Taphonomy

http://blog.webosaurs.com

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EEB464 Fall 2019

Learning objectives

Understand what causes biases in the fossil record
Learn about different kinds of body fossils
Create hypotheses about other biases

Statistical definition of bias

A systematic (built-in) error which makes all values wrong by a certain amount.

Example: You always measure your height wearing shoes with thick soles.

From MathIsFun.com (yes, not necessarily something you should go to as your main reference for questions)

Ecological pyramid

Predators

Herbivores

Producers

“In today's ecosystems herbivores are much more abundant than carnivores. It is therefore curious that at La Brea about 90% of the mammal fossils found represent carnivores. Most of the bird fossils are also predators or scavengers, including vultures, condors, eagles, and giant extinct, storklike birds known as teratorns. Why is this the case?”

http://www.ucmp.berkeley.edu/quaternary/labrea.html


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excerpt from "A Short History of Nearly Everything

http://blog.webosaurs.com

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National Geographic

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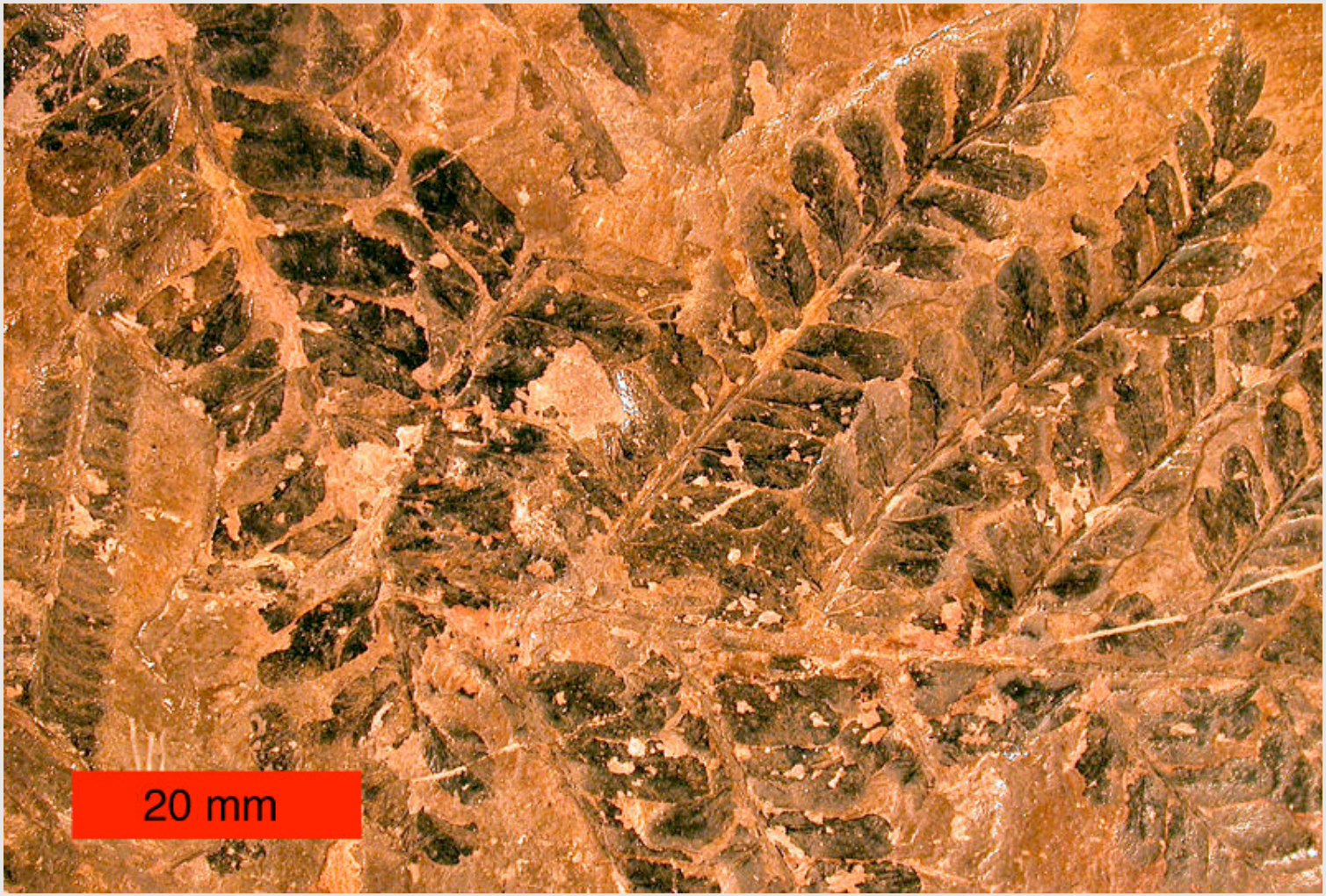
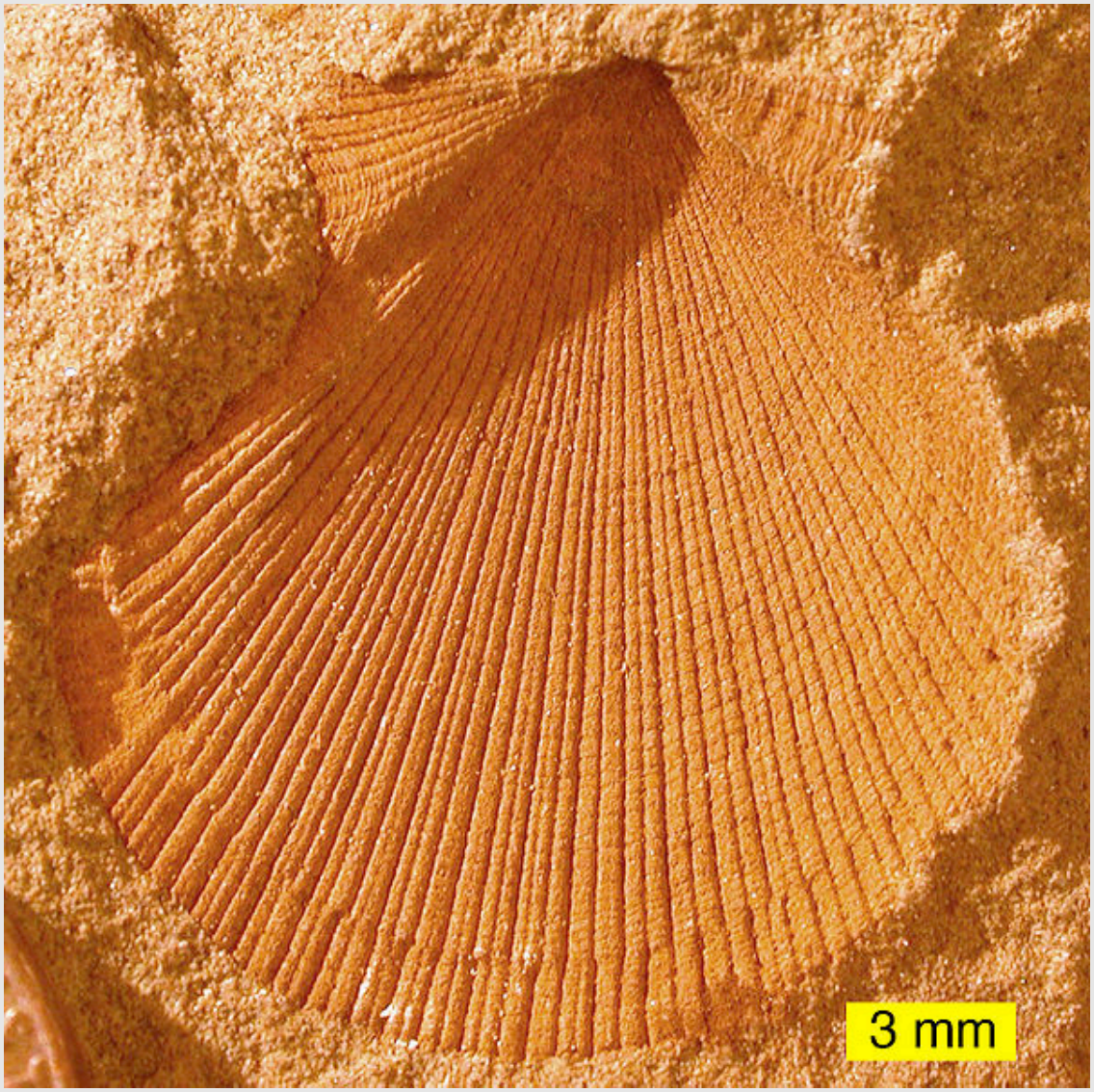
Permineralization: small spaces within organism (such as within cells) are filled with minerals. Think of pickling, but with precipitating minerals rather than pickle juice.



