



The University of Texas at Austin
Environmental Science Institute

Hot Science - Cool Talk # 125

A Dinosaur's Roar

Dr. Julia Clarke

April 7, 2023

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A dinosaur's roar

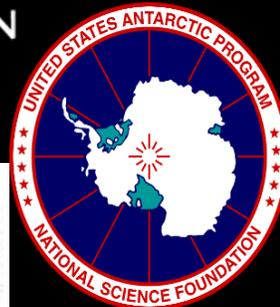


Dr. Julia Clarke

Wilson Professor in Vertebrate Paleontology
Jackson School of Geosciences
The University of Texas at Austin



GORDON AND BETTY
MOORE
FOUNDATION





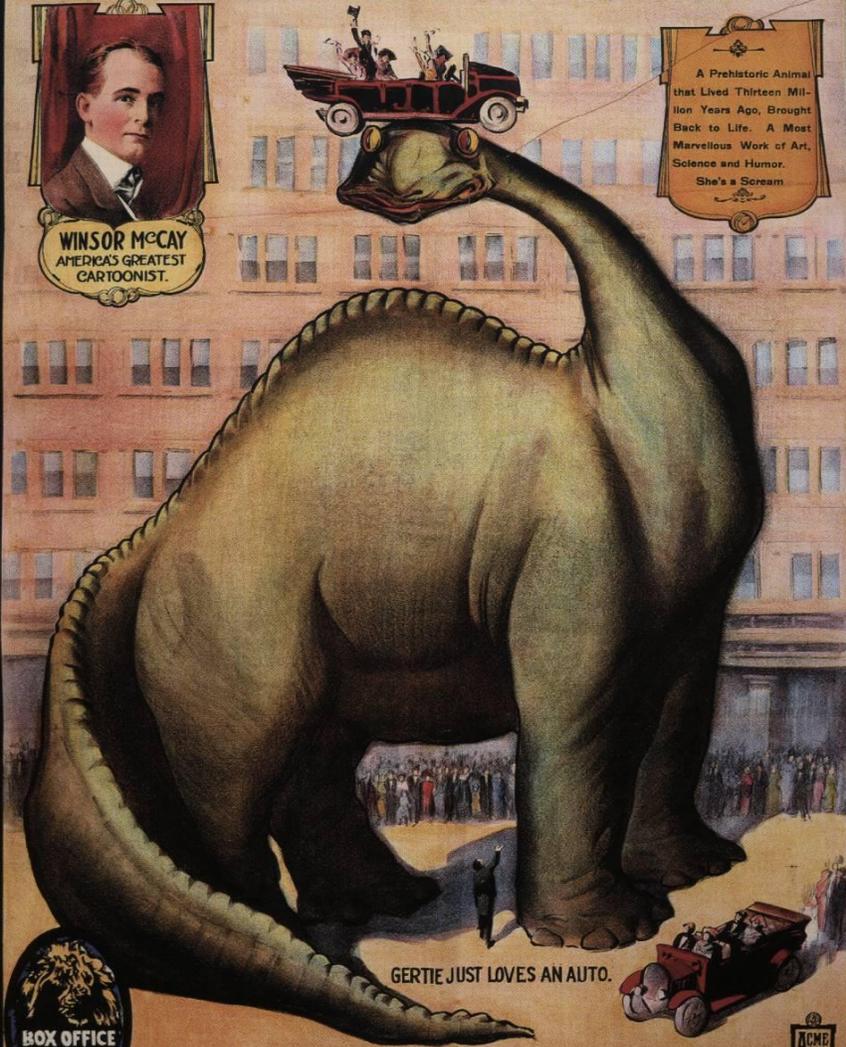
WINSOR McCAY'S "GERTIE"

WONDERFULLY TRAINED DINOSAURUS



WINSOR McCAY
AMERICA'S GREATEST
CARTOONIST.

A Prehistoric Animal
that Lived Thirteen Mil-
lion Years Ago, Brought
Back to Life. A Most
Marvelous Work of Art,
Science and Humor.
She's a Scream.



GERTIE JUST LOVES AN AUTO.



Released through **BOX OFFICE ATTRACTION CO.**
WILLIAM FOX, PRESIDENT. EXCHANGES IN ALL PRINCIPAL CITIES.



The Valley of Gwanji, 1969
Ray Harryhausen





Roar!!?



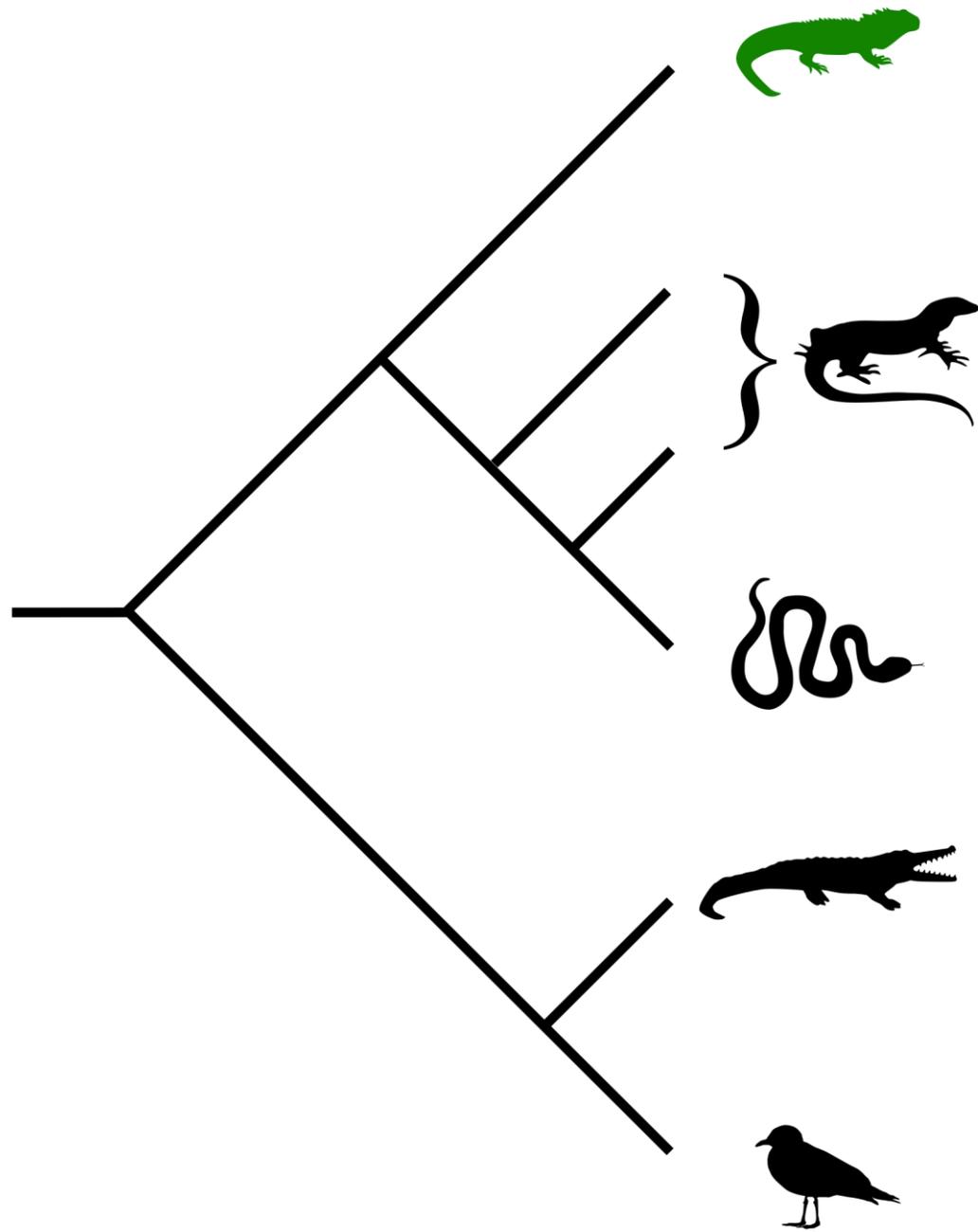
So how do we *start* to think about dinosaur sounds?

What are living animals we *should* be looking at-
that are closely related to dinosaurs?

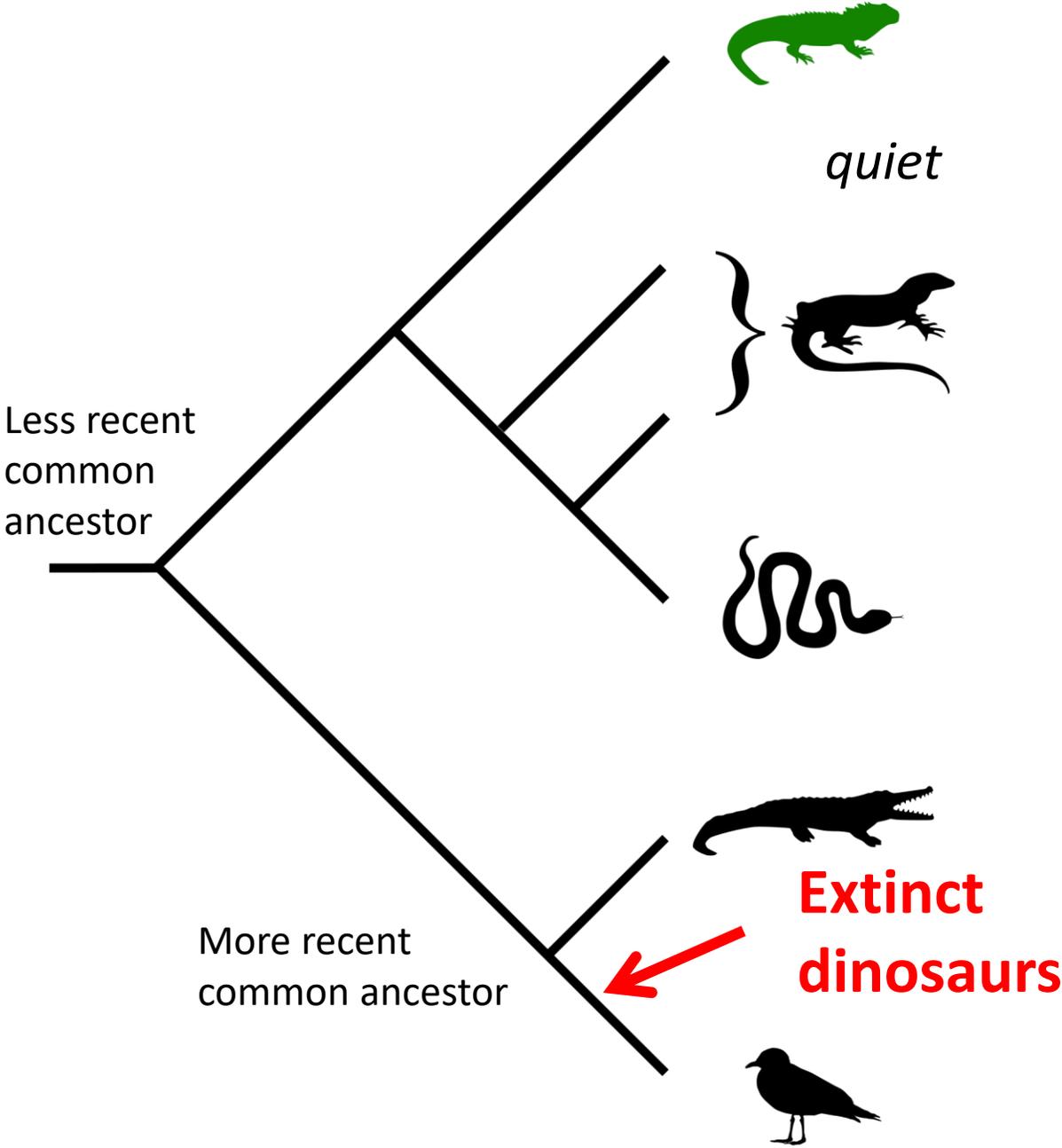


The Age of the Comet ascertained to a Nicety. The Antediluvians Recognise an Old Acquaintance of A.M. 1372.





How these animals are related (or not so related)





Living dinosaur

Closest living cousins of dinosaurs



SOUND LAYERS

- 00:00 SONIC BOOMS
- 00:24 REDWOOD TREES
- 00:37 WHALE BLOWHOLE
- 00:44 ALLIGATOR
- 00:59 LION
- 01:12 BABY ELEPHANT
- 01:44 COMPOSITE MIX
- 02:00 FINAL MIX
- 02:24 **GARY RYDSTROM COMMENTARY**

INDEPTHSOUND.COM

JURASSIC PARK

SOUND DESIGN COMMENTARY

ACTUAL SOUNDS FROM THE FILM



GARY RYDSTROM COMMENTARY

What do we know about the sounds cousins of dinosaurs and living dinosaurs actually make?

