Trends

http://pinchmealfredo.blogspot.com/2008_11_01_archive.html

http://scienceblogs.com/deepseanews/2007/04/why_is_the_giant_isopod_giant.php

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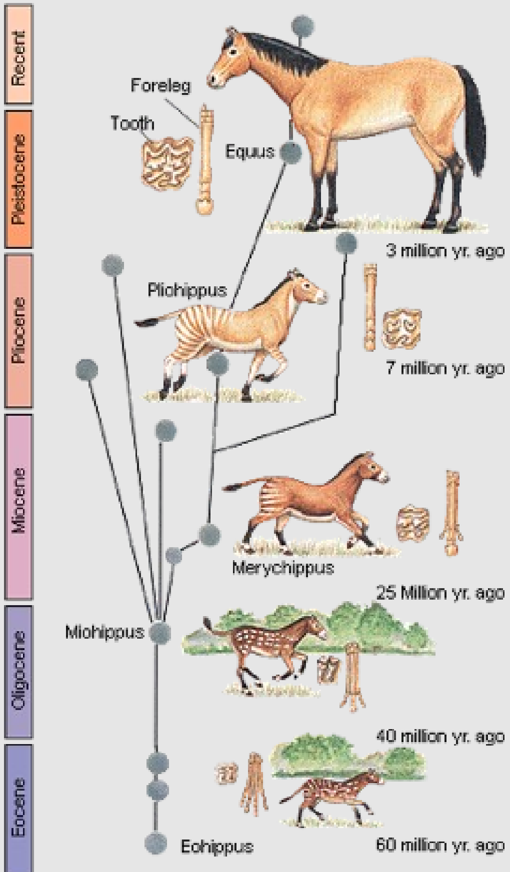
EEB464 Fall 2018

Learning objectives

- Understand kinds of biological trends
- Describe ways to test these trends

Cope's Rule

Widespread tendency of many animal groups to grow towards larger sizes



http://darwiniana.org/horses.htm

What could explain a trend?

How would you test it?

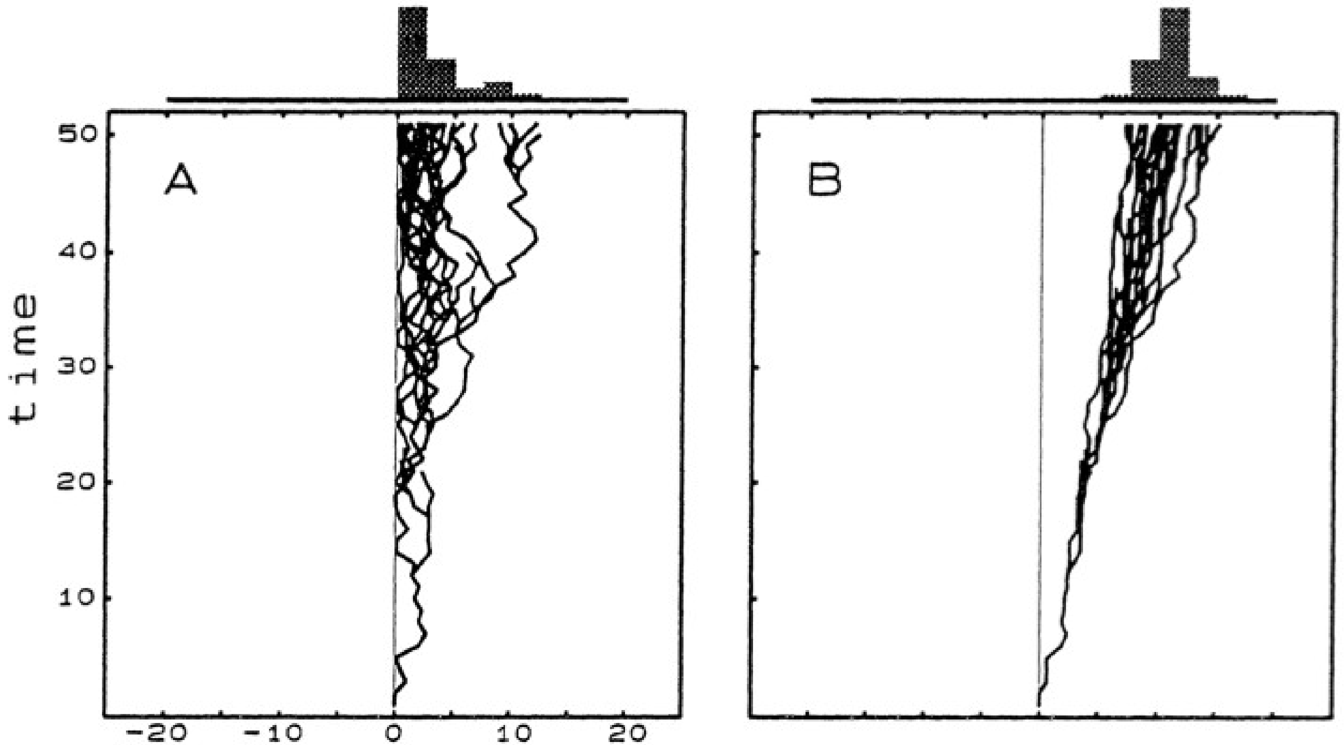


Fig. 1. Simulation of the diversification of a clade in a passive (A) and a driven (B) system. The horizontal dimension is unspecified, but it could be almost any variable (e.g., size, metabolic rate, speciation rate, location in space). See text for discussion of the general features of the computer model. In the passive system, a cushioning boundary is present at zero, meaning lineages that would otherwise cross the boundary are assigned their original value. In the driven system, no boundary is present, but increases are more likely than decreases. Histograms above show distributions for the clades after 50 time units.

MCSHEA. MECHANISMS OF LARGE-SCALE EVOLUTIONARY TRENDS. Evolution (1994) vol. 48 (6) pp. 1747-1763

