

# Evidence



Model Credit: Tyler Keillor, photograph by Ximena Erickson, from <http://blog.everythingdinosaur.co.uk/blog>

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EEB464 Fall 2018

# Learning objectives

- Think like a macroevolutionary biologist/paleontologist and reconstruct a community
- Learn how biologists gather evidence for macroevolutionary processes

Break into groups of two.

What do your “fossils” tell you?

What species live there [and not just the plants]?

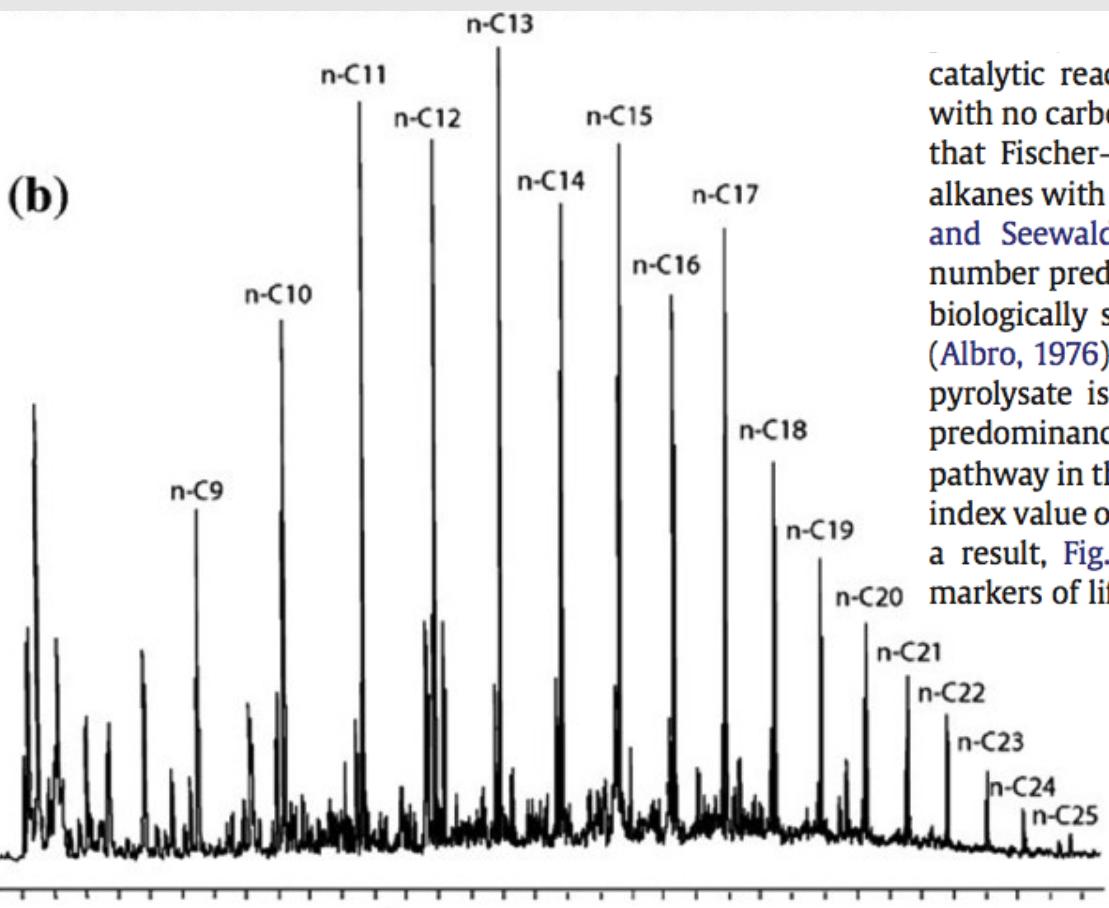
What's the climate like?

What else can you glean from them?

(wash hands after class)

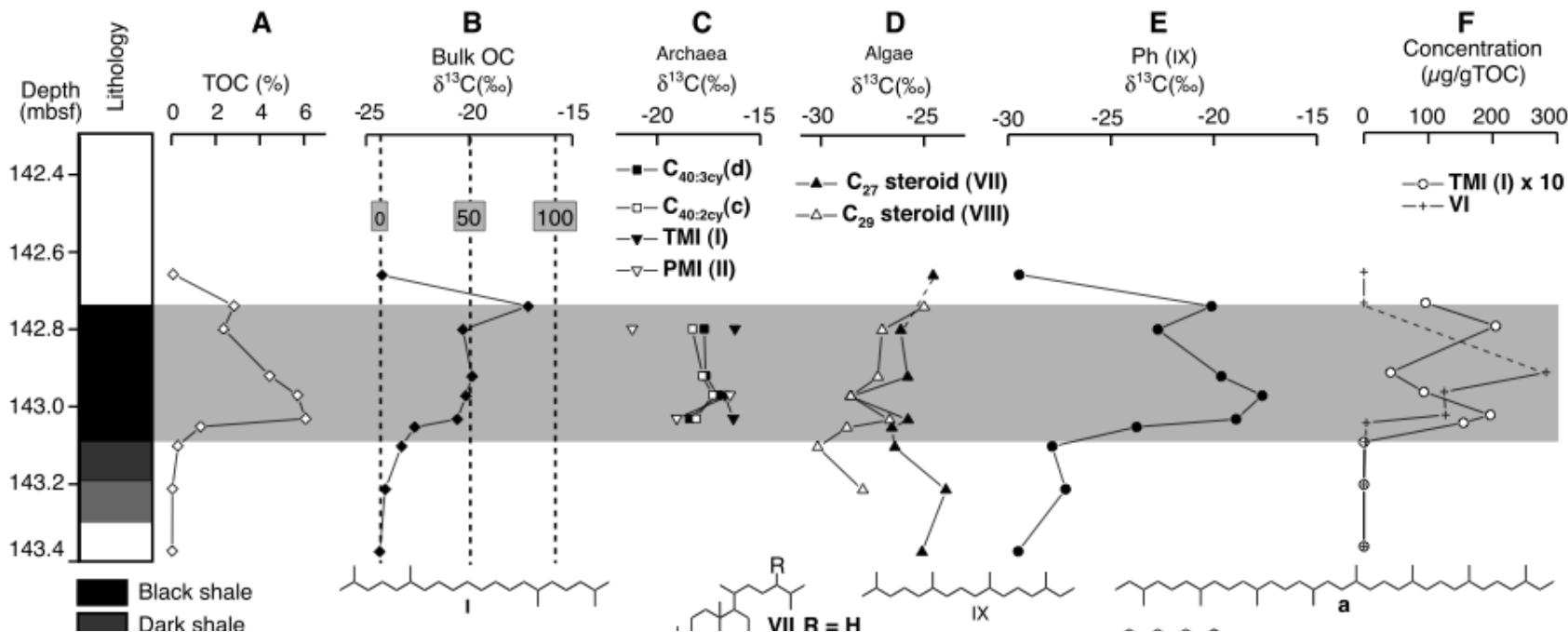
- Molecular fossil
- Trace fossil
- Body fossil
- Phylogenetics
- Extant organisms
- Experiments

(b)



