

# DEEP TIME

## *it's discovery and interpretation*

from ancient times to the 1600s, where time was thought of at all, it was supposed either *continuous & 'circular'* or of *rather short duration*

either way, the cosmos was thought of as being +/- unchanging & roughly the same age as humanity  
that is, there was no conception of **pre-human time**  
no real appreciation that the world had changed

## *A rose-red city, half as old as time*

John William Burgon, 1845



even as late as 1845 this could be meant literally!

but Petra, in modern Jordan, is a mere ~2100 years old

the 'young earth' idea came from a chronology worked out by Archbishop Ussher: Sunday 23 October 4004 BC

*the recognition that time is vast & mostly pre-human is one of humanity's greatest conceptual achievements*

*it is comparable in importance with the realization that the earth is not the centre of the universe, and that all life is related by descent, with modification*

# Nicolas Steno



he recognized the nature and origin of fossil shark teeth

but how did they get there?

also defined the principles of stratigraphy:

*the law of superposition*: "... at the time when the lower stratum was being formed, none of the upper strata existed";

*the principle of original horizontality*: "Strata were at one time parallel to the horizon";

*the principle of lateral continuity*: "...any strata were continuous";

*the principle of cross-cutting discontinuities*: "...a ... discontinuity ... must have formed after that stratum."

Steno's idea that fossils represent a chronology of living creatures of different times was a crucial element in Darwin's theory of descent.

## "... bursting the limits of time ..."



Georges Cuvier 1769 - 1832

In the late 1700s - early 1800s the principles and procedures for working out a reliable history of the earth were established by an international network of researchers & thinkers

**Cuvier** was prominent in starting to reconstruct history back into deep pre-human times

- what had happened in the past
- how long ago it happened

## a poor & lonely genius



William Smith, surveyor  
1769 - 1839

he surveyed coalfield and canals,  
and noticed that distinctive fossils  
were in specific layers of rock.

in cutting horizontal straight canals  
through miles of land he came to  
understand earth's 3-D structure

specific fossils always appeared in  
the same rock layers, and the layers  
were always in the same sequence

thus developed the idea of a  
global regular sequence of strata  
which could be mapped in space

fossils indicated their relative ages  
permitted a geo-historical timetable  
applicable to the whole planet

## thus strata show a regular ordered fossil sequence

it eventually became clear that fossil changes often  
involved the permanent disappearance of species

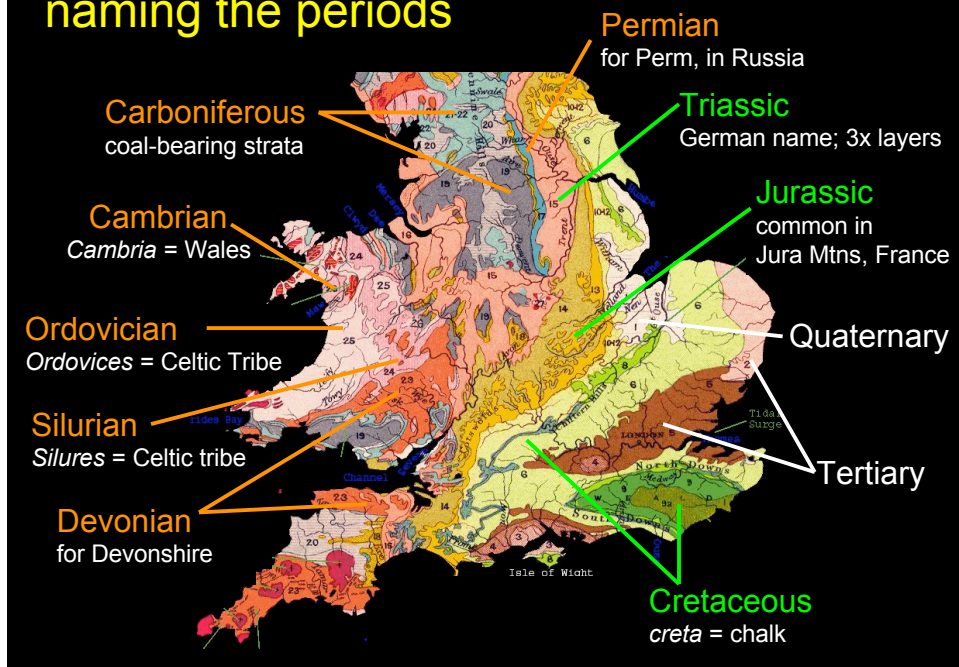
this was eventually understood as **extinction**

extinction boundaries (biotic change) came to be used  
for recognizing & naming geological divisions

thus began the compilation of a global system,  
correlating strata across the globe;  
work done from 1820 - 1850

the naming system reflected the prominence  
of strata of given ages in different nations

