Vertebrate evolution

An overview

Petrolacosaurus, an early diapsid reptile (from Sues, 2019)
Living vertebrate groups
Vertebrate phylogeny
Basic concepts of phylogenetic trees

Tree diagram shows connections based on closeness of relationship

Each node unites tips into a group or “clade”

**Figure 1.** A typical phylogenetic tree

**Figure 2.** Tree highlighting the clade defined by Node 2, which consists of *Triceratops*, *Pachycephalosaurus*, *Edmontosaurus*, and *Ankylosaurus*, as well as Nodes 3 and 4.
Trees can be drawn many ways
it is the connections that matter

Figure 3. The same tree drawn in several different styles. Four taxa have been pruned in E to construct a simplified tree that focuses on just *Triceratops*, *Edmontosaurus*, and *Tyrannosaurus*. 
Trees are reconstructed based on principles of evolution

- Node represents ancestor
- Branches represent separate evolutionary lineages leading to tips
- Each node corresponds to group of related lineages descended from a single common ancestor
Descent with modification

- Each node is scientifically supported by features that evolved uniquely in the group
- Features can be brand new, or they can be modifications of inherited features
- Ornithischian dinosaurs share modified pelvis (hip bones) where the pubis bone is retroverted (points backward)

Derived condition or “apomorphy”

Ancestral condition or “plesiomorphy”
Descent with modification

Ornithischian ancestor evolved pelvis that was a modification of the ones possessed by the last common ancestor of all dinosaurs

Ornithischian

Archosaur close to dinosaur ancestor

Derived condition or “apomorphy”

Ancestral condition or “plesiomorphy”

*Edmontosaurus* (from Victoria Museum)

*Asilisaurus* (from Sues, 2019)
Adaptive radiation
the diversification of a group of organisms into forms filling different ecological niches

From Sandilyan et al. 2018
# Heritage and habitus

every species is made up of a combination of derived and ancestral features

<table>
<thead>
<tr>
<th>Heritage</th>
<th>Habit</th>
<th>The totality of characters surviving from much earlier ages and gained in adjustment to earlier environments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Habit</td>
<td>The totality of characters related to present feeding, locomotion, reproduction, and the like.</td>
</tr>
</tbody>
</table>

Earliest vertebrates

*Haikouichthys* (Early Cambrian, 520-525 million years ago)

Jawless fishes ("agnathans")

Bony “armor” covering the body, very little bone in internal skeleton, no jaws
Ordovician through Devonian periods (485–358 mya)

**Heterostracans**

*Errivaspis waynensis* from the Early Devonian, United Kingdom (from Long, 2011, *The Rise of Fishes*)

**Osteostracans**

Vertebrate phylogeny

Images from PhyloPic
Placoderms, first jawed vertebrates (Gnathostomata)

Bony covering limited to head, jaws derived from first “gill arch”
Silurian and Devonian periods (443–358 mya)

*Dunkleosteus*, a placoderm from Devonian of Ohio (from Long, 2011, The Rise of Fishes)
Chondrichthys - sharks, rays and chimeras

loss of bone in skeleton, radial tooth eruption
Devonian to present

*Acmonistion*, stethacanthid shark from the Early Carboniferous

*Falcatus*, stethacanthid shark from the Early Carboniferous
(from Long, 2011, The Rise of Fishes)

*Helicoprion*, shark from the Permian
(from Long, 2011, The Rise of Fishes)

*Chlamydoselache* teeth
(from Long, 2011, The Rise of Fishes)
Actinopterygia - ray-finned fish

rays in fins, simplified gill skeleton
Silurian to present

Polypterus, ray-finned fish from Africa (from Long, 2011, The Rise of Fishes)

Howqualepis rostidens, Late Devonian, Australia (from Long, 2011, The Rise of Fishes)

Living wrasse, a teleost (from Long, 2011, The Rise of Fishes)

Cheirolepis, early actinopterygian (from Long, 2011, The Rise of Fishes)

Rays in fins, simplified gill skeleton
Silurian to present
Vertebrate phylogeny

Images from PhyloPic
Tetrapoda
**E412/G512 Vertebrate Paleontology**

- **Paleozoic**
  - **K-Pg extinction**
  - **P-Tr extinction**
- **Mesozoic**
  - **Cenozoic**
  - **Lampreys & Hagfish**
  - **Chondrichthyes** (cartilaginous fish)
  - **Actinopterygii** (Ray-finned fish)
  - **Coelocanth**
  - **Lissamphibia** (frogs, salamanders)
  - **Mammals**
  - **Squamata** (lizards and snakes)
  - **Crocodylomorpha**
  - **Birds**
  - **Heterostracans†**
  - **Osteostracans†**
  - **Placoderms†**
  - **Chondrichthyes**
  - **Actinopterygii**
  - **Coelacanth**
  - **Lissamphibia**
  - **Mammals**
  - **Squamata**
  - **Crocodylomorpha**
  - **Birds**
  - **Haikouicthyes†**
  - **Limnoscelis†**
  - **Tiktaalik†**
  - **Captorhinus†**

**Key Events**
- **65.5 MYA**
- **252 MYA**
- **541 MYA**
About genus and species names

*Tyrannosaurus rex* Osborn, 1905

- *Tyrannosaurus rex* is the formal Latin scientific name for a species.
- Names of species always have two parts: Genus name and species name.
- Genus name is always capitalized, species name is always lower case.
- Both names are always *italicized*.
- Genus name is unique (for animals, same name can be used for a different plant or microbe).
- Genus + species is unique, never used again for a different species.
- Species name by itself is not necessarily unique (can be used in combination with several genera).
- Genus name can be used by itself, species name must be used with genus name.
- Author’s name and date of original publication are often written after the scientific name.
- Names governed by the International Code of Zoological Nomenclature (registered in Zoobank.org since about 2010).
## Right

- *Tyrannosaurus rex*
- *T. rex*
- *Tyrannosaurus*

## Wrong

- *rex*
- *T. Rex*
- *T. rex*
Examples of unique combinations of species name *flavus*

*Perognathus flavus* Baird, 1855

*Potos flavus* (Schreber, 1774)

*Speleomantes flavus* (Stefani, 1969)

*Hemignathus flavus* Bloxam, 1827

*Piranga flava* Vieillot, 1822

*Laphria flava* (Linnaeus, 1761)