Compression fossils: flattened. Organic material generally modified to rock



Cast/mold fossil: Think making a plaster cast. The mold is the outside, the cast is the replacement inside

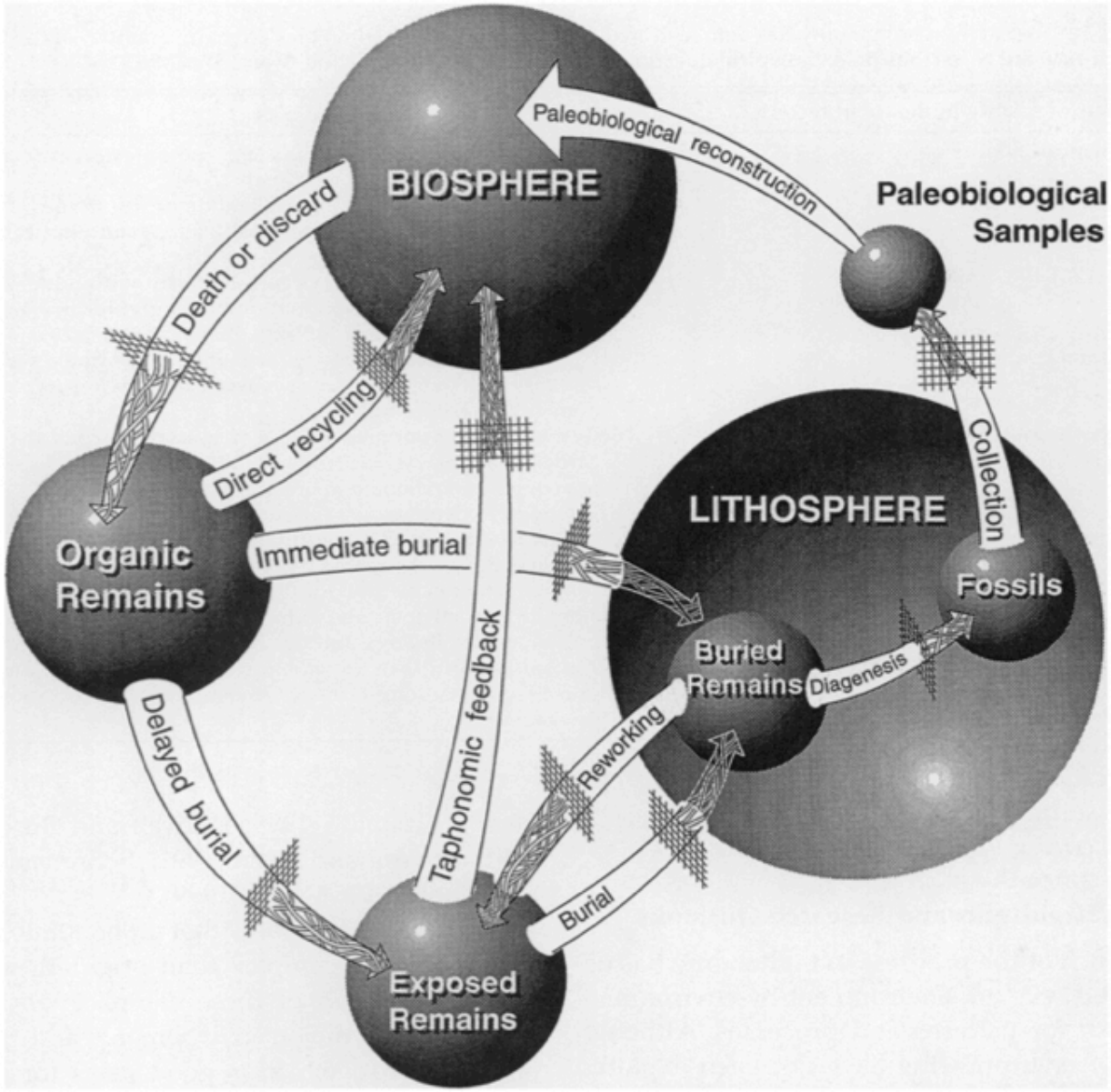


FIGURE 1. The main pathways for organic remains from death to paleobiological inference. Each path is affected by taphonomic processes and circumstances that filter the information as it passes to the next stage. Taphonomy is the study of how biological, chemical, and physical processes operating between each stage preserve or destroy organic remains and affect information in the fossil record (Behrensmeyer and Kidwell 1985).

