Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

8-2.1 Explain how biological adaptations of populations enhance their survival in a particular environment.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: In 3rd grade (3-2.2), students explained how physical and behavioral adaptations allowed organisms to survive. The biotic composition of an ecosystem including populations is part of 5th grade ecosystems study (5-3.2). In 7th grade (7-4.1), students summarized the levels of organization within an ecosystem that included populations.

It is essential for students to know that populations in a particular environment that are better adapted to living conditions there, and therefore are able to meet their survival needs, are more likely to survive and reproduce offspring with those traits.

- There are *variations* among species of similar populations.
- Organisms of a species differ from one another in many of their traits.
- An *adaptation* is a trait or behavior that helps an organism survive and reproduce.
- *Natural selection* is the process that explains this survival and shows how species can change over time. For example, certain traits or adaptations involving color, camouflage, food gathering (beaks, claws) and other physical traits, sensory abilities, or behaviors enhance the survival of a species.

It is not essential for students to know the specifics involved in the theory of evolution, a gradual change in species over time. Natural selection over a long period of time can lead to helpful variations accumulating while unfavorable ones disappear. Studying Darwin's voyage and data is also not included in this indicator.

Assessment Guidelines:
The objective of this indicator is to *explain* how biological adaptations of populations enhance their survival in a particular environment; therefore, the primary focus of assessment should be to construct a cause-and-effect model of various adaptations resulting in population survival in particular environments. However, appropriate assessments should also require students to *compare* species of a particular population as to the adaptation that allows them to survive; *infer* from information about a particular environment the adaptation that a particular organism would need to survive there; or *identify* an adaptation that enhances survival of an organism based on pictures, diagrams, or word descriptions.

Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

8-2.2 Summarize how scientists study Earth's past environment and diverse life-forms by examining different types of fossils (including molds, casts, petrified fossils, preserved and carbonized remains of plants and animals, and trace fossils).
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: In 3rd grade, students recognized types of fossils (including molds, casts, and preserved parts of plants and animals) (3-3.3) and inferred ideas about Earth's early environments from fossils of plants and animals that lived long ago (3-3.4). In 4th grade (4-2.1) and 6th grade (6-3.1), students classified groups of organisms showing the diversity of life-forms on Earth today. Further study on this topic will be part of high school Earth Science.

It is essential for students to know that a *fossil* is the preserved remains or traces of an organism that lived in the past, usually more that 10,000 years ago. Fossils give clues to the diversity of living things over the history of Earth, give clues to past climate and surface changes on Earth, and give clues to changes that have occurred with organisms over time.

NOTE TO TEACHER: Students need to study the formation process of mold, cast, petrified, preserved, carbonized, and trace fossils.
There are different types of fossils based on how they were formed. The environmental conditions that favor fossil formation are also essential to this study.

- *Mold fossil* – forms when sediments bury an organism and the sediments change into rock; the organism decays leaving a cavity in the shape of the organism.
- *Cast fossil* – forms when a mold is filled with sand or mud that hardens into the shape of the organism.
- *Petrified fossil (permineralized fossil)* – forms when minerals soak into the buried remains, replacing the remains, and changing them into rock.
- *Preserved fossil* – forms when entire organisms or parts of organisms are prevented from decaying by being trapped in rock, ice, tar, or amber.
- *Carbonized fossil* – forms when organisms or parts, like leaves, stems, flowers, fish, are pressed between layers of soft mud or clay that hardens squeezing almost all the decaying organism away leaving the carbon imprint in the rock.
- *Trace fossil* – forms when the mud or sand hardens to stone where a footprint, trail, or burrow of an organism was left behind.

Millions of fossils have been collected and studied. The *fossil record* gives important information about past life and environments on Earth. Certain fossilized organisms could only live in specific environments or under particular climate conditions. Extinction of life-forms as well as how and when new life-forms appeared is part of the fossil record.

NOTE TO TEACHER: This is not a study of evolutionary change, but a study of how fossils can show structural similarities and differences in organisms over time revealing the vast diversity of life forms that have and continue to exist here.

Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

It is not essential for students to know the evolutionary relationships among organisms that scientists are studying.

