CT Scanning of museum specimens: a case study of diversity from the inside out

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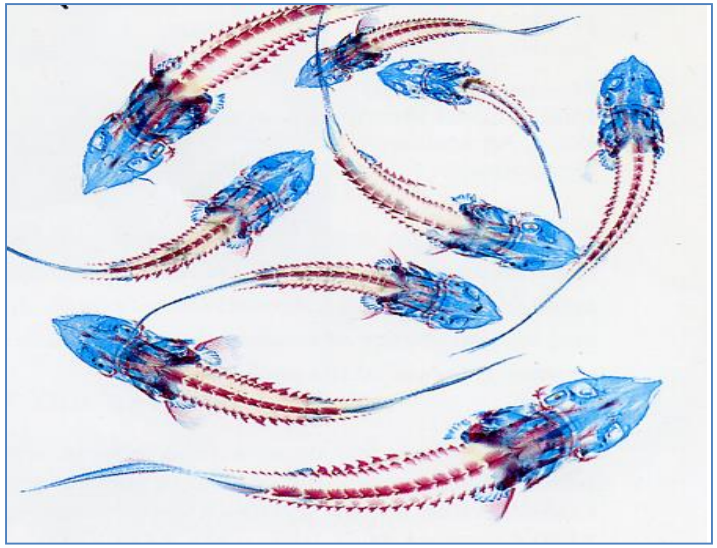
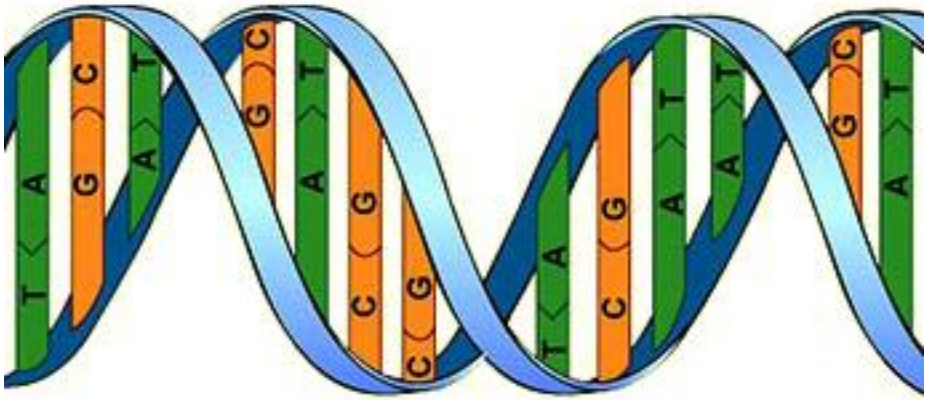
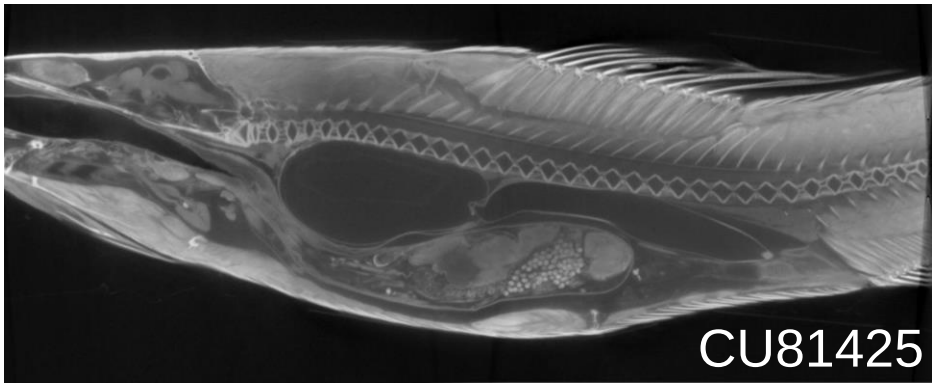
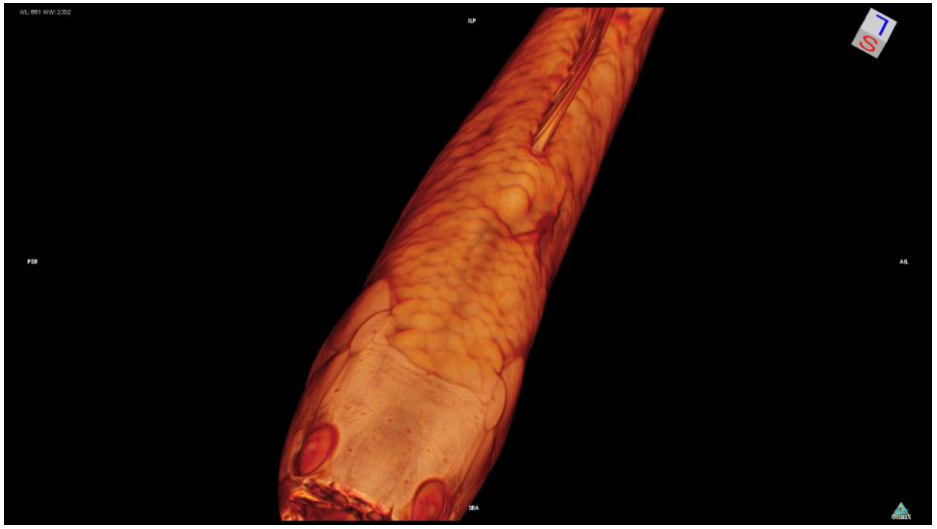
Evolutionary morphology and phylogenetics have long focused on:





Computed Tomography (CT) is being used increasingly for evolutionary morphology!

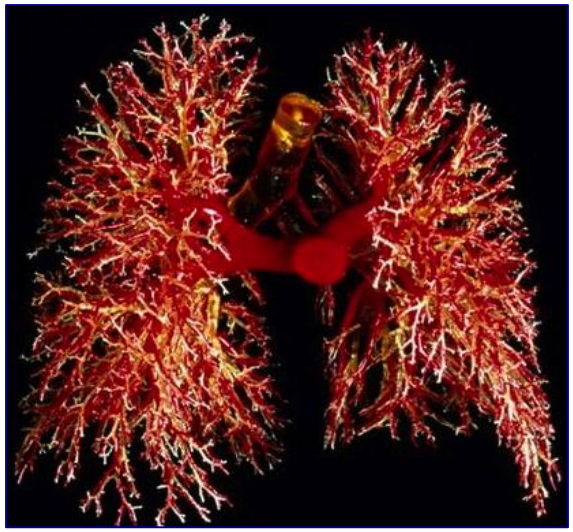


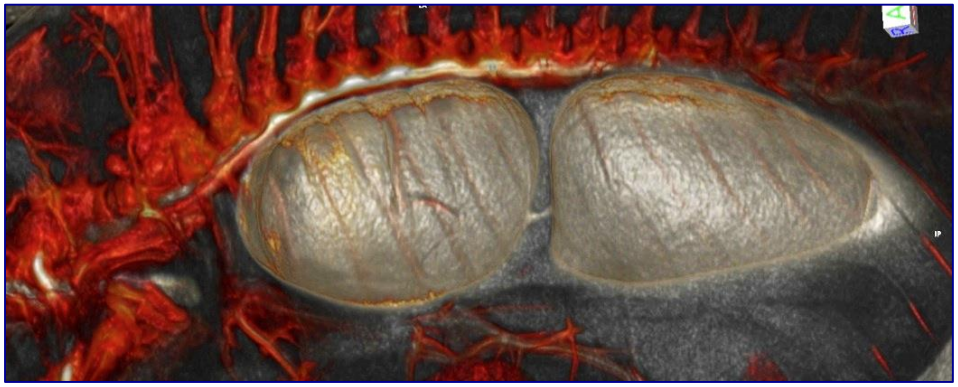


A charciform fish, *Hoplias*, collected ~1940s

but the extent and size of datasets present challenges to museum curators unlike any dissection ever did!

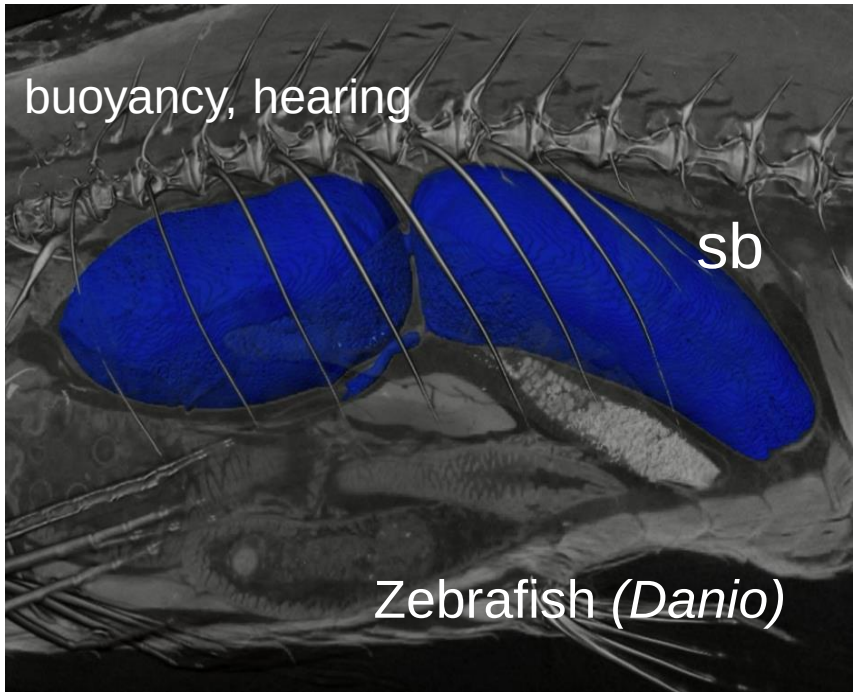
Today talk about a case study of anatomy using CT





Are gas bladders modified lungs?

