



Lecture 5

“Catastrophism and Uniformitarianism”

“Bursting the limits of time”

Georges Cuvier

Yesterday's Puzzle



What's this, and
what does it have
to do with
Massachusetts?

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Edward Hitchcock, 1793-1864

- Congregationalist
Pastor and geologist
- 3rd President of
Amherst College
- Studied fossil
footprints of
Connecticut River
Valley
- Author, *The Religion
of Geology and its
Connected Sciences*,
1851



Edward Hitchcock



H\]g]a U[Y]g]b hY di V]WXca U]b"



“Awful Changes”

“You will at once perceive,” continued Professor Ichthyosaurus, “that the skull before us belonged to some of the lower order of animals, the teeth are very insignificant the power of the jaws trifling, and altogether it seems wonderful how the creature could have procured food.”

The challenge of the new geology

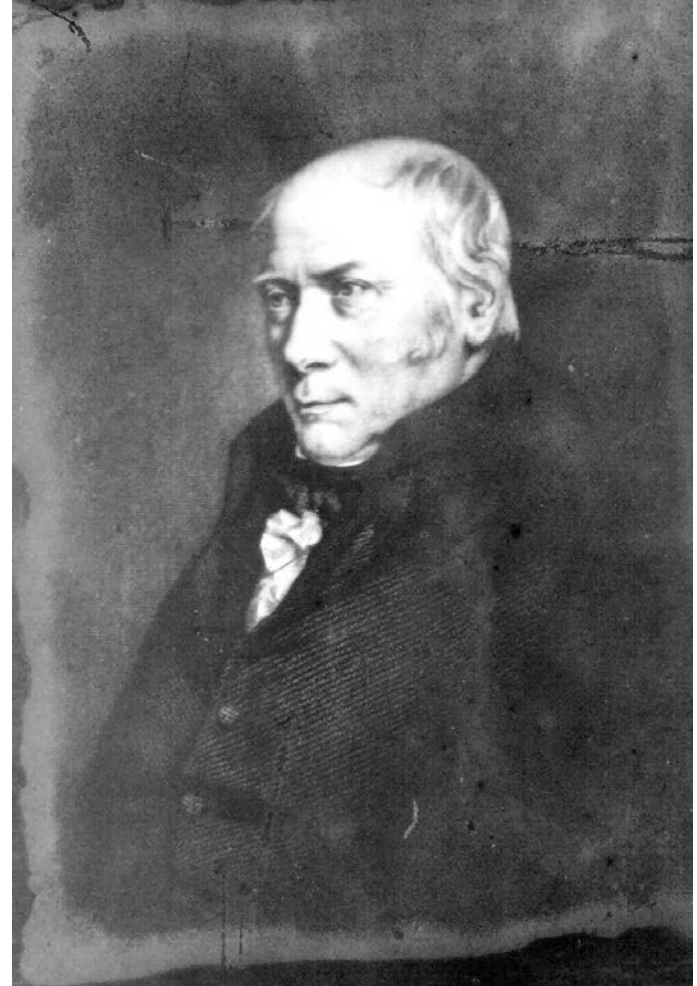
- The prevailing view of the living world in the 18th century was “atemporal”
- In the early-19th century, new geological knowledge obliged naturalists to think seriously about time

A key question was:

How to do that?

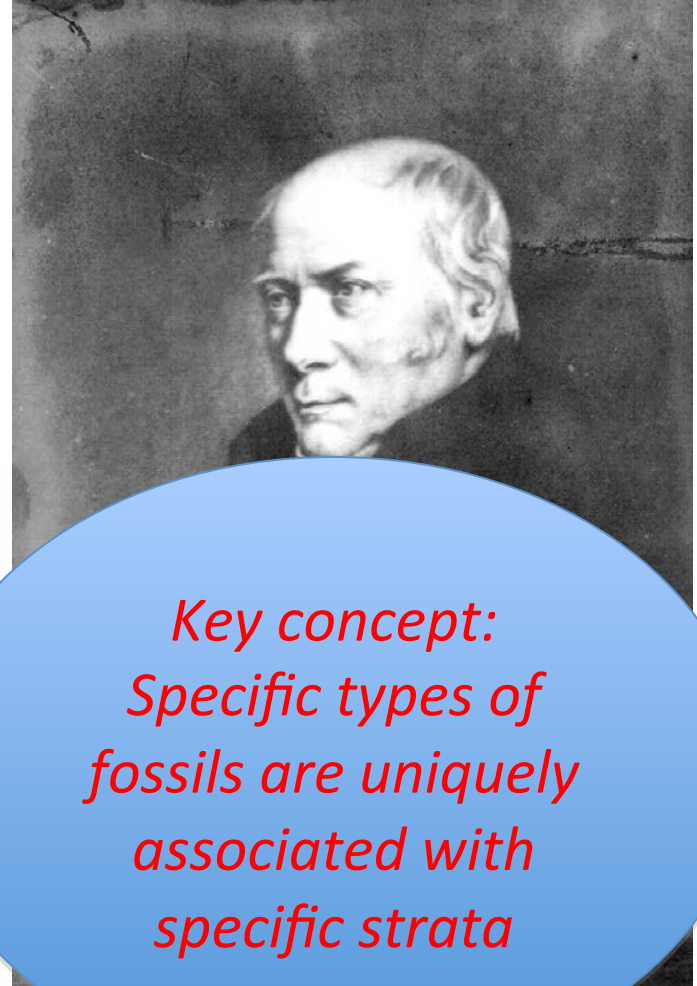
William Smith (1769–1839)

- Pioneer of stratigraphy, the study of sedimentary strata
- Recognized presence of distinctive & diagnostic fossils in individual strata
- Proposed principle of “faunal succession”



William Smith (1769–1839)

