BIO 221
Invertebrate Zoology I
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http://www4.nau.edu/isopod

Lecture 3

Transformation

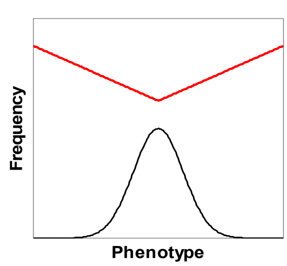
If directional selection occurs for prolonged periods, populations evolving over time may TRANSFORM.

Disruptive Selection

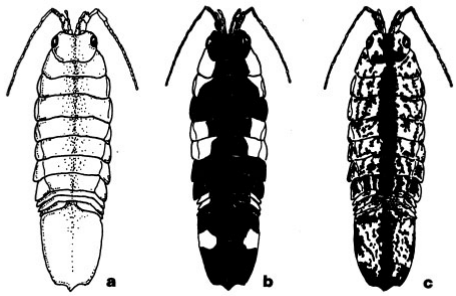
If the tails of the distribution undergo directional selection in opposite directions.

The population DIVERGES in character.

This is **DISRUPTIVE SELECTION**.



Disruptive Selection



Divergence

Populations may change for a variety of reasons.

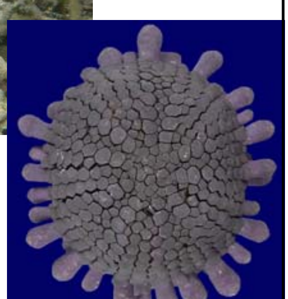
1. Exploitation of new habitat, food resources.

2. Change in environmental conditions.

a. ***Abiotic***: temperature, humidity, salinity, stress.

b. ***Biotic***: competition, predation, parasites

3. Change in social conditions.



ADAPTIVE RADIATION

In the fossil record there are PERIODIC EXPLOSIONS in species abundance

a. Occur when new adaptive zones open up.

1. Colonization of land.
2. Evolution of xylem, phloem, flowers
3. Evolution of multicellularity.

Precambrian Explosion

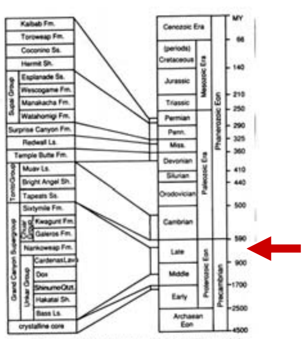


Figure 7. Comparison of the geologic column of the Grand Canyon with the Geologic Time Scale (After Haq and Van Eysinga, 1987)

Convergent Evolution

Species don't *always* diverge.

a. In some cases distantly related species may be faced with similar environmental circumstances.

b. If selection favors similar phenotypes, character **CONVERGENCE** is likely to occur.

Convergent Evolution: Sucking Insects

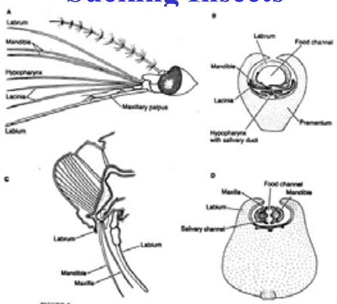


FIGURE 8

Convergent evolution: piercing-sucking mouthparts in the insect orders Diptera (mosquito) and Hemiptera (cicada). (A) Lateral view of the head of a mosquito (mouthparts separated for visibility). (B) Cross section of mosquito mouthparts. (C) Lateral view of the head of a cicada, in sagittal section. (D) Cross section of cicada mouthparts. The labrum encloses the food channel in the mosquito, but is abbreviated in the cicada; the maxillae form separate piercing organs (laciniae) in the mosquito, but enclose the food and salivary channels in the cicada. (From Atkins 1978)

Convergent Evolution: Limpets and Barnacles

Parallel Evolution

Species may follow similar evolutionary paths

a. Separation of populations may prevent gene flow.

b. Genetic drift, unique selection pressures may cause some divergence.

c. But primary selective pressures may stay the same.

d. Result: Species are ***distinct***, but ***retain similar morphology***.

Parallel Evolution: Epicaridean Isopods

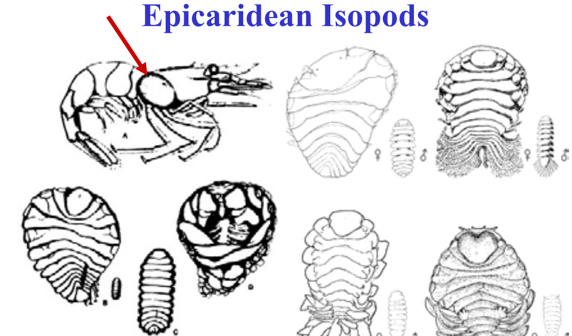


Figure 50. A, caridean shrimp with bopyrid parasite in branchial chamber. *Probopyrus pandalicola: B,* ♀ and ♂ in dorsal view, same scale; *C,* ♂ enlarged; *D,* ♀ ventral view, eggs removed from marsupium.

