From “Figured Stones” to Geologic Periods

brought to you by the letters C and V

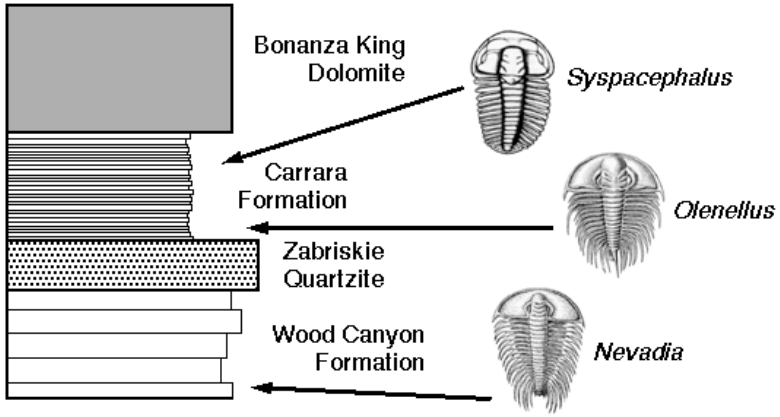
and by the number 9

(and by Dr. Waggoner)

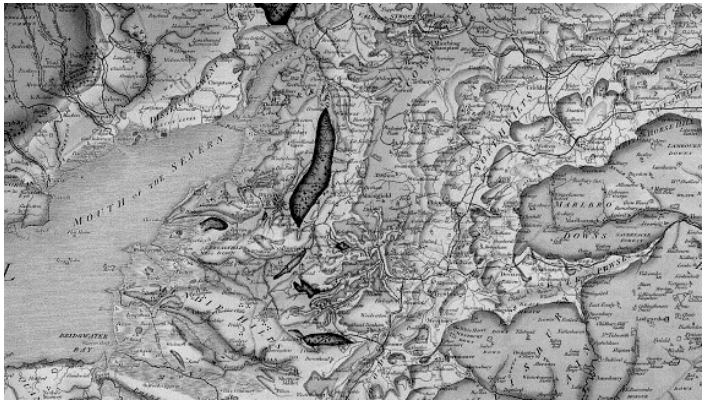
William Smith (1769-1839)

- A 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”.

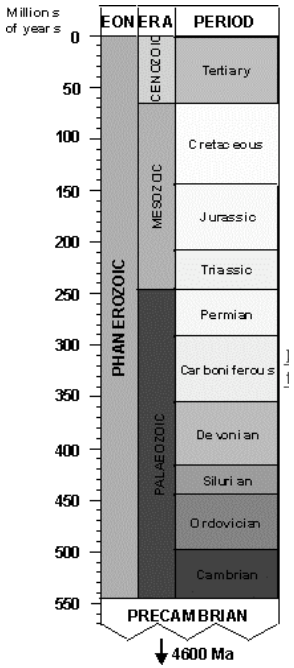
Here’s an example. On the left is a diagram of rock layers. On the right are three different fossils called *trilobites*, with the arrows showing where they appear. If you find these fossils anywhere in North America, you’ll find them in this order of appearance.



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.

