Senior High School

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DEPARTMENT OF EDUCATION

Earth Science for STEM

Quarter 2 – Module 12:

Describe How Index Fossils (also known as Guide Fossils) are Used to Define and Identify Subdivisions of the Geologic Time Scale

ALTERNATIVE DELIVERY MODE
ADM

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Quarter 2 – Module 12: Describe How Index Fossils (also known as Guide Fossils) are Used to Define and Identify Subdivisions of the Geologic Time Scale
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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

This module was written and intended for Grade 11 STEM students. It will help you to be accustomed to how index fossils (also known as guide fossils are used to define and identify subdivisions of geologic time scale. This module helps you to apply it in many different learning situations. The vocabulary level of students is the basis of the language used in this module. The lessons are arranged following the standard order and the sequence of the course.

The module is divided into three lessons namely:

- Lesson 1 – What is index fossils?
- Lesson 2 – History of Earth's Life Forms
- Lesson 3 – How Index Fossils Help Define Geologic Time Scale?

After going through this module, you are expected to:

1. define what is index fossils or guide fossils and subdivisions of geologic time scale.

2. identify how index fossils are used to described subdivisions of geologic time scale.

3. explain why it is rare for an organism to be preserved as a fossil.

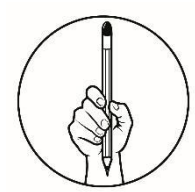
4. distinguish the difference between body fossils and trace fossils.

5. describe five types of fossilization and what a living fossil is.

6. value the importance of index fossils and give several examples.

7. explain how the fossil record shows us that species evolve over time.

8. describe the general development of Earth's life forms over the last 540 million years.



What I Know

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Index fossils are defined as _____.
   a. remnants of the living things.
   b. remnants of the non-living things.
   c. remnants of the planets and stars.
   d. remnants of the universe.

2. It is the process by which organic matter exposed to minerals over a long period is turned into a stony substance.
   a. Molds
   b. Petrified
   c. Trace
   d. Cast

3. Which of the following subdivision of geologic time portrays the differences in life forms?
   a. Period
   b. Epoch
   c. Eons
   d. Eras

4. Eons are divided into smaller time intervals known as eras. Which is the youngest era which means "new life"?
   a. Mesozoic
   b. Paleozoic
   c. Cenozoic
   d. Proterozoic

5. Precambrian takes up the history of the earth by how many percent?
   a. 60%
   b. 70%
   c. 80%
   d. 90%

6. Greek ammonites is named after the ram god who is _____.
   a. Rah
   b. Kareb
   c. Ahmed
   d. Ammon

7. Which of the following creatures when fossilized the bones become 12 meters (39 feet) a wingspan?
   a. dinosaur *Argentinosaurus*
   b. pterosaur *Quetzalcoatlus*
   c. *Protoceratops*
   d. Griffin

8. These index fossils are formed by preservation and the remains of specific species are found in the strata of_____.
   a. sedimentary rock
   b. igneous rock
   c. metamorphic rock
   d. Magma

9. Charles Walcott discovered a fossil with a soft body like a worm, five eyes, and a long nose like a vacuum cleaner hose. In which Paleozoic era does he discover the said fossil?
   a. Cambrian
   b. Silurian
   c.Ordovician
   d.Devonian

10. These living fossils are organisms that have existed for a tremendously long period from the Cambrian period up to the present without changing very much.
   a. Lingulata brachiopods
   b. Archaeopteryx
   c. Anomalocaris
   d. Ammonite

11. Which of the following is not considered as criteria to determine an index fossil?
   a. The fossilized organism must be easily recognizable.
   b. The fossils must be geographically widespread.
   c. The fossil must have lived for only a short time.
   d. The fossil must have lived for a long time.

12. The process in which a living organism becomes a fossil is called_____.
   a. Microfossils
   b. Fossilization
   c. index fossils
   d. living fossils

13. The term Phanerozoic means _____.
   a. “Time of unwell-displayed life”
   b. “Time of well-displayed life”
   c. “Time of well-unplaited life”
   d. “Time of well-replayed life”

14. The largest mass extinction in Earth history occurred at the end of the _____.
   a. Precambrian period, about 250 million years ago
   b. Phanerozoic period, about 250 million years ago
   c. Permian period, about 250 million years ago
   d. Archean period, about 250 million years ago

15. First mammals on Earth were seen during the Mesozoic era. It was how many million years ago?
   a. 130
   b. 150
   c.200
   d.251

Lesson 1 What are Index Fossils?

Source: https://www.flickr.com/photos/13906148@N00/4168549790/

Fossils are the preserved remains, or traces of remains of ancient organisms. Fossils are not the remains of the organism itself! They are rocks. A fossil can preserve an entire organism or just part of one. Bones, shells, feathers, and leaves can all become fossils.

What's In

Environments include the living and non-living things that surround and affect organisms. How an organism survives in its environment depends upon its characteristics. If an organism survives until adulthood, it can produce and pass its characteristics to its offspring. In this lab, you will use a model to find out how one characteristic can determine whether the individuals can survive in an environment.

Activity 1: Launch Lab: Survival Through Time

Do the activity below.
Procedures:

1. Cut 15 pieces each of green, orange, and blue yarn into 3-cm.
2. Scatter them on green construction paper.
3. Have your partners (mother or siblings) use a pair of tweezers to pick up as many pieces as possible in 15 seconds.
4. Think critically: Which colors did your partner select? Which color was least selected? Suppose that the construction paper represents grass, the yarn pieces represent insects, and the tweezers represent an insect-eating bird. Which color of insect do you predict would survive to adulthood?

Notes to the Teacher

Hello dear teachers, this module maybe used by learners with minimal supervision. The activities included are suitable for their level and capacity. Make sure that the learners had finished the previous modules. Thank you.

What's New

Activity 2: Reading Check

Material: Article about Index fossils

A. Read the article about Index fossils to identify subdivisions of geologic time scale and answer the activity below.

A fossil is the remain or evidence of a living thing. The most common fossils are bones, skills, teeth, leaves, spores, and seeds of pollen grains. Most fossils are formed when the whole part of an organism becomes buried in sedimentary rocks, which provide the most important evidence about the evolution of plants and animals. Fossils give clues about organisms that lived long ago. They also provide evidence about how Earth's surface changed overtime. Fossils helps scientist understand what past environments may have been like.

