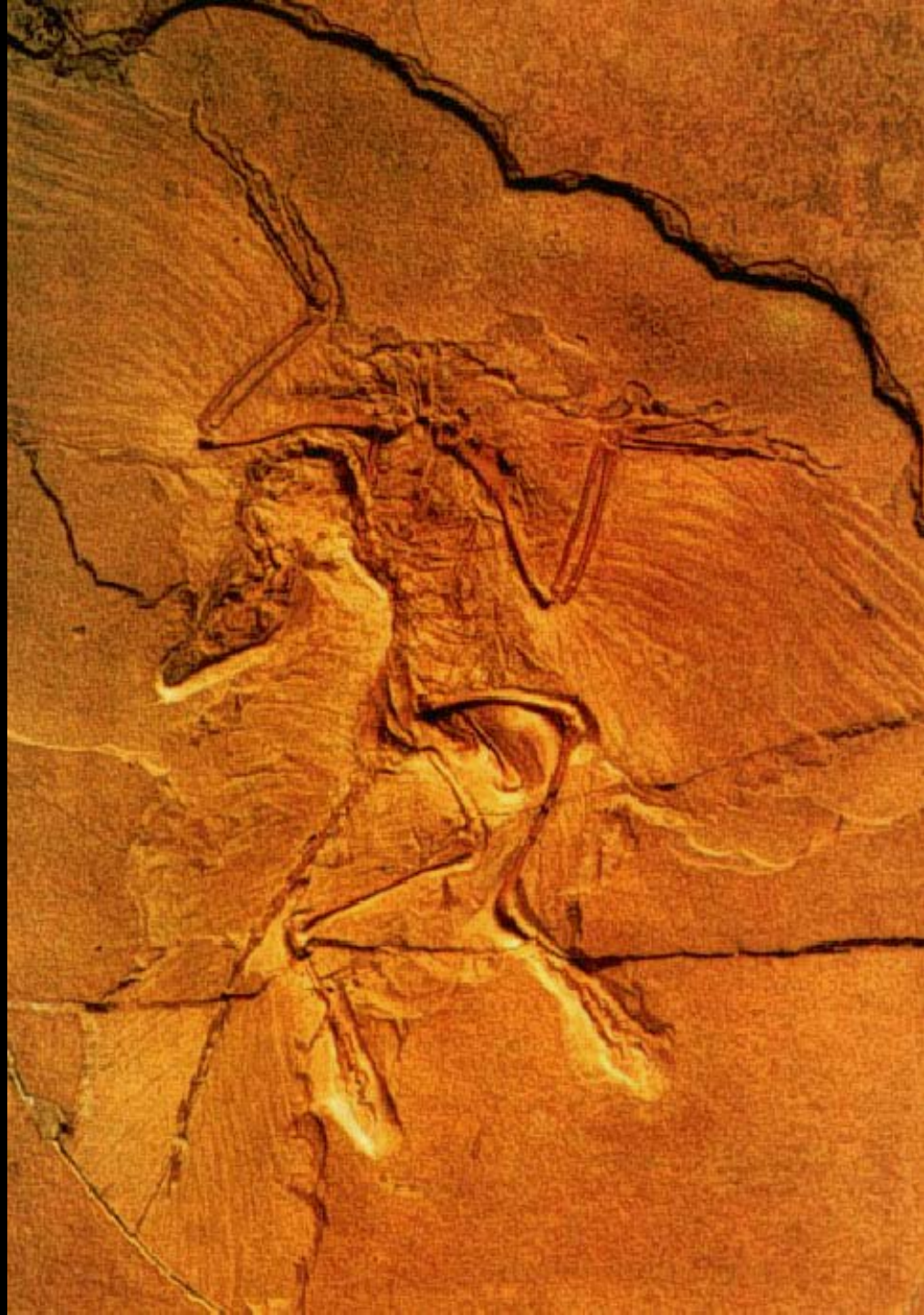
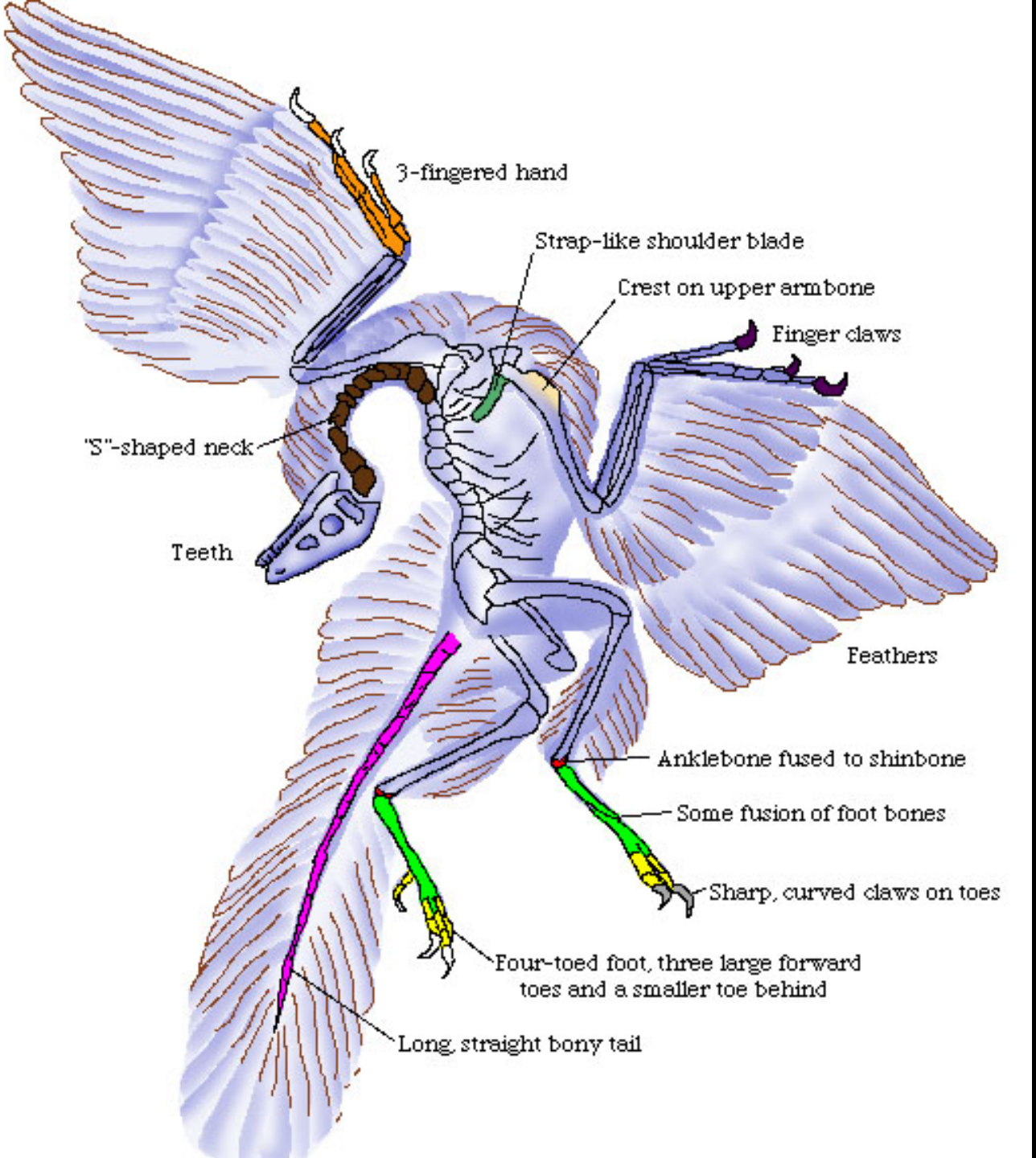
# Evolution of Birds

Geology 331
Paleontology

*Archaeopteryx*, the first bird. Its skeleton is nearly identical to *Compsognathus*.



# Another view of *Archaeopteryx*


3-fingered hand
Strap-like shoulder blade
Crest on upper armbone
Finger claws
"S"-shaped neck
Teeth
Feathers
Anklebone fused to shinbone
Some fusion of foot bones
Sharp, curved claws on toes
Four-toed foot, three large forward toes and a smaller toe behind
Long, straight bony tail

Yours truly with *Archaeopteryx* in Berlin, June 1998

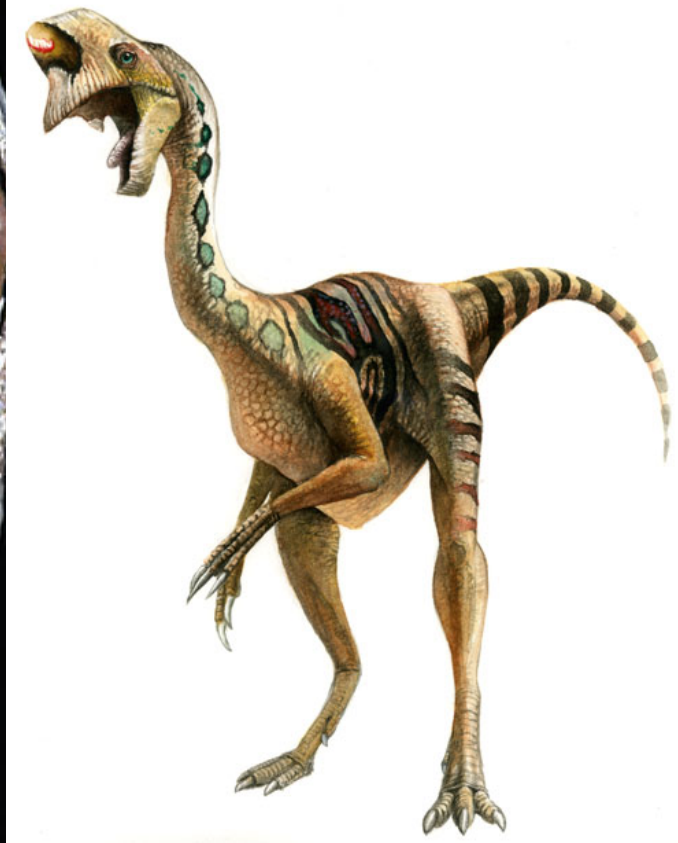
# *Archaeopteryx* carcass in a salty lagoon, 160 MY ago

*Archaeopteryx*

# Archaeopteryx

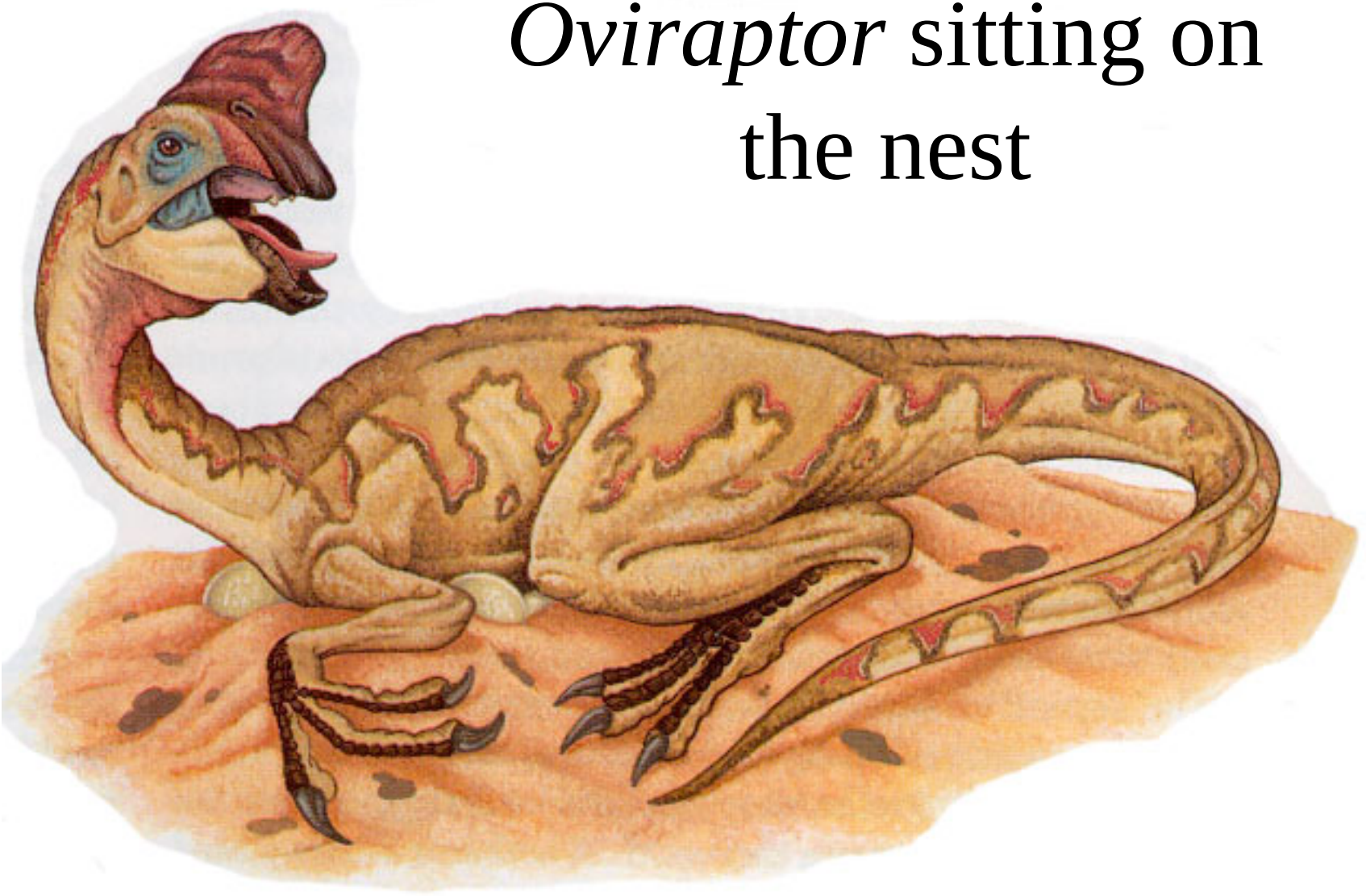
Dinosaurs show evidence of behaviors similar to birds, particularly complex nesting behavior.

