

# Origin and Evolution of Birds

Read: Chapters 1-3 in Gill but limited review of systematics

# Review of Taxonomy

- Kingdom: Animalia
  - Phylum: Chordata
    - Subphylum: Vertebrata
      - Class: Aves

Characteristics: wings, feathered, no teeth, jaws modified to form beak, pneumatic bones, scaled feet, lay eggs

# Competing Theories of Avian Evolution

1. Birds evolved from dinosaurs
2. Birds evolved from an earlier reptile
3. Subject of continued debate because of recent discoveries in northeastern China and recent discovery of 10<sup>th</sup> Archaeopterygidae specimen in Germany

# Geological Time Scale

| Eras     | Yrs BP | Periods    | Epochs                       | Life Forms                                |
|----------|--------|------------|------------------------------|---|
| Cenozoic |        | Quaternary | Recent<br>Pleistocene        | Human<br>civilization                     |
|          | 2      |            |                              |   |
|          |        | Tertiary   | Pliocene<br>Miocene,<br>etc. | Age of<br>Mammals                         |
|          | 65     |            |                              | Birds Evolved Here                        |
| Mesozoic |        | Cretaceous |                              | Dinosaurs, 1 <sup>st</sup><br>angiosperms |
|          | 130    |            |                              |   |
|          |        | Jurassic   |                              | Dinosaurs &<br>other reptiles             |
|          | 160    |            |                              |   |
|          |        | Triassic   |                              | Reptiles<br>including<br>thecodonts       |
|          | 210    |            |                              |   |



# Archaeopteryx

- Discovered in 1861 in Bavaria, Germany
  - Single feather found
  - Asymmetrical
  - 2 years after Darwin's '*Origin of Species*'
- Considered "missing link" between reptiles and birds
- 1877 10 miles from 1<sup>st</sup> fossil a second specimen found
- Currently 5 specimens (10 specimens of Archaeopterygidae in 2 genera)

# *Archaeopteryx lithographica* from 1877 in Bavaria

Dated as  
150 million  
YBP



# Similarities with Modern Birds

- Feathers
- Furcula (e.g., wishbone)
- Pectoral girdle similar
- Pelvis and legs similar

# Differences from modern Birds

- **Toothed jaws**
- **Long bony tail**
- **Abdominal ribs**
- **Less fusion of hand bones**
- **Small cranium**

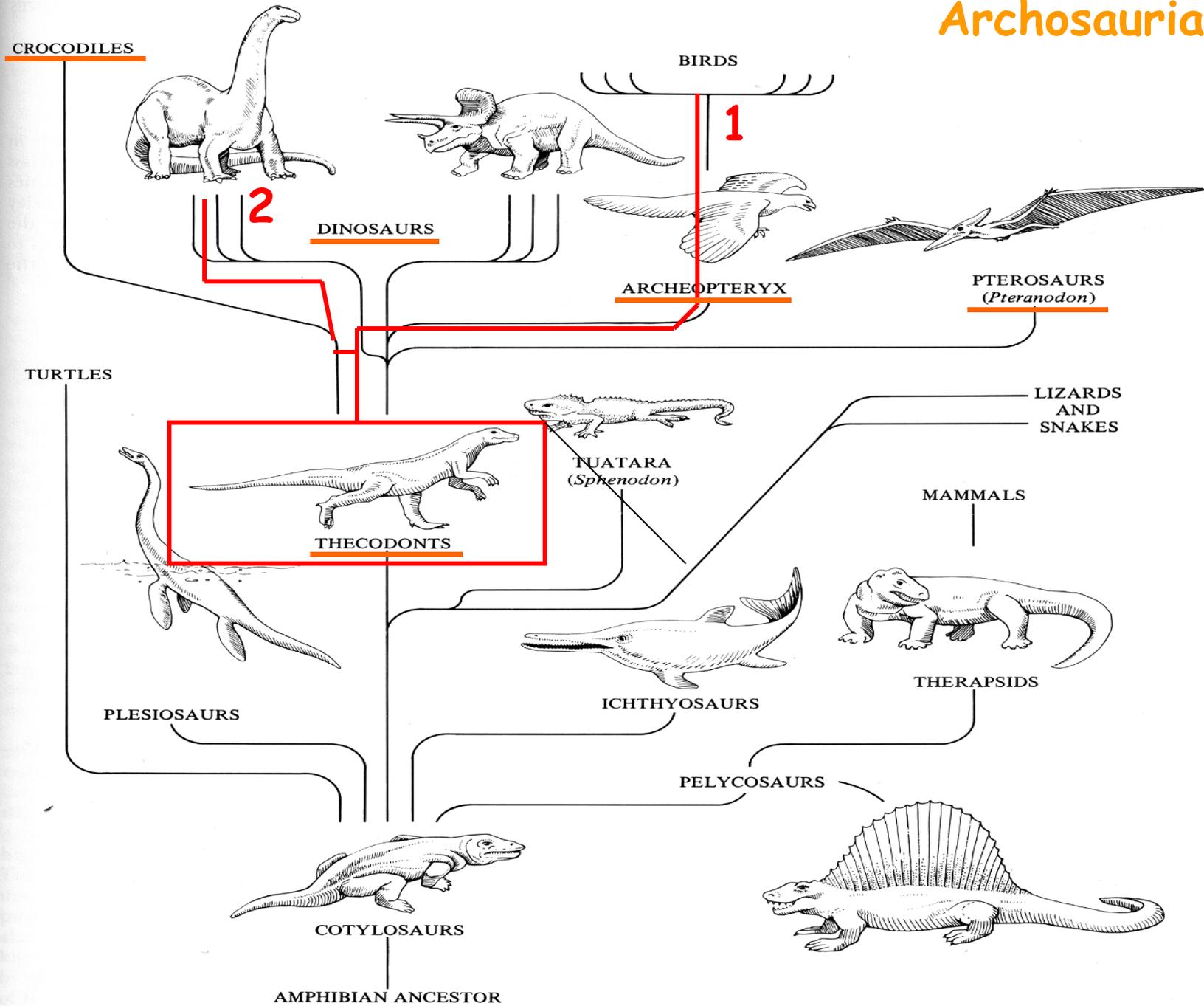


Comparable regions in black. Note: long tail, unmodified hand, weak sternum, small brain case, weak pelvis and presence of teeth