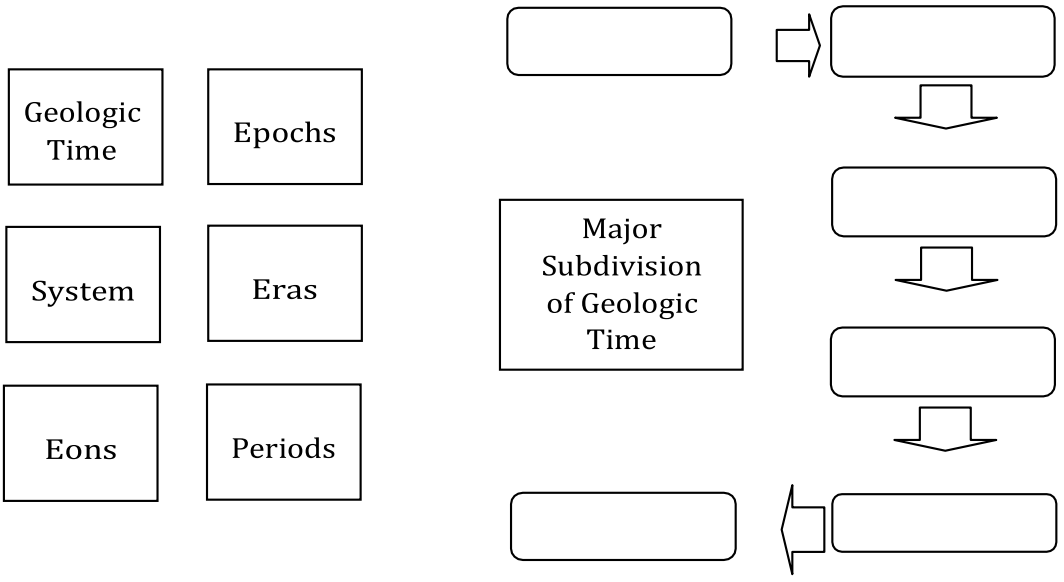
There are five main types of fossils namely: 1) Petrified fossils are formed through petrification that means turning into stones. It forms when minerals replace all part of an organism. 2) Molds and casts form when hard parts of an organism are buried in sediments such as sand, silt, or clay. A cast is formed as the result of mold. Minerals and sediments fill the mold's empty spaces and make a cast. (3) Carbon Films, all living things contain an element called carbon. When an organism dies and is buried in sediments, the material that make up the organism break down. Eventually, only carbon remains. (4) Trace fossils show the activities of organism. An animal makes a footprint when it steps in sand or mud. Overtime the footprint is buried in layers of sediment, then sediment becomes solid rock. (5) Preserved remains, and some organisms get preserved in or close to their original states. There are some ways it can happen;(a) Amber-an organism, such as insect, is trapped in a tree's sticky resins and dies. (b) Tar an organism, such as mammoth, is trapped in a tar pit and dies. (c) Ice-an organism, such as wooly mammoth, dies in very cold regions.

Geologic time is divided into four large segments called Eons: Hadean, Archean, Proterozoic, and Phanerozoic. The Phanerozoic Eon (the eon of visible life) is divided into Eras: The names of the eras are the Cenozoic ("recent life"), Mesozoic ("middle life") and Paleozoic ("ancient life"). The longest geologic era was the Precambrian. It began with the formation of the earth about 4.53 billion years ago and ended about 542 million years ago. So, the Precambrian takes up about 90% of the history of the earth. Next to eons, the longest subdivisions are the eras, which are marked by major, striking, and worldwide changes in the types of fossils present. Eras are subdivided into periods. Periods are units of geologic time characterized by the types of life existing worldwide at the time. Period can be divided into smaller units of time called epochs. Epochs also are characterized by the differences in life-forms, but some of these differences vary from continent to continent. Epochs of period in the Cenozoic era have been given specific names. Epochs of other periods usually are referred to simply as early, middle, or late. Epochs are subdivided into units of shorter duration called system.

Guide Questions:

1. How do fossils form?
2. How do index fossils help scientist to understand the past?
3. Which type of fossil contains carbon?
4. Which are the longest subdivisions of geologic time scale?
5. How long is the Precambrian era?

B. Arrange the major subdivision of the geologic time scale by choosing the right option beside the illustration. Copy the illustration and write your answer on a separate sheet of paper.



C. Match the types of fossils in Column A with their description in column B. Write the letter of the correct answer on a separate sheet of paper.

COLUMN A	COLUMN B
1. PERTIFIED FOSSIL	A. Some organisms get preserved in or close to their original states.
2. MOLDS AND CAST	B. All living things contain an element called carbon.
3. CARBON FILMS	C. Minerals and sediments that are left in the mold make a cast.
4. TRACE FOSSILS	D. It is formed when minerals replace all or part of an organism.
5. PRESERVED REMAINS	E. An animal makes a footprint when it steps in sand or mud.

What is It

Definition of terms:

A **fossil** is any remains of ancient life. It can be body fossils which are remains of the organism itself, or trace fossils, such as burrows, tracks, or other evidence of activity.

Preservation as a fossil is a relatively rare process. The chances of becoming a fossil are enhanced by quick burial and the presence of preservable hard parts, such as bones or shells.

Fossils form in five ways: preservation of original remains, permineralization, molds and casts, replacement, and compression.

Rock formations with exceptional fossils are called very important for scientists to study. They allow us to see information about organisms that we may not otherwise ever know.

Index fossils are fossils that are widespread but only existed for a short period. Index fossils help scientists to find the relative age of a rock layer and match it up with other rock layers.

Living fossils are organisms that haven't changed much in millions of years and are still alive today.

Fossils give clues about the history of life on Earth, environments, climate, movement of plates, and other events.

Adaptations are favorable traits that organisms inherit. Adaptations develop from variations within a population and help organisms to survive in their given environment.

Changes in populations accumulate over time; this is called evolution.

The **fossil record** shows us that present-day life forms evolved from earlier different life forms. It shows us that the first organisms on Earth were simple bacteria that dominated the Earth for several billion years.

Beginning about 540 million years ago more complex organisms developed on Earth. During the Phanerozoic Eon, all the plant and animal types we know today have evolved.

Many **types of organisms** that once lived are now extinct. Earth's overall environment, especially the climate, has changed many times, and organisms change too over time.

Fossils

Throughout human history, people have discovered fossils and wondered about the creatures that lived long ago. The griffin, a mythical creature with a lion's body and an eagle's head and wings, was probably based on skeletons of *Protoceratops* that were discovered by nomads in Central Asia. (Figure 1.1)

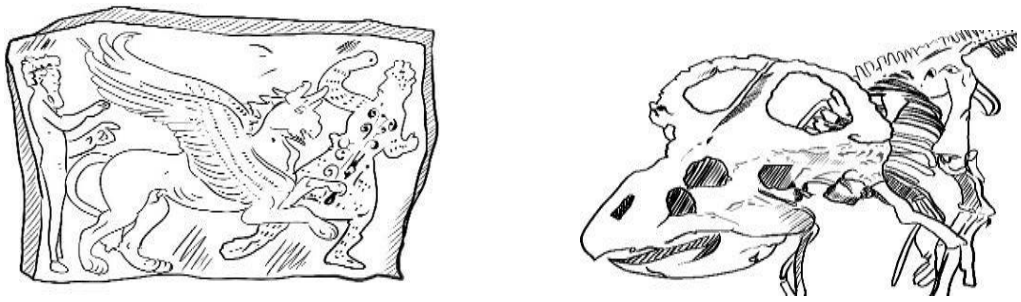


Figure 1.1. Skeletons of *Protoceratops*

Another fossil reminded the Greeks of the coiled horns of a ram. The Greeks named them ammonites after the ram god Ammon. Similarly, legends of the Cyclops may be based on fossilized elephant skulls found in Crete and other Mediterranean islands. Can you see why? (Figure 1.2)