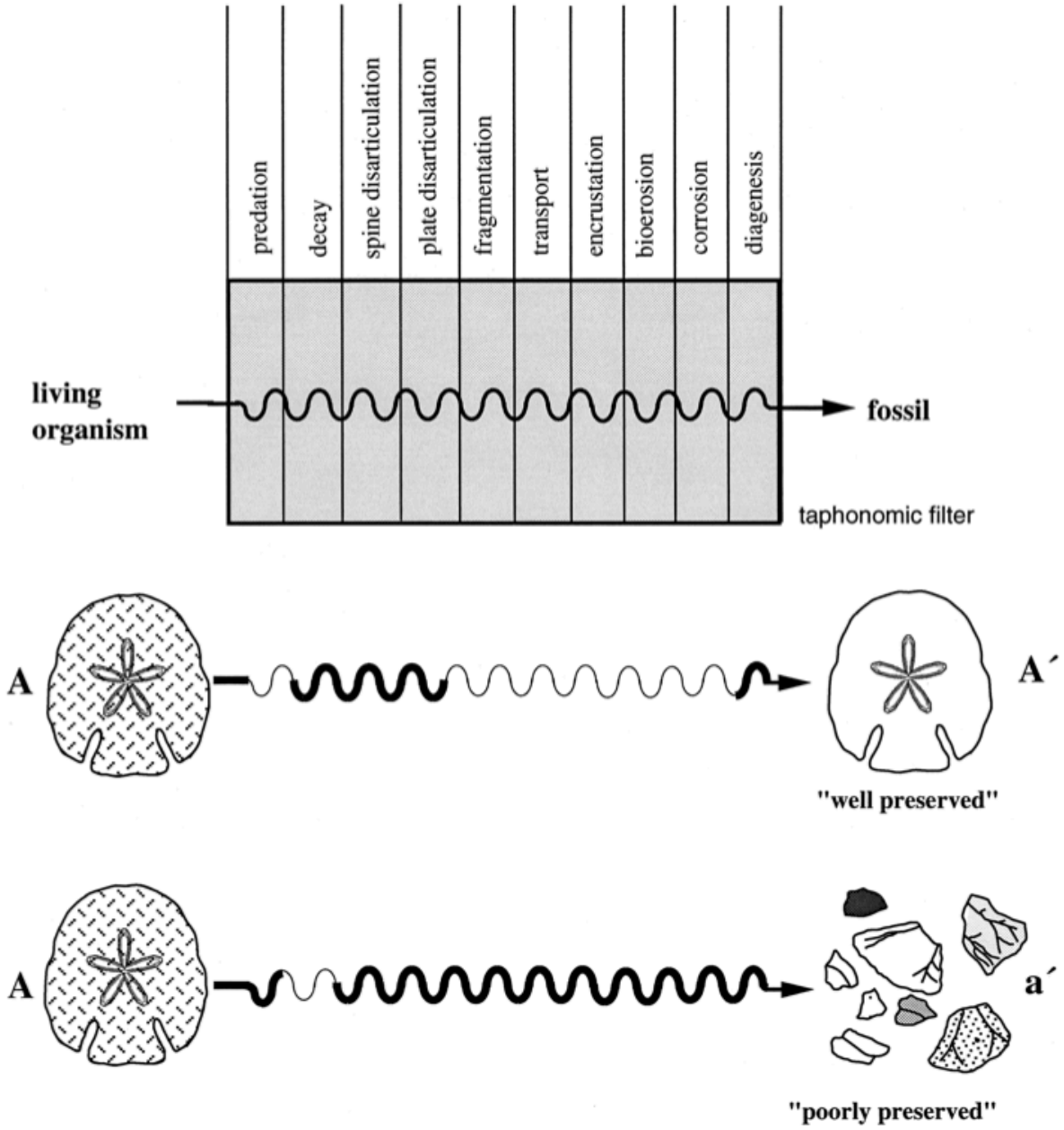


Fig. 1. Schematic diagram of the taphonomic processes leading to different preservations of an echinoid. The presence of a taphonomic feature is indicated by the thicker line (modified after Nebelsick, 1995).

Nebelsick. Taphonomic comparison between Recent and fossil sand dollars. Palaeogeogr Palaeocl (1999) vol. 149 (1-4) pp. 349-358