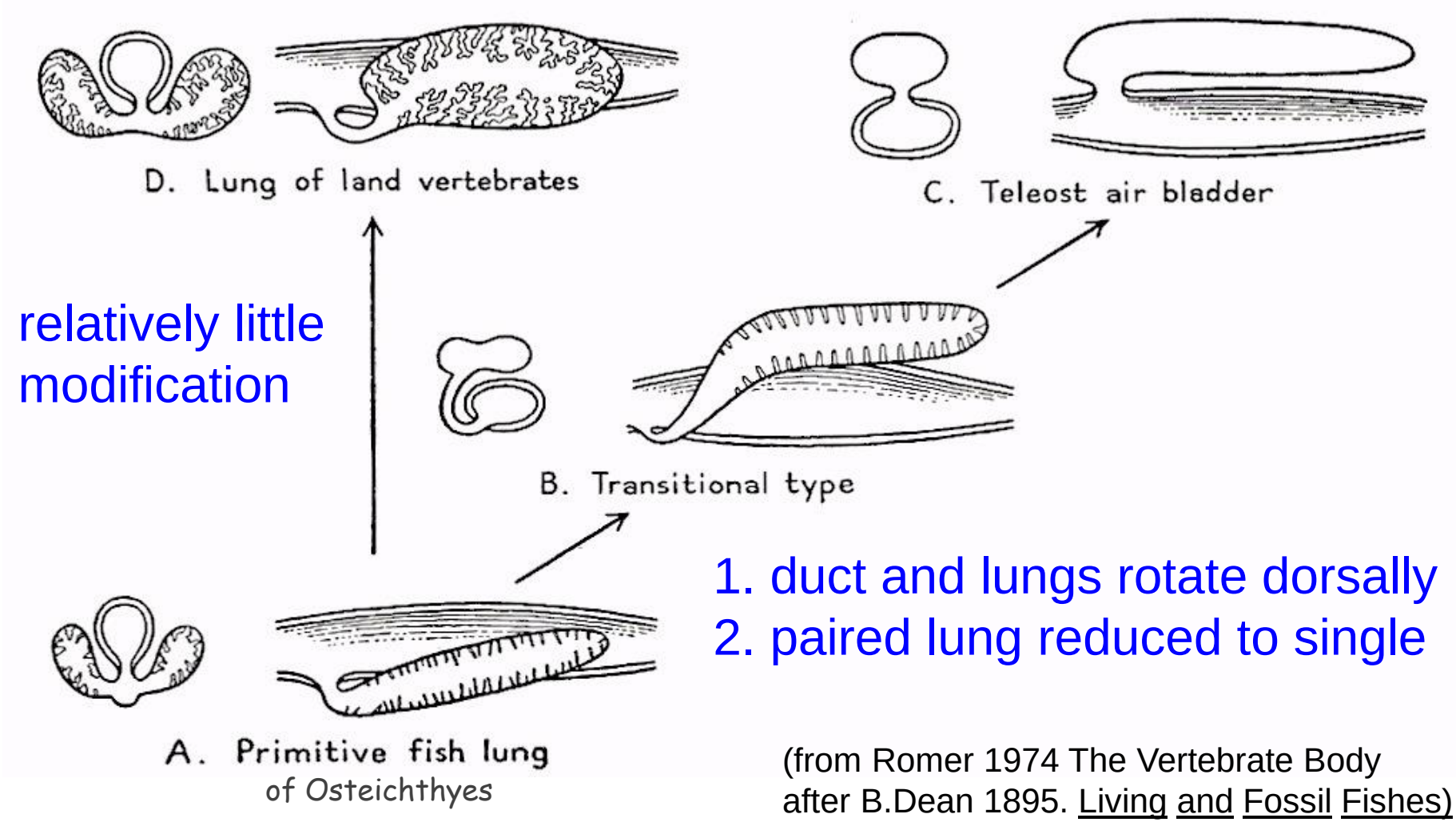
What is a gas bladder?



Functions: buoyancy, respiration, hearing, sound production

Orthodoxy: gas bladder is a modified lung

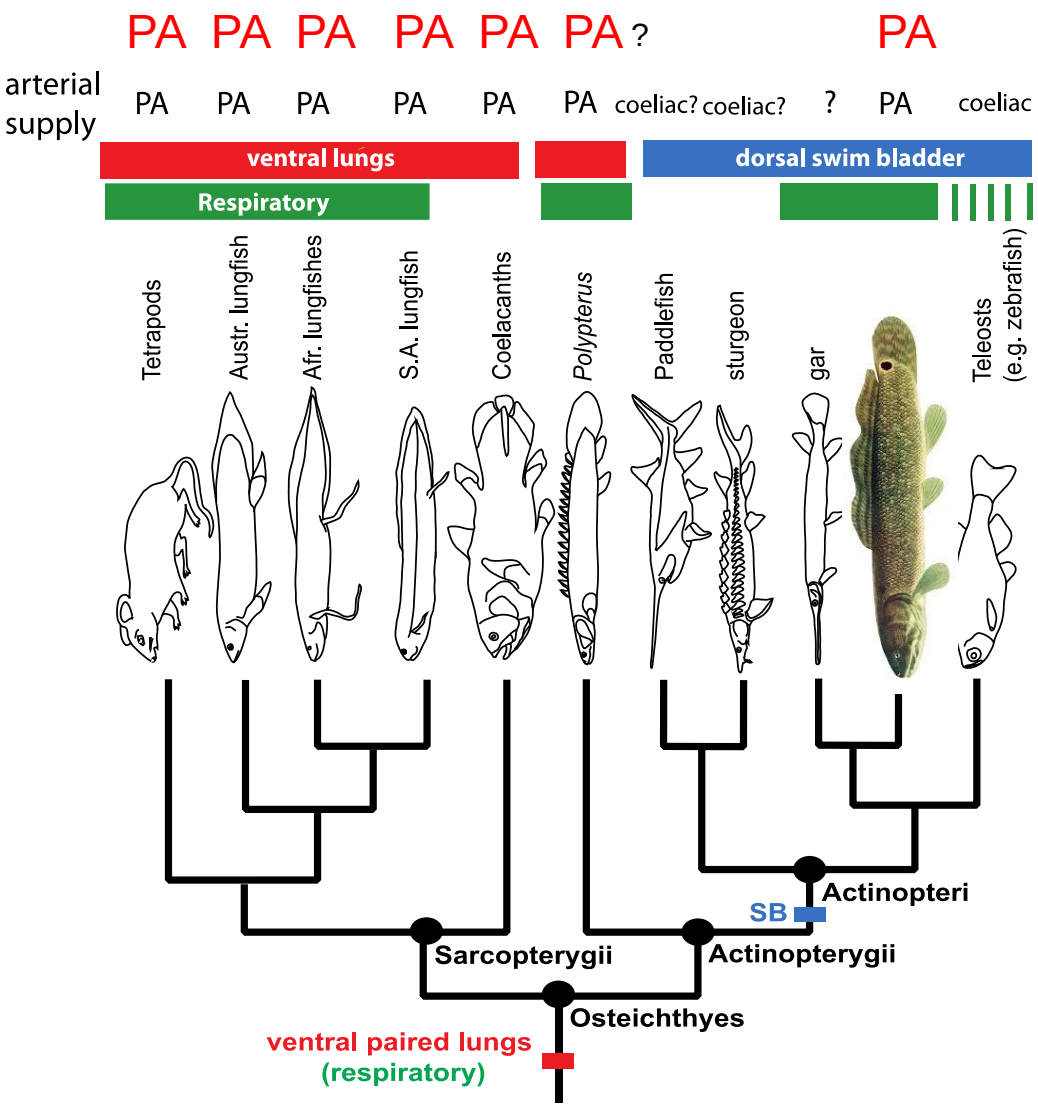
(but some controversy)



1. duct and lungs rotate dorsally
2. paired lung reduced to single

(from Romer 1974 The Vertebrate Body after B.Dean 1895. Living and Fossil Fishes)

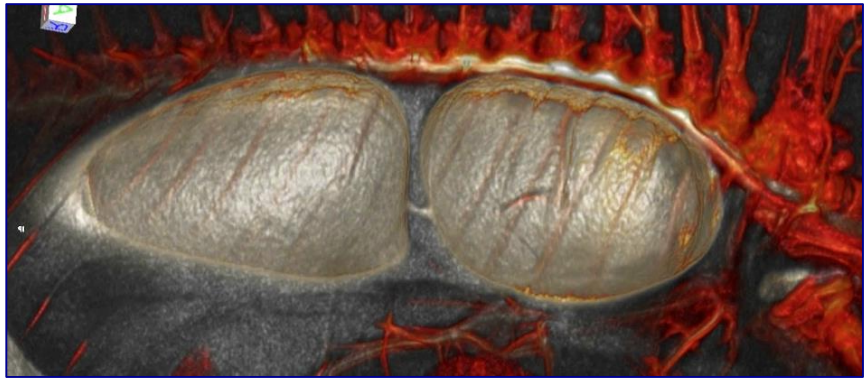
One source of controversy is the phylogentic distribution of the pulmonary artery supply