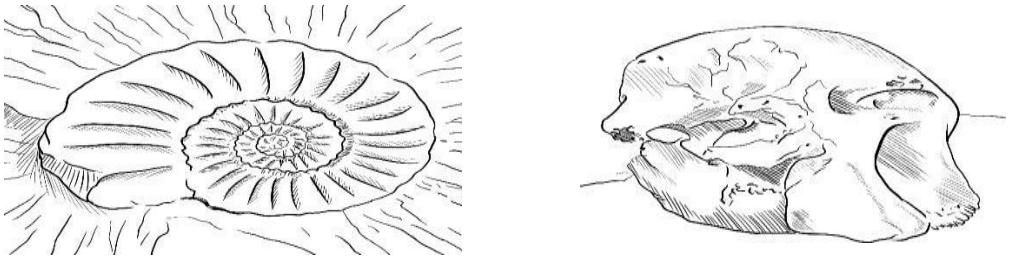


Figure 1.2. Ammonite (left) and elephant skull (right)

The giant pterosaur Quetzalcoatlus had a wingspan of up to 12 meters (39 feet). The dinosaur Argentinosaurus had an estimated weight of 80,000 kg, equal to the weight of seven elephants! Other fossils, such as the trilobite and ammonite, impress us with their bizarre forms and delicate beauty.

Figure 1.3. Kolihapeltis (left) and Ammonite (right)

Clues from Fossils

Fossils are our best form of evidence about the history of life on Earth. In addition, fossils can give us clues about past climates, the motions of plates, and other major geological events.

The first clue that fossils can give is whether an environment was marine (underwater) or terrestrial (on land). Along with the rock characteristics, fossils can indicate whether the water is shallow or deep and whether the rate of sedimentation is slow or rapid.

Fossils can also reveal clues about past climate. For example, fossils of plants and coal beds have been found in Antarctica. Although Antarctica is frozen today, in the past it must have been much warmer.

How are index fossils formed?

Index fossils are the preserved remains of specific species found in the strata of sedimentary rock. They are easily recognized by shape and lived for either a short period, geologically speaking, or completely vanished from the Earth in a known extinction event. Index fossils are usually sea creatures due to preservation conditions and how widespread ocean-dwelling creatures can proliferate on the planet.

Types of Fossils

Fossilization can occur in many ways. Most fossils are preserved in one of five processes; preserved remains, permineralization, molds and casts, replacement, and compression.

1. Preserved Remains

The rarest form of fossilization is the preservation of original skeletal material and even soft tissue. For example, insects have been preserved perfectly in amber, which is ancient tree sap. Several mammoths and even a Neanderthal hunter have been discovered frozen in glaciers.

2. Permineralization

The most common method of fossilization is permineralization. After a bone, wood fragment, or shell is buried in sediment, it may be exposed to mineral-rich water that moves through the sediment. This water will deposit minerals into empty spaces, producing a fossil. Fossil dinosaur bones, petrified wood, and many marine fossils were formed by permineralization.

3. Molds and Casts

In some cases, the original bone or shell dissolves away, leaving behind a space in the shape of the shell or bone. This depression is called mold. Later the space may be filled with other sediments to form a matching cast in the shape of the original organism. Many mollusks (clams, snails, octopi, and squid) are commonly found as molds and casts because their shells dissolve easily.

4. Replacement

In some cases, the original shell or bone dissolves away and is replaced by a different mineral. For example, shells that were originally calcite may be replaced by dolomite, quartz, or pyrite. If quartz fossils are surrounded by a calcite matrix, the calcite can be dissolved away by acid, leaving behind an exquisitely preserved quartz fossil.

5. Compression

Some fossils form when their remains are compressed by high pressure. This can leave behind a dark imprint on the fossil. Compression is most common for fossils of leaves and ferns but can occur with other organisms, as well.

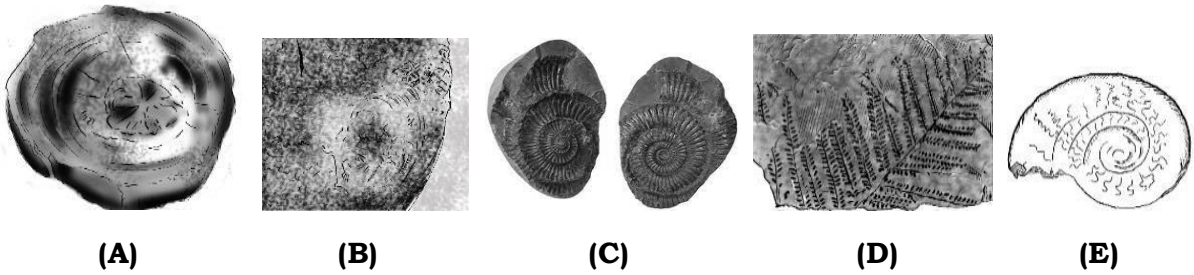


Figure 1.4. Five types of fossils

Insect preserved in (A) amber, (B) petrified wood, (C)cast and mold of a clamshell, (D)compression fossil of a fern, and (E)pyritized ammonite.

Exceptional Preservation

Some rock beds have produced exceptional fossils. Fossils from these beds may show evidence of soft body parts that are not normally preserved. Two of the most famous examples of soft organism preservation are the Burgess Shale in Canada and the Solnhofen Limestone in Germany.

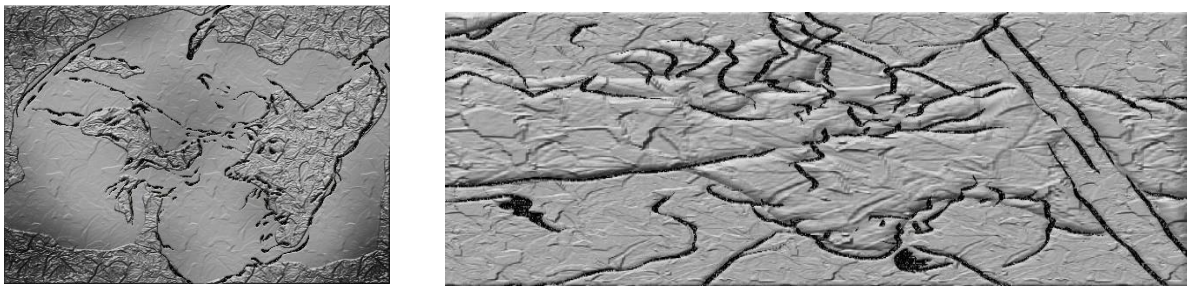


Figure 1.5. Fossils from Lagerstätten: *Archaeopteryx* (left) and *Anomalocaris* (right). Archaeopteryx was an early bird. *Anomalocaris* was an enormous predator (one meter long) that lived 500 million years ago.

Index Fossils and Living Fossils

Index fossils are widespread but only existed for a relatively brief period. When a particular index fossil is found, the relative age of the bed is immediately known.

Ammonites, trilobites, and graptolites are often used as index fossils, as are various **microfossils**, or fossils of microscopic organisms.