Noisy! Communication between babies and parents





Attracting a mate

Not right before a meal





Much closer relatives of dinosaurs



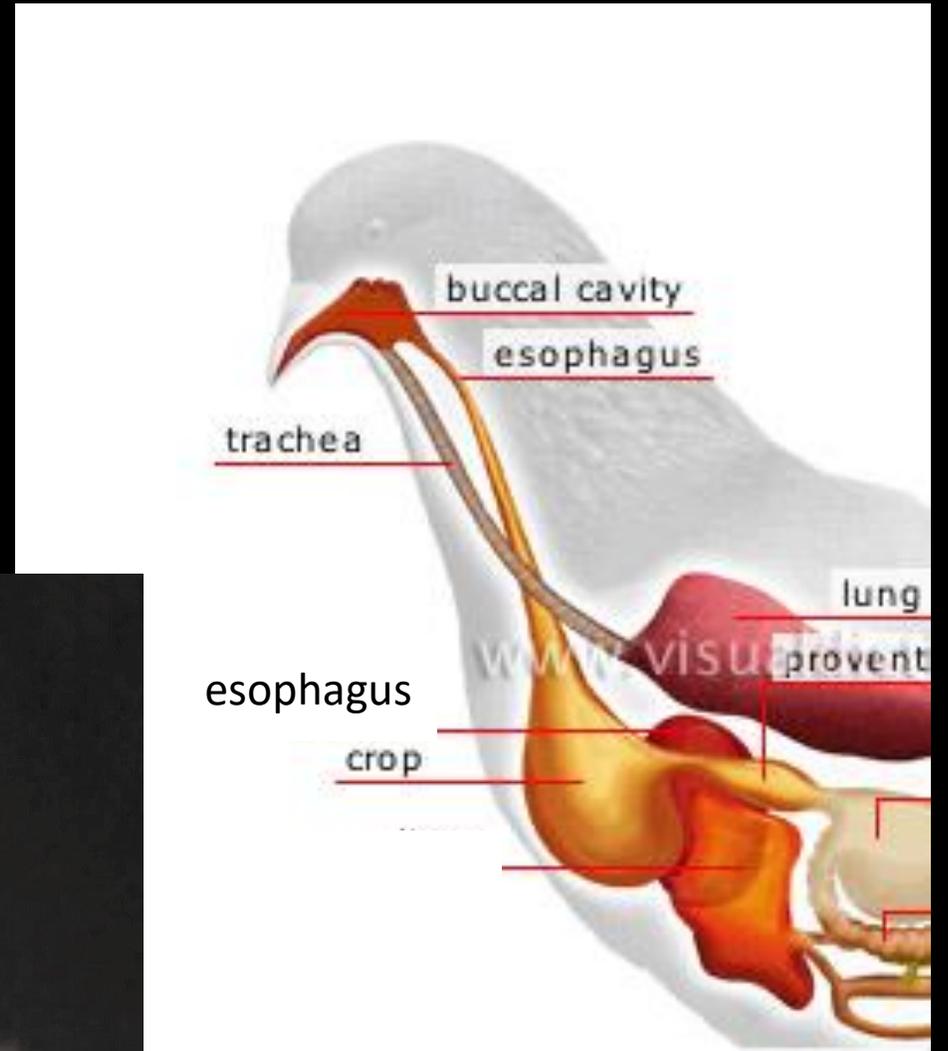
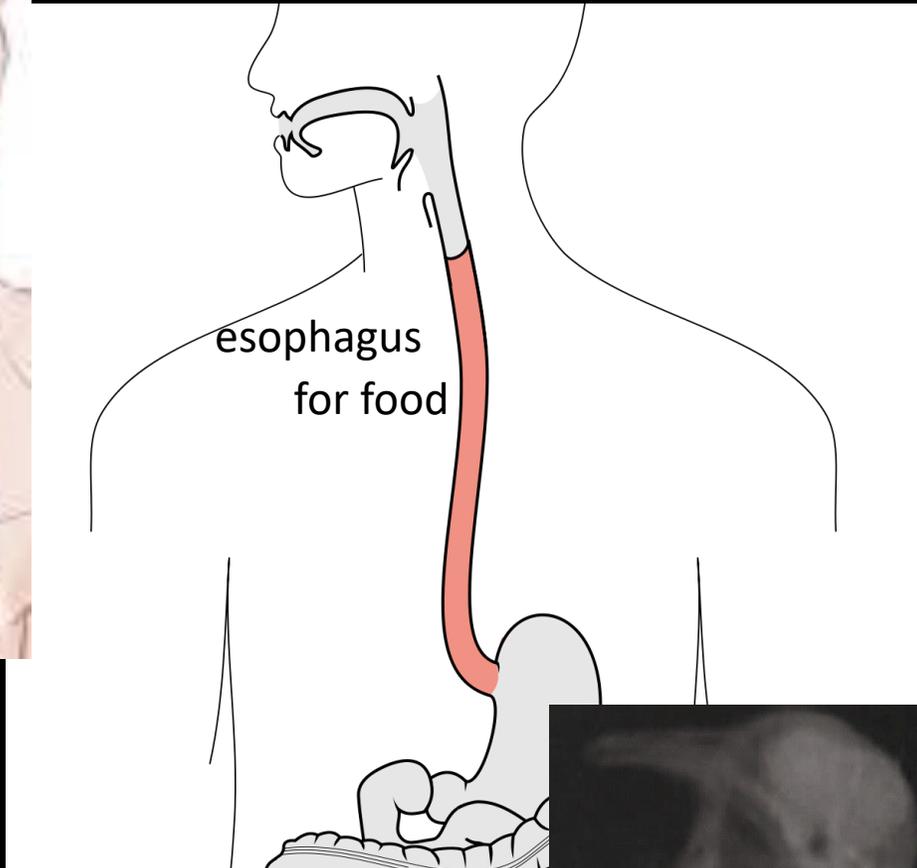


Much closer relatives of dinosaurs



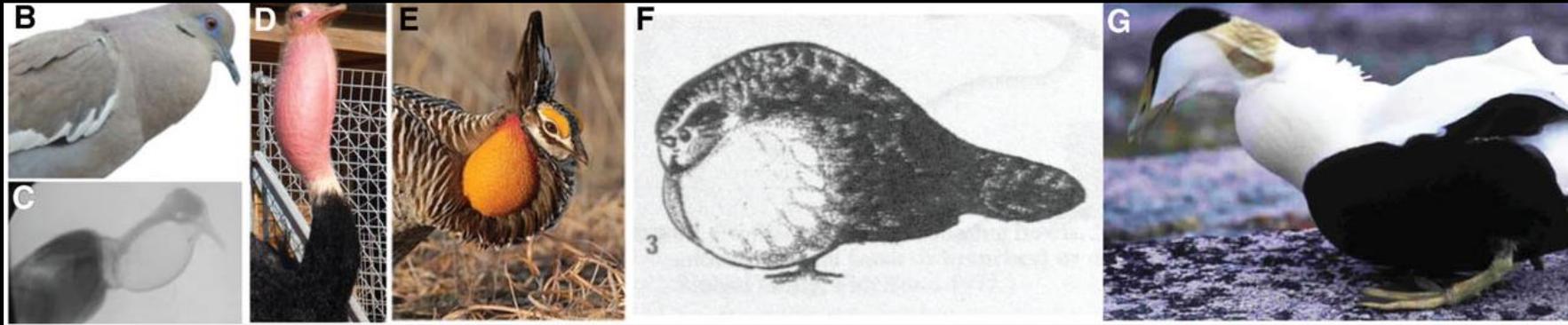
..... These sounds are made with the mouth completely closed....





Esophageal inflation

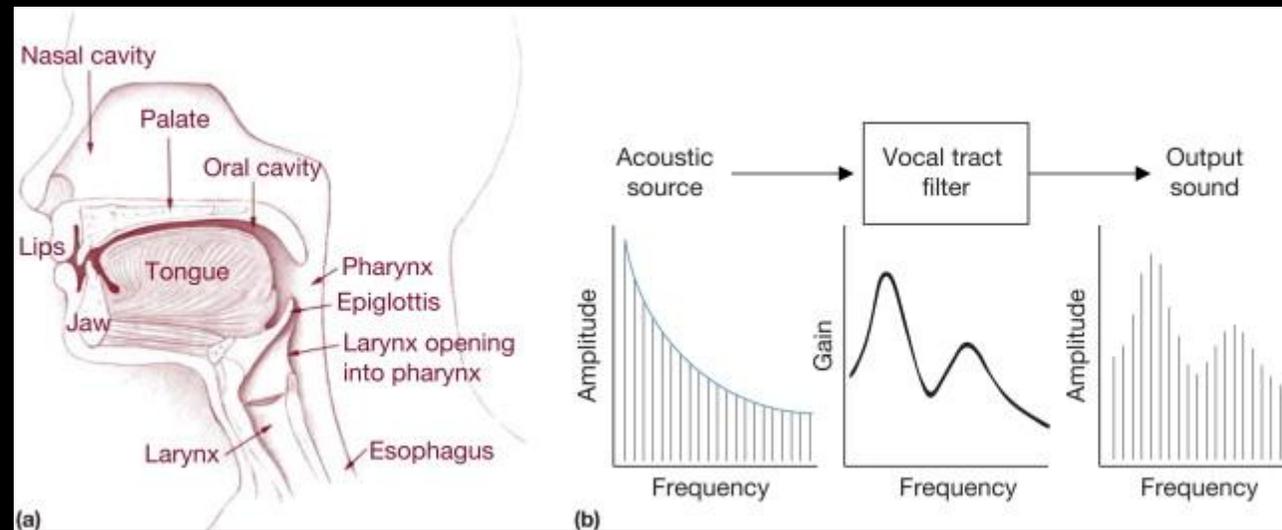




Riede, Eliason, Miller,
Goller, and Clarke, 2016

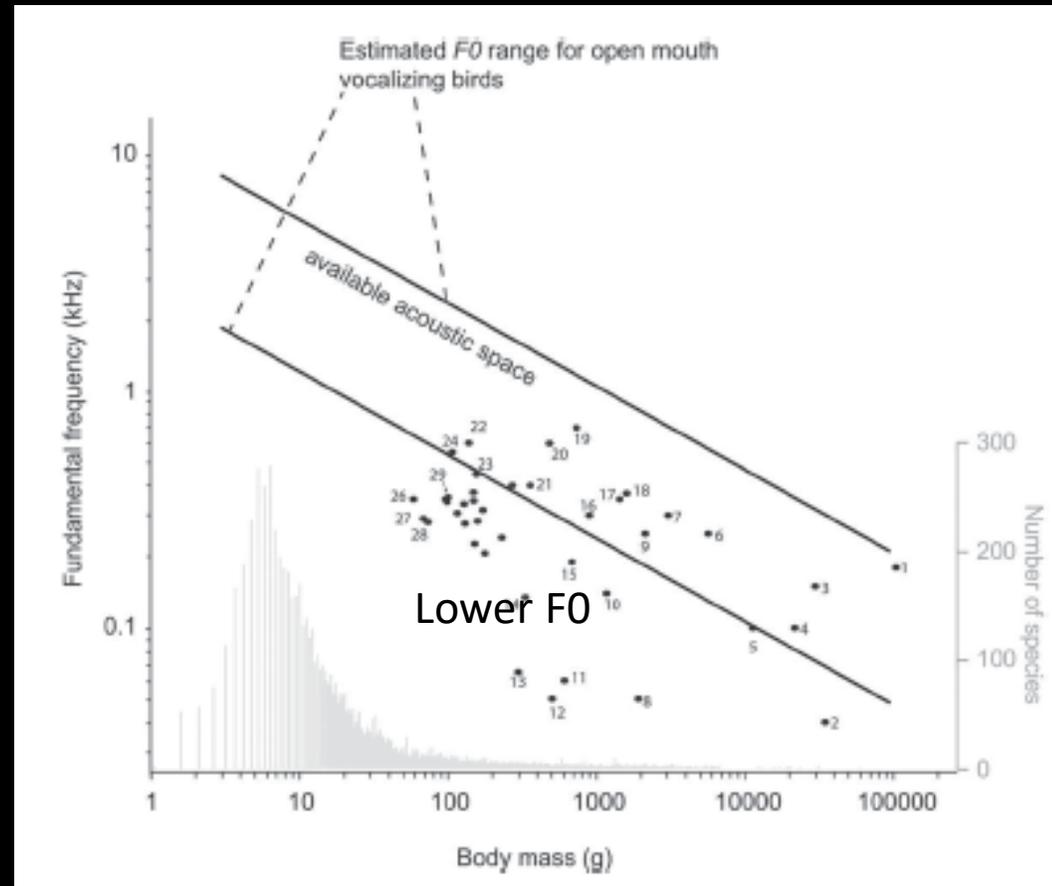
Vocal tract modifications affect frequency characteristics

