Macroevolution

Website: http://evolution.berkeley.edu/
Importance of reconstructing evolutionary histories

We can observe large scale patterns throughout life’s history
Macroevolution patterns

*Extinction:* is the disappearance of an entire species from the face of the Earth

*Mass extinctions:* events that have wiped out anywhere from 50% to 95% species

*Adaptive Radiation:* event in which a group of species rapidly diversifies

99% of species that have existed are extinct today
Convergent evolution:
Unrelated species develop similarities due to adaptation to similar environments

These similarities are called…

Analogous characters
similar looking structures
due to adaptation to similar environments
not due to common ancestry

Analogous characters are a result of convergent evolution

Homologous characters
characters in different organisms that are similar because they were inherited from a common ancestor that also had that
Sugar gliders live in Australia, and flying squirrels live in North America.

Sugar gliders have a pouch (like a kangaroo does)
Flying squirrels, on the other hand, have much larger babies and no pouch.

6. Are the "wings" (actually flaps of skin stretched between the legs) of sugar gliders and flying squirrels homologous or analogous structures?
7. Are the wings of a dragonfly (left) and the wing of a butterfly (right) homologous or analogous structures?
Macroevolution patterns

Evolution is not goal oriented

Vestigial structures: structures that are of little or no value to the organism, are historical remnants of ancestral structures

FIGURE 22.19
Vestigial structures. The skeleton of a whale reveals the presence of pelvic bones. These bones resemble those of other mammals, but are only weakly developed in the whale and have no apparent function.
Macroevolution patterns

Evolution is not goal oriented

Exaptation: existing structures that evolved and functioned in one setting and were then co-opted for a new function

FINDINGS

Evo-Devo and the Feather

The authors’ theory of feather origin grew out of the realization that the mechanisms of development can help explain the evolution of novel features—a field dubbed evo-devo. The model proposes that the unique characteristics of feathers evolved through a series of evolutionary novelties in how they grew, each of which was essential for the adaptation of the next stage. Thus, the theory builds on knowledge of the steps of feather development today rather than assumptions about what feathers might have been used for or about the groups of animals in which they might have evolved. Fossil discoveries from Liaoning, China, provide the first insights into which theropod dinosaurs evolved the feathers of each hypothesized stage. Based on the similarities between the primitive feather projections of this model and the shapes of the fossil skin appendages, the authors suggest that each stage evolved in a particular group of dinosaurs.

Stage 1

The first feature, a hollow cylinder

Stage 2

Tuft of unbranched barbs attached to a calamus

Stage 3

Barb ridge

Stage 4

Closed pentagonal vane (bristles on vane barbules attach to grooves on barbules of adjacent barb)

Stage 5

Closed symmetrical vane (resembling modern flight feathers)
Importance of reconstructing evolutionary histories

*We can organize species based on their evolutionary relationships*

*Using phylogenies as a basis for classification is a relatively new development in biology.*
This phylogenetic classification system names only monophyletic clades (groups of organisms that are ALL descended from a common ancestor).

Each colored rectangle below represents a clade:

- A clade
- Not a clade

Are the highlighted groups clades?
A **paraphyletic** group (pink box) includes the common ancestor and some, but not all, of the ancestor’s descendants.

A **polyphyletic** group (yellow box) does not include the common ancestor of the group.

A **monophyletic** group (blue box) includes the common ancestor and all descendants of that ancestor.

A monophyletic group can be removed from the tree with a single “cut.”

Common ancestor of monophyletic group H + I + J
8. Label each one of these groups

Group I: A, B, C
Group II: A, B, C, D, E, F
Group III: A, B, C, D, E, F, G
The case of birds and reptiles

<table>
<thead>
<tr>
<th>Linnaean Classification</th>
<th>- based on shared traits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class: Reptiles</strong></td>
<td>(cold-blooded, scaly, lay eggs)</td>
</tr>
<tr>
<td><strong>Class: Birds</strong></td>
<td>(warm-blooded, feathered, lay eggs)</td>
</tr>
<tr>
<td><strong>Class: Mammals</strong></td>
<td>(warm-blooded, furry, live young)</td>
</tr>
</tbody>
</table>
**Drug discovery**

When biologists used this approach to study fish, they discovered that more than 1200 species of fish not known to be venomous probably are!