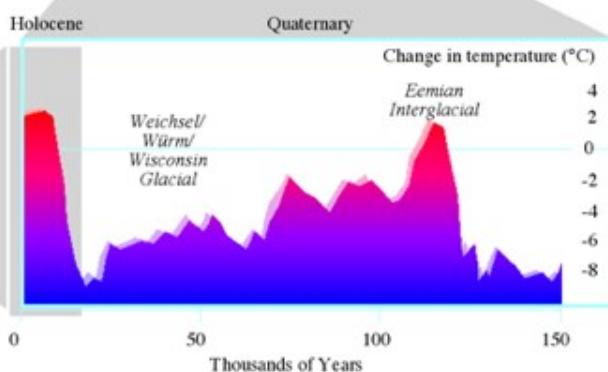
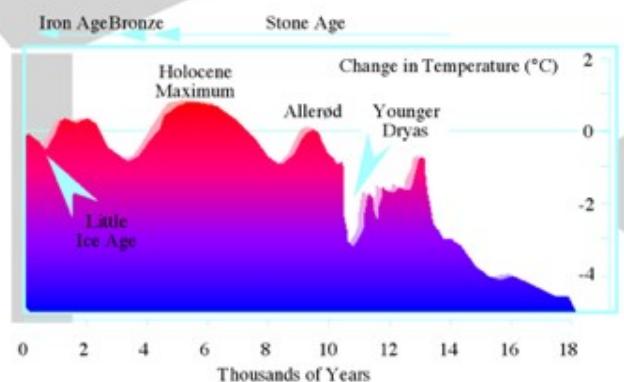
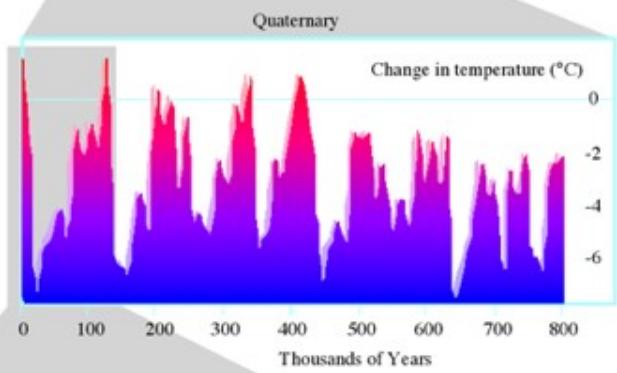
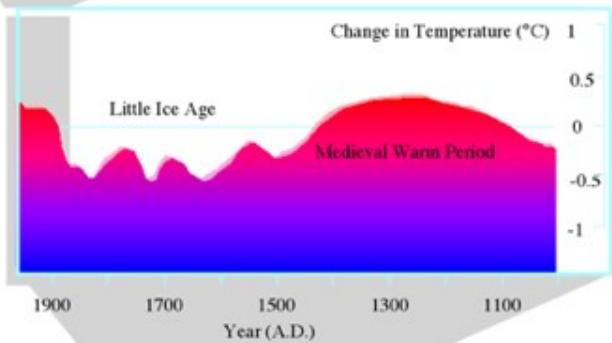
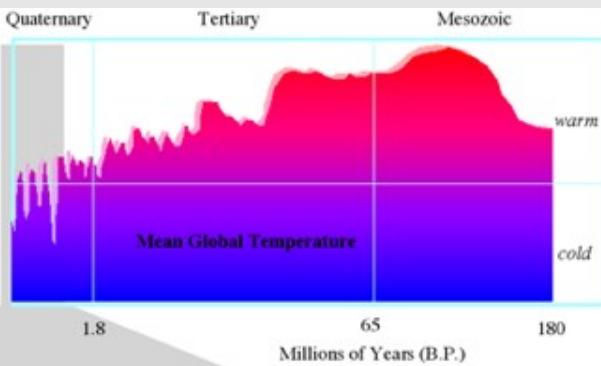
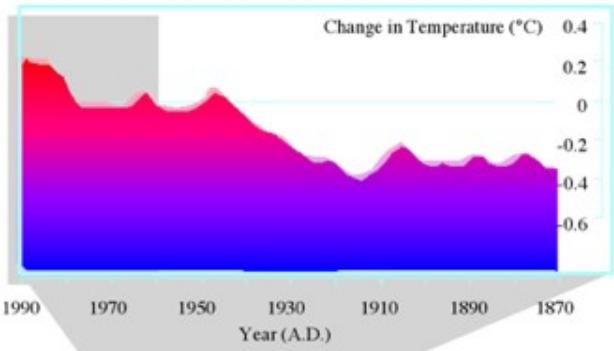
It was recently stressed that thermo-catalytic reactions yield homologous series of organic compounds with no carbon number preferences (Rushdi and Simoneit, 2001) and that Fischer-Tropsch-type products are dominated by unbranched alkanes with a characteristic linear decrease in abundance (McCollom and Seewald, 2006). In contrast, a weak odd-over-even carbon number predominance is a unique characteristics of organics formed biologically since it reflects biosynthesis using addition of C<sub>2</sub> units (Albro, 1976). The C<sub>10</sub>-C<sub>18</sub> range in the alkanes of the Warrawoona pyrolysate is characterized by such odd-over-even carbon number predominance (Fig. 3b), confirming the involvement of a biosynthetic pathway in the formation of these *n*-alkyl chains (a carbon preference index value of 1.2 is calculated in this range (Bray and Evans, 1961)). As a result, Fig. 3b provides evidence for the presence of molecular markers of life in this Warrawoona sample.

The biological origin of organic matter in the oldest siliceous sediments (cherts) is still debated. To address this issue, the insoluble organic matter (kerogen) was isolated from a chert of the Warrawoona group. The chemical structure of the kerogen was investigated through a combination of analytical techniques including solid-state <sup>13</sup>C nuclear magnetic resonance and pyrolysis. Although dominated by aromatic hydrocarbons, the pyrolysate comprises a homologous series of long chain aliphatic hydrocarbons characterized by odd-over-even carbon number predominance. This distribution is only consistent with a biological origin. As kerogen must be contemporaneous of the solidification of the chert, this observation should be regarded as an evidence for the presence of life on Earth, 3.5 By ago.



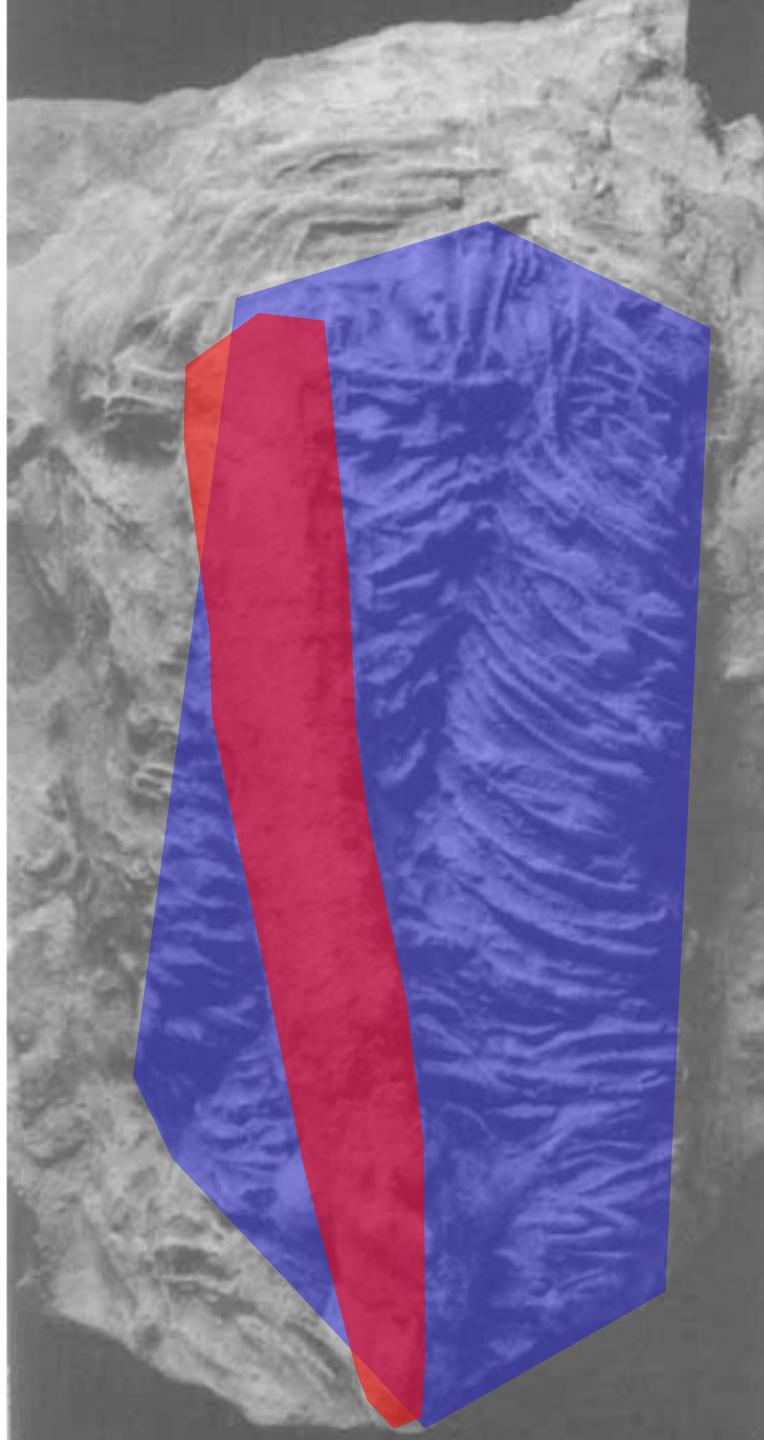
**Biogeochemical and stable carbon isotopic analysis of black-shale sequences deposited during an Albian oceanic anoxic event ( $\sim 112$  million years ago) indicate that up to 80 weight percent of sedimentary organic carbon is derived from marine, nonthermophilic archaea. The carbon-13 content of archaeal molecular fossils indicates that these archaea were living chemoautotrophically. Their massive expansion may have been a response to the strong stratification of the ocean during this anoxic event. Indeed, the sedimentary record of archaeal membrane lipids suggests that this anoxic event marks a time in Earth history at which certain hyperthermophilic archaea adapted to low-temperature environments.**