# Dinosaur parent, *Oviraptor*, died while sitting on eggs



# Recovering the fossil seen in last slide

# *Oviraptor* sitting on the nest

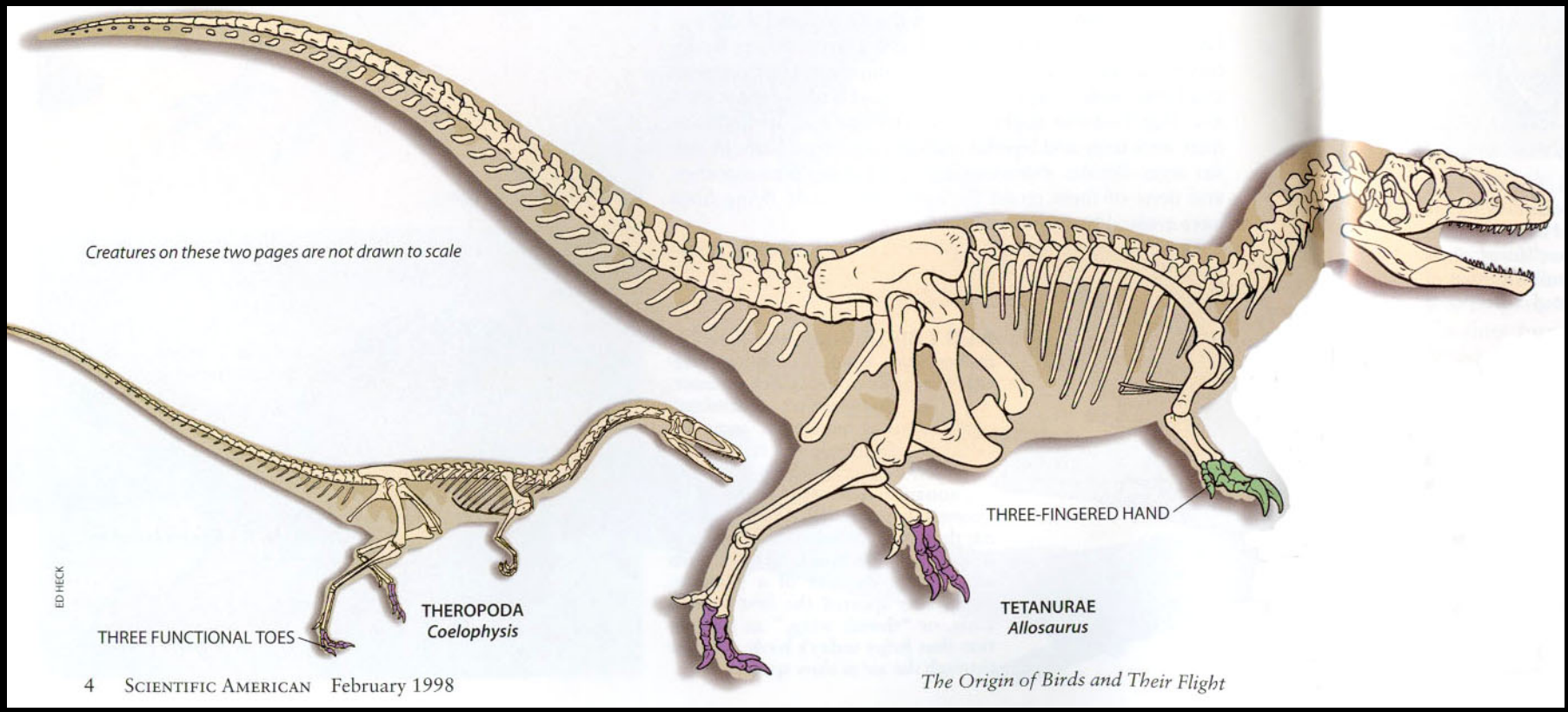


# Ostrich sitting on the nest

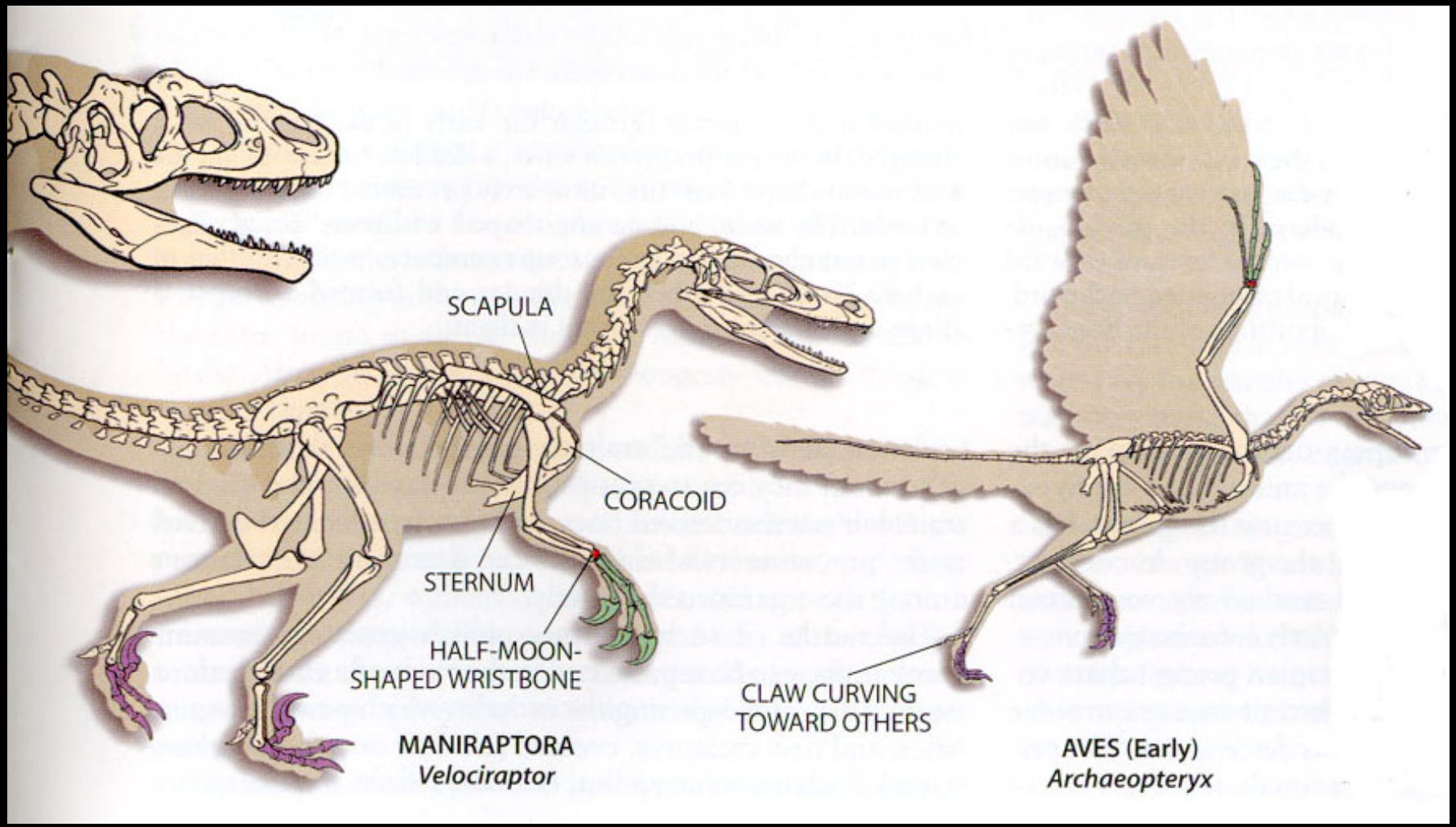
# Evidence for theropod ancestry of birds

- Morphologic similarities
- Cladistic analysis
- Feathered Fossils from China
- Dino Chicken: http://www.cbsnews.com/video/watch/?id=5658225n&tag=cbsnewsSidebarArea.0

# The Triassic theropod *Coelophysis* and the Jurassic theropod *Allosaurus*



The Cretaceous theropod *Velociraptor* and the Jurassic *Archaeopteryx*. Why is the best candidate for a theropod ancestor younger than the first bird?



# Dromaeosaurids (within Maniraptorans), including *Velociraptor* must have originated in the Jurassic, but were not preserved

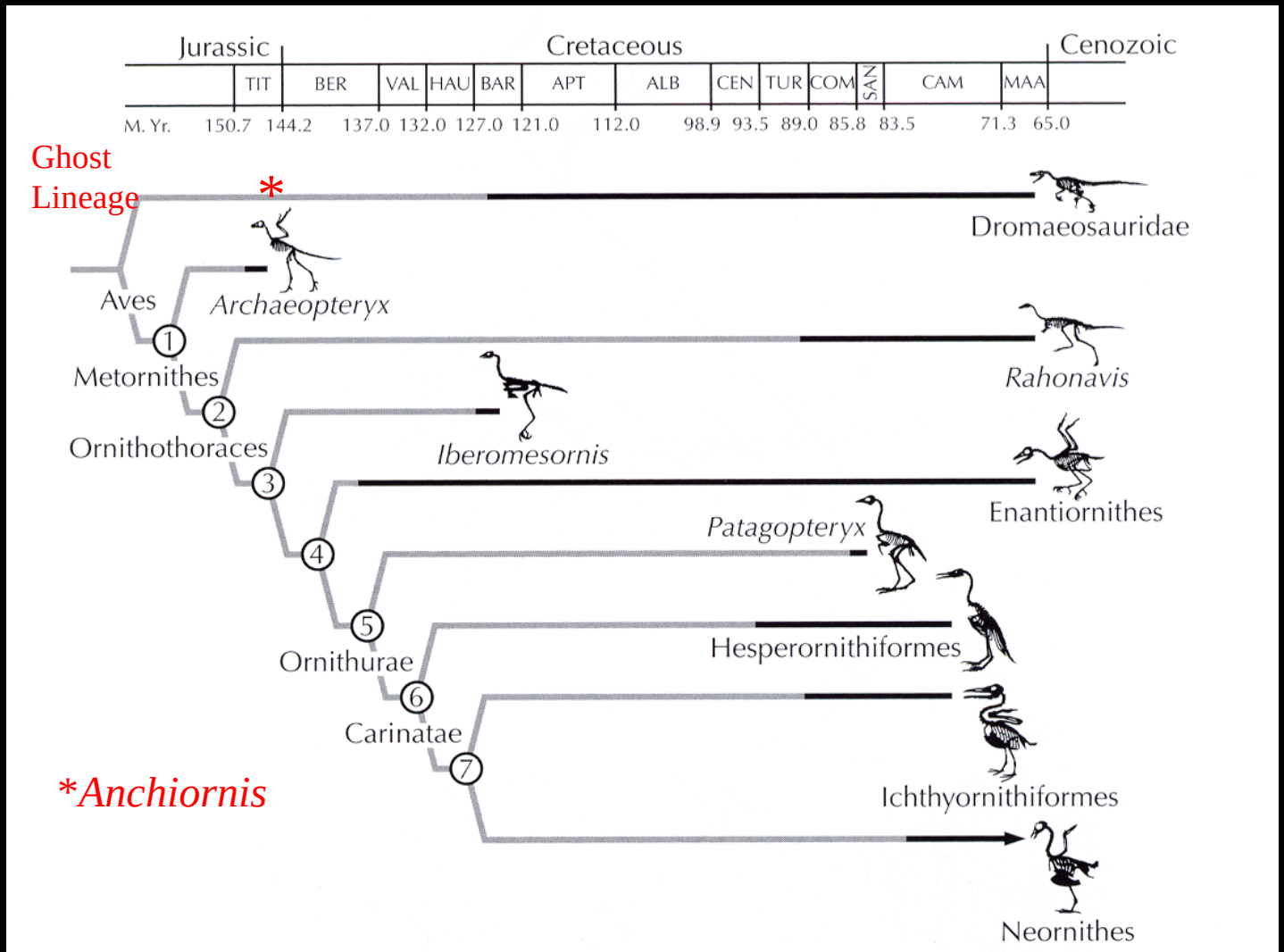
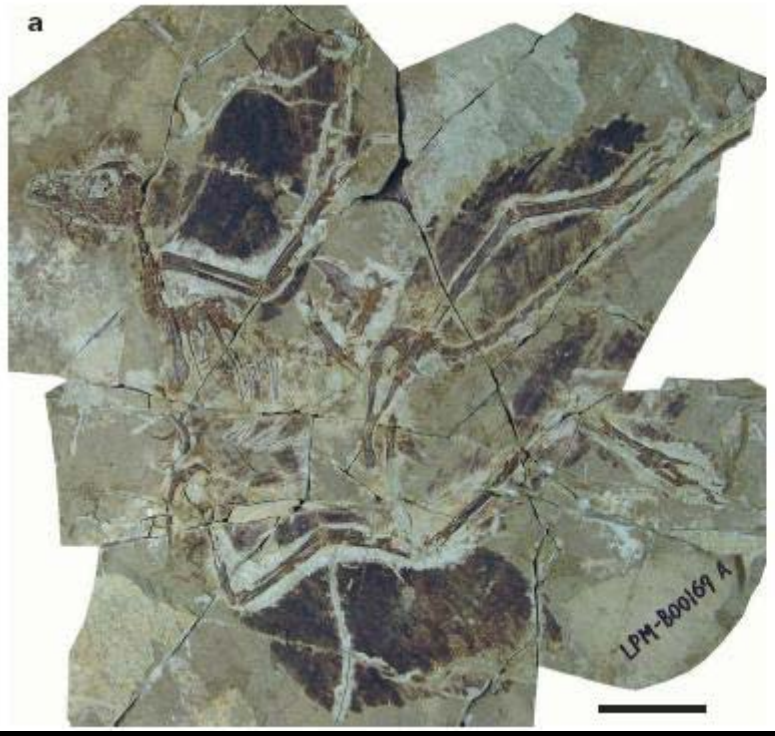
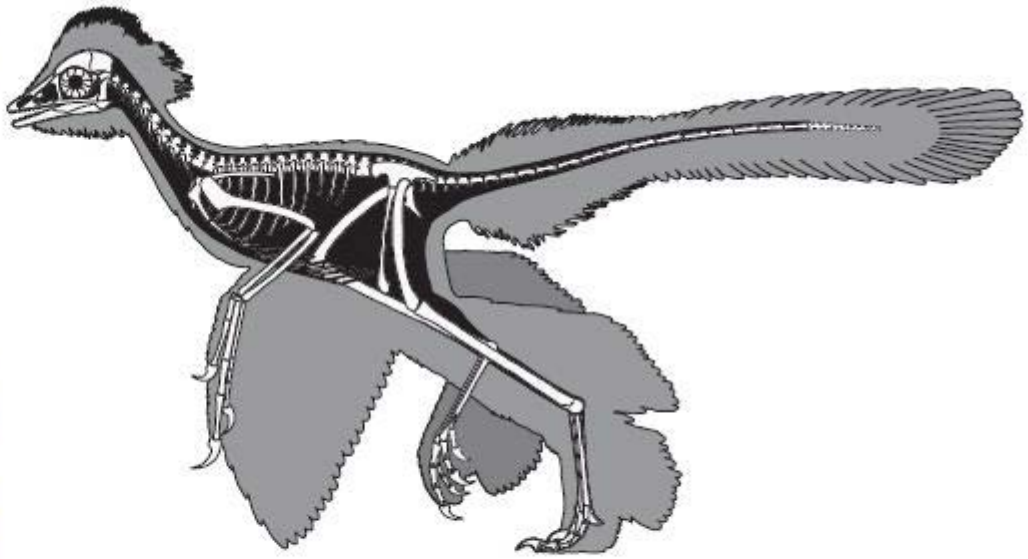