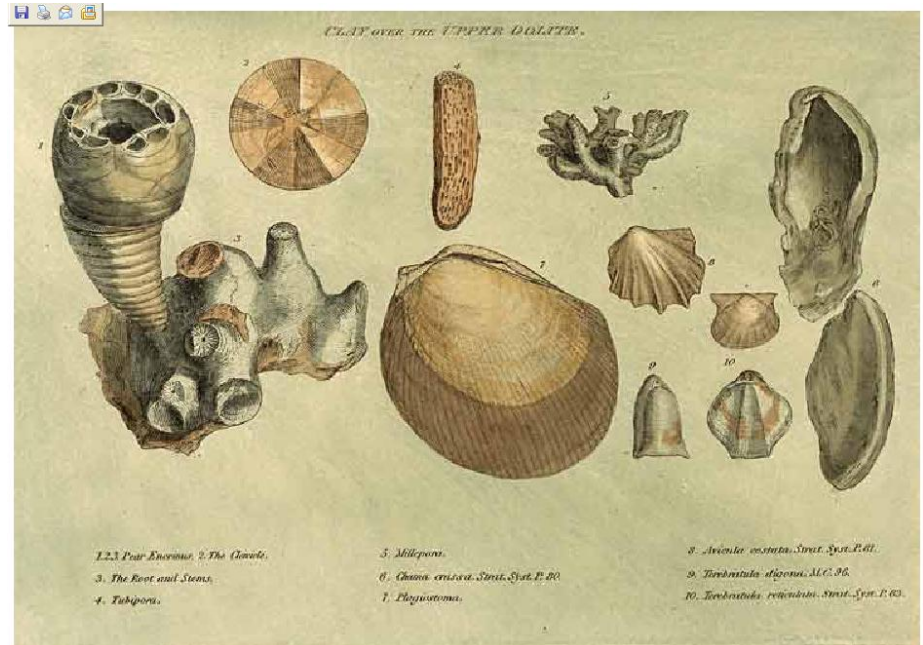
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*Key concept:
Specific types of
fossils are uniquely
associated with
specific strata*

Smith's principle of faunal succession

- Smith asserted that sedimentary rocks contain fossils that succeed each other vertically in a specific, reliable order that can be identified over wide horizontal distances.
- Acceptance of this principle allowed strata to be identified (and given 1 relative dates) by the fossils found within them.



Engraving from Smith's 1815 monograph on using fossils to identify strata

Georges Cuvier, 1769–1832

- Pre-eminent French naturalist and paleontologist
- Key works:
 - Discours Preliminaire (1812)¹
 - Le Regne Animal (1817)
 - Discours sur les revolutions de la surface de la globe (1826)
- Studied rocks of Paris Basin in the 1800s
- Developed a theory of earth history generally known as “catastrophism”



Question

Why is Cuvier regarded as such an important and influential biologist?

Some of Cuvier's key contributions

- The idea that different anatomical structures are so mutually interdependent that knowledge of some can allow inferences about the nature of others
- The idea that animals are built on a few fundamentally different body plans
- The idea that many (most? all?) fossils are the remains of animals that have become extinct
- The idea that there have been a succession of different eras of earth history, each of which was dominated by a characteristically different group of animals

Cuvier's principle of the “correlation of parts”

“Today comparative anatomy has reached such a point of perfection that, after inspecting a single bone, one can often determine the class, and sometimes even the genus of the animal to which it belonged, above all if that bone belonged to the head or the limbs. ... This is because the number, direction, and shape of the bones that compose each part of an animal's body are always in a necessary relation to all the other parts, in such a way that - up to a point - one can infer the whole from any one of them and vice versa.”

Georges Cuvier, 1798

Cuvier's principle of “the conditions of existence”

“If an animal's teeth are such as they must be, in order for it to nourish itself with flesh, we can be sure without further examination that the whole system of its digestive organs is appropriate for that kind of food, and that its whole skeleton and locomotive organs, and even its sense organs, are arranged in such a way as to make it skillful at pursuing and catching its prey. For these relations are the necessary conditions of existence of the animal; if things were not so, it would not be able to subsist.”

Georges Cuvier (1798)

Cuvier's work in taxonomy

The "Great Chain of Being"