effectively lengthen
the vocal tract



Closed mouth vocal behavior is a sound *shaper* not a sound maker

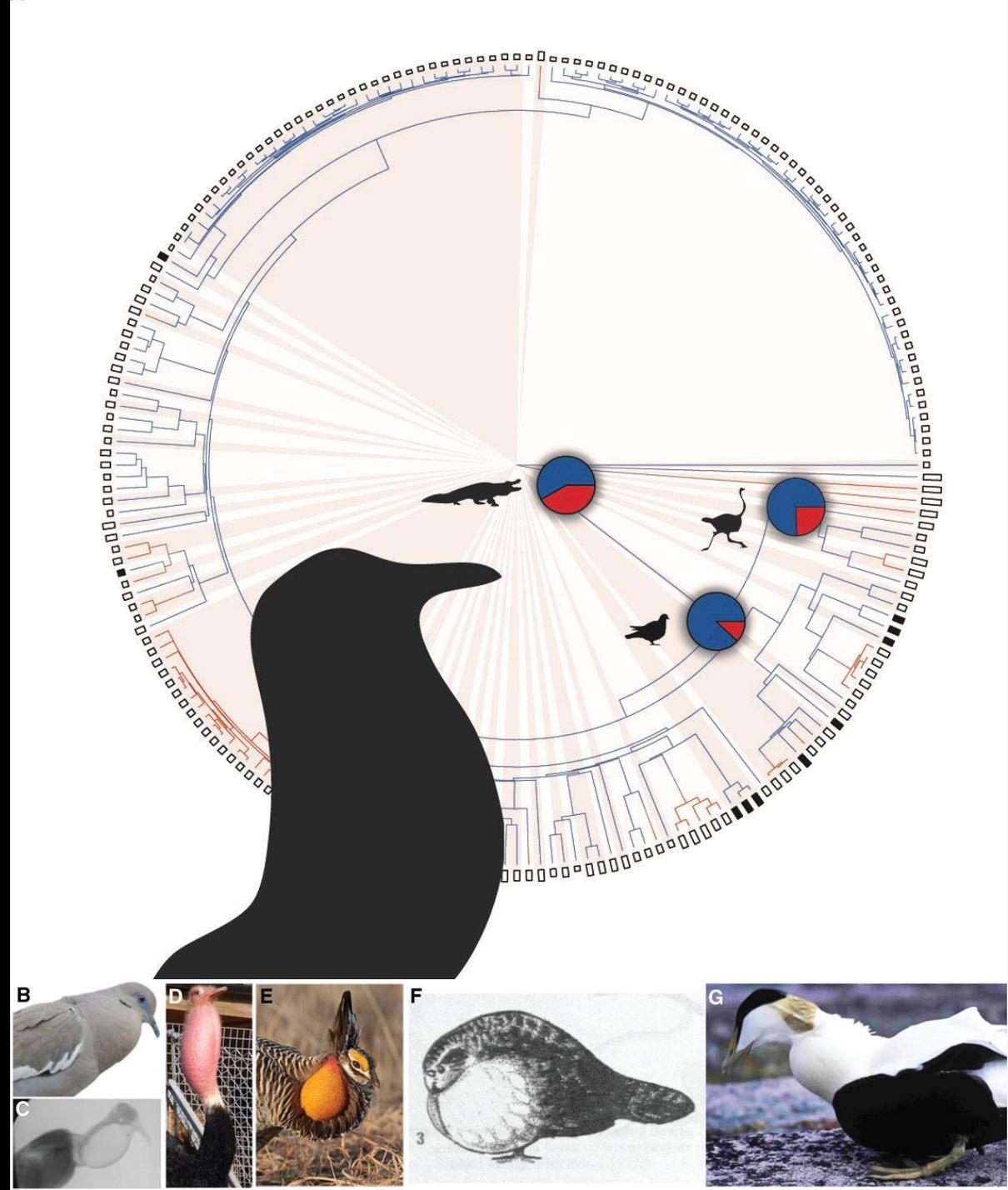
Closed-mouth vocal behavior

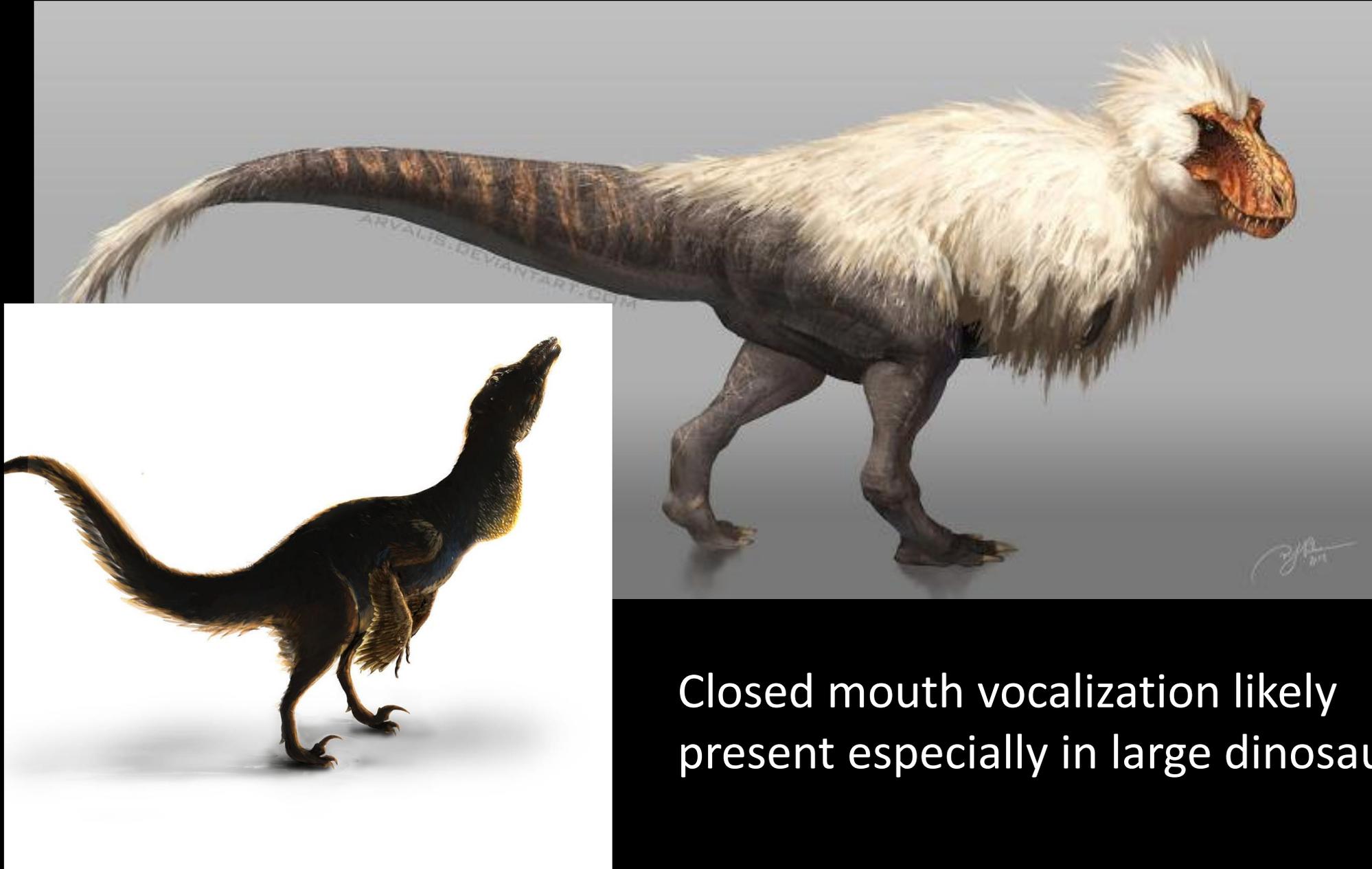


Riede et al. 2016

Living dinosaur closed
mouth sounds

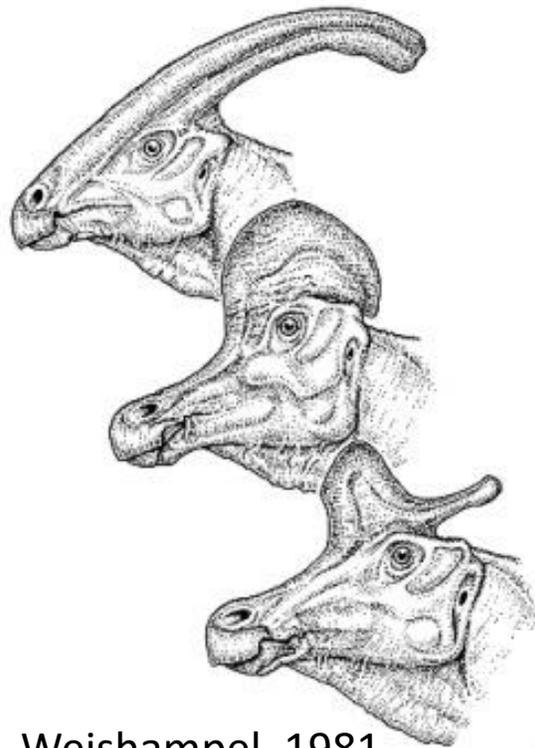
Associated with
increases in body size
Co-present with open
mouth sounds..



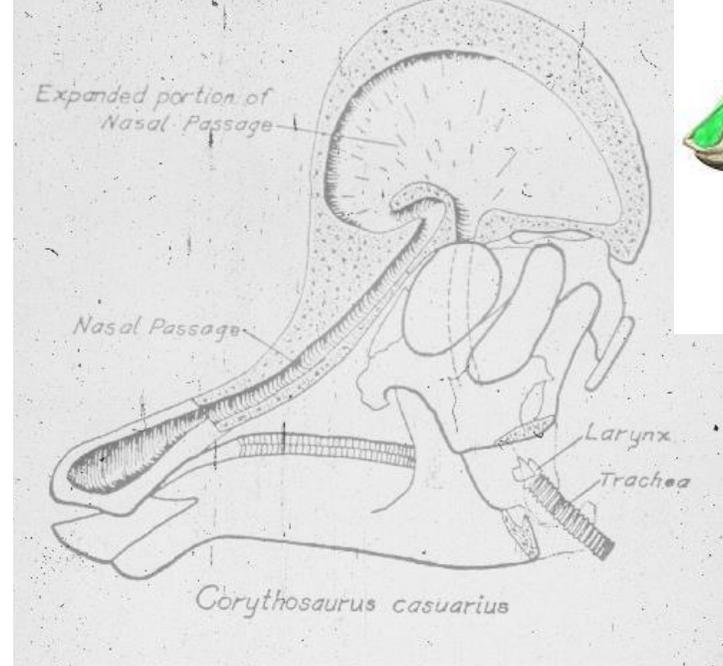


Closed mouth vocalization likely present especially in large dinosaurs

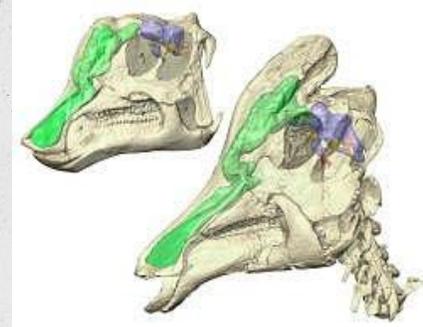
Previous
extinct
dinosaur
sound studies
found other
sound shapers



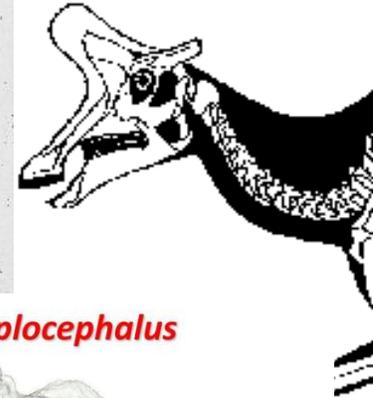
Weishampel, 1981



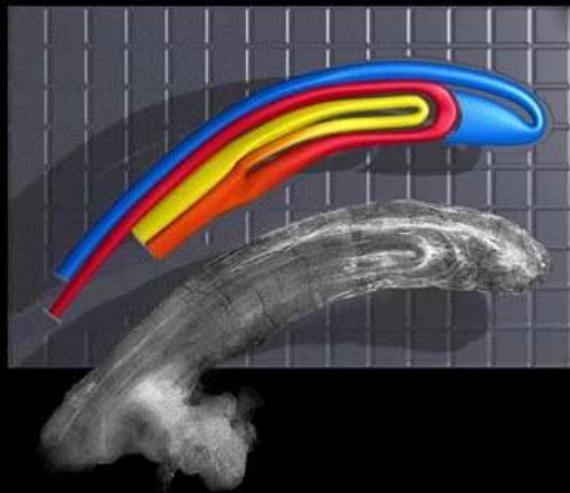
Panoplosaurus



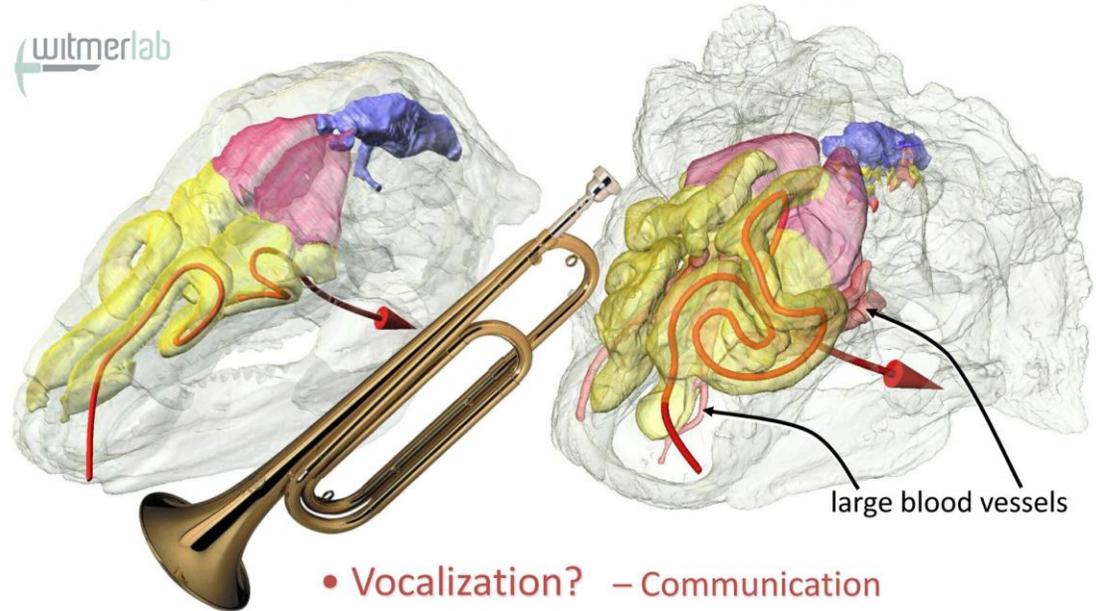
Euoplocephalus



Estimated resonant
properties of nasal
crest
(~50Hz-350Hz)



witmerlab



- Vocalization? – Communication
- Physiology? – Temperature regulation



Nope



Many dinosaurs (living and extinct) had sound shapers that emphasize low frequencies— deep voices especially at large size

