MACROEVOLUTIONARY TRENDS AND PATTERNS

EVOLUTIONARY TRENDS TOWARD GREATER COMPLEXITY

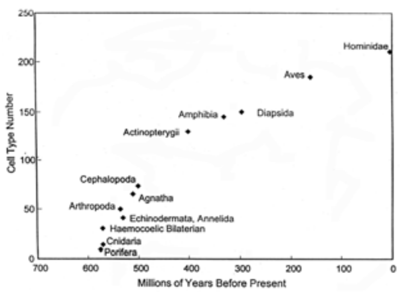
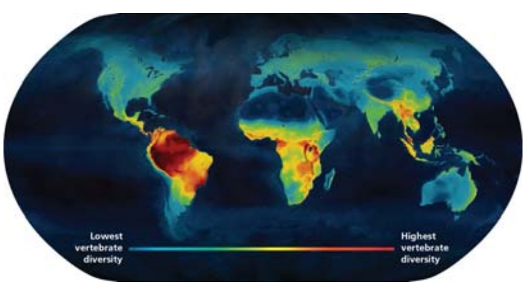
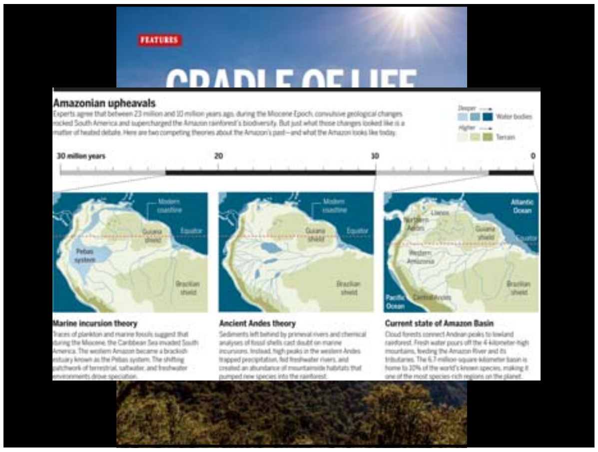


FIGURE 1. Estimated cell-type numbers of primitive members of selected metazoan taxa, inferred from counts of cells in living individuals, plotted against the estimated time of origin of the body plan of each taxon. Only taxa that are believed to have been rather near the upper bound of cell-type numbers when originating are included. For sources on which cell-type number estimates are based, and sources for ages, see Appendix.

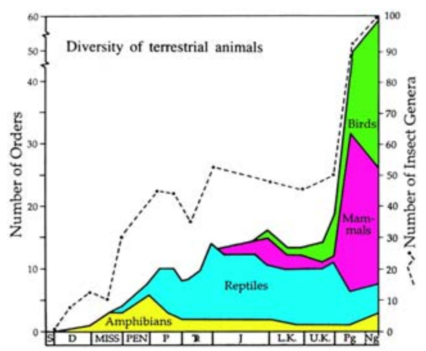
PATTERNS OF VERTEBRATE SPECIES DIVERSITY



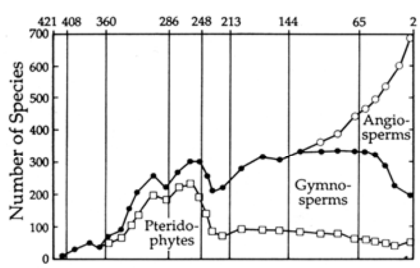
Biogeography: study of the distribution of species across space and time



EVOLUTIONARY TRENDS IN TAXONOMIC DIVERSITY

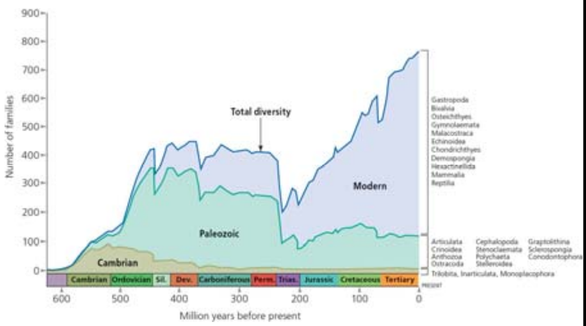


EVOLUTIONARY TRENDS IN TAXONOMIC DIVERSITY



Taxonomic richness of vascular plants, in the Northern Hemisphere

THREE “EVOLUTIONARY FAUNAS”