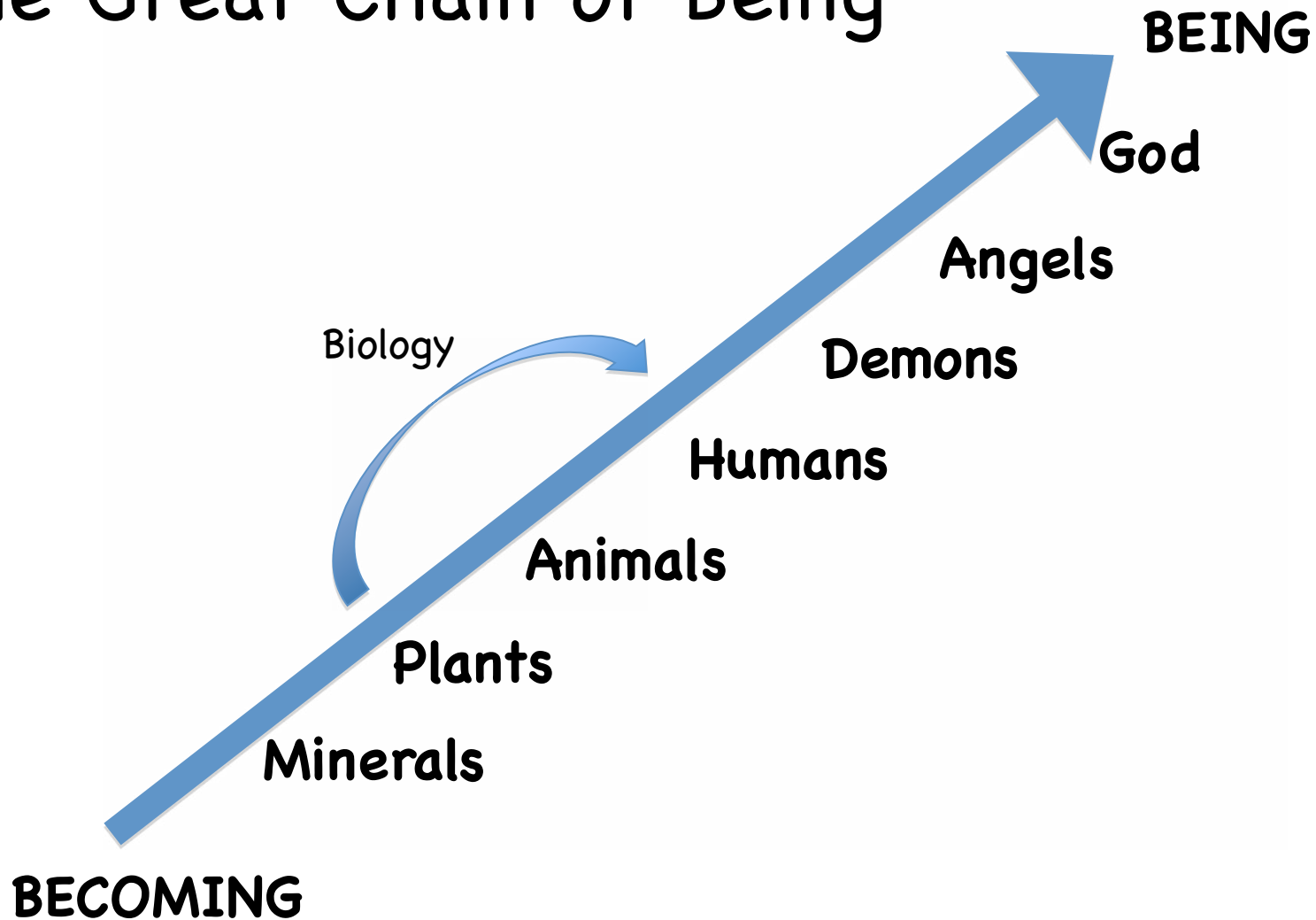
A linear scale of beings of increasing complexity, from the lowliest of mundane to the highest of celestial beings, and embracing the entire world of life

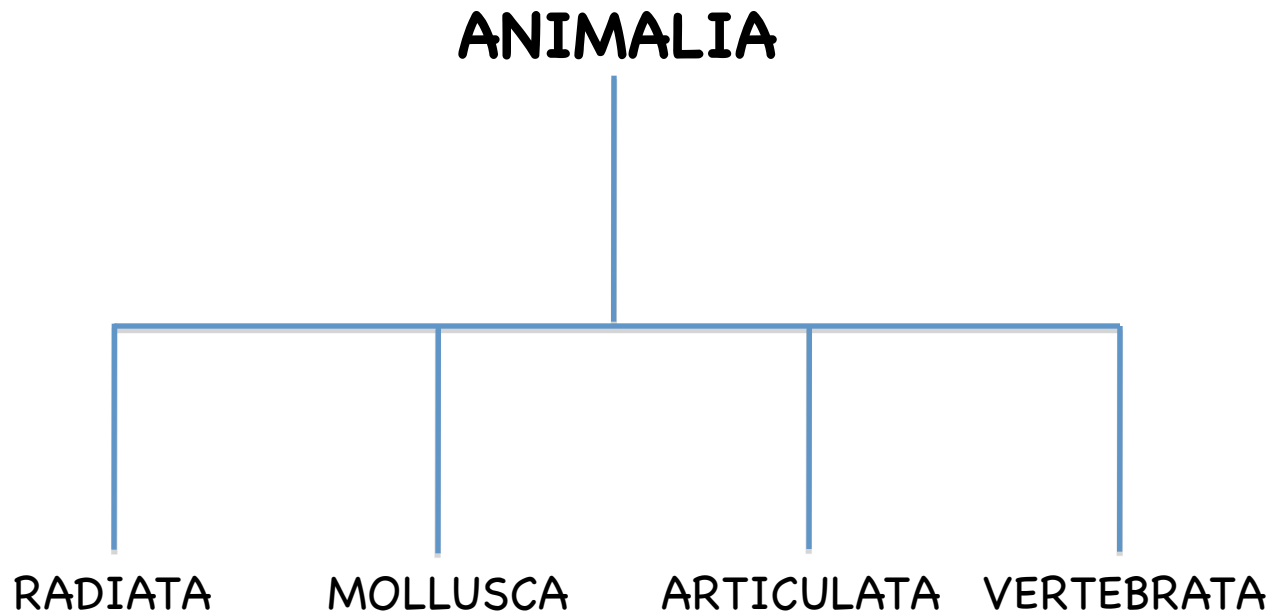
Cuvier's "Embranchments"

A fundamental division of animal life into four distinct types:

