

***In Vivo* X-Ray Imaging in Biomechanics and Developmental Biology**



Beth Brainerd
University of Massachusetts Amherst

Outline

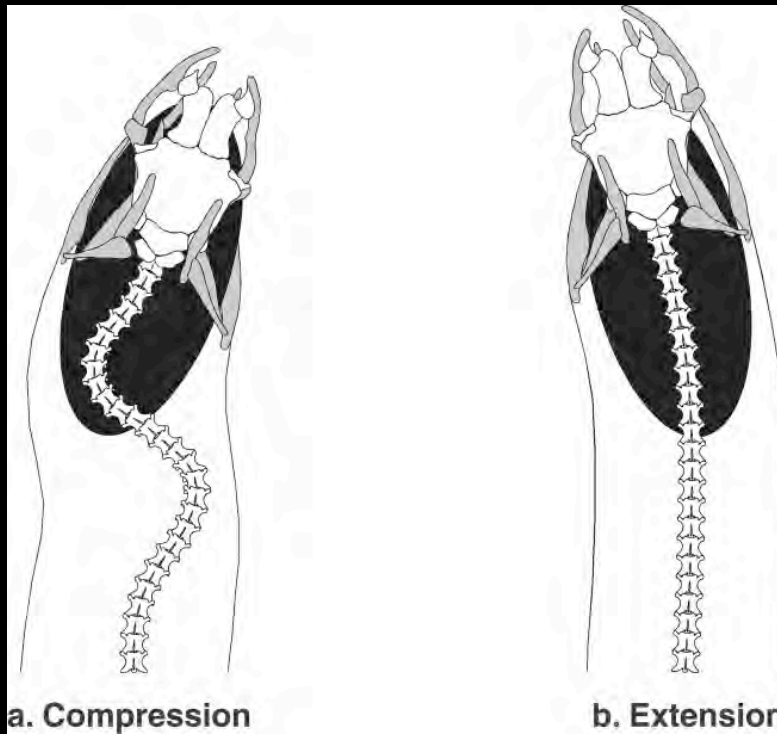
- 1) X-ray video**
- 2) X-ray CT and microCT**
- 3) CT in finite element modeling**
- 4) roto-scoping**
- 5) development**