Fig. 1. from C isotop tricycl (C), o (VIII)] phytol

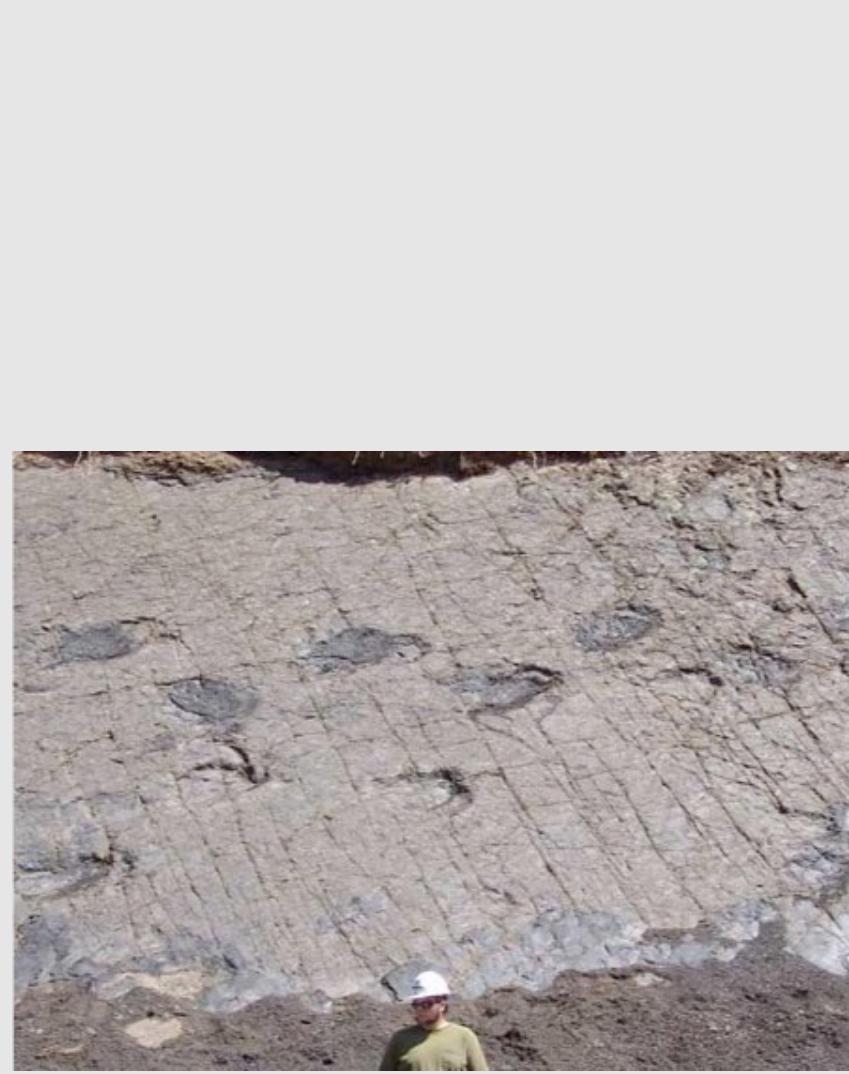
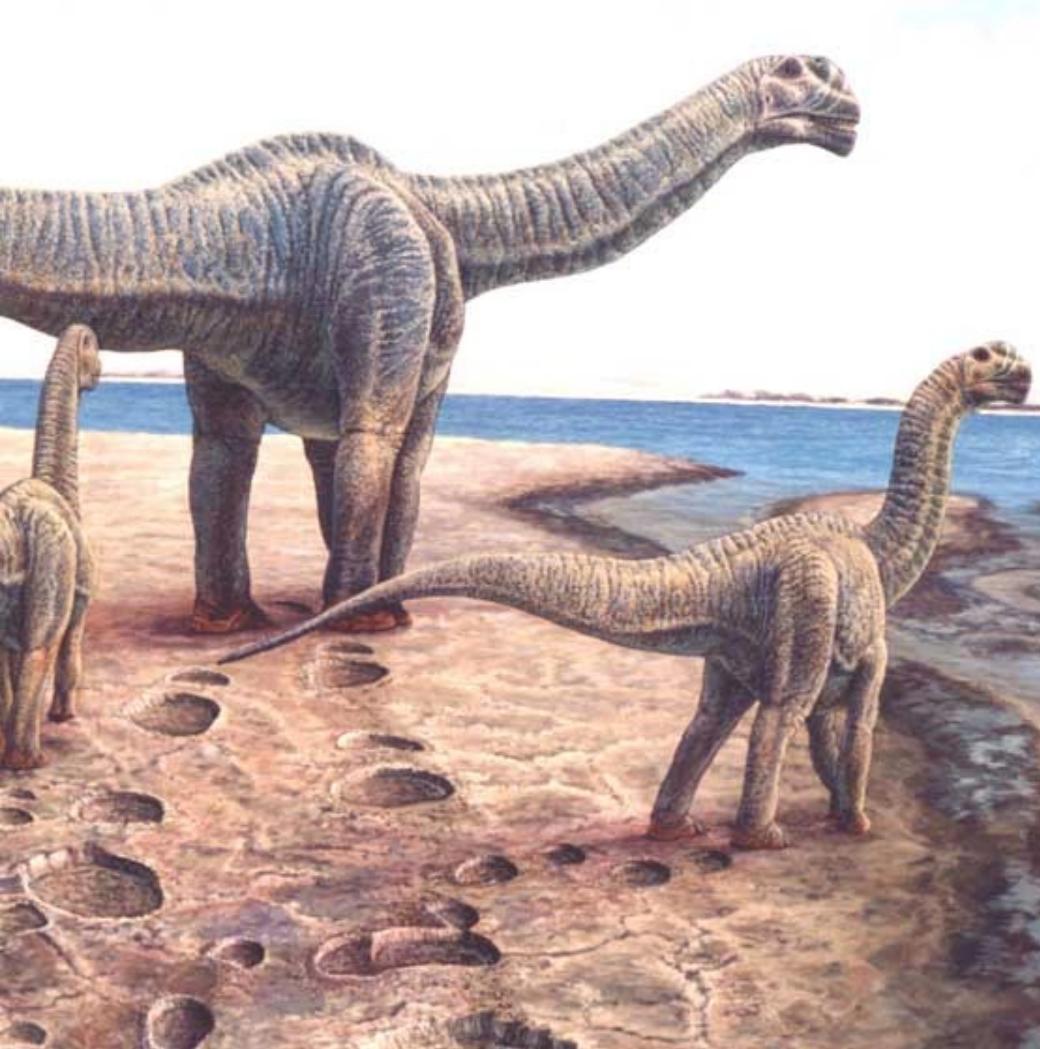


Worm  
burrow

Trilobite  
burrow



JENSEN. Predation by early Cambrian  
trilobites on infaunal worms-evidence  
from the Swedish Mickwitzia Sandstone.  
Lethaia (1990)