- *Radiata*
- *Mollusca*
- *Articulata*
- *Vertebrat*

The Great Chain of Being



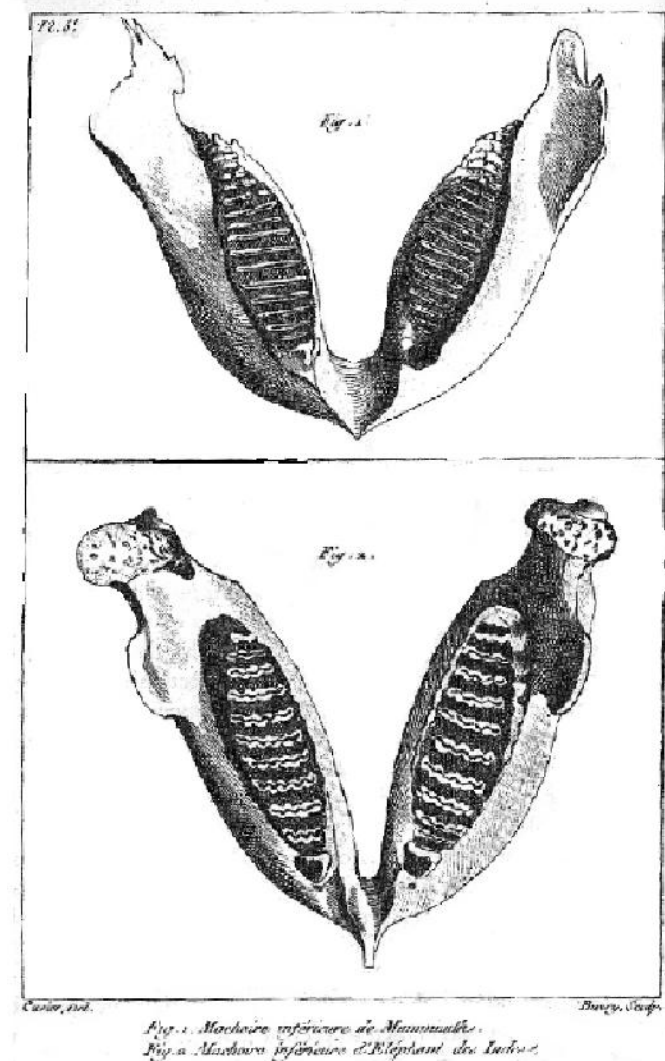


Cuvier's Four "Embranchments"

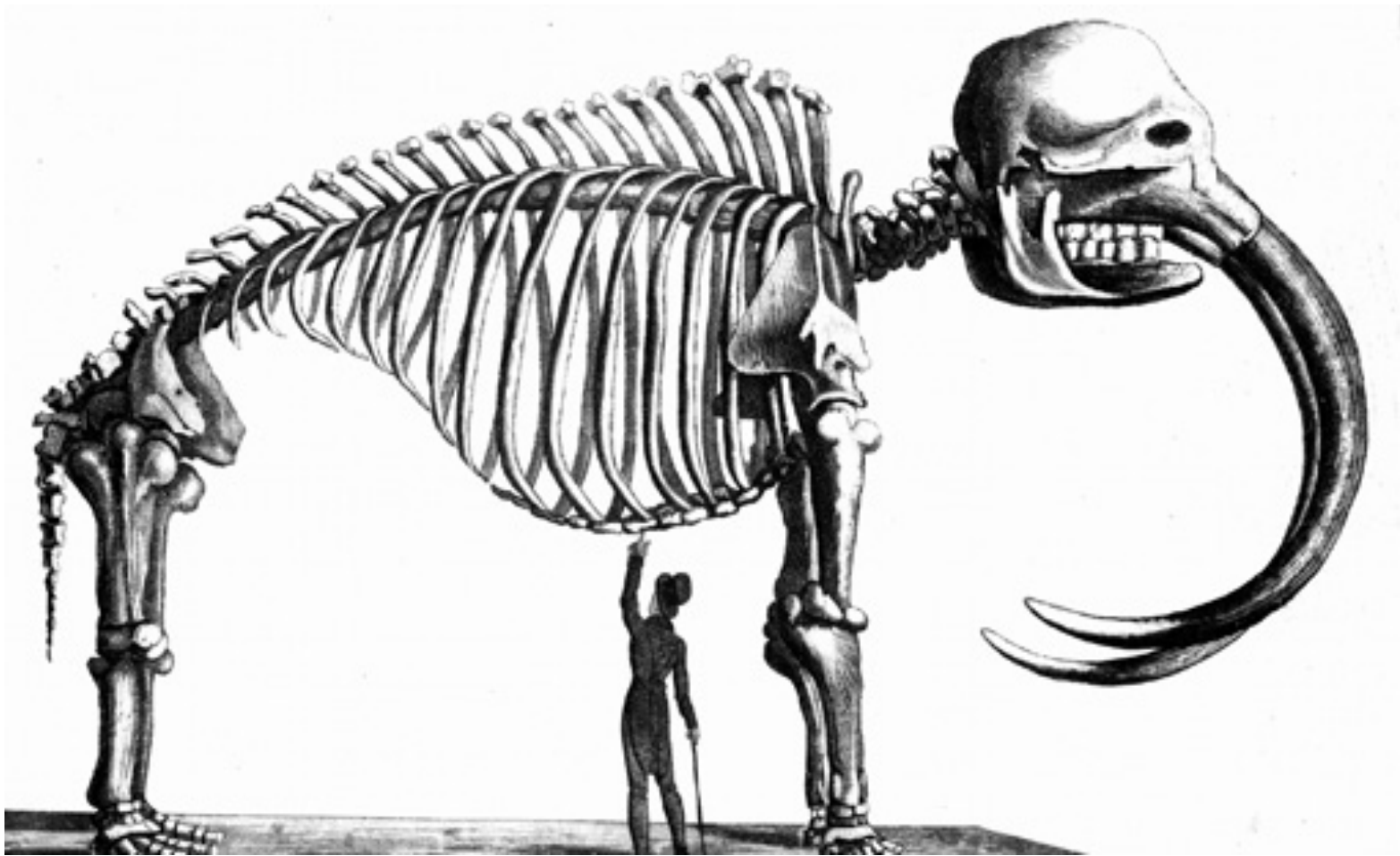
Cuvier's work on extinction

“All of these facts, consistent among themselves, and not opposed by any report, seem to me to prove the existence of a world previous to ours, destroyed by some kind of catastrophe.”

