Paleo Lab #5 - Fossilization and Fossil Identification

INTRODUCTION

The objectives of this exercise are to understand what fossils are, to recognize the different styles of fossil preservation, and to learn a small number of basic features that are useful in the identification of different groups of animal fossils. Specimens available in the laboratory and illustrations in this manual are only representative of these basic concepts of preservation and identification. In reality, no two fossils are exactly alike or necessarily identically preserved.

WHAT IS A FOSSIL?

Just as minerals are defined as naturally occurring inorganic solids with definite crystal structures and chemical compositions, a practical definition of the word fossil (from the Latin word "fossils" meaning "to dig up") consists of a small number of basic concepts.

1. A fossil represents *evidence of past life*. By *life*, we mean animal or plant life. Evidence can be either direct evidence, that is an actual part of the original plant or animal, or indirect evidence, namely some feature such as a footprint or burrow that was not actually a part of the animal or plant but does indicate its existence and life activity. The term *past* is vague, so we generally restrict it to an arbitrary time. For this purpose, we will say that evidence of past life older than 11,700 years (the beginning of the Holocene or Recent epoch of geologic time) potentially qualifies as a fossil.

2. There is actually something missing from our first part definition above. This important concept is that all fossils are also *naturally preserved*. In other words, natural processes of burial and chemical and physical activity have selectively preserved those evidences of past life. Consequently, preservation that results from human activity, such as embalming a mummy, excludes those items from being called fossils. Similarly, human artifacts are usually not called fossils.

PRESERVATION OF FOSSILS

Almost immediately after the death of an organism a variety of physically and chemically destructive forces begin to act on the remains. Soft, or *nondurable* parts are composed of organic compounds (those chiefly including hydrogen, carbon, and oxygen) and are particularly vulnerable to attack by other organisms, especially scavengers and microscopic fungi and bacteria. Rapid, nearly instantaneous, burial is necessary for preservation of nondurable parts, although bacterial decay will almost always take place. Hard, or *durable* parts also require rapid burial in order to improve chances for preservation. However, the fact that most durable parts are composed of minerals, unlike the organic composition of nondurable parts, makes them immune from such processes as bacterial decay.

There are several kinds of preservation that involve different physical and chemical processes. Some of these constitute **direct evidence** of the original organism, and some **indirect evidence**.

DIRECT EVIDENCE

1. *Complete preservation* is exceedingly rare because the most rapid burial conditions are required to prevent bacterial decay. Complete frozen carcasses of Pleistocene mammoths in the glacial ice of Siberia; insects preserved in amber (fossil tree sap); and some natural (that is, not embalmed by humans) mummies are the primary examples.

2. *Unaltered durable parts* primarily refers to those parts (such as shells, bones, teeth) that are composed of mineral material. To remain unaltered, those parts must retain their original mineral composition and the microscopic structure that was produced by the living organism. There are four common minerals found in durable parts of organisms:

A. **Apatite** (calcium phosphate) - found mainly in vertebrate bones and teeth, hardness - 5, does not react with acid.

B. **Calcite** (calcium carbonate)* - found mainly in shells and other skeletons of marine animals and plants, hardness - 3, effervesces with acid.

C. **Aragonite** (calcium carbonate)* ** - found mainly in shells and other skeletons of marine animals and plants, hardness - 3, effervesces with acid.

D. **Opal** (hydrated silica) ** - found in skeletons of a small number of marine animals and plants, hardness - 7, does not react with acid.

* Calcite and aragonite have similar chemical compositions and physical properties but differ in their orderly internal arrangements of atoms. The most reliable way to distinguish them is by X-ray methods.
** Aragonite and opal are structurally unstable and are extremely susceptible to alteration.

For our purposes, we will consider a fossil to be unaltered if it has retained its original mineral composition and lacks evidence of any additional preservation process. Altered durable or nondurable parts have undergone a physical or chemical change, usually by one of the following processes:

3. *Carbonization* is the most common preservation mode for organic durable and nondurable remains. Heat and pressure drive off hydrogen, oxygen and nitrogen, leaving only a dark film of carbon showing the outline of the fossil.

4. *Permineralization* (Petrification) involves the filling of pore spaces in a durable part by mineral material. A petrified bone thus becomes heavier than its unaltered porous counterpart. A petrified tree, where minerals have crystallized in cells, may show more of its original anatomy than its carbonized counterpart in a coal bed.

5. *Replacement* is caused by the removal of the original mineral (usually by

dissolution of calcite or aragonite) and then the filling of the space with a different mineral precipitated from solution. Usual replacement minerals, such as pyrite and quartz, make this mode of preservation obvious by their physical properties.