EVOLUTIONARY TRENDS TOWARD LARGER SIZE

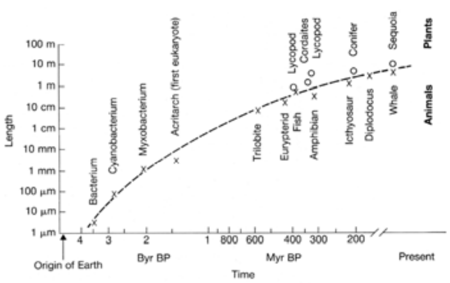


Figure 21.21 A graph of a rough estimate of the maximum size of living thing at different times in the history of life. Both axes are logarithmic. From Bonner (1988).

COPE’S RULE:

- **There is an *evolutionary trend* within lineages toward increased body size over time**

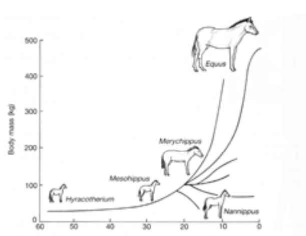


Figure 21.1 Cope's law in horses. The individual lineages are inferred ancestor–descendant lineages, though the real pattern would have had many more. The graph is based on 40 species of North American horse, and includes representatives of most of the main evolutionary groups. From MacFadden (1988b).

COPE'S RULE:

- Size increases in 10 lineages of bivalves during the Jurassic

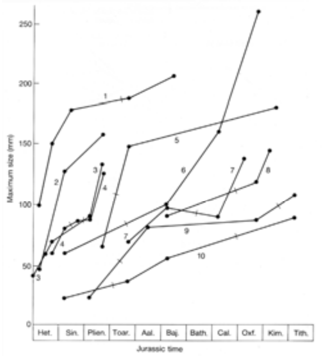


Figure 21.2 Patterns of size increase in 10 lineages of bivalves during the Jurassic. Note the *y*-axis is maximum size of an individual in the lineage. The names on the *x*-axis are the successive divisions of Jurassic time. Cross bars in a lineage indicate a change in species or subspecies. From Hallam (1975).

EXPLANATIONS FOR COPE'S LAW

- *Intraspecific* competition among individuals within lineages.
- *Interspecific* interactions among individuals from different lineages. Directional trend in character displacement.

COEVOLUTIONARY ARMS RACE BETWEEN PREDATORS AND PREY?

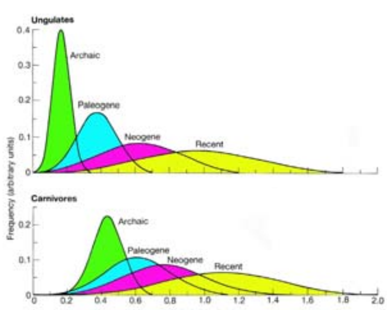


Figure 21.11 The distribution of relative brain sizes for carnivores (predators) and ungulates (prey) through the Cainozoic. There was an increase in brain size through time, and at any one time carnivores had bigger brains than ungulates. From Jerison (1973).

INSULAR DWARFISM AND GIGANTISM

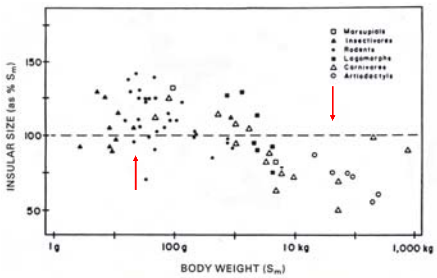


Figure 4.7. Size of island faunas as a function of mainland body size (S_m). Smaller mainland forms tend to increase in size on islands, from competitive release, while larger forms decrease in size due to reduced resources. Modified from Lomolino (1985).