Georges Cuvier, Mémoires sur les espèces d'éléphants vivants et fossiles, 1800



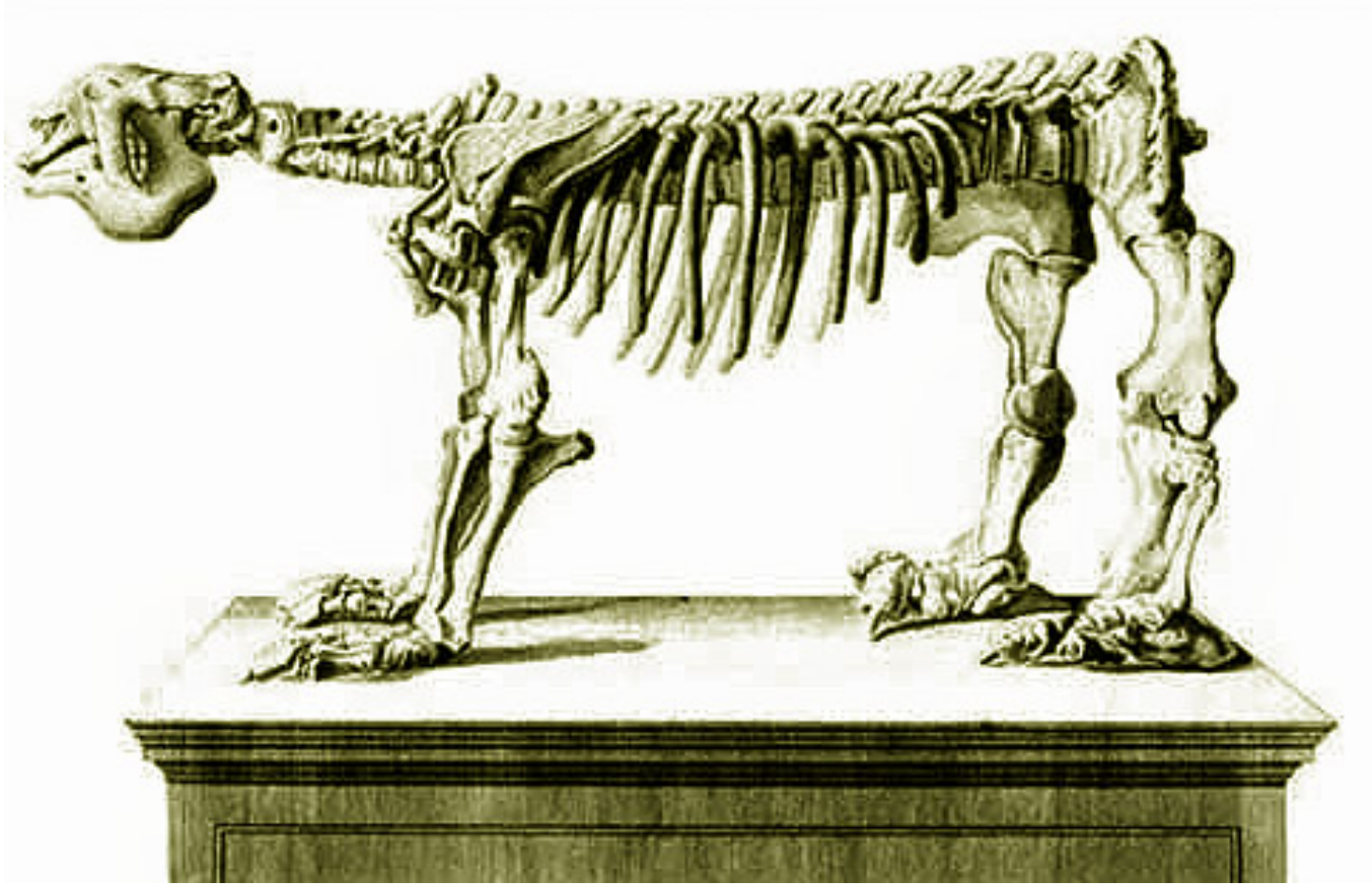
Cuvier's "fossil elephant"