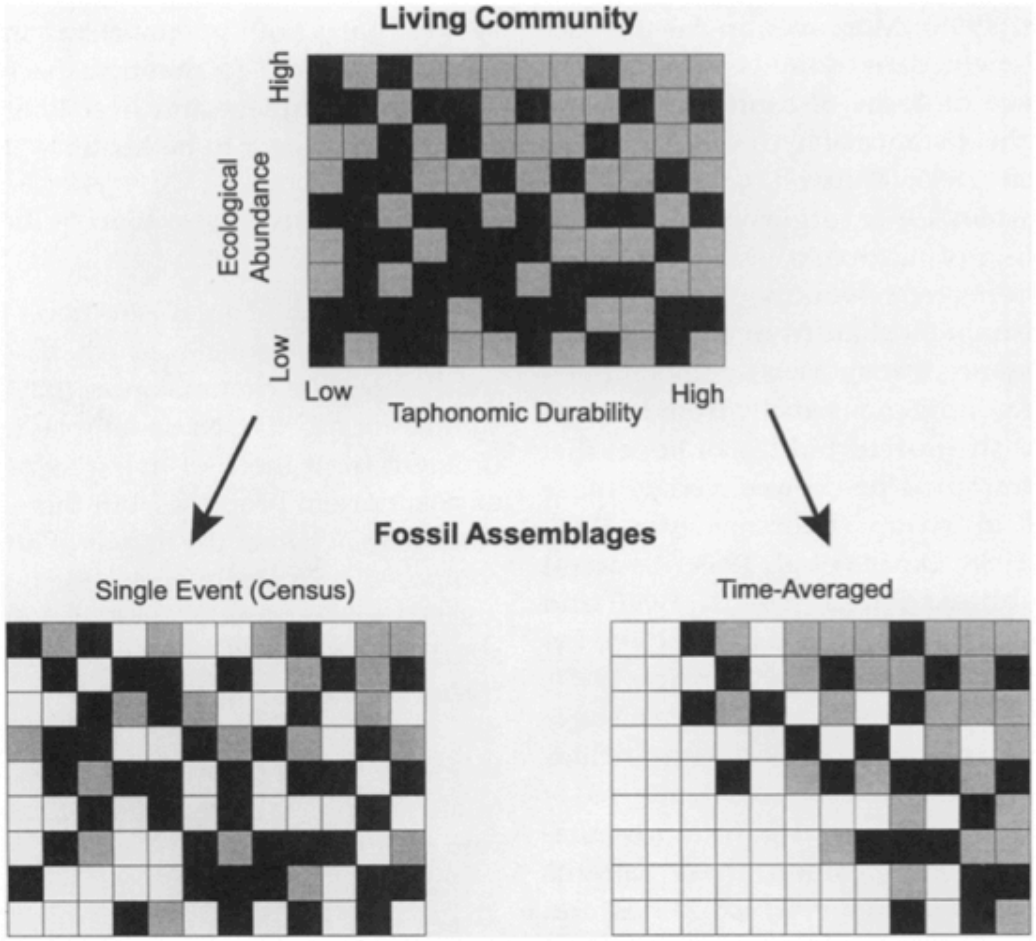


FIGURE 2. Schematic portrayal of information changes in two different types of fossil assemblages compared with a hypothetical living community at one point in time. Each cell is a species characterized by two variables, ecological abundance during life and taphonomic durability of the remains; the living community consists of equal numbers (50:50) of species that are permanent residents (black cells) and transients (gray cells, e.g., highly mobile forms or those on seasonal or longer-term population cycles). White cells in the fossil assemblages indicate species that are not preserved. The single-event assemblage (census) will capture most of the resident and some of the transient species (in this example, 80% and 37% of the cells (species) in the life assemblage, respectively) and is not strongly affected by taphonomic durability. In contrast, the attritional, time-averaged assemblage will be biased toward higher durability and more abundant species, capturing 44% of the resident and 52% of the transient species. A similar graphic model could be applied to all types of organisms or organic parts, with varying results for census versus time-averaged assemblages depending on the range of durability, type of community, environment, and length of time-averaging.

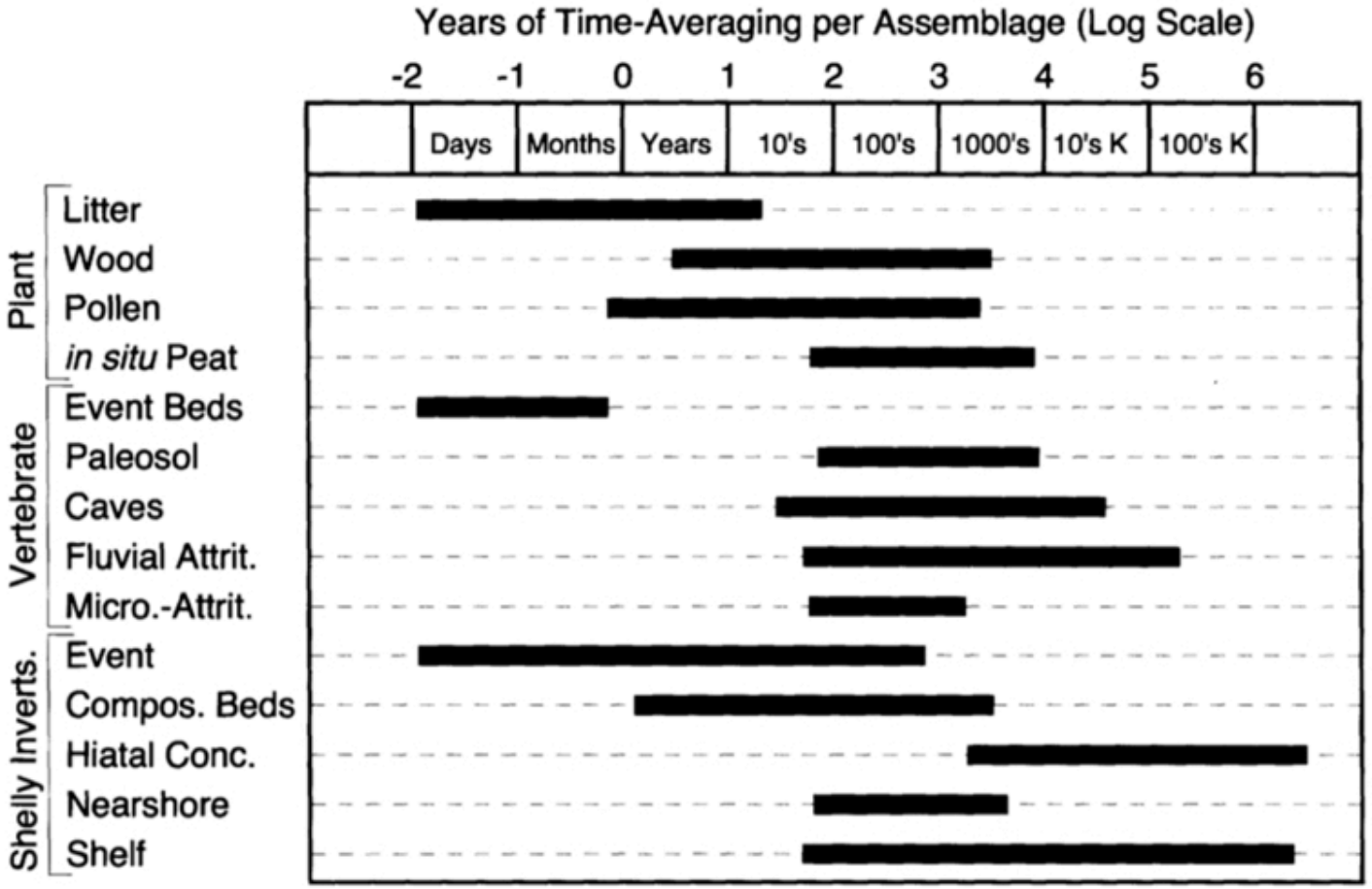
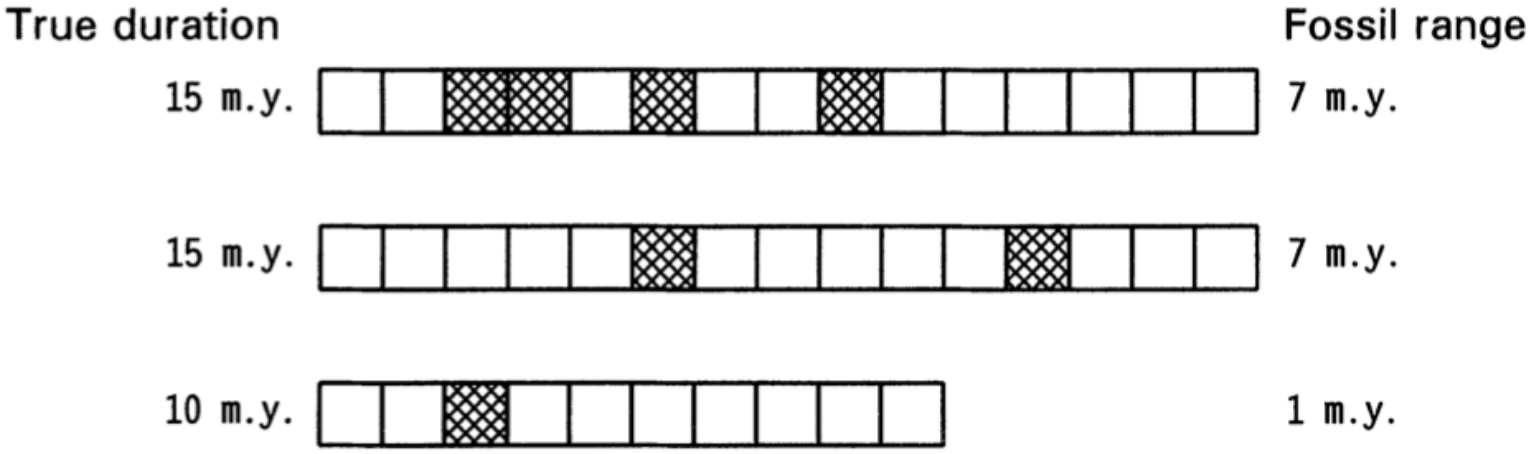