Living fossils are organisms that have existed for a tremendously long period without changing very much at all. For example, the Lingulata brachiopods have existed from the Cambrian period to the present, a period of over 500 million years!

Figure 1.6. Fossil *Lingula* (left) and modern *Lingula* (right)

Correlation by Index Fossils

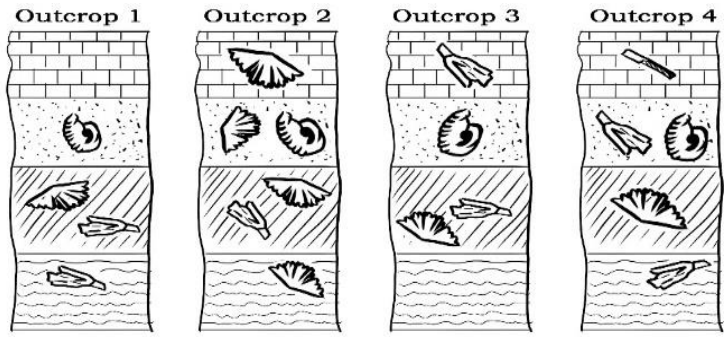
To be considered an index fossil, it must meet 3 criteria:

1. The fossilized organism must be easily recognizable. It must be easy to ID and look unique.
2. The fossils must be geographically widespread or found over large areas so that we can use them to match layers separated by huge distances.
3. The fossil must have lived for only a short time so that it appears in only a horizontal layer of sedimentary rocks.

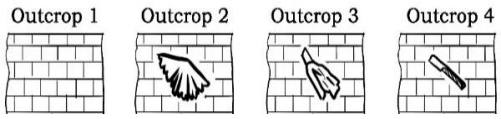
Example:

The diagram shows several rocks outcrops separated by large distances. In each outcrop are several fossils. Which of the fossils shown is an index fossil?

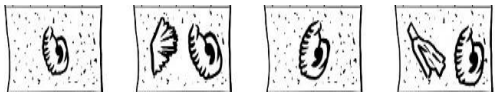
When choosing the right index fossil, we can reinterpret the characteristics of index fossil to help us as stated above: To find the index fossil you must eliminate any fossils that don't show up in each rock outcrop and those that show up in more than one layer per outcrop.



We can eliminate "Fossil 1" because it shows up in multiple layers in the same outcrop. (It lived for too long of a time in Earth's history to help establish dates of other rocks).

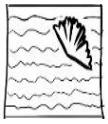


We can eliminate "Fossil 2" because it shows up in multiple layers in Column 2. (It lived for too long a time).



We can eliminate "Fossil 3" because it is only in one layer in one outcrop.

After we've eliminated all the fossils that don't fit the requirements, we have only 1 left that appears in all the outcrops, and only one layer per outcrop. So, the correct index fossil is:

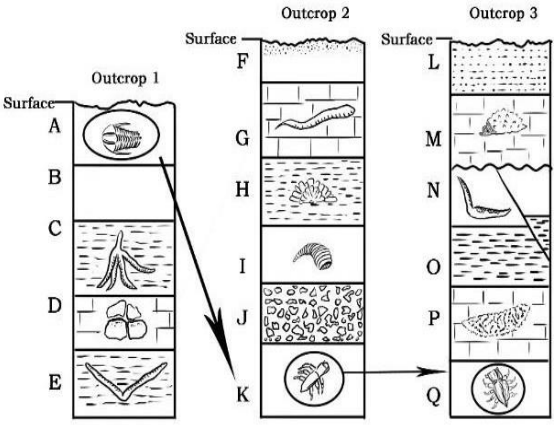


Using Index Fossils to Correlate Rock Layer

We can use index fossils and key beds to correlate or match rock layers with the same age. By doing this, we can then place other layers of rocks in order of their relative ages to find the oldest and youngest rocks in a series of outcrops.

Example:

Examine the outcrop and determine which layers are the oldest and youngest? To find the oldest and youngest layers in the entire diagram, we first must correlate the three outcrops. We can do this by using the trilobite index fossil because it appears in all three outcrops.



By correlating them, we now know that layers A, K, and Q are of the same age. So, to find the oldest rocks we look below them, and to find the youngest rocks we look above them. If we create a chart building our way up and down by looking directly above and below each layer, we will find the top and bottom.

Lesson 2 History of Earth's Life Forms

Today, we may take for granted that we live among diverse communities of animals that feed on each other. Our ecosystems are structured by feeding relationships like killer whales eating seals, which eat squid, which feed on krill. These and other animals require oxygen to extract energy from their food. But that's not how life on Earth used to be.

With an environment devoid of oxygen and high in methane, for much of its history Earth would not have been a welcoming place for animals. The earliest life forms we know of were microscopic organisms (microbes) that left signals of their presence in rocks about 3.7 billion years old. The signals consisted of a type of carbon molecule that is produced by living things.

What's In

The Phanerozoic Eon is divided into three chunks of time called eras—the Paleozoic, the Mesozoic, and the Cenozoic. Their life span is about 540 million years ago to the present. Each era will describe the different types of organisms developed at different times.

Activity 1: "My First"

Directions: Using the word bank, complete the table below.

First humans	First birds	First insects	First plant flowers
First grasses	First mammals	First reptiles	Age of Dinosaurs

Paleozoic	Mesozoic	Cenozoic
1.	4.	7.
2.	5.	8.
3.	6.	9.

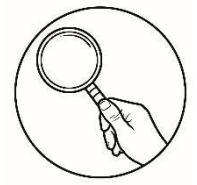
What's New

Time is one thing we all have an equal share. Therefore, we should all utilize time in a way that will allow us to shape and record events and happenings in our life. Make your history of life by creating a timeline of the important events in your life.

Activity 2: "My Own History"

Make a timeline of the important events of your life. You may opt to use the template below or make your own. Write your answer on a separate sheet of paper.

My Life Timeline **Name:** _____	
Years	**Important Events**
0	2002 – I was born in Batangas City at 6:44 am.
3	
5	
6	
9	
12	
15	



What is It

Charles Doolittle Walcott was a paleontologist, a scientist who studies past life on Earth. He was searching for fossils. Riding on horseback, he was making his way down a mountain trail when he noticed something on the ground. He stopped to pick it up. It was a fossil! One of the organisms preserved in the fossils had a soft body like a worm, five eyes, and a long nose like a vacuum cleaner hose.

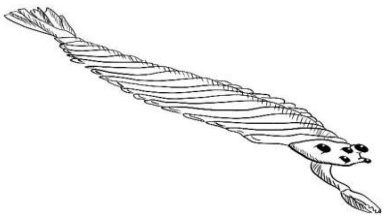


Figure 2:1. This bizarre animal with five eyes lived during the Cambrian.

The organisms in Walcott's fossils lived during a time of geologic history known as the Cambrian. The Cambrian period began about 540 million years ago. It marked the beginning of the Phanerozoic Eon. It also marked the beginning of many new and complex life forms appearing on Earth. In fact, the term Phanerozoic means "time of well-displayed life." We still live today in the Phanerozoic Eon. However, life on Earth is very different today than it was 540 million years ago.