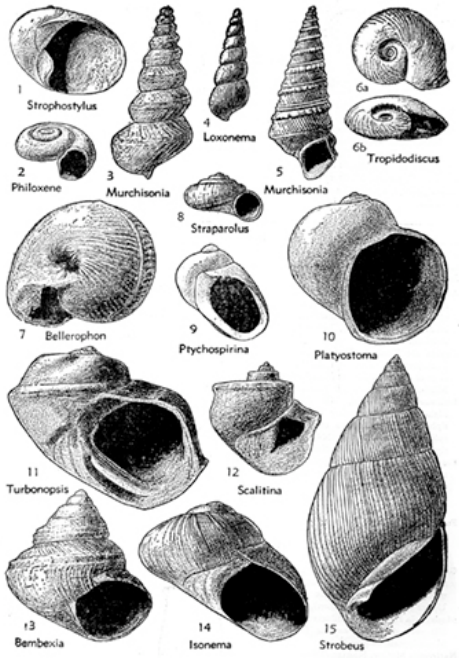


Click here for a bit more on Smith’s map

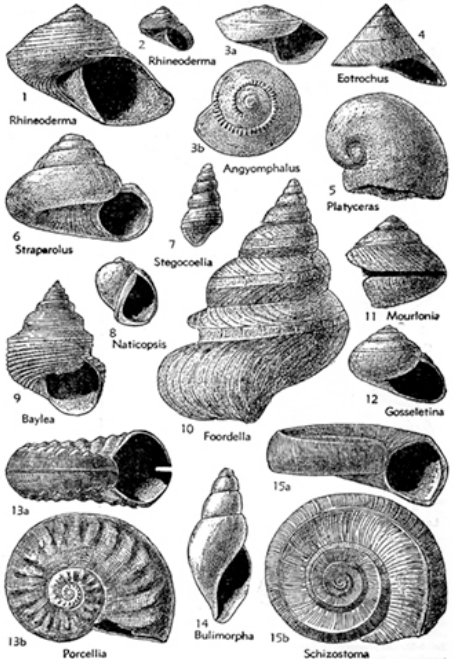


Geologic Time Scale

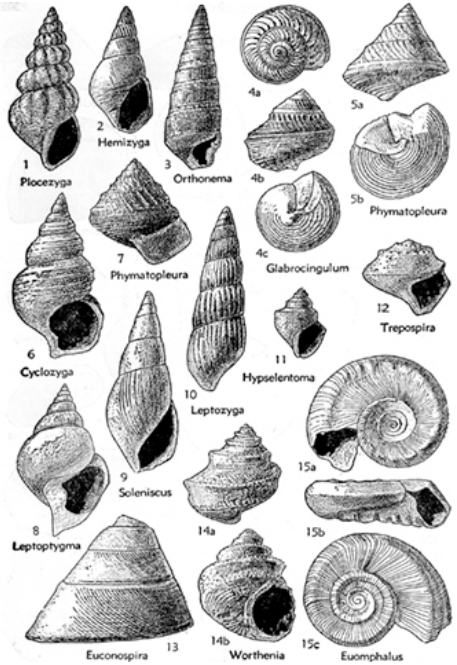
- Because fossils appeared in a predictable order, you can use them as markers of relative time.
- What's more, you can define time periods based on what was living at the time.
- This enabled geologists to construct a *relative* time scale, define time periods, and name them.



Just to give a small example: These are some fossil snails that are characteristic of a block of time that we call the *Devonian*. . .



. . . and in younger rocks, we can find another set of fossil snails, that we can use (along with many other types of fossil) to define another block of time, called the *Mississippian* (a.k.a. the *Lower Carboniferous*). . .



. . . and in still younger rocks, we find yet another set of fossil snails, that we use to define yet another block of time called the *Pennsylvanian* (a.k.a. the *Upper Carboniferous*).

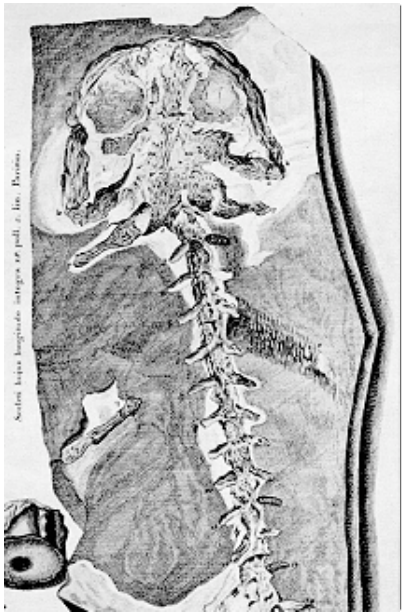
Georges Cuvier (1769-1832)

Even if we have only the extremity of a well-preserved bone we can, by examining it carefully, applying analogical skills, and comparing it with other materials, determine as much as if we had the whole animal.

A WWW bio of Cuvier

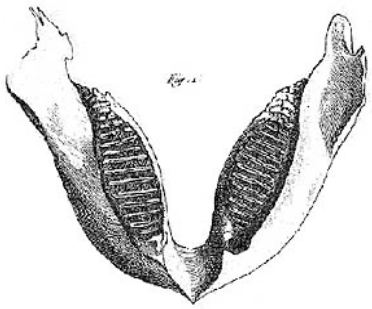
Cuvier was the first to make careful comparative studies of fossils with living animals. He is still known as the *Father of Comparative Anatomy*.

For instance. . . in 1735, this fossil from Oeningen, Germany, was interpreted as the skeleton of a man drowned in the Biblical Flood, and named *Homo diluvii testis* ["Man, a witness to the flood"].