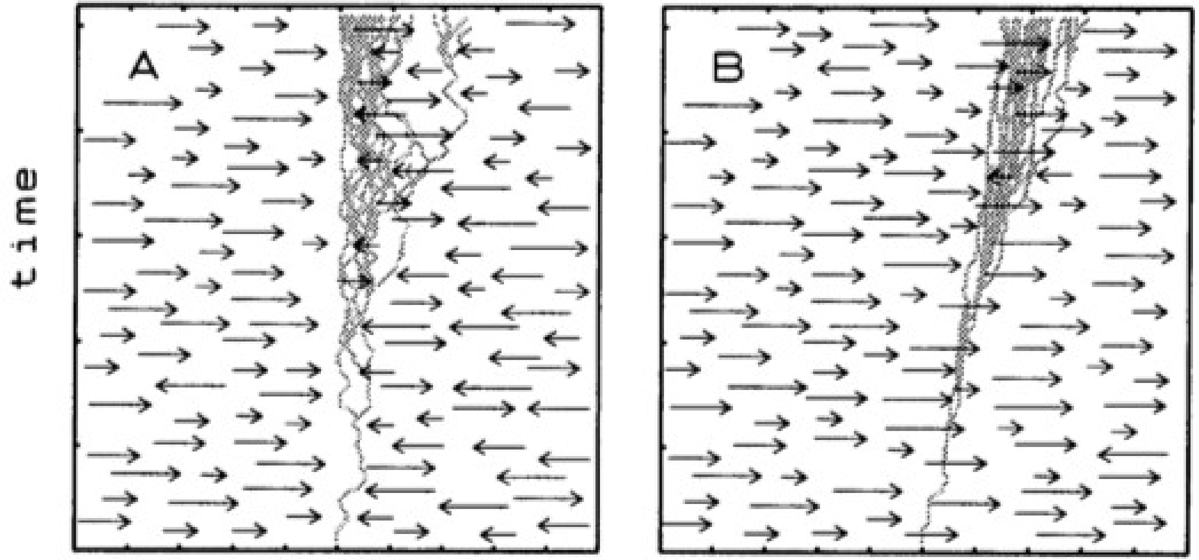
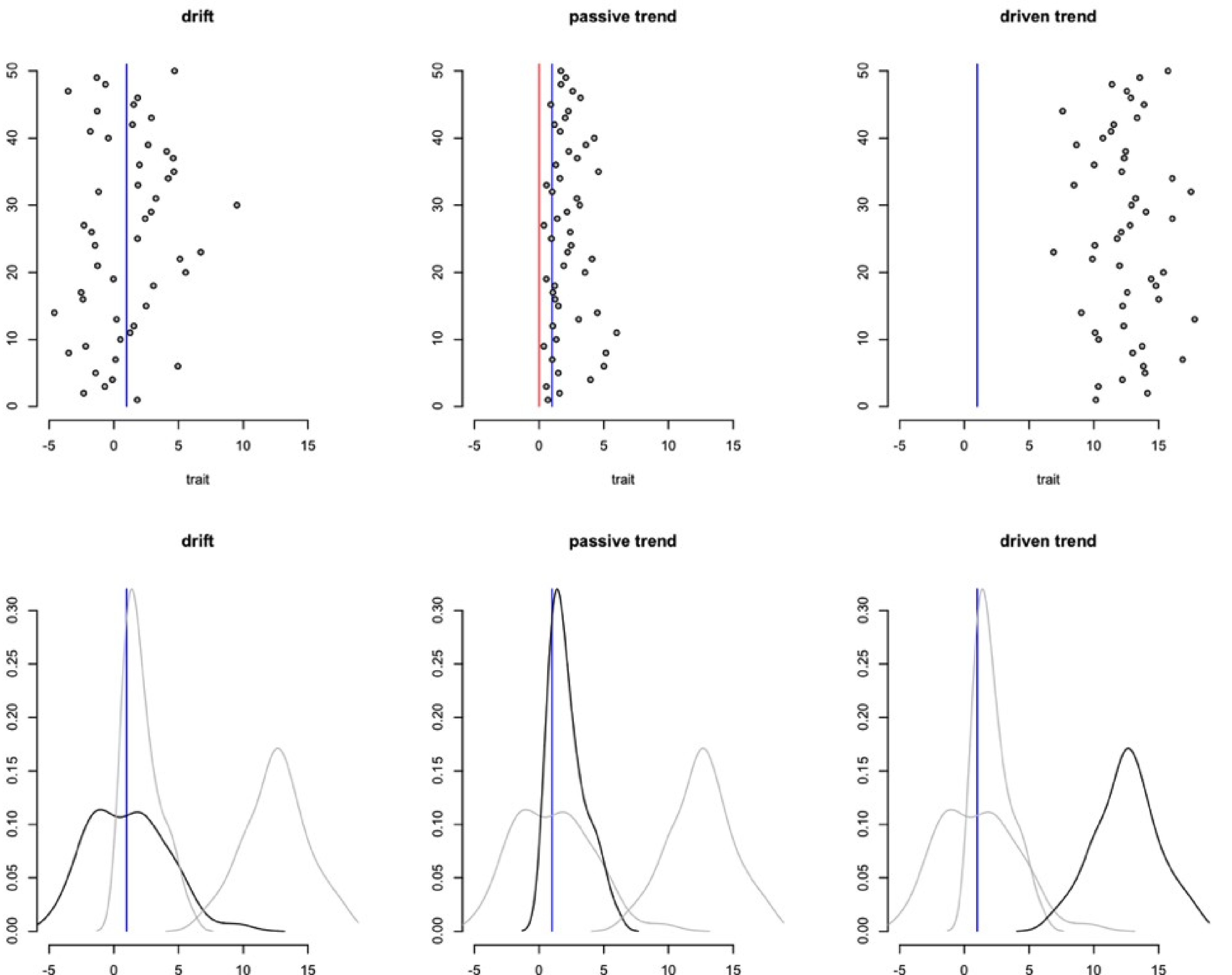
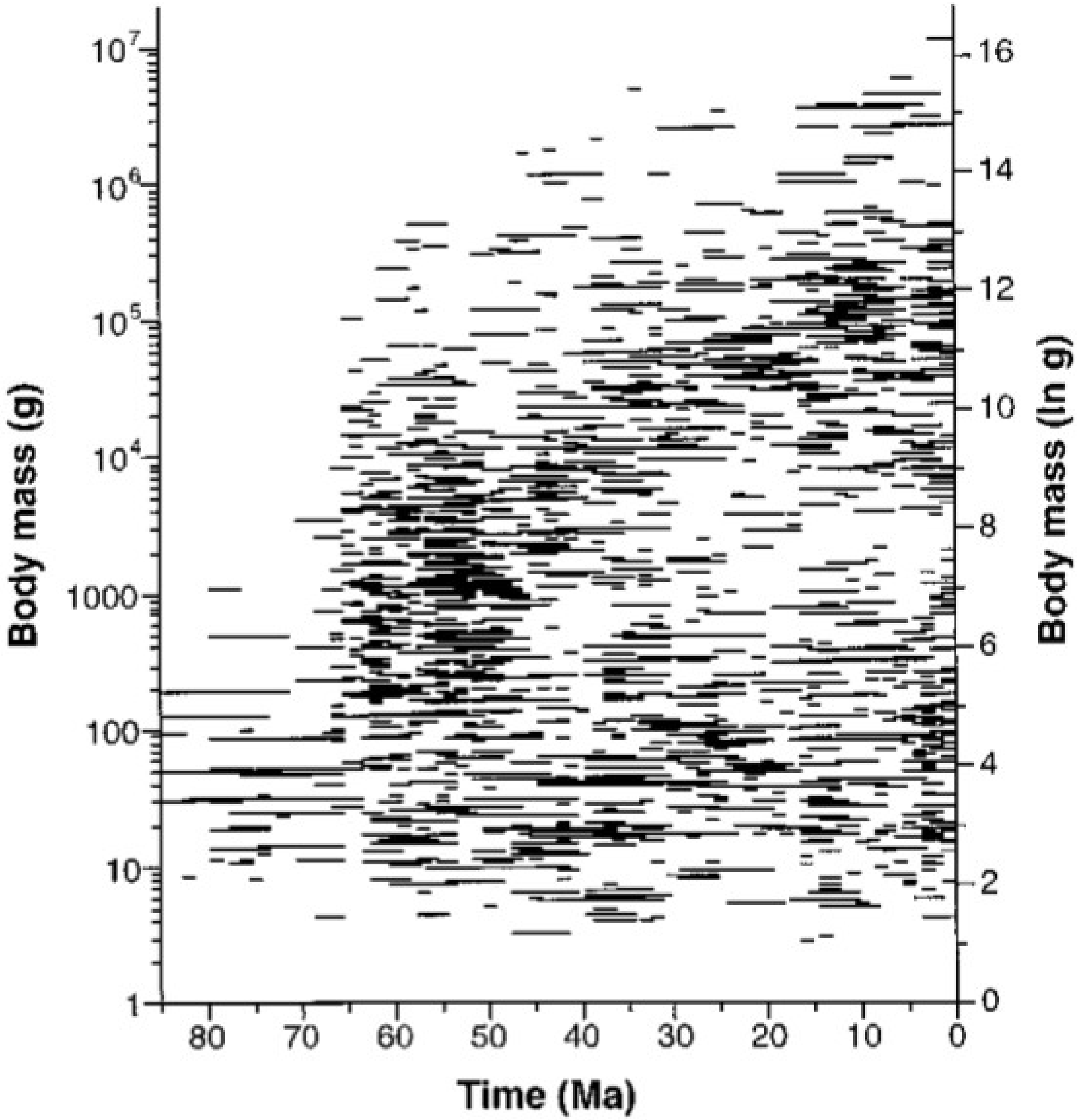


FIG. 4. Modification of figure 1 to show the sense in which a passive trend (A) occurs in a heterogeneous space and a driven trend (B) in a homogeneous space, with vectors representing regimes of evolutionary forces acting in concert (force fields). In the driven system, the field is more or less homogeneous in space and time, driving the lineages to the right. In the passive system, the concerted forces are concentrated on the left, creating a barrier; on the right, the orientation of vectors is random so that no *net* force acts, and diffusion occurs. See text for further discussion.