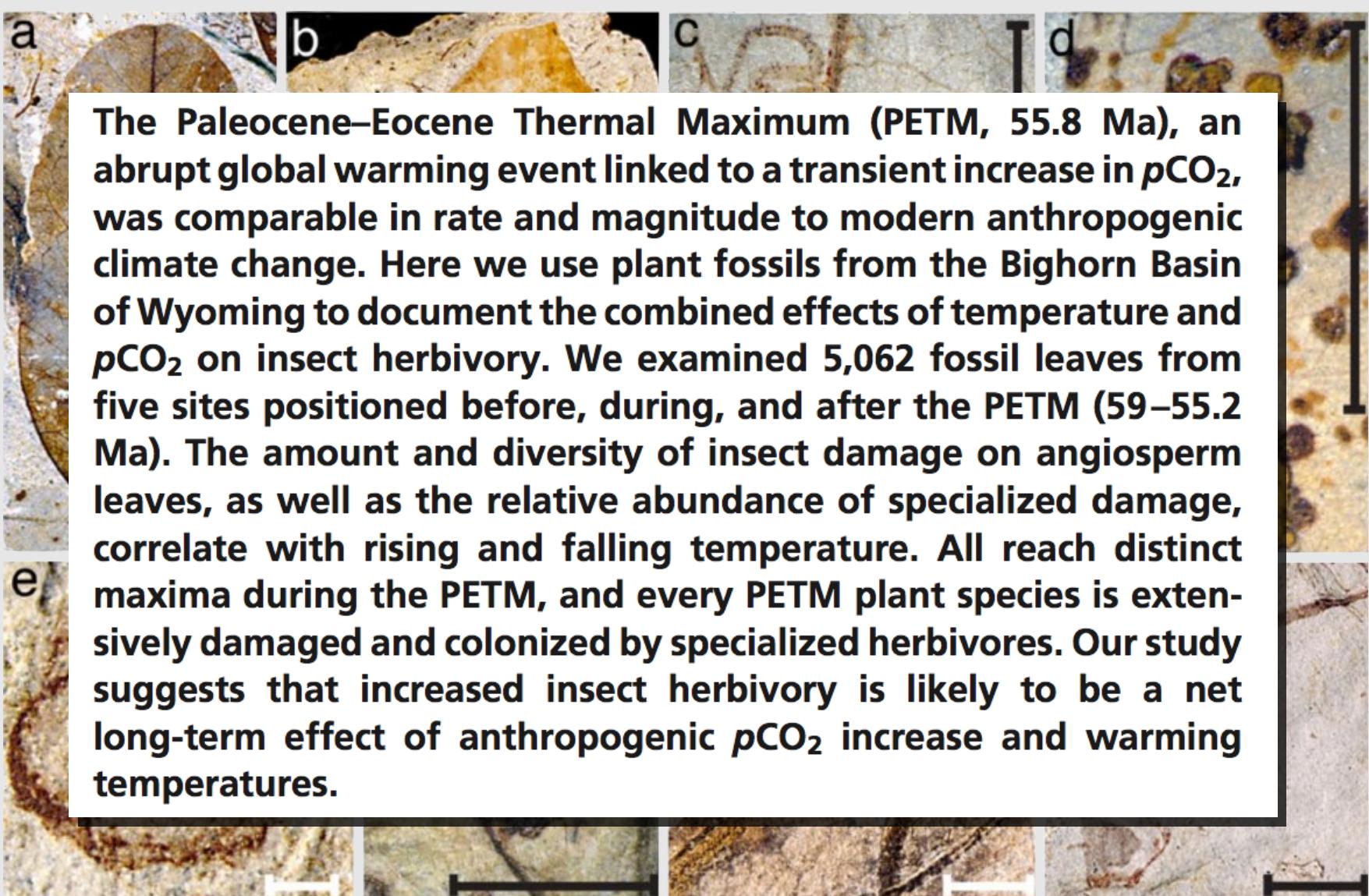
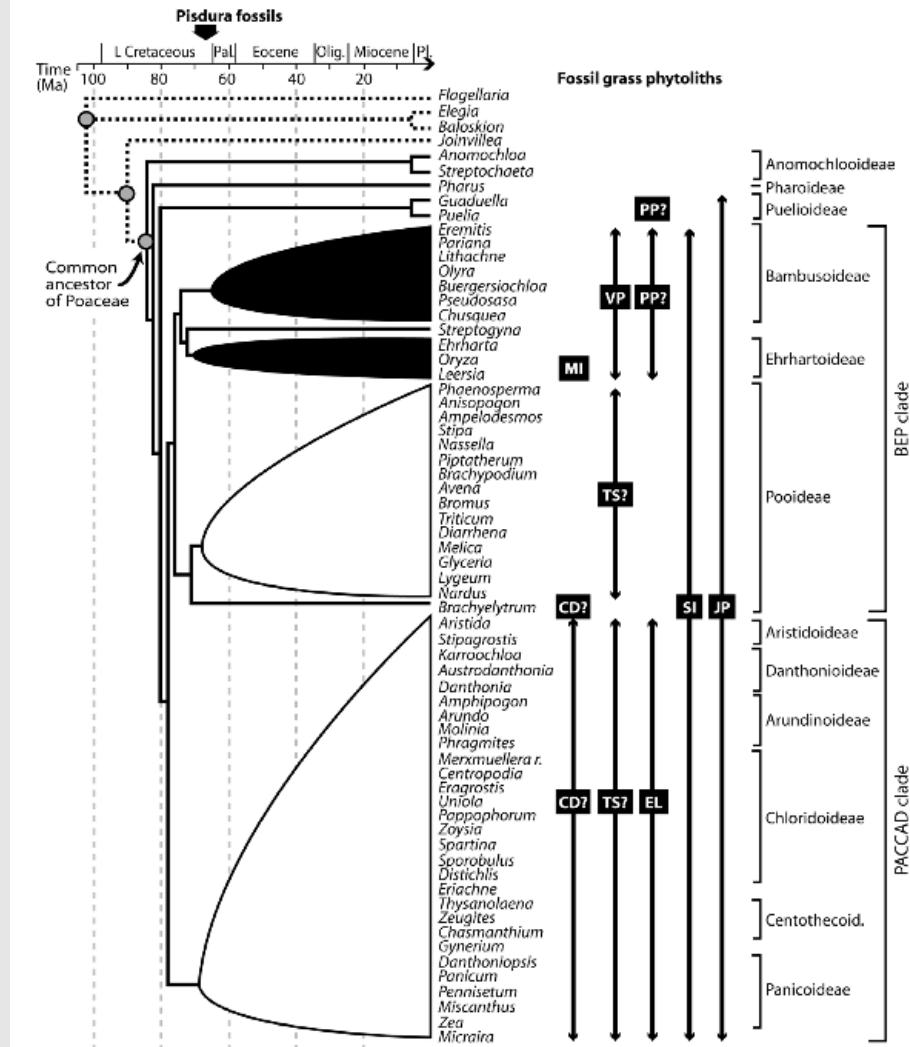
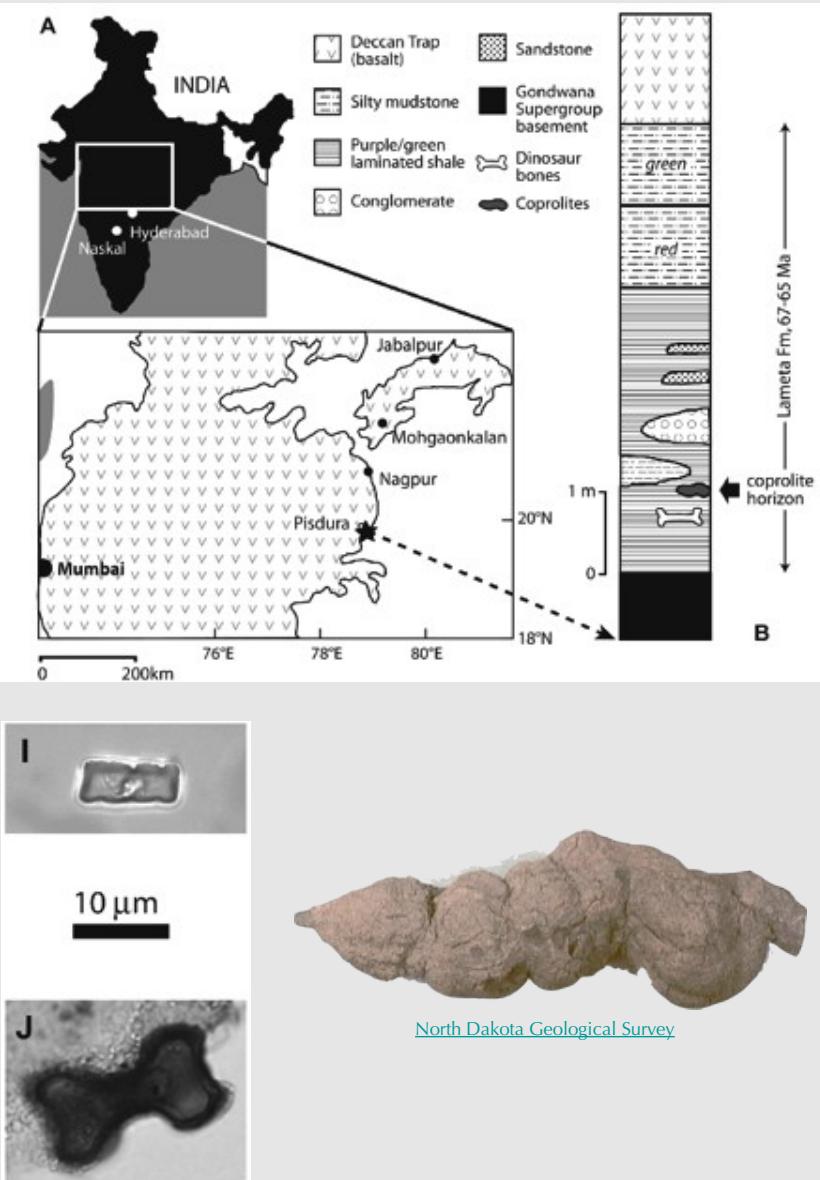


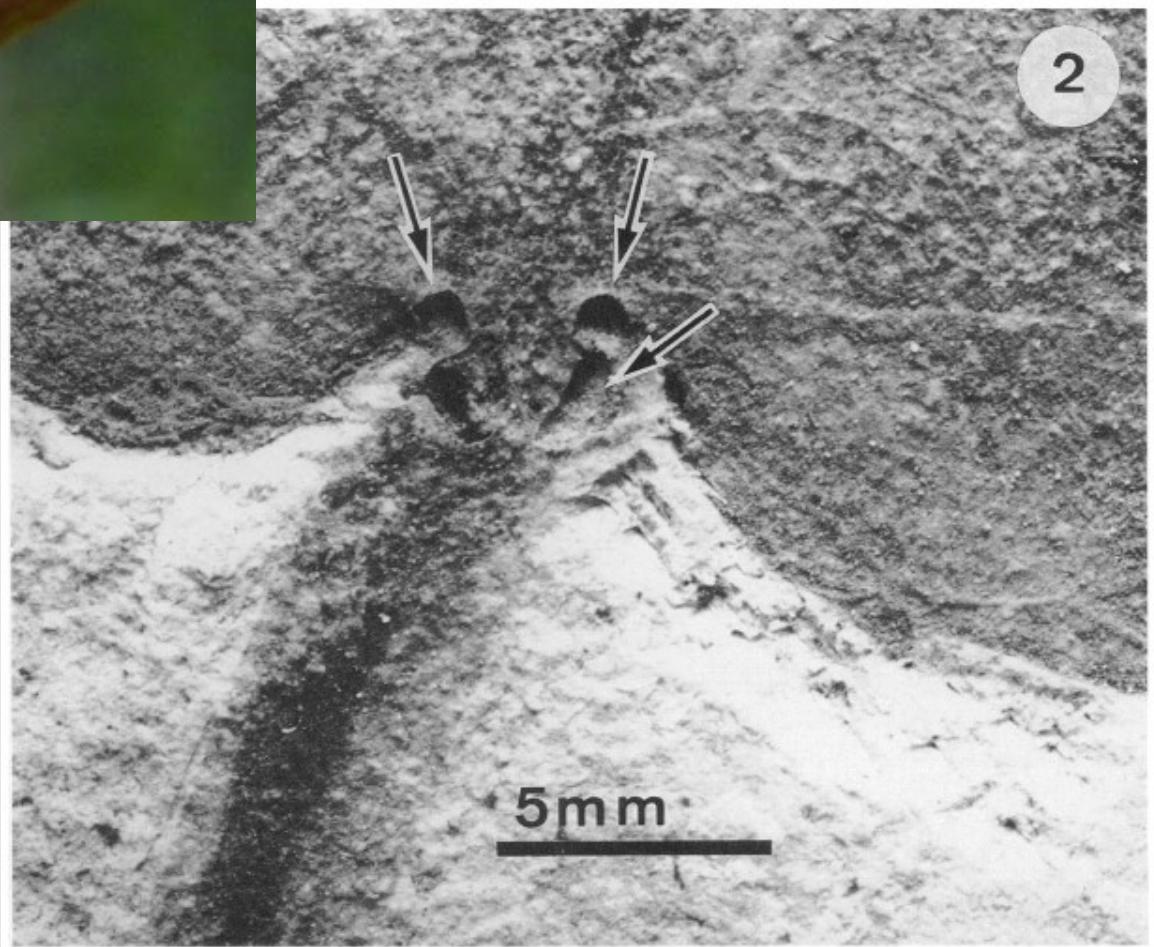
Fig. 1. Representative insect damage diversity on PETM leaves. (a) Dicot sp. WW007 (Fabaceae) leaf about one-third consumed by insect herbivores (USNM 530967). (b) Characteristic large, circular hole-feeding (DT4) found only on dicot sp. WW006 (530968). (c) Serpentine mine with a solid frass trail becoming massive (DT43) on an unidentifiable dicot (530969). (d) Polylobate to clustered galls (DT125) on dicot sp. WW007 (Fabaceae, 530970). (e) Blotch mine with a sinusoidal frass trail (DT37) on dicot sp. WW003 (530971). (f) Blotch mine with distinct coprolites and terminal chamber (DT35) on dicot sp. WW006 (530972). (g) Serpentine mine with a solid frass trail (DT43) on dicot sp. WW004 (530973). (h) Semilinear serpentine mine with terminal chamber (DT40) on dicot sp. WW005 (530974). (Scale bars: white, 1 mm; black, 5 mm.)