**Figure 12.8.** The family tree of Mesozoic birds, emphasizing some of the recent fossil discoveries. (Based on Chiappe 1995: fig. 1)

Prothero, 2007

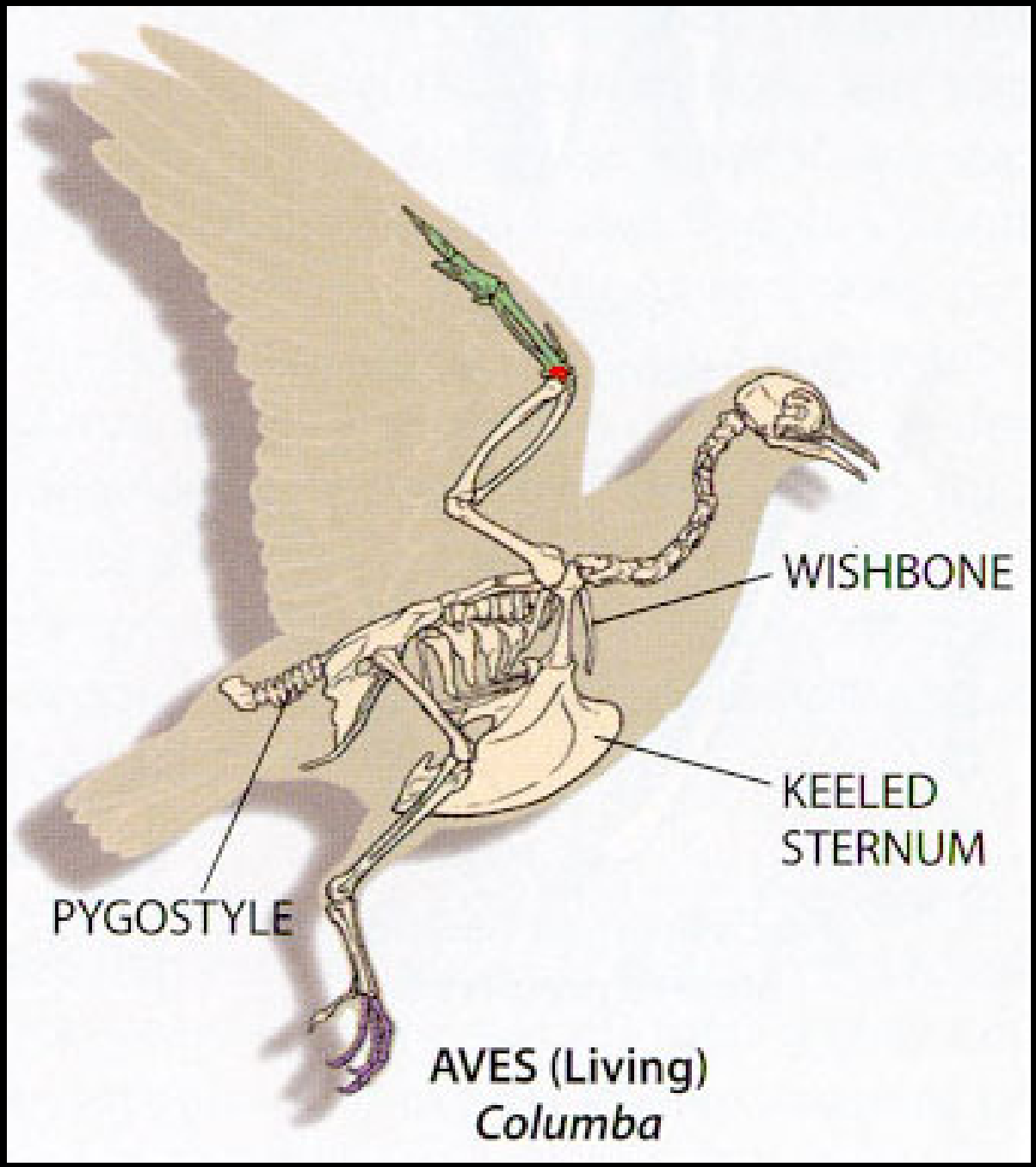
*Anchiornis* (“near bird”), a Late Jurassic feathered maniraptoran discovered in 2009. Closes the time gap between maniraptorans and *Archaeopteryx*.

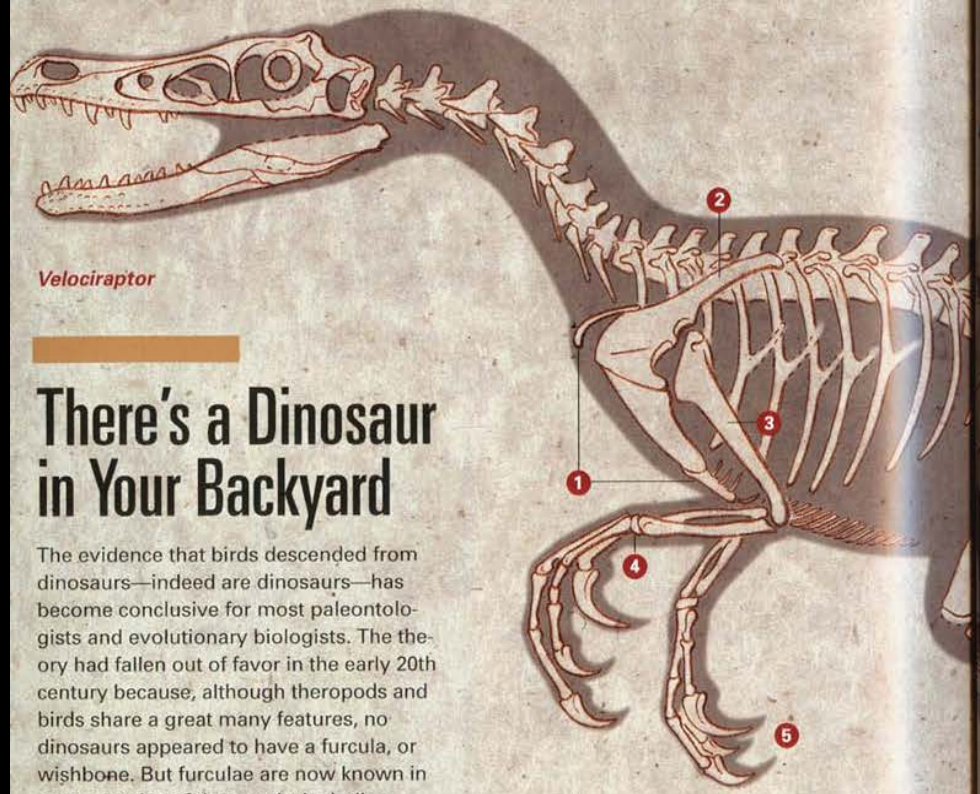


_Anchiornis huxleyi_ Xu et al. (2009) based on the new specimen (Hu et al., 2009)

# Anatomy of a living bird






*Velociraptor*

# There's a Dinosaur in Your Backyard

The evidence that birds descended from dinosaurs—indeed are dinosaurs—has become conclusive for most paleontologists and evolutionary biologists. The theory had fallen out of favor in the early 20th century because, although theropods and birds share a great many features, no dinosaurs appeared to have a furcula, or wishbone. But furculae are now known in many species of theropods, including *Velociraptor,* unearthed in Mongolia in 1991. Its two clavicle bones are joined to make a V-shaped furcula (below).

A few scientists reject the dinosaur–bird connection. They see the similarities as convergent evolution—the development of like traits in separate species. To them

dinosaurs and birds share a common ancestor (which has yet to be discovered) but evolved along separate paths.

## COMPARING DINOSAURS AND BIRDS

1 ***Wishbone and breastbone***
Many theropod dinosaurs have two clavicle bones fused into a furcula, or wishbone, as well as a sternum, or breastbone—both seen in modern birds.

2 ***Shoulder blade***
Birds and theropods have long, thin scapulae, or shoulder blades.

3 ***Bone mass***
Birds and birdlike dinosaurs have hollow and thin-walled bones, thus less body weight.