Earth' Diversity

Figure 2.2. Diversity of organisms on Earth.

There are over 1 million species of plants and animals known to be currently alive on Earth. (Figure 12.2) Look around you and notice that the organisms on this planet have incredible **variation**. One of the most remarkable features of Earth's organisms is their ability to survive in their specific environments.

For example, **polar bears** have thick fur coats that help them stay warm in the icy waters that they hunt in.

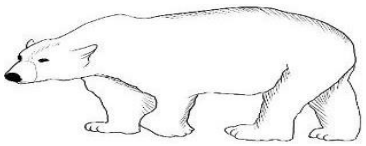


Figure 2.3. Polar bear

Other organisms have special features that help them hunt for food or avoid being the food of another organism. For example, when zebras in a herd run away from lions, the zebras' dark stripes confuse the lions and make it hard for them to focus on just one zebra during the chase. Hummingbirds have long thin beaks that help them drink nectar from flowers. Some plants have poisonous or foul-tasting substances in them that keep animals from eating them.

Adaptations and Evolution

The characteristics of an organism that help it survive in each environment are called adaptations. Adaptations develop when certain variations in a population help some members survive better than others. Often the variation comes from a mutation or a random change in an organism's genes. The ones that survive pass favorable traits on to their offspring.

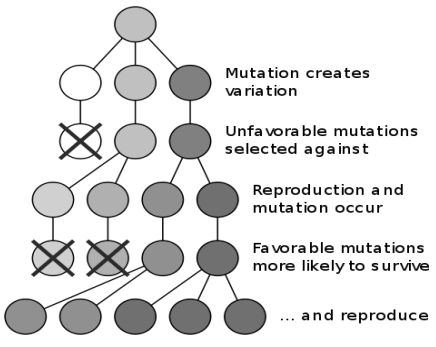


Figure 2.4. Adaptations and Evolution

Changes and adaptations in a species accumulate over time. Eventually, the descendants are very different from their ancestors and may become a whole new species. Changes in a species over time are called evolution. It shows us that many of the life forms that live today developed from earlier, different life forms.

For example, horse fossils show us that about 60 million years ago horses were much smaller than they are today (Figure 12.5). Fossils also show us that horses' teeth and hooves have changed several times as horses have adapted to changes in the environment.

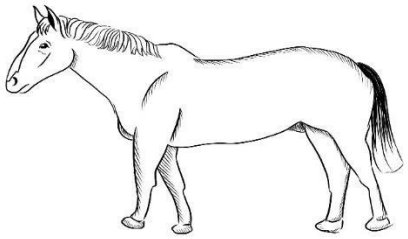


Figure 2.5. Horse

Studying the Fossil Record

Like the organisms that were represented in Walcott's fossils, many of the organisms that once lived on Earth are now extinct. Earth's overall environmental conditions have changed many times since the Cambrian, and many organisms did not have the traits to survive the changes. Those that did survive the changes passed traits on to their offspring. They gave rise to the species that live today.

We study fossils to learn about how species responded to change over the Earth's long history. Fossils show us that simple organisms dominated life on Earth for its first 3 billion years. Then, between 1 and 2 billion years ago, the first multi-cellular organisms appeared on Earth. Life forms gradually evolved and became more complex. During the Cambrian period, animals became more **diverse** and complex.

Phanerozoic Eon

The Phanerozoic Eon is divided into three chunks of time called eras—the Paleozoic, the Mesozoic, and the Cenozoic Table (1). They span from about 540 million years ago to the present. We now live in the Cenozoic Era.

The table below shows how life has changed during the long span of the Phanerozoic Eon. Notice that different types of organisms developed at different times. However, all organisms evolved from a common ancestor. Life gradually became more diverse and new species branched out from that common ancestor. Most modern organisms evolved from species that were now extinct.

Table 1. Development of Life During the Phanerozoic Eon

Era	Millions of Years Ago	Major Forms of Life
Cenozoic	0.2 (200,000 years ago)	First humans
	35	First grasses; grasslands begin to dominate land
Mesozoic	130	First plants with flowers
	150	First birds on Earth
	200	First mammals on Earth
	251	Age of dinosaurs begins
Paleozoic	300	First reptiles on Earth
	360	First amphibians on Earth
	400	First insects on Earth
	475	First reptiles on Earth
	500	First amphibians on Earth

The eras of the Phanerozoic Eon are separated by events called mass extinctions. A mass extinction occurs when large numbers of organisms become extinct in a short amount of time. Between the Paleozoic and the Mesozoic, nearly 95% of all species on Earth died off.

Between the Mesozoic and the Cenozoic, about 50% of all animal species on Earth died off. This mass extinction, 65 million years ago, is the one in which the dinosaurs became extinct. Earth's climate changed numerous times during the Phanerozoic Eon. Just before the beginning of the Phanerozoic, much of the Earth was cold and covered with glaciers.

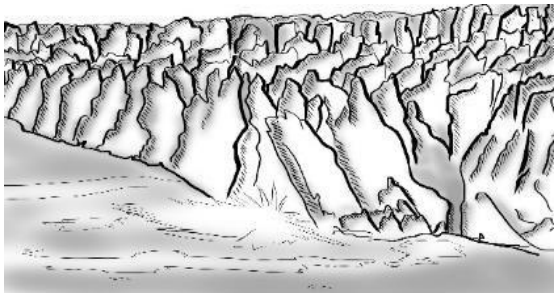


Figure 2.6. Glacier

The Phanerozoic began, however, the climate was changing to a warm and tropical one. (Figure 12.7) The glaciers were replaced with tropical seas. This allowed the Cambrian Explosion of many new life forms on Earth. During the Phanerozoic, Earth's climate has gone through at least 4 major cycles between times of cold glaciers and times of warm tropical seas.

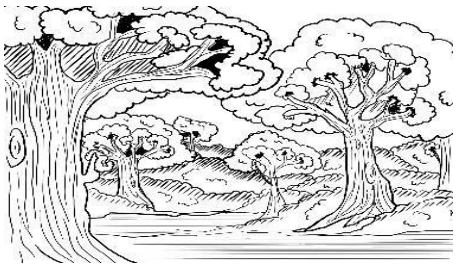


Figure 12.7. Tropical Changes

Lesson 3 How Index Fossils Help Define Geologic Time?

Index fossils are used to define geological periods. These fossils can be defined as "commonly found, widely distributed fossils that are limited in time span." If one finds an index fossil in each layer, then one has bounds on the age of the layer. Using the index fossils, the geological periods are defined. These are intervals of time that are believed to have lasted for tens of millions of years, in most cases. The geological periods make up the "geological column" which lists the periods in sequence. The question arises whether the "geological column" is real or results from the attempt to make sense of the fossil distribution.

Because the geological periods always, or almost always, appear in the proper sequence in the fossil record, though some periods may be missing in places. It is argued that the geological column is real and represents the order in which various life forms existed in the past. However, this argument is circular. The geological periods are defined using index fossils, and the index fossils are chosen so that the resulting geological periods occur in order.