Assessment Guidelines:
The objective of this indicator is to *summarize* how scientists study Earth's past environment and diverse life-forms by examining different types of fossils; therefore, the primary focus of assessment should be to generalize major points about the fossils listed in the indicator, fossil formation, and evidence gleaned from the fossil record. However, appropriate assessments should also require students to *identify* a type of fossil from its description or formation process; *compare* one type of fossil to another or one life-form with a related form in Earth history; *identify* an environmental condition evident because of a fossil presence; or *exemplify* the changes in a species over time in Earth's history using the fossil record.

Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

8-2.3 Explain how Earth's history has been influenced by catastrophes (including the impact of an asteroid or comet, climatic changes, and volcanic activity) that have affected the conditions on Earth and the diversity of its life-forms.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: This is new material for this grade level. This indicator should be studied along with 8-2.5, the diversity of life present on Earth over time using the geologic time scale.

It is essential for students to know that along with the study of the geologic time scale, the changes in life forms, additions and extinctions, are often accompanied by changes in environmental conditions on Earth. These environmental changes have been influenced by the impact of an asteroid or comet, climatic changes, and volcanic activity.

Impact of an asteroid or comet
Earth's atmosphere protects the planet from many of the meteors that enter it, resulting in their burning up before striking the surface.

- At the end of the Mesozoic Era, when reptiles, early birds and mammals thrived, many groups of animals disappeared suddenly.
- Scientists hypothesize that possibly a large asteroid or comet impacted with Earth. This impact caused dust and smoke to rise into the atmosphere and cause climatic changes, as well as the dying of many forms of plant life and animals that depended on those plants for food.
- A major life form that disappeared at this time was the dinosaur.

Climatic changes
Earth's environments have many different climates even today. Climate is an ever-changing condition on Earth.

- Earliest life forms were influenced by the climates produced by the forming atmosphere and oceans of Earth.
- Life on land developed and flourished in the tropical climates and warm shallow seas during the Paleozoic Era. Throughout this era as different land environments formed and sea levels changed, new life forms developed. Other life forms that could not adapt or find suitable conditions, especially many marine species, disappeared.
- During the Mesozoic era, many climate changes occurred due to plate tectonics and the movement of landmasses. Plants and animals that survived through this time had structures and systems that allowed for greater adaptations, such as seed coverings for plant seeds and protective body coverings or constant internal temperature for animals.
- During the present Cenozoic era, climate conditions continue to change. Major ice ages caused the climate to become much cooler as ice sheets and glaciers covered many areas of Earth. Many mountain ranges formed causing climate differences due to elevation and due to location near those ranges.

Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

Volcanic activity

From the earliest days while Earth was forming to present day, volcanic activity has been part of the nature of this changing planet.

- During the Precambrian time volcanic activity was one of the most natural events, but lava flows, ash clouds in the atmosphere, and heat made conditions for life forms extremely difficult. Those simple life forms often did not survive these conditions.
- As continent collided and mountains built up due to plate tectonics, volcanoes also formed. Volcanic activity continued to be common in the Paleozoic era. During the rapid movement of plates in the Mesozoic era, collisions and subduction produced extensive volcanic activity around plate boundaries.
- Plate boundaries are still the location of much of Earth's volcanic activity.
- Very explosive volcanic activity can send ash and dust high into the atmosphere where it is carried great distances around the Earth. The Sun can be blocked for long periods of time. This violent type of activity can disrupt many of Earth's processes and ultimately the life forms that depend on those processes.

The eras of Earth history can be studied in light of conditions on Earth, the effect of those conditions on life-forms, and the possibilities of rapid changes to both (environmental conditions and life forms) due to catastrophes.

It is not essential for students to know exact causes of the many extinctions during Earth's geologic history, but understanding of how an impact, or climatic change, or volcanic activity can affect conditions for life forms to survive generally on Earth is important.

Assessment Guidelines:

The objective of this indicator is to *explain* how Earth's history has been influenced by catastrophes; therefore, the primary focus of assessment should be to construct a cause-and-effect model of a catastrophic event's impact on the conditions and diversity of life-forms on Earth. However, appropriate assessments should also require students to *identify* an event that would be catastrophic to Earth; *infer* changes in conditions and life-forms that occurred during the recent ice ages; or *compare* the changes in environmental conditions during Earth's geologic history.

Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

8-2.4 Recognize the relationship among the units – era, period, and epoch – into which the geologic time scale is divided.
Taxonomy level: 1.1-A, B Remember Factual and Conceptual Knowledge

Previous/Future knowledge: The geologic time scale is new material for this grade. Further study will take place in high school Earth Science.

It is essential for students to know that the geologic time scale divides Earth's long history into units of time:

- *eras* are divided into *periods*
- *periods* can be further divided into *epochs*

Major information found on the geologic time scale includes:

- Precambrian is the name given to the earliest span of time in Earth history.
- Geologists divide the time between Precambrian and the present into three long units called *eras* (Paleozoic, Mesozoic, Cenozoic).
- The names of the eras are important, as is the order from oldest era to most recent.
- *Eras* are subdivided into units called *periods*.
- Cambrian being the first period is important.
- With a more complete fossil record available, the periods of the Cenozoic era are subdivided further into *epochs*.
- Present day Earth is in the Cenozoic era and the Quaternary period in the Holocene epoch.
- Geologic time has not ended.

It is not essential for students to know the dates involved with each era or period. Students do not need to memorize the names or order of the periods of Earth history.

Assessment Guidelines:
The objective of this indicator is to *recognize* the relationship among the units of the geologic time; therefore, the primary focus of assessment should be to locate this knowledge within the presented material on the relationships among the units (era, epoch, and period) and how they are subdivided. However, appropriate assessments should also require students to *identify* a unit's place in sequence; *recall* the three major era divisions; *identify* the first period of geologic history or the period of present day geologic time; or *recognize* that geologic history is ongoing – it has not ended.

Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

8-2.5 Illustrate the vast diversity of life that has been present on Earth over time by using the geologic time scale.
Taxonomy level: 2.2-B Understand Conceptual Knowledge

Previous/Future knowledge: Relating diversity of life to the geologic time scale is new content for this grade. This concept will be further studied in high school Earth Science.

It is essential for students to know that the geologic time scale is a record of the major events and diversity of life forms present in Earth's history.

- The geologic time scale began when Earth was formed and goes on until the present.
- At the end of each era a mass extinction occurred, many kinds of organisms died out, although there were other extinctions going on during each period of geologic time.
- Using the fossil record, paleontologists have created a picture of the different types of common organisms in each geologic period.

Paleozoic Era

- Began with the early invertebrates, such as trilobites and brachiopods; continued to develop early vertebrate fish, then arachnids and insects; later came the first amphibians, and near the era's end the reptiles became dominant.
- Early land plants included simple mosses, ferns, and then cone-bearing plants.
- By the end of the era, seed plants were common.
- The mass extinction that ended the era caused most marine invertebrates as well as amphibians to disappear.

Mesozoic Era

- Reptiles were the dominant animals of this era, including the various dinosaurs.
- Small mammals and birds also appeared.
- Toward the end of the era, flowering plants appeared and the kinds of mammals increased.
- The mass extinction that ended the era caused the dinosaurs to become extinct.

Cenozoic Era

- New mammals appeared while others became extinct.
- The diversity of life forms increased.
- Flowering plants became most common.
- Humans are also part of the most recent period of this era.

Various models, diagrams, and pictures can be used to illustrate the vastness of time involved in geologic time and to show the diversity of life evident across geologic time. Through the illustrations, not only does the diversity of life-forms increase, but the complexity of those life-forms also increases.

It is not essential for students to know in detail the myriads of organisms that appeared during the various periods. They do not have to include the geologic events of each era and/or period,

but reference to major geologic changes especially continental changes due to plate tectonics is helpful.

Assessment Guidelines:
The objective of this indicator is to *illustrate* the diversity of life that has been present on Earth over time; therefore, the primary focus of assessment should be to give illustrations of these concepts or use illustrations to show understanding of diversity of life over geologic time. However, appropriate assessments should also require students to *interpret* a diagram of life forms over geologic time; *exemplify* major life forms that dominated an era; or *compare* life forms in one era with those in another.

Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

8-2.6 Infer the relative age of rocks and fossils from index fossils and the ordering of rock layers.