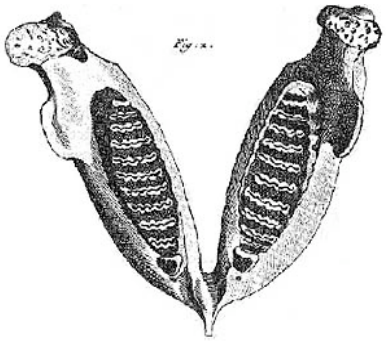


Unfortunately for some. . . In 1802, Cuvier studied the specimen and realized that it was the fossil skeleton of an unusually large salamander.

And there were other problems for the traditional worldview posed by these ancient bones! Take this giant jawbone, for instance. . .



Cuvier compared this jaw of an ancient elephant-like beast called a **mammoth. . .**



. . . with the bones of living elephants, such as the Indian elephant shown here. . .

. . . and showed that they weren't identical!
Similar, yes. . . but with consistent differences!

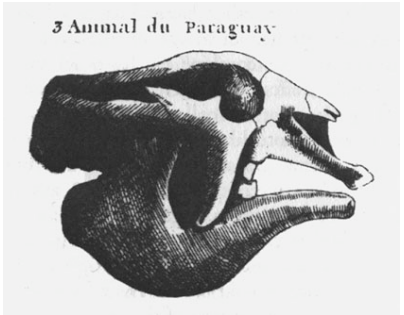
The same was true for the "Irish elk", a giant European deer (not really an elk, and not restricted to Ireland) whose bones had been known for centuries. . .

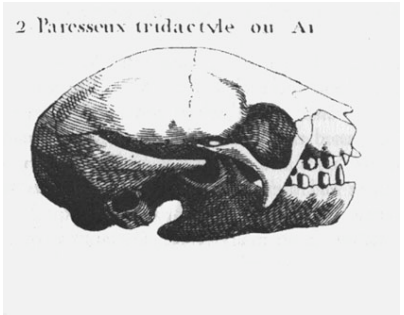
But mammoths were gigantic— the size of elephants! If they were still alive, we'd have found them by now.

Conclusion: The mammoth must have

GONE EXTINCT!

And the same was true for countless other animals, including the extinct giant sloth on the left (compared with a living South American tree sloth on the right).

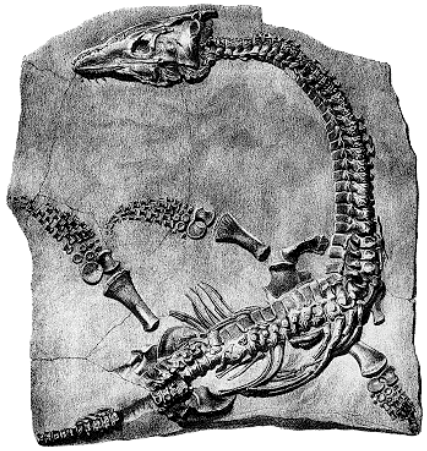




This bothered people: Why would God create something, only to let it vanish forever? And how could you accommodate that many extinct species in a young Earth?

What was more: the older the fossils were, the *less* likely they were to resemble living organisms.

- The youngest fossils included relatively familiar forms, like the long-horned bison at the top.
- Older fossils included less familiar beasts, such as the vaguely rhino-like *titanothere*. . .
- And if you went back far enough in time, you found bizarre reptile-like animals with no living counterparts at all.



Fossil plesiosaur, discovered in the 1820s by Mary Anning at Lyme Regis, England

The idea of an incalculably ancient Earth, which had once housed strange extinct beasts, was increasingly accepted — especially as things like *this* turned up in the rocks. How could the huge and growing diversity of bizarre extinct lifeforms be crammed into 6000 years?

"But what then was this primitive earth where all the beings differed from those that have succeeded them? What nature was this that was not subject to man's dominion? And what revolution was capable of destroying it, to the point of leaving as trace of it only some half-decomposed bones?"
—Georges Cuvier, 1796

Cuvier explained all this with his theory of *serial catastrophism*.

- Long periods of an unchanging, steady-state Earth had been interrupted by violent upheavals that had largely wiped out the life of the preceding period.
- New life forms had appeared after each upheaval. (Cuvier refused to speculate *how* that had happened.)
- Cuvier himself wasn't especially religious. . . but many people who were supported serial catastrophism. In their view, the Great Flood described in the Bible was simply the most recent catastrophe in a long series.