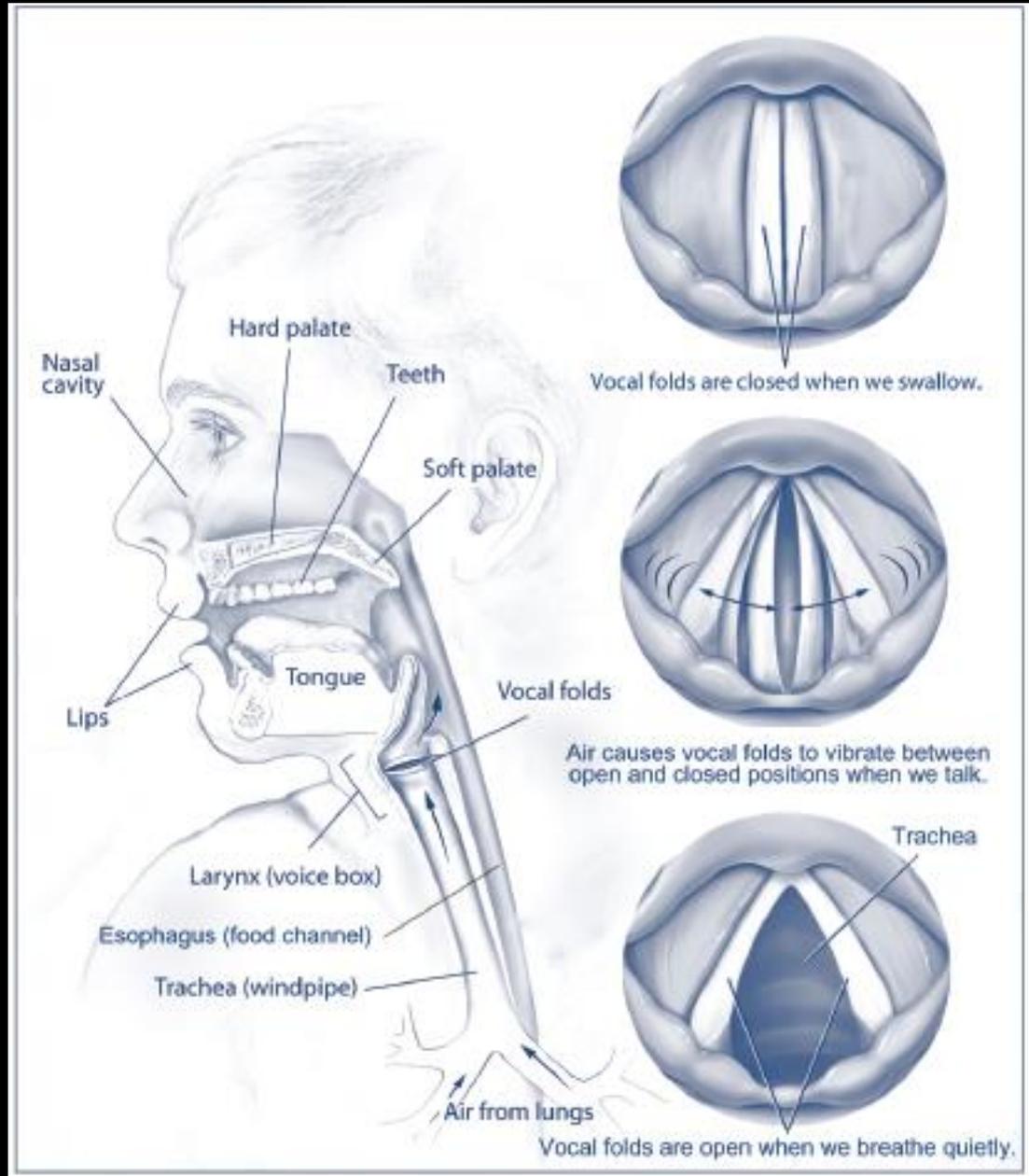


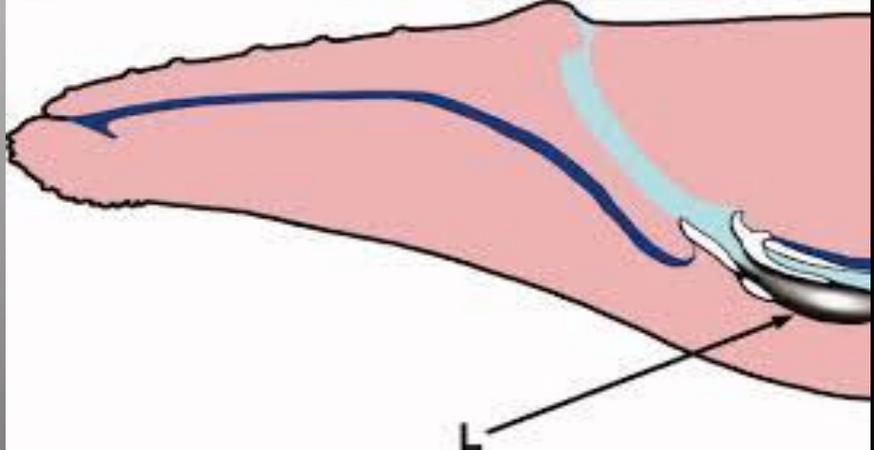
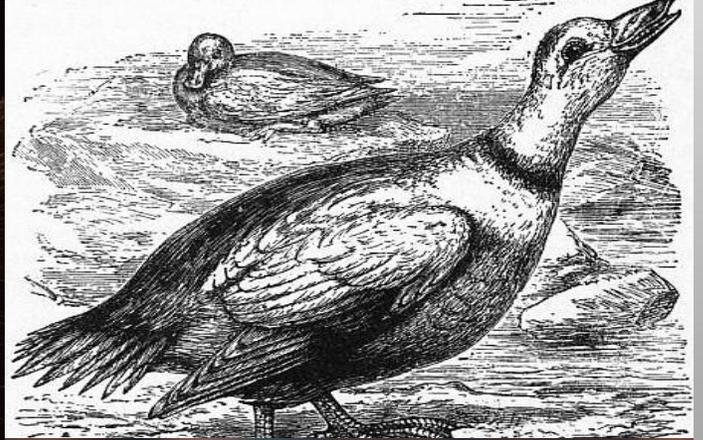
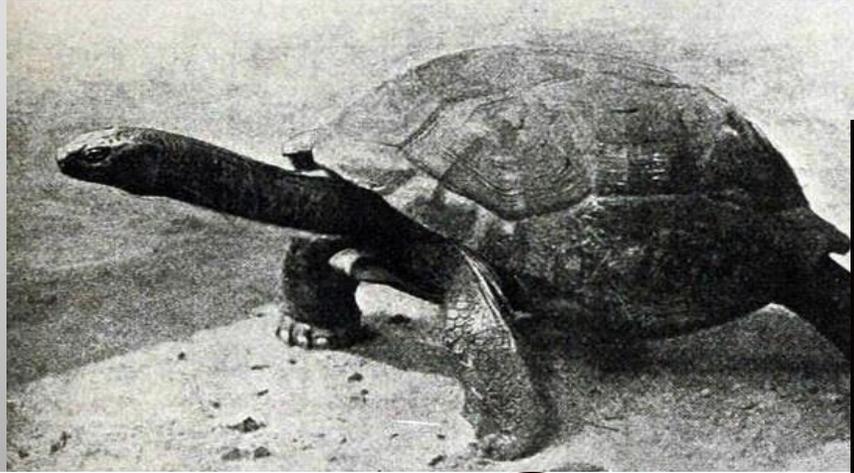
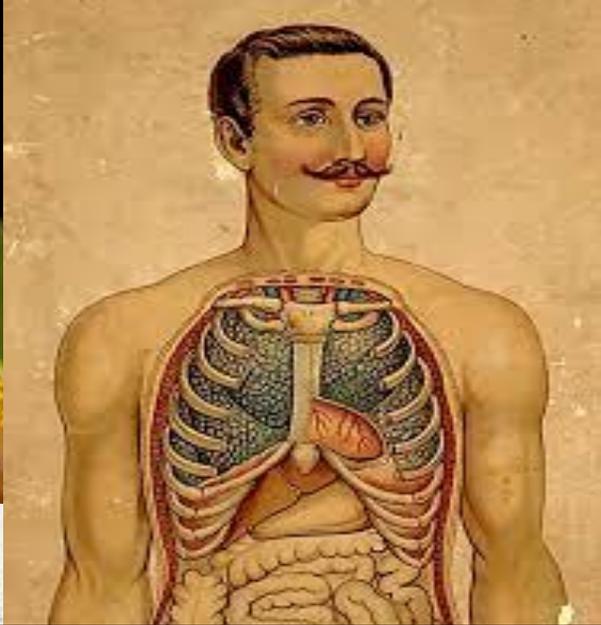
A sound made with the mouth closed and not *made* by a resonating chamber but *shaped*

We need to talk about sound *makers*...

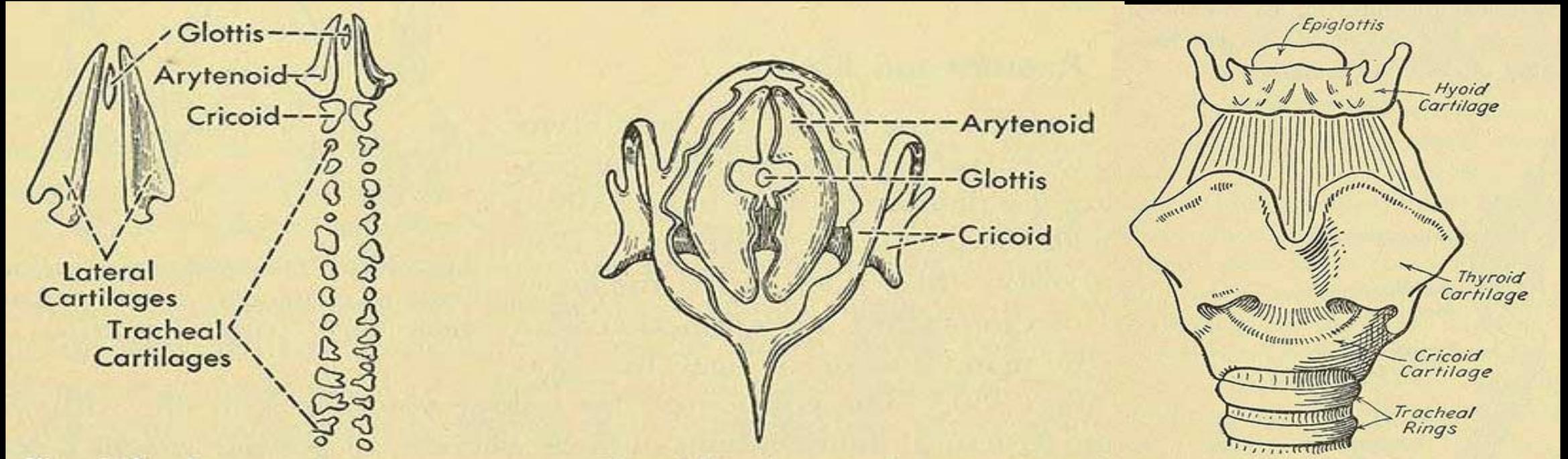
How do animals make sounds?







Larynx – contain a *sound maker* at the end of the airway...

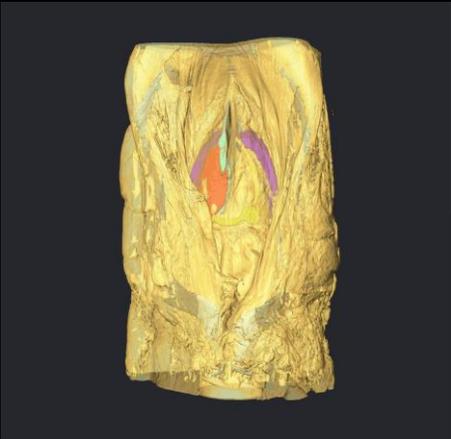


Salamanders

Frog

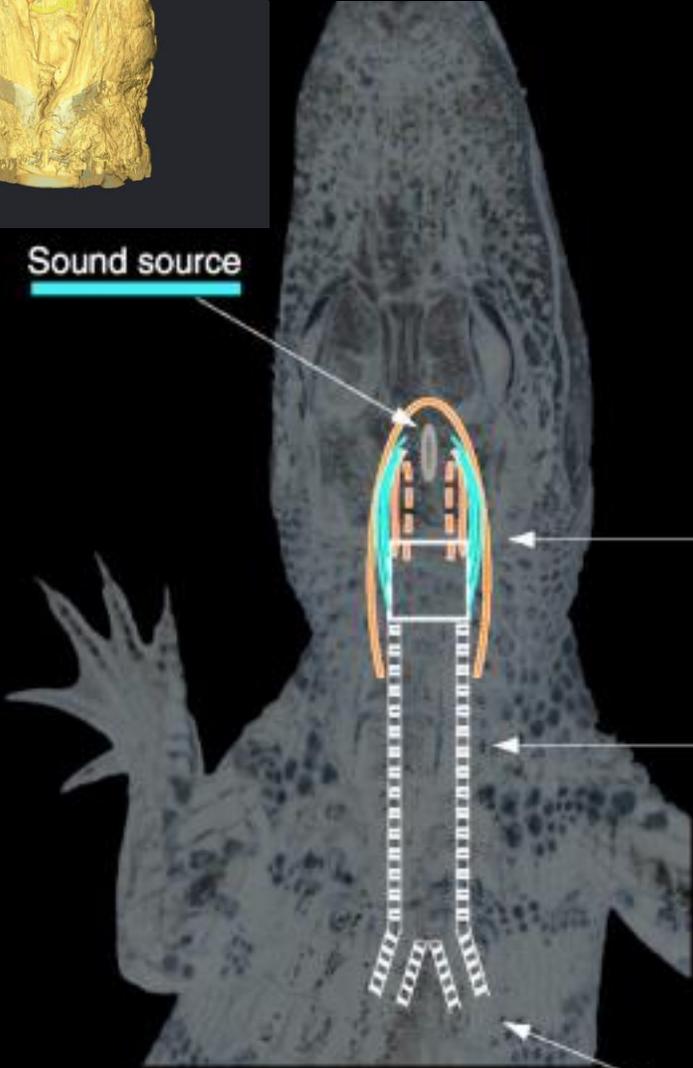
Human

Sound makers: vocal folds



Larynx

Sound source

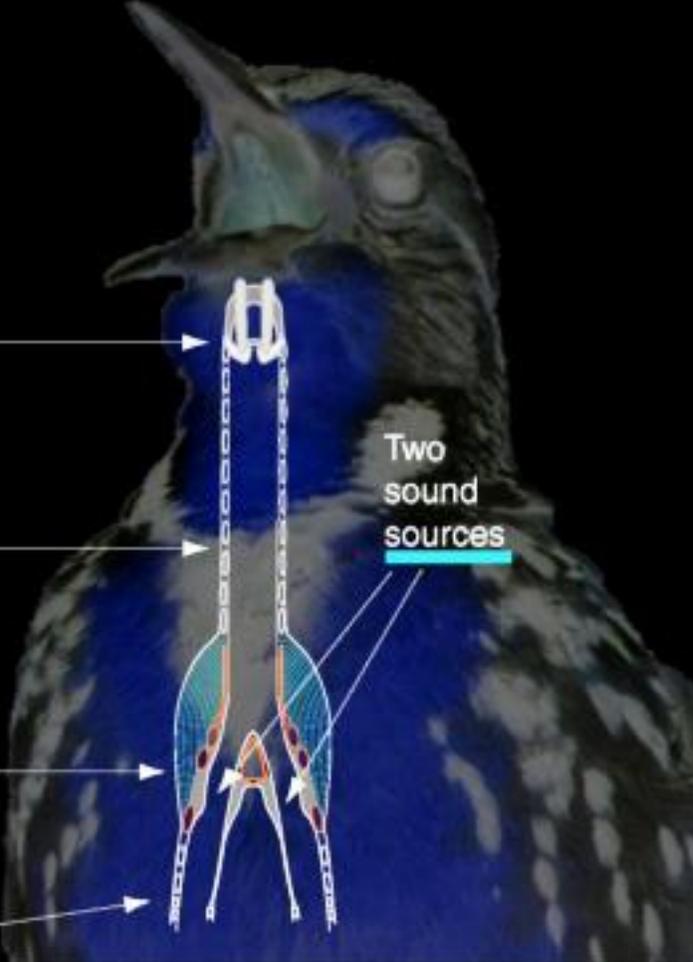


Larynx

Trachea

Syrinx

Bronchi



Two sound sources

The Avian Syrinx

Birds possess a **larynx** in the ordinary position ; but it is another apparatus, the **lower larynx** or *syrinx*, developed either at the end of the trachea, or at the commencement of each *bronchus*, which is their great vocal organ.

- Huxley, 1872, Manual of the anatomy of vertebrated animals.



Syrinx



Crocodylia



Extinct diversity

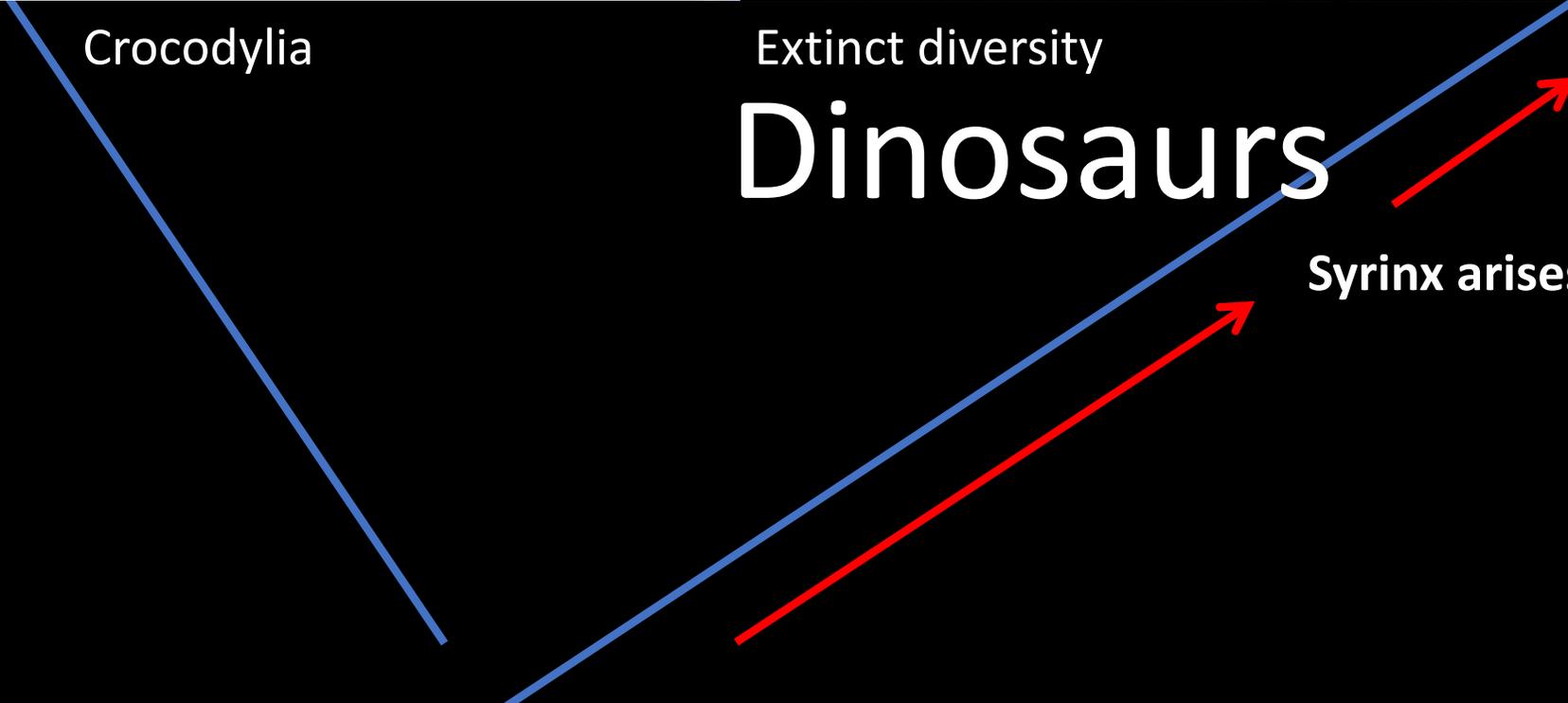


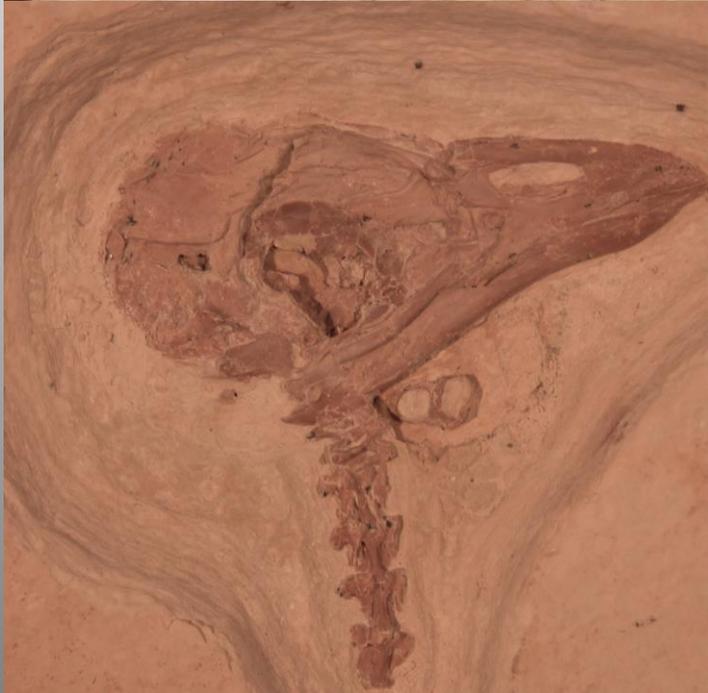
Living birds

Dinosaurs

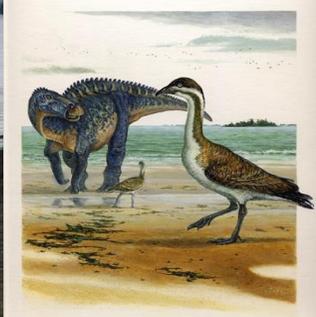
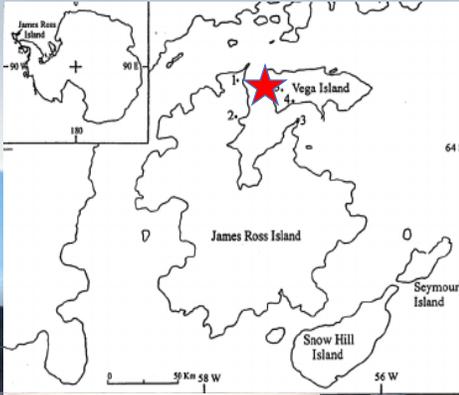
Syrinx arises