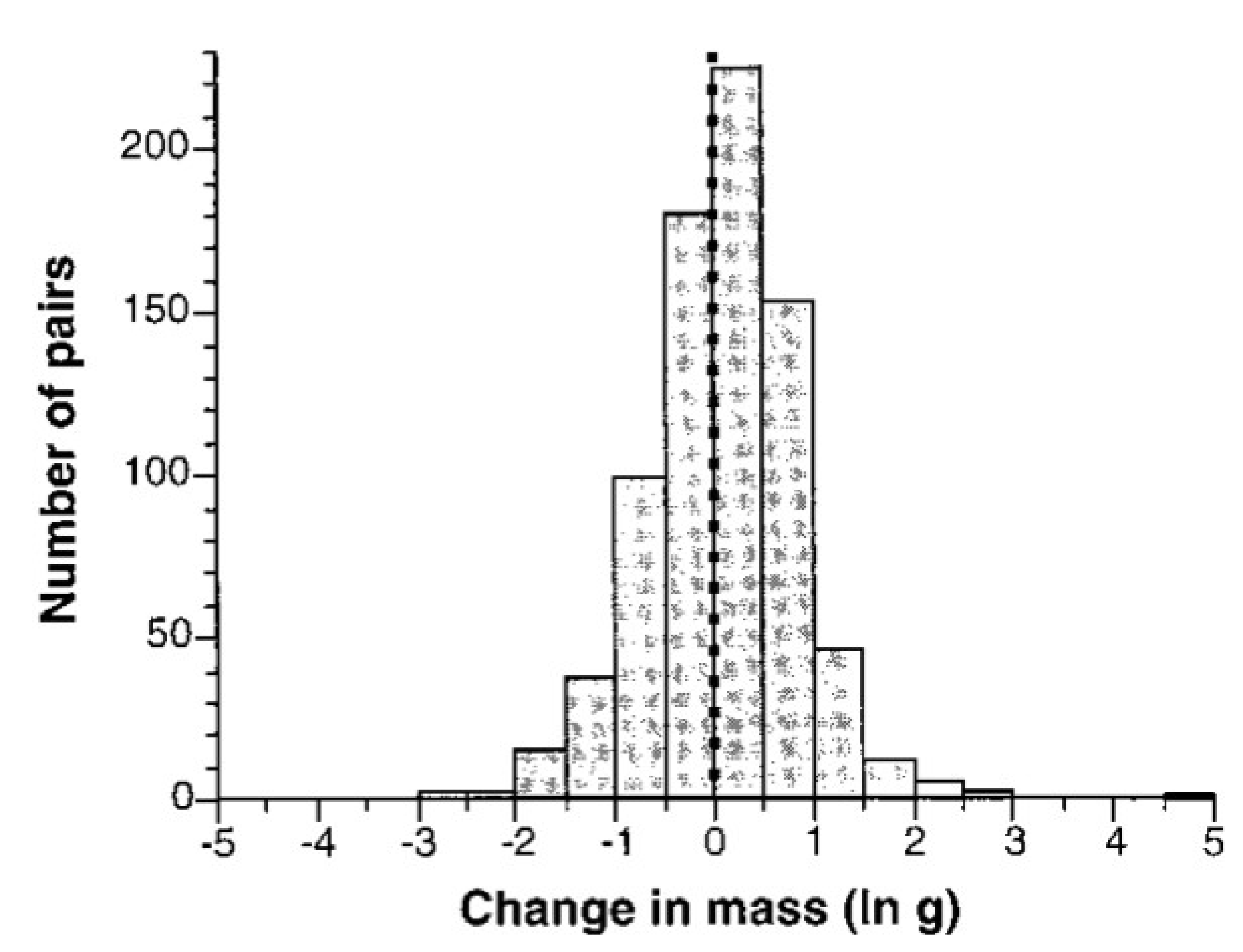
MCSHEA. MECHANISMS OF LARGE-SCALE EVOLUTIONARY TRENDS. Evolution (1994) vol. 48 (6) pp. 1747-1763

Watch the glowing robot on the floor


drift
passive trend
driven trend
trait
trait
trait
drift
passive trend
driven trend



Alroy . Cope's rule and the dynamics of body mass evolution in North American fossil mammals. Science (1998) vol. 280 (5364) pp. 731-734



Alroy . Cope's rule and the dynamics of body mass evolution in North American fossil mammals. Science (1998) vol. 280 (5364) pp. 731-734

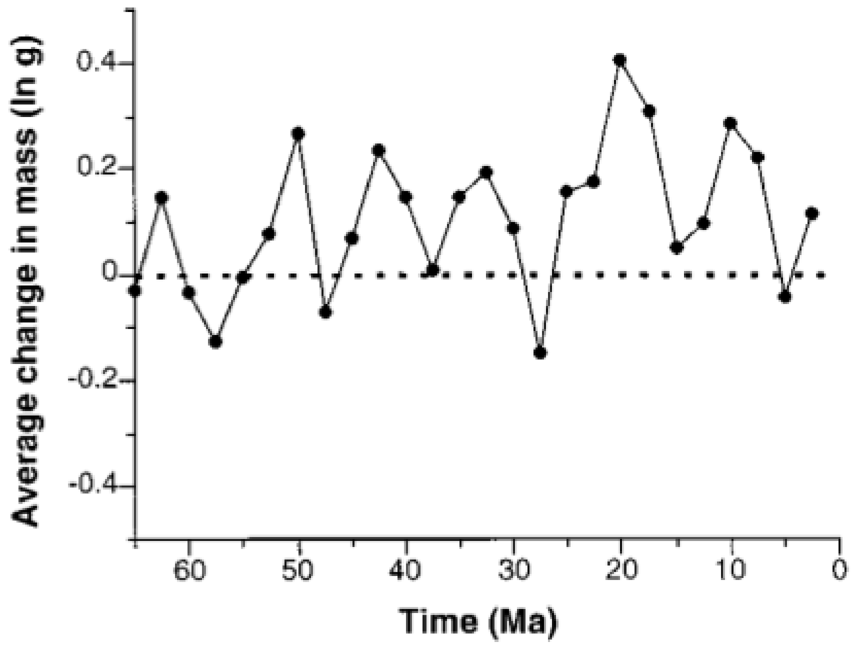
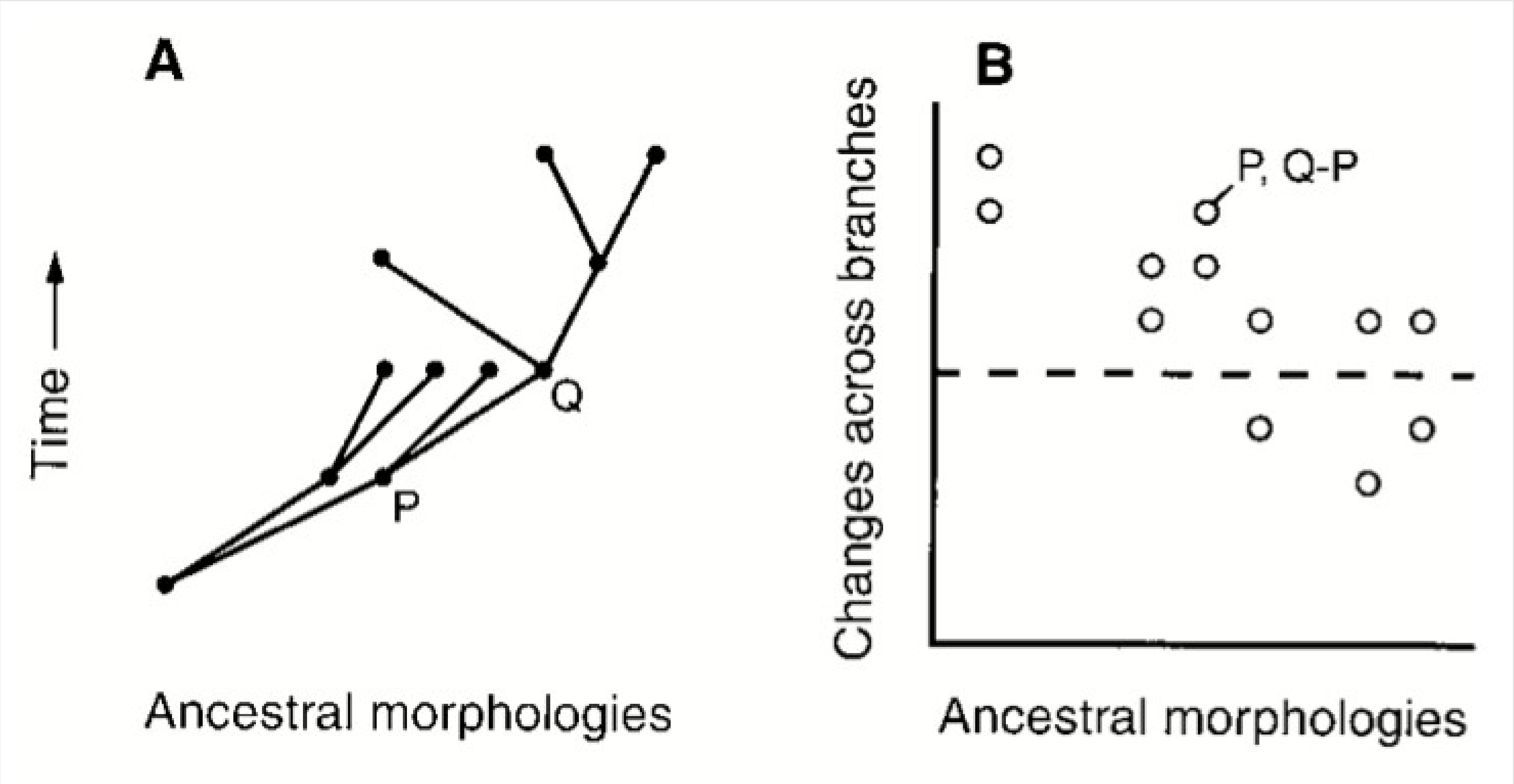


Fig. 3. Trend in strength of the within-lineage Cope's rule effect through the Cenozoic. Here, the data shown in Fig. 2 are binned into intervals 2.5 My long and averaged. Sample sizes range from 12 to 79 older-younger species pairs per interval, with an average of 29.1. Alternative bin sizes of 1 to 10 My yield similar patterns. Cretaceous data are too sparse to allow reliable averages to be computed. The dashed line illustrates the expected average change of zero if there is no effect.

