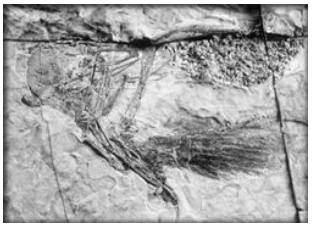
Barney to Big Bird: The Origin of Birds

The "fuzzy raptor"



Caudipteryx

The discovery of feathered dinosaurs in Liaoning, China, has excited the many paleontologists who suspected a direct link between dinosaurs and birds.

…But the idea of a close link between between dinosaurs (or at least reptiles) date back to the discovery of the remains of *Archaeopteryx* in the Upper Jurassic Solnhofen Limestone of Bavaria (Germany).

A wee bit of background on the Solnhofen Limestone:

In the Late Jurassic, much of what is now Germany was covered by a warm shallow sea fringed with reefs made by sponges and corals.

Between these reefs and the land were isolated lagoons that were cut off from the rest of the sea. These lagoons were had too much salt and too little oxygen for anything more complex than bacteria or protists.

Solnhofen Limestone, cont'd

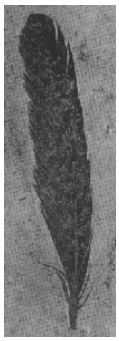
Any organisms that fell into, or were washed into, the lagoons were buried in soft carbonate mud devoid of oxygen.

Storms probably were responsible for the rapid rates of burial required for the exceptional preservation of remains in the lagoons.

Thus, delicate remains were frequently protected from scavengers and currents, and were preserved intact in what would become fine-grained limestone.

Quarry exposure of Solnhofen Limestone

Archaeopteryx- First significant specimen



The first fossil of *Archaeopteryx* was a single feather, found in 1860.

This feather was not only exceptionally preserved, but showed the asymmetric form that is characteristic of flight feathers.

Archaeopteryx- the London specimen

This specimen found in 1861, called “The London Specimen” was significant in that it established the type of bird from which the single feather found the previous year was derived.

(Note there are so few specimens of *Archaeopteryx* that they are named for the museums/cities in which they are curated).

The London Specimen resides in the British Museum in London, U.K.

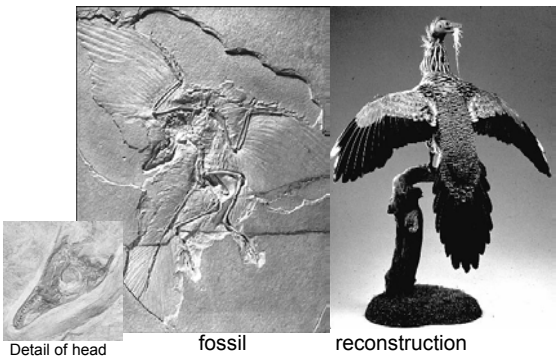
Berlin Specimen

By far the most famous and best preserved specimen of Archaeopteryx is the Berlin specimen discovered in 1877 (curated in the Humboldt University Museum of Natural History in Berlin)

This specimen shows most of the significant features that are considered evidence of a dinosaur-bird connection.

Archaeopteryx lithographica

What are the similarities and differences between Archaeopteryx and modern birds ?



Detail of head

fossil

reconstruction

Birds share many characteristics with theropod dinosaurs, suggesting a close (and perhaps direct) link between the two groups. Even recently, *Archaeopteryx* has thrown paleontologists for a loops !

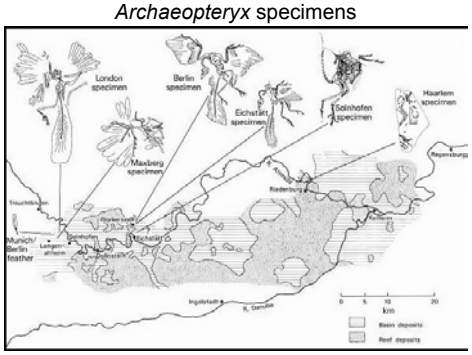
Archaeopteryx

The Solnhofen specimen, found in the 1960s, was initially identified as the theropod dinosaur *Compsognathus*.

Much later (1980s), it was noted that the dimensions of the forelimbs in the specimen were too long for *Compsognathus*. Further preparation also revealed very faint feather impressions, allowing this specimen to be identified as *Archaeopteryx*.

Compsognathus

Archaeopteryx specimens



Note that the Solnhofen limestone is quarried in many locations in Bavaria and at slightly different stratigraphic levels within this unit.

It is possible that more than one species is represented in the total number of specimens known (7 major specimens and some fragmentary material).

So how similar are birds and dinosaurs ?