# Competing Theories of Bird Evolution

1. Birds evolved directly from Thecodont reptiles
2. Birds evolved from small theropod dinosaurs (descendants of Thecodonts)

# Archosauria



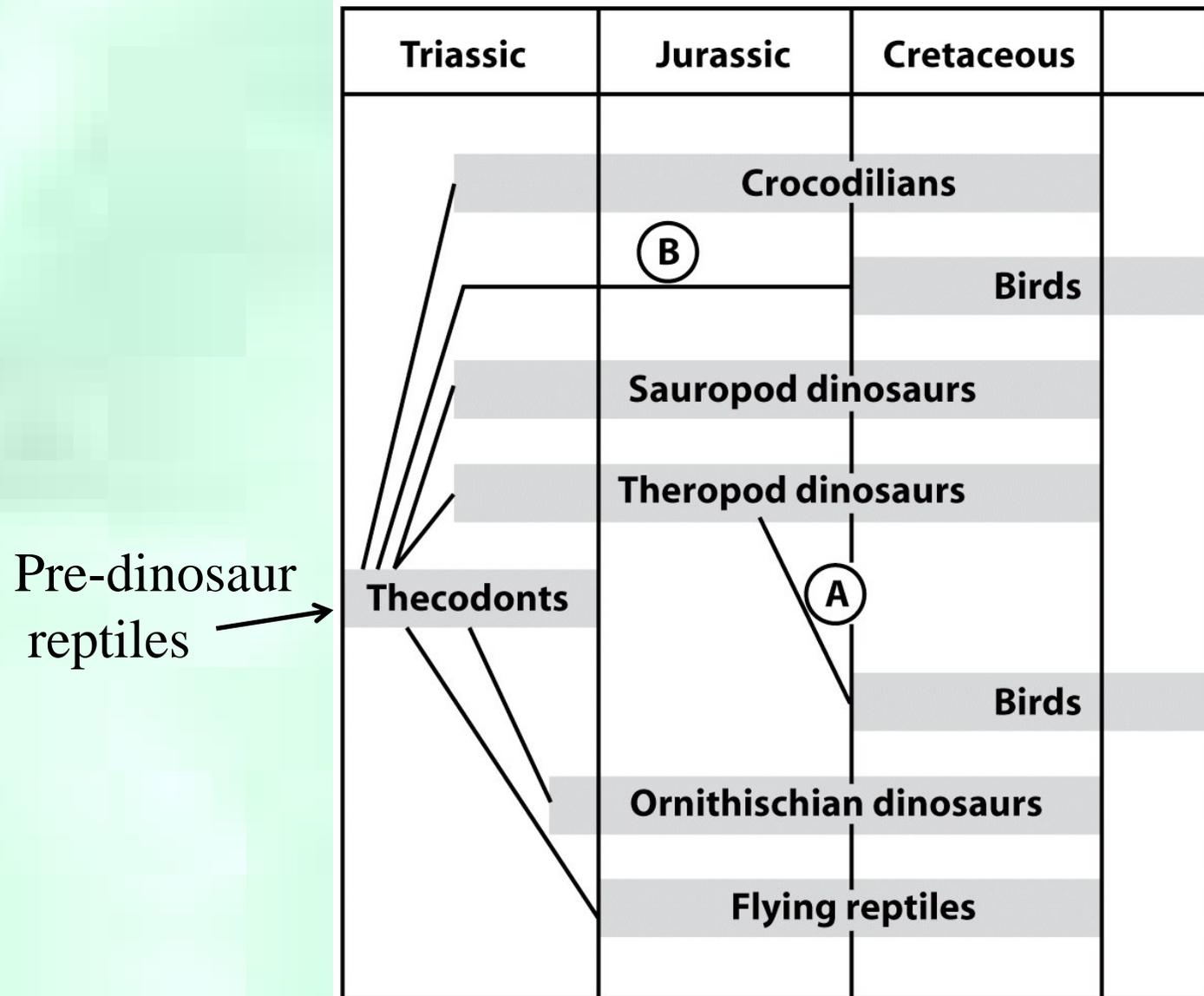
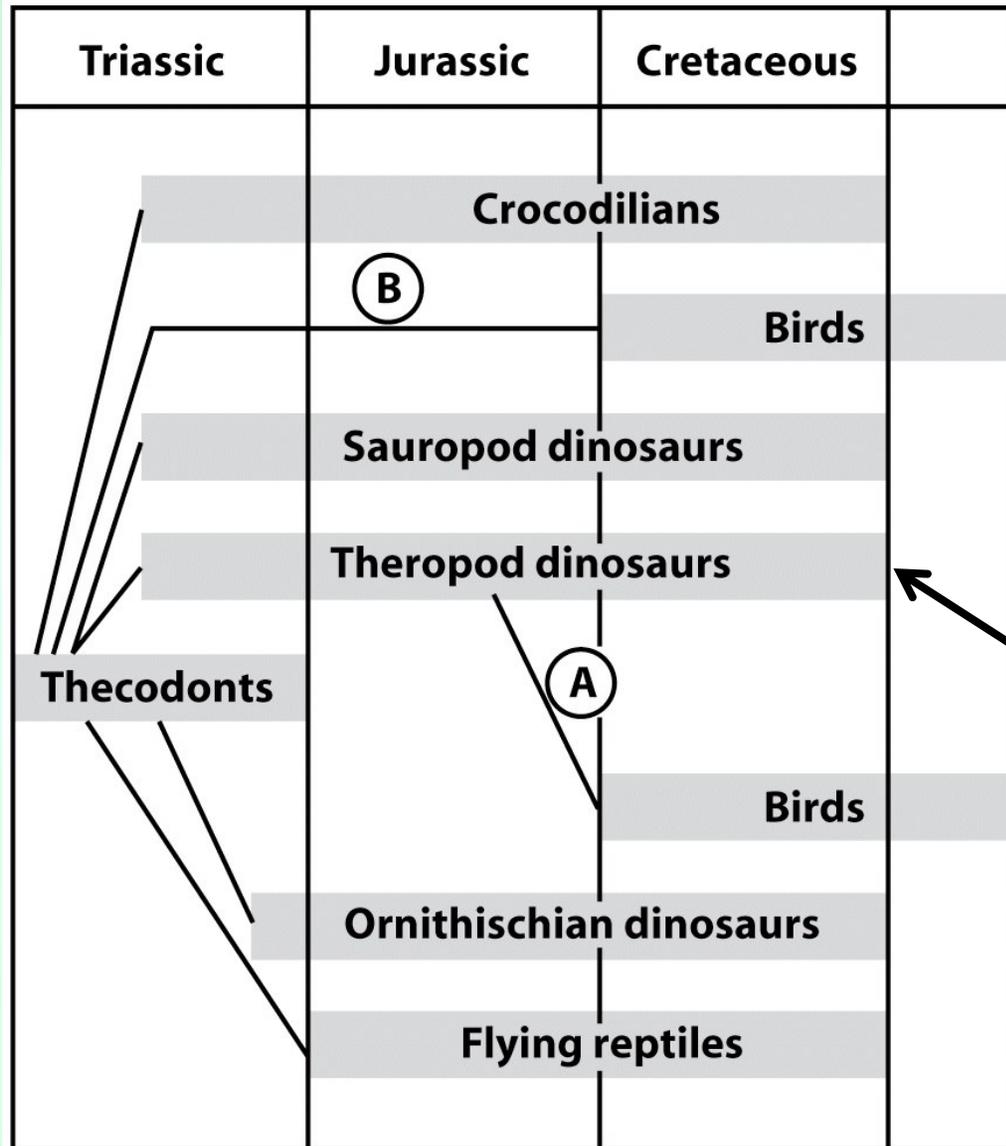