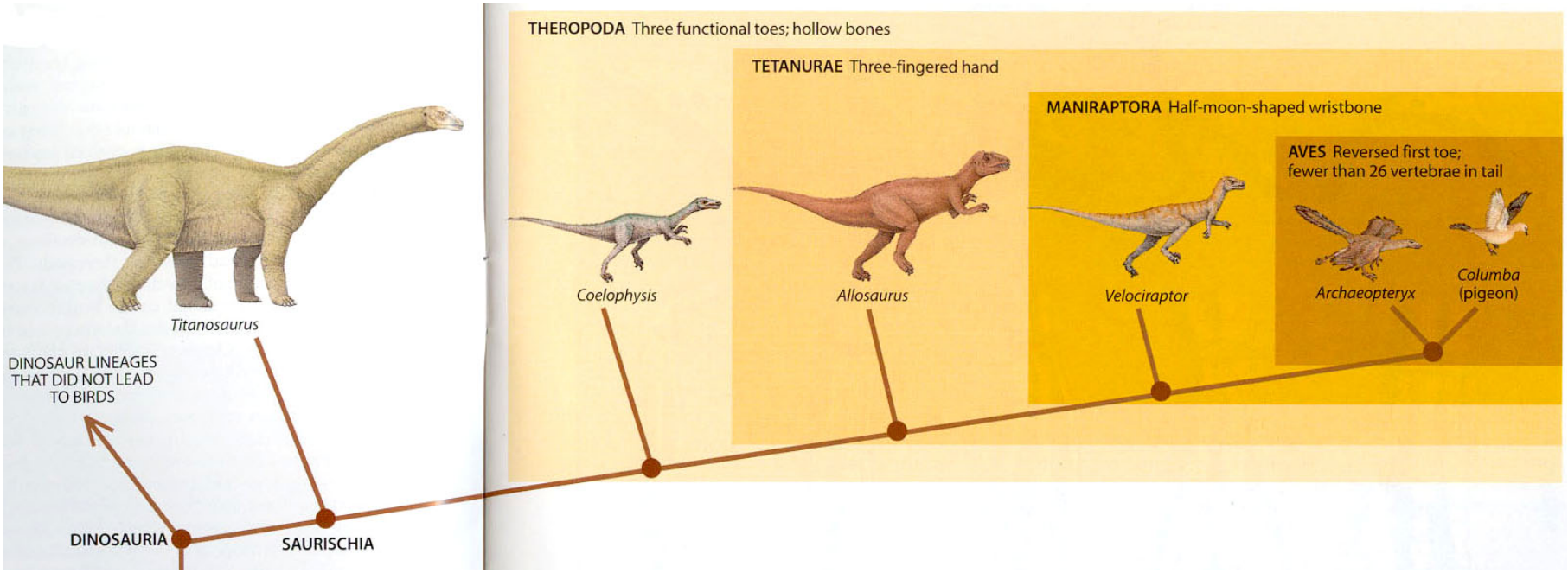
4 ***Swiveling wrists***

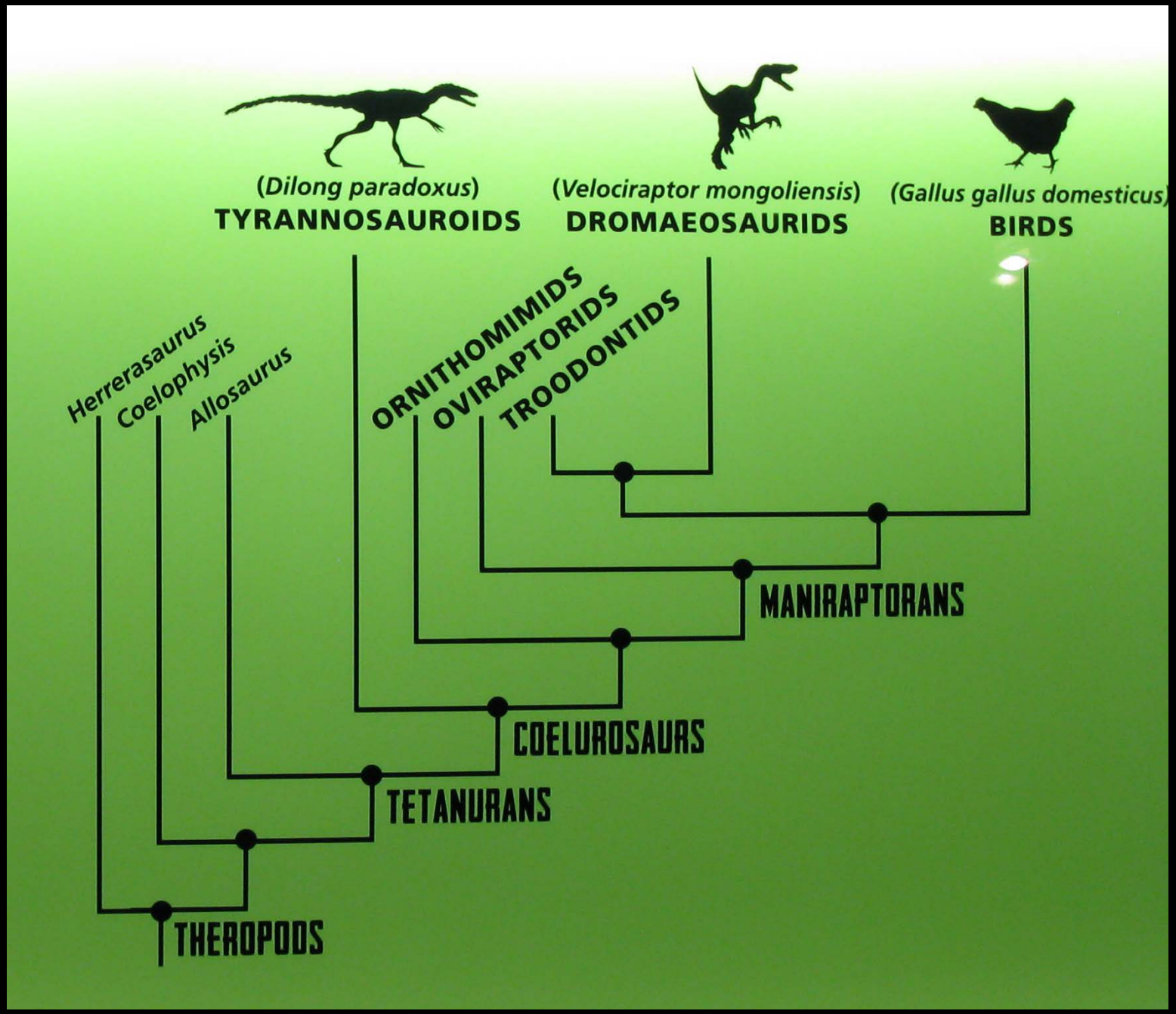
Crow


6 ***Pubis***
The pubic bone extends forward in most dinosaurs but backward in birds and some theropods.

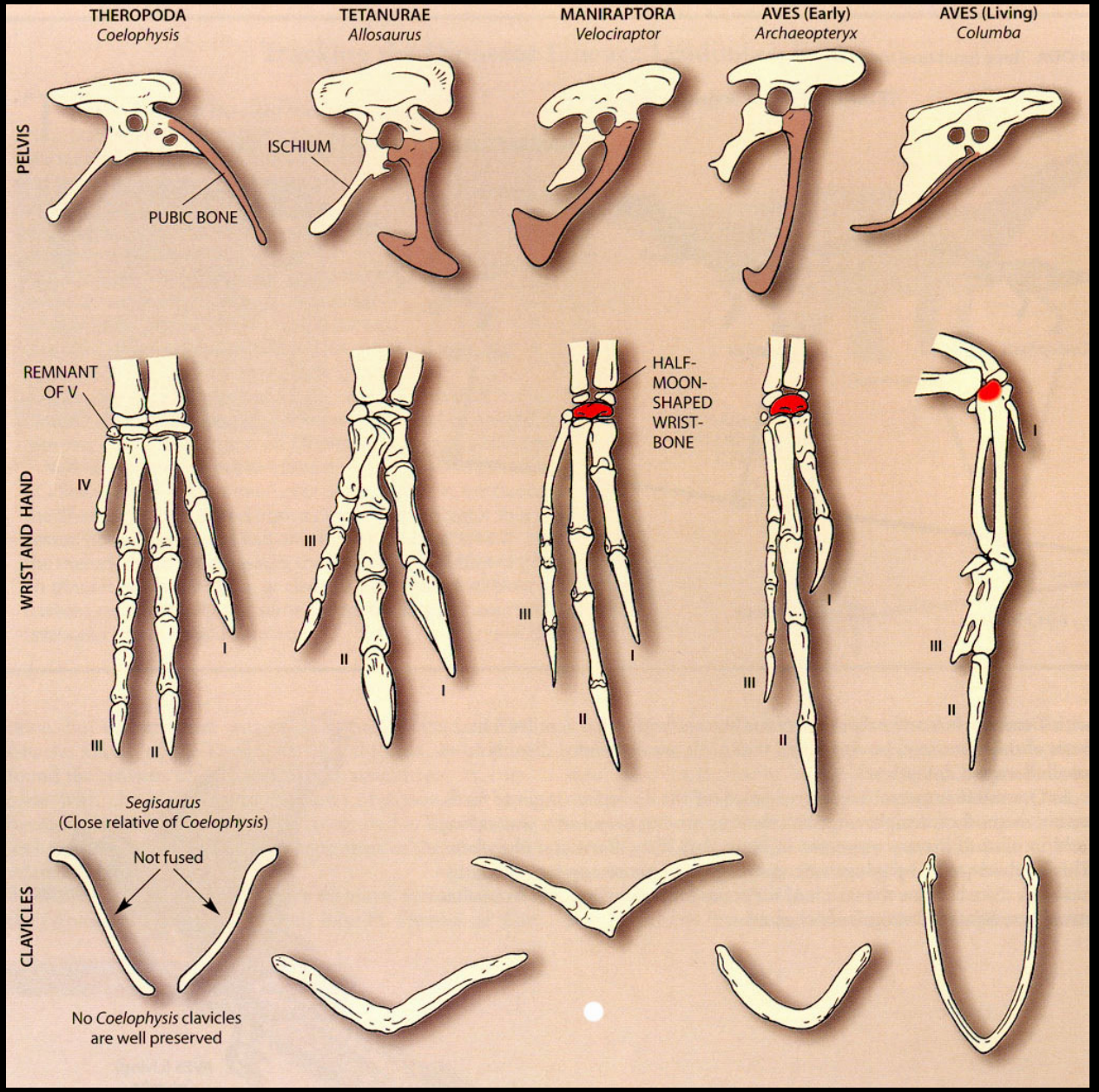
7 ***Legs***
Birds and theropods are "obligatory bipeds," meaning that their muscle and bone structure

# Cladistic analysis supports the evolution of birds from ancestors like *Coelophysis*, *Allosaurus*, and *Velociraptor*




(Dilong paradoxus)
TYRANNOSAUROIDS
(Velociraptor mongoliensis)
DROMAEOSAURIDS
(Gallus gallus domesticus)
BIRDS
ORNITHOMIMIDS
OVIRAPTORIDS
TROODONTIDS
Herrerasaurus
Coelophysis
Allosaurus
MANIRAPTORANS
COELUROSAURS
TETANURANS
THEROPODS

# Morphologic features supporting evolution of birds from theropods



# Classification vs. Phylogeny

- Linnean Classification

Class Reptilia

Class Dinosauria

Class Aves

*Archaeopteryx*

Linnean scheme obscures evolutionary relationships.

- Phylogenetics or Cladistics – no categories, but a nested hierarchy shows evolutionary relationships

Reptilia

Diapsida

Archosauria

Dinosauria

Theropoda

Maniraptora

Aves

*Archaeopteryx*

# Classification vs. Phylogeny

## Pros

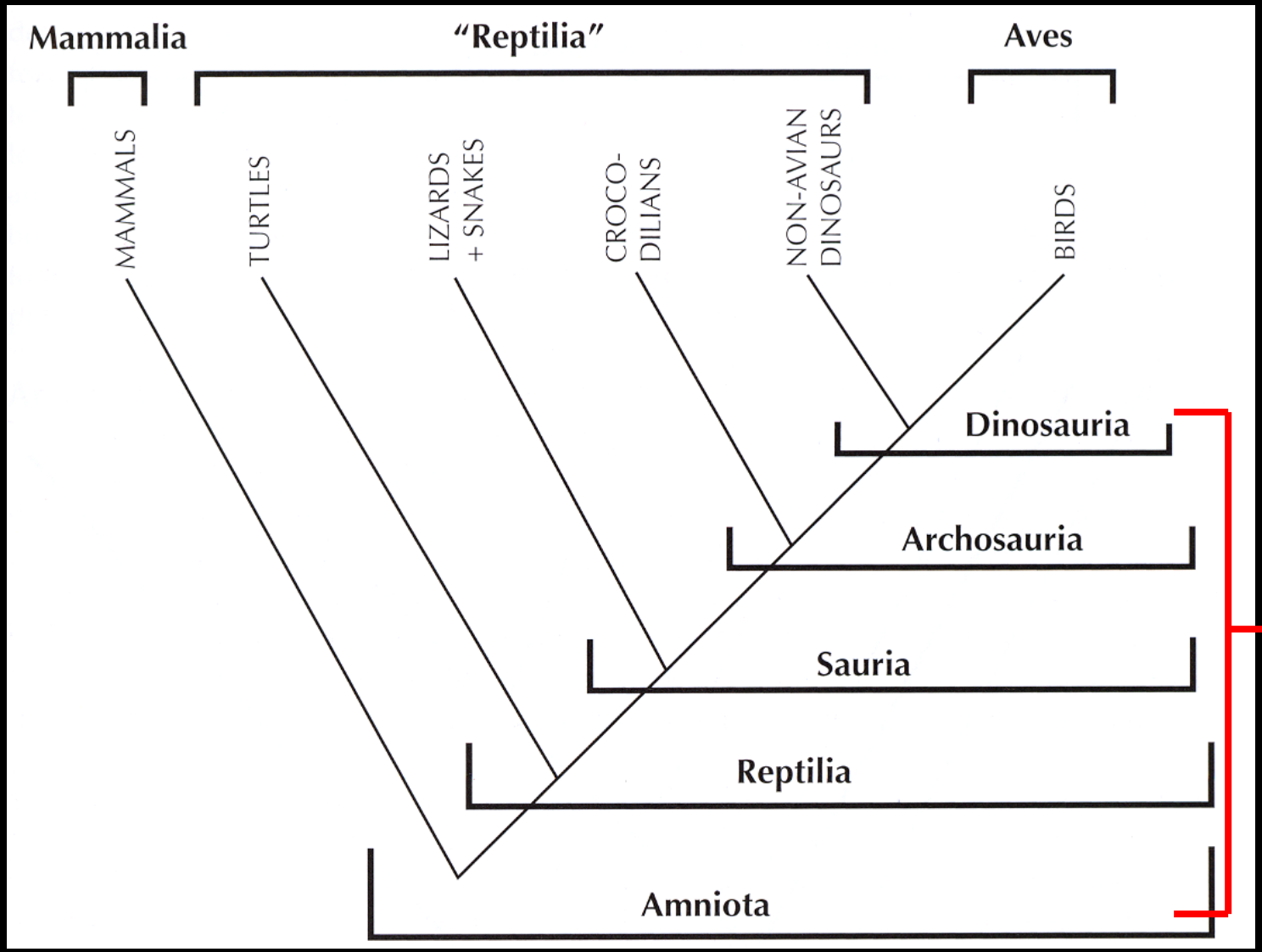
- Linnean scheme is simple and places major groups at a high taxonomic level.
- Cladistics scheme shows evolutionary relationships in a nested hierarchy.

## Cons

- Linnean scheme fails to show evolutionary relationships between groups.
- Cladistics scheme is cumbersome because of so many names. Lack of ranks is confusing to non-specialists.

Conclusion: Classification and Phylogenetics serve different purposes.