Parallel Evolution: Lepidopteran Wing Patterns

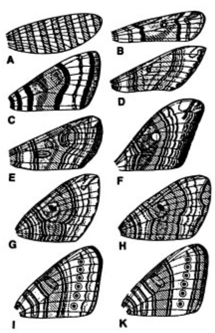


FIGURE 9

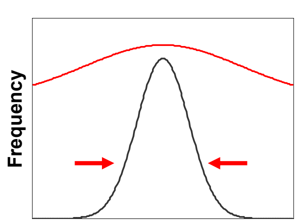
Parallel evolution in the wing patterns of Lepidoptera (moths and butterflies). Similar patterns of pigmentation have evolved repeatedly. (A) Tineidae and Tortricidae; (B) Pyralidae; (C) Arctiidae; (D) Sphingidae; (E) Noctuidae; (F) Saturniidae; (G,H) Geometridae; (I,K) Nymphalidae. (From Rensch 1959)

Stabilizing Selection

Appears to produce NO CHANGE.

Yet it ***can*** produce a major evolutionary pattern.

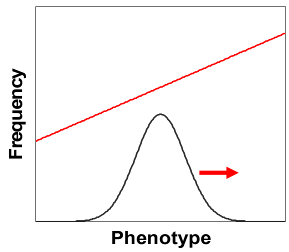
1. This fitness function can lead to ***character stasis***.
2. Much of the fossil record exhibits this pattern, especially in marine communities



Directional Selection

Generates *directional* change

1. The intensity of selection, heritability of character influence the *rate* of change
2. Sometimes change is ***slow and gradual*** -the type envisioned by Darwin.
3. Sometimes change is ***rapid*** - so rapid that it is not reflected in fossil record.



All of these processes contribute to PATTERNS of evolutionary change we *can* observe.

Patterns of Evolution:

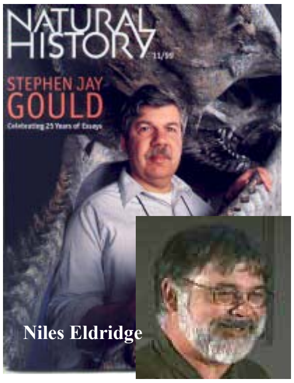
Phyletic Gradualism:

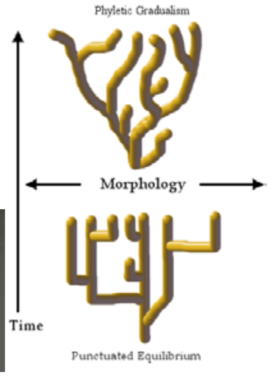
Gradual character change over time.

Punctuated Equilibrium:

Combination of character stasis and rapid character change over time.

Punctuated Equilibrium





There are also other explanations for evolutionary change.

Extinction

Catastrophic or gradual extinction events may remove portions of species variation.

1. If populations go extinct,

a. competition may be ***relaxed***.

b. new ***adaptive zones*** may become available

c. populations could respond ***rapidly***.

2. Intermediate forms that gave rise to other forms may be ***lost***.

Chance

Sometimes unexpected events can change selective pressures such that rapid change will occur

1.Small populations and reduced migration rates can ***reduce*** genetic variation.

a. This may ***limit*** the evolutionary potential of a population.

b. Or, it may produce ***genetic interactions*** that produce new phenotypes.

c. New combinations may have ***higher fitness*** than old combinations.

Chance, too

Sometimes unexpected events can change selective pressures such that rapid change will occur

2. If populations are suddenly reduced in size, they are called "***population bottlenecks***,"

3. If few individuals are isolated in new locations these evolutionary changes are called "***founder effects***."

Evolutionary Progress vs. Stochastic Events

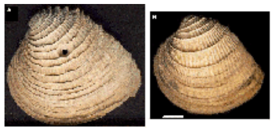


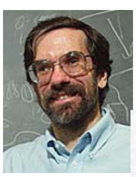
Figure 1.

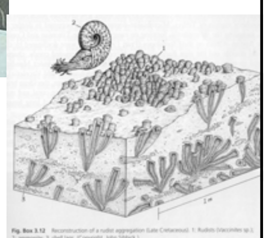
G. Vermeji 1987

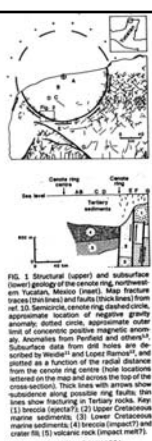
Evolution and Escalation: an Ecological History of Life, **Princeton Univ. Press.**

Jablonski & Raup 1993; 1995: End Cretaceous Bivalve Extinctions

They argue that there is ***no relationship*** between ecological position, habitat type, habitat location and physical size and the probability of extinction.