Figure 2-6  
*Ornithology, Third Edition*  
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Goes back to discovery of Archaeopteryx, most accepted theory

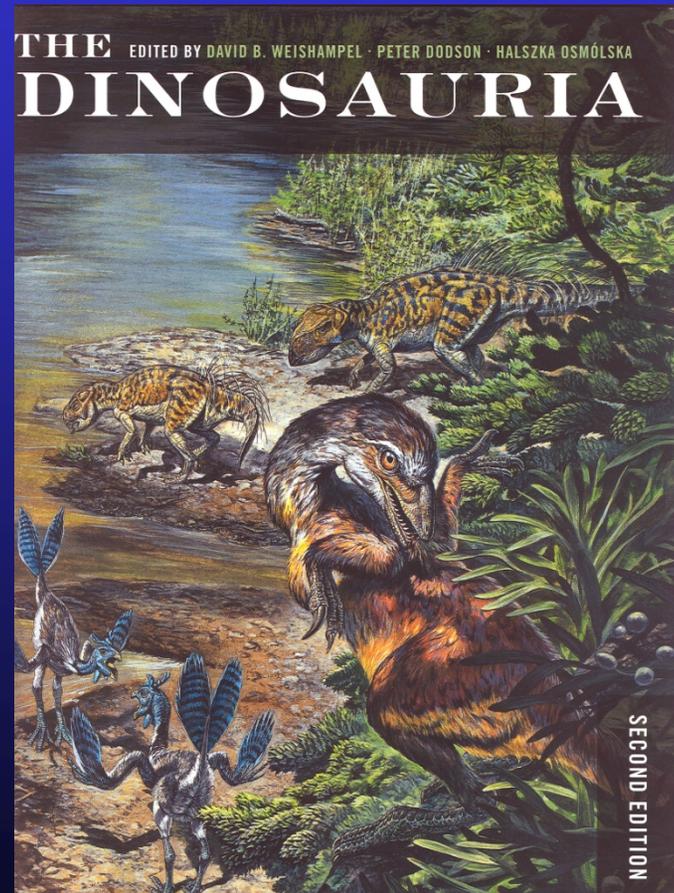
Figure 2-6  
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# History of the debate about the origin of birds

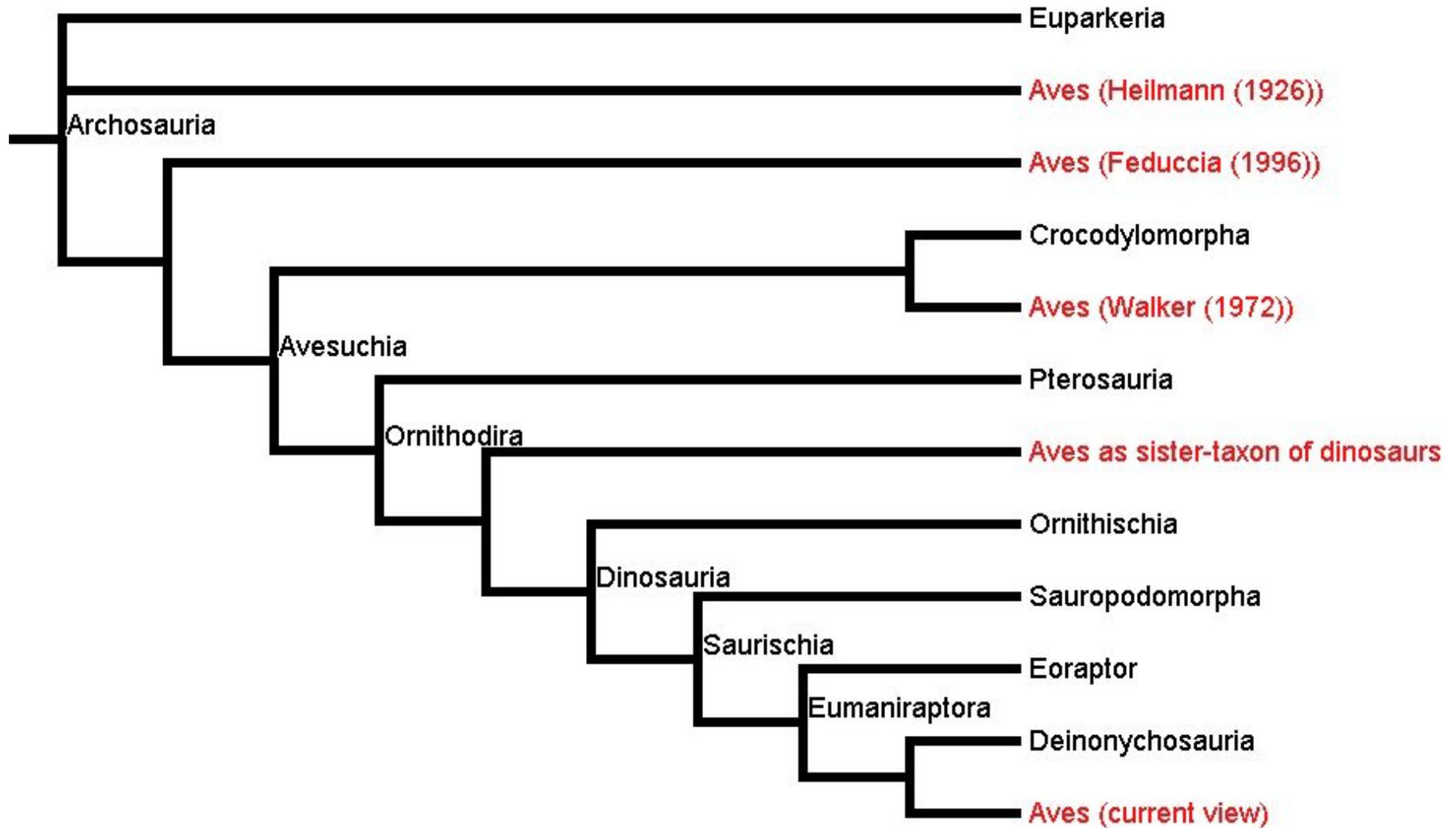
- Thomas Huxley (1868) developed the theropod hypothesis.
- Heilmann (1926) argued that birds evolved from "thecodont" archosaurs.
- Ostrom (1973) revived the theropod hypothesis.
- Gauthier (1986) put Ostrom's hypothesis into a phylogenetic framework.

