Background: Fossils, rock strata and the geologic time scale

Fossils always seem to excite us. Whether finding a fossil, or simply observing one, the opportunity to experience an actual organism from the ancient past elicits a sense of wonder. Fossils include any preserved remains of life. Fossils can be molds (such as an imprint of a fern), traces of activity (such as animal burrows or footprints), preserved remains (such as bones, shells and exoskeletons), or casts (such as what is produced when decayed organisms leave behind molds that are later filled with rock or minerals). Fossils are usually found in sedimentary rock because the heat and pressure associated with the formation of igneous and metamorphic rock is not conducive to fossil formation or preservation.

The formation of sedimentary rock begins with weathering of existing rock to form sediment, sediment transport, and accumulation in depositional environments. Sediment is deposited in layers in a sequence, forming the oldest rocks at the bottom and the youngest rocks at the top. This is known as The Law of Superposition (Fig. 1) and can be compared to dirty laundry in a hamper. If the hamper has been filling up over the course of a week, we can assume that the laundry toward the bottom of the pile was deposited before the laundry at the top (if no one has gone digging in the hamper to find a pair of dirty socks). This principle allows geologists to determine the relative age of an individual rock layer (stratum) with respect to rock layers (strata) above and below it, assuming the rock sequence has been undisturbed.

Fossils within sedimentary rock strata can be used as indicators of the relative age of the rock in which they are preserved. Take for example fossils of the genus *Perisphinctes,* a marine mollusk. Fossilized *Perisphinctes* shells are widely distributed from Antarctica to Germany and Argentina

to Yemen. More importantly mollusks of the genus *Perisphinctes* lived only during the Middle to Late Jurassic epochs, roughly 174 to 145 million years ago. Because *Perisphinctes* fossils are relatively abundant and widespread, and because the genus survived for a relatively short time before it went extinct (it is confined to the Jurassic period), it is perfectly situated for use in the relative dating of sedimentary rock strata. When a geologist finds a fossilized *Perisphinctes* shell, the geologist can determine that the sedimentary layer in which the fossil is found was deposited during the Jurassic period—as was the mollusk. Not all fossils are so useful as a means for dating rock strata. Take fossils of the sea snail genus *Turritella*, for example. This sea snail rose to large numbers during the Cretaceous period and has been around ever since, which amounts to 145 million years. This makes it rather difficult to figure out when sedimentary rock containing *Turritella* fossils were deposited (even relatively), at least using this method. Fossils that are especially useful for the relative dating of rock strata are known as index fossils because they indicate the span of geologic time for the rocks in which they are preserved

In fact, the geologic time scale, which divides Earth′s history into time spans such as the Jurassic and Cretaceous periods, was largely generated by differentiating rock strata using the relative abundance of multiple fossilized species. Figure 2, produced by the USGS, illustrates the correspondence between forms of life which existed during limited periods and the spans of geologic time that they help to define. Here you can see the fossil types that correspond to different geologic periods, such as organisms of the genus *Paradoxides*, giant trilobites that characterize the Cambrian Period and organisms of the genus *Mucrospirifer*, brachiopods that characterize the Ordovician Period. The boundaries between these major time periods were defined by mass extinction events. Although it is difficult to use fossils to characterize the 88%

of Earth history prior to the Phanerozoic Eon (because the fossil record for this time is so sparse), evidence from rock strata is the basis for organizing the geologic time scale that describes the remainder of Earth's 4.6-billion-year history.