The significance of this for the creation-evolution controversy is that creationists sometimes attempt to construct flood models to produce a rigid sequence of fossils as displayed in textbook diagrams of the geological column. The flood models don't need to reproduce this sequence so exactly. Any flood model that puts the fossils in an approximate order would probably by chance create some fossils of limited distribution. That could then be considered as index fossils and used to define a geological column with properties such as the current column possesses.

What's In

Activity 1: "Vital Events of One's Life Cycle"

Create a picture compilation of the important events of your life. Put it in a short folder. Rubrics will be used to evaluate your output.

Rubrics:

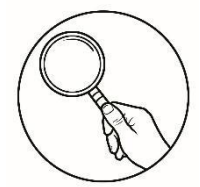
	Poor 5 pts	**Fair 10 pts**	**Good 20 pts**	**Excellent 30 pts**
Organization	The pictures & words were not organized/ balanced.	The pictures & words were generally organized/balanced.	The pictures & words were well organized and included several different types of media photos or art.	The pictures were extremely well organized/ balanced and included several different types of pictures, words, drawings.

Content Knowledge	The picture collage did not demonstrate the student's understanding of the assignment.	The picture collage generally demonstrated student's understanding of the assignment, but a few things were lacking.	The picture collage clearly demonstrated student's understanding of the assignment.	The picture collage sincerely demonstrated the student's understanding of the gratitude assignment. The student added extra information.
Format	The student did not follow the format given for this assignment.	The student generally followed the format given for this assignment; however, there were still a few things missing.	The student followed the format given for this assignment and included all required information.	The student followed the format given for this assignment and included all required information. The student may have also included something extra.
Creativity	Not much effort was put into making the collage colorful, unique, or eye-catching.	Some effort was given to make the collage interesting.	The student demonstrated creative methods for designing a collage. Various materials were utilized.	The student demonstrated creative methods for designing a collage. Various materials were utilized. It was very neat and appealing.

What's New

Activity 2: "Reflections"

Read the quotation below and do some reflection. Write at least 3 to 4 sentences about your insights.



What is It

Geologic Time

The first principle you need to understand about geologic time is that the laws of nature are always the same. This means that the laws describing how things work are the same today as they were billions of years ago. For example, water freezes at 0°C. This law has always been true and always will be true. Knowing the natural laws helps you think about Earth's past because it gives you clues about how things happened very long ago. It means that we can use present-day processes to interpret the past. Imagine you find **fossils** of sea animals in a rock. That law has never changed, so the rock must have formed near the sea. The rock maybe millions of years old, but the fossils in it serve as a clue for us today about how it was formed.

Now imagine that you find that same rock with fossils of a sea animal in a place that is very dry and nowhere near the sea. How could that be?

Remember that the laws of nature never change. Therefore, the fossil means that the rock formed by the sea. This tells you that even though the area is now dry, it must have once been underwater. Clues like this have helped scientists learn that Earth's surface features have changed many times. Spots that were once covered by warm seas may now be cool and dry. Places that now have tall mountains may have once been low, flat ground. The place where you live right now may look very different in the far future. Every fossil tells us something about the age of the rock it's found in, and index fossils are the ones that tell us the most. Index fossils (also called key fossils or type fossils) are those that are used to define periods of geologic time.

Characteristics of an Index Fossil

A good index fossil is one with four characteristics: it is distinctive, widespread, abundant, and limited in geologic time. Because most fossil-bearing rocks formed in the ocean, the major index fossils are marine organisms.

Boom-And-Bust Organisms

Any type of organism can be distinctive, but not so many are widespread. Many important index fossils are of organisms that start life as floating eggs and infant stages, which allowed them to populate the world using ocean currents. The most successful of these became abundant, yet at the same time, they became the most vulnerable to environmental change and extinction.

Trilobites, Hard-Shelled Invertebrates

Consider trilobites, a very good index fossil for Paleozoic rocks that lived in all parts of the ocean. Trilobites were constantly evolving new species during their existence, which lasted 270 million years from Middle Cambrian time to the end of the Permian Period, or almost the entire length of the Paleozoic. Because they were mobile animals, they tended to inhabit large, even global areas. They were also hard-shelled invertebrates, so they fossilized easily. These fossils are large enough to study without a microscope.

Small or Microscopic Fossils

Other major index fossils are small or microscopic, part of the floating plankton in the world ocean. These are handy because of their small size. They can be found even in small bits of rock, such as wellbore cuttings. Because their tiny bodies rained down all over the ocean, they can be found in all kinds of rocks.

Terrestrial Rocks

For terrestrial rocks, which form on land, regional or continental index fossils may include small rodents that evolve quickly, as well as larger animals that have wide geographic ranges. These form the basis of provincial time divisions.

Defining Ages, Epochs, Periods, and Eras

Index fossils are used in the formal architecture of geologic time for defining the ages, epochs, periods, and eras of the geologic time scale. Some of the boundaries of these subdivisions are defined by mass extinction events, like the Permian Triassic extinction. The evidence for these events is found in the fossil record wherever there is a disappearance of major groups of species within a geologically short amount of time.

Geologic Time Scale

Today, the geologic time scale is divided into major chunks of time called eons. Eons may be further divided into smaller chunks called eras, and each era is divided into periods. We now live in the Phanerozoic eon, the Cenozoic era, and the Quaternary period. Sometimes, periods are further divided into epochs, but they are usually just named "early" or "late", for example, "late Jurassic", or "early Cretaceous."

Note that chunks of geologic time are not divided into equal numbers of years. Instead, they are divided into blocks of time when the fossil record shows that there were similar organisms on Earth.

One of the first scientists to understand geologic time was James Hutton. In the late 1700s, he traveled around Great Britain and studied sedimentary rocks and their fossils. He believed that the same processes that work on Earth today formed the rocks and fossils from the past. He knew that these processes take a very long time, so the rocks must have formed over millions of years. He is sometimes called the "Father of Geology."

Figure 3.1 shows you a different way of looking at the geologic time scale. It shows how Earth's environment and life forms have changed.

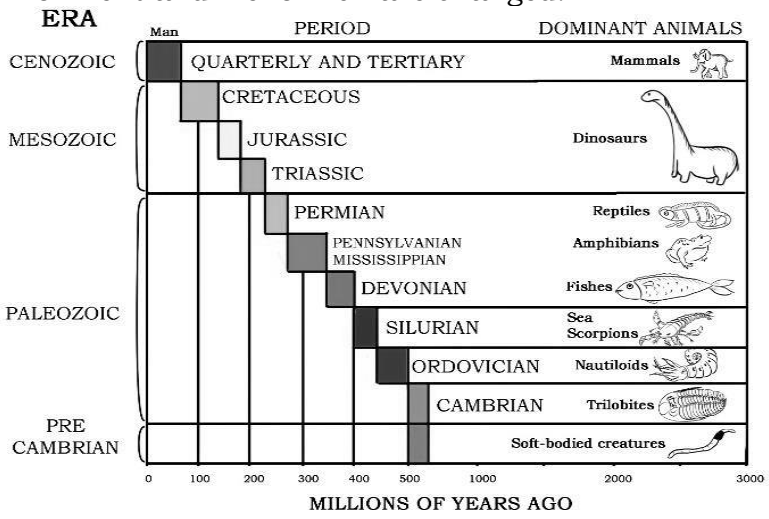
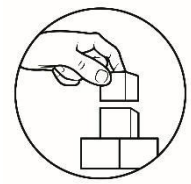


Figure 3.1. Sample of a Geologic Time Scale

- A fossil is any remains of ancient life. Fossils can be body fossils, which are remains of the organism itself, or trace fossils, such as burrows, tracks, or other evidence of activity.
- Preservation as a fossil is a relatively rare process. The chances of becoming a fossil are enhanced by quick burial and the presence of preservable hard

parts, such as bones or shells.