# Some of the paleontologists who are using phylogenetic methods to study the origin of birds

- Michael Benton, James Clark, Luis Chiappe, Philip Currie, Thomas Holtz, Peter Makovicky, Teresa Maryanska, Mark Norell, Halszka Osmolska, Kevin Padian, Paul Sereno
- *The Dinosauria*, 2nd edition (Weishampel et al., 2004) is a recent authoritative reference.



# Hypotheses for the origin of birds



# Reptilian Ancestry of Birds

- “There is little doubt that birds evolved from some line of Mesozoic reptiles. Which line is still a matter of debate.” (Gill 1995)
- “Fossils of *Archaeopteryx* are our principal evidence of the transition from reptiles to birds” (Gill 1995) and “one of the most important fossils of all time” (Gill 2007)

# Evidence for evolution of birds from reptiles

1. Skulls hinge on single condyle
2. Lower jaws made of several bones
3. Single bone in middle ear - stapes
4. Uncinate processes on ribs
5. Ankle joint is intertarsal
6. Certain bones are pneumatic
7. Scales on legs
8. Lack of skin glands

# Evidence for evolution of birds from reptiles

9. Pleural cavity and air sacs
10. Eyes of birds & some lizards contain pecten
11. Nucleated red corpuscles
12. Similar blood proteins
13. Egg-laying
14. Presence of egg tooth

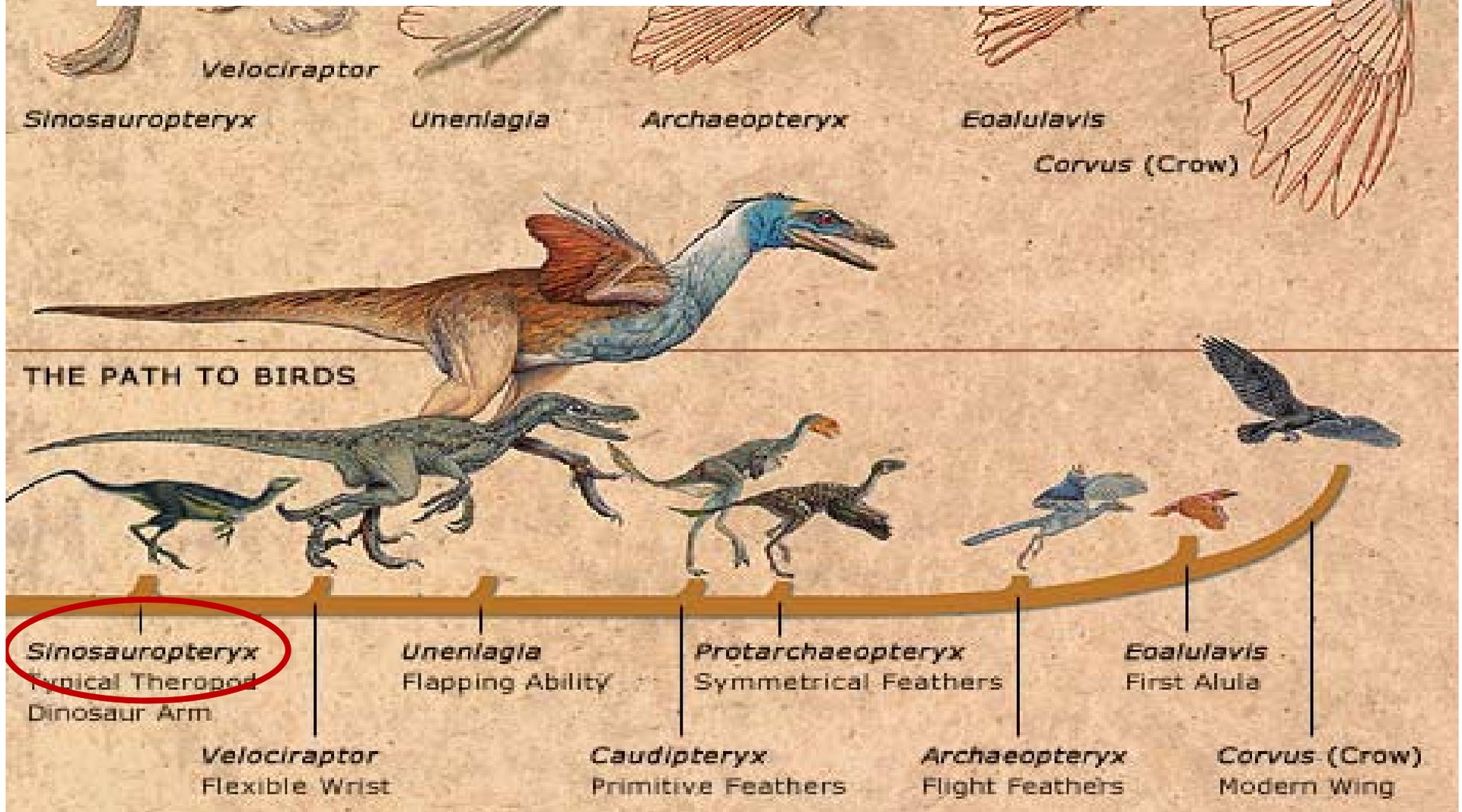
# Major differences with reptiles

1. Warm-blooded
2. 4 chambered heart (3 in reptiles)
3. Presence of feathers (possibly in dispute with latest fossils from China)