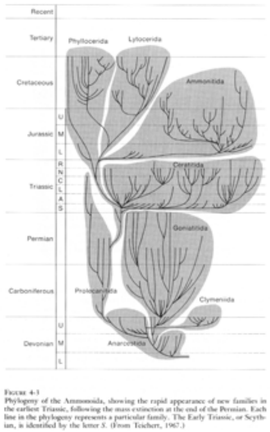
- DWARFISM IN ISOLATED ISLAND POPULATIONS OF WOOLLY MAMMOTH

- MATURE INDIVIDUALS AS SMALL AS 4 FT HAVE BEEN FOUND ON ALEUTIAN ISLANDS

THE TENDENCY OF SMALL HERBIVOROUS ANIMALS TO ENLARGE, AND CARNIVORES AND UNGULATES TO DWARF ON ISLANDS "SEEMS TO HAVE FEWER EXCEPTIONS THAN ANY OTHER ECOTYPIC RULE IN ANIMALS" (Van Valen 1973)

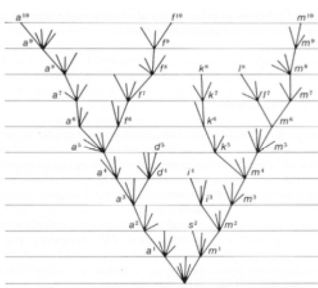
HYPOTHESES:

- Competitive release in small animals leads to natural selection for increasing body size.
- Resource limitation for larger animals leads to selection for smaller body size.



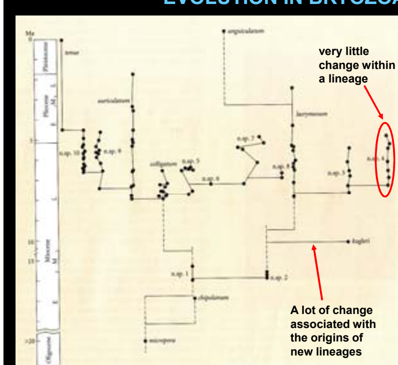
How is the process of evolution by speciation (cladogenesis) related to the diversification of phenotypes?

DARWIN'S VIEW OF GRADUAL CHANGE WITHIN LINEAGES OVER MANY GENERATIONS



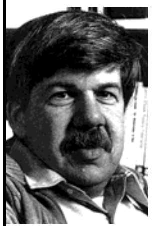
Darwin (1859)

EVOLUTION IN BRYOZOANS



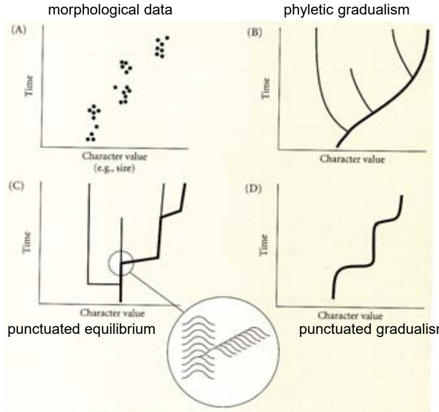
- "Moss animals" -- filter-feeding, colonial.
- Characters changed little within species, over about 4.5 My.
- Characters changed rapidly, from one stable state to another, as new species originated.
- Most features thus exhibited a pattern of long periods of stasis, and occasional periods of rapid change.

PUNCTUATED EQUILIBRIUM

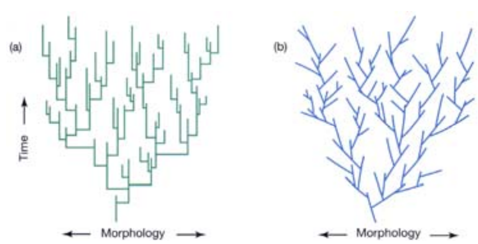


- Proposed by Stephen Jay Gould and Niles Eldredge in 1972.
- **Two parts:** (1) A claim about the pattern of change in the fossil record, and (2) A hypothesis about evolutionary processes.
- **Pattern:** Little over extended periods of geological time followed by rapid change from one stable state to another. **The stasis is punctuated by change.**
- **Hypothesis:** Characters evolve primarily in concert with true speciation (cladogenesis). If new species evolve primarily in marginal populations, then the transitions will almost never be observed in the fossil record. Recall our discussion of rapid divergence in peripheral populations (i.e., peripatric speciation)