# Linnean Classification

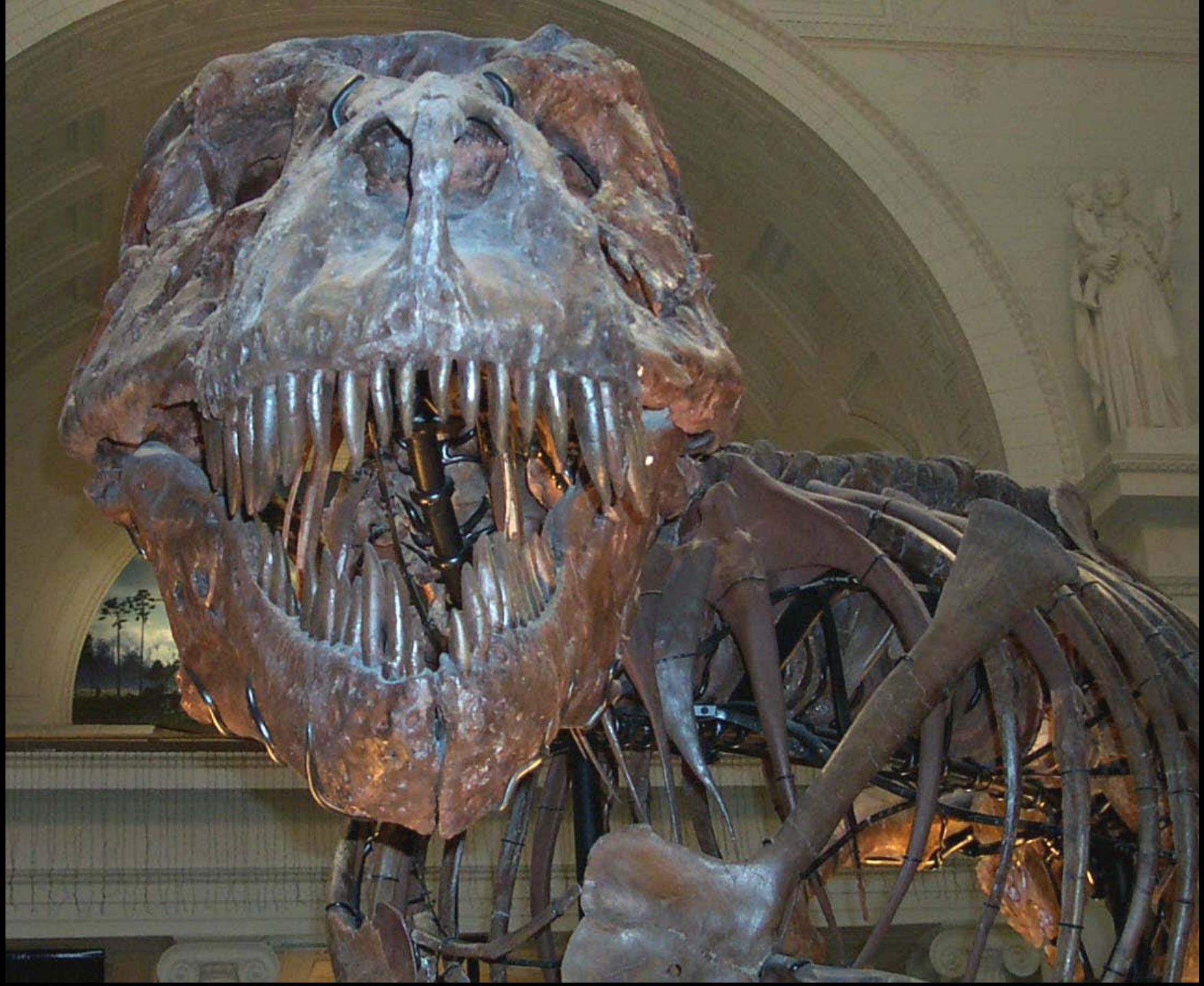


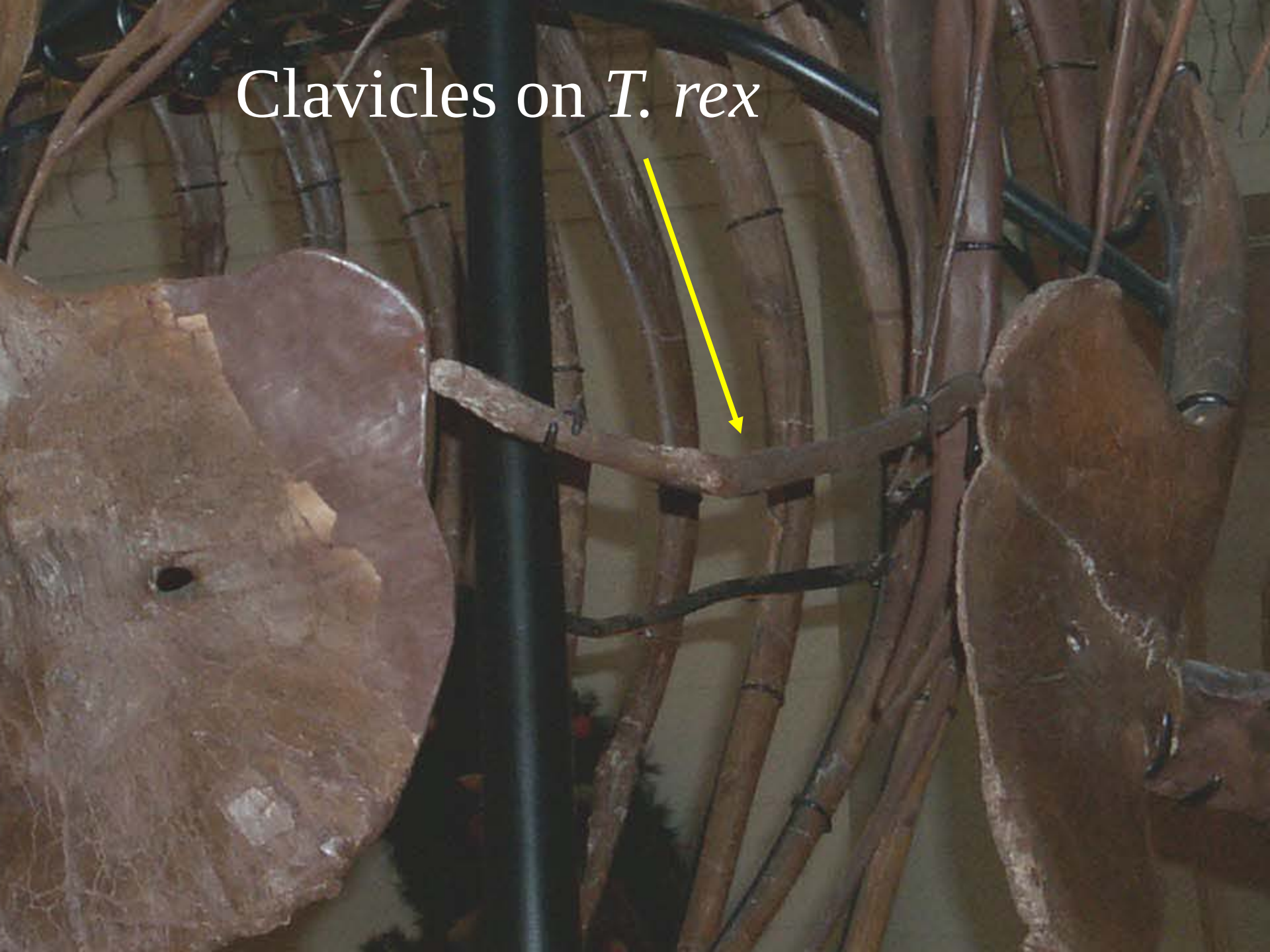

Cladistics

Prothero, 2007

# Sue on display in Chicago


*T. rex* Sue at the
Field Museum




Clavicles on *T. rex*

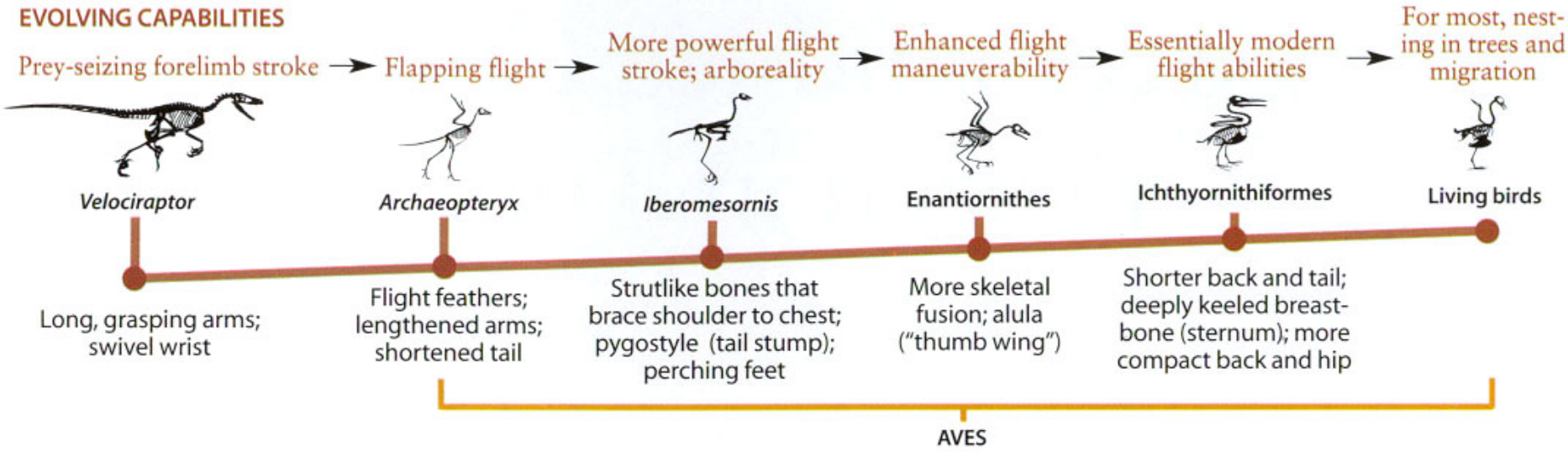
Peter Larson showing the clavicles attached to the shoulder blades of *T. rex*.


Healed broken ribs

Perching toe of birds

# A feathered theropod

# Cladogram showing evolution of improved flight capabilities in birds




CLADOGRAM OF BIRD EVOLUTION indicates that birds (Aves) perfected their flight stroke gradually after they first appeared approximately 150 million years ago. They became arboreal (able to live in trees) relatively early in their history, however. Some of the skeletal innovations that supported their emerging capabilities are listed at the bottom.

## EVOLUTION OF A WING

***Sinosauropteryx***
Typical theropod dinosaur arm

***Velociraptor***
Flexible wrist

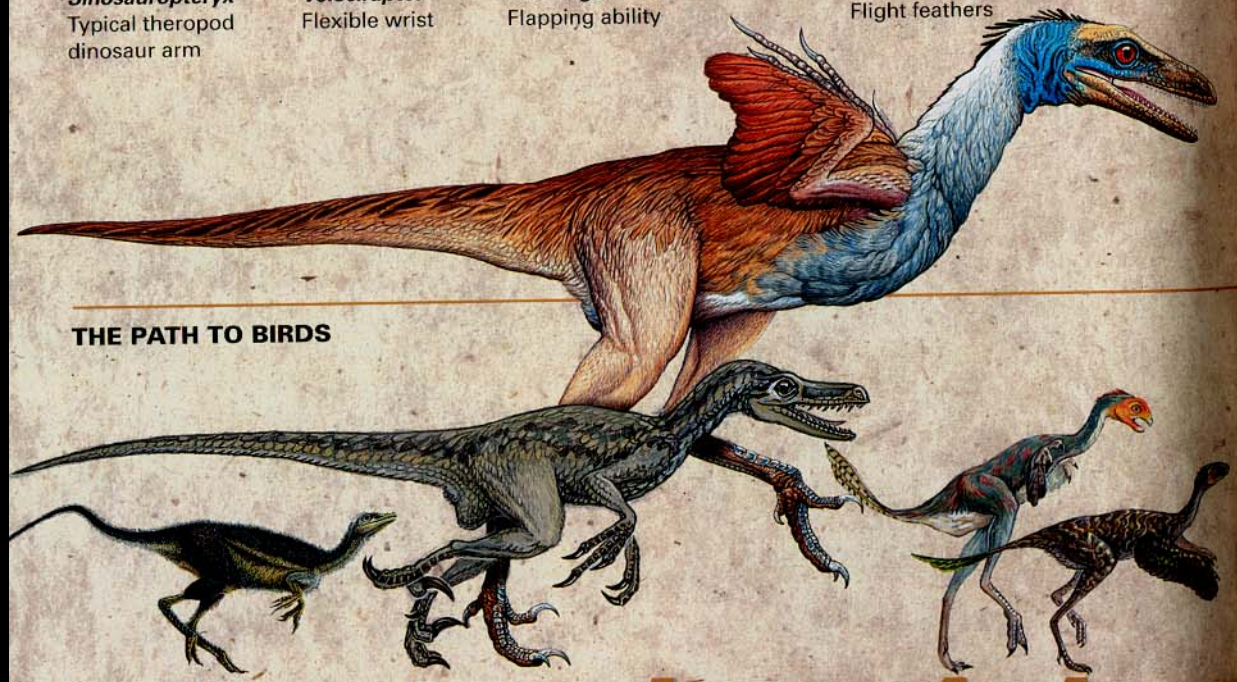
***Unenlagia***
Flapping ability

***Archaeopteryx***
Flight feathers


***Eoalulavis***
First alula

***Corvus* (Crow)**
Modern wing

## THE PATH TO BIRDS



**DINOSAURS**

**BIRDS**

***Sinosauropteryx***
Covered with fila-

***Velociraptor***
This predatory the-

***Unenlagia***
Found in Patagonia,

***Caudipteryx***
Straddling the

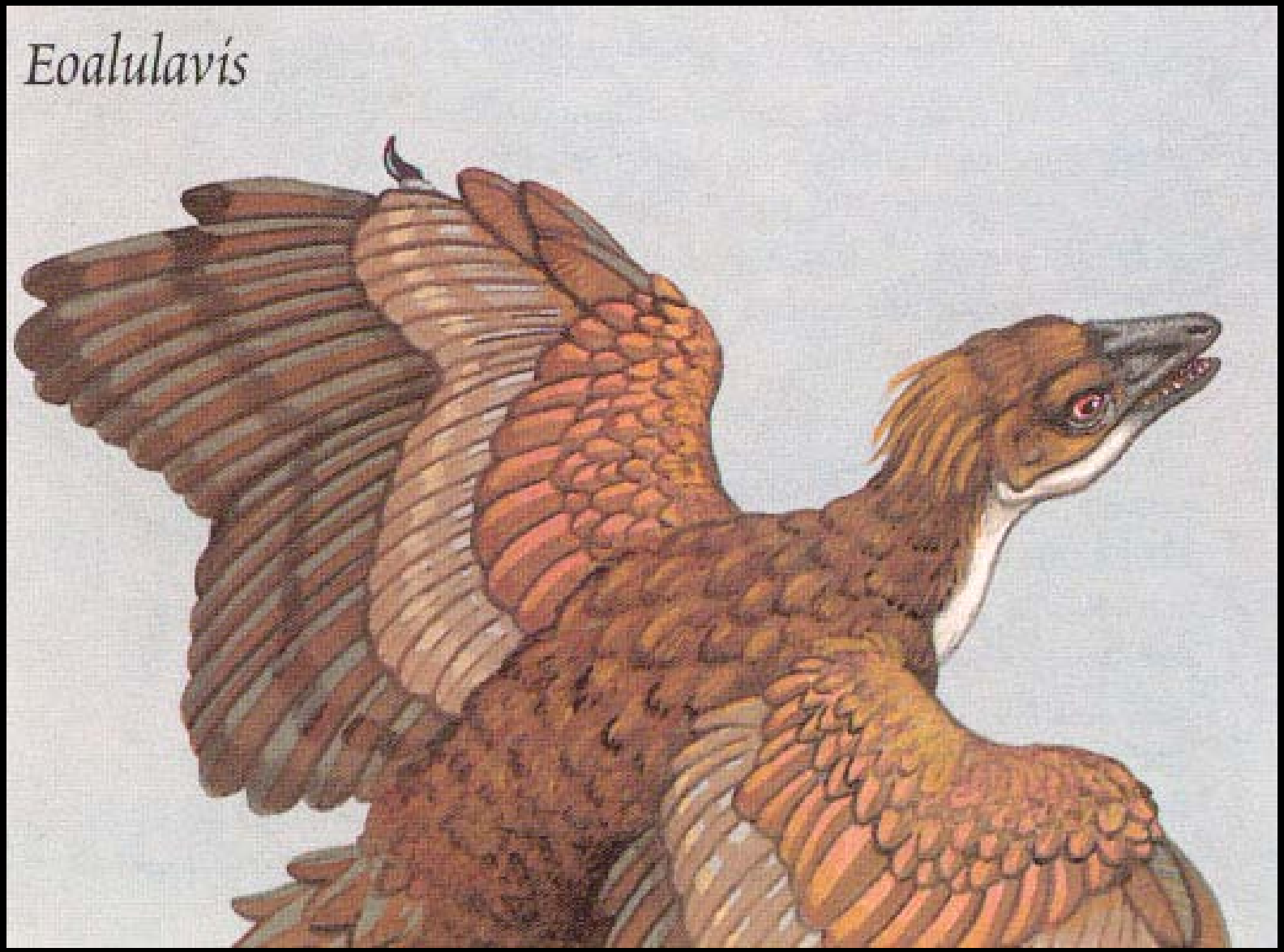
***Protarchaeopteryx***
Another discovery