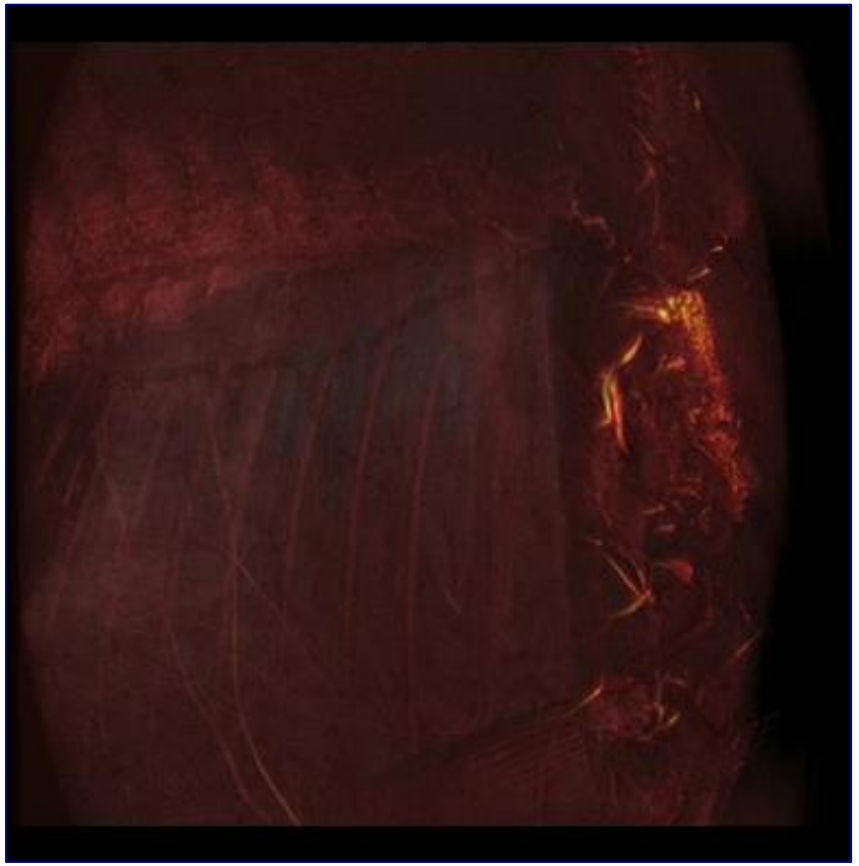


Is the bowfin pulmonary artery (PA) convergent or homologous?

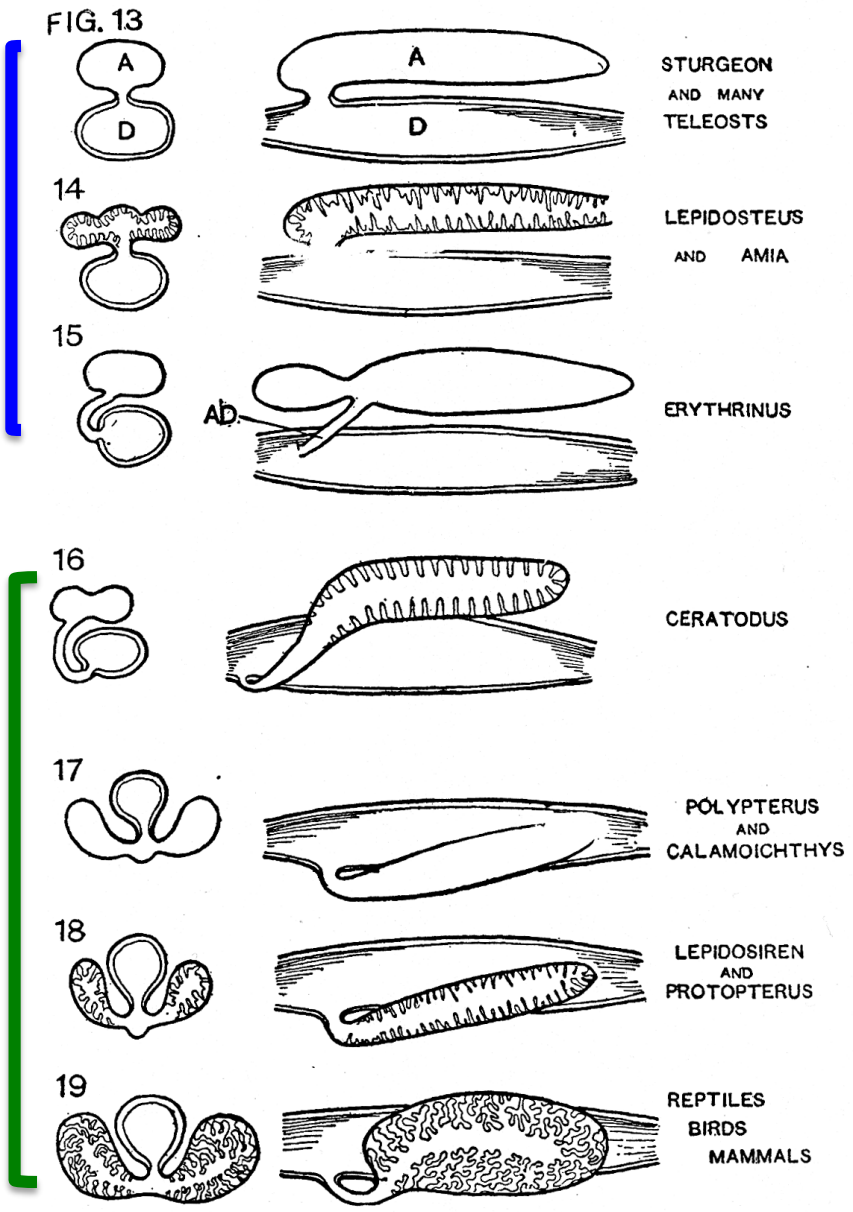
3-D study of the arterial supply in rayfinned fishes & lungfish

Injected barium into dorsal aorta of euthanized fish
Imaged with micro-CT (spatial res 50-100 microns)
Analyzed with Microview and Osirix.