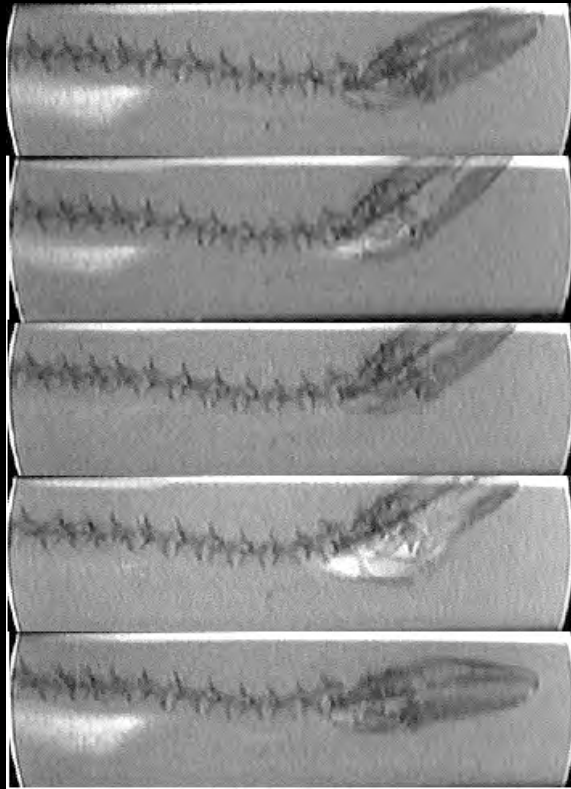
x-ray video – skeletal structures



x-ray negative images

“concertina” swallowing





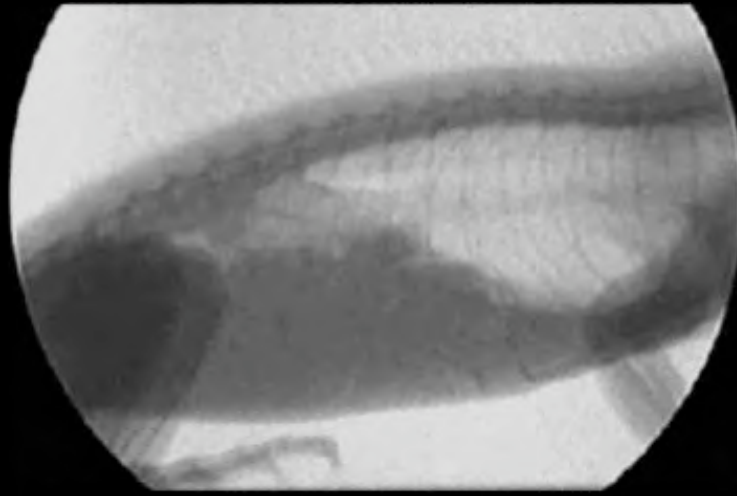
**image low density
gases**

**biomechanics of
breathing**

aspiration breathing



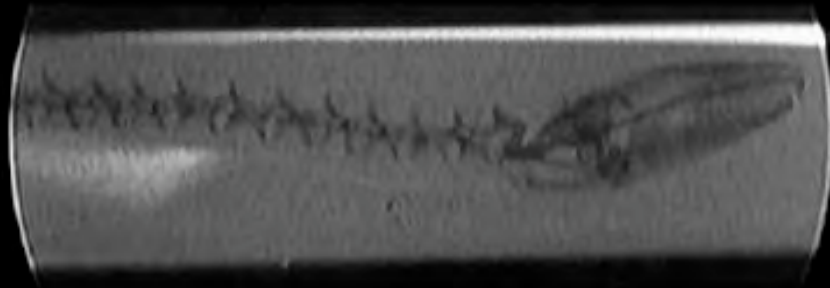
aspiration breathing



aspiration breathing



buccal pump breathing

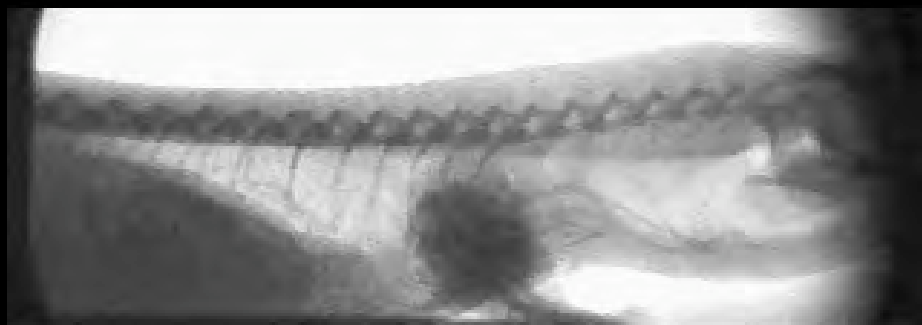


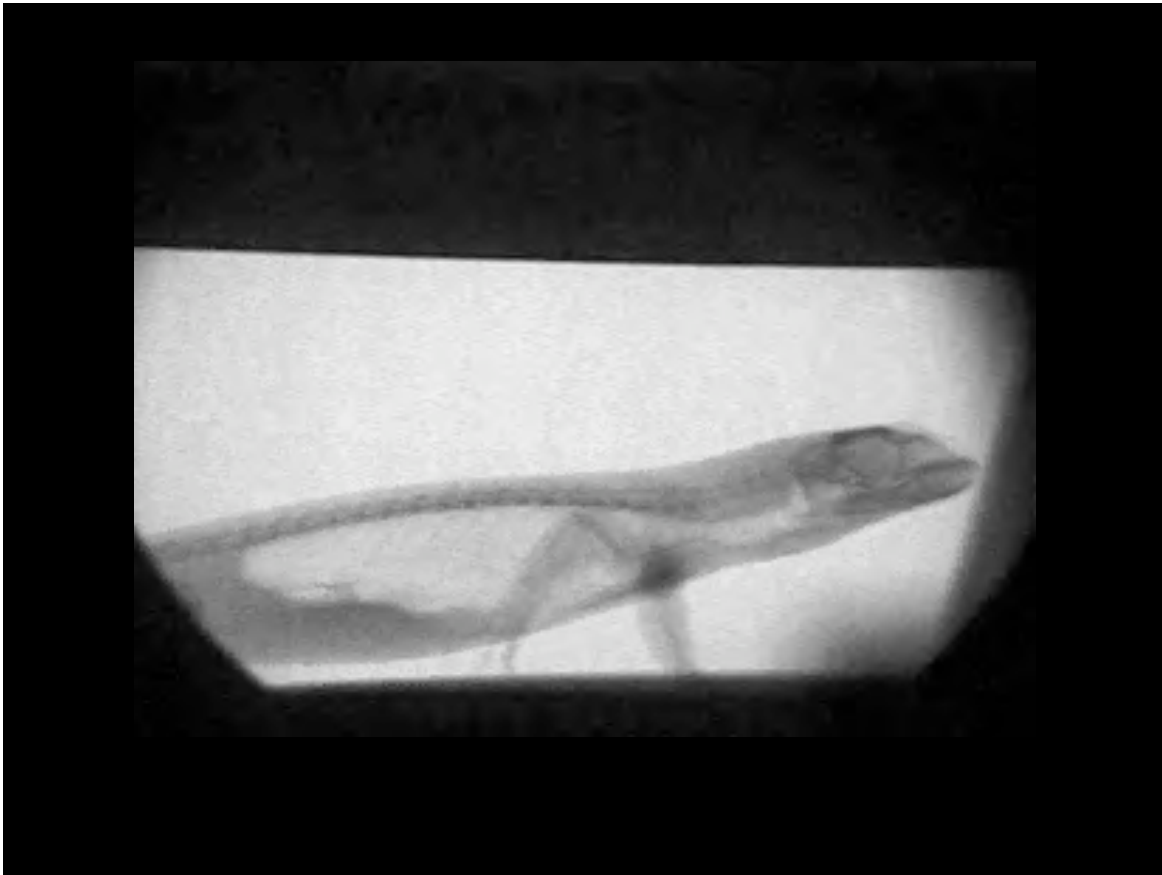
“recoil” aspiration breathing



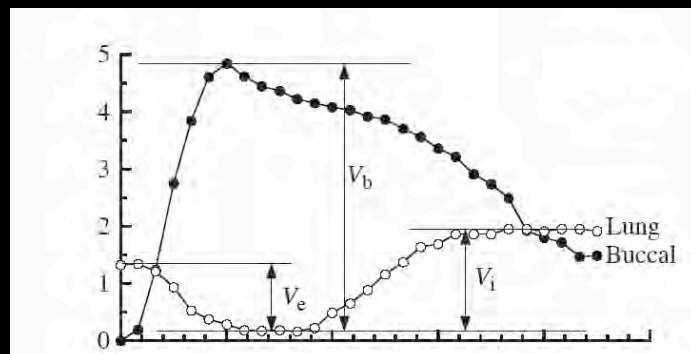
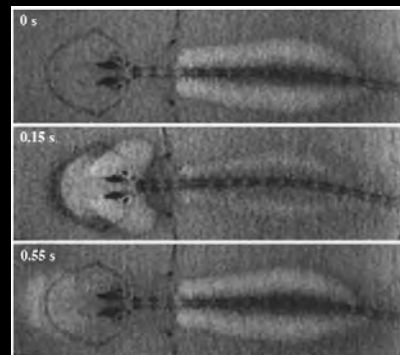
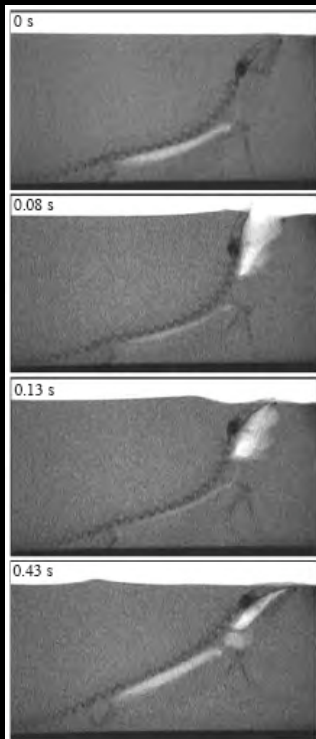
recorded at 200 frames per second

monitor lizard





quantitative measurements



X-ray CT and microCT

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Archaeopteryx

Archaeopteryx, the earliest known flying bird (avialan) from the Late Jurassic period, possessed asymmetrical flight feathers on its wings and tail, together with a wing feather arrangement shared with modern birds. This suggests some degree of powered flight capability but, until now, little was understood about the extent to which its brain and special senses were adapted for flight. The authors investigated this problem by computed tomography scanning and three-dimensional reconstruction of the braincase of the London specimen of *Archaeopteryx*. The results suggest that *Archaeopteryx* closely resembled modern birds in the dominance of the sense of vision and in the possession of expanded auditory and spatial sensory perception in the ear.

[more...]

Golden-Fronted Woodpecker

16-Jul-2004

Melanerpes aurifrons, the golden-fronted woodpecker, is a permanent resident in central Texas. These woodpeckers typically are found in temperate and tropical regions of North America and extend as far north as southwestern Oklahoma and south to the northern region of Nicaragua. The most striking feature of the skull is the hyoid apparatus (highlighted in red), which extends from its usual position just ventral to the lower mandible and wraps posteriorly around the skull to end between the orbits immediately dorsal to the base of the upper beak. This bony structure aids the woodpecker in extending its tongue extremely long distances in order to spear insects beneath bark or leaf litter.