***Archaeopteryx***
The feathers of this

***Eoalulavis***
Found in Spain,

***Corvus***
At the zenith of

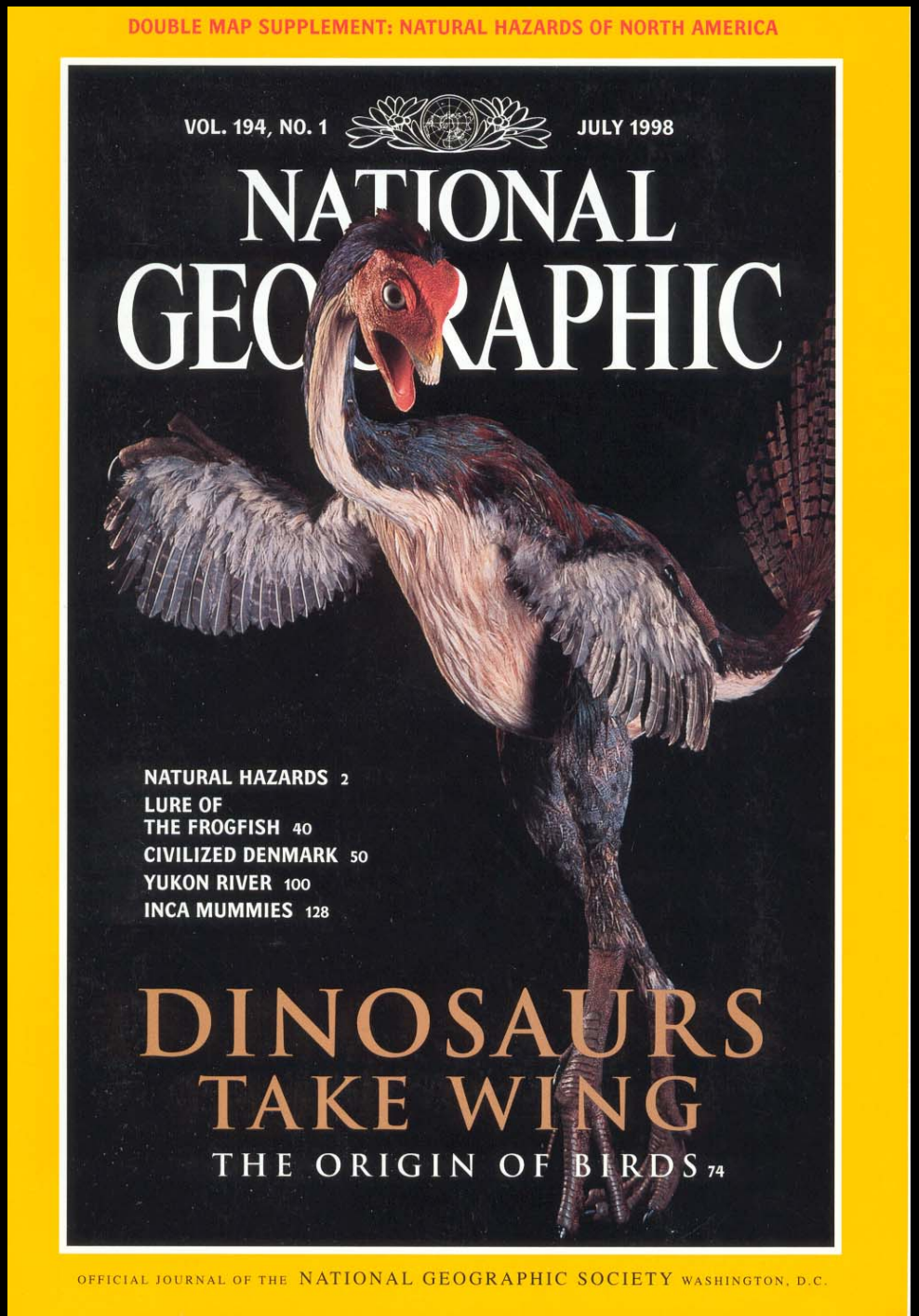
# Cretaceous toothed bird with wing claws

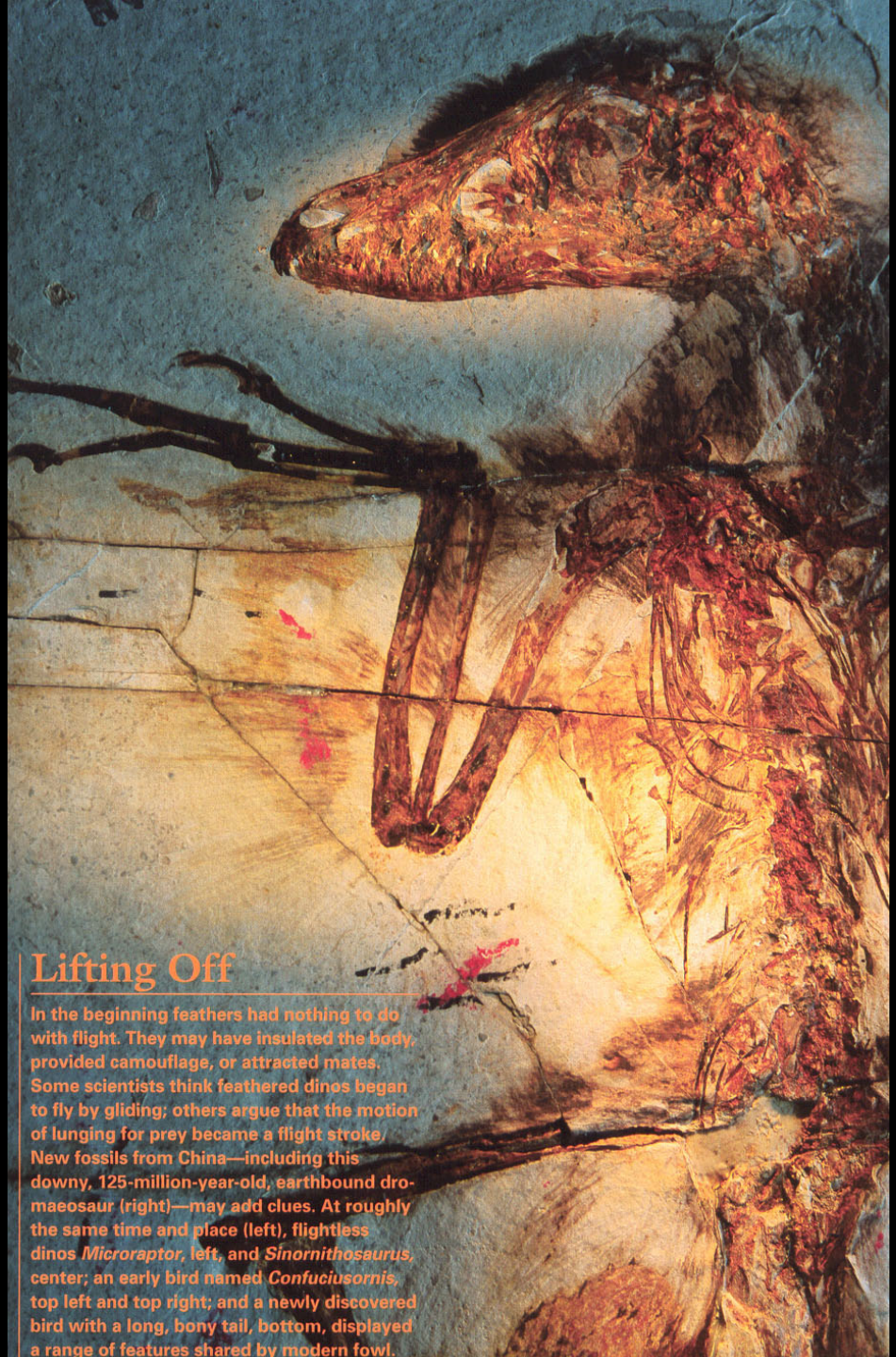


# Cretaceous toothed bird with wing claws

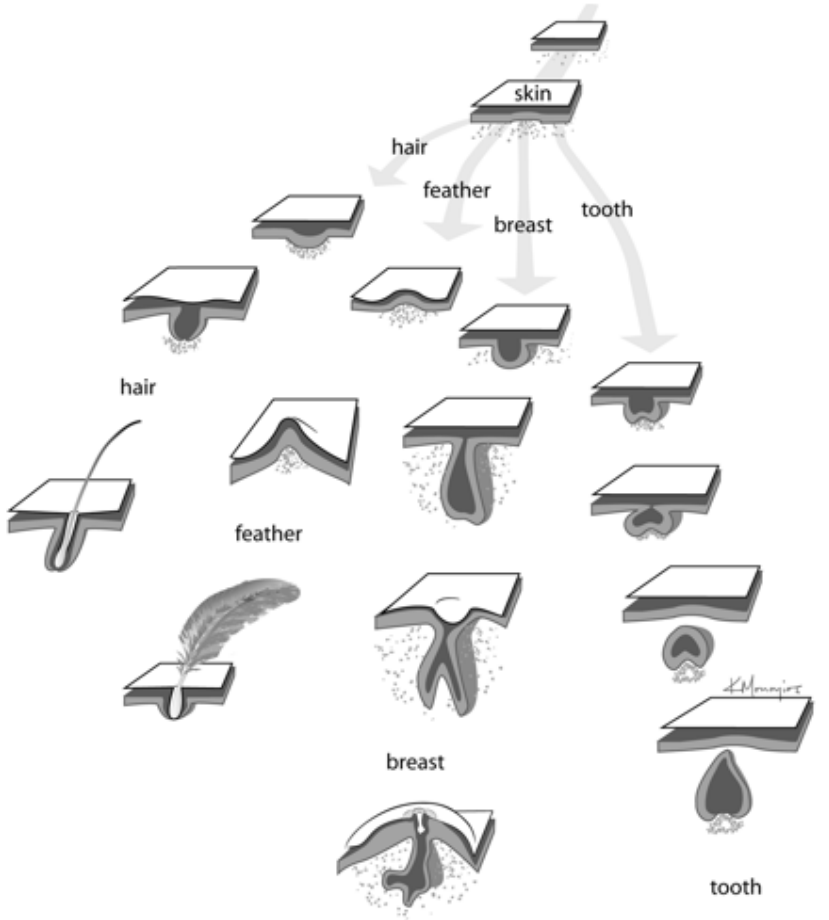
No toothed birds survived the K/T extinction event

Where did birds come from? They evolved from theropod dinosaurs.






# Feathered dinosaur from China, 2002




Teeth, breasts, feathers, and hair all develop from the interactions between layers of skin.

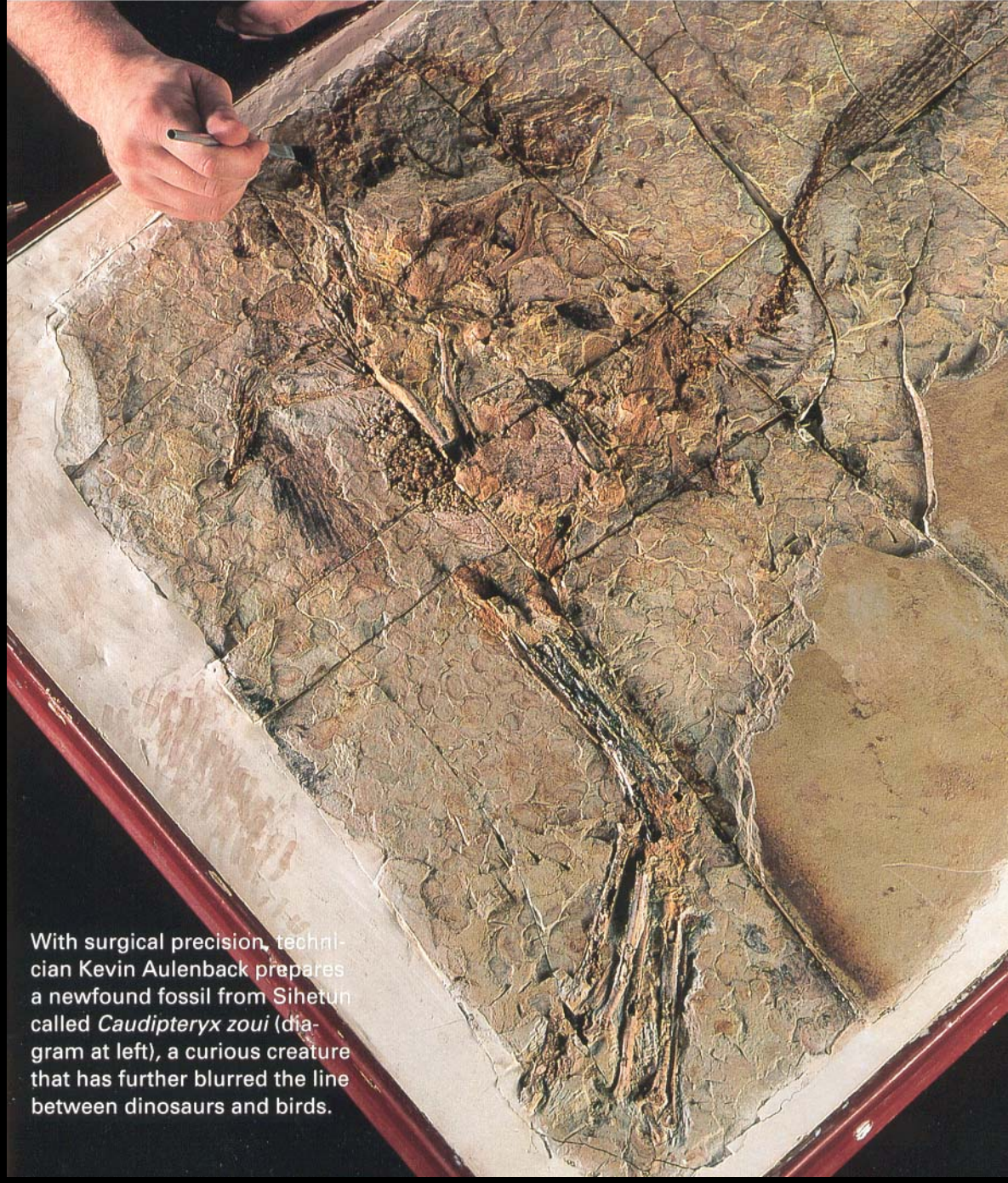
# Another feathered dinosaur from Laioning, China