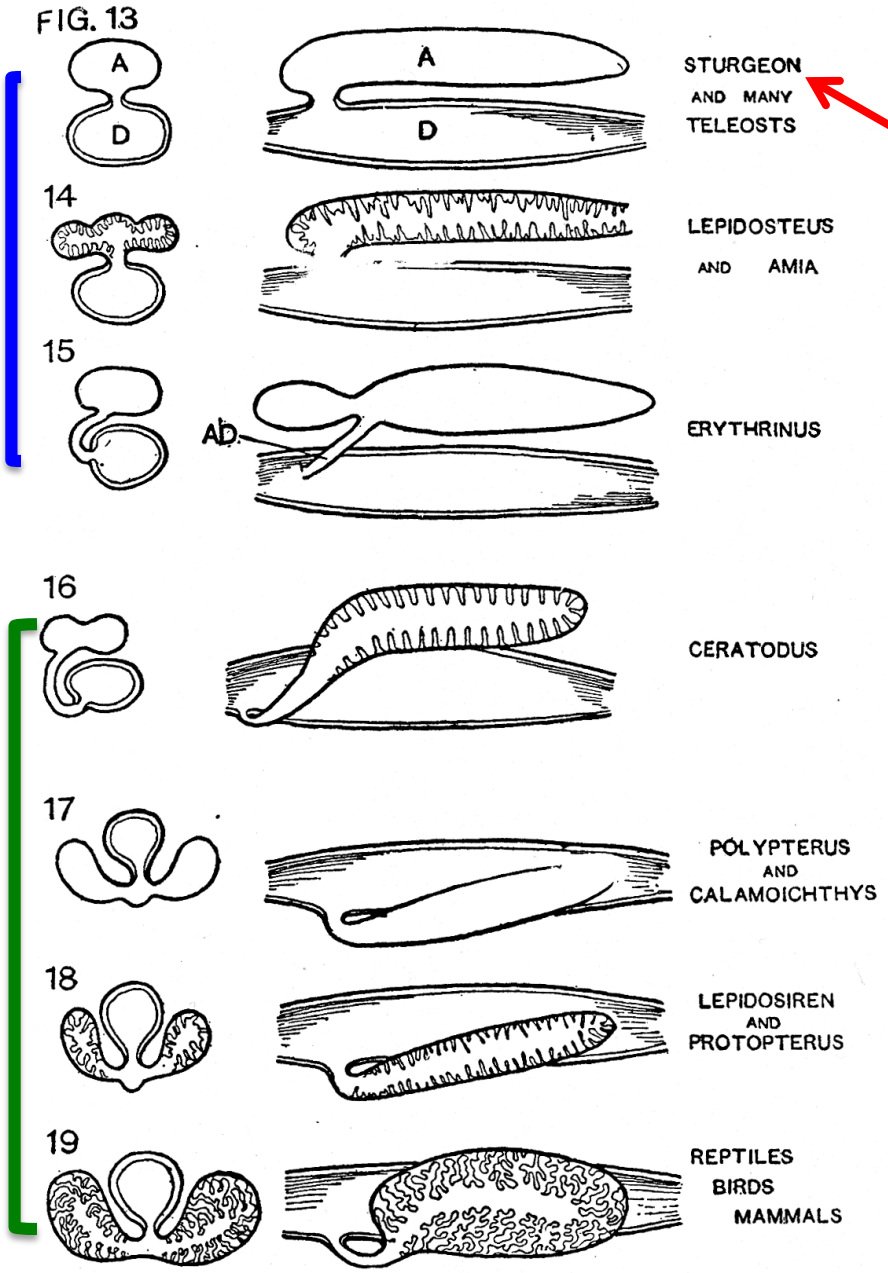


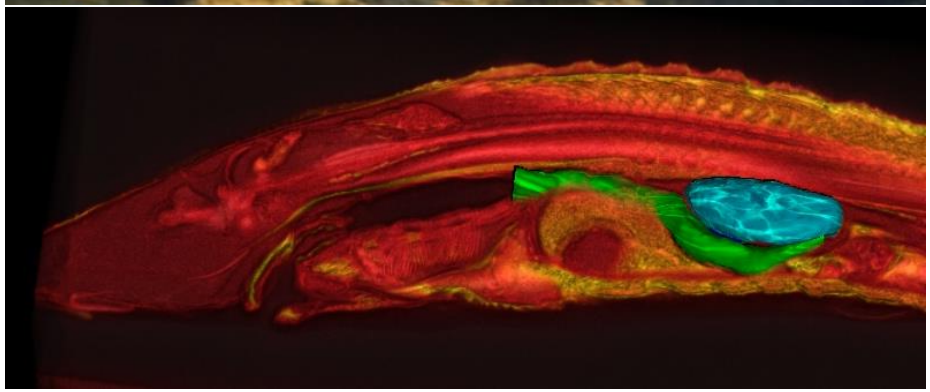
Using micro-CT to show what some AOs actually look like…

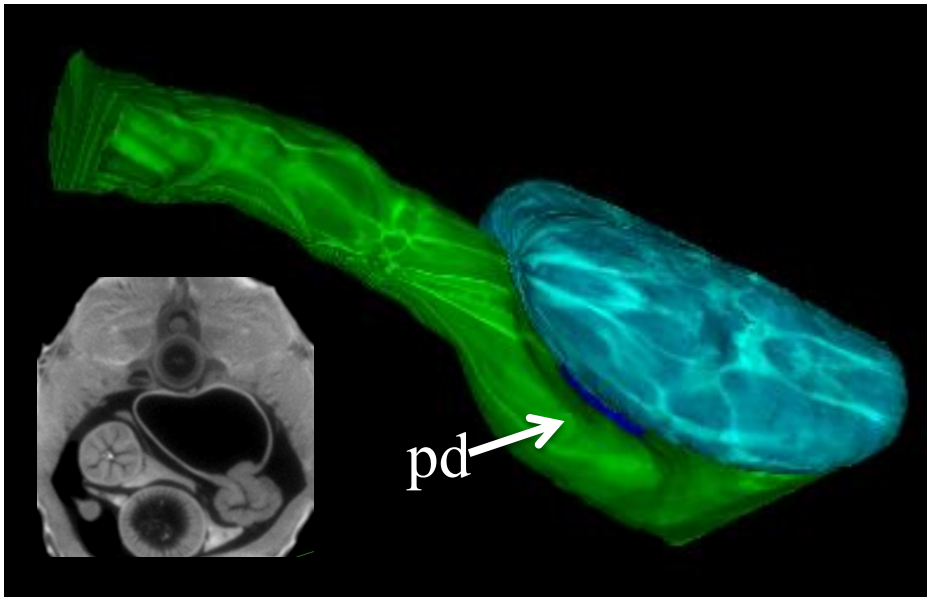


AO =air-filled organ, a collective term for lungs & gas bladders

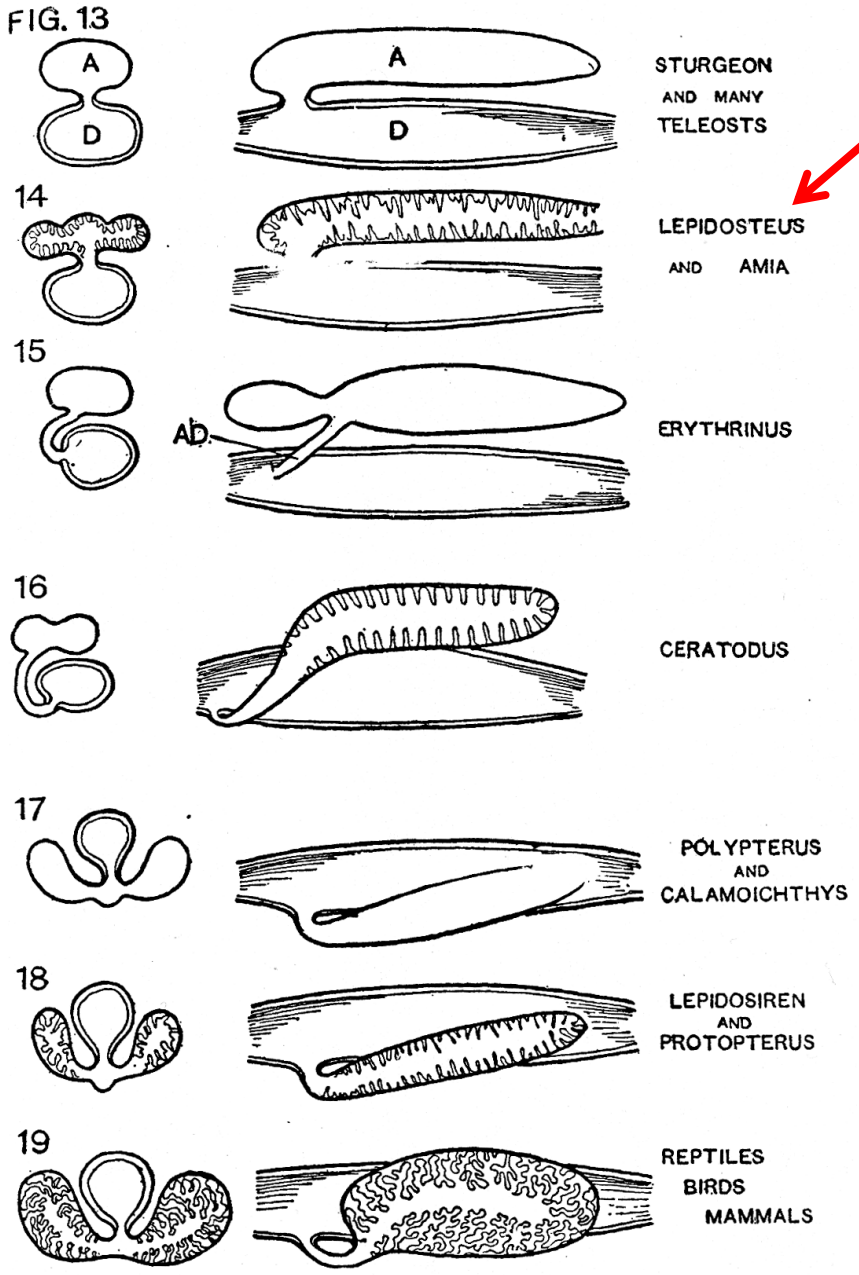
Sturgeon (*A. transmontanous*)

