

The Discovery of Earth's History

Biol 4415/5415

Evolution

Summer 2005

Dr. Ben Waggoner



There are as many species as the Creator produced diverse forms in the beginning.

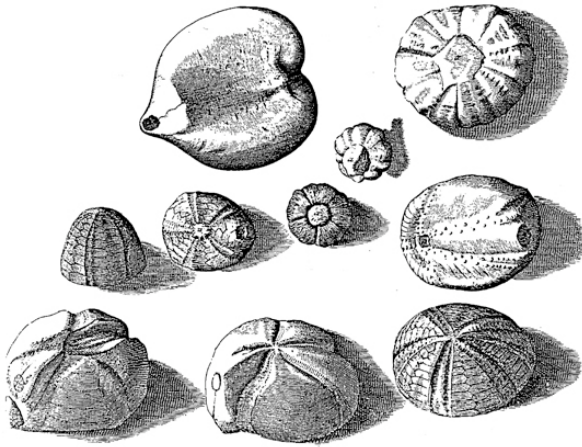
At first, Carl Linnaeus thought that species were fixed and unchanging entities.

Linnaeus later modified his belief:

- He discovered that hybridization between plant species could give rise to forms unlike either parent
- He discovered what we would now call *mutations*, affecting the entire form of a plant
- He also suggested that climate and environment might somehow “mold” new species.
- In 1779, Linnaeus wrote that “Species are the work of time”.

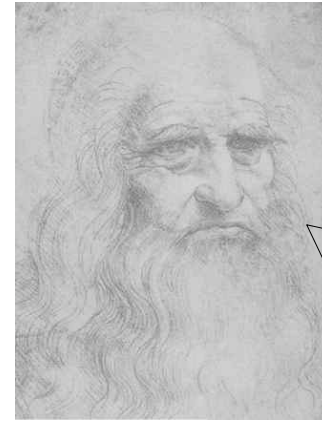


But to Linnaeus, new species were developed from a fixed number of originally created species. Change was possible only within fixed limits. This is a problem with Linnaeus's philosophy of classification—it doesn't recognize the possibility that things could change without limits.

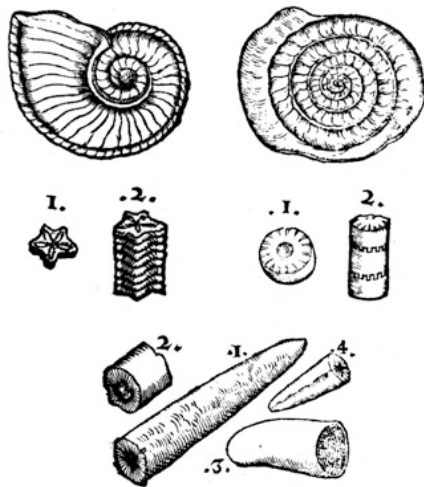


The problem was that odd bones, shells, and stranger things were turning up in rocks—which seemed to suggest that there *had* been a great degree of change. . .

No less a person than Leonardo da Vinci (1452-1519) had speculated that these *fossilii* must mean that the Earth had once been very different. . .



Since things are much more ancient than letters, it is no marvel if, in our day, no records exist of these seas having covered so many countries. . . But sufficient for us is the testimony of things created in the salt waters, and found again in high mountains far from the seas.



The problem was that some of what were then called “figured stones” looked like living organisms— but others were much less like any known living thing. Some scholars argued that “figured stones” had grown in the Earth by some natural power, and had never been alive.



Nicholas Steno (1638 - 1686), a Danish anatomist, and later a Roman Catholic priest (beatified in 1988 by Pope John Paul II), was one of those who found time to look at these “figured stones”. . .



Steno proposed that if a “figured stone” or “*fossilium*” looked like a living organism under close inspection, that was because it once had *been* a living organism.

This is his drawing of the head and teeth of a shark, which he used to demonstrate that certain odd stones, called *glossopetrae*, were in fact the teeth of ancient sharks.



This was part of a much more general theory of how solids could form inside other solids (like rock layers, crystals, etc., in addition to what we now call fossils). Steno derived two general “laws” from his work on solids. . .



(Bryce Canyon, UT)

Law of Original Horizontality: In a sequence of sedimentary rocks, the layers of rock were originally formed lying horizontally. (However, they may be disturbed after forming.)

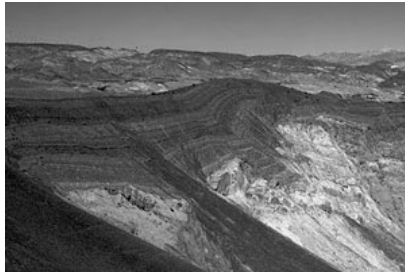


(Ventura County, CA)

Law of Superposition: In a sequence of sedimentary rocks, the oldest are the lowest, and the youngest are the highest — *unless* something has disturbed the rocks after they were formed.