Crow

Bambiraptor

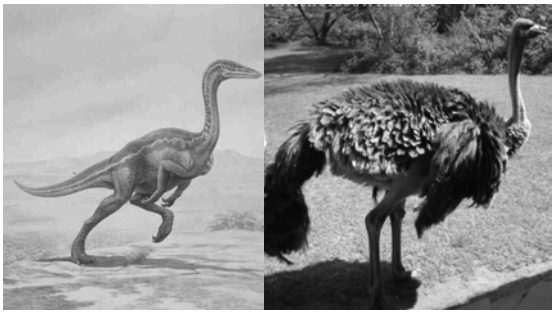
Hands versus wings

Hoatzin chick

Archaeopteryx

Hoatzin chicks retain the three fingers in a “hand” prior to the forelimb developing into an adult wing

S-Shaped Neck, Locomotion on Toes



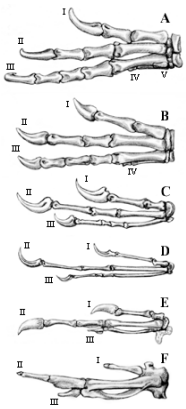
Ornithomimus ostrich

Foot Morphology

hind foot, vulture

Hind foot, *Deinonychus*

Hand Morphology



A. *Herrerasaurus*- five digits are present, Digit V shaded yellow and hidden on other side of hand.

B. *Coelophysis*. Note that digit V is gone.

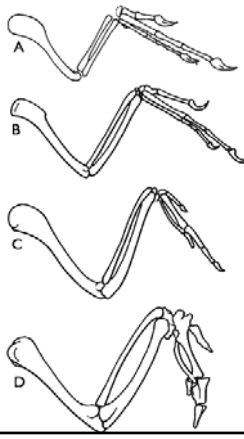
C. *Deinonychus*. Note loss of both digits V and IV

D. *Archaeopteryx*. Note very close correspondence in proportions and relative lengths of bones to Deinonychus.

E. Hoatzin embryo. Number of bones reduced in digit III.

F. Hoatzin adult. Most of the bones of the hand fused

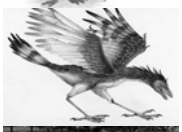
Another Set of Examples



Ornitholestes (theropod dinosaur)

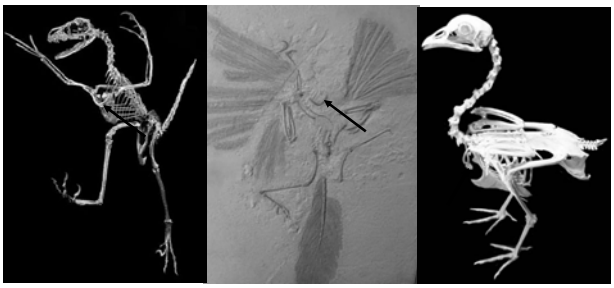
Archaeopteryx

Sinornis (a Cretaceous bird)



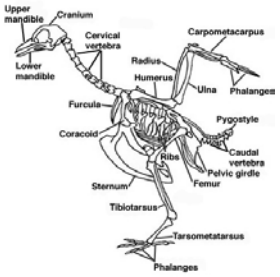
Modern chicken

Furcula (Wishbone)



Bambiraptor *Archaeopteryx* *chicken*

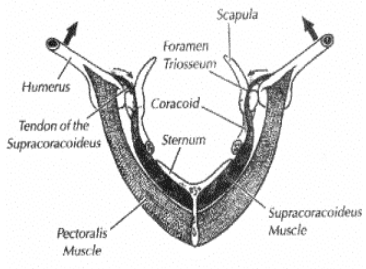
Why have a wishbone ?



In birds, has to do with frequent use of arms for flight.

Upstroke

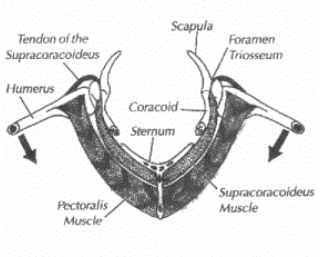
The upstroke in flight is made possible by a pulley system involving muscles and tendons.



- The supracoracoideus muscle (the "tender" of a chicken breast) is attached to the sternum.
- Contraction of the supracoracoideus pulls on a tendon that loops through the top of the shoulder and is attached to the upper surface of the humerus (upper arm).
- The arm is raised as the tendon pulls tight.

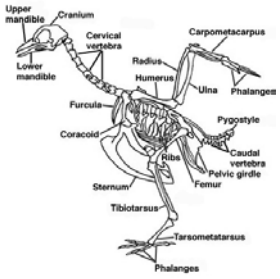
Downstroke

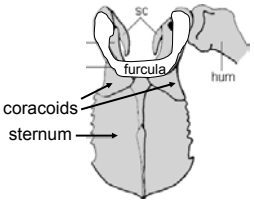
The downstroke in flight is accomplished by outer chest muscles.