Alroy . Cope's rule and the dynamics of body mass evolution in North American fossil mammals. Science (1998) vol. 280 (5364) pp. 731-734



Alroy. Understanding the dynamics of trends within evolving lineages. Paleobiology (2000) vol. 26 (3) pp. 319-329

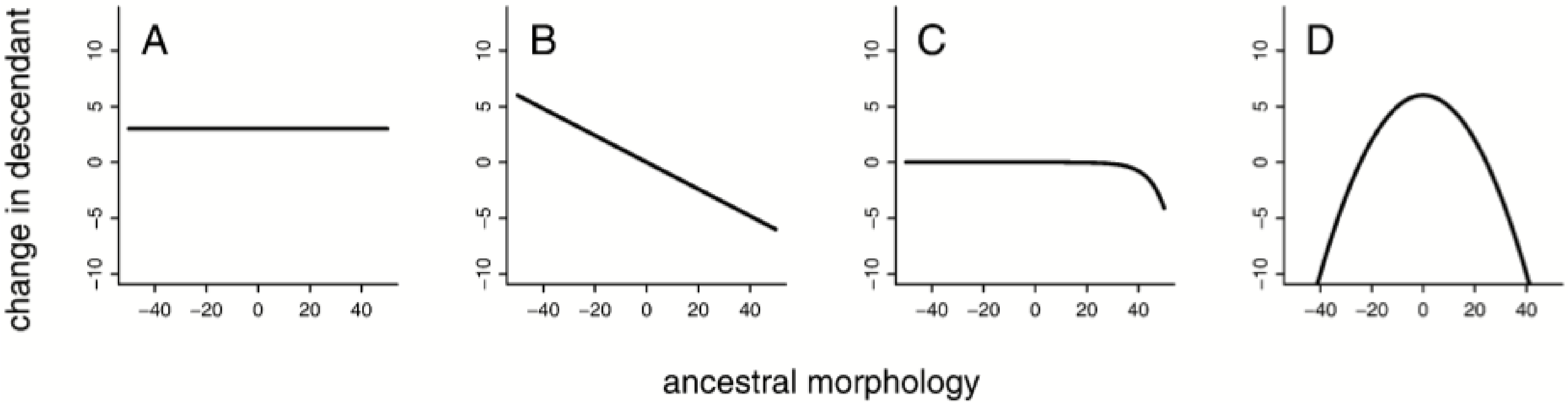


FIGURE 2. Examples of change-vs.-ancestor plots. A, A system exhibiting a simple driven trend. Average ancestor-descendant change is positive and constant for all ancestral morphologies. B, A system exhibiting a stable equilibrium (a ''point attractor'') at size = 0 units. Taxa below this point tend to increase on average, and taxa above this point tend to decrease. C, A system exhibiting an upper bound. All taxa have zero average change except taxa with the largest morphologies, which tend to decrease on average. D, A system exhibiting two equilibria at size = ±30. An unstable equilibrium (a ''repeller'') occurs at size = −30; taxa below this point tend to decrease on average, and taxa slightly above this point tend to increase. A stable equilibrium (a ''point attractor'') occurs at size = +30; taxa slightly below this point tend to increase on average, and taxa above this point tend to decrease.

Wang. Accounting for unequal variances in evolutionary trend mechanisms. Paleobiology (2005) vol. 31 (2) pp. 191-198