Marjum Pass, UT



Ubehebe Crater, Death Valley, CA

Steno's Law says *nothing at all* about *how* old a rock sequence is, or how long it took to form. The layers on the left we now reckon formed over several million years; those on the right formed in a few weeks or months.

All it is is a statement of *relative age*.



Mind you, rock layers may be bent and deformed in various ways. . .

(Hagios Pavlos, Crete, Greece)



Rocks don't have to form a continuous sequence, either. Here the pinkish-red layer (210 million years old) is overlain by a thin dark brown layer that caps these hills (4 million years old). 206 million years is missing from the rock record. (More later on how we calculate these ages!)

(Painted Desert, Petrified Forest National Park, AZ)



Layers may be faulted out of their original order. The red cliffs in the foreground are 200+ million years younger than the gray limestones behind them, which were pushed above them along a *thrust fault*.

(Red Rock National Recreation Area, Clark County, NV)



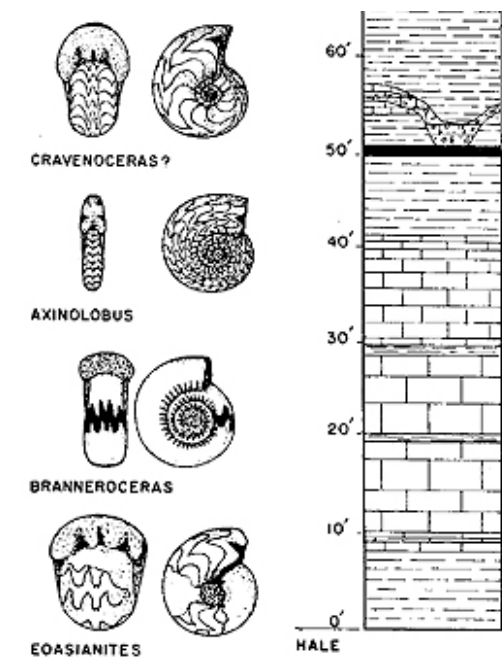
But the point is that when the arrangement of rock layers has been disrupted, the disruption leaves traces—we can compensate for changes in the arrangement of rock layers, and reconstruct how they were originally laid down.

William Smith (1769-1839)



- An English civil engineer and surveyor, Smith came across numerous fossils during his work on canal surveying and mine engineering.
- He realized that different layers contained different fossils. . .
- But what was more: fossils always occurred in a predictable order of appearance. The order of fossils in sedimentary rocks was the same all over England. This is the “Law of Succession”.

<p>data, n. s. <i>Asaphus Buchii</i>, <i>Pentamerus</i>, <i>Leptaena</i>, <i>Orthis</i>, <i>Calymene</i>, <i>Blumenbachii</i>. The Bar Trilobite and others.</p> <p>h. <i>As. caudatus</i> variety, <i>C. Blumenbachii</i>. <i>Lingula</i>, n. s. <i>Orthis</i>, n. s., and others. <i>Cyrtia trapezoidalis</i>, <i>Dalm.</i> <i>Delthyris</i>, n. s. <i>Orthocera</i>, n. s. <i>O. annulata</i>, <i>M. C.</i> <i>Crinoidea</i>, &c.</p> <p>i. <i>Pentamerus laevis</i>, <i>M. C.</i> <i>P. oblongatus</i>, n. s. <i>Leptaena</i>, n. s. <i>Pileopsis</i>, n. s. <i>Orthis</i> <i>Calymene</i>, <i>Dalm.</i>, and several new species. <i>Terebratula</i>, n. s. <i>Tentaculites</i> and <i>Crinoidea</i>, } Corals rare. abundant.</p> <p>k. <i>Nucula</i>, n. s. <i>Pentamerus</i>, n. s. <i>Trilobites</i> of undescribed species, including the genus <i>Cryptolithus</i> of N. America, and 14 species of the genus <i>Orthis</i> have been found, including <i>O. aperturatus</i>, <i>Dalm.</i>, all differing from those of the overlying formations.</p> <p>l. <i>Asaphus Buchii</i>. <i>Agnostus</i>, <i>Brongn.</i>, undescribed <i>Trilobites</i> of three species; differing from those of the overlying formations.</p> <p>m. Few organic remains have yet been observed in this great system, but it is underlain by fossiliferous strata and limestones, which will be described by Professor Sedgwick.</p>	<p>and west side of Malvern Hills: east side of Abberley Hills, Dudley, Worcestershire: Long Hope, near May Hill, and Tortworth, Gloucestershire: Prescoed and Cil-na-Caya, near Usk.</p> <p>h. Buildwas, Hughley, Wistanstow, and Clungunford, Salop: escarpments in Montgomery, Radnor, Brecknock, and Caermarthen shires: west flank of Malvern Hills, Alfrick, Worcestershire: centre of Wren's Nest, Dudley, &c. &c.</p> <p>i. Banks of the Onny, near Horderley, Acton Burnell, Chatwall: the Hollies near Hope Bowdler, Cheney Longville, Acton Scott: east flank of Wrekin and Caer Caradoc, Salop: Eastnor Park, Obelisk, and centre of Woolhope Valley, Herefordshire: May Hill, and Tortworth, Gloucestersh.</p> <p>k. Horderley, Hoar Edge, Long Lane, and Corton, Shropshire: Ankerdine Hill, Old Storridge, Howlers Heath, SW. of Malvern Hills, Worcestersh.: May Hill, Gloucestersh.: and the same localities as i in Shropshire: Powis Castle, Guilsfield, and Alt-y-maen, Montgomerysh.: Castell Craig, Noeth Grug, and Llandovery, Caermarthenshire.</p> <p>l. Rorington and Hope, near Skelve, Shropshire: Llandrindod and Wellfield, near Builth, Radnorshire: Tan-yr-Alt to Llandeilo, Caermarthenshire.</p> <p>m. The Longmynd, Linley, Haughmond, Lyth, Pulverbatch Hills, Salop: Gwastaden, east of Rhyader, Radnor, &c. &c.: hills west of Llandovery, Caermarthenshire.</p>
--	--



