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CONNECTICUT
COLLEGE

What is a fossil?

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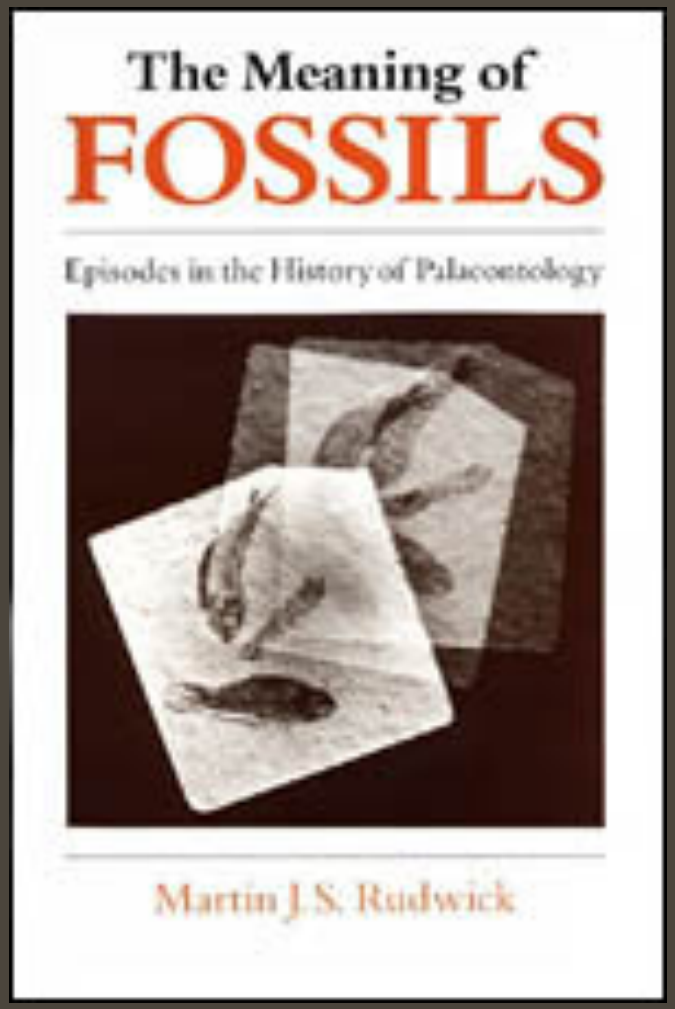
Motivations

The concept of fossil helps to delineate the disciplinary turf of paleontology.

Major developments in the field have sometimes involved rethinking the meaning of fossils.



A thought experiment

Imagine a planet ("Afossilia") just like ours, but without any fossils … Suppose that God has removed all the fossils from the rocks.

What exactly would the Afossilians be missing?

Main claims

1. The concept of a fossil is hopelessly muddled and confused. We don't really know what fossils are.

2. But this conceptual confusion doesn't matter much for current paleontological practice, which focuses on inferring processes from patterns in large sets of data.

Sources of confusion

1. Some pseudofossils are really trace fossils.

2. “Fossil” does not pick out a natural kind.