6. *Recrystallization* is a general term to describe physical changes, but not chemical changes, in mineral parts. For example, both aragonite and opal are minerals that are "unstable" at or near the earth's surface and, with time, alter to calcite and quartz, respectively. Because the resultant minerals have similar physical properties to the original minerals, it will not be possible to recognize this mode of preservation with certainty during this and subsequent labs. However, these transformations occur rapidly, in a geologic sense, so that any fossil belonging to a group of organisms that is characterized by either an aragonite or opal skeleton is almost always recrystallized and not unaltered.

INDIRECT EVIDENCE

Remember that not all fossils were actually parts of an organism. The following are the most common types of indirect evidence for past life.

7. *Tracks, trails and burrows* represent animal activity over or within a body of sediment. The animal may have long ago moved on, but outlines of tracks, trails and burrows (collectively called ichnofossils) remain, so long as they were rapidly buried before waves or currents could disrupt them. Hollow cavities left by the decay of roots would be indirect evidence for the presence of plants.

8. *Molds* are impressions of the remains of an organism, and usually form as the result of chemical dissolution of a calcium carbonate skeleton. Sediment filling the inside of the original skeleton forms an internal mold, whereas the external mold shows the impression of the outside of the organism or part. Casts are natural replicas of remains formed by filling of molds.

9. *Coprolites* are the fossil excrement of many types of marine and terrestrial animals.

IDENTIFYING FOSSILS

It is important to begin learning some basics of fossil identification that will be helpful in the following lab:

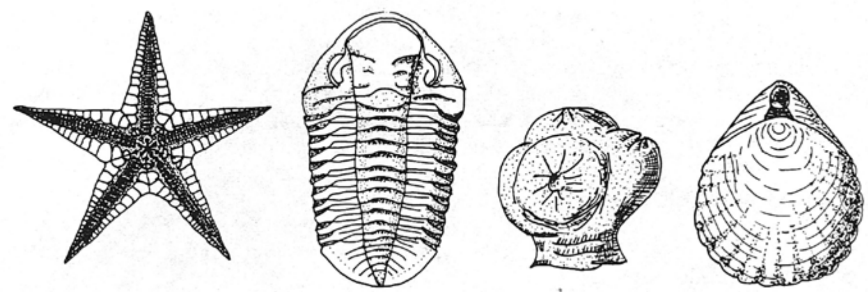
The three basics to be learned here are:

1. Body or skeletal symmetry
2. Numbers of skeletal component parts
3. Colonial vs. solitary organisms

Rarely is any one of these the sole basis for identification, but together and with knowledge of skeletal mineralogy they go a long way in helping us to identify the major fossil groups.

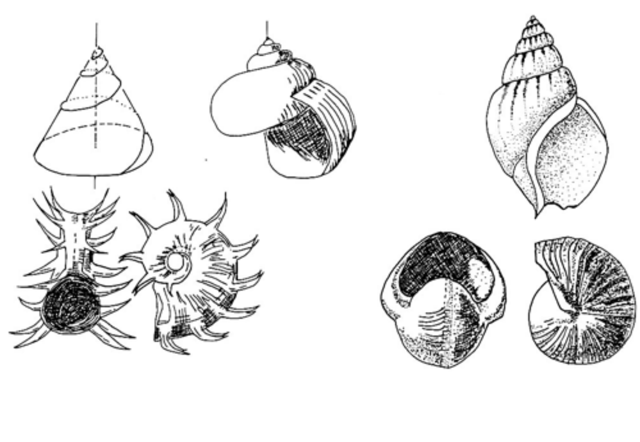
1. Symmetry is the balance of proportions in an object or organism that allows it to be divided into two or more nearly equal parts. Organisms typically show either a bilateral (2 part) symmetry, radial (more than 2 part) symmetry or no symmetry at all.

Examine the sketches below and determine whether the organisms represented have bilateral, radial or no symmetry. Draw a line or lines on the sketches to show how each could be cut into equal identical parts.

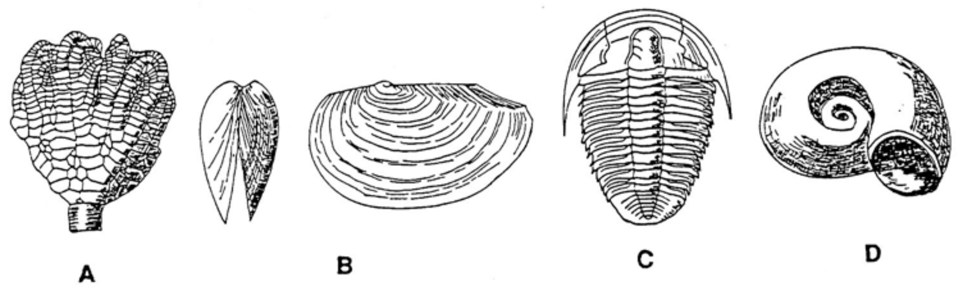


a.______________ b.______________ c.______________ d.______________

A special kind of symmetry is the spiral or coil, which is especially common in one group of animals, the mollusks. **How would you additionally describe the type of spiral symmetry in terms of bilateral, radial, or no symmetry in the diagrams below?**