Taxonomy level: 2.5-B Understand Conceptual Knowledge

Previous/Future knowledge: The concept of relative age using ordering of rock layers and index fossils is new content for this grade. This concept will be further studied in high school Earth Science.

It is essential for students to know that the *relative age* means the age of one object compared to the age of another object. Relative age does not tell the exact age of an object. The relative age of rocks and fossils can be determined using two basic methods: ordering of rock layers and index fossils:

Ordering of Rock Layers

- Scientists read the rock layers knowing that each layer is deposited on top of other layers.
- The *law of superposition* states that each rock layer is older than the one above it.
- So using this layering, the relative age of the rock or fossil in the rock is older if farther down in the rock layers.
- Relative dating can be used only when the rock layers have been preserved in their original sequence.

Index Fossils

Certain fossils, called index fossils, can be used to help find the relative age of rock layers. To be an index fossil –

- an organism must have lived only during a short part of Earth's history;
- many fossils of the organism must be found in rock layers;
- the fossil must be found over a wide area of Earth;
- the organism must be unique.

The shorter time period a species lived, the better an index it is. A key example of an organism used as an index fossil are *trilobites*, a group of hard-shelled animals whose body had three sections, lived in shallow seas, and became extinct about 245 million years ago. Therefore, if a trilobite is found in a particular rock layer, it can be compared with trilobites from other layers to estimate the age of the layer in which it was found.

Fossils that are found in many rock layers, therefore living long periods of time, do not qualify as index fossils.

It is not essential for students to know how to interpret complex layering due to intrusions and extrusions, faults, or unconformities, although some students may be challenged with this task. Complex layering is part of the high school Earth Science course. It is also not essential for students to know the processes involved in absolute dating using radioactive element decay.

Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

Assessment Guidelines:

The objective of this indicator is to *infer* the relative age of rocks and fossils; therefore, the primary focus of assessment should be to draw conclusions about relative age from presented material on layering of rocks and index fossils. However, appropriate assessments should also require students to *interpret* drawings or diagrams that show data about rock layers and fossils; *compare* rock layers in order to determine common points of relative time; or *recall* the law of superposition.

Earth's Biological History

8-2 The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)

8-2.7 Summarize the factors, both natural and man-made, that can contribute to the extinction of a species.
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: Students in 1st, 2nd, and 3rd grade studied factors that plants and animals need in order to survive. In 6th grade, students illustrated animal behavioral responses (6-3.5) and internal stimuli (6-3.6) that ensure their survival. In 7th grade (7-4.3), students explained how natural hazards and limiting factors affect populations. This is the first time that extinction of species is a concept.

It is essential for students to know that a species is extinct if no members of that species are still alive. Most organisms that have ever lived on Earth are now extinct.

Natural factors can cause extinctions such as has happened throughout Earth history.
- Organisms that could not survive changes due to volcanic eruptions and global warming, global cooling during ice ages, changes in oxygen levels in seawater, or a massive impact from an asteroid or comet became extinct.
- Natural extinctions have occurred throughout geologic history.
- Not all have been necessarily negative in that extinctions often clear the way for new kinds of life.

Man-made factors have caused extinctions in more recent times, such as the cutting of the rainforest regions, removing natural habitats, over-harvesting, and pollution.
- Many plants and animals are likely to become extinct in the near future if humans do not make changes in way they are damaging Earth, and removing the survival needs of many organisms.
- Human effects on the environment could threaten some biological resources that humans may need.

Species that have recently become extinct or that are endangered can be studied to discover what natural or man-made survival resources caused the extinction or endangerment and what could have been or could be done to prevent it from happening.

It is not essential for students to know the specifics about the extinction of any particular species. Students do not need to make value or moral judgments about what man has or has not done with regards to extinction or endangerment of species; they are not evaluating the topic.

Assessment Guidelines:
The objective of this indicator is to *summarize* the factors that contribute to the extinction of a species; therefore, the primary focus of assessment should be to generalize major points about natural and man-made contributions to extinction. However, appropriate assessments should also require students to *infer* whether presented information could lead to extinction of a species; *compare* natural factors with man-made factors that could cause extinction; or *exemplify* species that are presently extinct due to natural factors or human factors.