Vocal behavior





- 68-66 Ma, Vega Island, Antarctica



Clarke et al. 2005 *Nature*

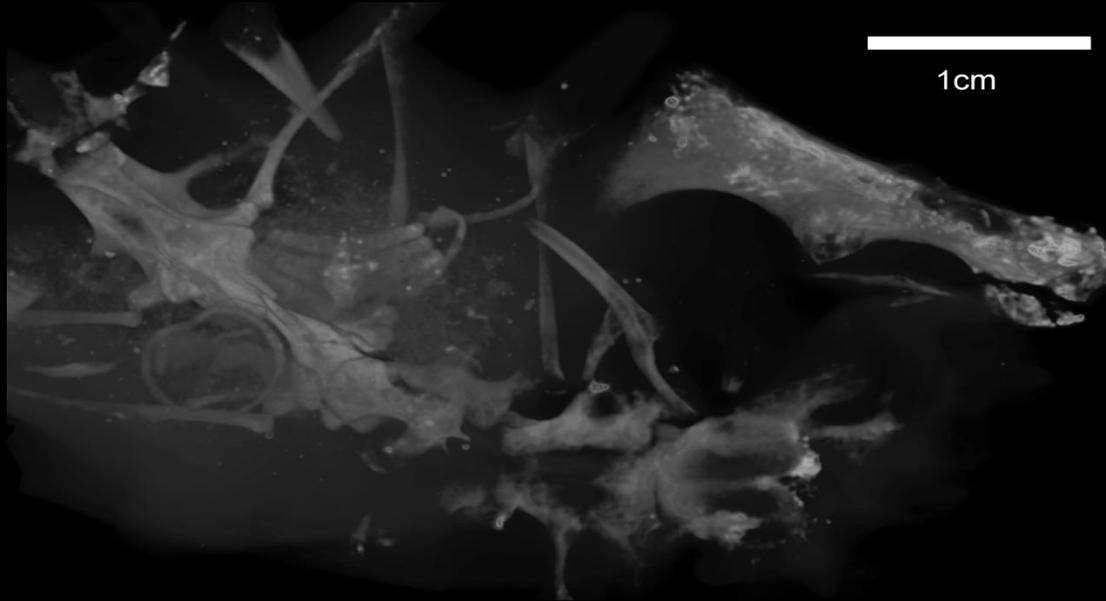


Clarke et al. 2016 *Nature*

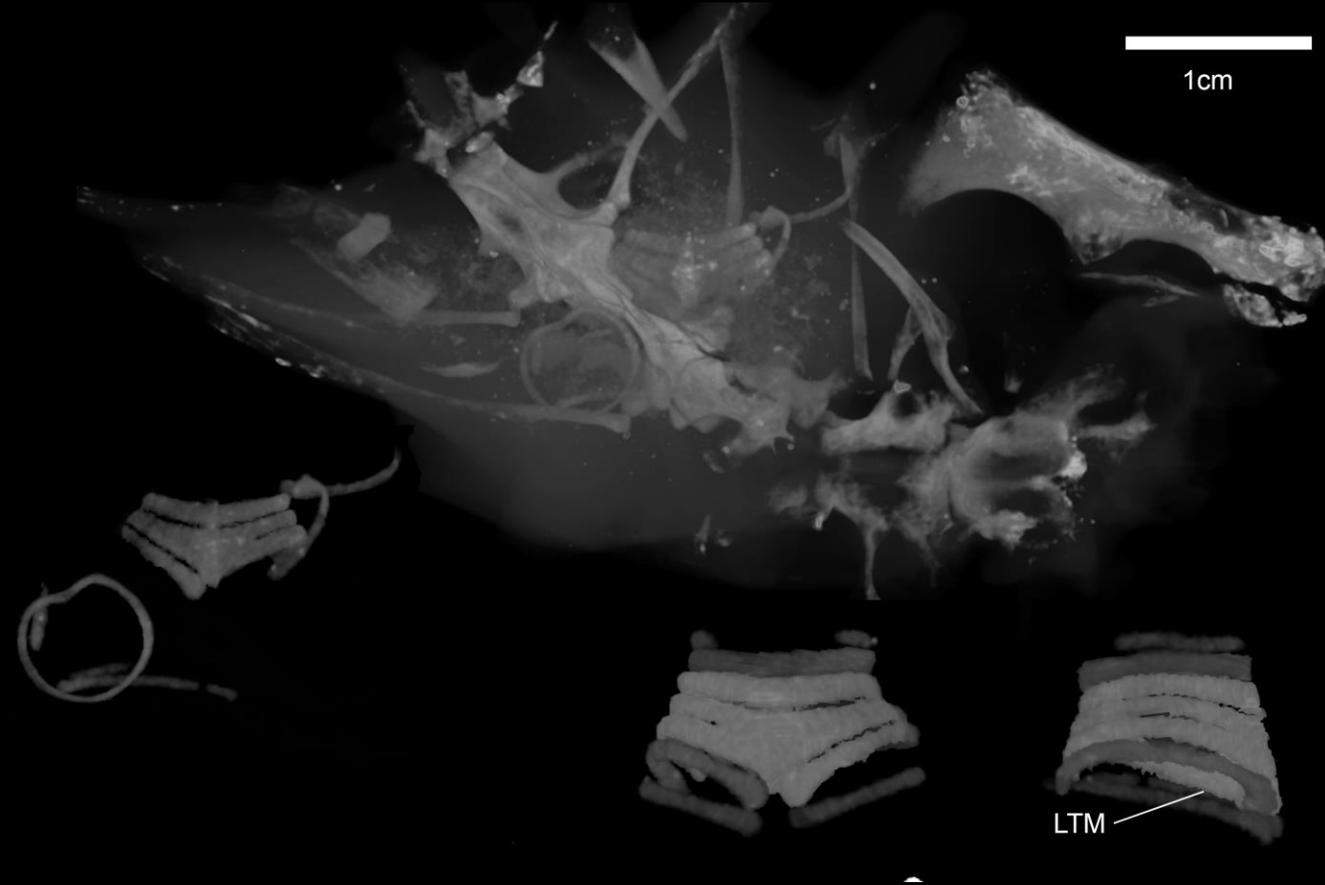


Clarke et al. 2016 *Nature*

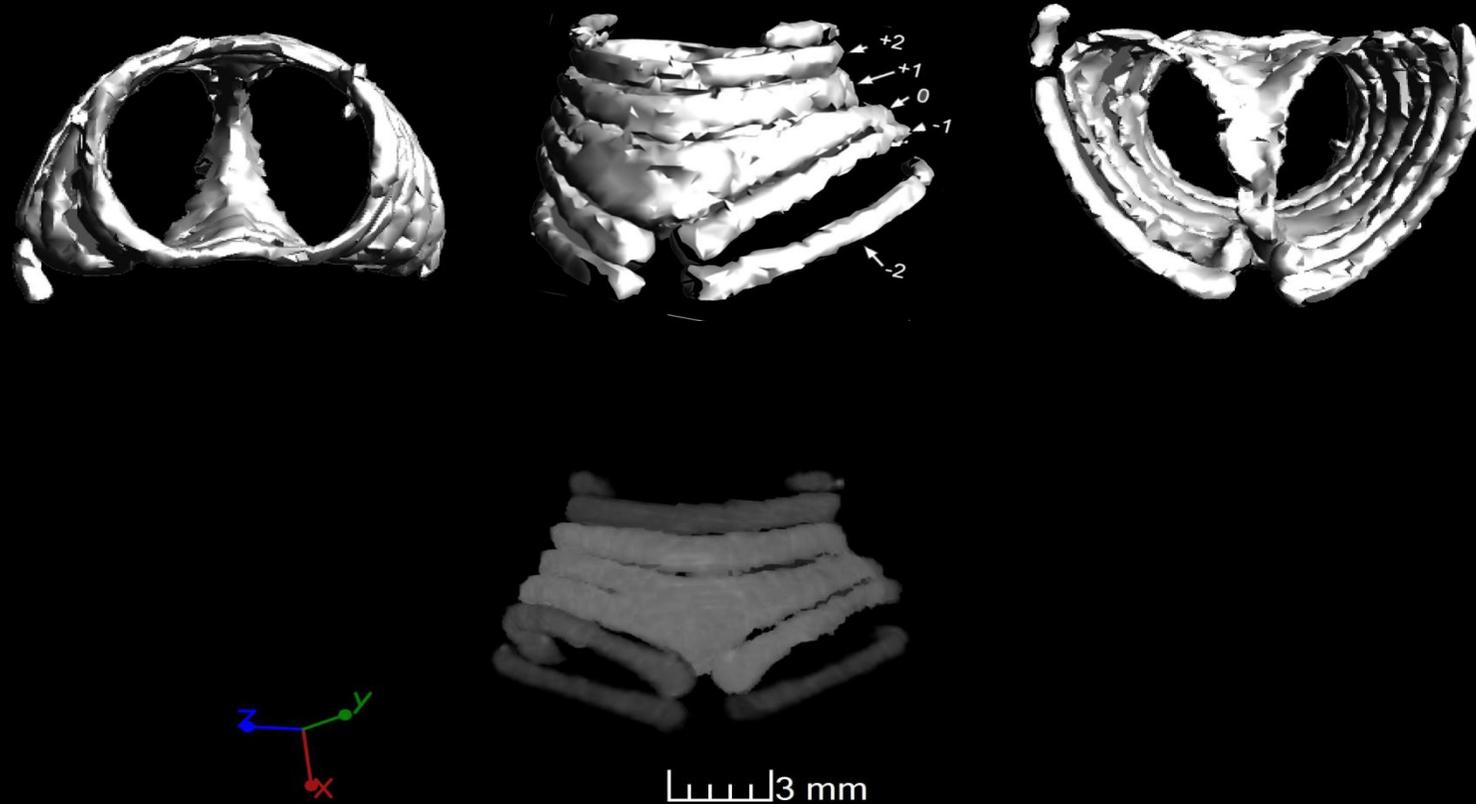
2013, x-ray computed tomography (CT) data of the *Vegavis* fossil...

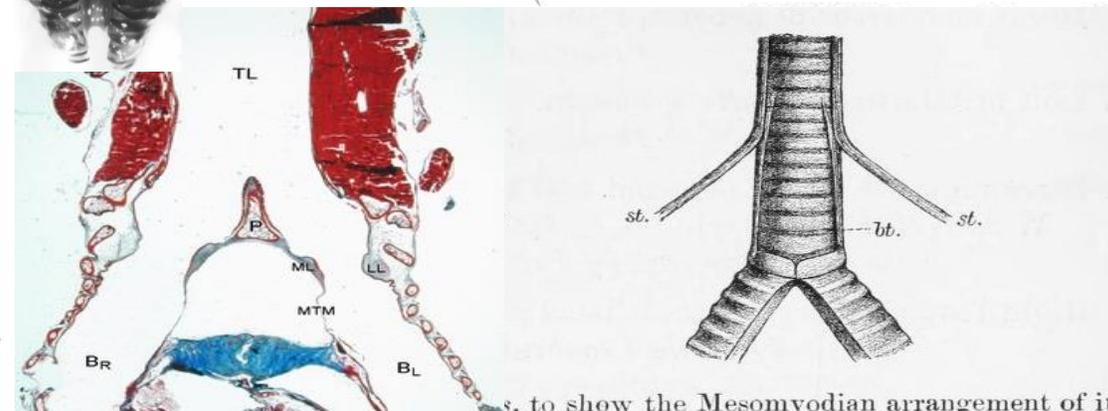
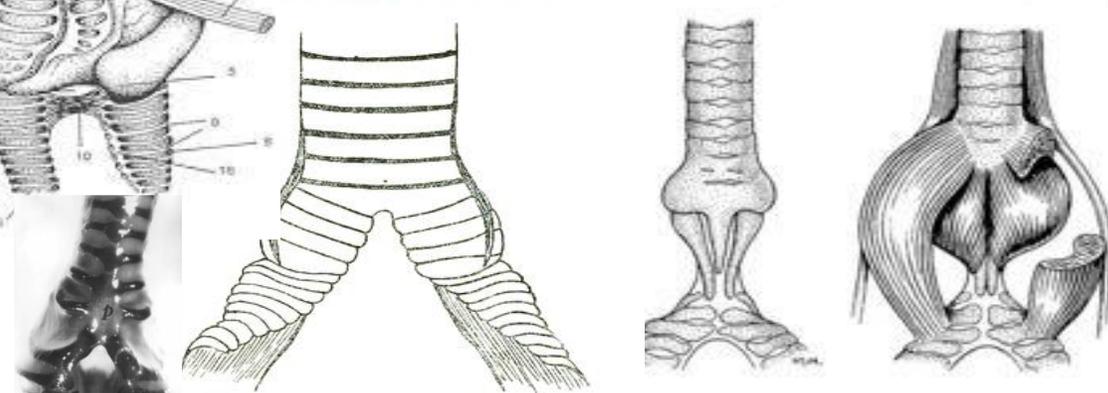
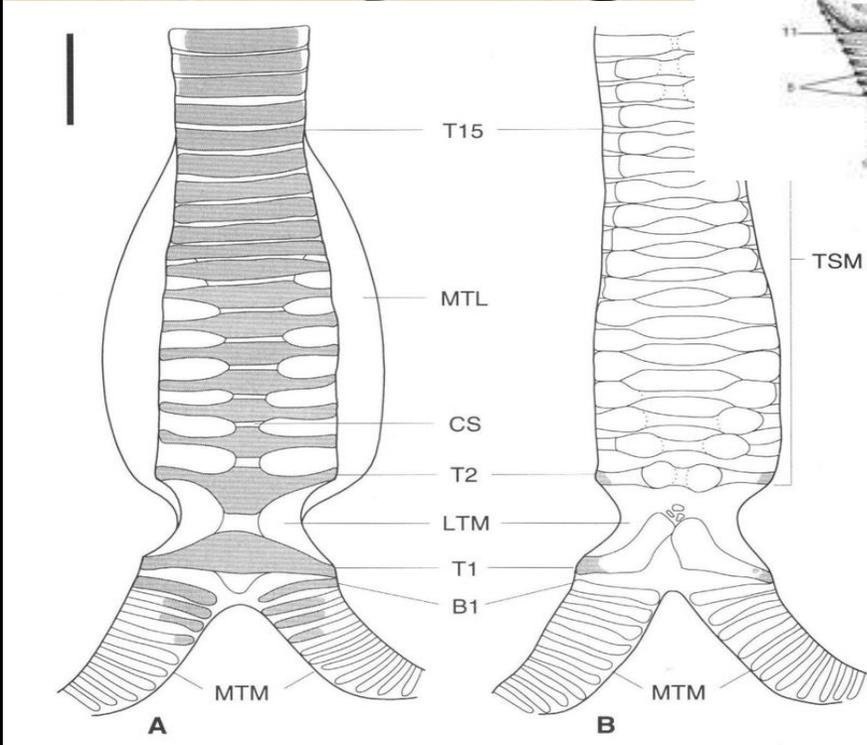
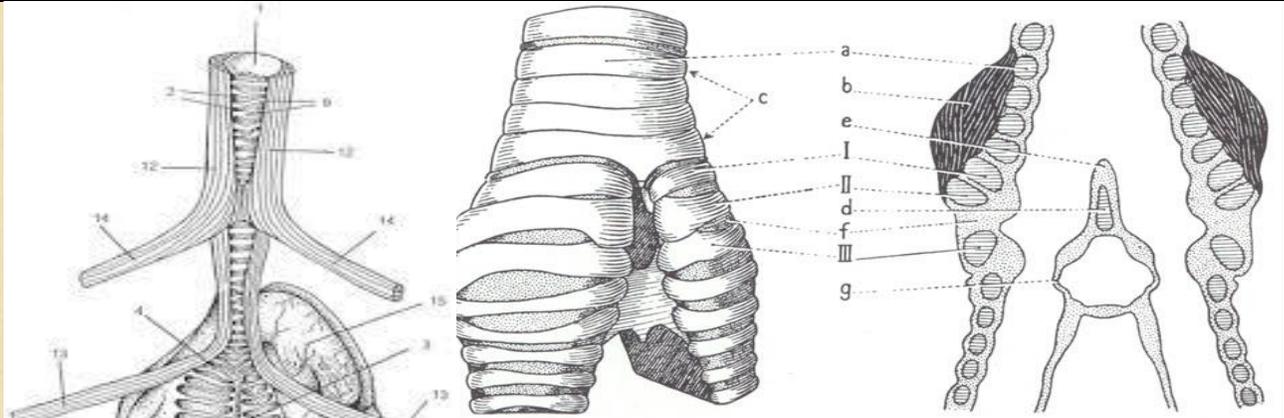
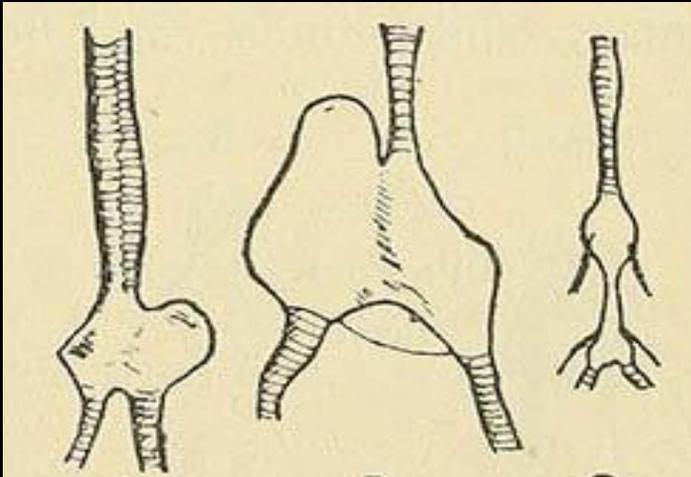