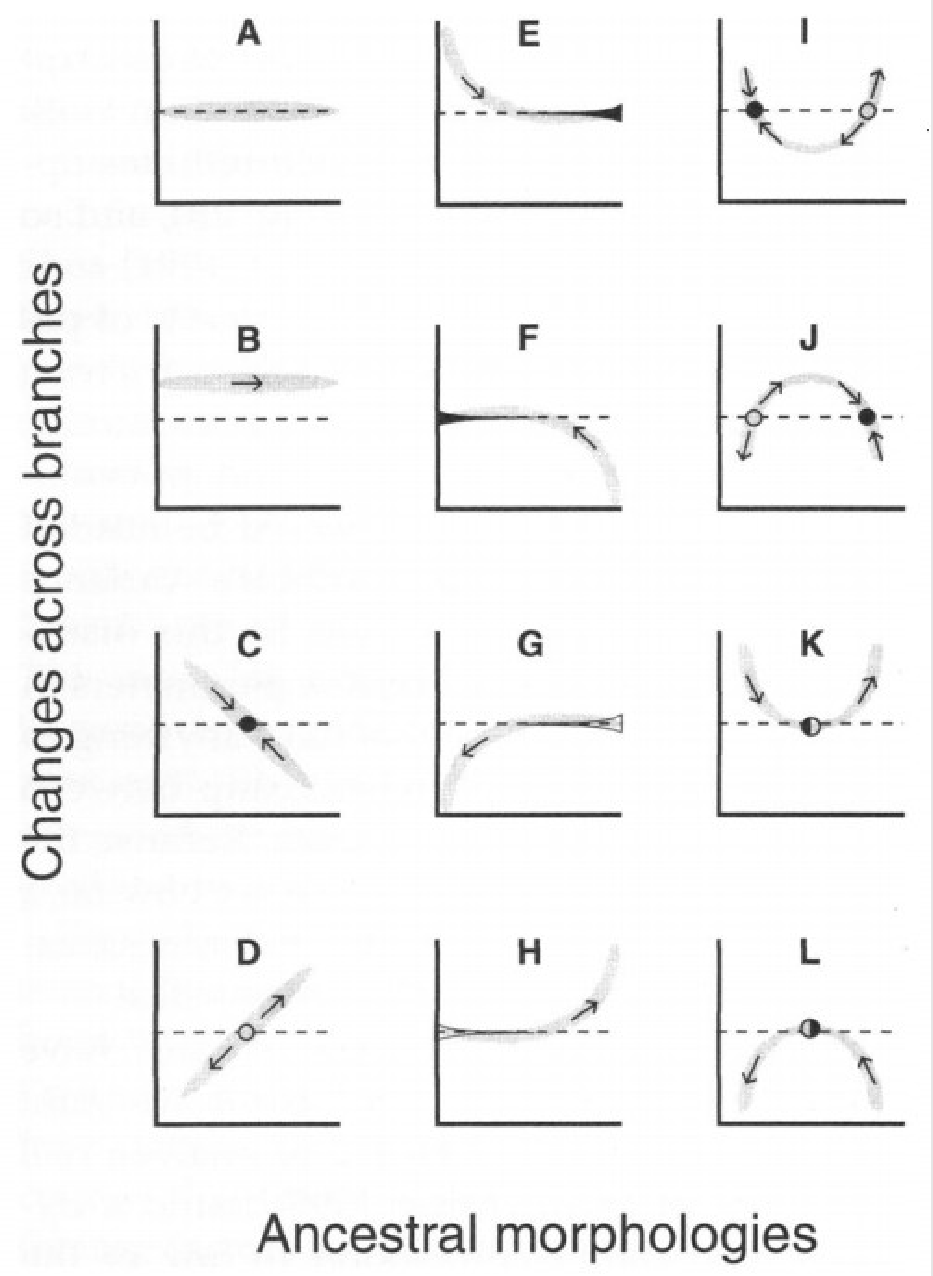
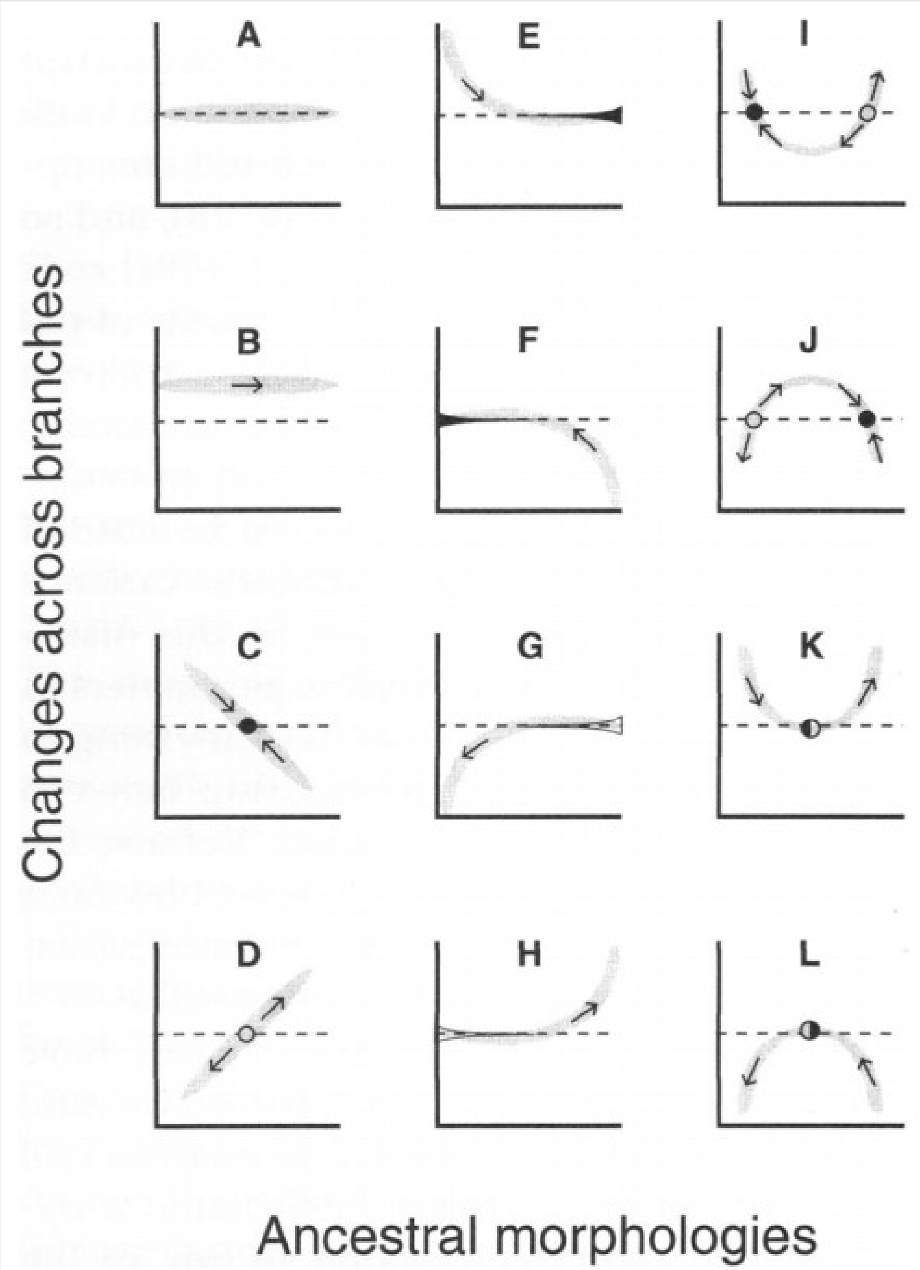
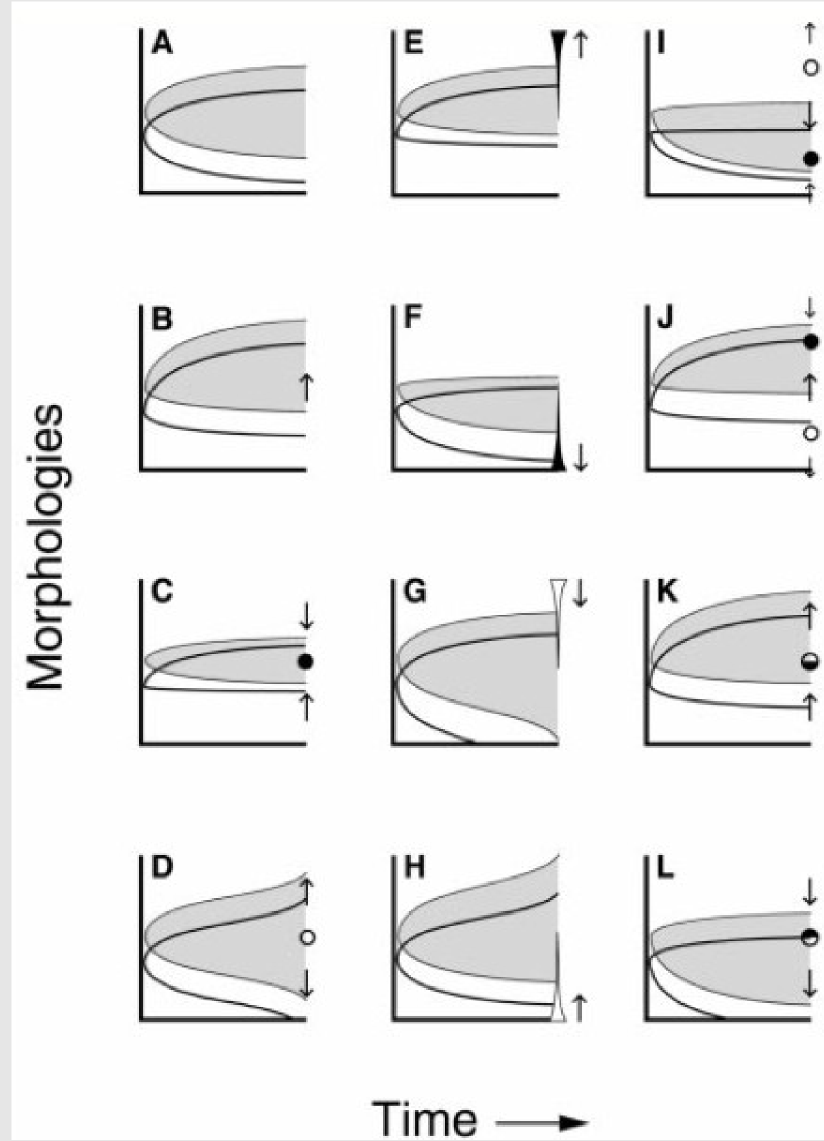


FIGURE 2. Sketches of qualitatively distinct dynamics of evolutionary change. Ancestral morphological values (e.g., size or complexity) are contrasted with differences between descendants and ancestors (e.g., amounts of evolutionary change in size or complexity). Dashed lines indicate evolutionary changes of zero; filled circles and tapering shapes are stable equilibria; open circles and tapering shapes are unstable equilibria; arrows show expected directions of change toward stable equilibria or away from unstable equilibria; gray shapes suggest possible scatters of data points. A, Random change. B, Constant, directed bias. C, Single stable point equilibrium. D, Single unstable point equilibrium. E, Stable equilibrium zone implying a "lower bound." F, Stable equilibrium zone implying an "upper bound." G, Unstable equilibrium zone implying a "lower cliff." H, Unstable equilibrium zone implying an "upper cliff." I, Double point equilibria: lower is stable, upper is unstable. J, Double point equilibria: lower is unstable, upper is stable. K, Point equilibrium that is stable for low values but unstable for high values (i.e., a saddle). L, Point equilibrium (saddle) that is unstable for low values but stable for high values.

Alroy. Understanding the dynamics of trends within evolving lineages. Paleobiology (2000) vol. 26 (3) pp. 319-329