FIGURE 3. Estimated limits on time-averaging of selected types of continental plant tissues and vertebrate and marine invertebrate assemblages. The different categories (tissues versus deposits) reflect the fact that paleobotanists regard tissue type as playing the most important role in time-averaging for plant remains, while paleozoologists regard depositional environment or process as more important. Modified from Kidwell and Behrensmeyer 1993.

Cockle Shell Beach, near Kippford, Dumfries & Galloway
Unusual beach composed entirely of cockle shells between large rocks.



R = Prob(preservation at least once in interval)
(1 − R) = Prob(non-preservation)

In general, Prob(range = t if duration = T):

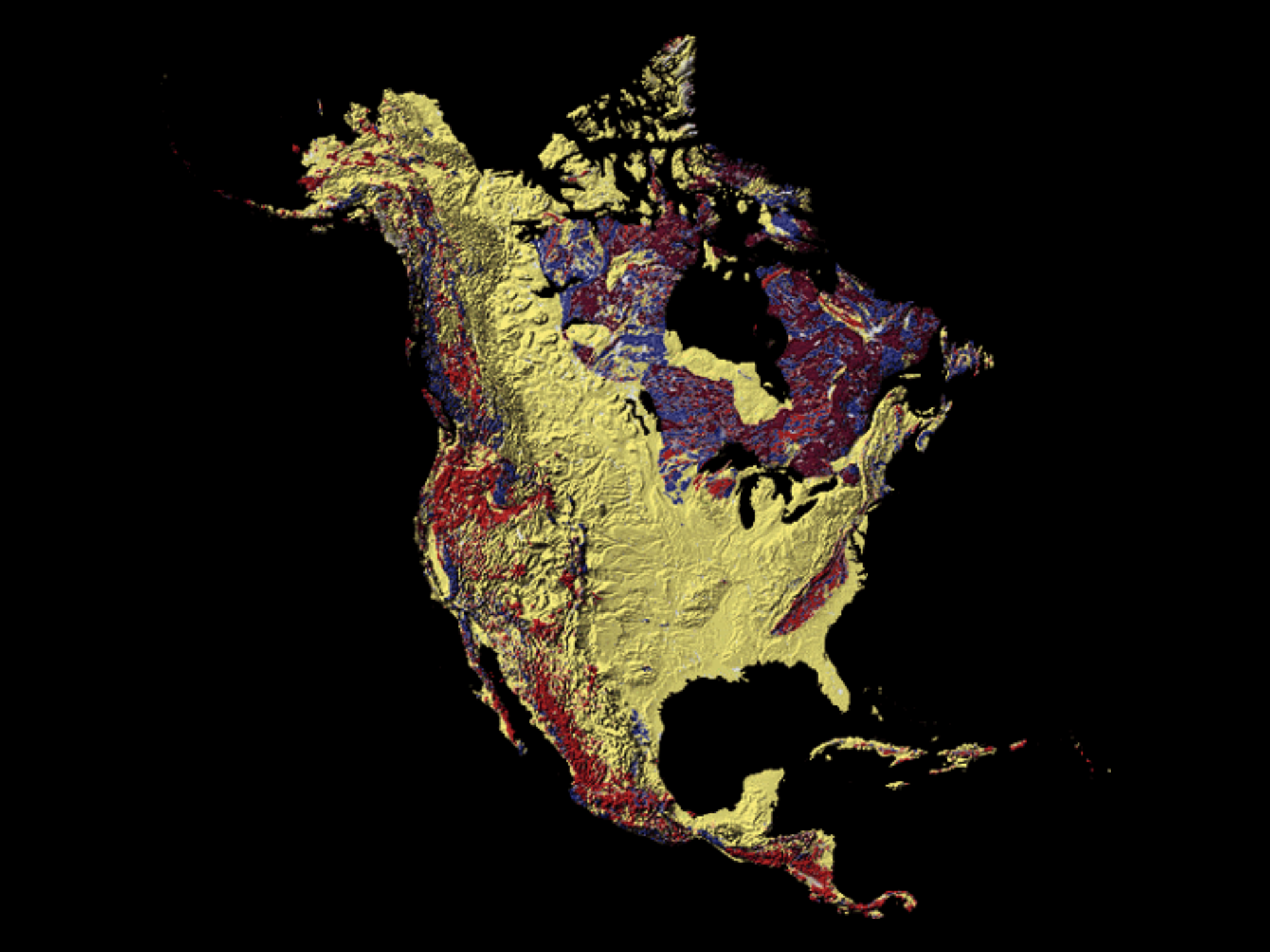
$= (1 - R)^{T}$ if t = 0

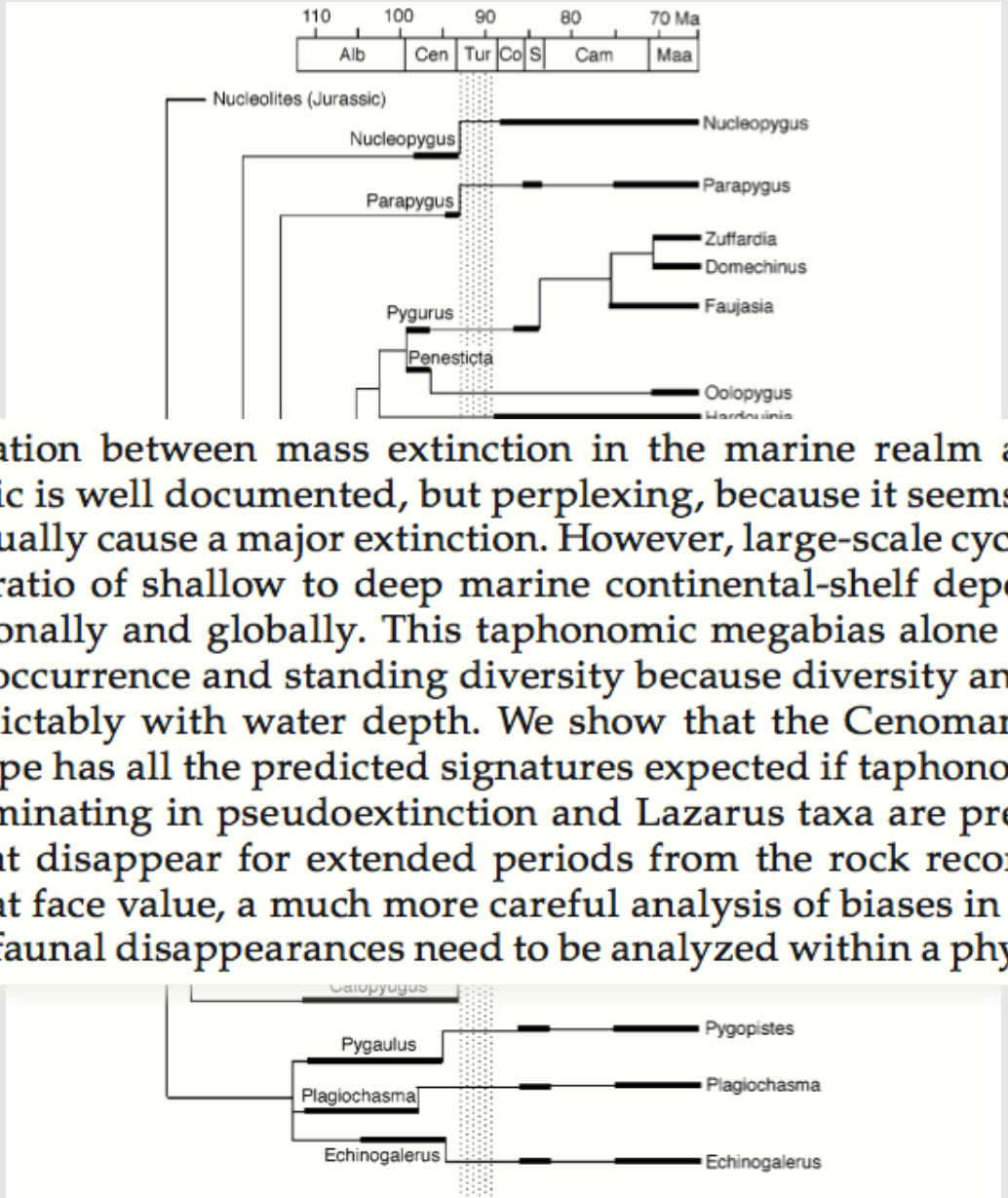
$= T(1 - R)^{(T-1)}R$ if t = 1

$= (T - t + 1)(1 - R)^{(T-t)}R^{2}$ if t > 1

FIGURE 1. Relationship between taxonomic duration and fossil range. Time is in discrete intervals (here, one million years), and durations and ranges are treated as ranging through each interval of occurrence. Empty intervals indicate non-preservation; hatched intervals indicate preservation of taxon at least once during interval. Probability that taxon with true duration *T* has range *t* is easily derived (Appendix 1).

Foote and Raup. Fossil preservation and the stratigraphic ranges of taxa. Paleobiology (1996) vol. 22 (2) pp. 121-140





Abstract.—The association between mass extinction in the marine realm and eustatic sea-level change in the Mesozoic is well documented, but perplexing, because it seems implausible that sea-level change could actually cause a major extinction. However, large-scale cycles of sea-level change can and do alter the