[more...]

rapid prototyping



3D printer



20mm



20mm

Monodelphis

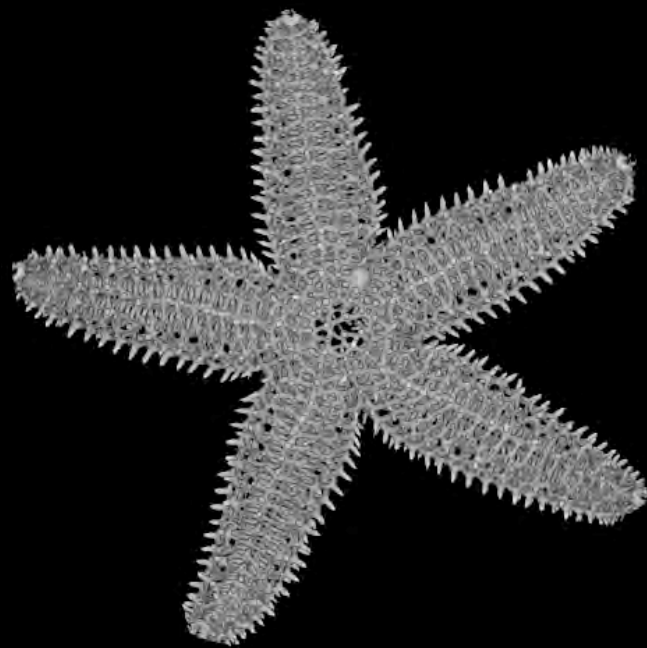
X-ray CT



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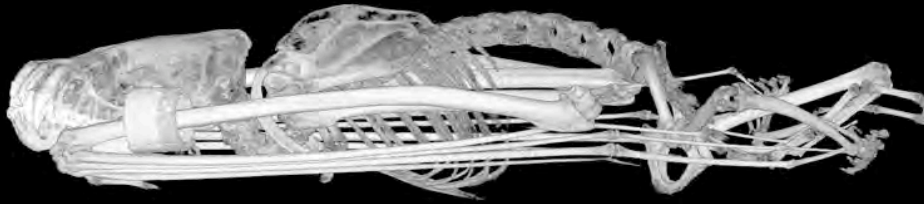
X-ray CT



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X-ray CT



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X-ray CT and finite-element modeling



University of Texas at Austin, Computed Tomography Lab,
DigiMorph Project, Tim Rowe, PI

rotoscoping

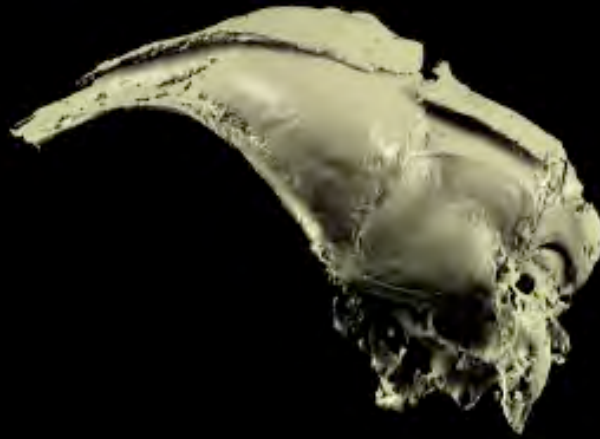


injected contrast agents



L. Whitmore, Ohio University
from Digimorph library

fossils – *Archaeopteryx*



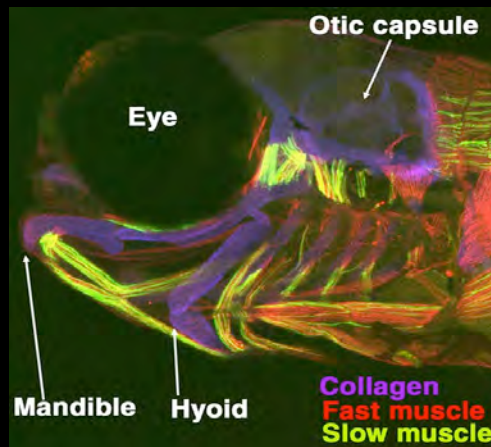
fossils – *Confuciusornis*



X-ray CT – summary

- skeletons, including fossils
- gas-filled spaces
- injected contrast agents
(e.g. circulatory system)
- *in vivo* x-ray CT

Developmental Biology



**confocal
microscopy**

image from L.P. Hernández

X-ray imaging, later stages



**chick embryo
10 days**

X-ray imaging, later stages



**chick embryo
20 days**

X-ray imaging in developmental biology

good for imaging skeletal development, circulatory system, gas-spaces

later stages of development than confocal microscopy

requirements:
high resolution ($10\mu\text{m}$)
ideally *in vivo*

Future uses of x-ray imaging and APS

biomechanics of vertebrate embryos and juveniles may be a good use of APS synchrotron imaging