Another example, this time from northwestern Arkansas. The rock layers around Fayetteville (right) contain fossils of coiled shells (technically called *ammonoids*, on the left). Different layers have different shells—and the shells appear in the same order in rocks all over the world.

An example of Smith's principle. The left-hand side lists fossils in order, from oldest (bottom) to youngest (top). Localities are on the right.

Smith used fossils as tools to map out where different rock layers were found. His geologic map of England and Wales (published in 1815) was the first of its kind.

Each rock layer is represented by a unique color.



Click [here](#) for a bit more on Smith's map

Geologic Time Scale

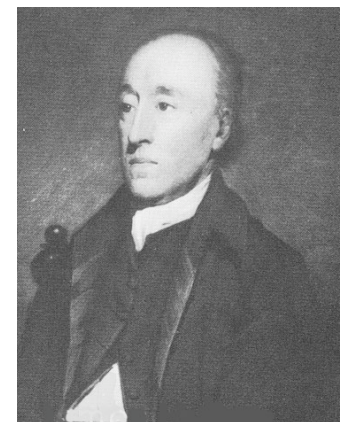
- Because fossils appeared in a predictable order, you can use them as markers of relative time.
- What's more, you can define time periods based on what was living at the time.
- This enabled geologists to construct a *relative* time scale, define time periods, and name them.

But where had all these layers come from? The German mining geologist Abraham Gottlob Werner (1750-1817) thought that all the rocks in the world had precipitated out from a vast world ocean, a theory called *neptunism*.



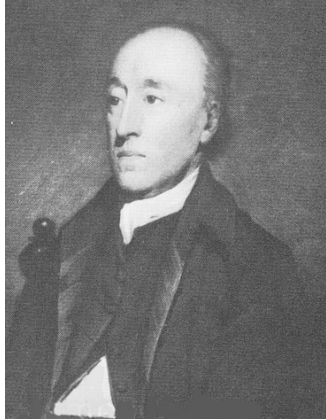
James Hutton (1726-1797)

- Scottish landowner who became interested in geology
- Hutton argued that some rocks had been molten once (*plutonism*).
- He proposed, in his book *Theory of the Earth* (1785) that geologic time had been indefinitely long: “we find no vestige of a beginning,—no prospect of an end.”
- For Hutton, the Earth was a self-renewing machine, thanks to its internal heat. As old mountains were eroded away, new ones were uplifted; as the sea covered some lands, it receded from others.