Looking at CT data of the fossil... the oldest known fossil evidence of a dinosaur vocal organ!

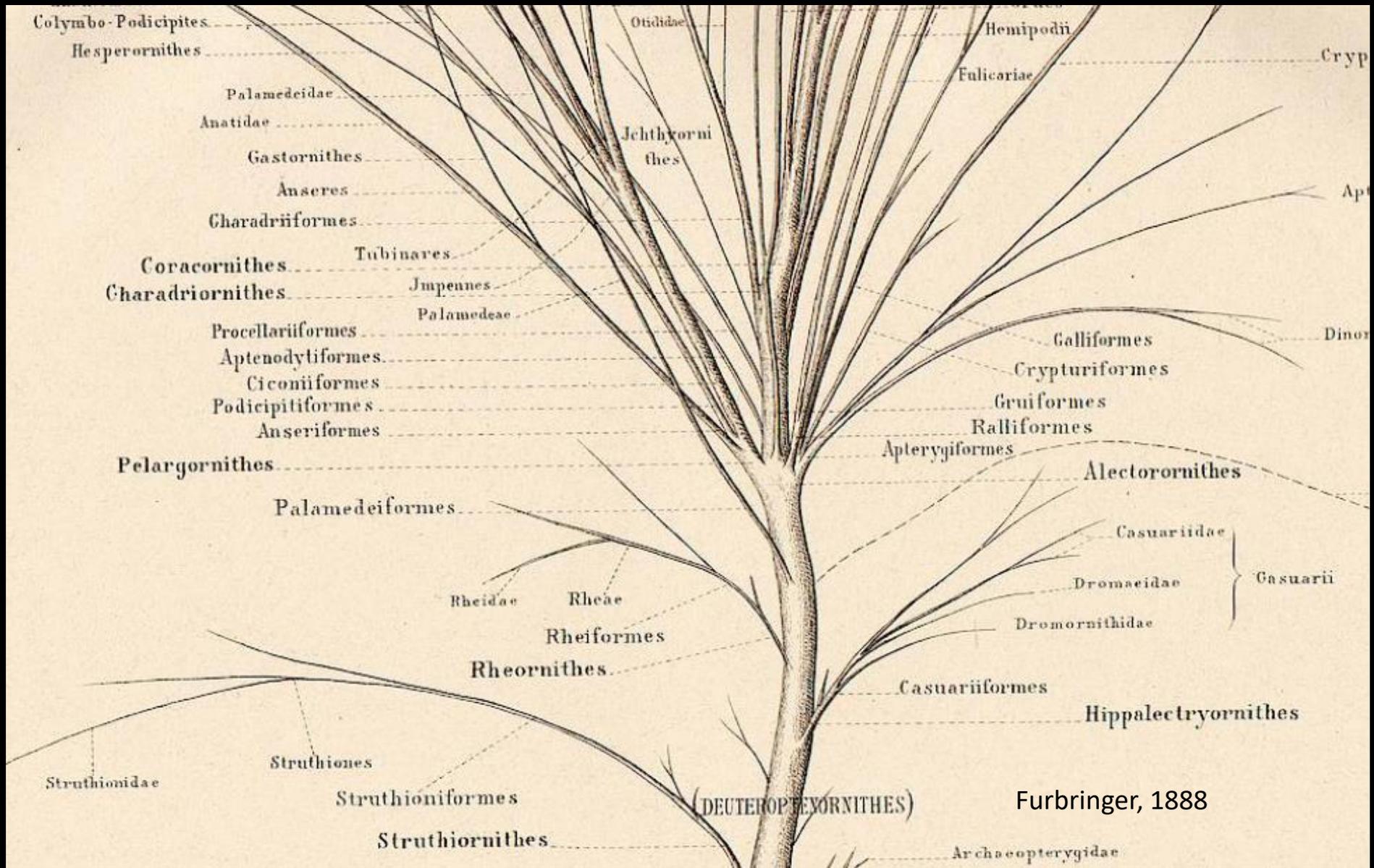


New data: new questions.



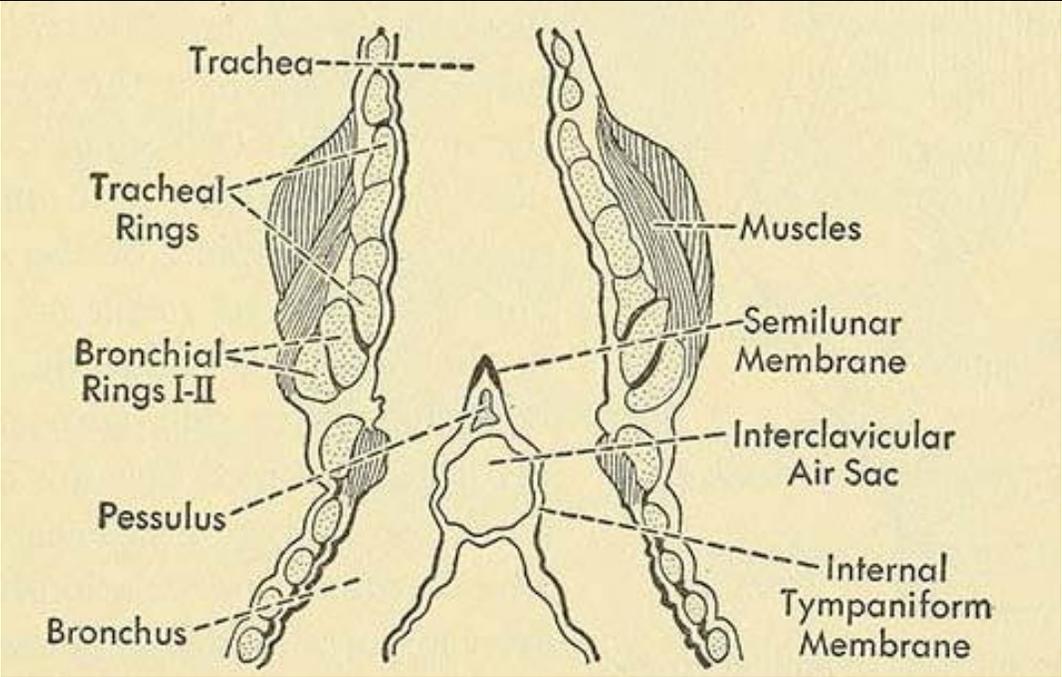


s, to show the Mesomyodian arrangement of its



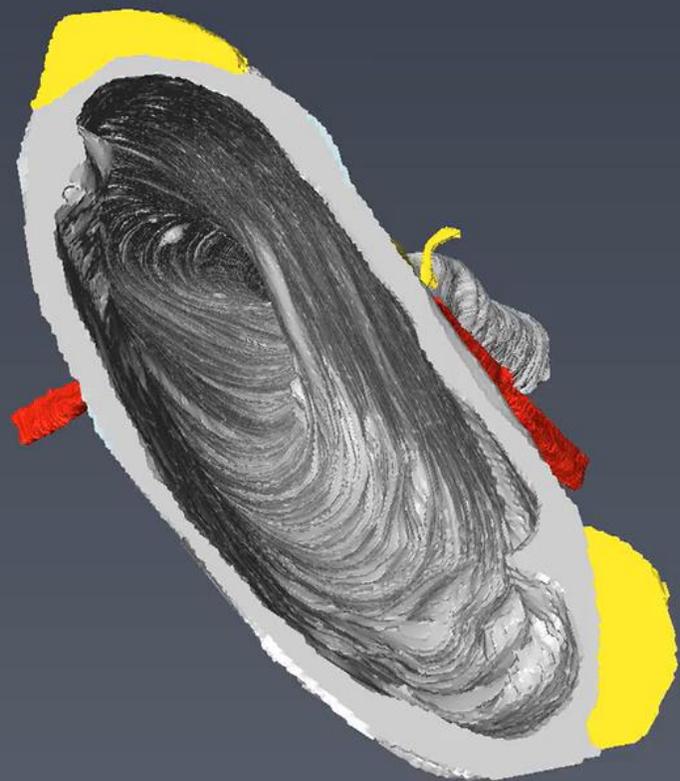
Furbringer, 1888





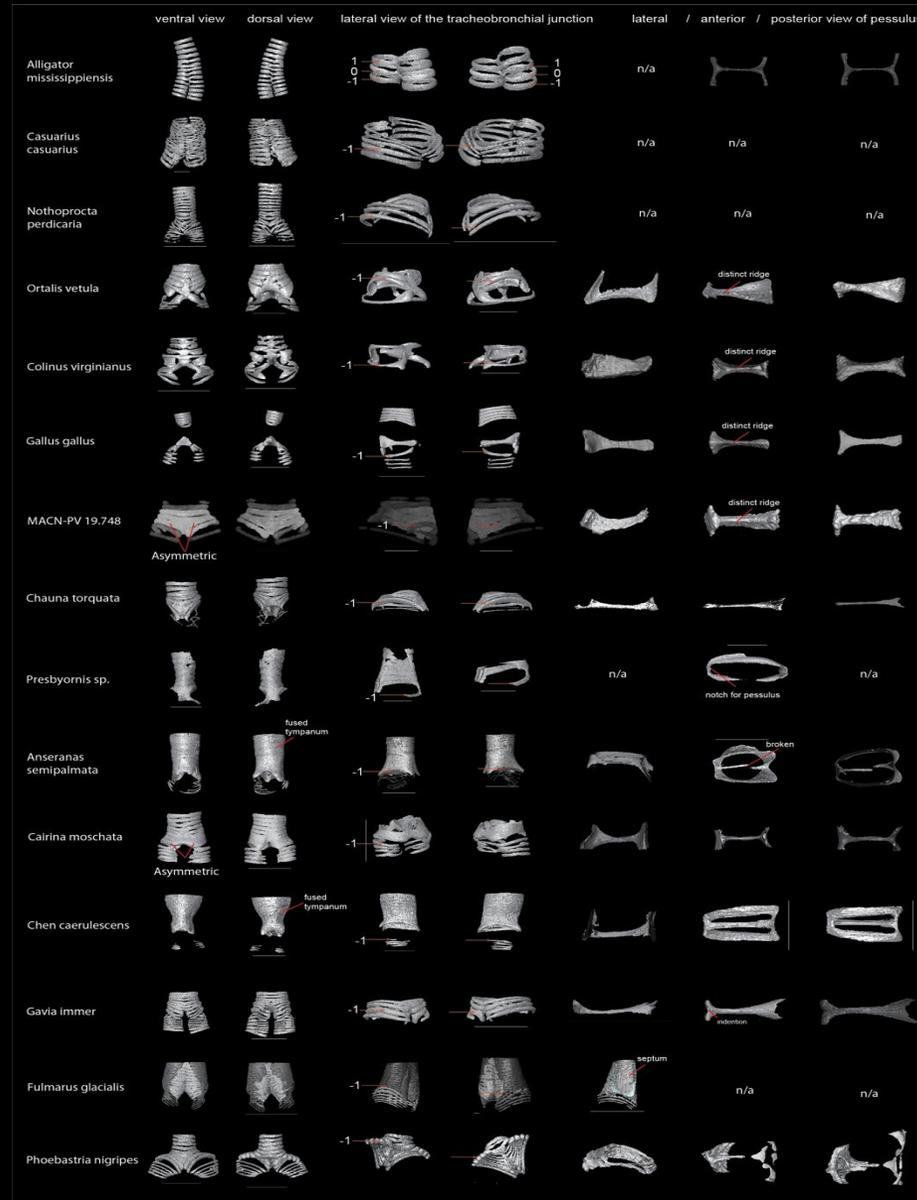


Gesner, 1551



Movie and
segmentation by
L. Legendre

- 3D data on the geometry of the syrinx in fossil and extant taxa, anatomy that had never before been compared