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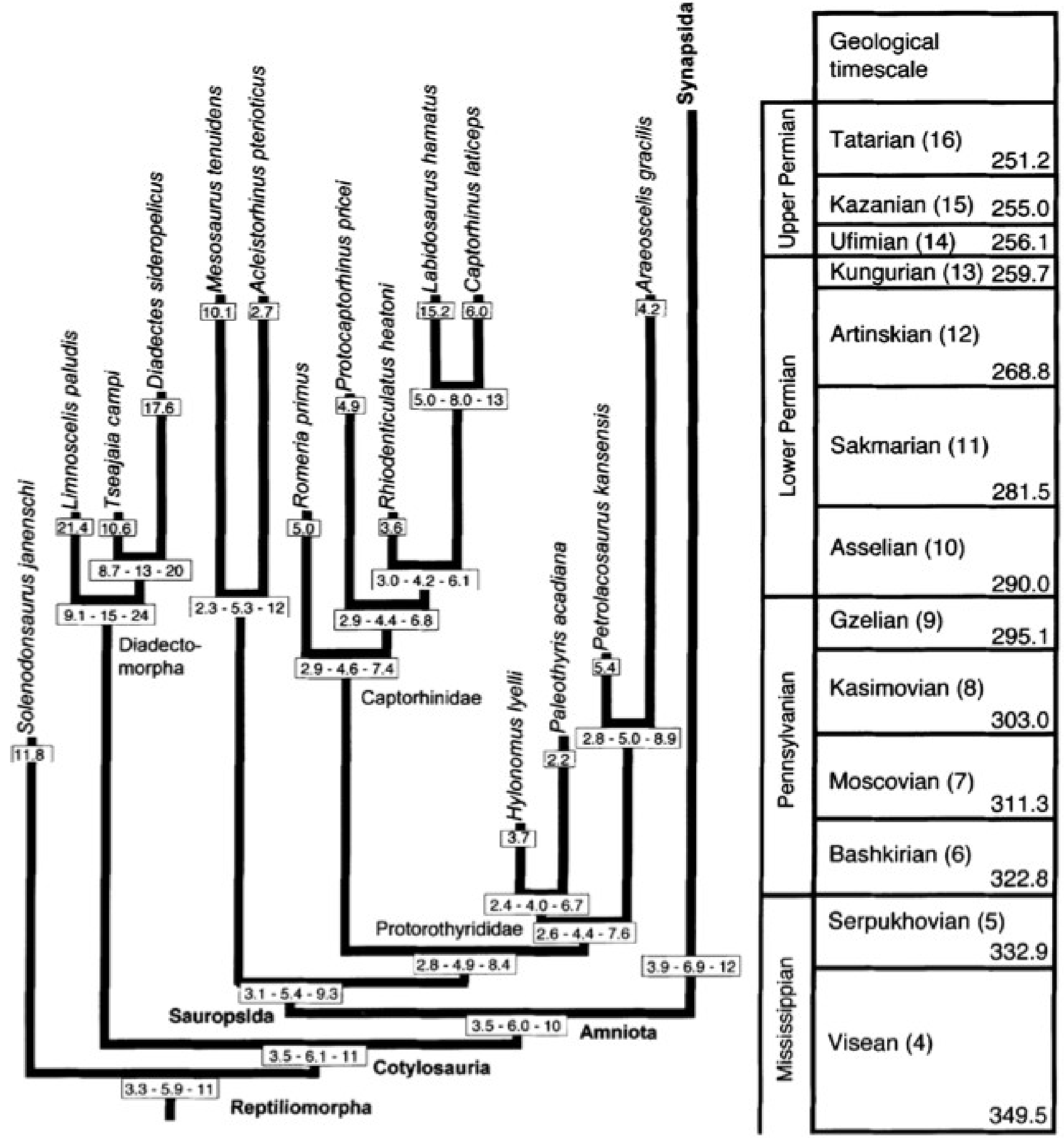


FIGURE 7. Cranial length evolution in reptiliomorphs. All lengths are expressed in cm, and represent the distance from the anterior tip of the premaxilla to the posterior end of the skull table. Abbreviations as in Figure 4. Extant taxa are in bold type.

Laurin. The evolution of body size, Cope's rule and the origin of amniotes. Syst Biol (2004) vol. 53 (4) pp. 594-622

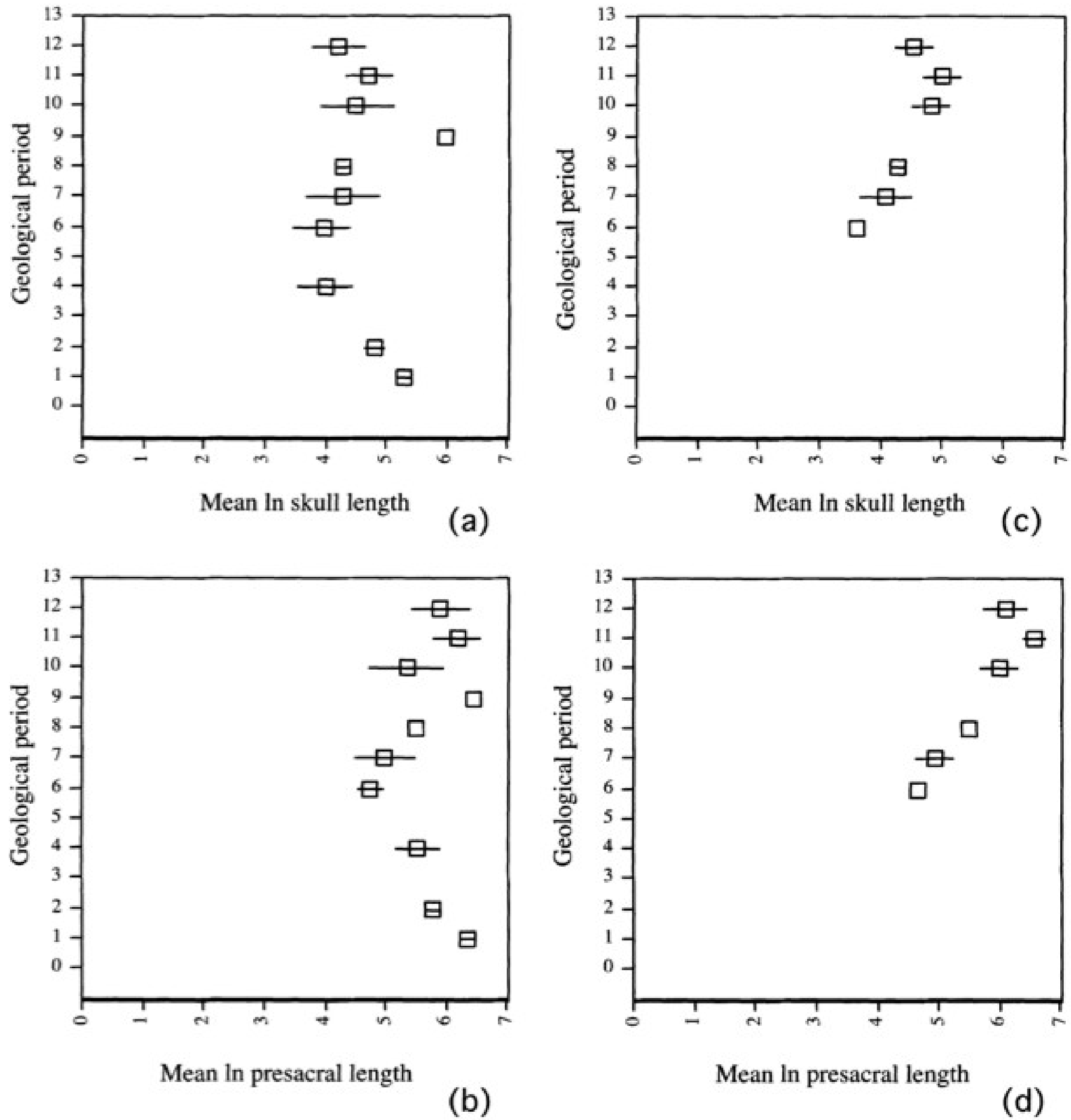
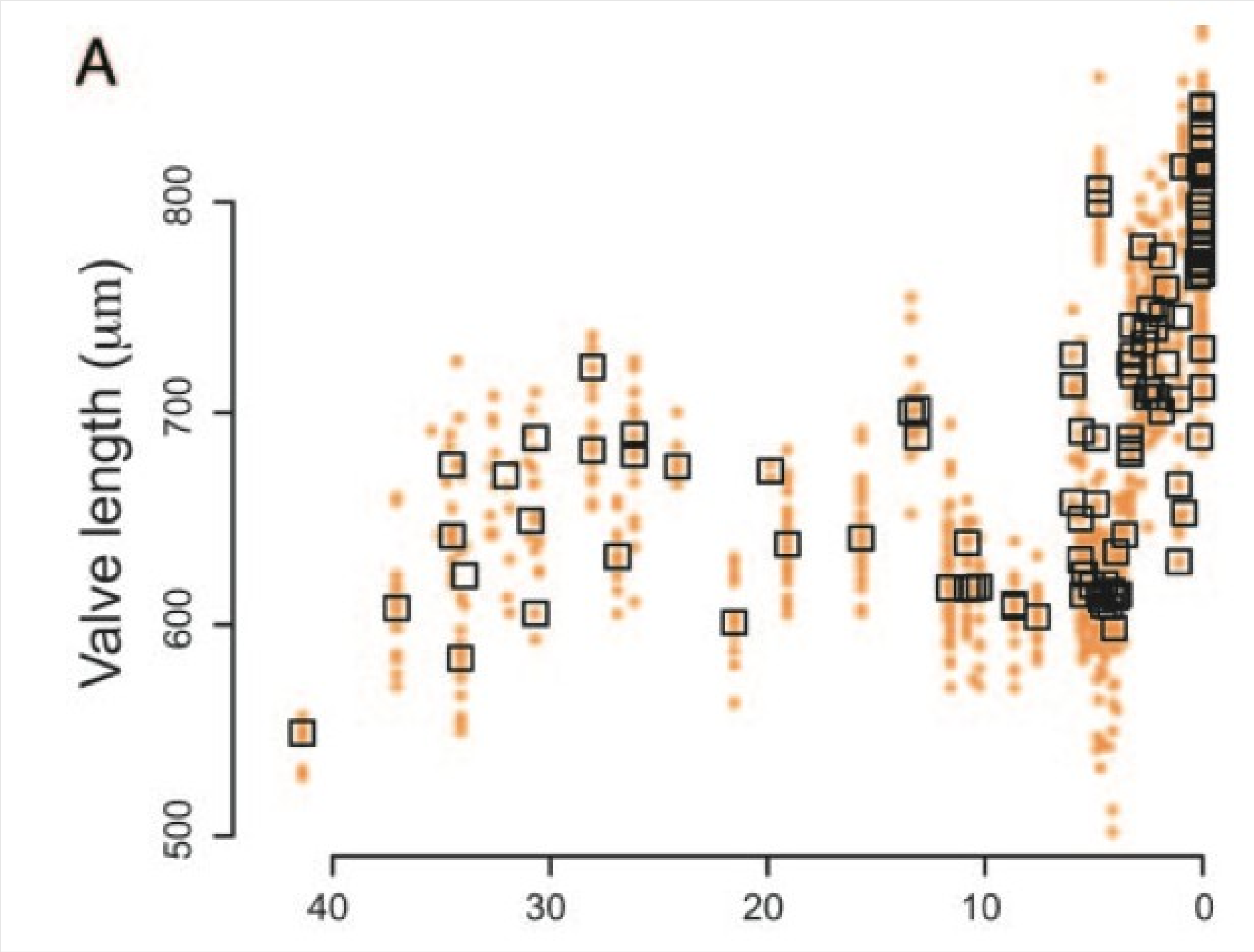