ratio of shallow to deep marine continental-shelf deposits preserved in the rock record both regionally and globally. This taphonomic megabias alone could be driving patterns of first and last occurrence and standing diversity because diversity and preservation potential both change predictably with water depth. We show that the Cenomanian/Turonian faunal event in western Europe has all the predicted signatures expected if taphonomic megabias was the cause. Grade taxa terminating in pseudoextinction and Lazarus taxa are predominantly found in the onshore facies that disappear for extended periods from the rock record. Before other mass extinctions are taken at face value, a much more careful analysis of biases in the rock record needs to be carried out, and faunal disappearances need to be analyzed within a phylogenetic framework.

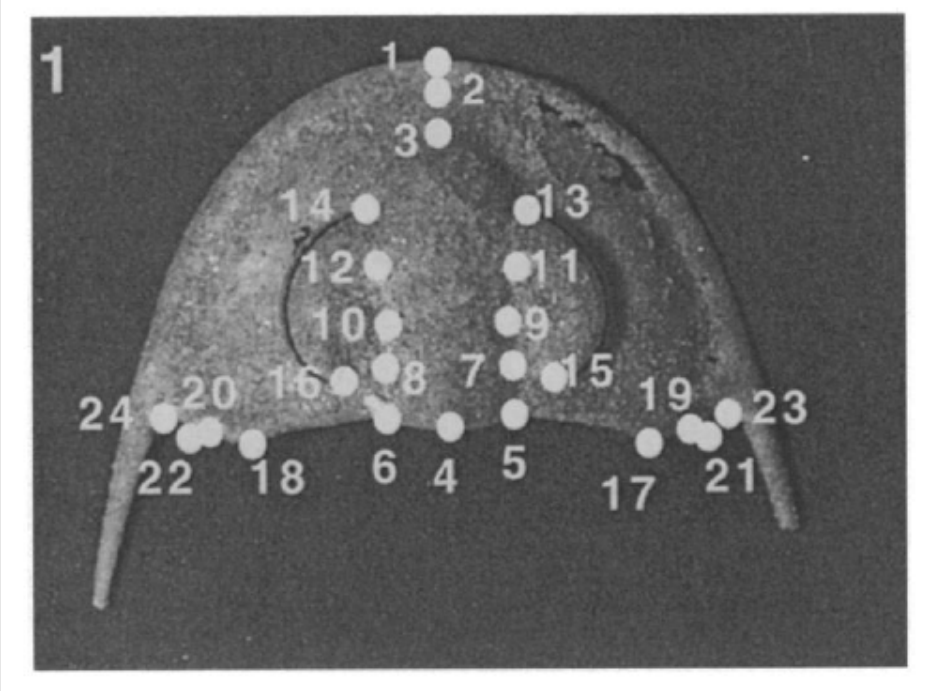
FIGURE 8. Cladogram of Late Cretaceous cassiduloid genera calibrated against their stratigraphic records. Characters are as listed in Smith (in press) and the data matrix is available on request. Cenomanian taxa are treated as possible ancestors to derived clades if they have one or fewer autapomorphies. Each name is a terminal taxon in the analysis. Parsimony analysis was conducted using the program PAUP (Swofford 1999). A heuristic search algorithm with 100 random-addition replicates found 139 trees of length 132 steps with a CI of 0.41 and RI of 0.76. Characters were then reweighted according to their rescaled consistency index and the search repeated. This found 60 equally parsimonious trees, and the strict consensus of those is what is calibrated against the stratigraphic record. Stippled zone indicates time interval when cassiduloids are absent from Europe.