- Fossils form in five ways: preservation of original remains, permineralization, molds and casts, replacement, and compression.
- Rock formations with exceptional fossils are called very important for scientists to study. They allow us to see information about organisms that we may not otherwise ever know.
- Index fossils are fossils that are widespread but only existed for a short period. Index fossils help scientists to find the relative age of a rock layer and match it up with other rock layers.
- Living fossils are organisms that haven't changed much in millions of years and are still alive today.
- Fossils give clues about the history of life on Earth, environments, climate, movement of plates, and other events.
- Adaptations are favorable traits that organisms inherit. Adaptations develop from variations within a population and help organisms to survive in their given environment.
- Changes in populations accumulate over time; this is called evolution.
- The fossil record shows us that present-day life forms evolved from earlier different life forms. It shows us that the first organisms on Earth were simple bacteria that dominated the Earth for several billion years.
- Beginning about 540 million years ago, more complex organisms developed on Earth. During the Phanerozoic Eon, all of the plant and animal types we know today have evolved.
- Many types of organisms that once lived are now extinct. Earth's overall environment, especially the climate, has changed many times, and organisms change too over time.



What's More

Activity 3: Identifying an Index Fossil

Fill in the table below by identifying each sample as index fossil or not. Write the criteria and support your answer.

CRITERIA
Easily Recognizable = the diagram clearly illustrates each fossil.
Widespread = the fossil must show up in each of the different outcrops/columns
Short Lived= any fossils that don't show up in each rock outcrop and those that show up in more than one layer per outcrop.

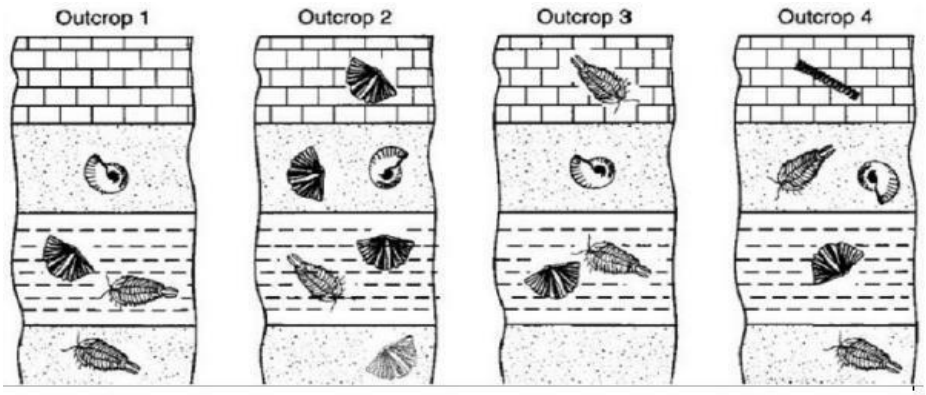


Figure 3.2. Index Fossil

Sample Fossils	Is it an Index Fossil? (Yes/No)	Criteria to identify Index Fossil	Reason
Fossil #1: 			
Fossil #2: 			
Fossil #3: 			
Fossil #4: 			

Activity2: Geologic History

Directions: Copy the table on a separate sheet of paper. Draw or illustrate at least two samples of plants and animals during different eras.

Era	Plants	Animals
Cenozoic		
Mesozoic		
Paleozoic		

What I Have Learned

Activity 1: "Fill Me Up"

Fill in the blank and choose your answer in the box provided. Write your answer on a separate paper.

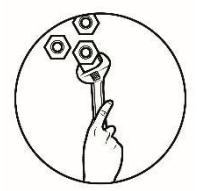
preserved remains	past climates	sedimentary rock
motions of plates	permineralization	replacement
molds and casts	major geological events	Compression
microfossils	must be easily recognizable	adaptations
Fossilization	lived for only a short time	mass extinction
Living fossils	geographically widespread	variation

1. Fossils are our best form of evidence about the history of life on Earth, in addition, fossils can give us clues about _____, _____, and _____.
2. Index fossils are the preserved remains of specific species found in the strata of _____.
3. Most fossils are preserved in one of five processes; _____, _____, _____, and _____, _____.
4. Ammonites, trilobites, and graptolites are often used as index fossils, as are various _____, or fossils of microscopic organisms.
5. _____are organisms that have existed for a tremendously long period of time without changing very much at all.
6. To be considered an index fossil, it must meet 3 criteria: The fossilized organism
(1). _____
(2). _____
(3). _____
7. The process of a once living organism becoming a fossil is called _____.
8. An amazing diversity of organisms on Earth and it is called as _____.
9. The characteristics of an organism that help it survive in each environment are called _____.
10.The eras of the Phanerozoic Eon are separated by events called _____.

Activity 2: "Vocabulary Words to Remember!"

Arrange the following jumbled vocabulary words. Write your answer on a separate paper.

1. **B E R A M** _____Fossilized tree sap.
2. **S O F L I S** _____Any remains or trace of an ancient organism.
3. **A T O R I C P L** _____A climate that is warm and humid.
4. **T A C S** _____A structure that forms when sediments fill a mold and harden, forming a replica of the original structure.
5. **E A R I N M** _____Of or belonging to the sea.
6. **D O L M** _____ An impression made in sediments by the hard parts of an organism.
7. **C R E T A L O S F S I** _____Evidence of the activity of an ancient organism. Examples include tracks, trails, burrows, tubes, boreholes, and bite marks.
8. **L I A R S E R E T R I L A S** _____Of or belonging to the land
9. **L A C I G E R S** _____Large sheets of flowing ice.
10.**L E N S T A O O L O G P I T** _____A scientist who studies Earth's past life forms.



What I Can Do

Activity: "Finding Index Fossil"

Since we only have one outcrop, we do not need to worry about the criteria being widespread. We do need to look at the criteria of being short-lived which means the index fossil will be found in one layer(s). Write your answer on a separate sheet of paper.