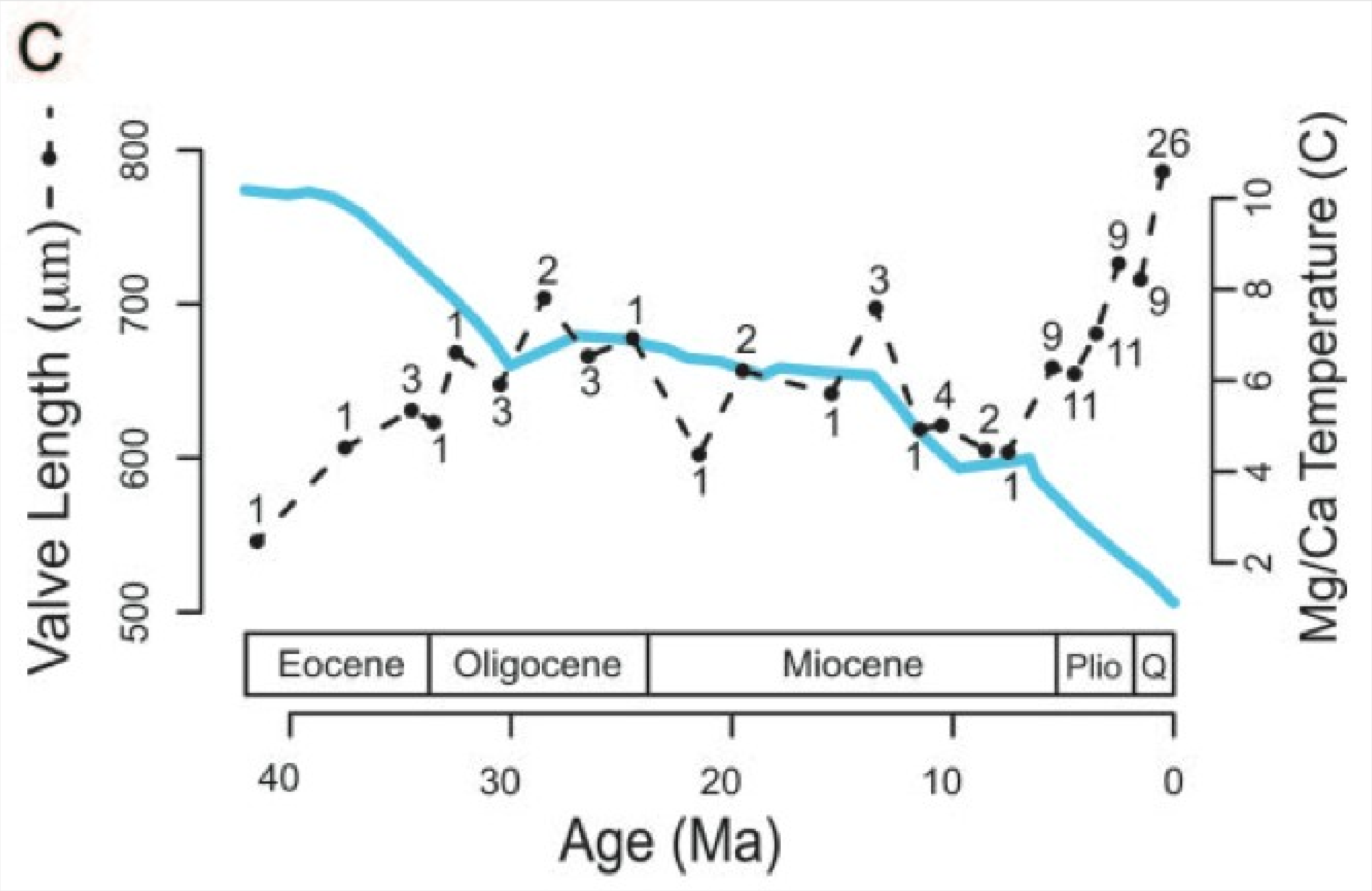
FIGURE 11. Mean body size (x-axis) through time (y-axis). (a) Mean cranial length of stegocephalians. (b) Mean presacral length of stegocephalians. (c) Mean cranial length of reptiliomorphs. (d) Mean presacral length of reptiliomorphs. For reptiliomorphs (c, d), there are no size data before period 6 because reptiliomorphs appear in the fossil record at that time; no size data are available for that group in period 9. In period 1, sampled taxa are finned, primitively aquatic sarcopterygians closely related to stegocephalians; periods 2 to 12 are represented only by stegocephalians. The time periods are defined in Appendix 3. All values have been log-transformed (ln of the dimensions, in mm). The horizontal bars passing through each point represent the standard deviation. Points without bars represent single values. There are no data for period 3.

Laurin. The evolution of body size, Cope's rule and the origin of amniotes. Syst Biol (2004) vol. 53 (4) pp. 594-622



Time

Hunt and Roy. Climate change, body size evolution, and Cope's Rule in deep-sea ostracodes. Proceedings Of The National Academy Of Sciences Of The United States Of America (2006) vol. 103 (5) pp. 1347-1352



