Geologic Time

Outcomes

Students will be expected to

- describe how fossils are used to distinguish geologic time (332-7)

Elaborations—Strategies for Learning and Teaching

The geologic time scale spans ~4.5 billion years, which is often too much time for students to comprehend. The 500 or so million years that are detailed are the result of paleontological studies of fossil remains and/or traces. These studies have correlated geologic time such that the divisions of the Phanerozoic eon are known by the life forms that dominated them. Index fossils are used to establish time frames, which allow geologists to order those times in chronological sequence. Students should recognize that the time prior to the Phanerozoic eon (i.e. Precambrian era) has been divided; however, uncertainty exists in the time due to its old age and the lack of life-forms during the time.

Teachers could refer to Topic 1 - Unit 4 in Edukit for supplemental instructional material.

- define fossil

Teachers should include trace fossils and actual physical remains as examples of fossils. Students do not generally think about this and tend to be surprised to learn that indirect evidence such as footprints, burrows, feces, stomach stones and so on can provide a wealth of information. They may also be surprised to learn about the breadth of information that one can obtain indirectly. For example, a measurement of the depth and surface area of a footprint when coupled with the supposed soil characteristics in which it was made can give a reasonably accurate measure of the creature's body mass.

- describe three conditions necessary for fossilization

Students should recognize that hard body parts form better fossils and that rapid burial by fine-grained sediments and low oxygen levels prevent decomposition. Although rare, it is possible for soft-bodied organisms to become fossilized (e.g. buried by volcanic ash).

- describe the formation of various types of fossils. Include:
  - (i) petrifaction by replacement
  - (ii) carbonization
  - (iii) mould and cast
  - (iv) preserved intact (frozen, amber)
  - (v) imprints (soft tissue)
  - (vi) trace fossils (e.g., dinosaur eggs, coprolite)

The focus of this delineation should be on how the various types of fossils form and not on the characteristics of each fossil type. For example, the formation of petrified fossils results from the replacement of organic matter with crystallized mineral material.

Trace fossils can include many different forms and should include: eggs, coprolites, gastroliths, footprints and burrows/tunnels.

Fossils and Geologic Time

Suggested Assessment Strategies

Paper and Pencil

- Given strata for two or more locations, correlate the strata to show their relationship.
- Create a news story to highlight a particular fossil type recently found in your area. Describe the fossil and how it was formed.

Presentation

- Create a power point presentation showing various types of fossils and how they formed.

Performance

- Create your own Quiz-Quiz-Trade activity cards (Appendix C) related to fossil types. Quiz a classmate, trade, then continue.
- Create molds and casts using various media such as plasticine, plaster, or latex. Plastic plants or animals could be used to create impressions.

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 226, 228

Edukit

ST p. 183

ST p. 184

ST pp. 183-186

Fossils and Geologic Time (continued)

Outcomes

Students will be expected to

- explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced (115-7)
- identify and describe the work of paleontologists (117-7)
- use instruments effectively and accurately for collecting data (213-3)
- identify limitations of a given classification systems and identify alternative ways of classifying to accommodate anomalies (214-2)
- Identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty (214-10)
- describe geological evidence that suggests life forms, climate, continental positions, and Earth's crust have changed over time (332-7)

Elaborations—Strategies for Learning and Teaching

Core Laboratory Activity: Estimating Dinosaur Size and Speed from Trackways

The laboratory outcomes 117-9, 213-8, 214-2, 215-6, and 332-7 are addressed, in whole or in part, by completing **CORE LAB #2** "Estimating Dinosaur Size and Speed from Trackways".

Fossils and Geologic Time (continued)

Suggested Assessment Strategies

Interview

- From a trackway, a paleontologist estimates the size of the dinosaur to be 7.68 m tall. Ask students to identify all the possible sources of error in the estimate. Use a rubric to identify their skill level.

Paper and Pencil

- Describe the process a paleontologist would follow to estimate the size of a dinosaur from a single foot print.
- Explain how present day organisms are used to estimate the sized and speed of dinosaurs
- Having completed the Core Lab, discuss the importance of accuracy in measurement and data collection.
- Identify the limitations of using trackways to estimate the size and speed of dinosaurs.

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

Core Lab #2: "Estimating Dinosaur Size and Speed from Trackways", Appendix B

The Geologic Time Scale

Outcomes

Students will be expected to

- illustrate the geologic time scale and compare to human time scales (332-4)

Students need to recognize the progression from the largest time frame (eons) to the smallest time frames (epochs). It is not necessary for students to memorize the specific names of each period or epoch.

  - identify that the geologic time scale is divided into eons, eras, periods, and epochs

  - recognize that Precambrian time represents the greatest part of Earth history

It should be recognized that the Precambrian has the least amount of life forms due to pre-existing physical and chemical environmental conditions at that time (e.g. low levels of free oxygen in atmosphere, extreme temperatures, extreme UV levels, and metamorphism of rocks).

  - recognize that the Phanerozoic eon represents the emergence of complex life forms

This is often referred to as the time of visible life and it represents the emergence of more complex life as organisms evolved.

  - distinguish between Precambrian time and the Paleozoic, Mesozoic, and Cenozoic eras

Dating or aging is not required; limit to matching periods with life forms in chronological order. It should be noted that the Phanerozoic eon is divided into three eras: the Paleozoic; Mesozoic; and Cenozoic. Students should be careful not to confuse the Phanerozoic eon with the Paleozoic era.