# Evolutionary Tree

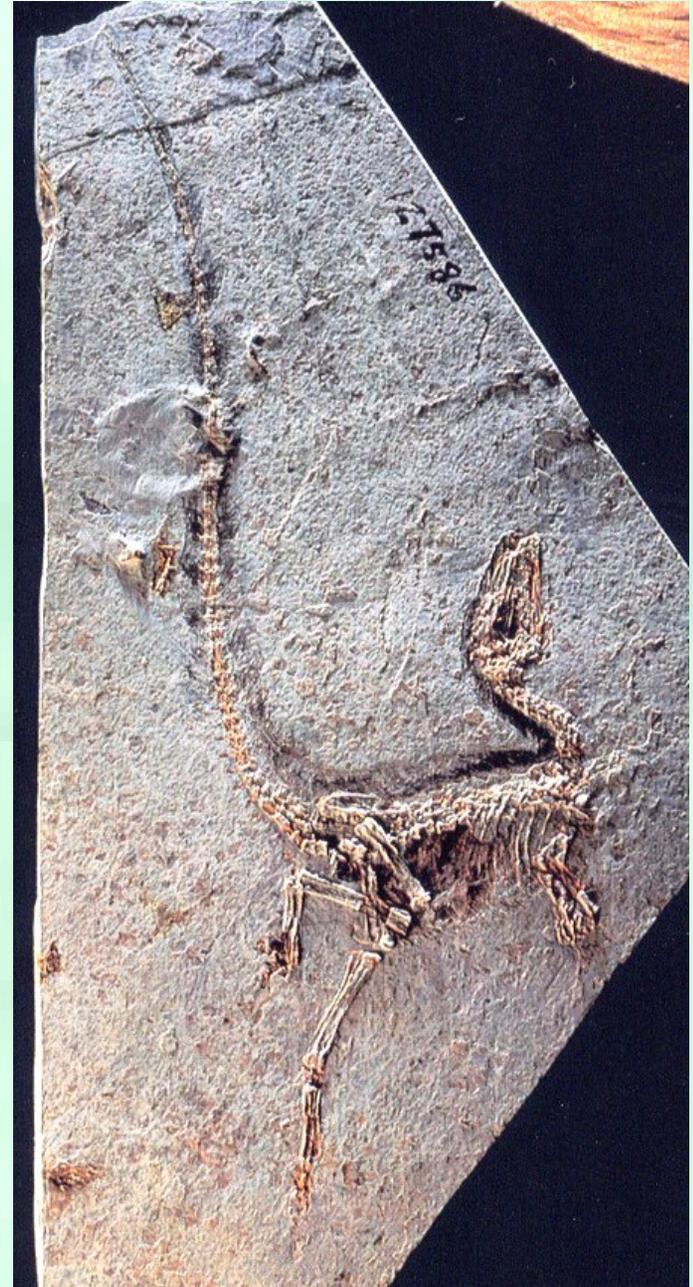
(Theropod theory)

[www.pbs.org/wgbh/evolution/library](http://www.pbs.org/wgbh/evolution/library)



# Sinosauropteryx

- Covered with filaments
  - Protofeathers
- Filaments probably provided insulation
- Elongated tail
- > 120 million YBP
- Classified as a Theropod dinosaur