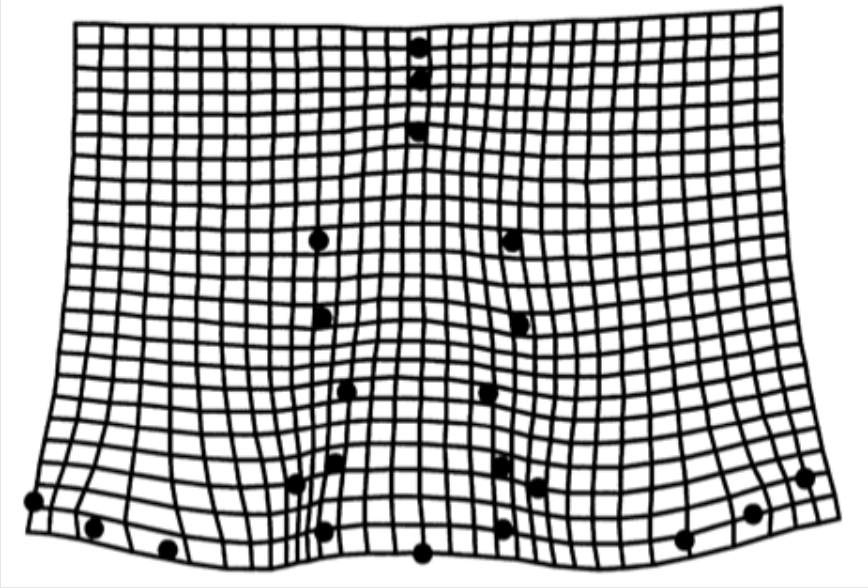
Smith et al. Sea-level change and rock-record bias in the Cretaceous: a problem for extinction and biodiversity studies. Paleobiology (2001) vol. 27 (2) pp. 241-253

ABSTRACT. Durophagous crabs were found to make unusually high rates of predatory mistakes by attacking empty gastropods and models of intact bivalves. This mistaken predation is attributed to the crypticity of the shell: if a crab cannot readily determine whether a shell contains food, as is the case with gastropod shells, it will crush it. In contrast, empty bivalve shells (represented by half-shells) are readily examined by crabs and rejected. The taphonomic implications, and importance for the gastropod fossil record, are two-fold. First, where predatory crabs are abundant, shells of gastropods are prone to detrimental biological destruction at three levels: while alive, inhabited by hermit crabs and empty. Bivalves are subject to predation at only one level: while alive. Second, because empty gastropods are preyed upon, peel marks on fossil gastropods are therefore not a reliable indication of crab predation. Mistaken predation is a source of taphonomic bias that needs to be considered in interpreting predation events in fossil gastropods.

D. Gordon E. Robertson

Walker and Yamada. Implications for the gastropod fossil record of mistaken crab predation on empty mollusc shells. Palaeontology (1993)





Webster and Hughes. Compaction-Related Deformation in Cambrian Olenelloid Trilobites and Its Implications for Fossil Morphometry. Journal of Paleontology (1999) vol. 73 (2) pp. 355-371

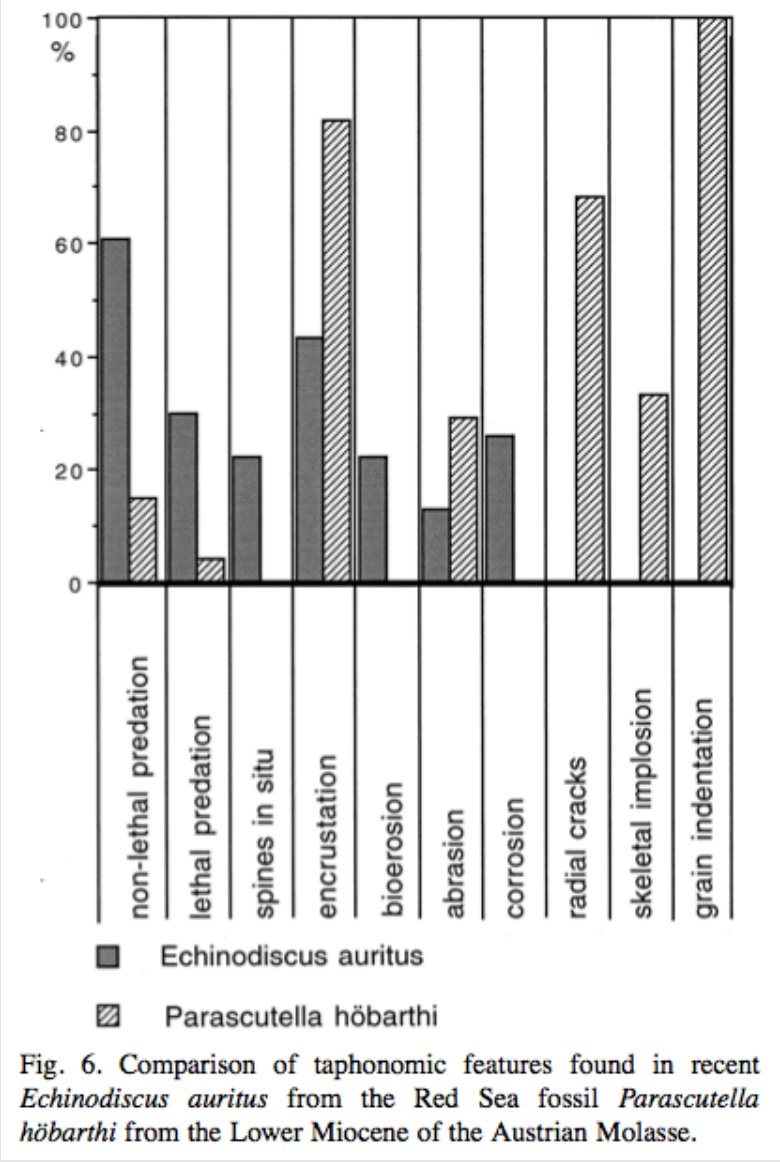
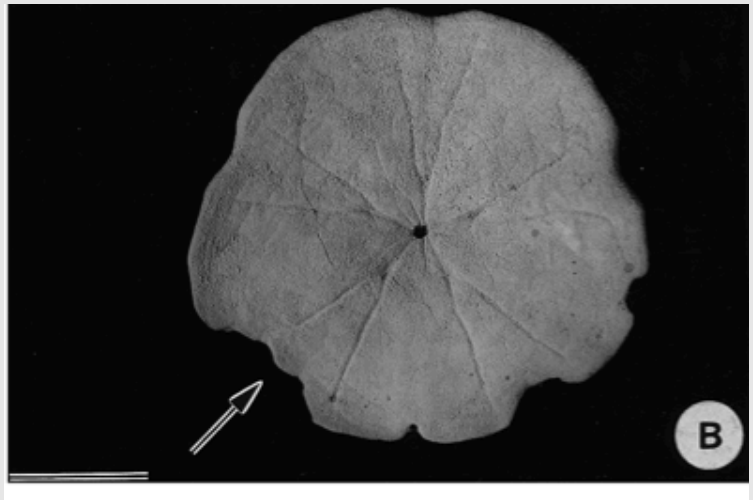