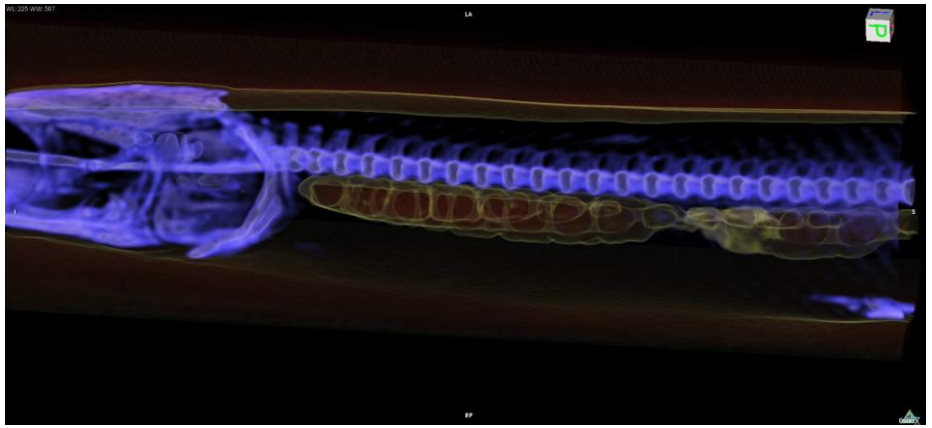


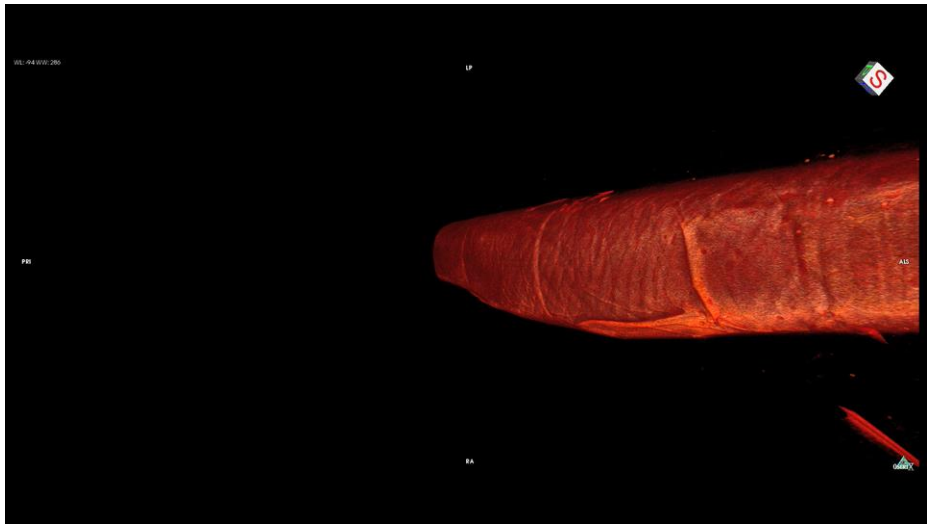




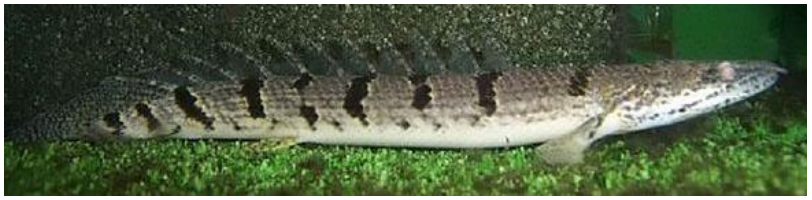
Gar *(L. platyrhynchus)*







lungs of bichir *(Polypterus ornatipinnis)*



dorsal view

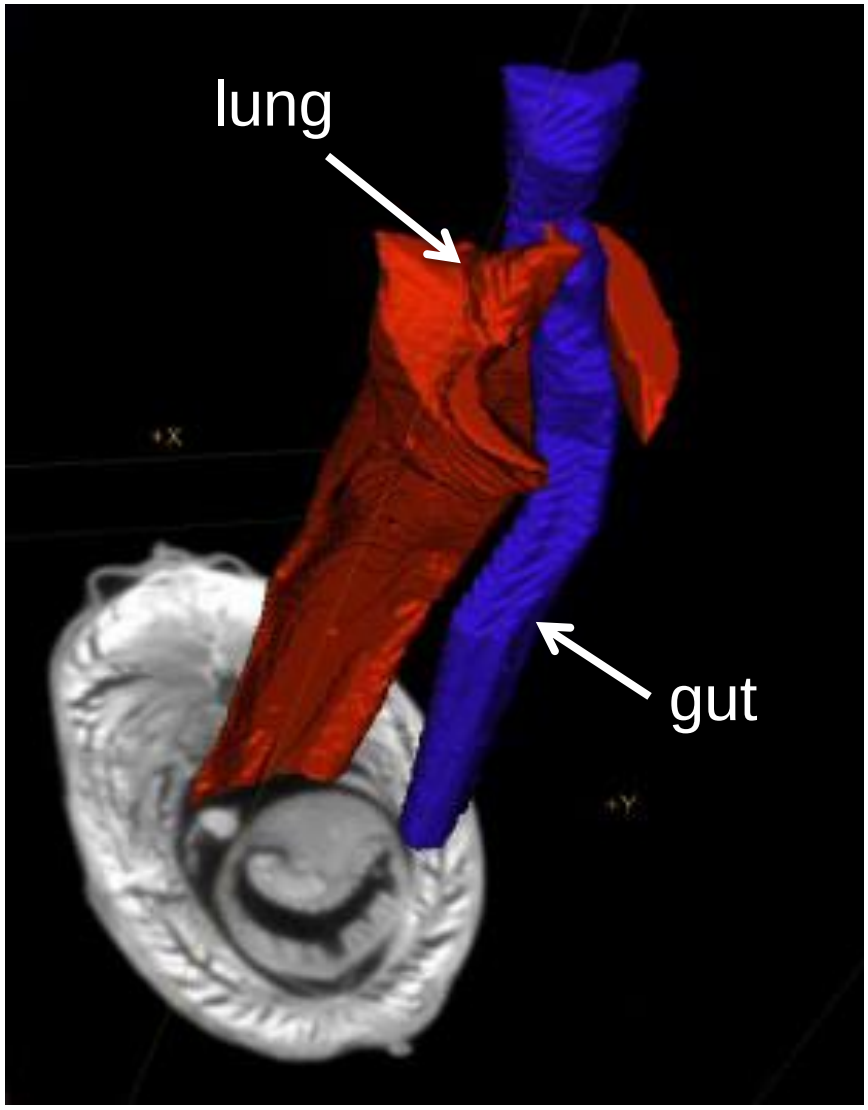
lungs

gut

lateral view

ventral view

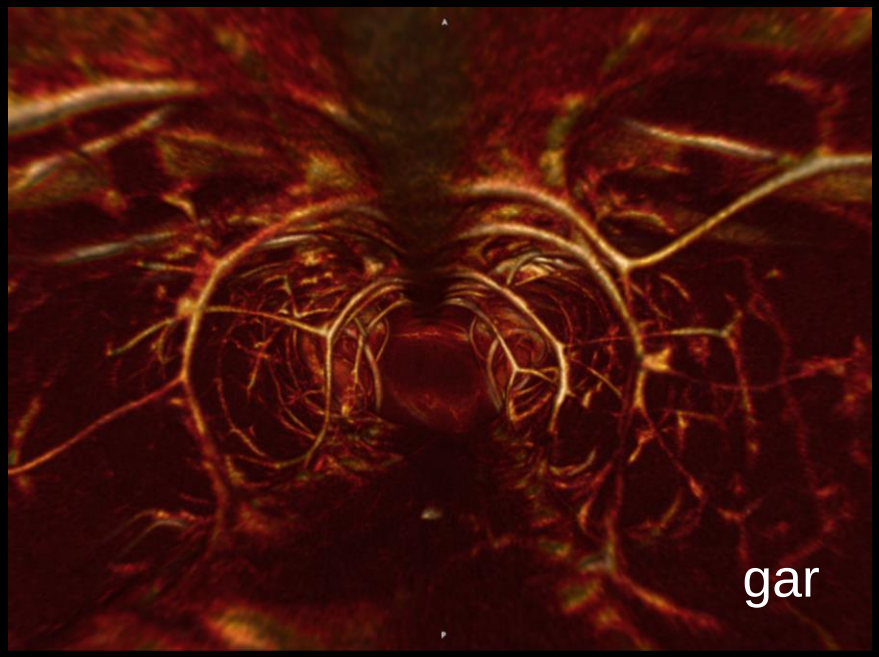
African lungfish (*Protopterus dolloi*)



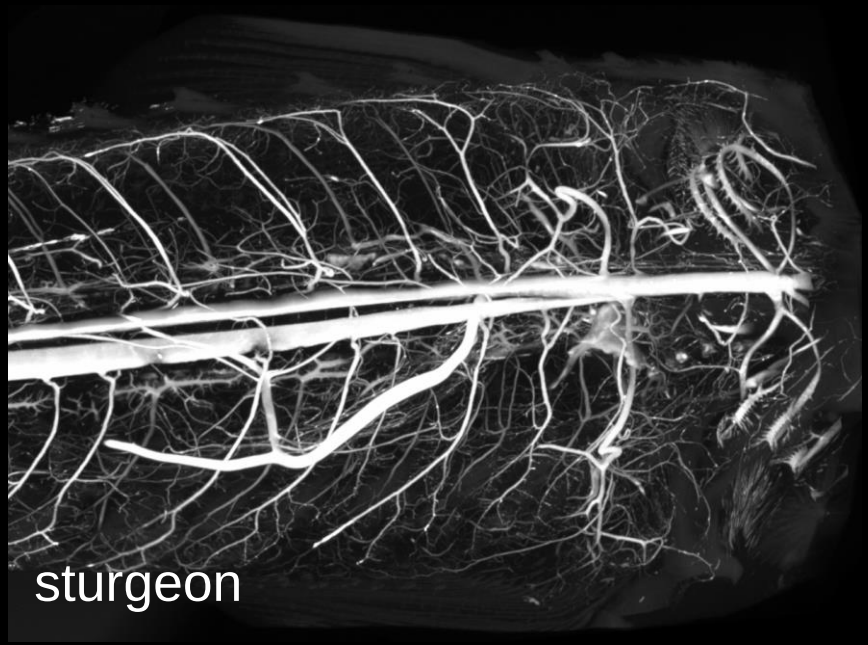
- Duct connects ventrally
- Lung largely dorsal
- Very long (98% coelom)
- Vesicular internally