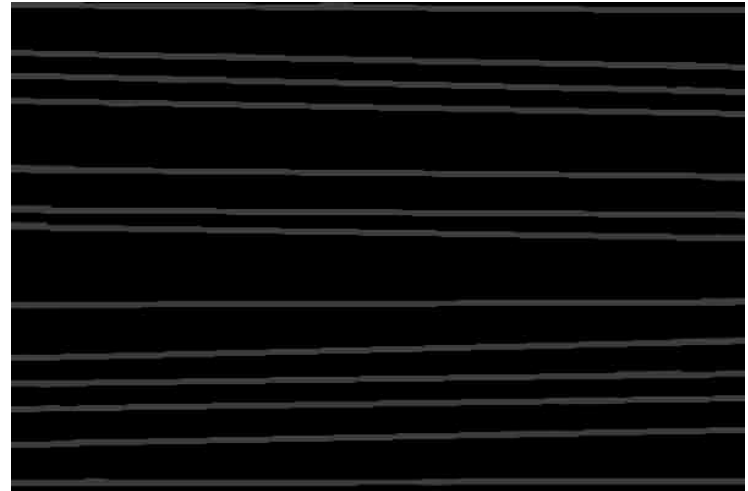


[A Web page on Hutton. . .](#)

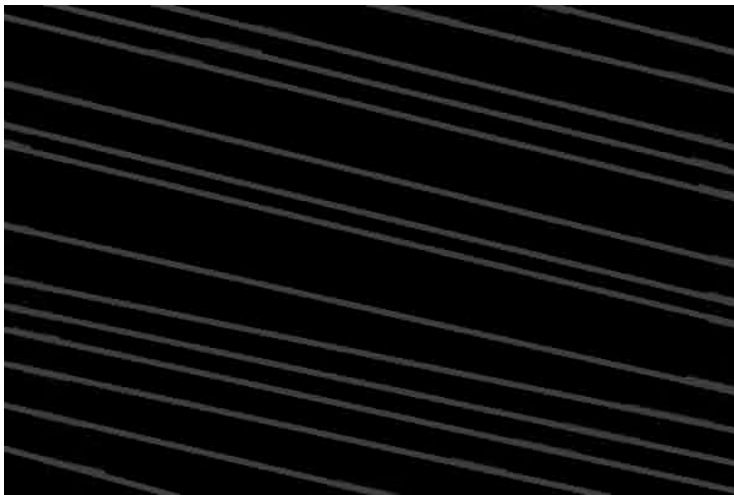
James Hutton, continued. . .



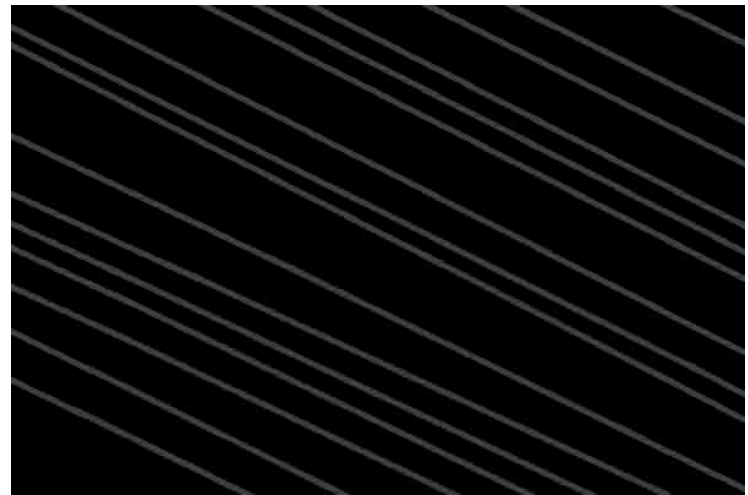
- One of Hutton's strongest arguments for his view of the Earth was his discovery of *angular unconformities*.
- *Angular unconformities* are a type of gap in the order of sedimentary layers. They take a long time to form—they cannot be formed instantaneously.
- The next slides are diagrams that show how an angular unconformity forms. . .



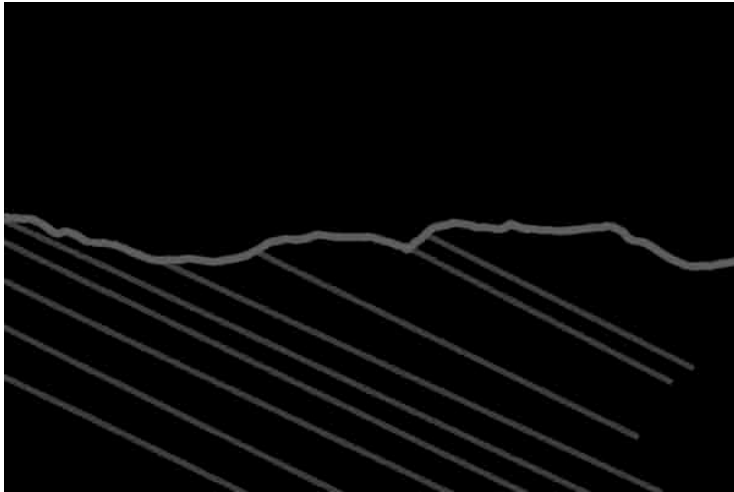
Start with some more or less horizontal layers laid down. . .