**Fig. 3.** Systematic affinities of fossil phytolith morphotypes (Supporting Online Text) reported from Maastrichtian coprolites from Pisdura, central India, suggesting significantly older dates for taxonomic diversification within the grass family (Poaceae) than previously assumed (1–3). The phylogeny is from the Grass Phylogeny Working Group (1). Approximate ages for the crown node of Poaceae and for immediate sister taxa (marked with a gray circle) were provided by molecular clock analysis (5). White shapes indicate open-habitat grass clades; black shapes and all other terminal taxa indicate closed-habitat grasses. Fossil phytolith morphotypes are as follows: CD, Chitaleya deccana; EL, Eliasundo lameti; JP, Jainium pisdurensis; MI, Matleyites indium; PP, Pipmoa pearsalla; SI, Stebbinsina intertrappea; TS, Thomassonites sinuatum; VP, Vonhueneites papillosum.



<http://abugblog.blogspot.com/2010/05/ants-helping-plants-extrafloral.html>



Pemberton. Fossil extrafloral nectaries, evidence for the ant-guard antiherbivore defense in an Oligocene *Populus*. American Journal of Botany (1992)

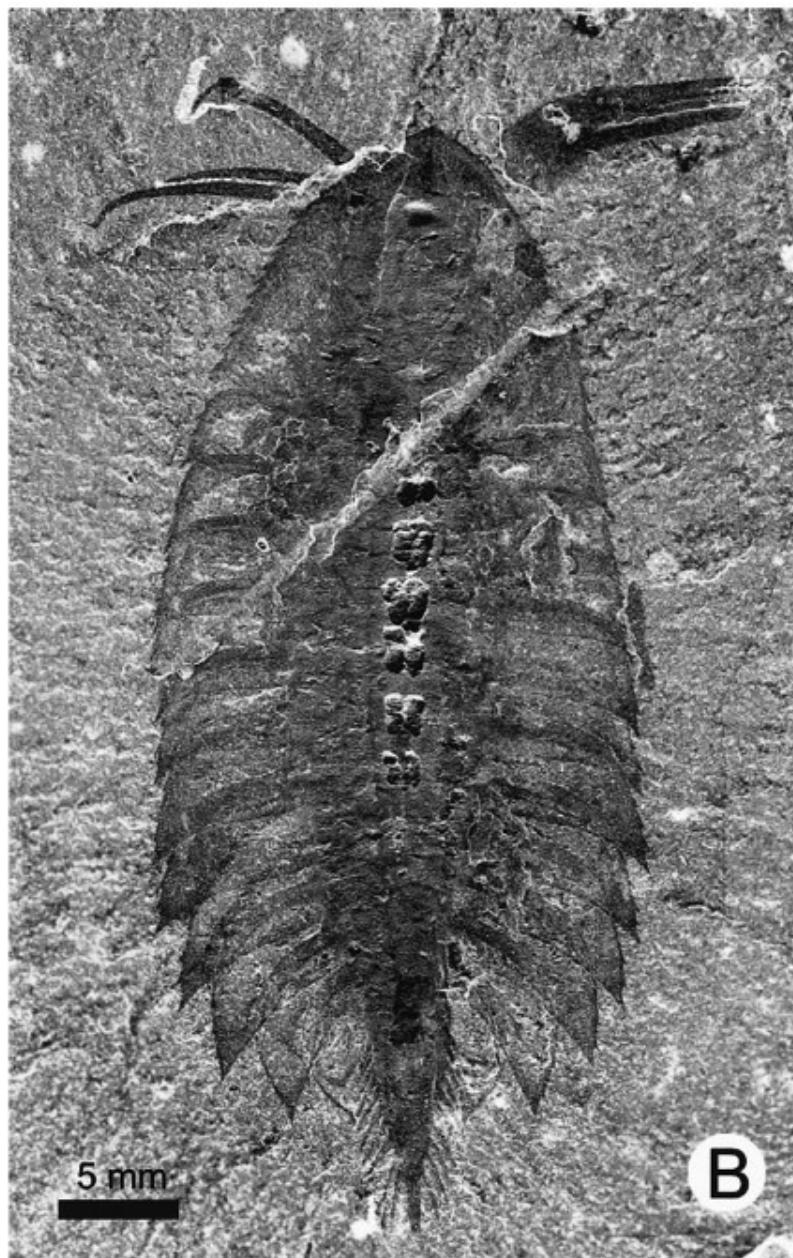
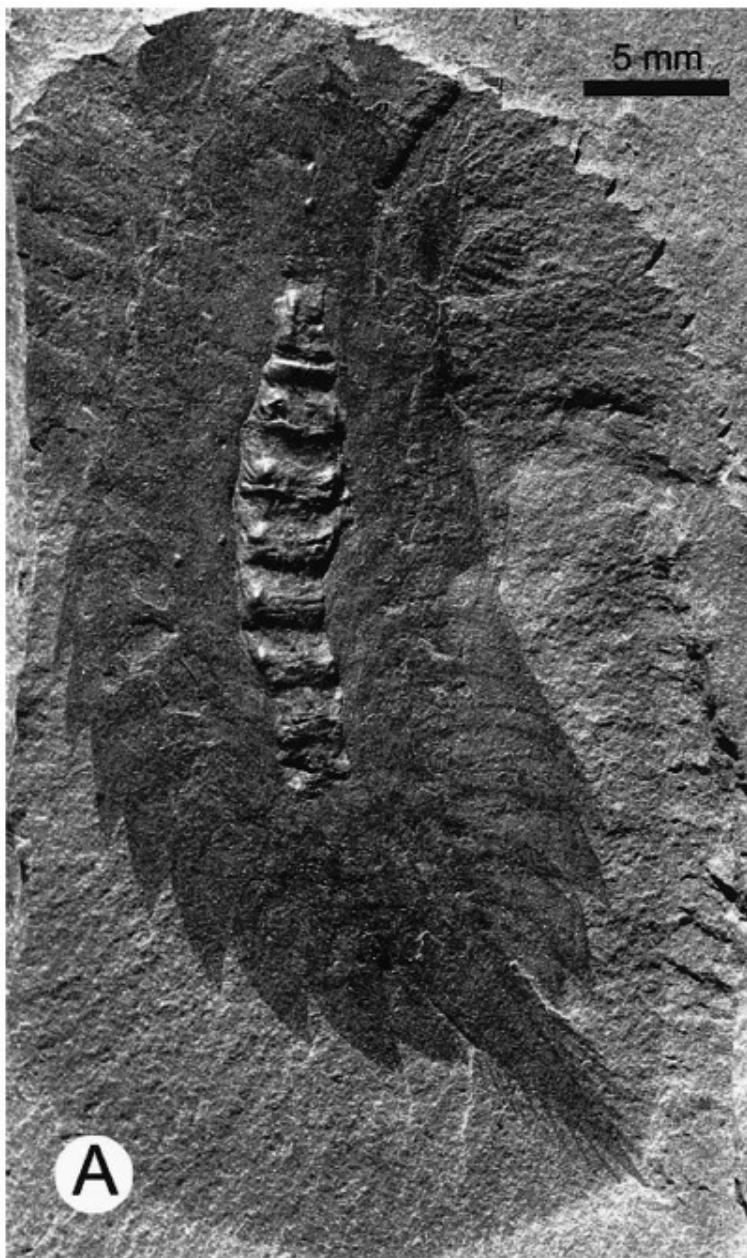
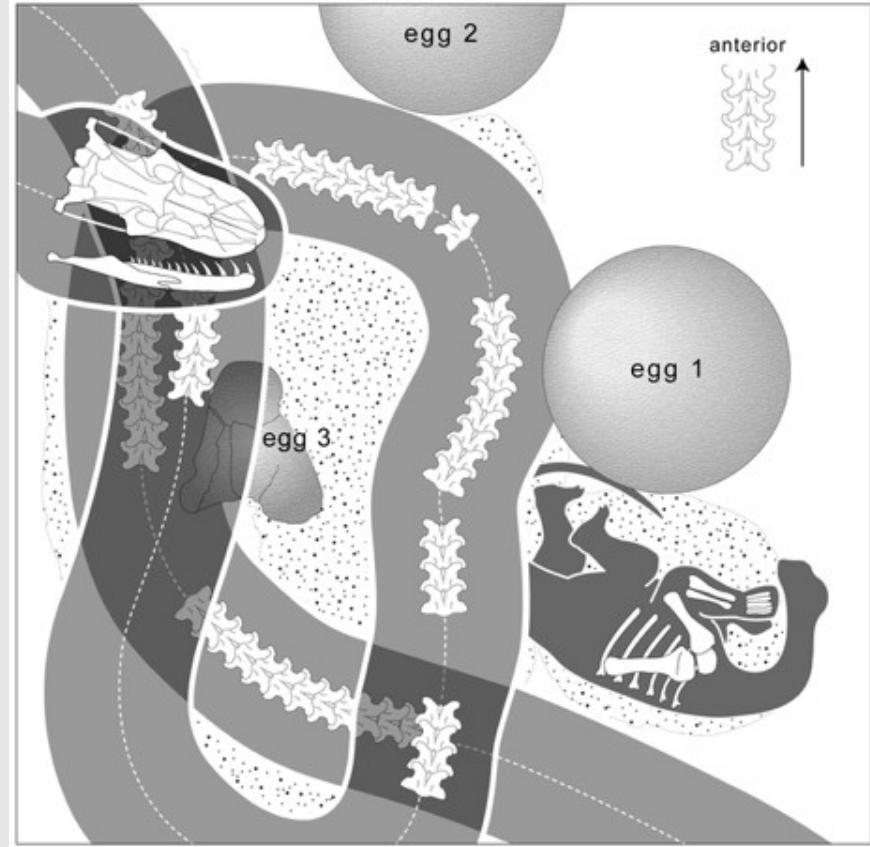
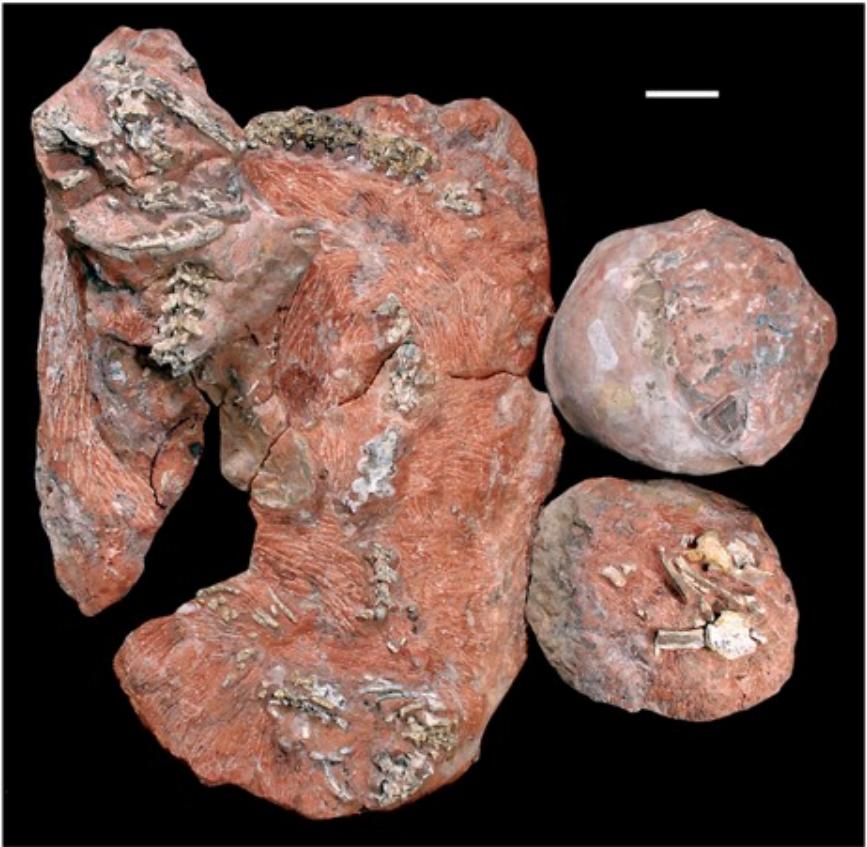