The End Cretaceous Extinction (65 myr ago)

A ***catastrophic event*** appears to be responsible for the extinction of the dinosaurs and many other species.

Chixulub Crater in Yucatan, Mexico.

Samples Examined

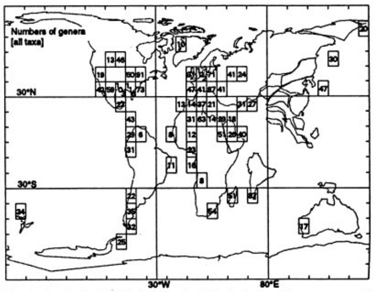


Fig. 1. Sample sizes in the 57 10° latitude-longitude blocks that contain one or more of the 106 bivalve assemblages (20), plotted on Maastrichtian geography. Rudists are included.

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Habitats Sampled

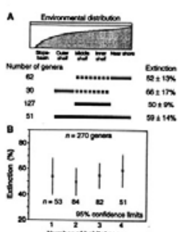

Fig. 2. Extinction intensity relative to bathymetric distribution for K-T bivalve and gastropod genera of the Gulf and Atlantic Coastal Plain. Habitat zones reflect environmental energy rather than absolute depth and are inferred according to sedimentary and stratigraphic criteria given by Bottjer and Jablonski (17). (A) There are no significant differences in extinction intensities [±95% confidence limits (32)] according to position on the continental shelf. From top to bottom, data are for: genera that reach the shallowest depths but do not encompass the entire shelf; genera that reach the outer shelf but do not encompass the entire shelf; genera at intermediate depths only; and genera that range over the entire shelf. (B) There are no significant differences in extinction intensities according to the breadth of distribution [number of habitat zones and shown in (A)] on the continental shelf.

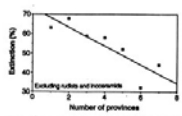

Fig. 3. Statistically significant inverse relation between extinction intensity and the number of biogeographic provinces occupied (22) for all range classes with >10 genera (Kendall's rank test, $P < 0.05$). This plot conveys the structure of the data (the line is a simple least squares best fit) but is inappropriate for regression analysis because error terms increase with the number of provinces (more genera are restricted than widespread).

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Extinction Intensity

Jablonski & Raup 1993; 1995: end cretaceous bivalve extinctions

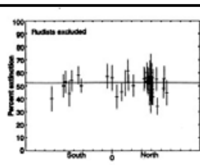

Fig. 2. Extinction intensity and latitude for the 60 fossil assemblages containing at least 25 nonrudist genera (18, 19). The horizontal line marks the mean (52.2% extinction). No significant trends or gradients are detectable.

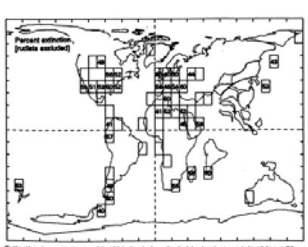

Fig. 3. Extinction intensity in the 33 10° latitude-longitude blocks that contain at least 25 nonrudist genera. Although the distribution is somewhat patchy, as expected from sampling error, there are no recognizable hot spots or gradients. The mean of the 33 values is 50.7%, and the median is 51.

What Is The Significance Of This Result??

1. Evolution viewed as ***progress*** can lead to the conclusion that life on Earth becomes increasingly ***highly evolved*** and that evolutionary patterns are ***repeatable processes***.

2. Jablonski and Raup's data suggest that natural selection and evolutionary change may simply be a ***process*** that arises ***spontaneously*** in replicating entities; extinction occur without respect to "progress."

3. It is certainly the ***simplest*** explanation for what we see.

4. It also suggests the importance of ***contingency*** on evolution.

a. This is the idea that evolution on Earth (or anywhere) would ***not*** proceed the same way twice if allowed to run again.

Contingency

- Things were ***very different*** without George Bailey.
- It suggests that humans are a very ***unlikely*** evolutionary event indeed.

Why Mention These Things?

Because biological classification schemes attempt to make their designations in a way that reflects *evolutionary history*.

a. As mentioned in lab, this requires:

1. Identifying characters that group taxa by their relative ***similarity***.

2. Determining whether these characters are:

a. ***ancestral*** - representing earlier forms.

b. ***derived*** - representing more specialized forms.

Phylogenetic Systematics

Constructing a framework that represents the probable line of descent is the *job* of an evolutionary biologist

The only way to link related taxa is by identifying ***synapomorphies***, i.e., shared, derived characters.

However,

The variety of evolutionary processes described above can cause difficulties in character identification.

a. There may be considerable modification of morphology by ***selection*** and ***chance***–

b. ***Parallelism, convergence*** and ***character loss*** can make it difficult to determine which characters arose first.

c. So given that pitfalls exist, what are the ***goals and guideposts***?

THE GOAL:

Identification of related taxa

(Monophyletic Groups)