Micro-CTs of injected fish

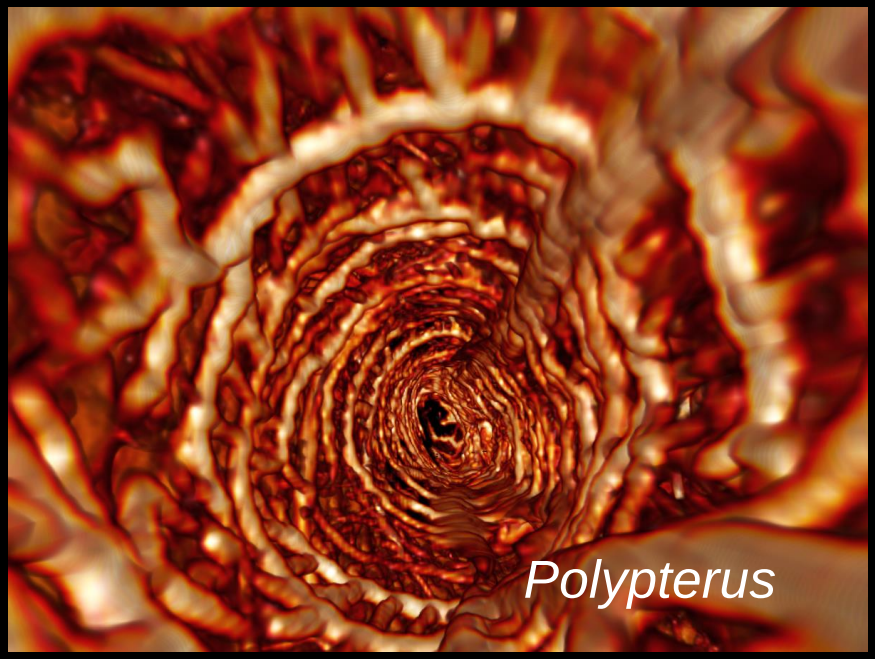
lungfish



gar



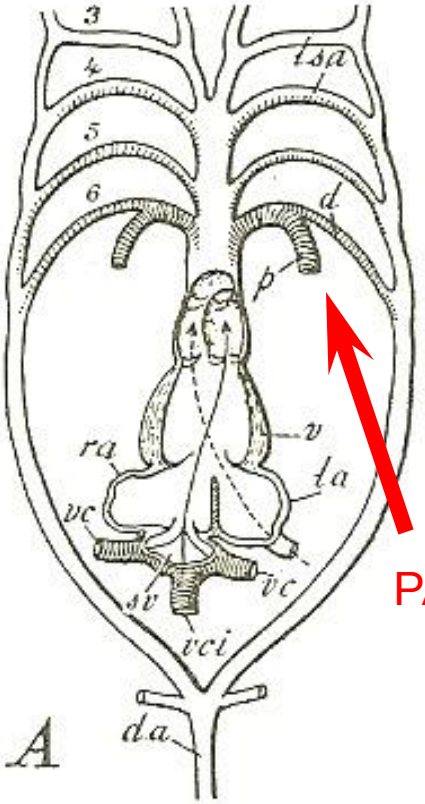
sturgeon



Polypterus

Pulmonary arteries branch off the 4th efferent branchial artery

anterior

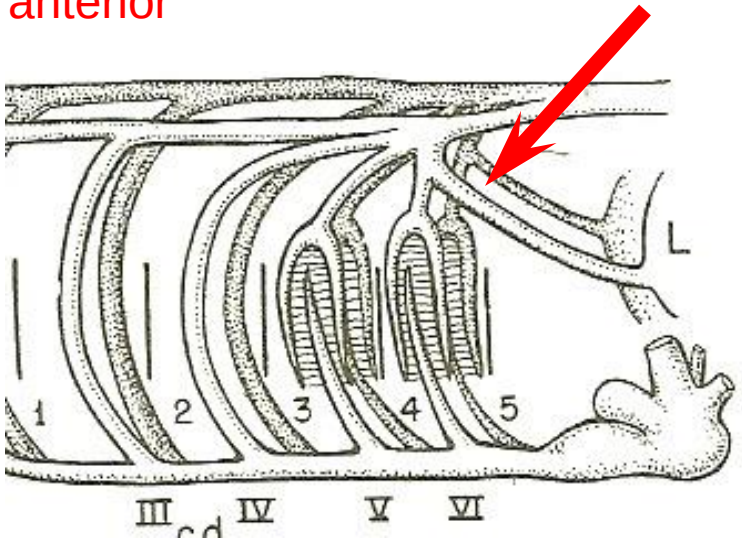


PA

dorsal view

amphibian

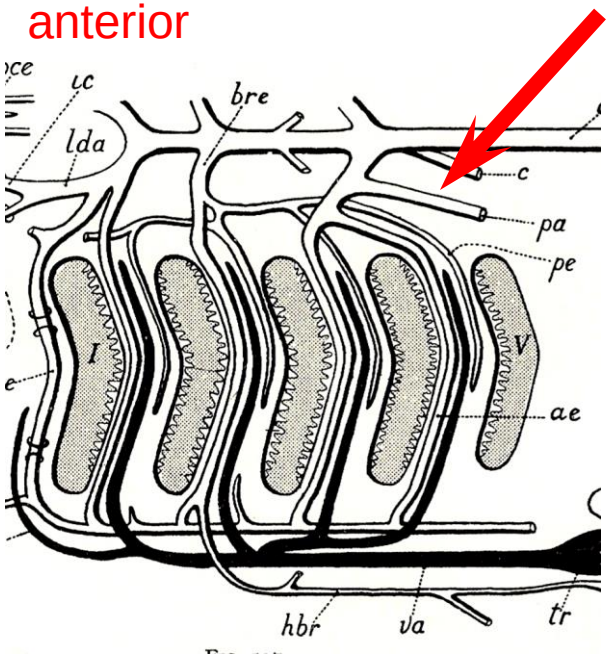
anterior



lateral view

African lungfish

anterior

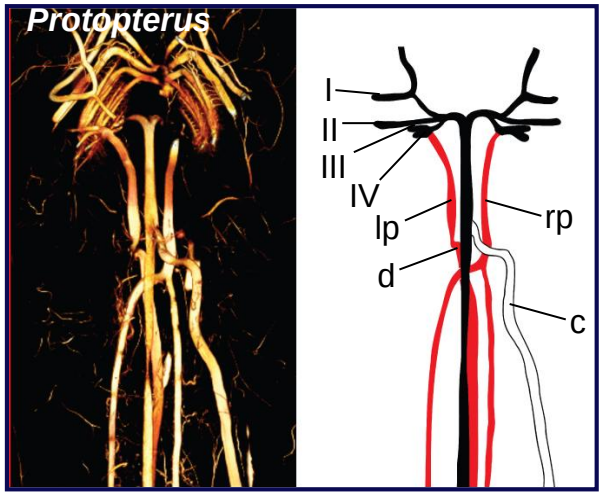


lateral view

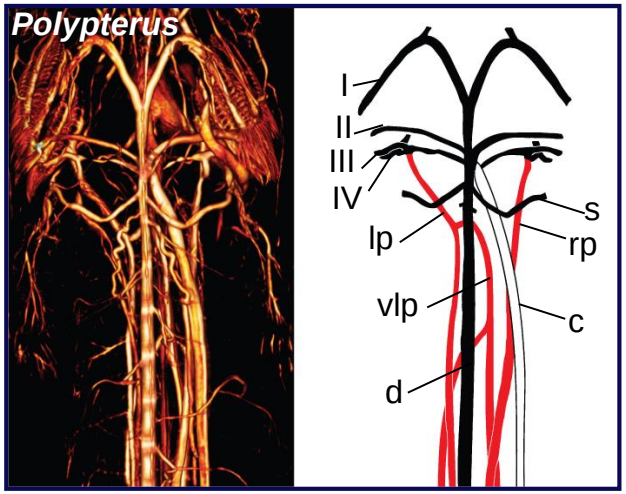
bowfin

Comparative study of arterial vasculature

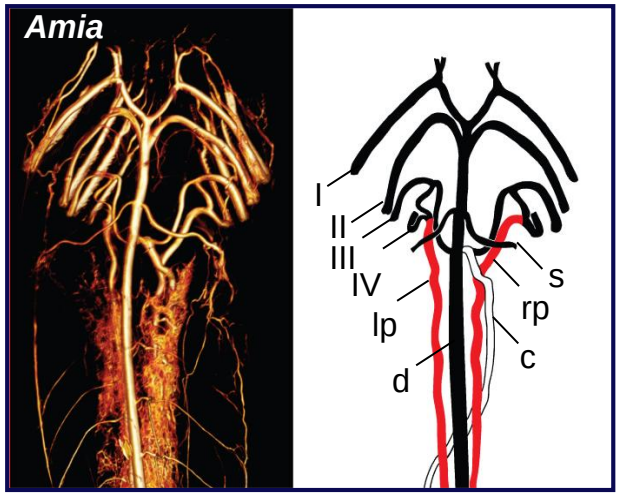