FIGURE 2. Bedding-plane *Leanchoilia* with phosphatized midgut glands showing bilateral organization. A, ROM 54214; heavily phosphatized midgut with conspicuous biserial nodes. B, ROM 54211; lightly phosphatized midgut with pronounced sagittal and segmental divisions, resulting in biserial patches of phosphate.

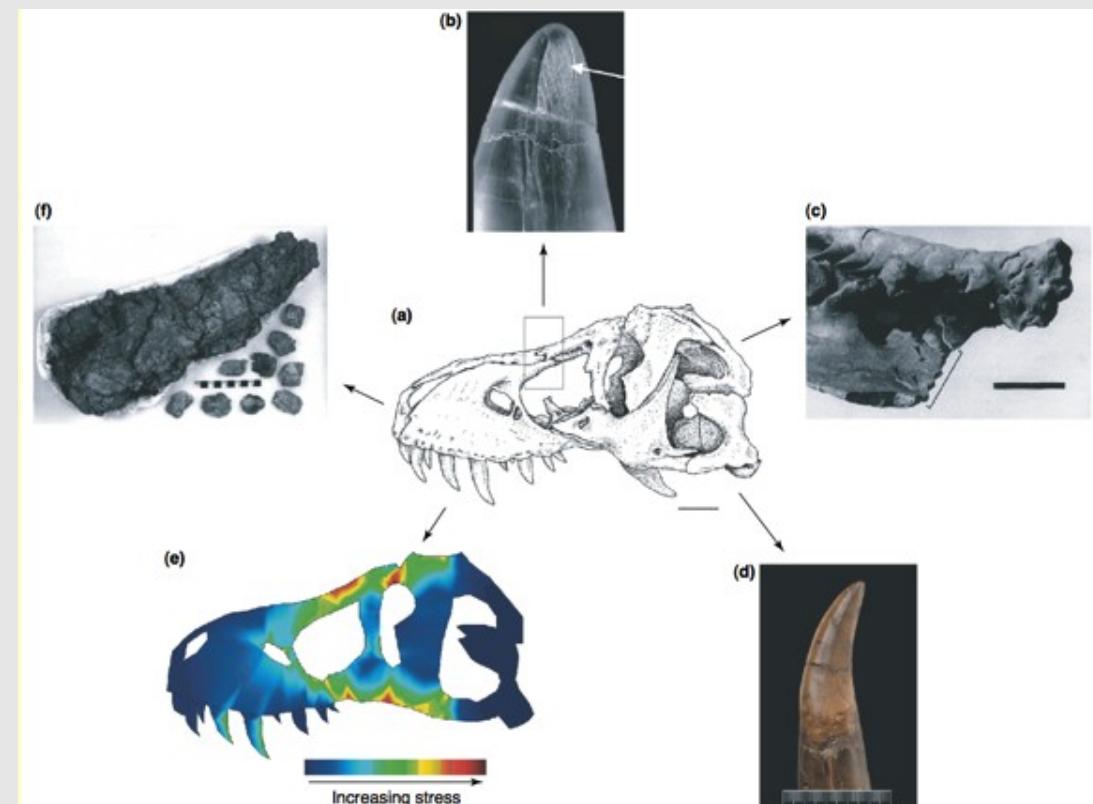


Model Credit: Tyler Keillor, photograph by Ximena Erickson, from <http://blog.everythingdinosaur.co.uk/blog>

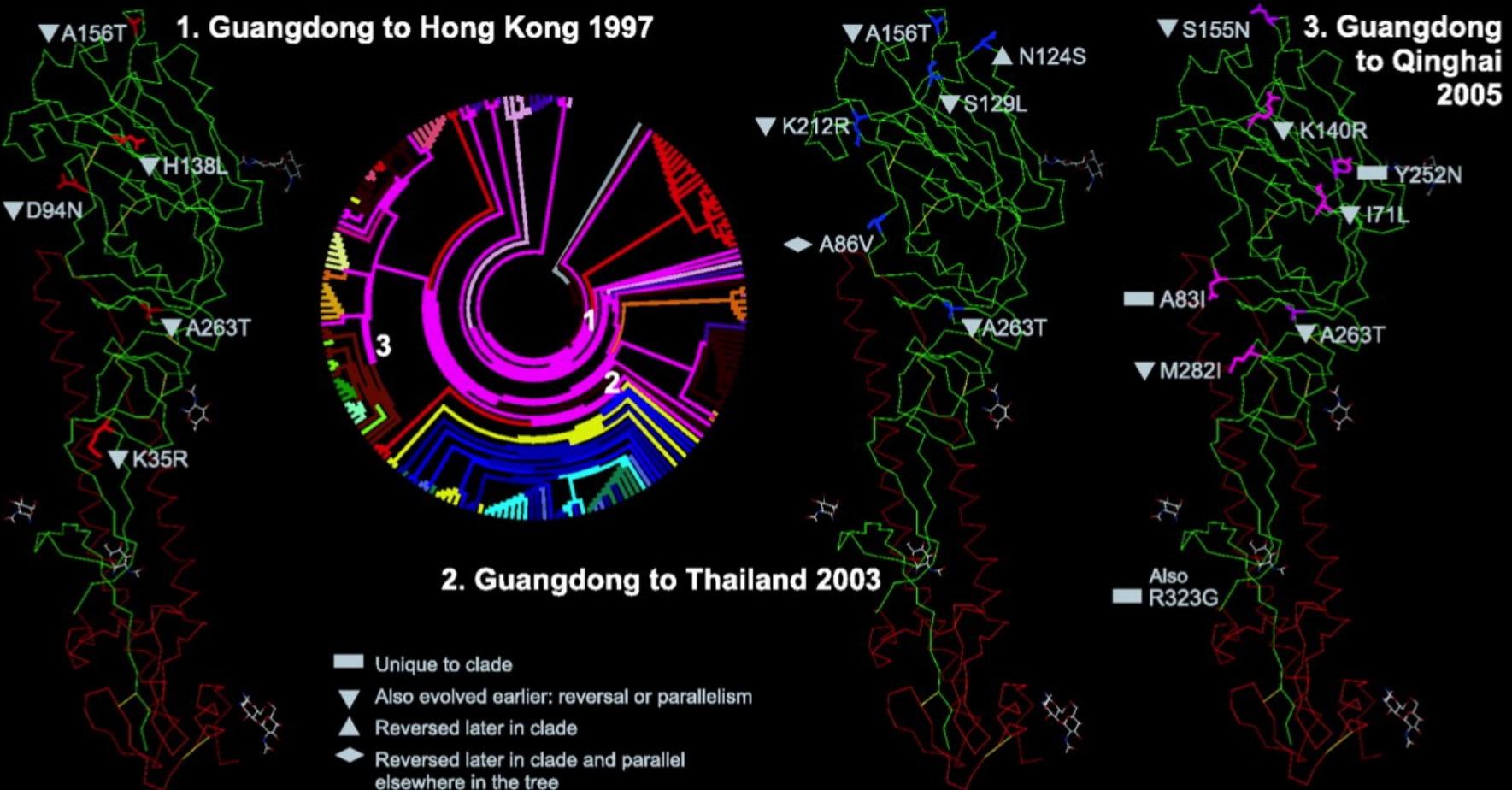
By combining evidence from descriptive anatomical work, physical modelling, mathematical approaches and new technologies, palaeontologists are able to gain a more comprehensive knowledge of dinosaur feeding behaviour, which, in turn, improves our understanding of Mesozoic ecology. Here, we demonstrate how this approach can be used to investigate the palaeobiology of *Tyrannosaurus rex*, whose gargantuan size and specialized anatomy have made it a favourite of functional morphologists.