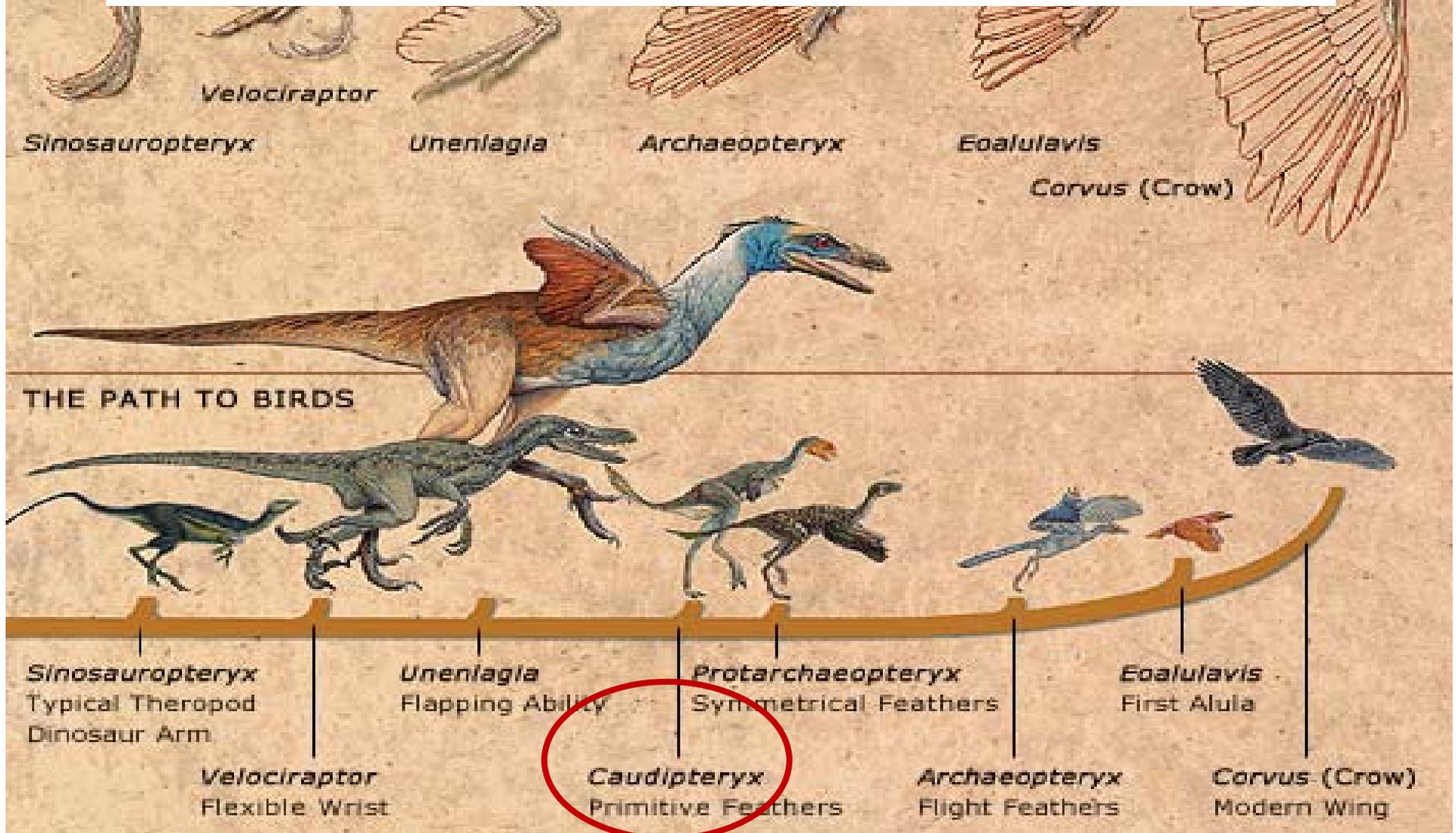




The downy filaments of *Sinosauropteryx* measure as long as 1.5 inches but lack aerodynamic quality. Such material is so fragile that it is rare to find it well preserved.

# Evolutionary Tree

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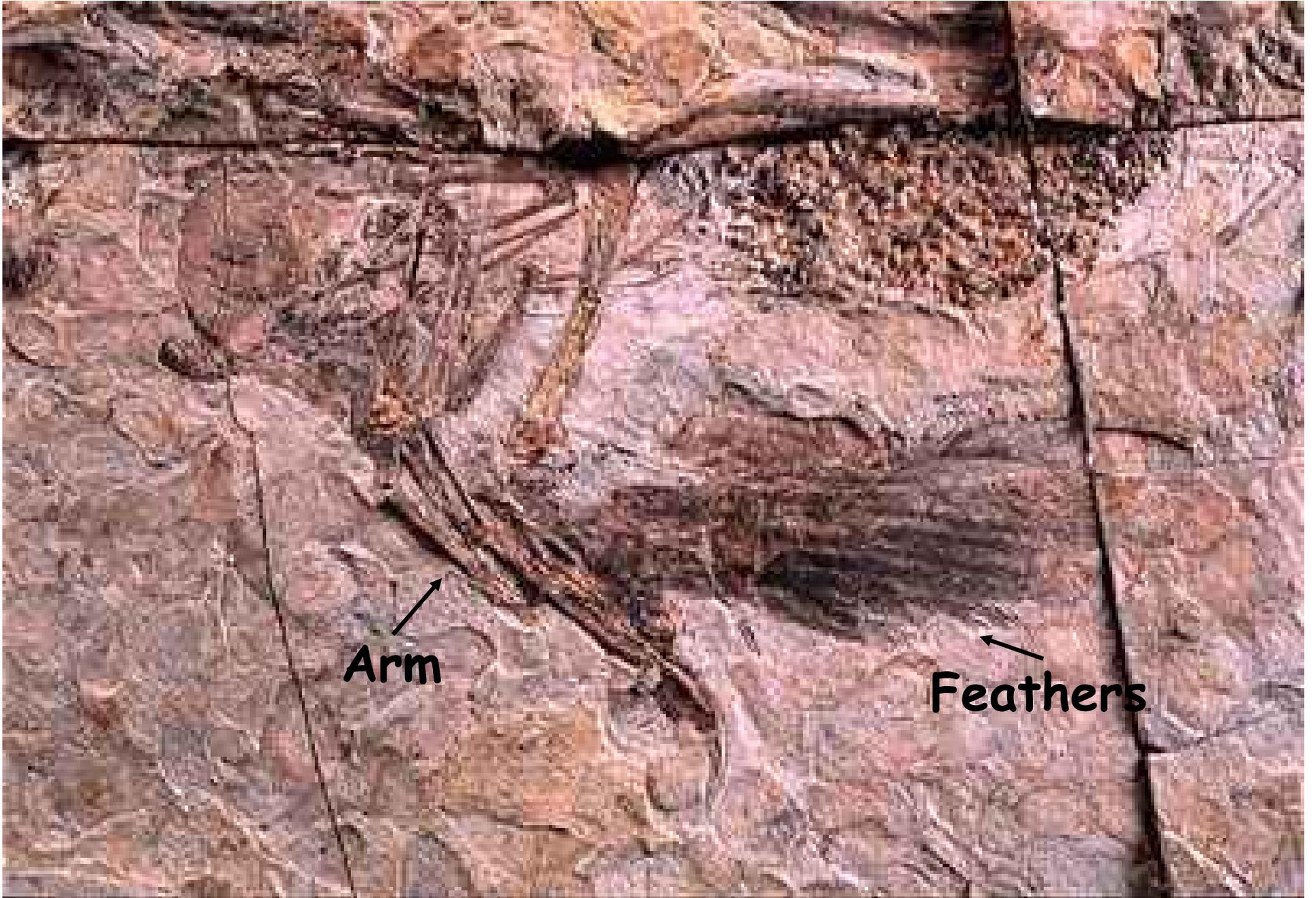


# Caudipteryx

- Sharp, bulbous rooted teeth
- Teeth confined to upper jaw
- More advanced feathers than