3. It’s even tough to identify necessary conditions for being a fossil.

Sources of confusion

4. The need for an arbitrary age cut-off.

5. Literal vs. metaphorical uses of “fossil” are difficult to distinguish.

6. Puzzling cases: e.g. Ambergris

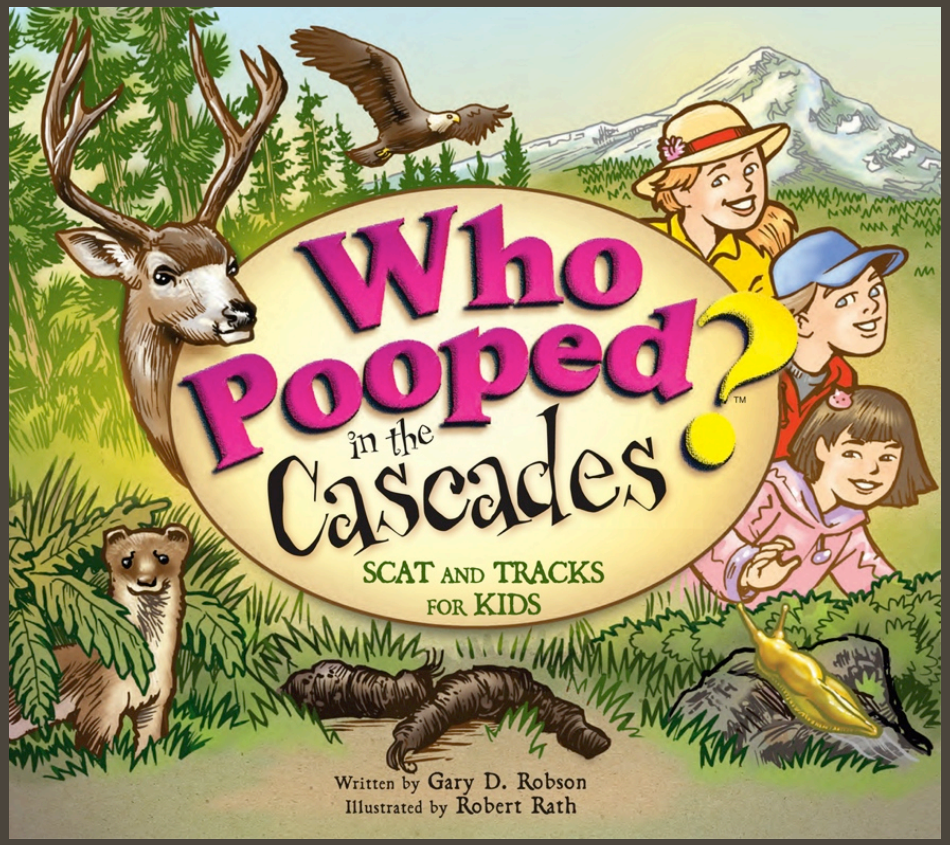
7. The problem of multiple casting & molding

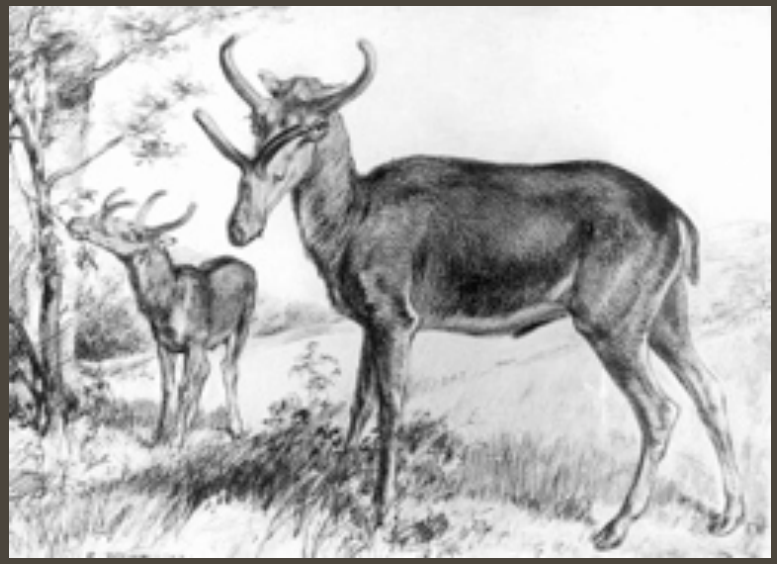
The $10,370 coprolite

“This truly spectacular specimen is possibly the longest example of coprolite ever to be offered at auction. It boasts a wonderfully even, pale brown-yellow coloring and terrifically detailed texture to the heavily botryoidal surface across the whole of its immense length. The passer of this remarkable object is unknown, but it is nonetheless a highly evocative specimen of unprecedented size, presented in four sections, each with a heavy black marble custom base, an eye-watering 40 inches in length overall.”