Comparisons of the craniodental morphology of *T. rex* (Figure 1a) to living animals indicate that this animal was a carnivore. Wear facets on the teeth show that tyrannosaurids practiced repeated shearing between upper and lower dentitions [44] (Figure 1b), offering a processing mechanism for flesh and bone. Puncture-like bite marks on a *Triceratops* pelvis [15] (Figure 1c) and extensive damage to the tail of one specimen of the duck-billed dinosaur *Edmontosaurus* [62] demonstrate the ability of *T. rex* to penetrate bone. Two types of repetitive biting behaviour are observed: deep puncture of thinner cortical bone and, in deeper cortical bone, shallow puncture followed by pulling of the teeth across the bone surface [15]. Comparison of the cutting ability of fossilised teeth to that of varied replica blades demonstrated that stout tyrannosaurid teeth (Figure 1d) functioned as pegs with poor cutting ability. Instead, the teeth were used to 'grip-and-rip' prey – the 'puncture-pull' feeding hypothesis [17,18]. Space-frame analysis suggests that the *T. rex* skull was constructed to resist strong, vertically directed bite forces [25]. FEA provides information on stress-strain patterns within the skull, and confirms that the *T. rex* cranium could withstand large feeding-induced puncture-pull loads [34] (Figure 1e). Furthermore, FEA studies suggest that tyrannosaurid nasal bones were fused and thickened to withstand large compressive and shear stresses, and that open skull sutures assisted in 'shock-absorption' during powerful bites [34].

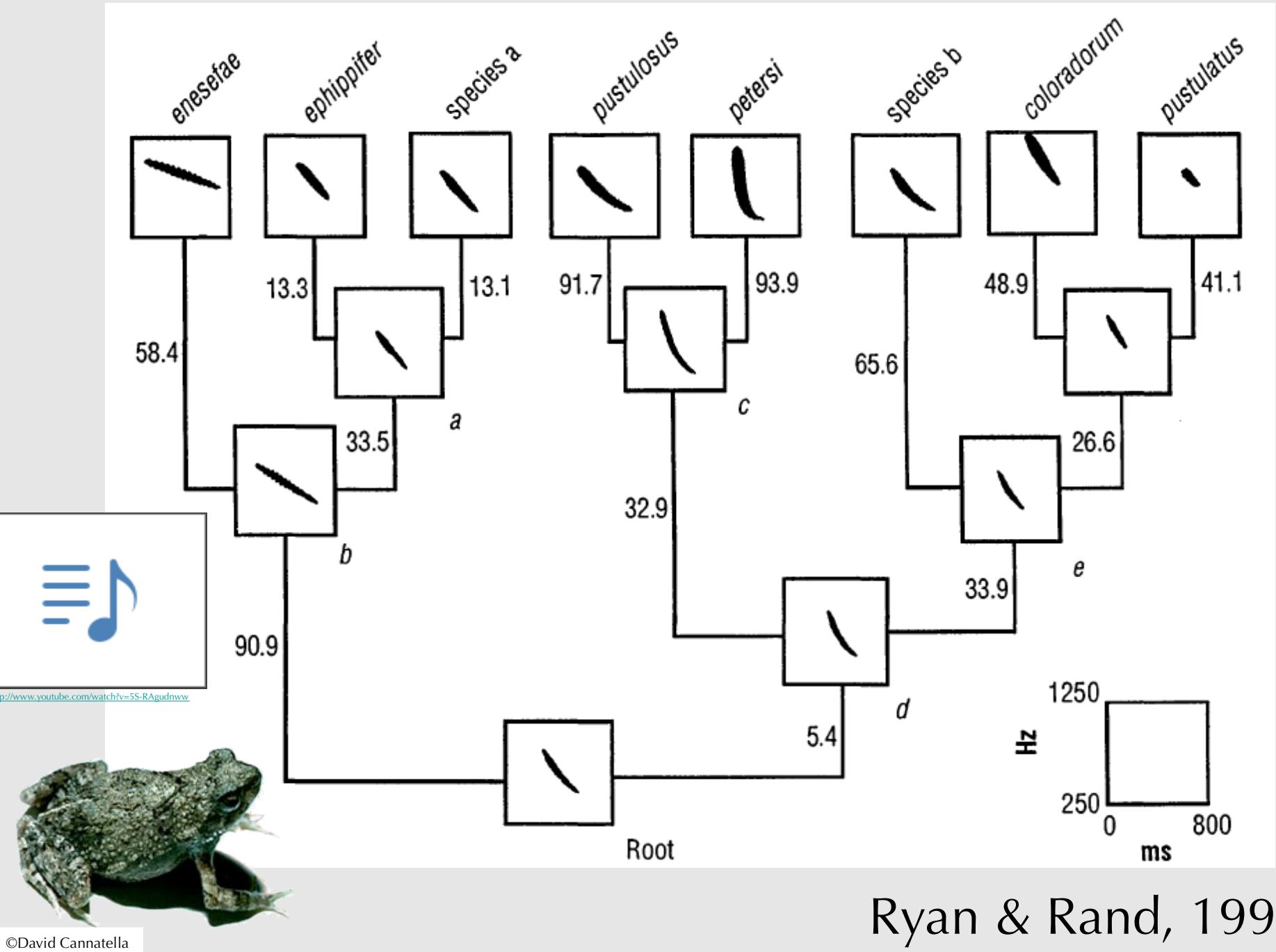
Replica teeth driven into bovine bone (mimicking the morphology of the bitten *Triceratops* pelvis) indicate that *T. rex* could produce bite forces exceeding 6410 Newtons [16], well in excess of those estimated for modern lions, showing that a *T. rex* bite could shatter bone [16]. This hypothesis is confirmed by the discovery of a *T. rex* coprolite [65] (Figure 1f) that contains large quantities of pulverized bone pertaining to an ornithischian dinosaur. In this instance, the bone of the prey animal was only partially digested, indicating that gut-residence time was short [65]. Finally, although most palaeontologists agree that *T. rex* was an active predator at least some of the time [49,50], recent ecological energetic analysis of the *T. rex*-bearing Hell Creek Formation suggests that, providing competition for carrion was low, it could have survived purely as a scavenger [29].