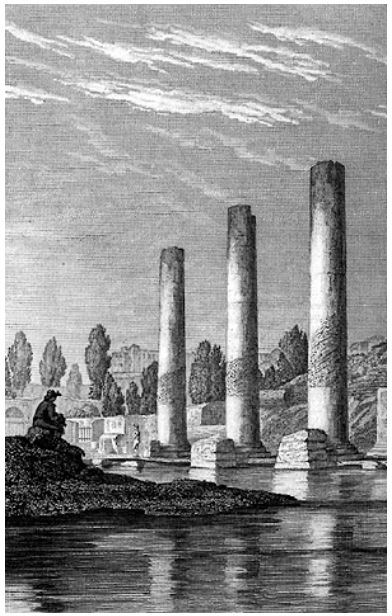
Charles Lyell
(1797-1875)

The "Father of Modern Geology", Lyell devised new ways of thinking about Earth history and using geological evidence. He expanded on Hutton's approach and proposed *uniformitarianism* as an approach to reading the past in the rocks. . .

Lyell's uniformitarianism

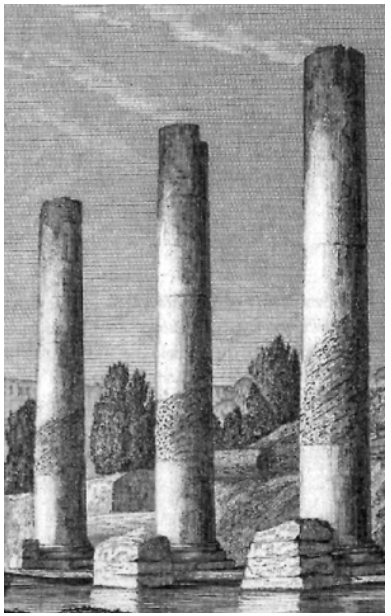
("the present is the key to the past")

- Uniformity of law: the laws of science have not changed over time
- Uniformity of process: the natural processes going on on Earth today have always operated
- Uniformity of rate: the processes affecting the Earth have always operated at the same gradual rates and the same intensities
- Uniformity of state: the Earth has not changed overall



You didn't need to assume that massive catastrophes, unlike anything in human experience, had altered the face of the Earth. All you needed, to explain geology, was (1) processes that can be observed today, and (2) lots and lots of time.

Let's look at the ruined Temple of Serapis, at Puzzuoli, near Naples on the island of Sicily, built by the ancient Romans. . .



The temple was built on land, and was in use at least up to 200 AD.

It's now right at the edge of the sea; the old floor is submerged at high tide.

The columns are riddled with holes made by a type of marine clam that bores into solid rock.

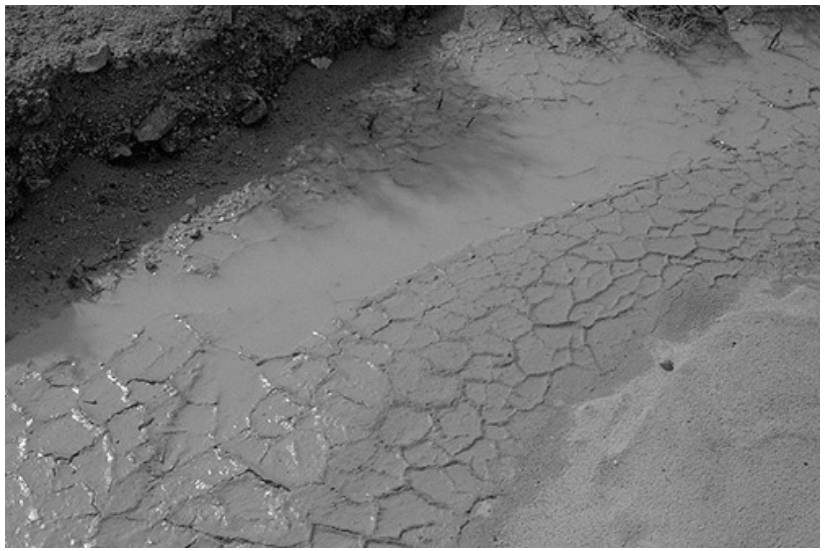
CONCLUSION: Over less than 2000 years, the temple has sunk, and then been raised, a few tens of feet. If this can happen in a few thousand years. . . what could happen in millions of years?

Lyell also visited the nearby volcano of Etna, in Sicily. . .