## Sinosauropteryx

- Speedy runner, incapable of flight



Arm

Feathers

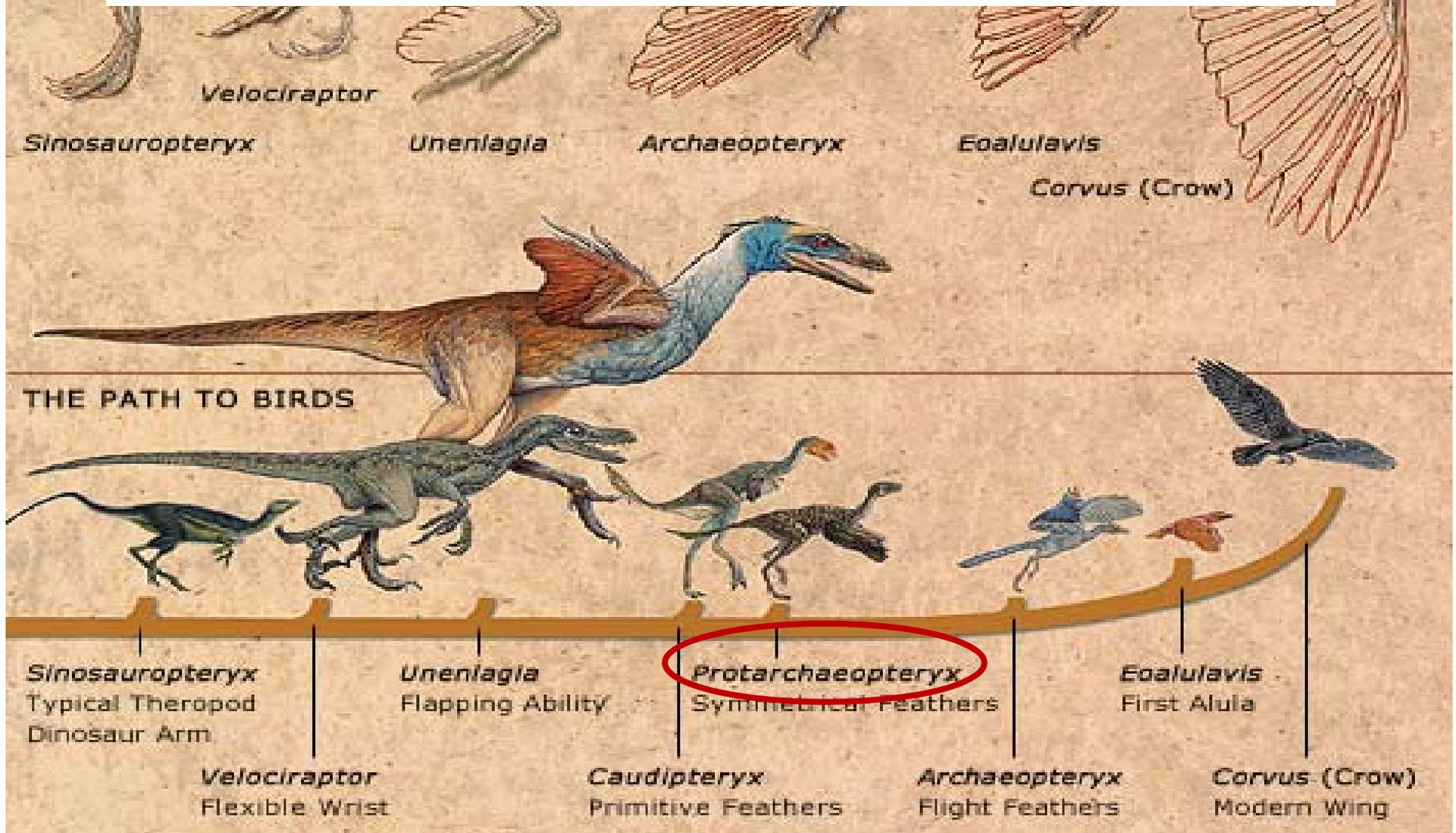
# Artist's Rendition of Caudipteryx



[www.nationalgeographic.com/events/98/dinosaurs/](http://www.nationalgeographic.com/events/98/dinosaurs/)

# Evolutionary Tree

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# Protarcheopteryx

- Similar, but more primitive than Archeopteryx
- Symmetrical feathers
- Probably incapable of powered flight
- Possible ancestor of Archaeopteryx



# Current State of Knowledge

- Fossils in China support theory that birds evolved from Theropod dinosaurs
- Supported by recent Science article (“A Well-Preserved *Archaeopteryx* specimen with Theropod Features” - Science 310:1483-1486, 2005)
- Feathers probably evolved for insulation - enabling birds to become endothermic
- Flight evolved later