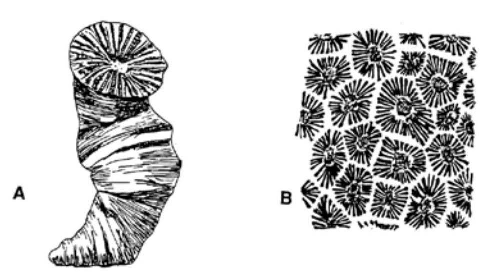


2. When discussing the mineral skeleton of an animal or plant, it is useful to know how many parts are present. For example, our human skeleton has 206 bones, whereas a snail has only a single shell. The figure below shows several kinds of organisms that have a different number of parts to their skeletons.



Four different fossils showing differing number of skeletal parts. A. Crinoid with extremely large number (more than 1000) of calcite plates held together by soft tissue. B. Pelecypod (clam) shell shown in two different views to demonstrate the two-part shell. C. Trilobite composed of approximately 16 segments. D. Gastropod (snail) shell composed of only a single part.

3. Solitary and colonial organisms are two important levels of organization that we can relate to most living and fossil animals. Solitary animals, of which humans are excellent examples, live their lives without any permanent physical attachment to another individual of the same species. The vast majority of such solitary animals are produced by sexual reproduction, and each animal secretes only one set of skeletal parts (providing that it has a skeleton). Colonies of animals (excluding “colonies” of social insects) form by the asexual reproduction of individuals from a parent individual by a process called budding. In most instances, budding maintains a physical attachment between “parent” and budded individuals. Skeletons secreted by individuals comprising a colony usually appear as a grouping of similar appearing units, each of which housed one individual.



A. Solitary coral skeleton, showing radial symmetry at the top, produced by a single coral animal. B. Colonial coral skeleton overall has no symmetry, but is composed of many individual units, each formed by a single coral animal, showing similar radial symmetry.

TRACE FOSSILS

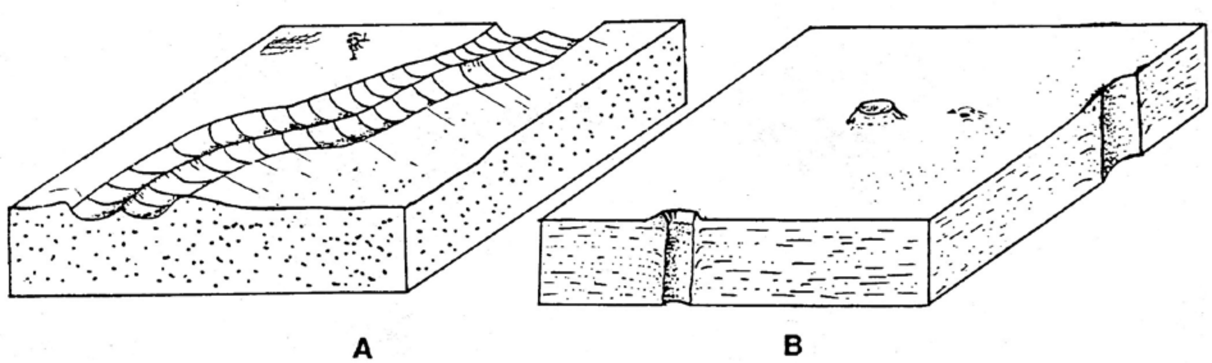
The tracks, trails and burrows previously mentioned as "Indirect Evidence" for past life are usually collectively grouped as "Trace Fossils." We treat them separately here for a number of reasons.

1. Unless the animal or plant that actually made the trace was preserved in the trace, it is virtually impossible to recognize sometimes even the group of organisms, let alone the species that made it.

2. Traces reflect body form and symmetry or parts in contact with the sediment, and many similar appearing traces, such as vertical tube-shaped burrows, may have been made by unrelated types of animals.

3. More than anything, traces are records of an animal's activity. Although the animal that made the trace may not be known, we may know what it was doing, such as resting, crawling on the sea floor burrowing down into the sediment, feeding, or moving upward through the sediment to keep from being smothered.

We will examine trace fossils as two groups: (1) those on the surfaces of sedimentary rock beds and (2) those within sedimentary rock beds.



Two kinds of trace fossils: A. a bed-surface trace, and B. a vertical-tube trace.

What conclusions might you draw concerning the life habits of the organism that produced the surface trace (A) versus those that produced the vertical tubes (B)?

#	Symmetry	Body Parts	Colonial vs. Solitary	Mode of Presservation	NOTES
1					
2					
3					
4					
5					
6					

#	Symmetry	Body Parts	Colonial vs. Solitary	Mode of Presserveration	NOTES
7					
8					
9					
10					
11					
12					

#	Symmetry	Body Parts	Colonial vs. Solitary	Mode of Presservation	NOTES
13					
14					
15					
16					
17					
18					