The Wilkes Formation, Toledo, Washington, USA

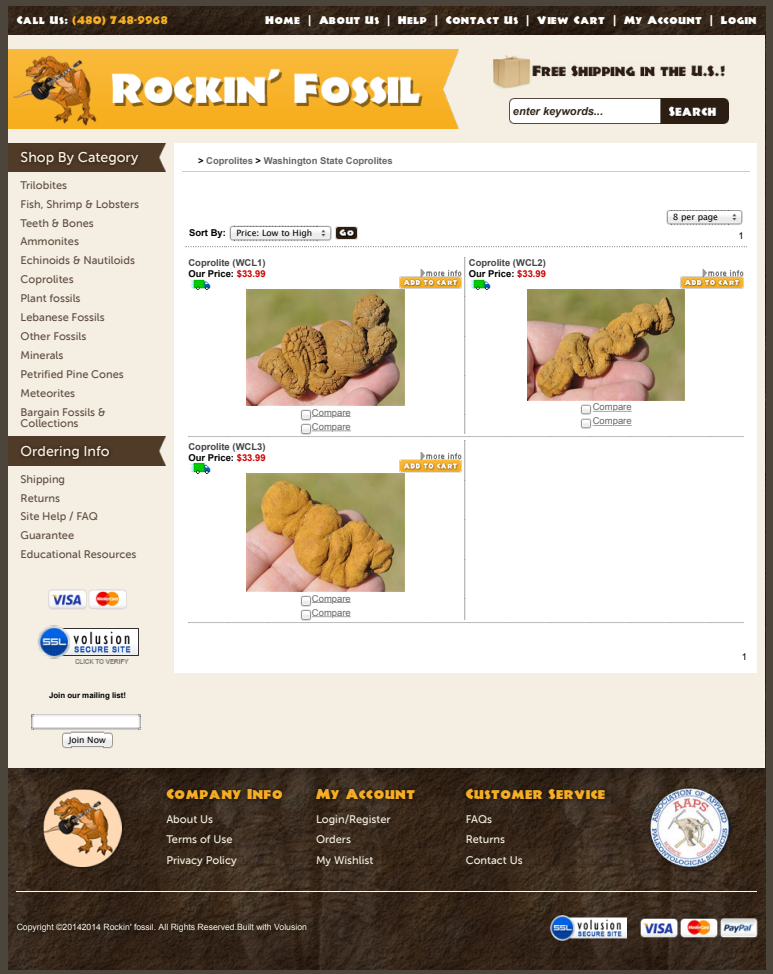
Who did it?





Miocene four-horned deer

You can buy a coprolite from rockinfossil.com for $33.99



Or coprolite jewelry

Fossils *vs*. Pseudofossils

"Excrement-shaped masses of siderite and limonite have been reported from clay-rich sedimentary rocks that range in age from Late Permian to Holocene. These objects have been widely accepted as being coprolites, but the ferruginous composition, absence of internal inclusions, and scarcity of associated vertebrate remains suggest that they may instead be **pseudofossils** created by mechanical deformation of plastic sediment."

G.E. Mustoe, "Enigmatic origin of ferruginous "coprolites": Evidence from the *Miocene Wilkes Formation, southwestern Washington"* GSA Bulletin 116(2001): 673-681.

Fossils *vs.* Pseudofossils

"A new hypothesis for the origin of these so-called coprolites is proposed, relying on organic-rich sediment, but inorganic processes. In this scenario, organic rich silt and clay was forcefully injected into hollow wood fragments and through knotholes, creating the characteristic features formerly cited as conclusive evidence for the fecal origin of these objects."

Patrick Spencer, "The "coprolites" that aren't: the straight poop on specimens from the Miocene of southwestern Washington State" *Ichnos* 2(1993): 231-236.