Etna is surrounded by cinder cones on the flanks—only one of which, Monte Rossi, formed in recorded history (in 1669)

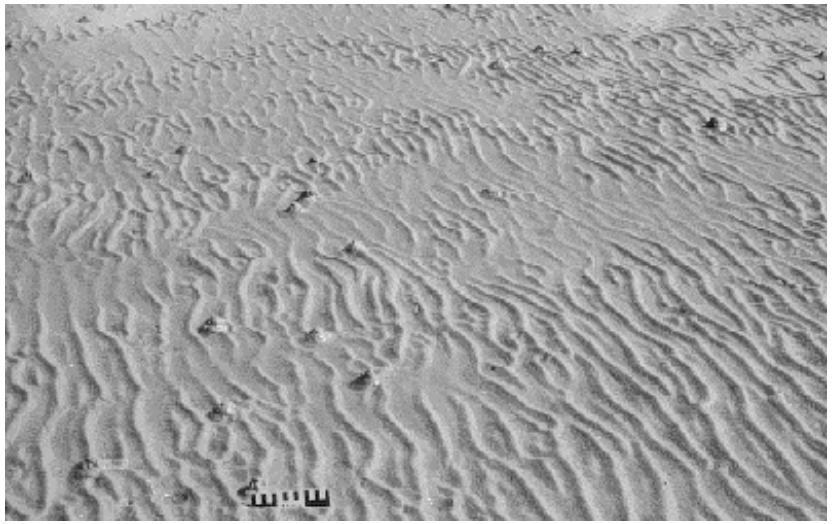
Lyell reasoned thus. . .

- Cinder cones form relatively infrequently.
- But there are dozens of cinder cones surrounding Etna. . .
- . . . and hundreds more that were later buried by lava from Etna itself (but visible in canyons cut into Etna).
- So Etna must be millions of years old.

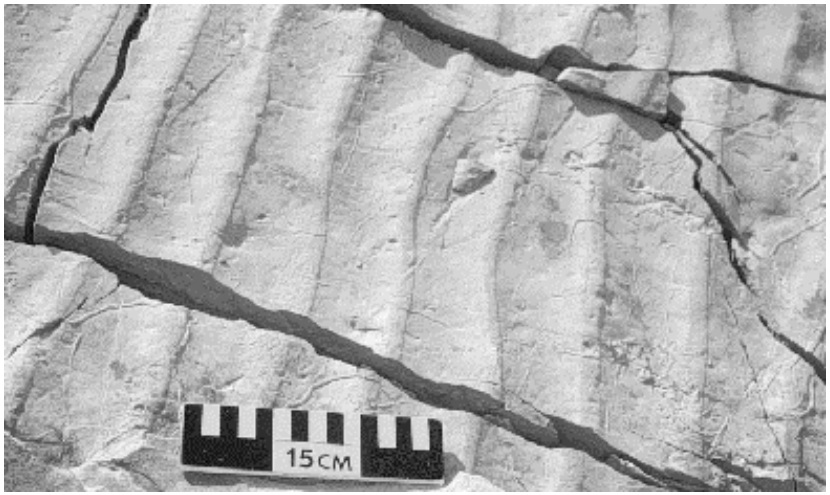


Modern mudcracks, forming as a mud puddle dries out
(Grimshaw Lake, southern Inyo County, CA)

Ancient mudcracks, preserved in 100 million-year-old rocks
(Clayton Lake State Park, NM)



Modern ripple marks forming on a sandy beach
(Beaufort Island, NC)



100 million-year-old ripple marks in sandstone
(San Juan Basin, NM)

Ancient layers of smooth pebbles
(Roadcut along Beatty Cutoff Road, Death Valley, CA)

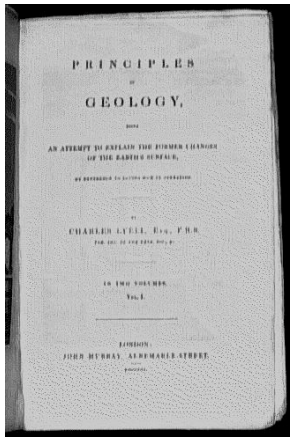
Modern beach made up of smooth pebbles

(Central California)

Lyell's "uniformitarianism" today

- Uniformity of law: accepted; well-tested
- Uniformity of process: generally accepted, although we now know of certain exceptions
- Uniformity of rate: we now know that this doesn't necessarily hold. Geologists can make room for "catastrophic" events
- Uniformity of state: definitely not!