Clarke et al. 2016



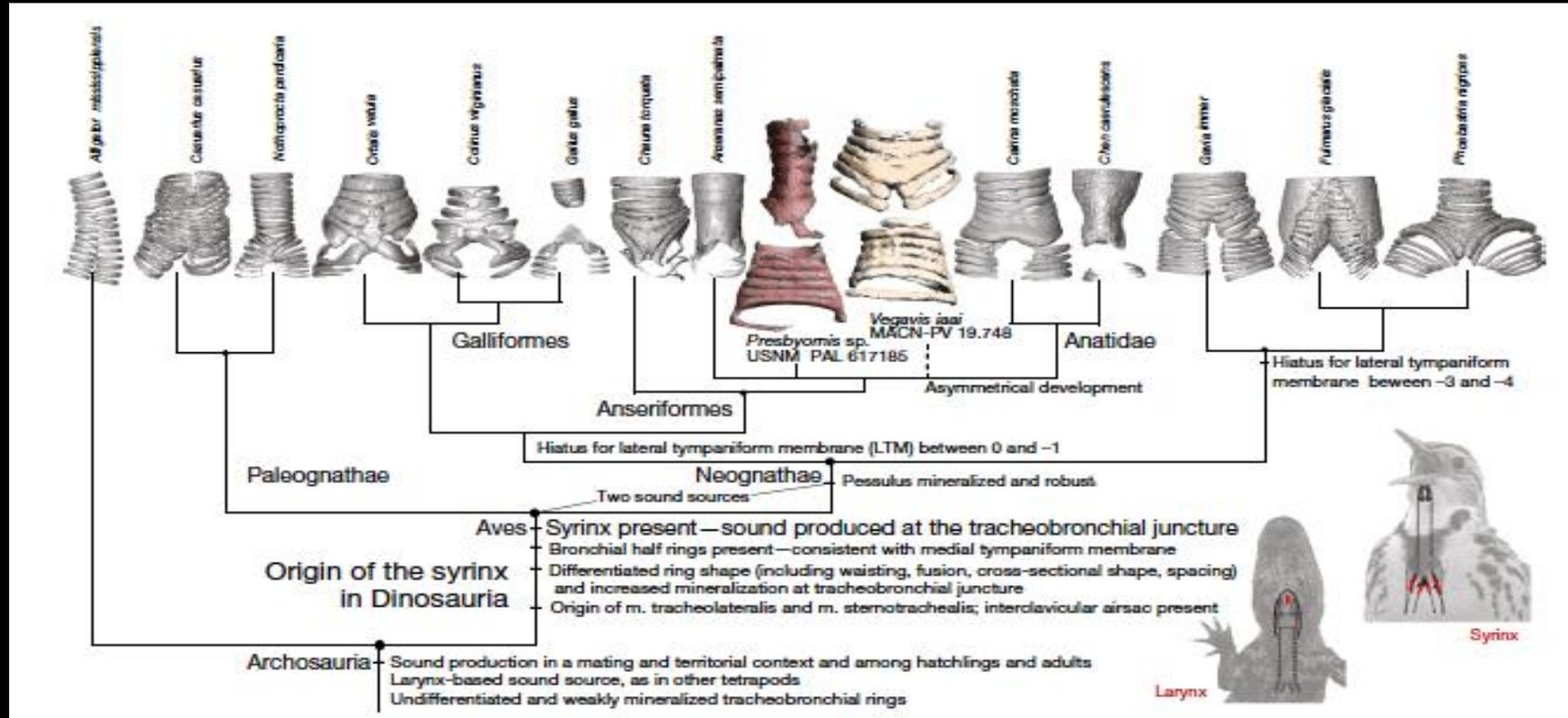
Vegavis iaai

Cretaceous
syrinx fossil

Antarctica

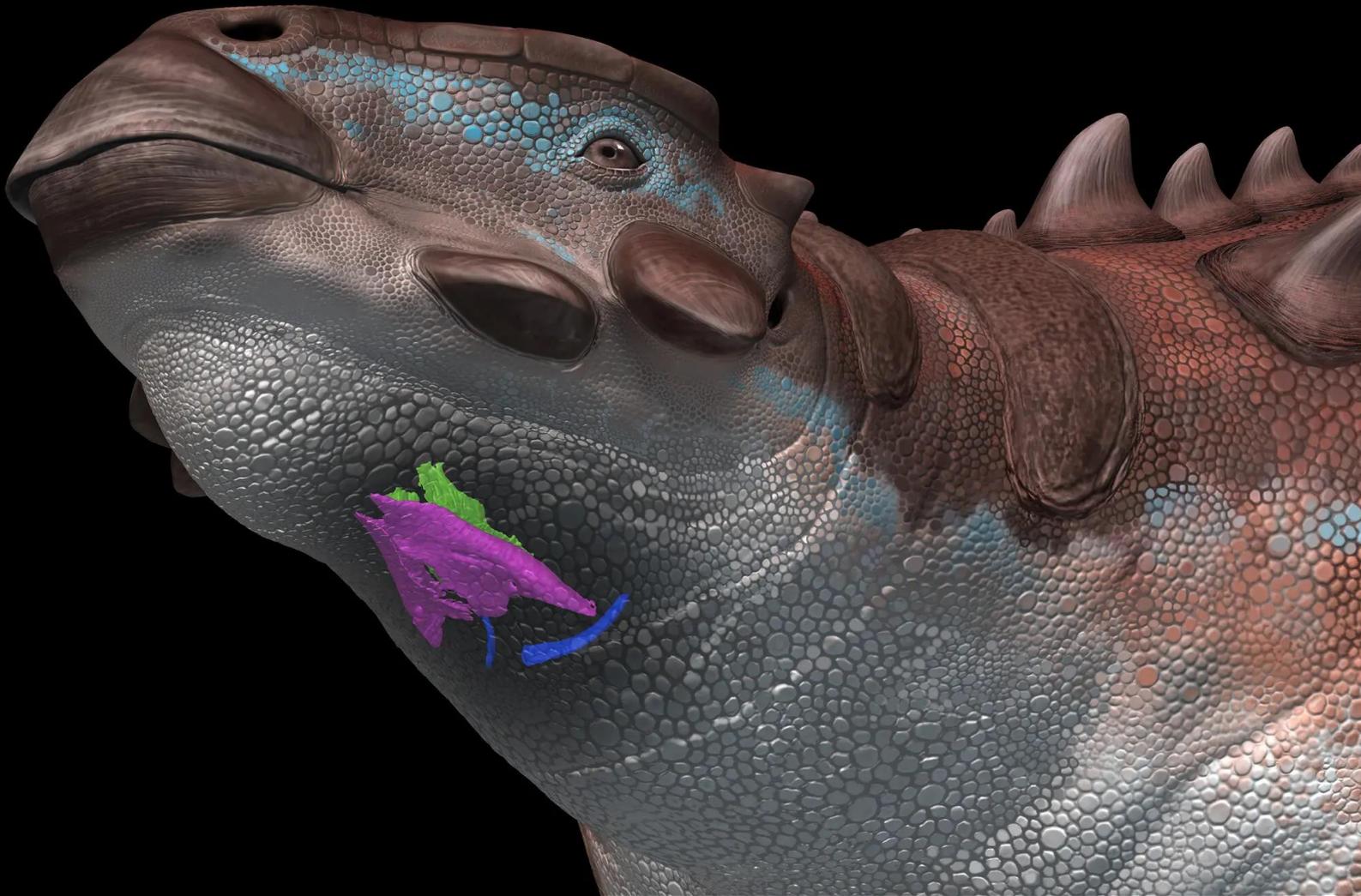
Larynx in
modern
alligators

The first anatomical (rather than functional) description of a syrinx; placement of the earliest fossils



What else might fossils tell us about dinosaur
sound making ?

What about this one?



Larynx fossil reported
– proposed to be
“bird like”

(But no evidence of
larynx function in
sound *shaping* or
producing in birds)

The New York Times

TRILOBITES

What Sounds Did Dinosaurs Make?

A new study of a fossilized ankylosaur suggests it could have uttered birdlike calls.

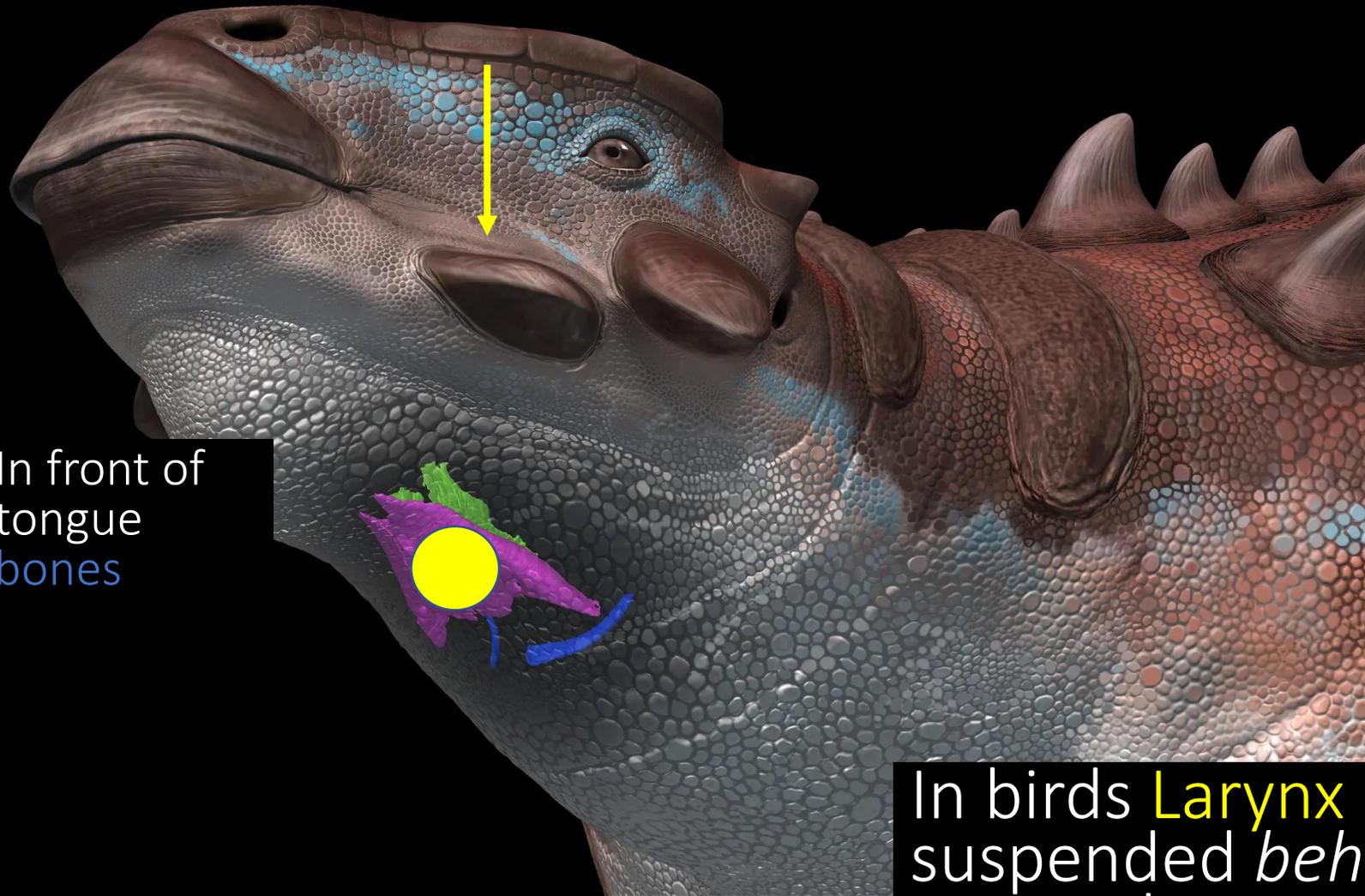
March 21, 2023

It's not clear how the structures that the team analyzed would allow an ankylosaur to vary sounds, Dr. Clarke said. Birds don't use the larynx for this purpose. They have an organ she called a hyolaryngeal basket that moves up or down to modify their calls. And the larynx shows up in all tetrapods — a group that includes animals like birds, reptiles and mammals that descended from four-limbed creatures. The anatomy described in the research varies across animals whether they can vocalize or not. "We don't know what any of this variation means," she said.

"Ankylosaurs are weird," Dr. Clarke said. "That is the main message."

The larynx parts under study might have had more to do with keeping food out of the airway because they helped to open and close it, she said. And the layout of related structures in this ankylosaur also looked completely different than those of many other dinosaurs, ones that Dr. Clarke has studied and that show up in the literature.

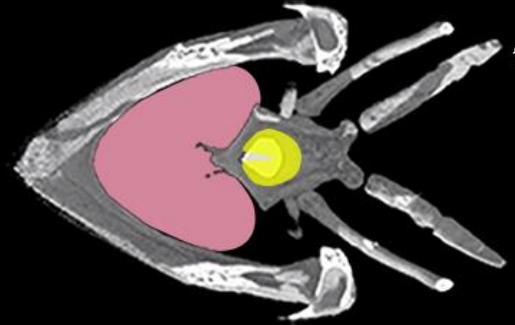
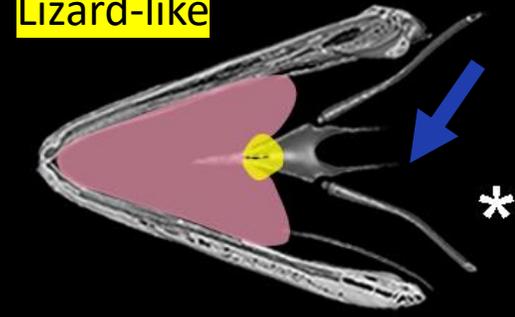
Rest of structure lizard like!



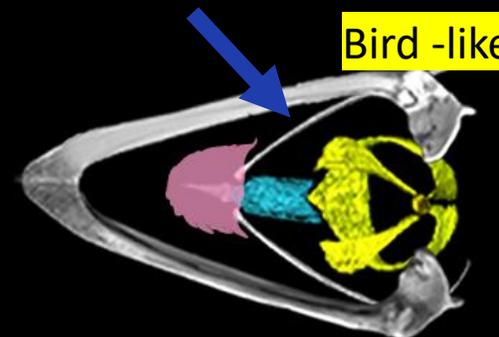
In front of tongue bones

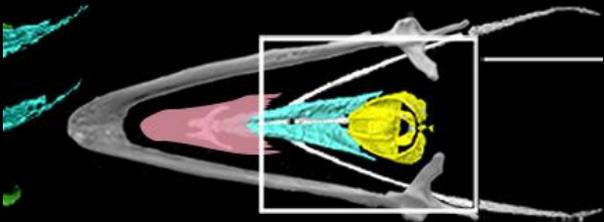
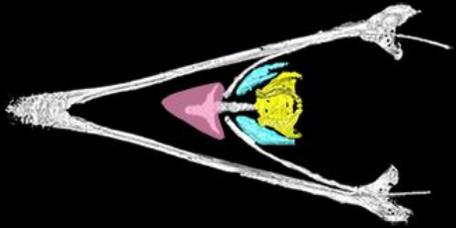
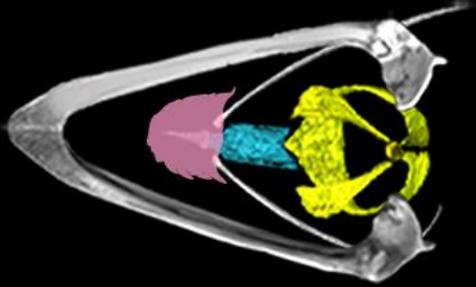
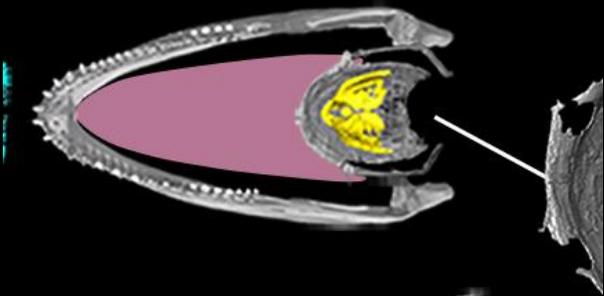
In birds **Larynx** suspended *behind* tongue bones