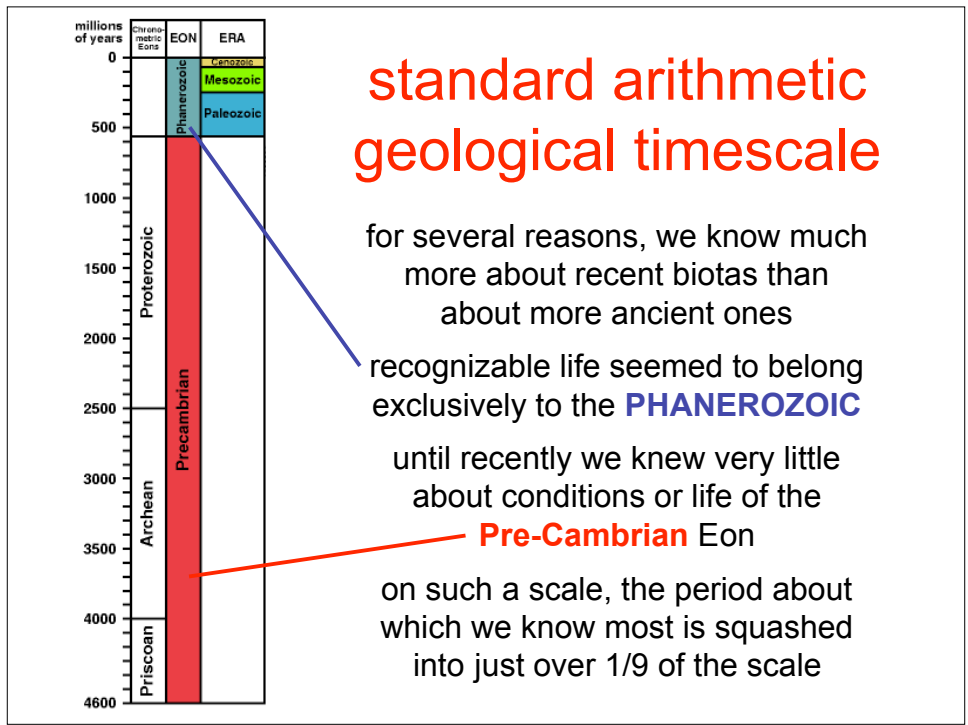
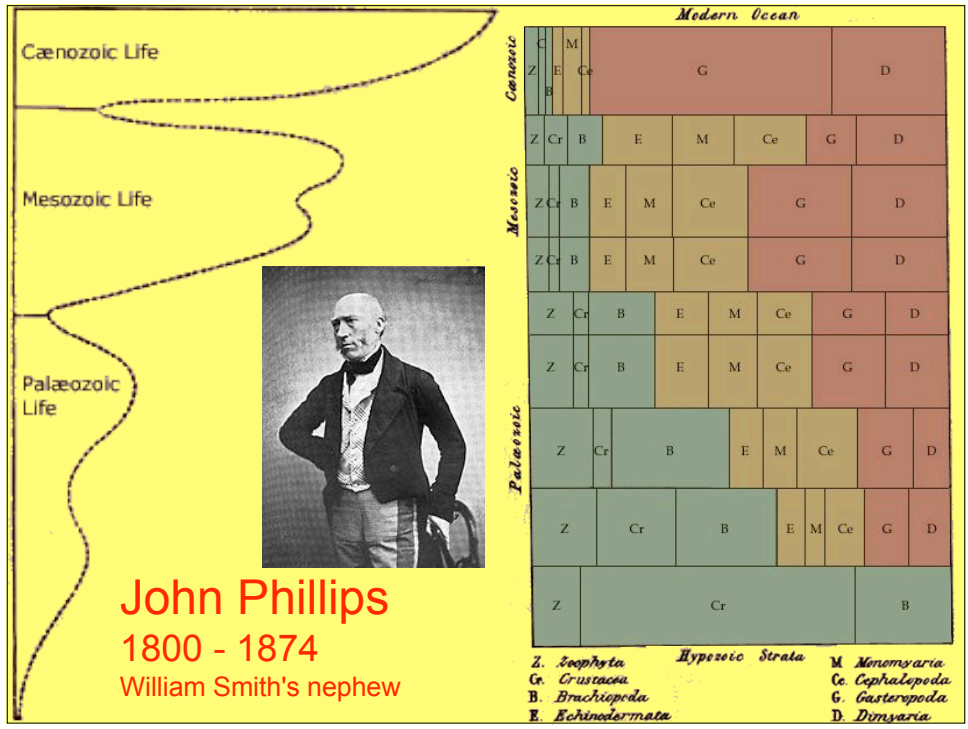
## naming the periods