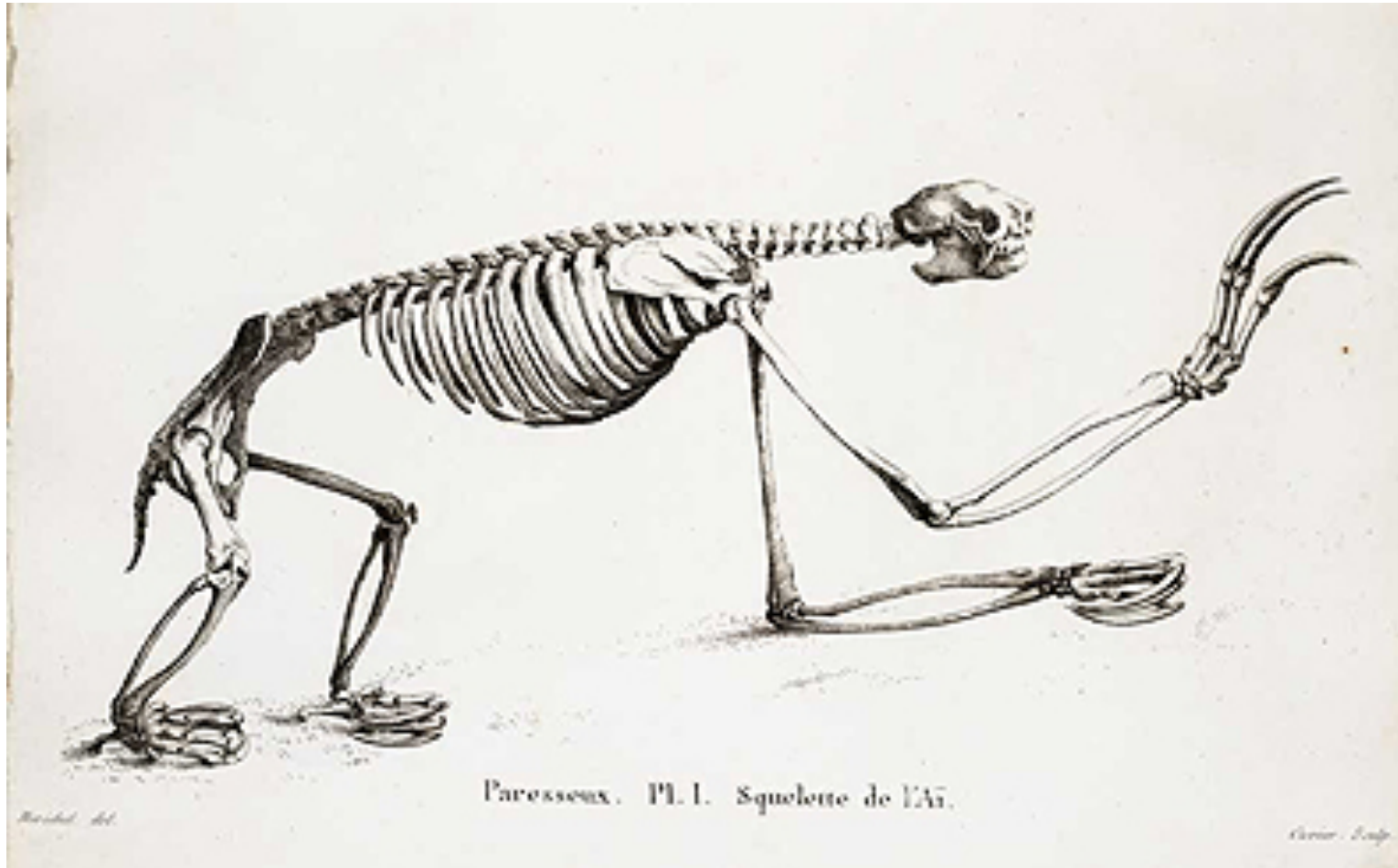
Fossil Megatherium



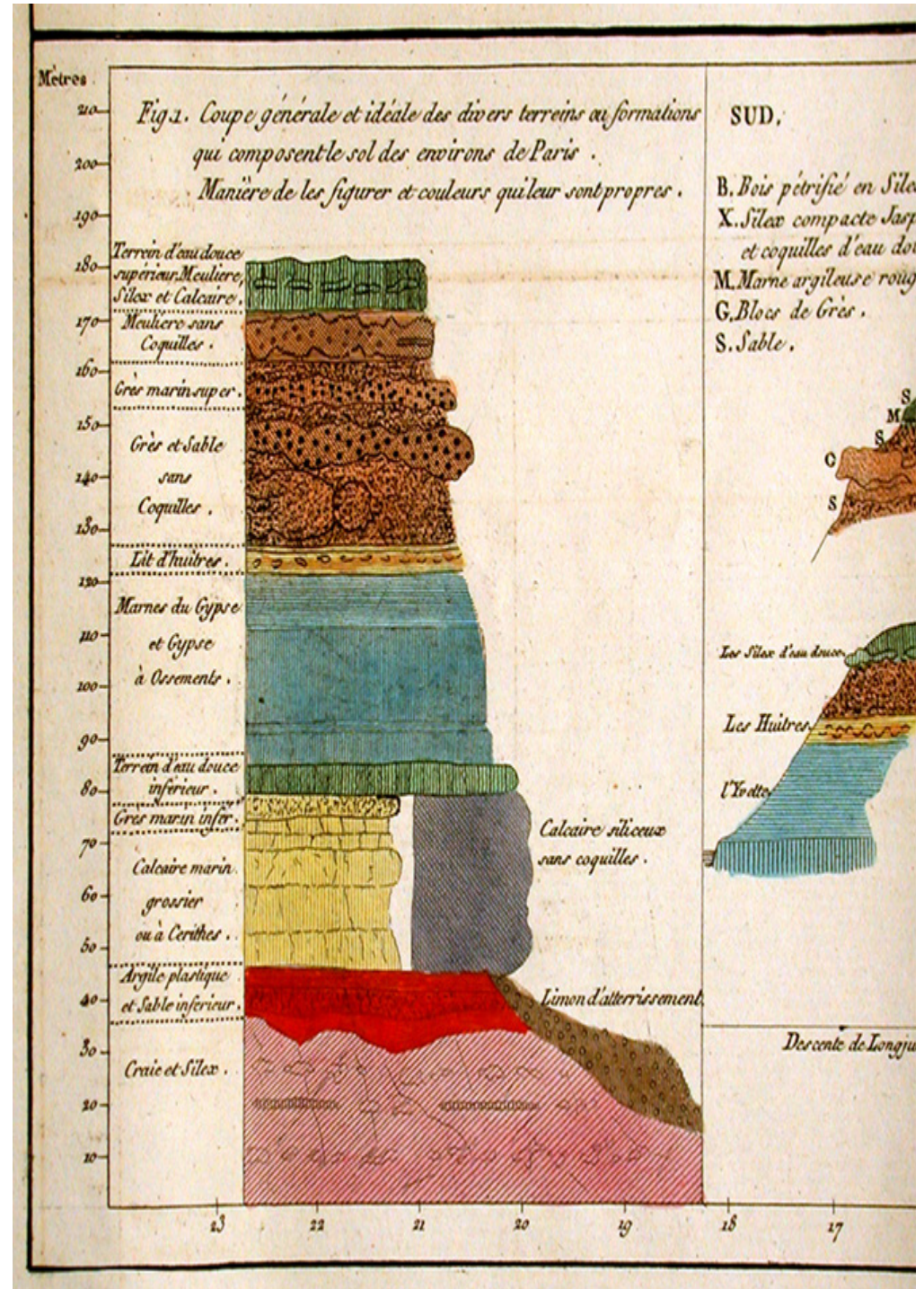
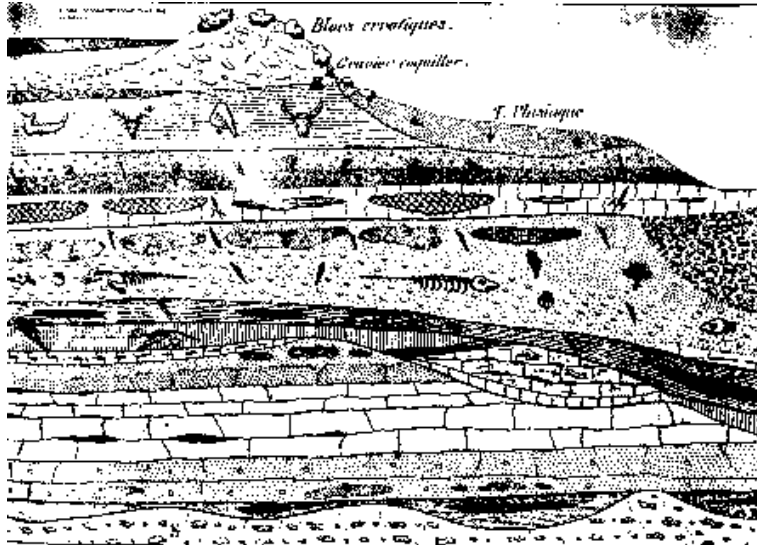
Jefferson's Megatherium