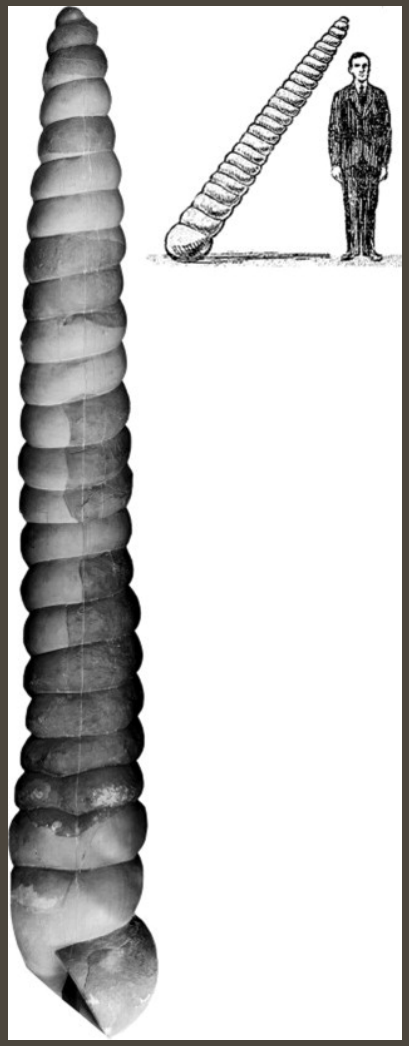
“I’d make a thin section to see if there was any residue in there from the last meal.”

“I’ve done it with enough of them, and I haven’t found a dang thing in there. I have written more than a few letters to fossil supply houses and asked them to stop selling them as coprolites”

Patrick Spencer, quoted by B. Switek, “Was Six-Million-Year-Old Turd Auctioned for $10,000 a Faux Poo?” *National Geographic News*, July 29, 2014.

Some pseudofossils, such as these dendrites, have inorganic origins

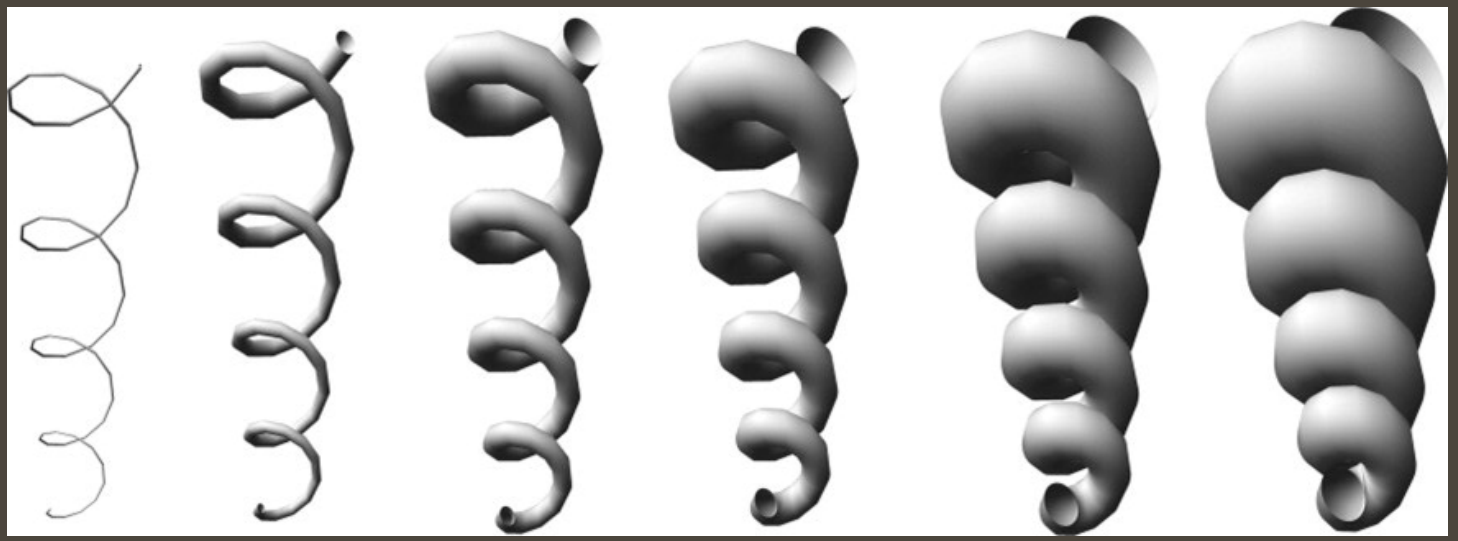
Dinocochlea: The "Terrible snail"?