Birds evolved from feathered theropods


*Sinornithosaurus millenii* (life-sized reconstruction)
Name derived from: Greek 'Chinese bird lizard'
Pronounced: SINE-or-nith-oh-SAWR-us

# Feathered theropods

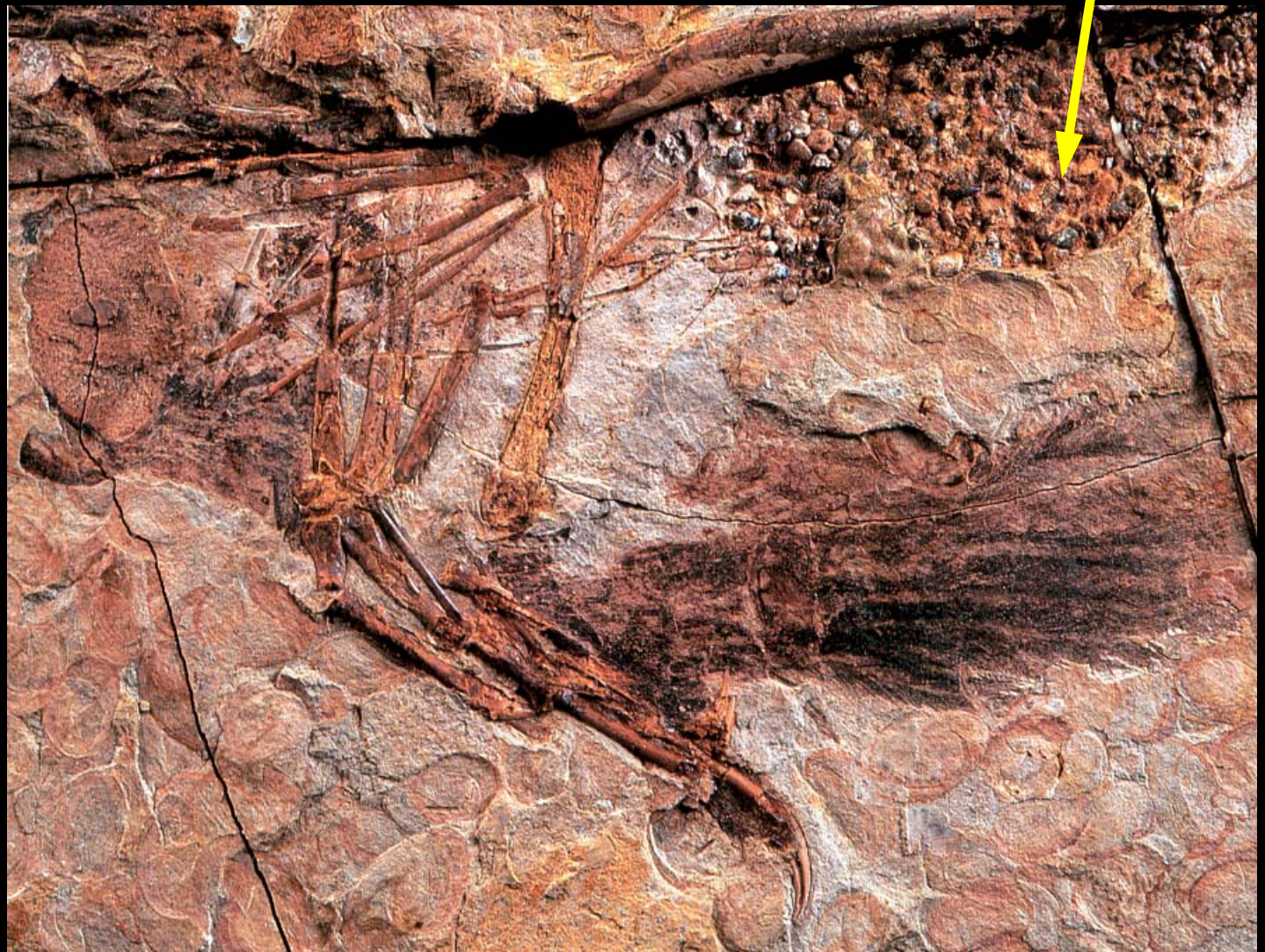
Feathered theropod dinosaur from China, 1998

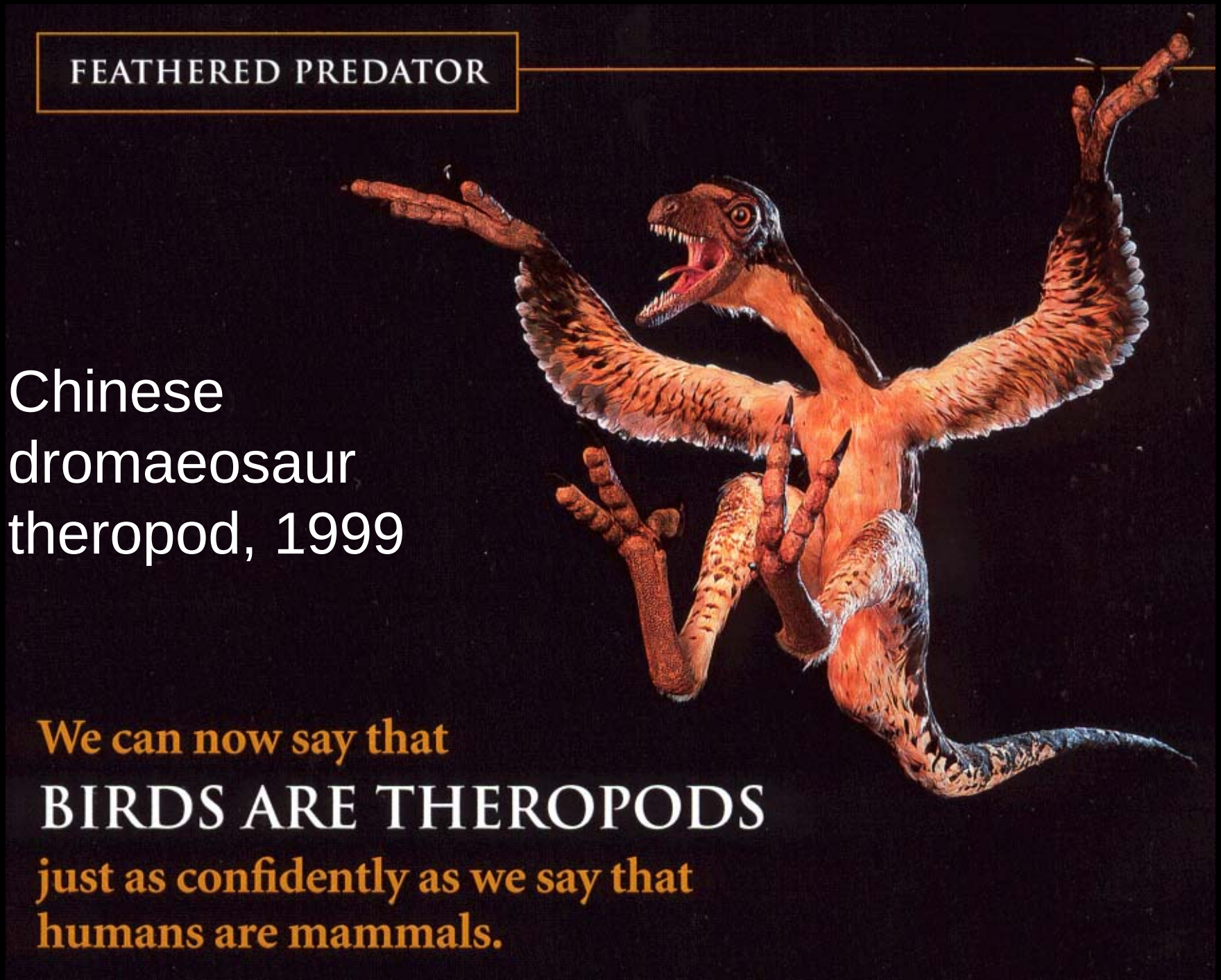


With surgical precision, technician Kevin Aulenback prepares a newfound fossil from Sihetun called *Caudipteryx zoui* (diagram at left), a curious creature that has further blurred the line between dinosaurs and birds.

# Reconstruction of feathered dinosaur

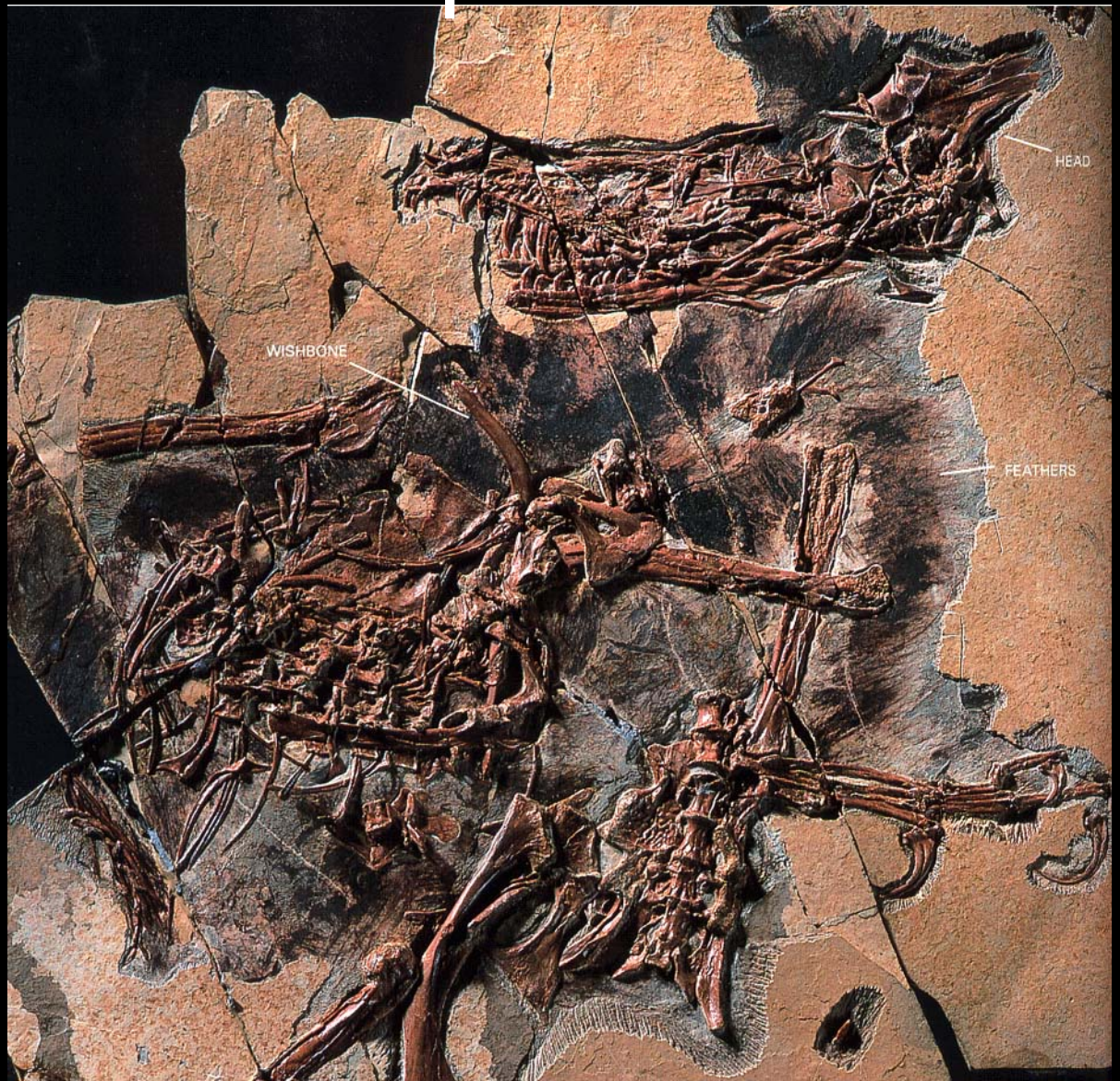
# Fossilized gastroliths in feathered dinosaur