Ground sloth



Cuvier collaborated with Alexandre Brongniart (Paris Mining School) in studying the geology of the Paris basin



Cuvier's verdict on the Paris Basin

- The successive strata of the Paris basin contained characteristically different kinds of fossils (molluscs, as well as vertebrates)
- Comparison with living animals made it clear that some of these fossils were the remains marine, while others were the remains of fresh water animals
- Conclusion: in the geological past, the Paris basin had been by turns sea, fresh water lake and dry land

Cuvier's 'Catastrophism'

- There has been a succession of sharply distinct eras in the history of life
- Each era is characterized by its own distinctive fossil fauna and flora
- Eras are separated by sudden, catastrophic events in which one set of plants and animals is swept away and replaced by another

Cuvier's influence

He transformed the study of both comparative anatomy and paleontology

He provided a theoretical system – ‘catastrophism’ – that became the principal organizational framework for historical geology for more than a generation

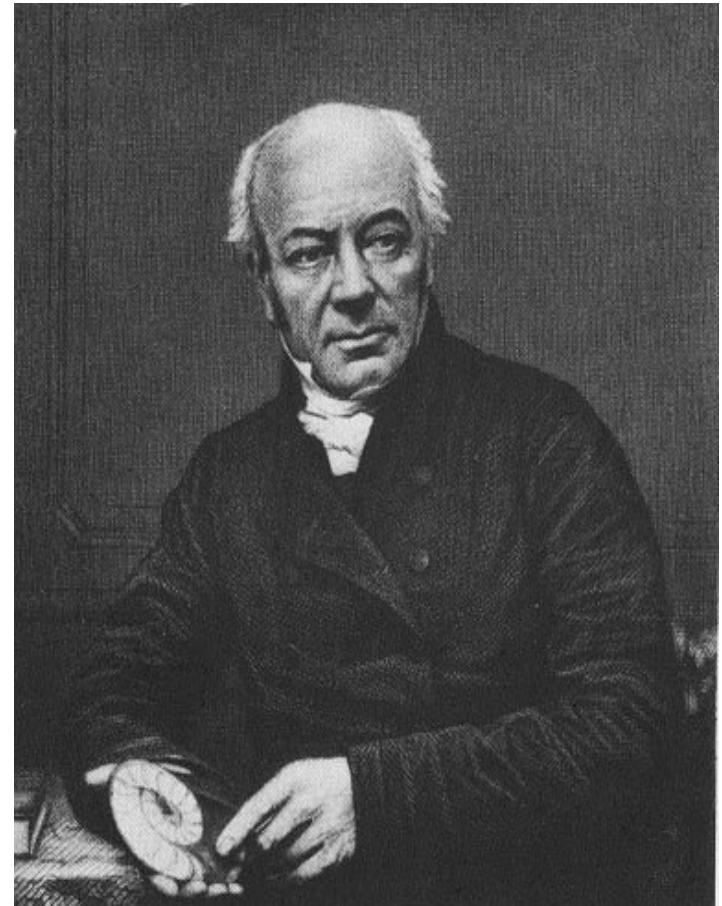
He provided multiple grounds for rejecting the speculative evolutionary ideas of the late Enlightenment

The new geology and natural theology

- In Britain, Cuvier's catastrophism was seized upon by geologists and natural theologians eager to find a new accommodation between science and religion
- Three that we shall consider briefly were:
 1. *William Buckland*
 2. *Adam Sedgwick*
 3. *Hugh Miller*

1. William Buckland, 1784–1856

- Geologist & Anglican clergyman, Fellow of Corpus Christi, Oxford & Dean of Westminster
- First Reader in Geology, University of Oxford
- *Key works include:*
 - *Vindiciae Geologicae*, 1820
 - *Reliquiae Diluvianæ*, 1823
- Early advocate of ‘catastrophist’ geology



Buckland, *Vindiciae Geologicae*, 1820

- Buckland was a natural theologian as well as a highly respected geologist. His first important pronouncements on geology at Oxford University were an attempt to show how the new geology confirmed the Biblical record:

“[A] universal deluge at no very remote period is proved on grounds so decisive and incontrovertible, that, had we never heard of such an event from Scripture . . . Geology itself must have called in the assistance of some such catastrophe, to explain the phenomena of diluvian action which are universally presented to us, and which are unintelligible without recourse to a deluge exerting its ravages at a period not more ancient than that announced in the Book of Genesis.”