Lyell wrote about all of this in a classic book, *Principles of Geology*. . .


PRINCIPLES
OF
GEOLOGY,

CHARLES LYELL, Esq. F.R.S.

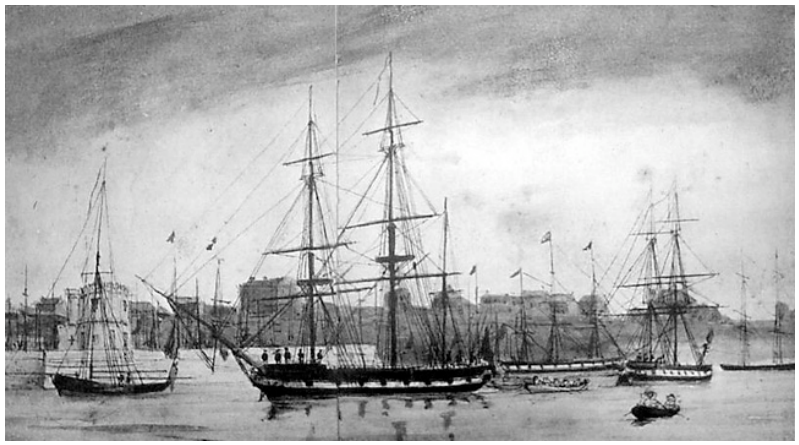
IN TWO VOLUMES.
Vol. I.

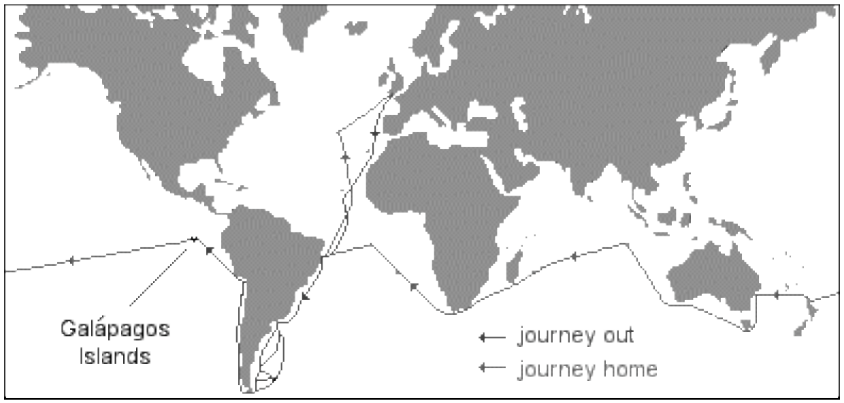
LONDON:
JOHN MURRAY, ALBEMARLE STREET.

. . . which became the favorite reading matter of a young naturalist fresh out of college, named Charles Robert Darwin.

Charles Robert Darwin, born in 1809, later came up with the theory of evolution by natural selection—which I won't go into here—but Lyell was a powerful influence on him, and he used Lyellian geology to solve a number of problems.

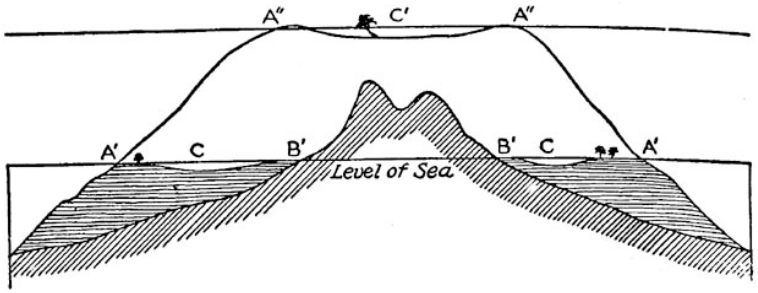
Darwin was the naturalist on board *HMS Beagle*, an exploring ship that sailed around the world. . .





As Darwin was reading Lyell, the *Beagle* reached South America early in 1832—and spent the next three years traveling up and down the Atlantic and Antarctic coasts.

Then the *Beagle* crossed the Indian Ocean, where Darwin came up with some very Lyellian theories for how coral islands formed (which he basically got right. . .



Coral atolls are ring-shaped islands in the Pacific. . . Darwin reasoned that they formed as coral grew on the tops of extinct and subsiding volcanoes.