1. Which layer(s) contain Fossil A?

_____

2. Which layer(s) contain Fossil B?

_____

3. Which layer(s) contain Fossil C?

_____

4. Which layer(s) contain Fossil D?

_____

5. Which layer(s) contain Fossil E?

_____

6. Which layer(s) contain Fossil F?

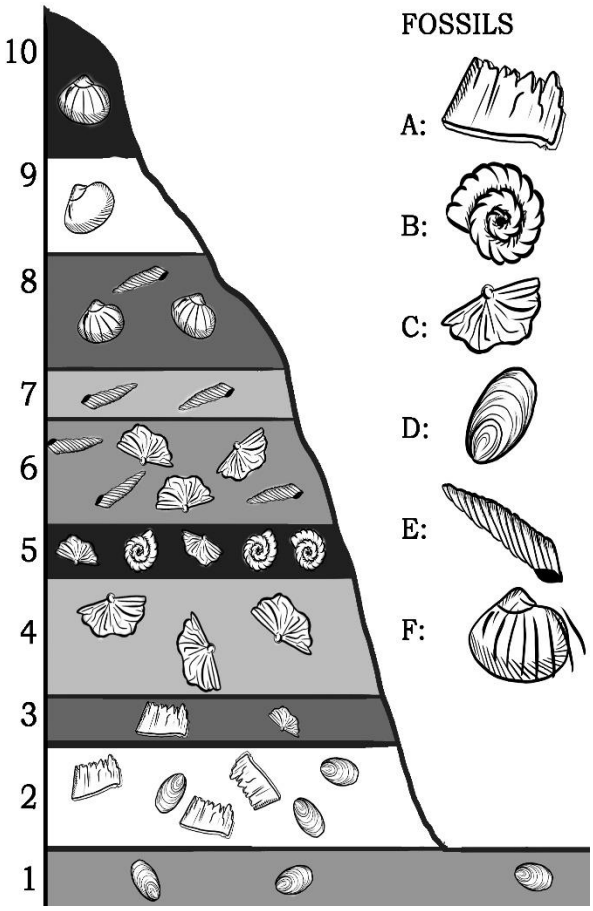
_____

7. Therefore the index fossil is Fossil _____.

8. The longest-lived fossil is Fossil _____ because it was found in _____ layers.

9. Determine the relative age of the fossils:

_____ (youngest fossil)
_____
_____
_____
_____
_____ (oldest fossil)



Assessment

Multiple Choice. Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. What are the common fossils?
    a. Bones and teeth
    b. Spores and seeds
    c. Options A and B are correct.
    d. Options A and B are incorrect.

2. What type of preserved fossils are trapped in a tree's sticky resins and dies?
    a. Amber
    b. Tar
    c. Ice
    d. Wood

3. Which Era represents "ancient life?
    a. Cenozoic
    b. Mesozoic
    c. Paleozoic
    d. Proterozoic

4. When did the Precambrian Era begin?

    a. 4.53 billion years ago
    b. 4.54 billion years ago
    c. 4.55 billion years ago
    d. 4.56 billion years ago

5. What is the shorter unit of Epochs?

    a. Period
    b. Time
    c. System
    d. Eon

6. A good index fossil must include four characteristics except for _____.
    a. distinctive
    b. widespread
    c. abundant
    d. long life

7. _____ is another name for index fossil.
    a. Key fossils
    a. Pattern fossils
    b. Lead fossils
    c. Design fossils

8. He is sometimes called the “Father of Geology.”
    a. Charles Darwin
    b. Charles Doolittle Walcott
    c. James Hutton
    d. James Ingram

9. _____ means that an organism completely dies out.
    a. Adaptation
    b. Extinction
    c. Evolution
    d. Regeneration

10. Which of the following statement is correct about the Geologic Time Scale?
    a. It is divided into major chunks of time called Eras. Eras may be further divided into smaller chunks called eons, and each eon is divided into periods.
    b. It is divided into major chunks of time called eons. Eons may be further divided into smaller chunks called eras, and each era is divided into periods.
    c. It is divided into major chunks of time called periods. Periods may be further divided into smaller chunks called eras, and each era is divided into eons.
    d. It is divided into major chunks of time called eras. Eras may be further divided into smaller chunks called period, and each period is divided into eons.

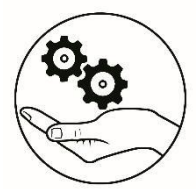
11. Which of the following represents the longest time?
    a. Precambrian
    b. Paleozoic
    c. Mesozoic
    d. Cenozoic

12. Which rock type are fossils most common?
    a. sedimentary
    b. igneous
    c. metamorphic
    d. all these commonly contain fossils

13. Which of the following will not make a fossil?
    a. animal footprints
    b. loose animal bones
    c. plant impressions (casts)
    d. decomposed organic material

14. Most periods in the geologic time scale are named for _____.
    a. geographic localities
    b. catastrophic events
    c. paleontologists
    d. fossils

15. Which geologic era do human beings evolve?
    a. Cenozoic
    b. Mesozoic
    c. Paleozoic
    d. Precambrian



Additional Activities

Worksheets

A. Fossils and Ancient Life

For Questions 1–3, complete each statement by writing the correct word or words.

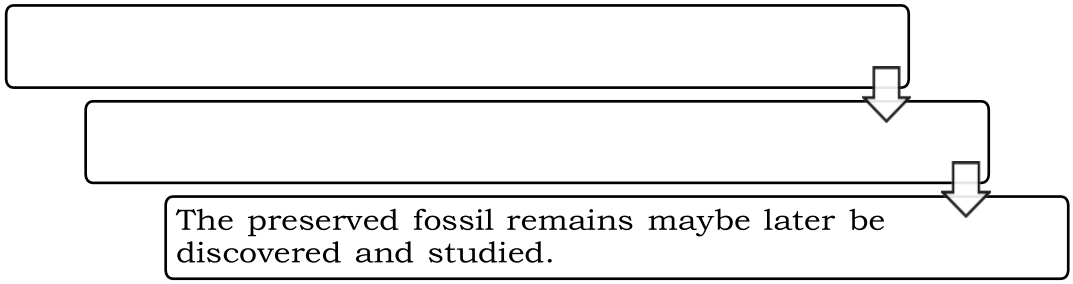
1. Species that died out are said to be _____.
2. Most fossils are found in layers of rock _____.
3. Scientists who study fossils are called _____.
4. What is the fossil record?

   _____
   _____

5. What information does the fossil record provide?

   _____
   _____

6. Explain how fossils are formed. Fill in the chart below.



B. Dating Earth's History

7. What is an index fossil? What do index fossils reveal about other material found with them?

   _____
   _____

8. Fossil A is found in a layer of rock above a layer containing Fossil B. Which fossil is probably older? Explain your answer.

   _____
   _____

9. List the two techniques paleontologists used to determine the age of fossils.

   _____
   _____

Answer Key

What I Know

1. A
2. B
3. A
4. C
5. A
6. D
7. B
8. A
9. C
10. A
11. D
12. B
13. A
14. C
15. C

What's More

1. no, widespread outcrops/columns
2. no, short lived layer/row
3. yes, widespread and short lived, everyone
4. no, short lived layer /row

What I Can Do

1. 2,3
2. 5
3. 3, 4, 5, 6
4. 1, 2
5. 6, 7, 8
6. 8, 9, 10
7. B
8. C, 4
9. F, E, B, C, A, D

Assessment

1. C
2. A
3. C
4. A
5. C
6. D
7. A
8. C
9. B
10. B
11. A
12. A
13. D
14. A
15. A

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