Kirkdale Cave, Yorkshire



As portrayed by Buckland

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VRXURI . LLNGDCH &DYH VHH KWS ZZZ \RXVXEH FRP Z DW
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As it appears today

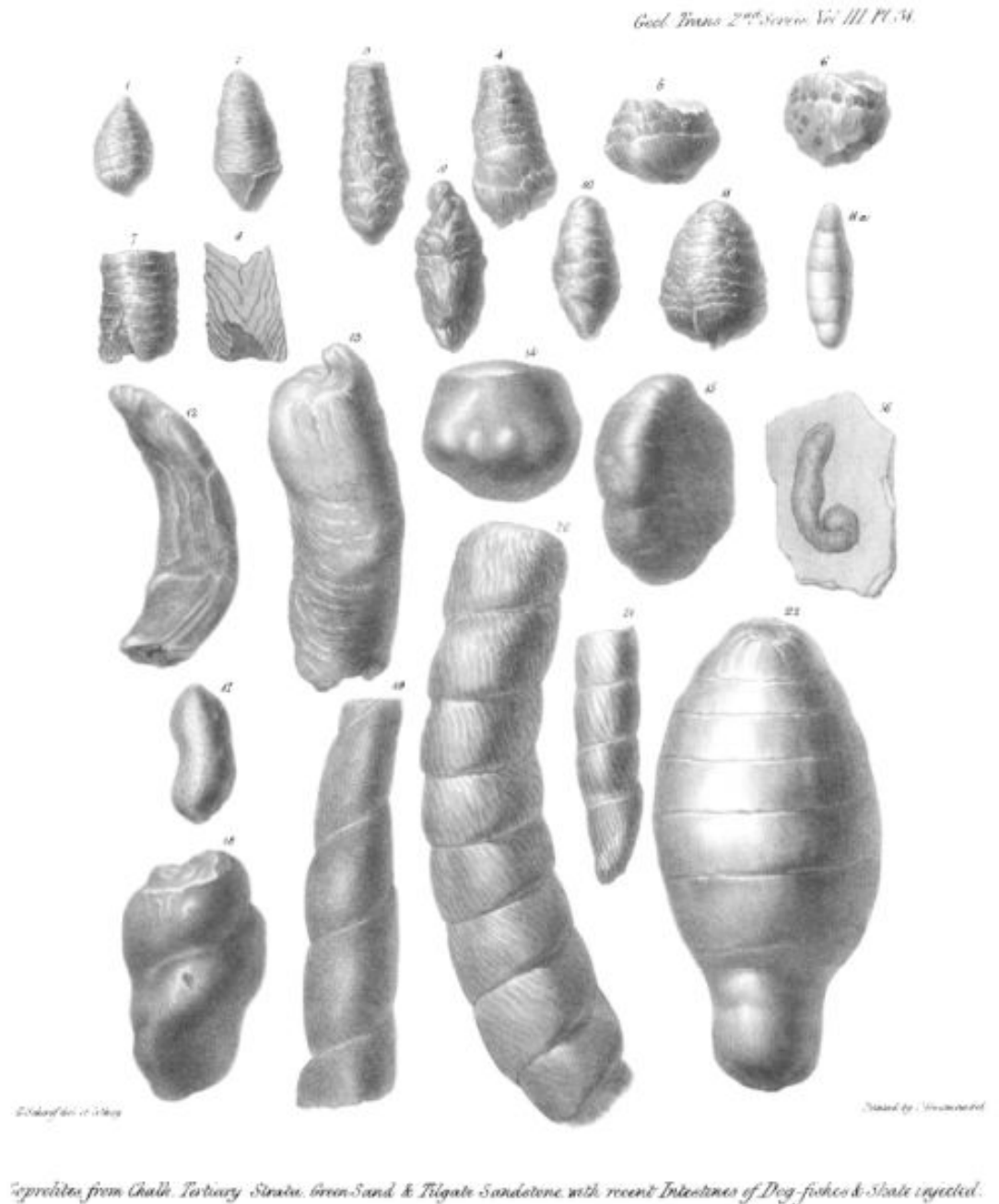
- Buckland found evidence of life prior “to the last great convulsion that has affected [the planet’ s] surface.”
- He identified the 1 fossilized bones of hyena, tiger, elephant (mammoth), hippo, & rhino



“It must already appear probable, from the facts above described, particularly from the comminuted state and apparently gnawed condition of the bones, that the cave in Kirkdale was, during a long succession of years, inhabited as a den of hyaenas, and that they dragged into its recesses the other animal bodies whose remains are found mixed indiscriminately with their own: this conjecture is rendered almost certain by the discovery I made, of many small balls of the solid calcareous excrement of an animal that had fed on bones... It was at first sight recognized by the keeper of the Menagerie at Exeter Change, as resembling, in both form and appearance, the faeces of the spotted or cape hyaena, which he stated to be greedy of bones beyond all other beasts in his care.”

One of
Buckland's
many
discoveries:

Coprolites -
fossilized feces



Buckland's Catastrophism

- Accepts Cuvier's idea of a long series of sharply separate ages in the history of life
- Pioneers techniques for reconstructing prehistoric life (Kirkdale cave)
- At first, interprets recent "diluvial" deposits as evidence that the most recent catastrophe to overcome the world was Noah's Flood; but later, accepts that the data are better explained by the action of ice
- Integrates developing understanding of earth history with Genesis through "Gap" theory

“Gap” Theory

Key Idea:

The word "beginning" in Genesis means an undefined period between the origin of the earth and the creation of its current inhabitants, during which geology reveals that a series of successive extinctions and creations of new kinds of plants and animals took place.

Buckland's Reputation

“Where shall we our great Professor inter
That in peace may rest his bones?
If we hew him a rocky sepulchre
He'll rise and break the stones
And examine each stratum that lies around
For he's quite in his element
underground.”

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