MACROEVOLUTIONARY TRENDS AND PATTERNS

EVOLUTIONARY TRENDS TOWARD GREATER COMPLEXITY

Patterns of vertebrate species diversity

Biogeography: study of the distribution of species across space and time
THREE “EVOLUTIONARY FAUNAS”

EVOLUTIONARY TRENDS TOWARD LARGER SIZE

COPE’S RULE:

- There is an evolutionary trend within lineages toward increased body size over time
COPE’S RULE:
- Size increases in 10 lineages of bivalves during the Jurassic

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?

![Graph showing the distribution of relative brain sizes for various species and ungulates](image-url)
INSULAR DWARFISM AND GIGANTISM

- 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

- 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

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

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

Normal Adult Phenotype

Novel Neotenic Phenotype

THRESHOLD

Liability $T_A$

FIGURE 23: The development of the leg and axial bones of Hempt's experimental chicks (right), compared to their state in reptiles, Archaeopteryx, and the normal condition in modern birds. (From Fracasso 1973)

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.