This represents a treasure trove of potentially useful chemicals for drug developers.

**Tracking a disease to its source**

![Diagram showing the phylogeny of SARS virus strains]
Descent with modification as a theory

One of the strengths of a theory is that it can be tested using independent lines of evidence.
Fossil record provides snapshots of the past

- Fossils form when organisms are buried by sediments or preserved in oxygen poor environments.

- Fossils can be the remains of organisms or signs of organisms preserved over time.

- Shows different life forms and also clues to the way they lived.
Fossil record supports descent with modification

If one species descended from another:

Fossils should show an ordered pattern (through time one form is replaced by similar but different forms)

**EVIDENCE**

- Fossil record shows that organisms have appeared in an ordered and consistent sequence
- Fossils that show the intermediate states between an ancestral form and that of its descendants, are called *transitional forms* example: **Tiktaalik**
Do gaps on the fossil record disprove evolution?

Transitional forms during this time are not preserved as fossils.
Fossils link ancestral species to those living today and also link two species living today.

Today’s species do not look very similar, but as we go lower in the fossil layers the differences disappear.
Geographical distribution of organisms on the earth supports descent with modification

If one species descended from another:
Look who lives in America and is a marsupial?

Marsupial mammals are found in the Americas as well as Australia.

They are not found swimming across the Pacific Ocean, nor have they been discovered wandering the Asia.

How could marsupials have gotten from one place to a location half a world away?
Plate tectonics causes
Continental drift

Continents have been and are constantly on the move

Continental drift in the past
Continental drift shows that continents came together 250 mya and drifted apart 180 mya.

Marsupials rode the continents to their present positions.

Jurassic Period — 160 mya

- Fossil remains of the Triassic land reptile Cynognathus.
- Fossil evidence of the Triassic land reptile Lystrosaurus.
- Fossils of the fern Glossopteris.
- Fossil remains of the freshwater reptile Mesosaurus.
DNA and protein sequences support descent with modification

If one species descended from another, we expect that similar species should have similar DNA or similar proteins.

### Amino acids reveal evolution

<table>
<thead>
<tr>
<th>Organism</th>
<th>Number of amino acid differences from humans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chimpanzee</td>
<td>0</td>
</tr>
<tr>
<td>Rhesus monkey</td>
<td>1</td>
</tr>
<tr>
<td>Rabbit</td>
<td>9</td>
</tr>
<tr>
<td>Cow</td>
<td>10</td>
</tr>
<tr>
<td>Pigeon</td>
<td>12</td>
</tr>
<tr>
<td>Bullfrog</td>
<td>20</td>
</tr>
<tr>
<td>Fruit fly</td>
<td>24</td>
</tr>
<tr>
<td>Wheat germ</td>
<td>37</td>
</tr>
<tr>
<td>Yeast</td>
<td>42</td>
</tr>
</tbody>
</table>
**Hox** genes in flies and people. The head-to-tail organization of the body is under the control of different *Hox* genes. Flies have one set of eight hox genes, each represented as a little box in the diagram. Humans have four sets of these genes. In flies and people, the activity of a gene matches its position on the eDNA: genes active in the head lie at one end, those in the tail at another, with genes affecting the middle of the body lying in between.
Structures present during embryo stages support descent with modification

Since embryo development is coded in the DNA (inherited and changeable)
Optional study guide book

- Read chapter 22
  Complete interactive question 22.4
  Test your knowledge questions:
  1, 5, 6, 7, 8, 9, 11, 12, 13, 14

- Read chapter 25.4, 25.5, 25.6
  Complete interactive question 25.5
  Test your knowledge questions:
  1, 5, 6, 7, 8, 9, 11, 12, 13, 14