# H5N1 bird flu: phylogeography & evolution

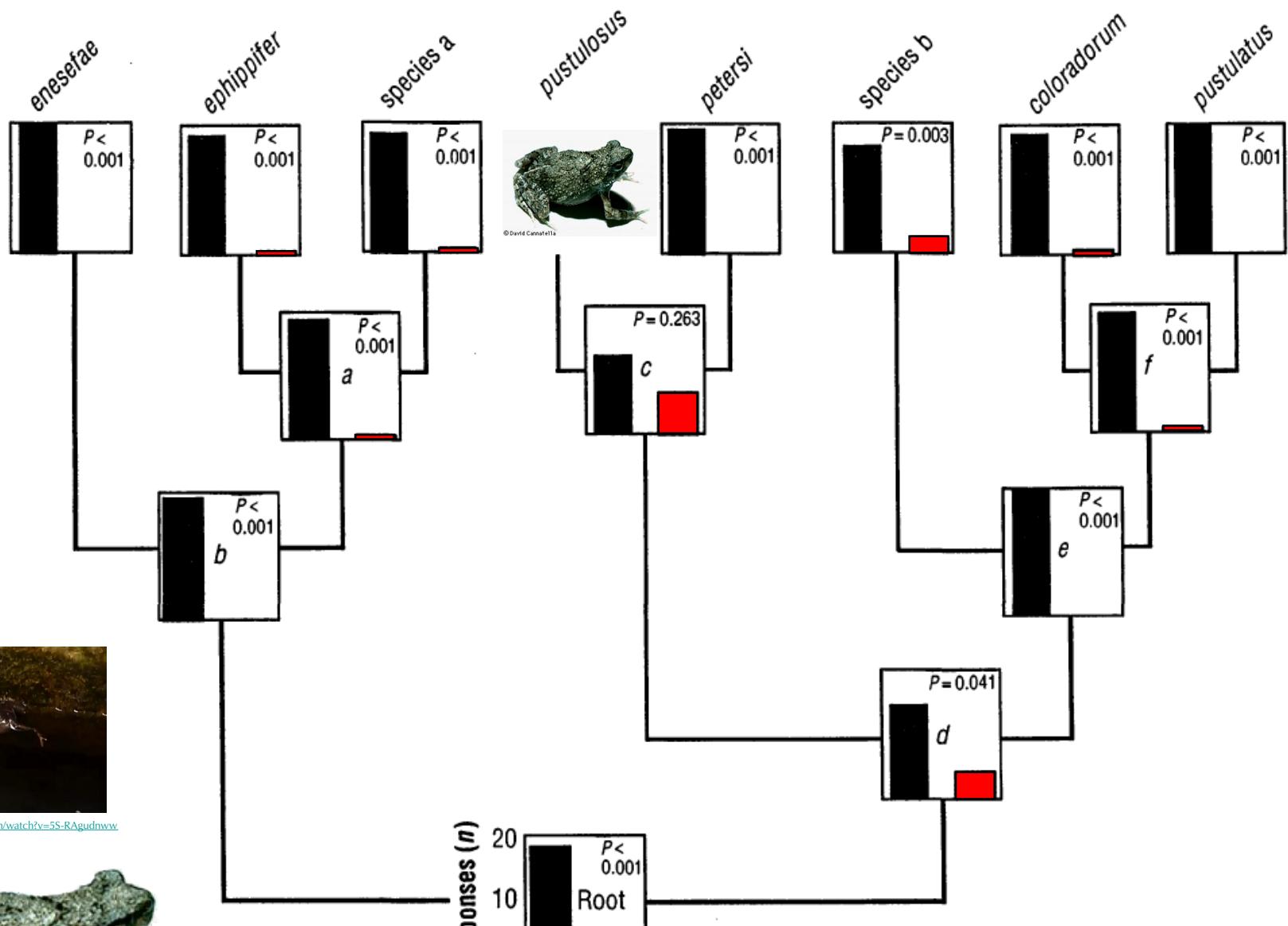


Wallace et al, 2007



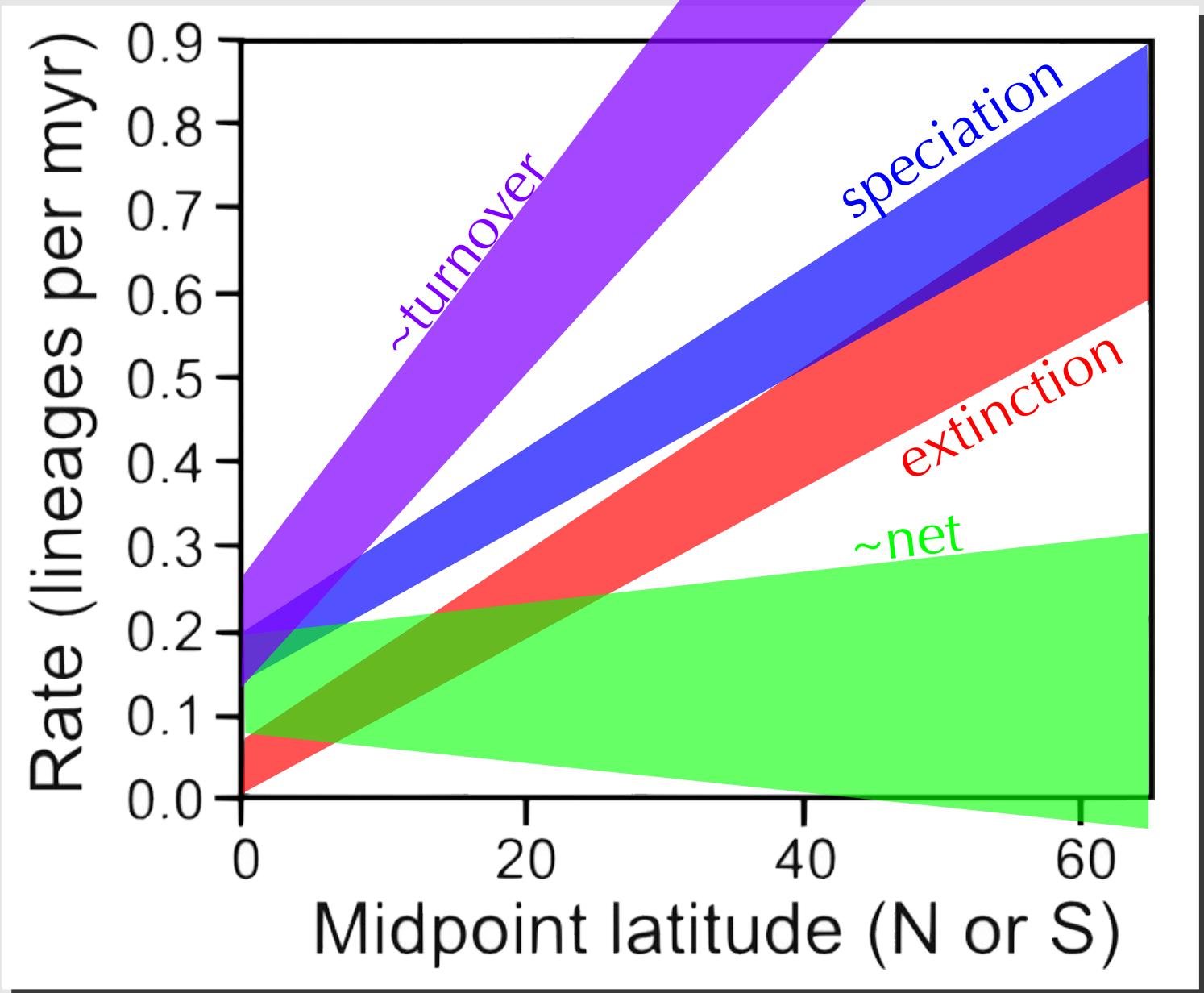


[http://www.sbs.utexas.edu/ryan/multi\\_media.html](http://www.sbs.utexas.edu/ryan/multi_media.html)



Ryan & Rand, 1995

©David Cannatella



Weir & Schluter, 2007



Stickleback species pair from Paxton Lake, British Columbia.  
Gravid benthic top, gravid limnetic bottom.

Photo by Todd Hatfield, taken from [http://www.zoology.ubc.ca/~schluter/stickleback/stickleback\\_species\\_pairs/Stickleback\\_Species\\_Pairs.htm](http://www.zoology.ubc.ca/~schluter/stickleback/stickleback_species_pairs/Stickleback_Species_Pairs.htm)

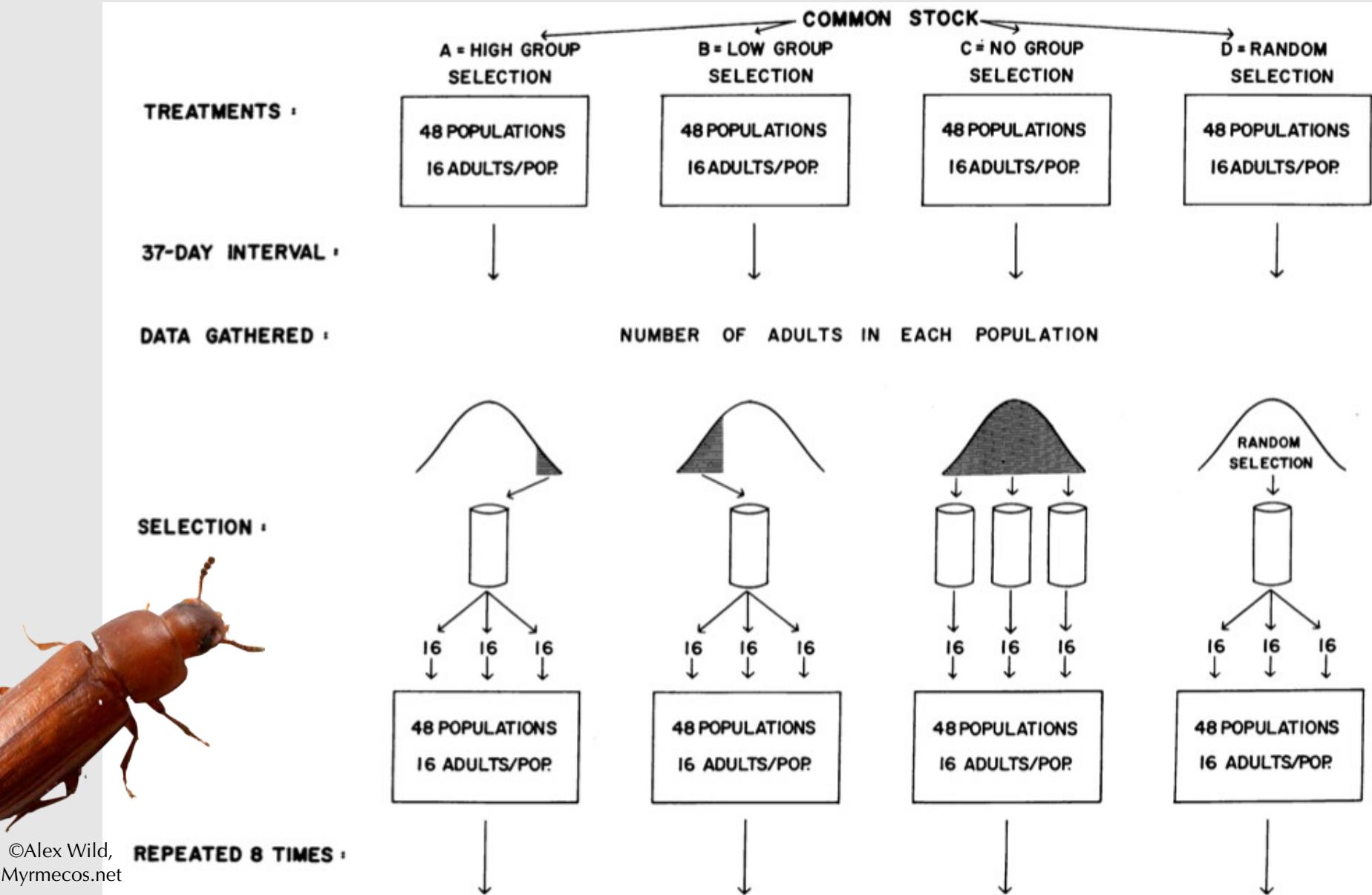


FIG. 1. The experimental design used in the study of group selection. The curves indicated prior to "Selection" represent smoothed histograms of the census data gathered for each treatment with numbers of adults on the abscissa and numbers of populations on the ordinate.

Think of macroevolutionary questions. Which source(s) of evidence would you use to address these?

- Molecular fossil
- Trace fossil
- Body fossil
- Phylogenetics
- Extant organisms
- Experiments