African lungfish

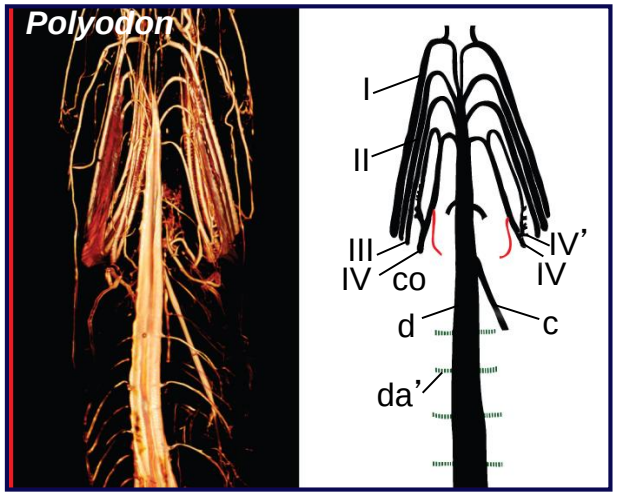


bichir

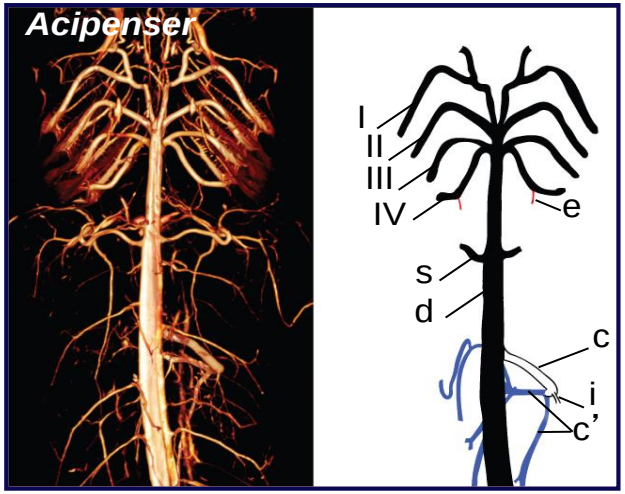


bowfin

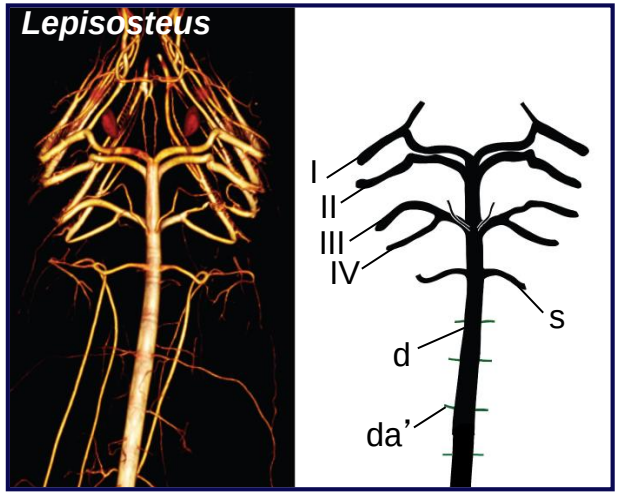




paddlefish



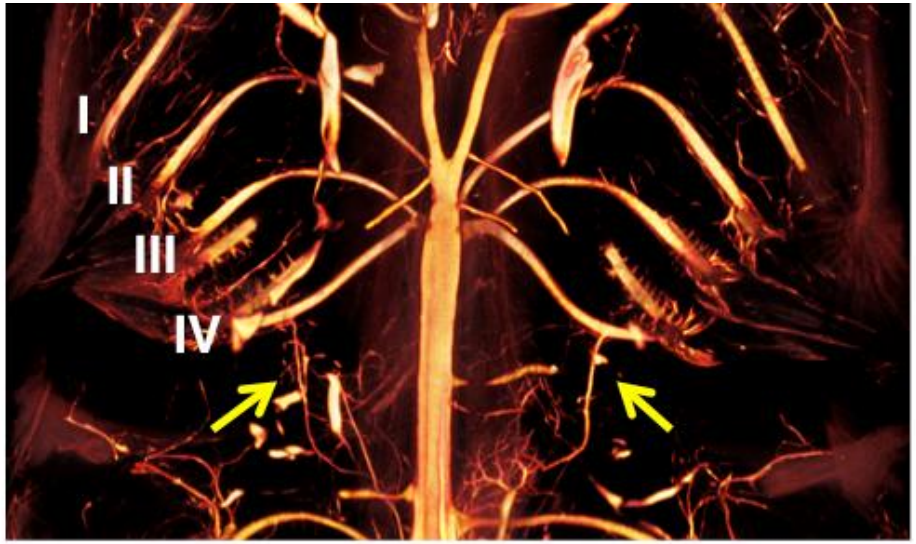
sturgeon



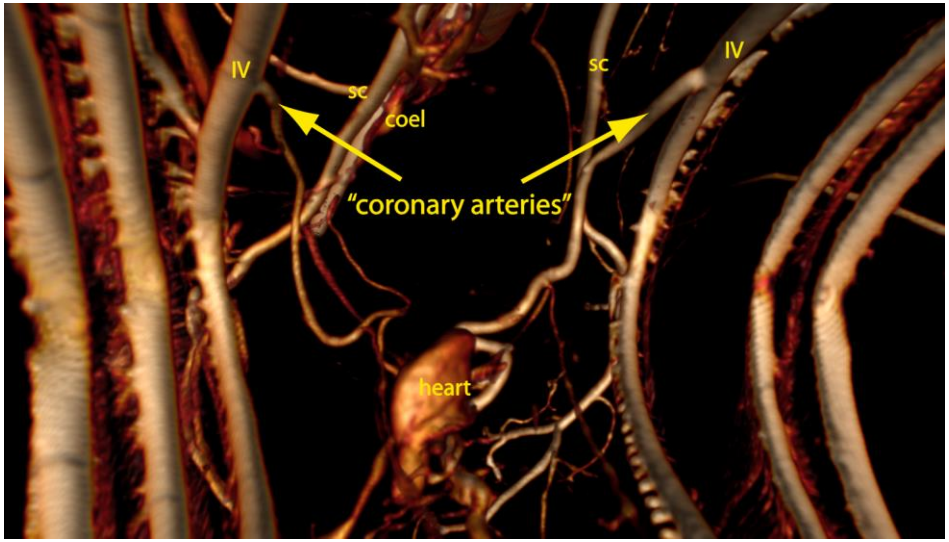
gar

From Longo, Riccio, and McCune 2013

Sturgeon and paddlefish have small arteries which branch off the 4th branchial efferent arteries



Esophageal arteries in *Acipenser* (arrows)

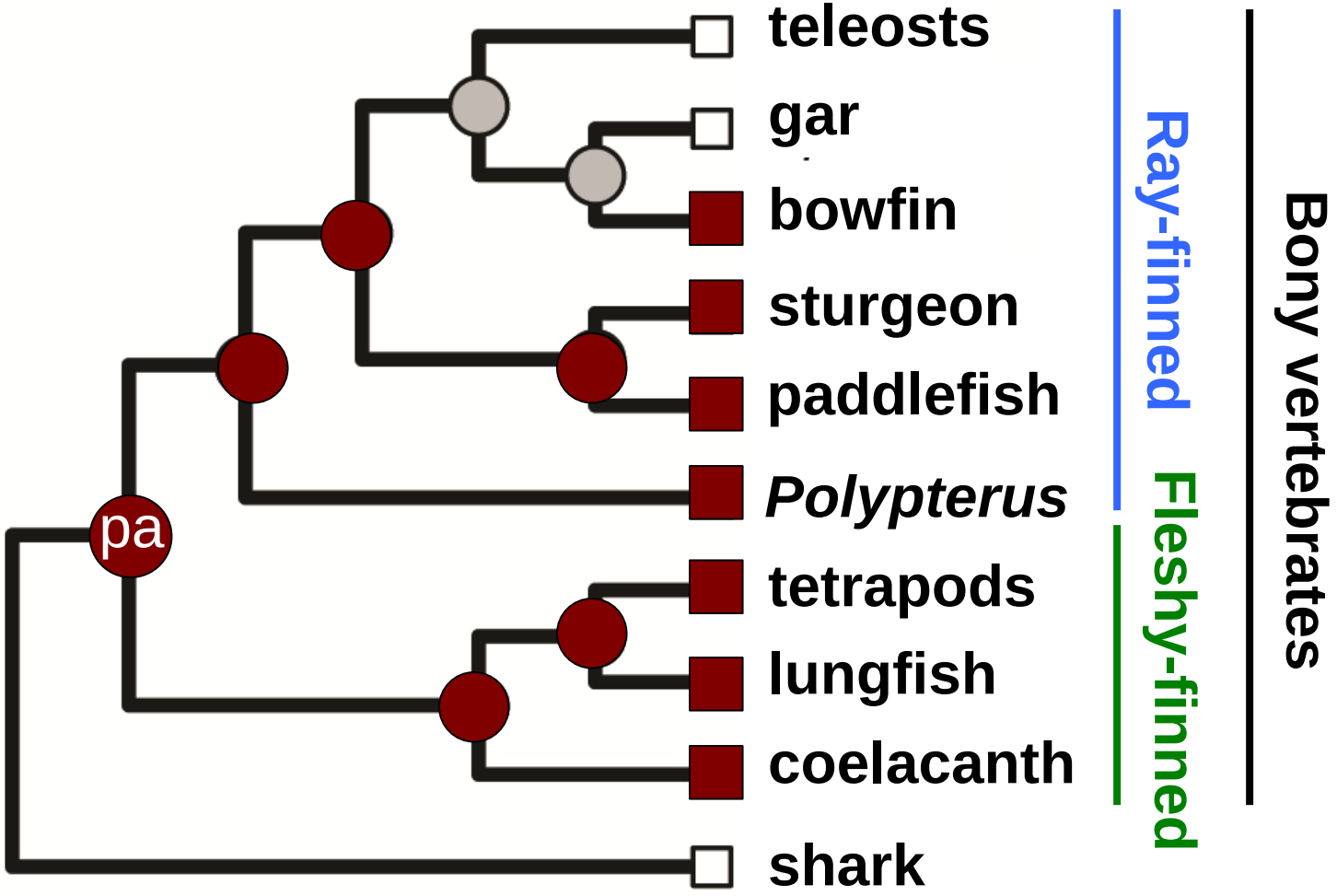


Coronary arteries in *Polyodon* (arrows)

Are these vestigial pulmonary arteries?