First thought to be an internal cast of a gastropod shell, found near Hastings, UK, in 1921, 2.2m long.

Later dismissed as a pseudofossil: an unusual concretion in lower Cretacous sediments.

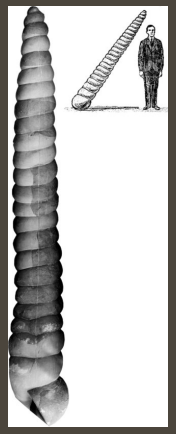
Or is *Dinocochlea* a concretion that formed around a burrow created by a worm?



P.D. Taylor and C. Sendino, "A new hypothesis for the origin of the supposed giant snail Dinocochlea from the Wealden of Sussex, England," *Proceedings of the Geologists' Association* 122(2011): 492-500.

Authentic pseudofossils?

Can a pseudofossil also be a fossil?



“Fossil” does not pick out a natural kind

Permineralization

Casting & molding

Compression and carbonization

Even trace fossils (ichnofossils) do not comprise a natural kind

Fossilized burrows from Chaco Canyon, NM

nature

LETTERS

Fossil steroids record the appearance of Demospongiae during the Cryogenian period

Gordon D. Love[1,2], Emmanuelle Grosjean[3], Charlotte Stalvies[4], David A. Fike[5], John P. Grotzinger[5], Alexander S. Bradley[5], Amy E. Kelly[3], Maya Bhatia[2], William Meredith[6], Colin E. Snape[6], Samuel A. Bowring[2], Daniel J. Condon[2]† & Roger E. Summons[1]

Fossil steroids, a biomarker for sponges, from 635 mya (chemofossils)

Banded iron formation—a trace fossil?

Compare: Jade

Jadeite

Nephrite

“Jade” picks out a heterogeneous group of minerals.

“Fossil” picks out the products of heterogeneous historical processes.

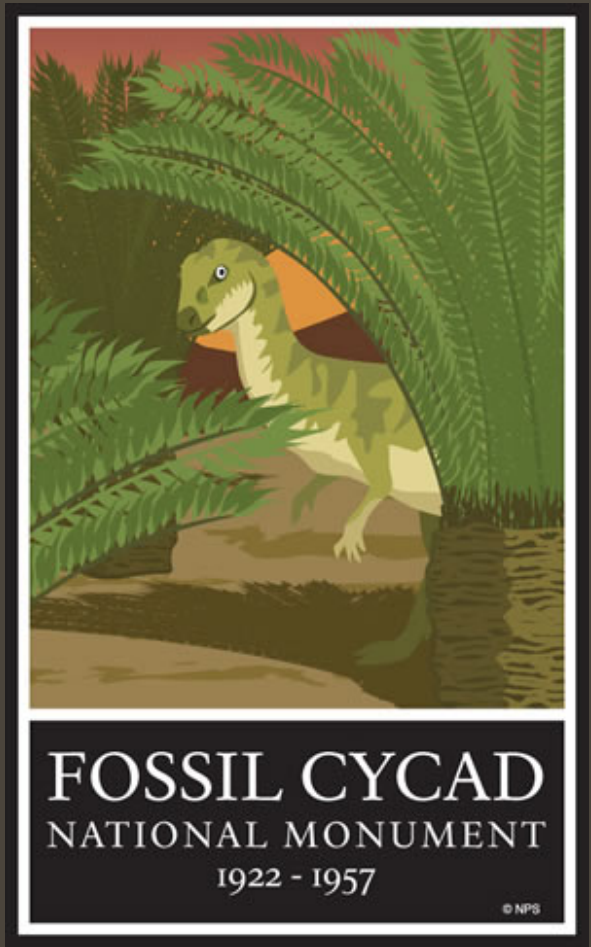
Living fossils

not really fossils—it's just a metaphor

Wollemi Pine

Living fossils

not really fossils—it's just a metaphor



A necessary condition?