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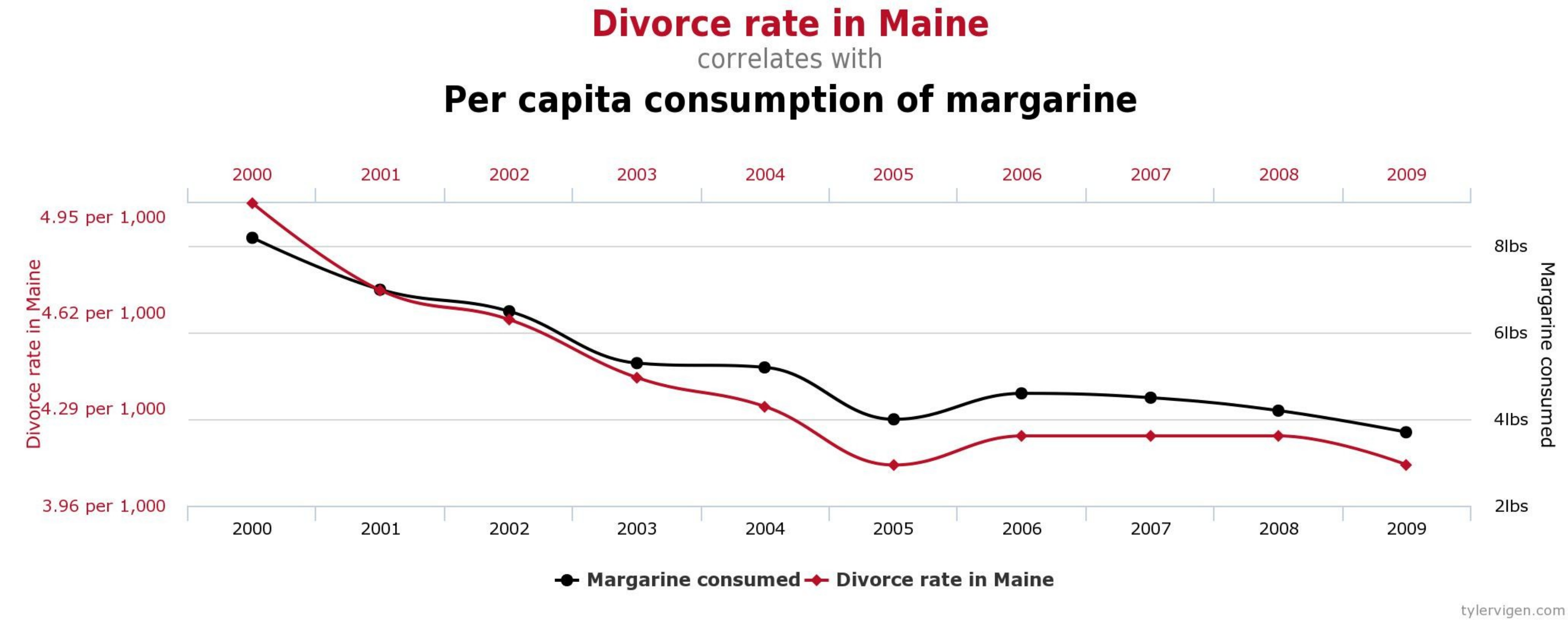
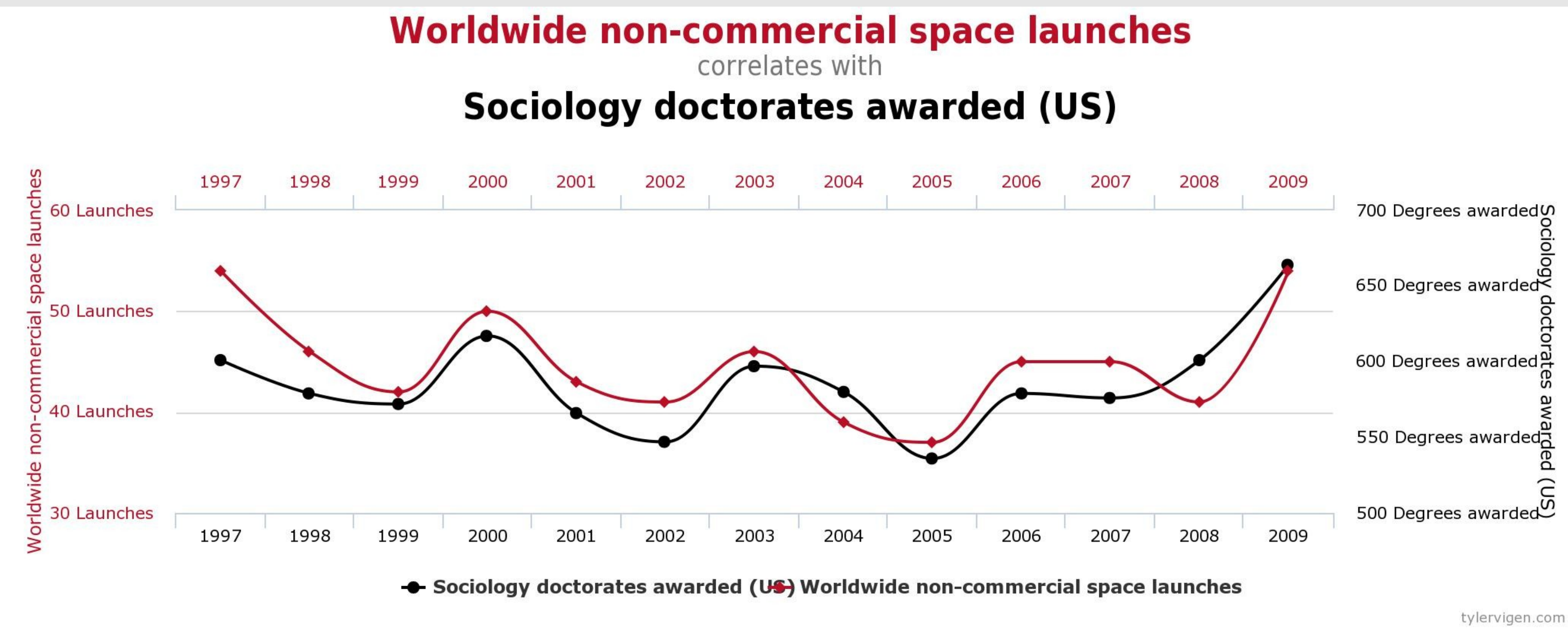


Divorce rate in Maine
correlates with
Per capita consumption of margarine
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
4.95 per 1,000
4.62 per 1,000
4.29 per 1,000
3.96 per 1,000
Divorce rate in Maine
8lbs
6lbs
4lbs
2lbs
Margarine consumed
Margarine consumed
Divorce rate in Maine
tylervigen.com



Worldwide non-commercial space launches
correlates with
Sociology doctorates awarded (US)
1997
1998
1999
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2007
2008
2009
60 Launches
50 Launches
40 Launches
30 Launches
Worldwide non-commercial space launches
700 Degrees awarded
650 Degrees awarded
600 Degrees awarded
550 Degrees awarded
500 Degrees awarded
Sociology doctorates awarded (US)
Sociology doctorates awarded (US)
Worldwide non-commercial space launches
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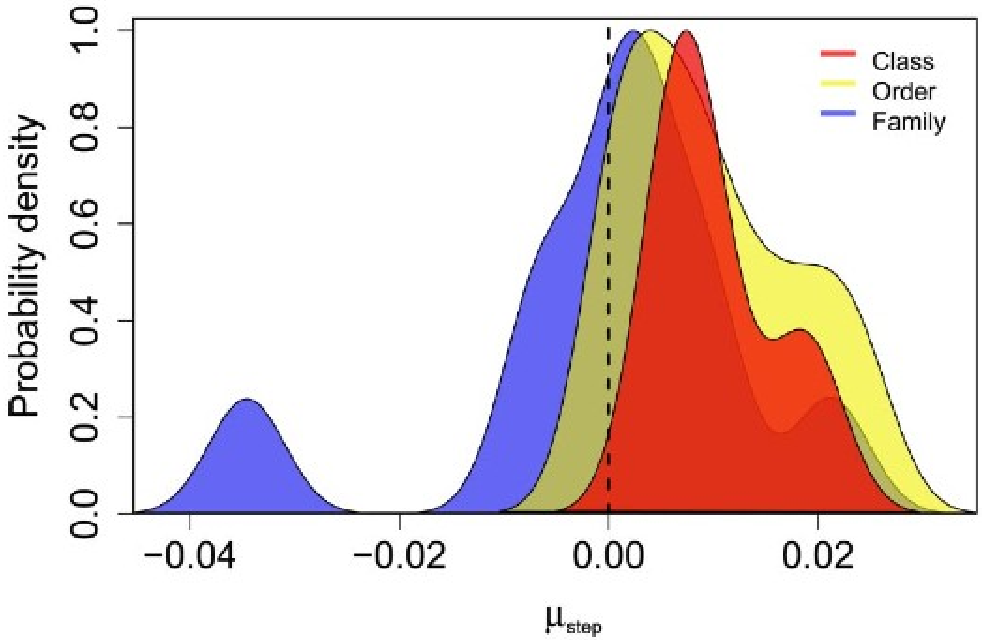

Fig. 3. Within-clade directionality parameter distributions within three hierarchical clade levels. The directionality parameter, μ_{step}, is the maximum-likelihood estimate for the mean rate of directional size change ($\log_{10}$ ml/Myr) within a brachiopod clade. Large clades [classes ($n = 4$) and orders ($n = 11$)] all have statistically positive distributions consistent with Cope's rule, whereas small, constituent clades (families, $n = 10$) are indistinguishable statistically from zero tendency (*SI Appendix*, Table 5). Distributions were estimated by using Gaussian kernel density estimation with shared bandwidth (0.00361); maximum-likelihood estimates are available in *SI Appendix*, Table 3. Similarly distinct distributions occur in the joint directionality parameters for each clade level and when the parameters for DRW, URW, and stasis models are combined by using multimodel inference (23, 24).

Novack-Gottshall and Lanier. Scale-dependence of Cope's rule in body size evolution of Paleozoic brachiopods. Proceedings Of The National Academy Of Sciences O
The United States Of America (2008) vol. 105 (14) pp. 5430-5434

Predict evolutionary trends.
What evidence is there for and against them?