Fig. 6. Comparison of taphonomic features found in recent *Echinodiscus auritus* from the Red Sea fossil *Parascutella höbarthi* from the Lower Miocene of the Austrian Molasse.



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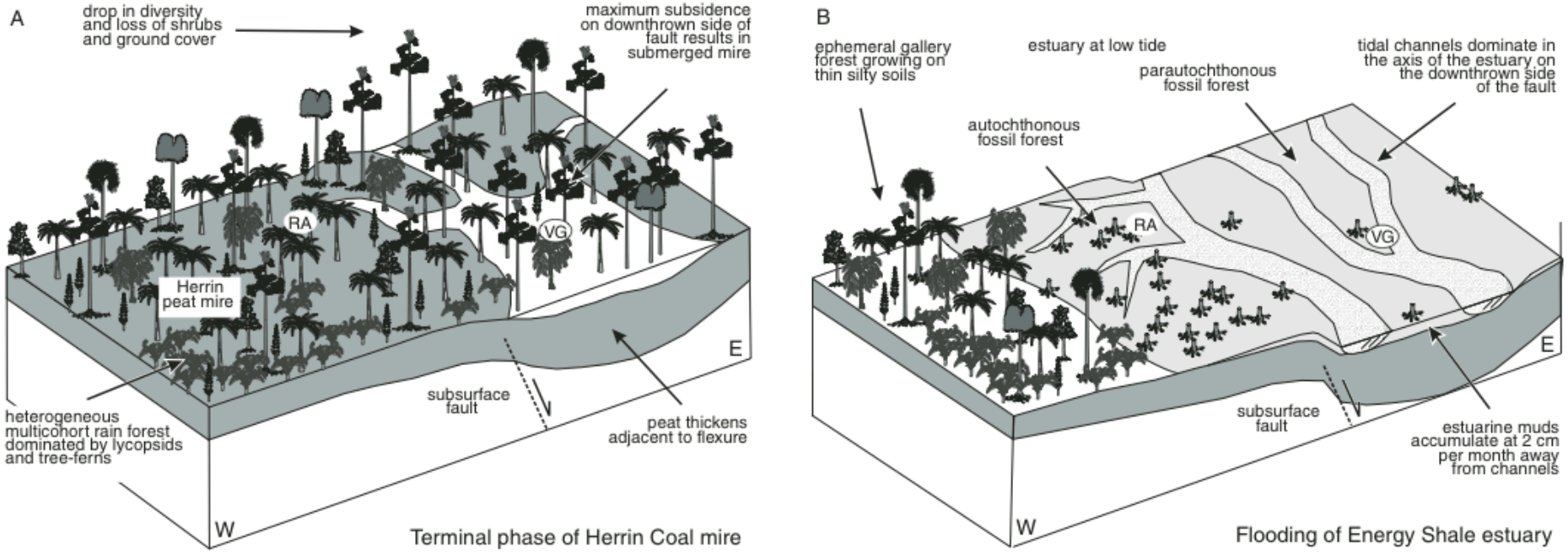

Figure 3. Model for origin of fossil forest. (A) Onset of differential subsidence and its effects on mire community structure.

(B) Preservation of mire forest following abrupt subsidence of estuarine trough.

DiMichele et al. Ecological gradients within a Pennsylvanian mire forest. Geology (2007) vol. 35 (5) pp. 415

Smithsonian magazine, Layne Kennedy

A good example is the study of the macrovertebrate assemblage from the lower Pleistocene site at Venta Micena (Orce, southeastern Spain). Taphonomic analysis showed that the giant, short-faced hyenas (*Pachycrocuta brevirostris*) selectively transported ungulate carcasses and body parts to their maternity dens as a function of the mass of the ungulates scavenged. The fracturing of major limb bones in the dens was also highly selective, correlating with marrow content and mineral density. Important differences in bone-cracking intensity were related to which species the bones came from, which in turn biased the composition of the bone assemblage. The analysis of mortality patterns deduced for ungulate species from juvenile/adult proportions revealed that most skeletal remains were scavenged by the hyenas from carcasses of animals hunted by hypercarnivores, such as saber-tooths and wild dogs. Analytical study of the Venta Micena assemblage has unlocked paleobiological information that was lost during its taphonomic history, and has even provided paleobiological information that was not preserved in the original bone assemblage, such as the paleoethology of *P. brevirostris*, which differed substantially from modern hyenas in being a strict scavenger of the prey hunted by other carnivores.

Palmqvist and Arribas. Taphonomic decoding of the paleobiological information locked in a lower Pleistocene assemblage of large mammals. Paleobiology (2001) vol. 27 (3) pp. 512-530

What are other biases, besides taphonomic biases, that could affect our data?