Proposal: Something is a fossil only if it is a geological item.

Virtue: This explains why living fossils are not really fossils.

A necessary condition?

Proposal: Something is a fossil only if it is a geological item.

Problems:

1. It's not entirely clear what makes something a geological item.
2. Fossilization comes in degrees.

Do these items belong to the geological record?

Ambergris

Bone breccia

Problem case: Ambergris (“gray amber”)

Produced in the intestines of sperm whales, perhaps to ease the passage of sharp objects through the gut.

Often contains the beaks of giant squids.

Undergoes some chemical changes, esp. oxidation, while drifitng at sea, becoming gray and waxy.

An old age requirement?

"A fossil is the remains of ancient life, but it is not practical to define a minimum age limit for fossils. Nevertheless, about 10,000 years before present is often taken as an arbitrary dividing line between what is fossil and what is Recent."

"Fossilization," *The Encyclopedia of Prehistoric Life*, ed. by R. Steel and A.P.Harvey, McGraw-Hill, 1979.

Motivation for the 10,000 year cut-off

Every living organism is a trace of prehistoric life. The genes and proteins in all of our bodies contain information about phylogeny, about evolutionary rates and divergence points (as revealed by molecular clock studies).

Are we all fossils?

Absurd consequences?

DNA obtained from a mammoth carcass >10 kya is a molecular fossil

But DNA from the thylacine <100 years old is not.

The difference between 100 ya and 10,000 ya is geologically trivial.

Absurd consequences?

Worse, should we say that the mammoth DNA, 5,000 years ago, was not (yet) fossil material, but that it *became* fossil DNA with the passing of time, in the absence of any other physical transformation?

Literal vs. metaphorical usage

Literal fossils

Metaphorical fossils

But what about ….

Molecular fossils? Chemofossils?

A puzzling case: Fossil water

The term evokes an analogy with fossil fuels.

But fossil water has inorganic (glacial) origins.

Is this a metaphorical use (like “living fossil”) or a literal use of the term “fossil” in a different sense?

Could fossil water be a pseudofossil?

Linguistic fossils

(These are just fun to think about.)

If I had my ***druthers*** …

To give something short ***shrift*** …

… hoisted by one's own *petard*

The words "druthers," "shrift," and "petard" never occur outside the context of these phrases.

The problem of multiple casts

The Carnegie *Diplodocus* (on the right)

Is a human-made cast of a fossil still a fossil?

What if multiple casting & molding happened naturally?

Therefore,

The concept of a fossil is something of a mess.

A dismissive response

Because “fossil” is not a theoretical term, very little is at stake here. This is not like the terms “species” or “fitness,” which figure centrally in evolutionary theory.

But paleontologists *do* theorize about fossils. Taphonomists test generalizations about them. Fossilization is an unobservable historical process.

Other possible responsesto all this

(1) Try to clear up the conceptual confusion. One approach: Go pluralist, distinguishing different senses of "fossil" appropriate to different contexts.

(2) Tolerate, or even embrace, the conceptual confusion. We don't know what fossils are, and that is not such a problem.

The costs of clarity

One can achieve clarity by means of revisionary proposals.

For example: a fossil (broad sense) = any presently observable evidence of past life.

But this would involve broadening the meaning of “fossil” beyond recognition.

What makes the confusion tolerable?

Paleontologists are largely interested in identifying and explaining *patterns* in the fossil record, i.e. in large samples of fossil data.

Pattern/process inference does not require conceptual clarity about what fossils are. It just requires having a lot of them.

An imperfect analogy

The fossil concept plays somewhat the same role for paleontology that the concept of life plays for biology.

There are relatively few scientific contexts where a precise definition of “life” is needed (e.g. astrobiology).

Thank you

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