- The pectoralis muscle (the big part of a chicken breast) is attached to the underside of the humerus and the keel of the sternum.
- Contraction of the pectoralis muscle pulls the arm downward.

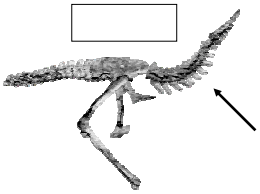
The furcula (wishbone) acts as a spring to restore shoulder (coracoid) bones to the position necessary for the next upstroke.





Front view: note that furcula props open the shoulder bones like a spring.

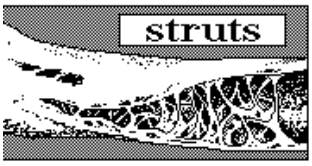
Pygostyle ("Parson's Nose")



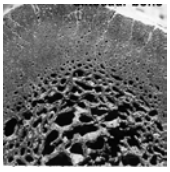
Nomingia (Oviraptorosaur)

vulture

Hollow bones



Oblique section of bird humerus



Cross-section of dinosaur bone

The bones of a bird are incredibly lightweight (due to the large amount of empty space inside), but at the same time, are remarkably strong.

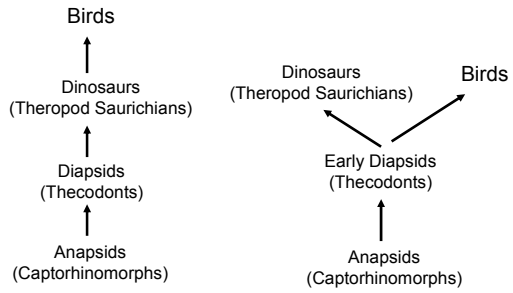
The strength is provided by interior struts (similar to the gridwork in a highrise building).

Lightweight construction: "Sue"

The overall skeletal structure of theropod dinosaurs is also optimized for light weight (note even the skull is basically supported by vertical "struts."

What are the differences ?

Did birds arise from dinosaurs ? …Or directly from thecodonts ?



For many years this was debated. But since the discovery of feathered dinosaurs from China, a dinosaur ancestry appears to be more likely

Origin of Flight in Birds

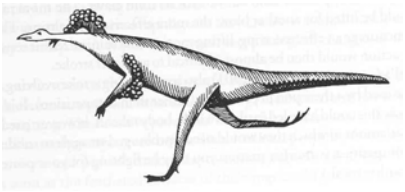
Arboreal Hypothesis:

Transition from parachuting to gliding, then to flapping and powered flight. Modern "flying lizards" use "skin wings" supported by elongated ribs for parachuting and gliding over short distances.

Main objection: The legs of theropods (and *Archaeopteryx*) are generally much longer than the arms, which would have made climbing difficult.

Cursorial Hypothesis:

"Protofeathers" (modified scales) provided lift for running dinosaur



Main Objection: Running would have created lots of drag (actually slowing the animal down), which would have prevented the animal from reaching the speed necessary to take off.

The Running Raptor:

Wings evolved as devices for coralling swarming food sources (e.g. insects)

Main Objection: the blast of air that would have accompanied by rapid limb motion (swatting action) would have been allowed insects to readily escape.

Display and Fighting Hypothesis:

Long feathers originally used for display.

Downward “smashing” motion of forelimbs of a fighting bird resembles the power stroke in flight.

Bird-like dinosaurs able to leap highest in fights were selected for.

Reconstruction of *Caudipteryx*

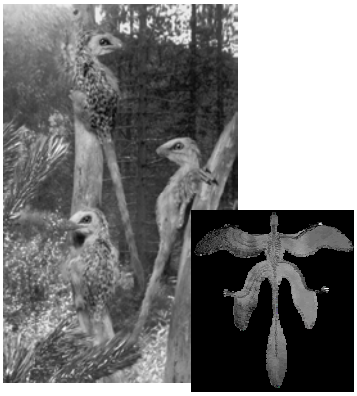
Roosters

Interesting Recent Discovery

Feathered dinosaur *Microraptor* had plumage on both front and hind limbs (which, in turn, were similar in size).

Microraptor would have been well-suited to parachuting/gliding.

Perhaps the arboreal hypothesis for the origin of flight in birds isn’t so far off the mark after all ?



So where do birds fit ?

Some paleontologists are convinced that the similarities of birds and dinosaurs are close enough to include birds in the group Dinosauria.

In essence this would suggest that birds are merely dinosaurs that can fly, and that perhaps dinosaurs might not be extinct after all !

END OF LECTURE