Elaborations—Strategies for Learning and Teaching

The Geologic Time Scale

Suggested Assessment Strategies

Presentation

- Create a time line (time scale) to represent significant events in your life. Divide your time line into appropriate segments and sub-segments.
- Create a poster for a specific unit of geological time. The posters can then be joined to form a geological time scale. Pictures may be hand drawn, cut from magazines, or found on the internet.

Paper and Pencil

- How important were fossils to the development of the geological time scale?

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 10, 236-240

The Geologic Time Scale (continued)

Outcomes

Students will be expected to

- illustrate the geologic time scale and compare to human time scales (332-4)

(continued)

- list the dominant life forms present at each era. Include:
  - (i) single-celled and other simple life forms (Precambrian)
  - (ii) invertebrates (early Paleozoic)
  - (iii) fishes (middle Paleozoic)
  - (iv) first land plants (between early and middle Paleozoic)
  - (v) amphibians (late Paleozoic)
  - (vi) reptiles (Mesozoic)
  - (vii) birds (Mesozoic)
  - (viii) flowering plants (Mesozoic)
  - (ix) mammals (Cenozoic)

- list the time frame that correlates with the dominant life form on Earth. Include:
  - (i) Cenozoic - Age of Mammals
  - (ii) Mesozoic - Age of Reptiles
  - (iii) Paleozoic (late) - Age of Amphibians
  - (iv) Paleozoic (middle) - Age of Fishes
  - (v) Paleozoic (early) - Age of Invertebrates

Elaborations—Strategies for Learning and Teaching

Students could use the following mnemonic device to remember the dominant life forms present at each Era:

Since
I
Found
Flying
Angels
Riding
Brooms
Forget
Medicine

Teachers should ensure that students realize that the Paleozoic era represents more than one dominant form of life. For example, the early part of the Paleozoic era is referred to as the Age of Invertebrates, the middle part of the era is referred to as the Age of Fishes, and the late (most recent) part of the Paleozoic Era is referred to as the Age of Amphibians.

Students should recognize that there was an explosion of life at end of Precambrian (start of the Phanerozoic eon, Paleozoic era, Cambrian period)

Teachers could refer to the Edukit article “Evolution through Geologic Time” (Topic 1 - Unit 4) for supplemental instructional material.

The Geologic Time Scale (continued)

Suggested Assessment Strategies

Performance

- Create a collage to represent the various ages in geologic time.
- Students could use the school parking lot to demonstrate the scale of each section of the geologic times scale. For example, placing themselves appropriate distances from each other to represent the relative size of each time span.
- Students could create their own Quiz-Quiz-Trade question cards related to the dominant life forms present during each era. (Appendix C)

Pencil and Paper

- Construct a pie chart or scale diagram representing the time periods of Earth's geologic time scale to show the relative size of each.
- Complete the Edukit "Evolution through Geologic Time Student Worksheet" (Topic 1 - Unit 4).

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 10, 236-240

Edukit

The Geologic Time Scale (continued)

Outcomes

Students will be expected to

- illustrate the geologic time scale and compare to human time scales (332-4)

(continued)

- list the time frame that correlates with the dominant life form on Earth. Include:
  - (i) Cenozoic - Age of Mammals
  - (ii) Mesozoic - Age of Reptiles
  - (iii) Paleozoic (late) - Age of Amphibians
  - (iv) Paleozoic (middle) - Age of Fishes
  - (v) Paleozoic (early) - Age of Invertebrates

Elaborations—Strategies for Learning and Teaching

Teachers should emphasize the progression of the complexity of life forms and the punctuated stops that occurred through mass extinctions. Students should recognize that life forms early on were simple single celled organisms that progressed to more complex forms when environments permitted. This progression was also halted, at times, for some life forms through mass extinctions when environmental changes selected against certain forms. This in turn allowed other organisms to flourish in the absence of the others.

At this time, teachers could reiterate the systems concept by outlining the interdependence of evolving life forms on the atmospheric, hydrologic, and geologic conditions through Earth's history. Changes in one or more spheres directly impact the biosphere and the development and progression of life forms on Earth through time.

Outcomes

- recognize that life forms, climate, continental positions, and Earth's crust have changed over time (332-7)

- identify two mass extinction events in Earth's history. Include:
  - (i) Permian-Triassic boundary
  - (ii) Cretaceous-Tertiary boundary

Elaborations—Strategies for Learning and Teaching

Teachers should emphasize when these events occurred as well as the major organism(s) for each event. The Permian-Triassic boundary extinction occurred approximately 245 million years ago with 96% of marine species disappearing. Trilobites would be an identifiable species to have gone extinct. The Cretaceous-Tertiary boundary extinction occurred approximately 65 million years ago with over 50% of all species going extinct. This time ended the reign of the "dinosaurs" or large reptiles.

Again, changes in life forms, including the extinction of an appearance of life forms, are interrelated to the other three spheres: hydrosphere, atmosphere, and geosphere.

Teachers could refer to Edukit Topic 3 - Unit 4 for supplemental instructional material.

The Geologic Time Scale (continued)

Suggested Assessment Strategies

Paper and Pencil

- Write a descriptive news story about a major extinction. Include what organisms were affected, how it happened (theories) and what resulted (what new organisms arose).

Presentation

- Create a presentation to bring attention to the potential impacts of climate change on polar bears.

Performance

- Role play different species as they prepare for climate change or extinction (eg. Ice Age).
- Interview an extinct organism to determine: when it lived; what environment it lived in; what other organisms existed with it; and what caused its extinction. Students could create a list of of other interesting questions to ask.
- Students could perform the Edukit activity “A Geo TV Special – What Caused Mass Extinctions?” (Topic 3 - Unit 4).

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 10, 236-240

ST pp. 10, 238

Edukit