Read box 14.1 in Z&E



TWO ALTERNATIVE VIEWS OF THE PROCESS OF DIVERSIFICATION



- **Punctuated Evolution: all the character change is directly associated with cladogenesis.**
- **Gradual Evolution: all the character change is within lineages (anagenesis).**

AN EXAMPLE OF GRADUALISTIC EVOLUTION:
Morphological change in Trilobites

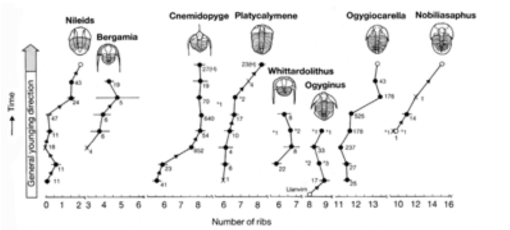


Figure 19.8 Gradual evolution in Sheldon's study of Ordovician Welsh trilobites. In eight lineages, the pattern of change is gradual rather than punctuated. Time goes up the page (total time span 3 million years) and the biometric variable (number of ribs) is on the bottom. From Sheldon (1987).

AN EXAMPLE OF GRADUALISTIC EVOLUTION:
Tooth Size Evolution in an Eocene Mammal

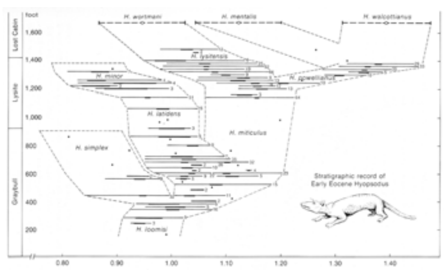
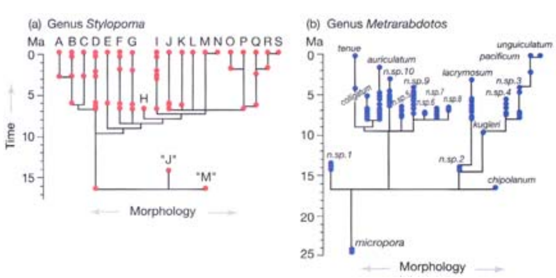


FIGURE 3-9
Changes in size within a phylogeny reconstructed for the Eocene condylarth *Hyopsodus* in northern Wyoming. On the horizontal axis is plotted the logarithm of the product of length and width (in millimeters) of the first lower molar (log L × W) of M_1. For each sample, the heavy bar represents the standard error and the light bar, the range of values. Numbers to the right indicate number of specimens in the sample; dots represent single samples. Open circles and horizontal dashed lines at the top are means and expected ranges for species poorly represented in the stratigraphic section but well studied elsewhere. (From Gingerich, 1974.)

AN EXAMPLE OF PUNCTUATED EVOLUTION:
Skeletal Morphology in Bryozoans



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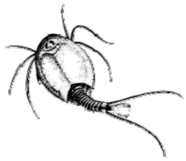
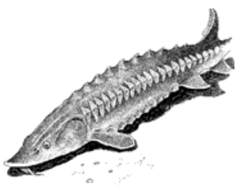
- LONG-TERM STASIS IS OBSERVED IN MANY LINEAGES: INVERTEBRATE EXAMPLES
  - Horseshoe Crabs: Little morphological change since the Early Triassic (230 MYA).



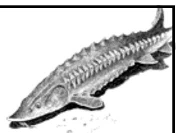
- Notostracans (Tadpole Shrimp): Little morphological change since the Late Carboniferous (305 MYA). Two Triassic forms are assigned to living species.

- LONG-TERM STASIS IS OBSERVED IN MANY LINEAGES: VERTEBRATE EXAMPLES

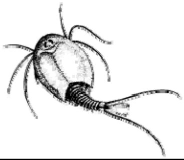
- Pangolins: Only seven living species, one of which dates to the Early Oligocene (35 MYA).