## not all extinctions are equal

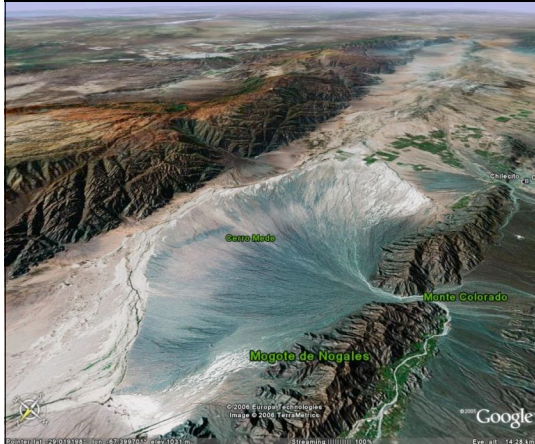
as knowledge of stratigraphy and fossil biotas developed, several matters became clarified:

- younger (higher) strata show more 'modern' forms
- older (lower) strata show more 'primitive' forms
- in general, younger strata have richer, more diverse biotas
- some disappearances (extinctions) seem much more severe (*more species go extinct; more higher taxa go extinct*)
  - that is, extinction rates vary substantially;this is the basis of grouping the PERIODS into ERAS





## time is relative



the fossil sequence in strata made possible only a **relative time-scale**; for a numerical scale we need **measurements** and **calculations**

Darwin, among others, used measurements of sedimentation rates and strata depths to calculate an estimate of the age of the earth and its stages

his figure was several hundred million years

He was greatly upset that this appeared refuted by Lord Kelvin's calculations from cooling rates, starting with a molten earth....

## absolute time

Lord Kelvin knew nothing of radioactivity, which keeps the earth warm

also, natural radioactive elements decay at a constant rate; measurement of the ratio of the element & its decay products, plus a knowledge of the radioactive decay rate, enabled precise estimates of the age of most rocks and minerals

in 1911, Arthur Holmes calculated an age of 370 My for a Devonian rock: radiometric dating was born

the current estimate of earth's age is

**4.57 billion yrs ( $4.5 \times 10^9$  y.)**

Period / ERA / EON	YEARS AGO WHEN the PERIOD BEGINS	
	10 <sup>x</sup>	all the zeros
The 3 Eras of the Phanerozoic are colour-coded below: Cenozoic (blue), Mesozoic (orange) & Paleozoic (purple).		
Quaternary	2x10 <sup>6</sup>	2,000,000
Tertiary	6.5x10 <sup>7</sup>	65,000,000
Cretaceous	1.5x10 <sup>8</sup>	150,000,000
Jurassic	2.0x10 <sup>8</sup>	200,000,000
Triassic	2.5x10 <sup>8</sup>	250,000,000
Permian	3.0x10 <sup>8</sup>	300,000,000
Carboniferous	3.5x10 <sup>8</sup>	350,000,000
Devonian	4.0x10 <sup>8</sup>	400,000,000
Silurian	4.5x10 <sup>8</sup>	450,000,000
Ordovician	5.0x10 <sup>8</sup>	500,000,000
Cambrian	5.5x10 <sup>8</sup>	550,000,000
PHANEROZOIC eon (all the above)	5.5x10 <sup>8</sup>	550,000,000
PROTEROZOIC eon	2.5x10 <sup>9</sup>	2,500,000,000
ARCHAEAN eon	3.5x10 <sup>9</sup>	3,500,000,000
Beginning of Life	3.8x10 <sup>9</sup>	3,800,000,000
HADEAN eon = Age of the Earth	4.5x10 <sup>9</sup>	4,500,000,000
BIG BANG = Age of the Universe	1.5x10 <sup>10</sup>	15,000,000,000

## rough times

you must bear in mind that these are rounded values (NOT precise), but they will give you a rough idea of earth's time scale

1 mm. per year gives 4600 km to represent earth's history

4600 km = approx distance from Cape Breton to Vancouver

Dinosaurs appear ~160km from Vancouver

Modern humans appear ~10-15 METRES from Vancouver

<http://instruct.uwo.ca/biology/284/time.html>

the time charts in your text and at this web address locate important bits of biological history on a logarithmic time-scale

the advantage of this kind of scale over the arithmetic one seen earlier is that it magnifies time more the more recent it is

it displays time by POWERS OF TEN

each deeper time chart includes 10x more time than the one above it

each more recent time chart magnifies the scale 10x over the one below it