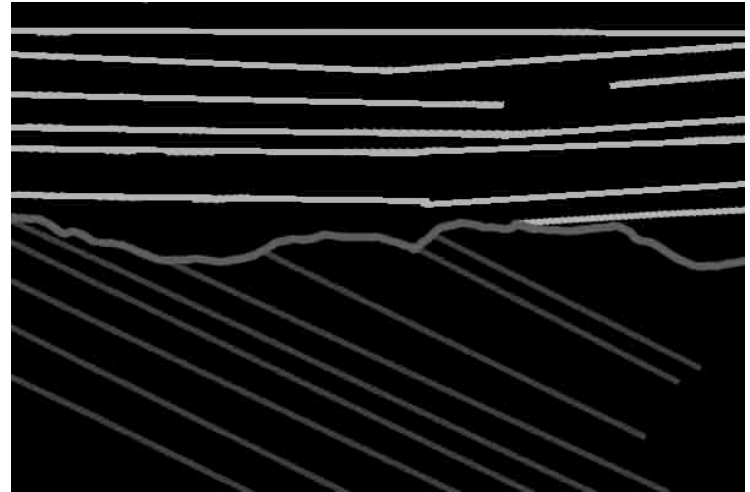
Now geologic forces tip them. . .



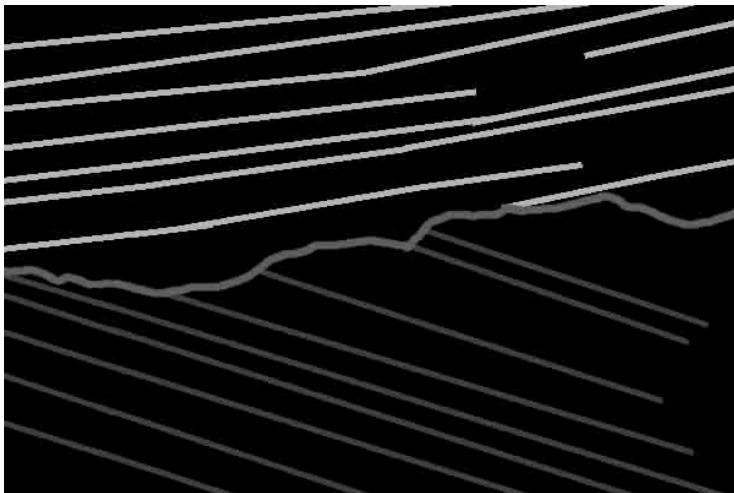
And tip them even further. . .



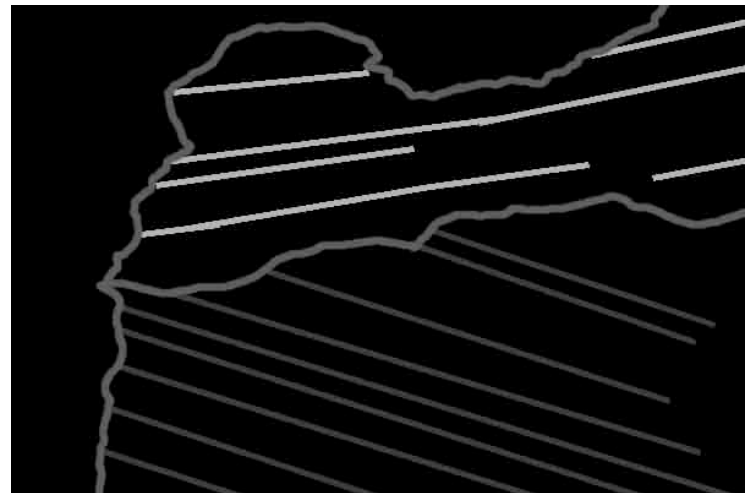
. . . and then erosion removes a portion.



If newer layers are later deposited on top of the old, we get this.



The sequence of sedimentary rocks may tip *again*. . .



And further erosion may erode both newer and older layers. . .



Actual angular unconformity
(China Ranch, Mojave Desert, southern Inyo County, CA)

Get the picture? An angular unconformity can't form quickly — it takes time for that uplift and erosion to happen!



Angular unconformity at Siccar Point, Scotland, studied by Hutton

An angular unconformity marks an interval of many years that is *missing* from the rock record.



Angular unconformity at the base of the Grand Canyon,
Arizona