- Sturgeons: Two living genera that extend back to the Late Cretaceous with little morphological change (80 MYA)

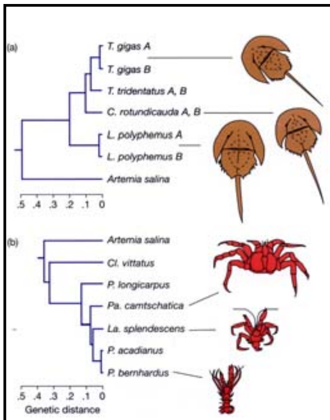


- Lineages that show high levels of morphological stasis also tend to show very little diversification by speciation.
- They seem to lack both anagenesis and cladogenesis.



HOW CAN WE EXPLAIN THIS LONG-TERM EVOLUTIONARY STASIS???

ARE THESE LINEAGES SIMPLY LACKING IN GENETIC VARIATION???



- **Molecular genetic analysis of two arthropod groups; 1) morphologically static Horseshoe Crabs, and 2) morphologically diverse shelled crabs, demonstrates that both lineages have *similar levels* of molecular genetic variation.**

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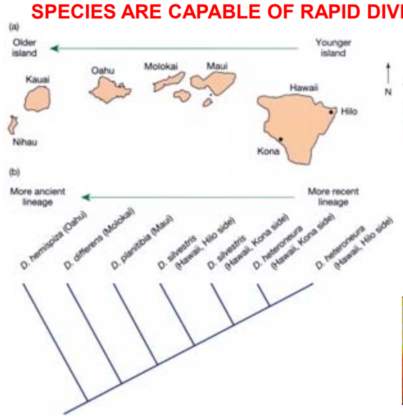
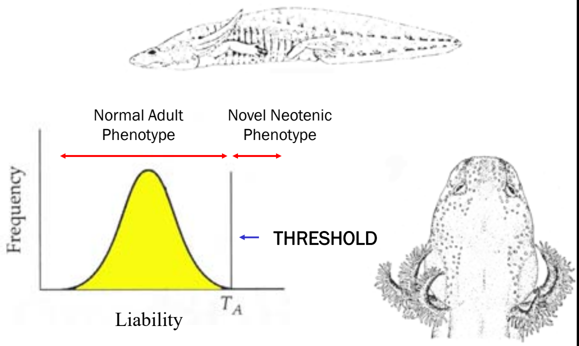
SPECIES ARE CAPABLE OF RAPID DIVERSIFICATION



PHENOTYPIC TRAITS MAY SHOW DRAMATIC CHANGES WITH LITTLE UNDERLYING GENETIC CHANGE



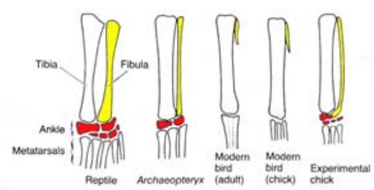
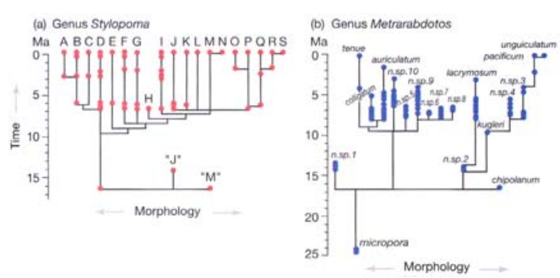


FIGURE 29
The development of the leg and ankle bones of Hampé's experimental chicks (right), compared to their state in reptiles, *Archaeopteryx*, and the normal condition in modern birds. (From Frazzetta 1975)

AN EXAMPLE OF PUNCTUATED EVOLUTION:
Skeletal Morphology in Bryozoans



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CAN WE CONNECT MICRO-EVOLUTIONARY PROCESSES AND MACRO-EVOLUTIONARY PATTERNS

The rates of evolutionary response that we measure with artificial selection experiments and the observations of rapid evolution from studies of contemporary natural populations suggest that most populations are capable of evolving 100 to 1000 times faster than average long-term rates estimated from the fossil record.

This has two important implications:

1) The abrupt changes and “punctuated” patterns in the fossil record may just reflect occasional bursts of rapid evolution.

2) The lower rate observed in the fossil record may be due to long-term stabilizing selection and interactions among organisms preventing diversification.