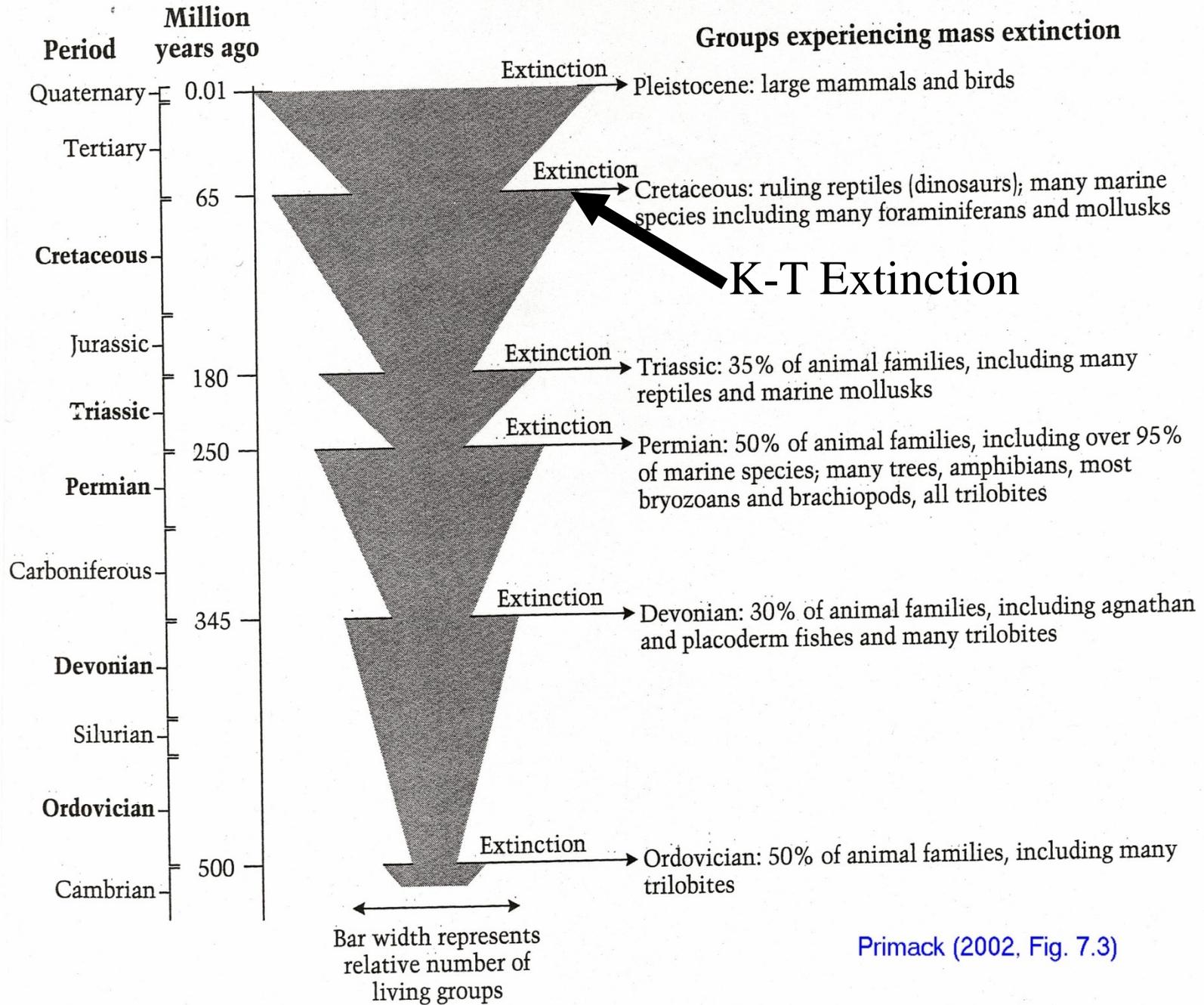
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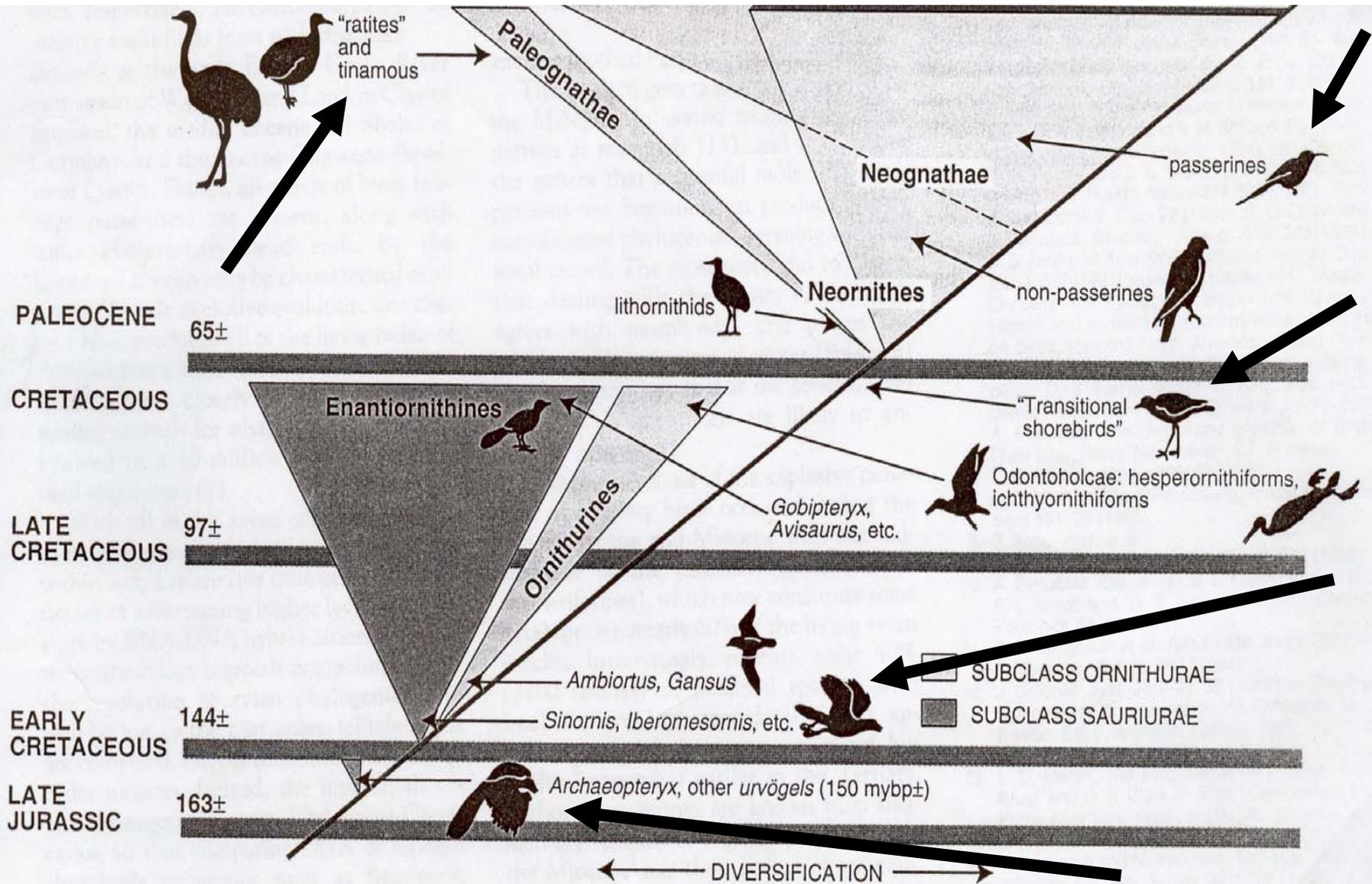
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- What percentage of all species that have ever lived on planet Earth have been estimated to have gone extinct?
  - a) About 30 %
  - b) About 50 %
  - c) About 75 %
  - d) Over 90 %

# Cretaceous

- Explosive speciation of Enantiornithines - OPPOSITE BIRDS
- Tarsal elements fused proximally to distally (reversed in modern birds)
- Large extinction episode
- Enantiornithines and Ornithurines became extinct in late Cretaceous
- Modern birds evolved from “transitional” shorebird





**New view of avian evolution.** Enantiornithines (opposite birds) were the dominant landbirds of the Mesozoic but coexisted with modern-type ornithurine birds in the early Cretaceous. *Archaeopteryx* may be closely allied with the enantiornithines, and together, they constitute the subclass

Sauriurae. After the late Cretaceous extinctions, the ornithurine birds began a modern, explosive adaptive radiation, almost all orders appearing within a period of 10 or so million years. By the Miocene, passerines became the predominant landbirds. Silhouettes not to scale.

# Birds Today

- **Approximately 9,000 - 9,600 species**
  - **Amphibia 4,184**
  - **Reptilia 6,300**
  - **Mammalia 4,000**
- **30 orders, 174 families and 2044 genera**