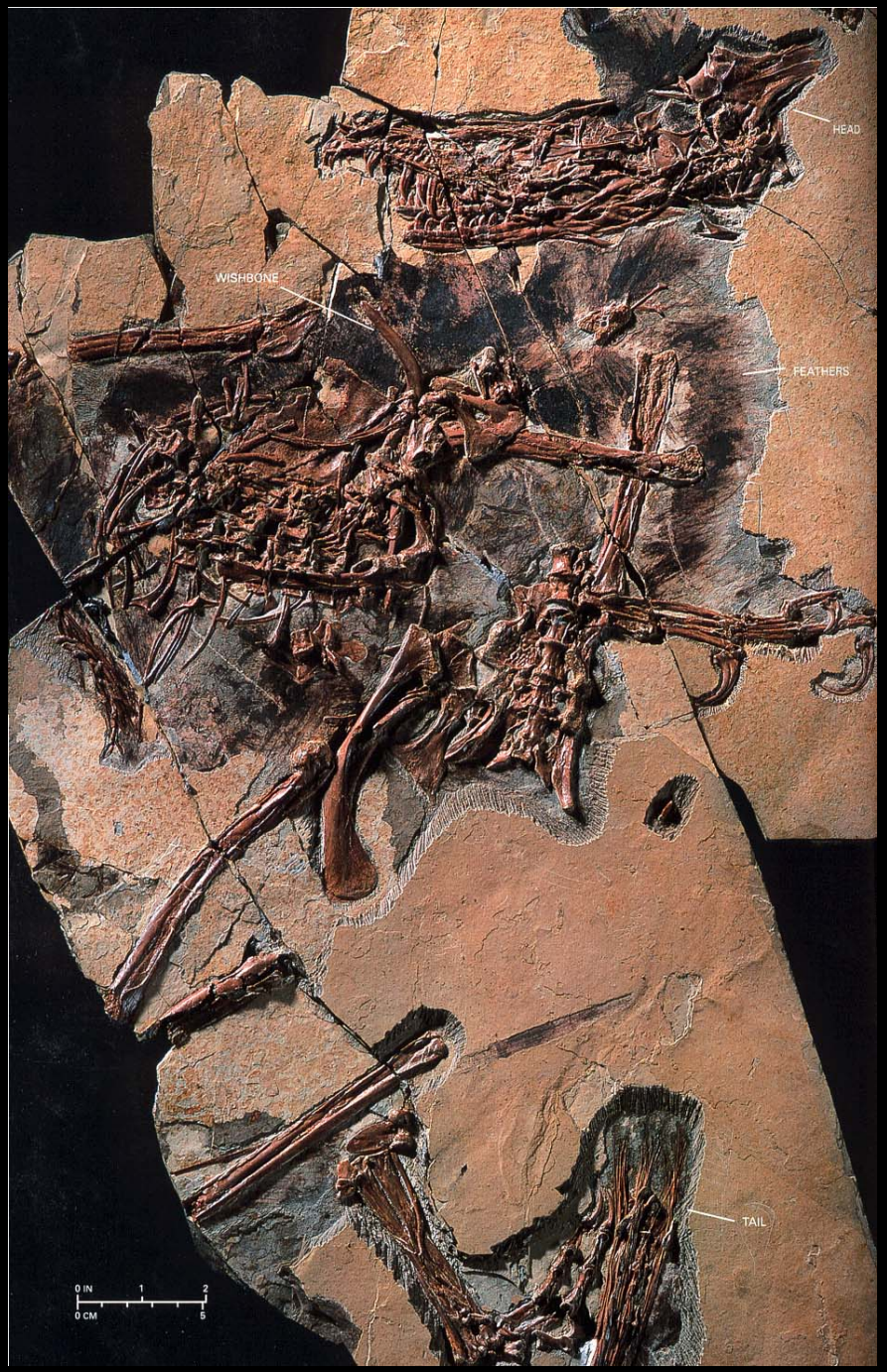

Chinese dromaeosaur theropod, 1999

# Chinese dromaeosaur theropod skeleton with preserved feathers



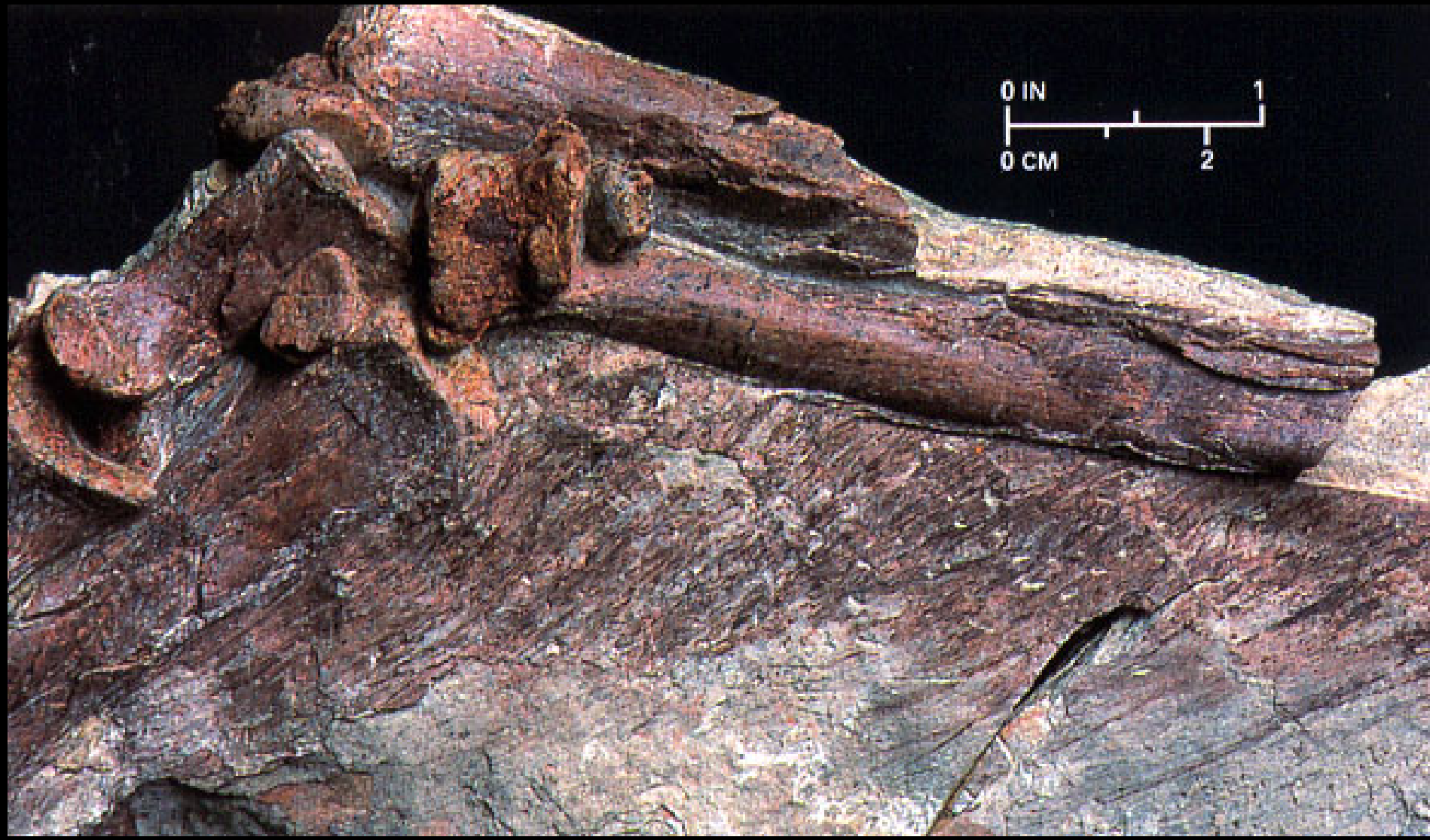
# Closeup of feathers on Chinese dromaeosaur theropod

Complete skeleton of Chinese dromaeosaur theropod with feathers, tail at the bottom.

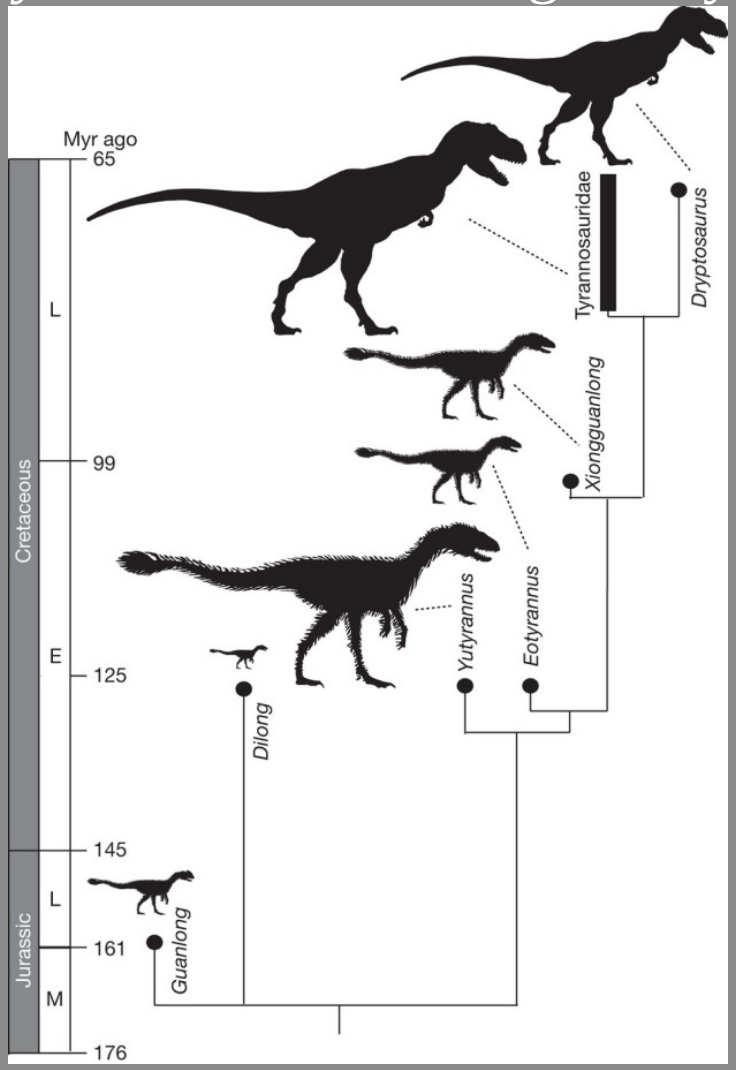


Tail of Chinese dromaeosaur showing bundles of bony ligaments for stiffening the tail, typical of theropods.

# Forearm bone of a therizinosaur theropod with preserved feathers



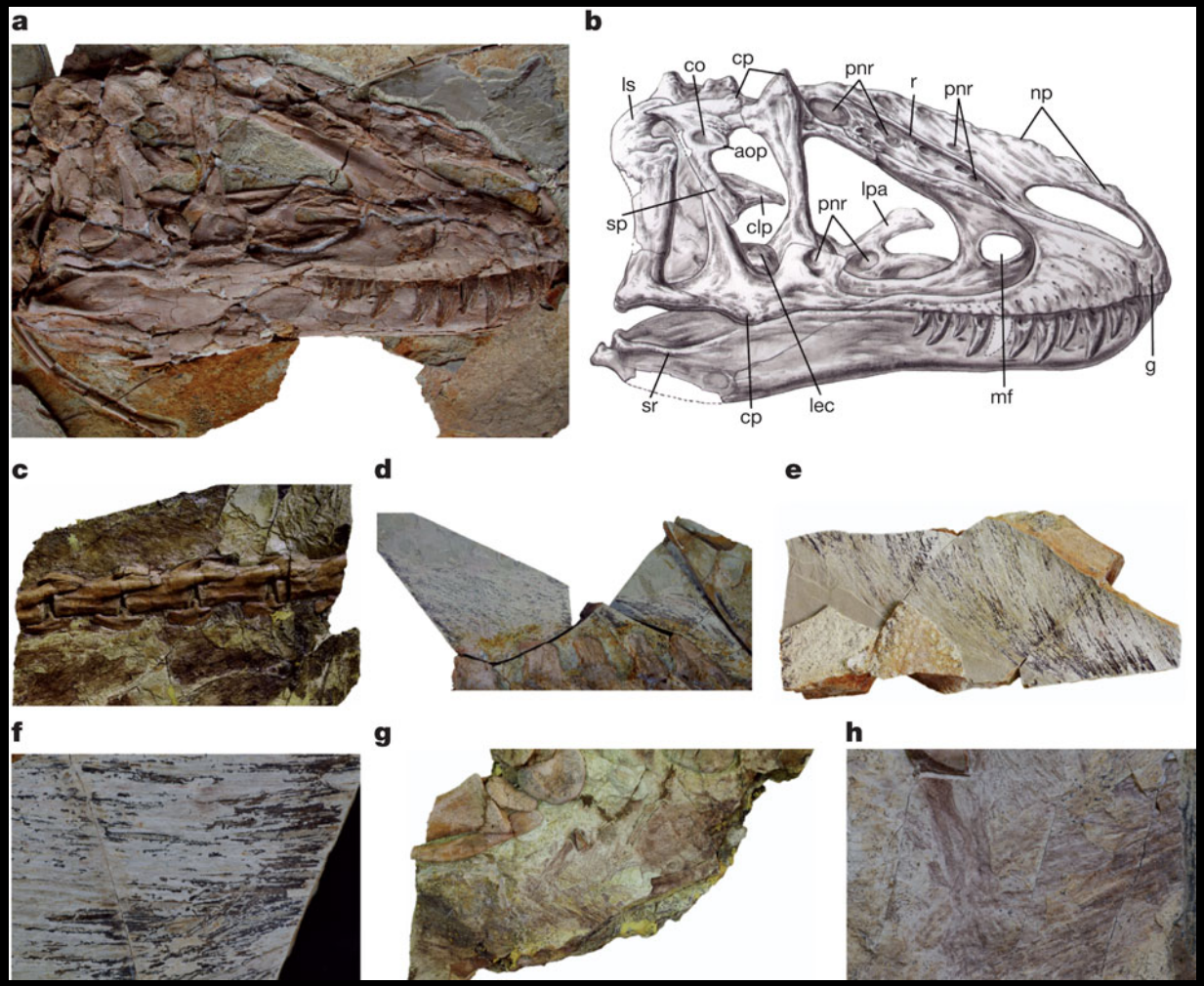
# A simplified cladogram showing the systematic position of *Yutyrannus huali* among the Tyrannosauroidea.




X Xu *et al*. *Nature* **484**, 92-95 (2012) doi:10.1038/nature10906

nature

# Selected elements of *Yutyrannus huali*




X Xu *et al*. *Nature* **484**, 92-95 (2012) doi:10.1038/nature10906

nature

# Actual fossil birds from China that are different from feathered dinos

# *Hesperornis*, a Cretaceous aquatic, toothed bird

# How the 'terror bird' tore its prey: South American Cenozoic predator, 60Ma-2Ma

http://cosmiclog.msnbc.msn.com/_news/2010/08/18/4918252-how-the-terror-bird-tore-its-prey