Longo, Riccio & McCune 2013

Bowfin PAs are homologous not convergent
PAs are synapomorphy of Osteichthyes



Ancestral states with R, using Max. Parsimony Reconstruction in APE package (Paradis 2004).

One project generated:

~12 jars

and

100.43 GB of CT data

(49,966 items)

of associated data

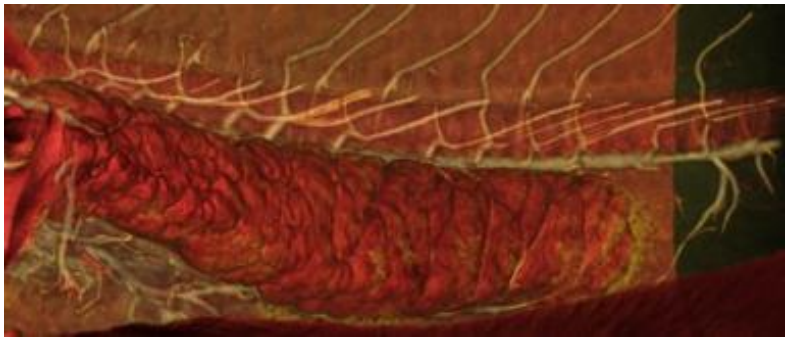
Acknowledgements

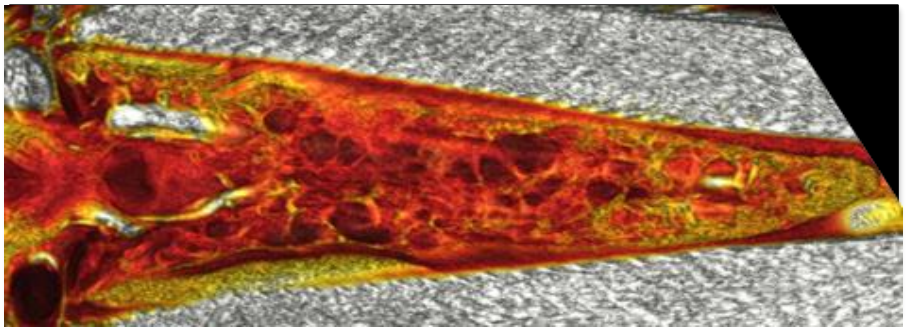
Collaborators:
Sara Longo (undergraduate thesis, Mark Riccio)

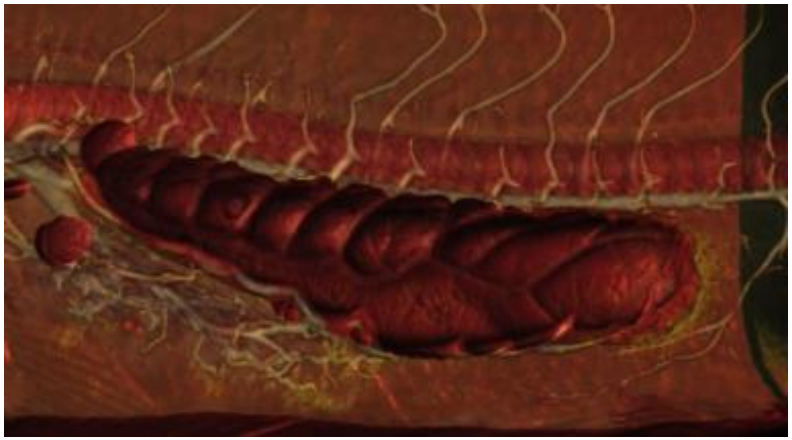
For help obtaining specimens:
Jan Hoover and Steven George, U.S. Army Engineer Research and Development Center, Waterways Experiment Station

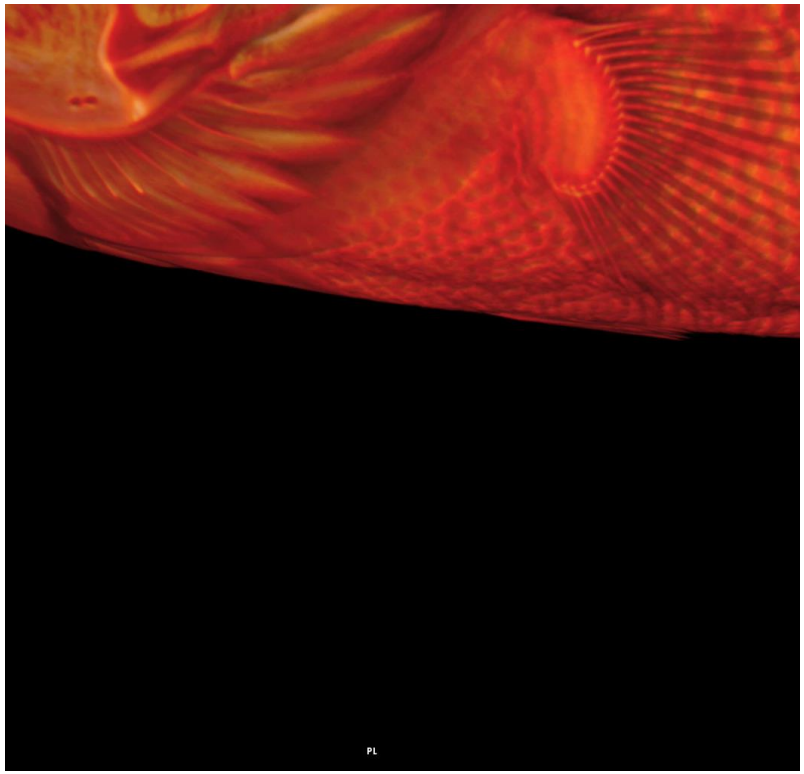
- Carl Rathjee, NY State D.E.C. Constantia Fish Hatchery
- Glenn Northcutt, Scripps Institute of Oceanography
- Charles Dardia, John Friel, Cornell Museum of Vertebrates.

Amia: dorsal AO is long (~70% coelom), bilobed, and vesicular internally.



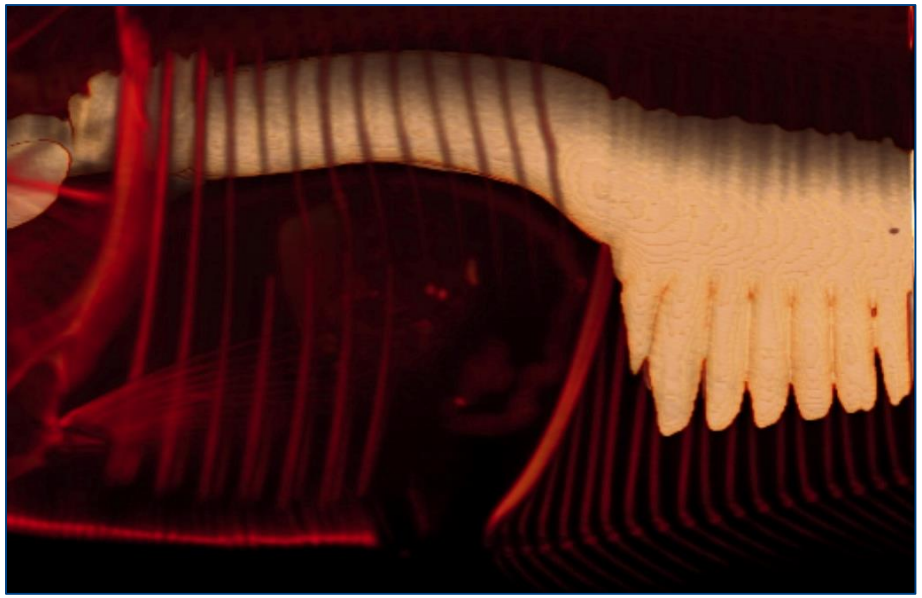




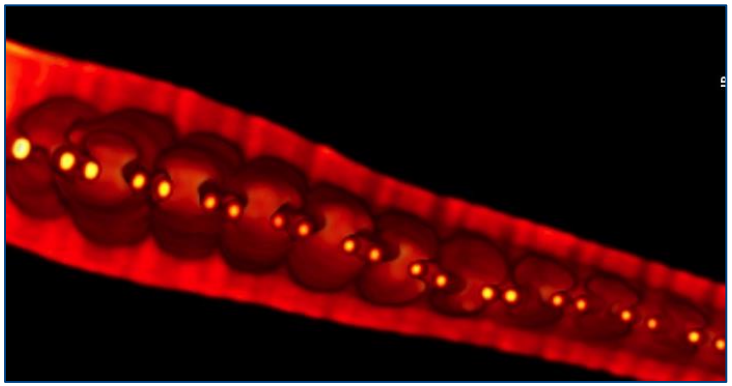


Endoscopy !

Swim bladder morphology is also diverse:



Chitala chitala



Soft tissue has been used some, but not extensively