Lizard-like



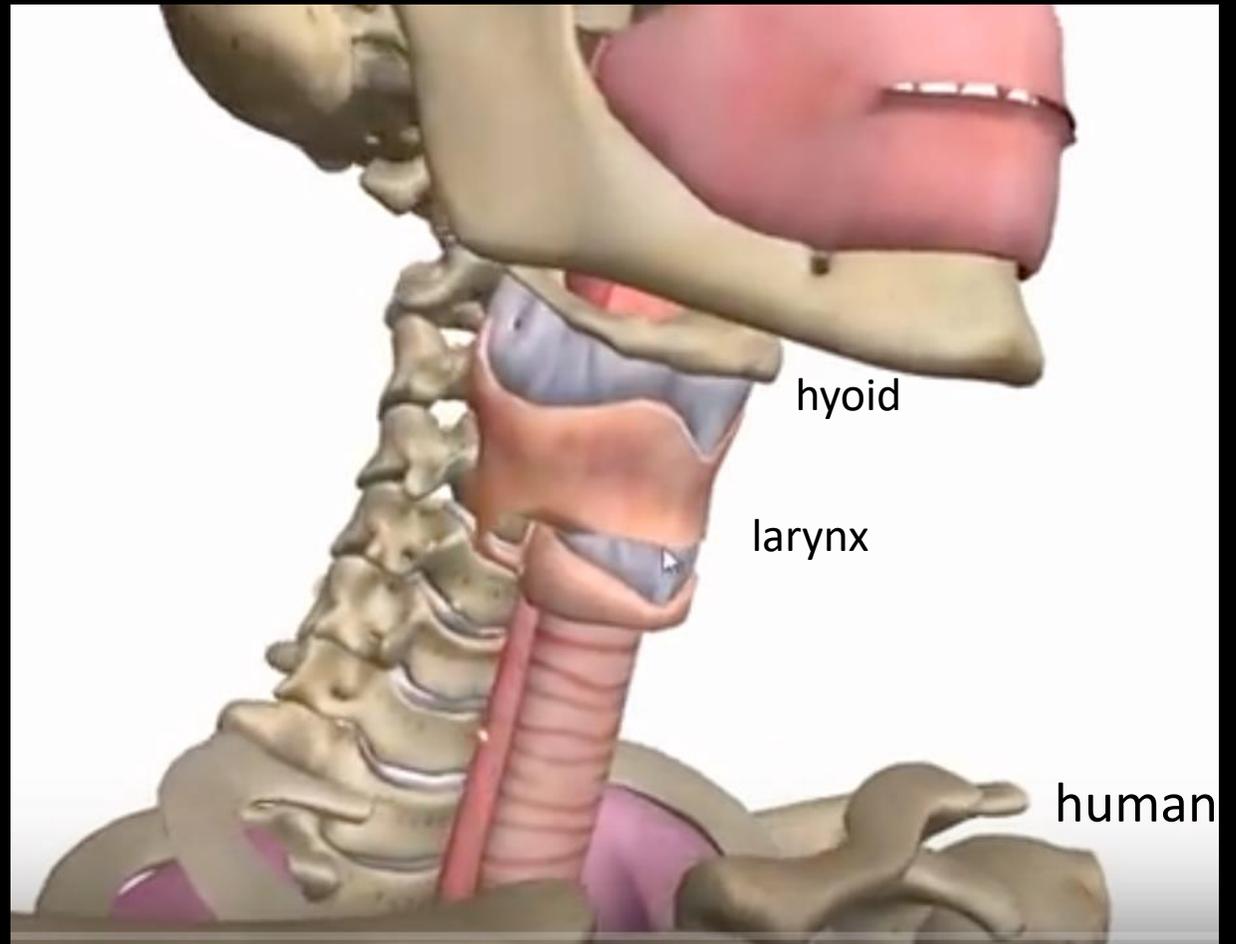
Bird-like





dorsal

**Similar
suspended
position of the
larynx in frogs,
mammals and
birds**



hyoid

larynx

human

Larynx-based vocal organ

**But also the bird larynx has no function
in *sound production or modification***

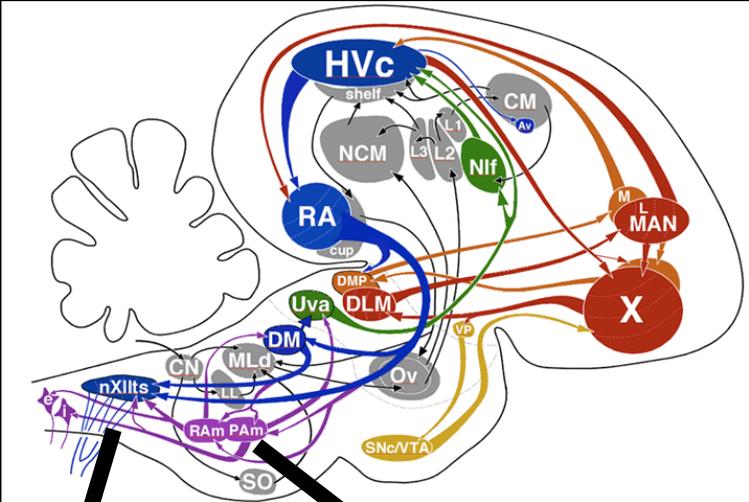
Li et al. 2017

So... what do we know so far about dinosaur sound making?

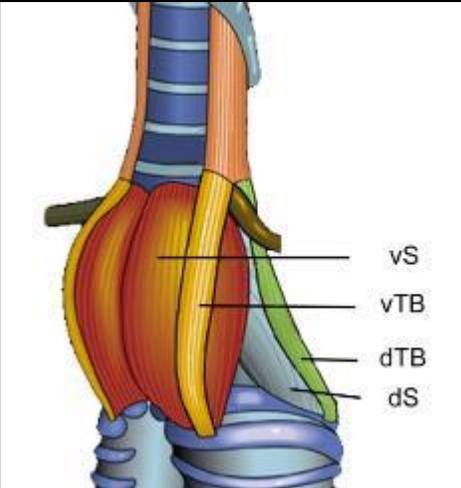
- Closed and open mouth vocalization likely
 - Riede et al. 2016
- Earliest evidence of a syrinx is still in modern birds – may have originated after origin of flight – explain increases in brain size in stem birds?
 - Clarke et al. 2016, Li et al. 2021
- Ankylosaurs are weird but not “bird-like”



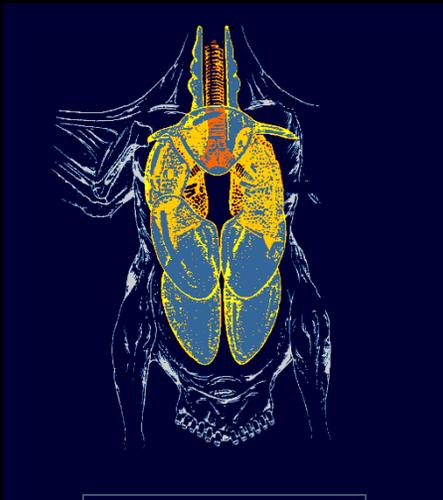
Bird Song



Brain

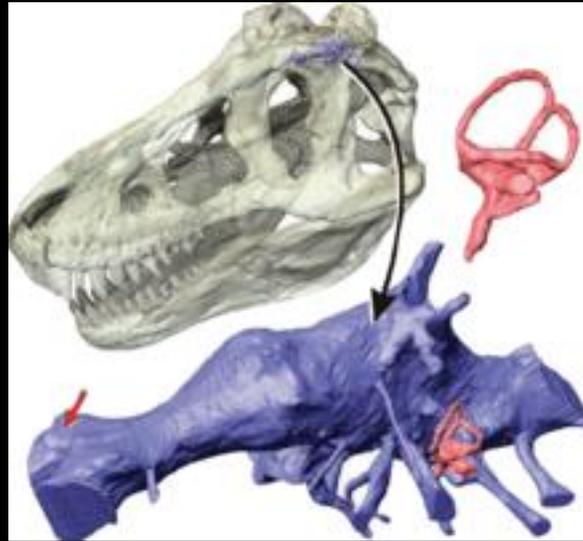


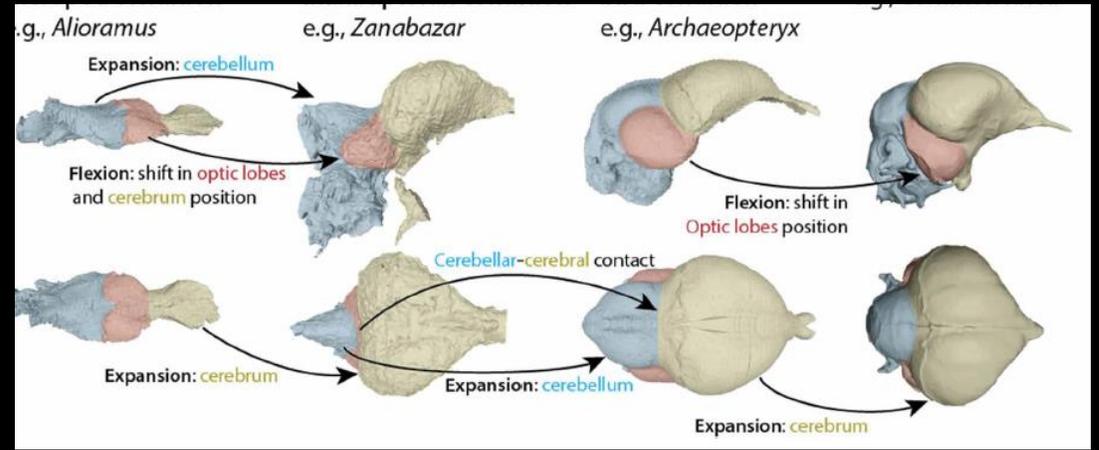
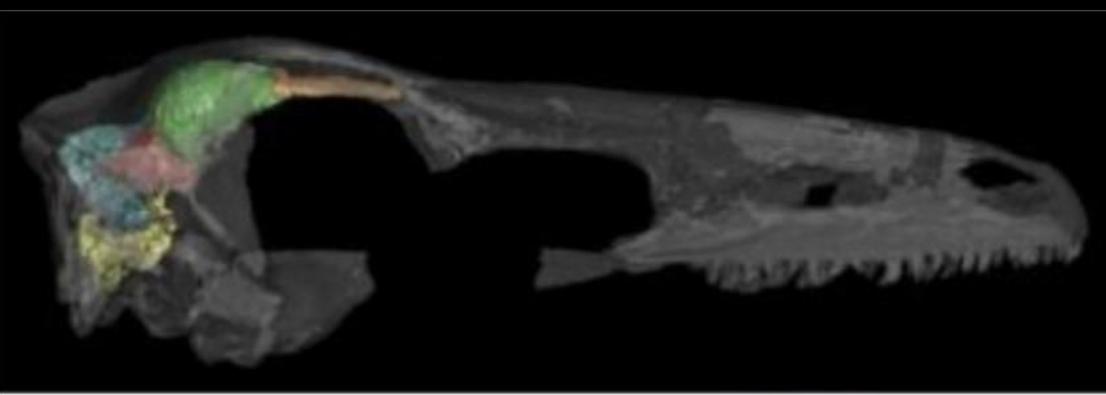
Syrinx



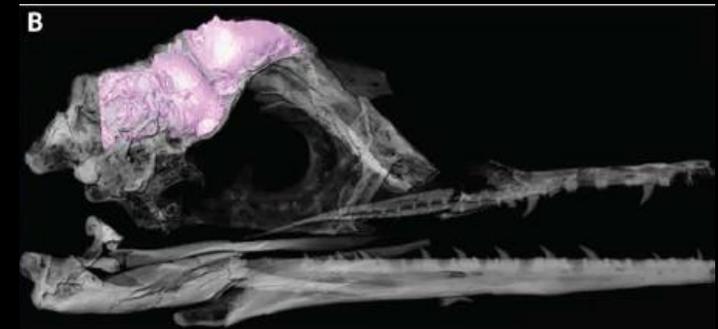
Respiration

Small brains....





Major shifts
in brain
shape after
evolution of
flight

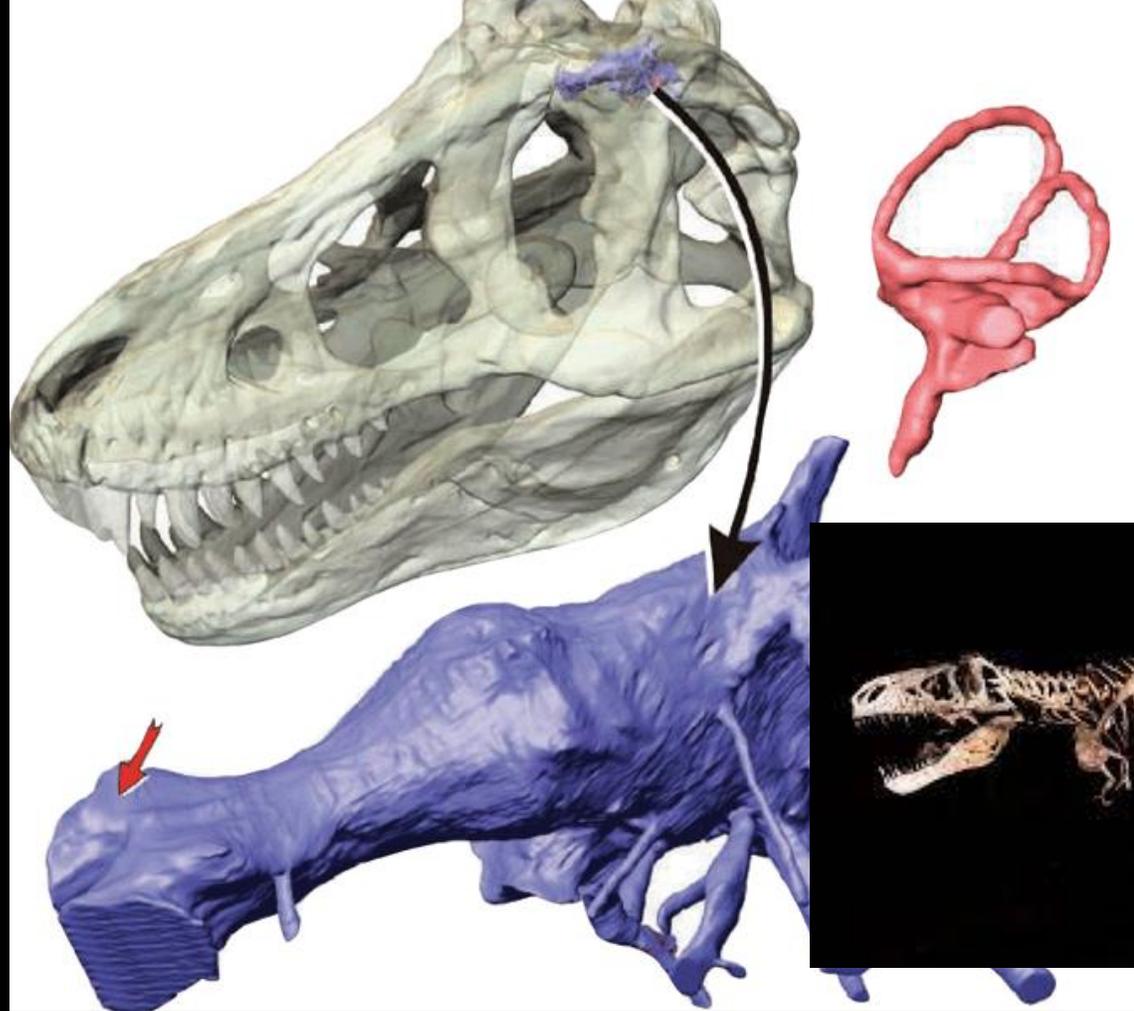


Torres et al. 2021

How *else* might we figure out what dinosaurs sounded like?

What about hearing?





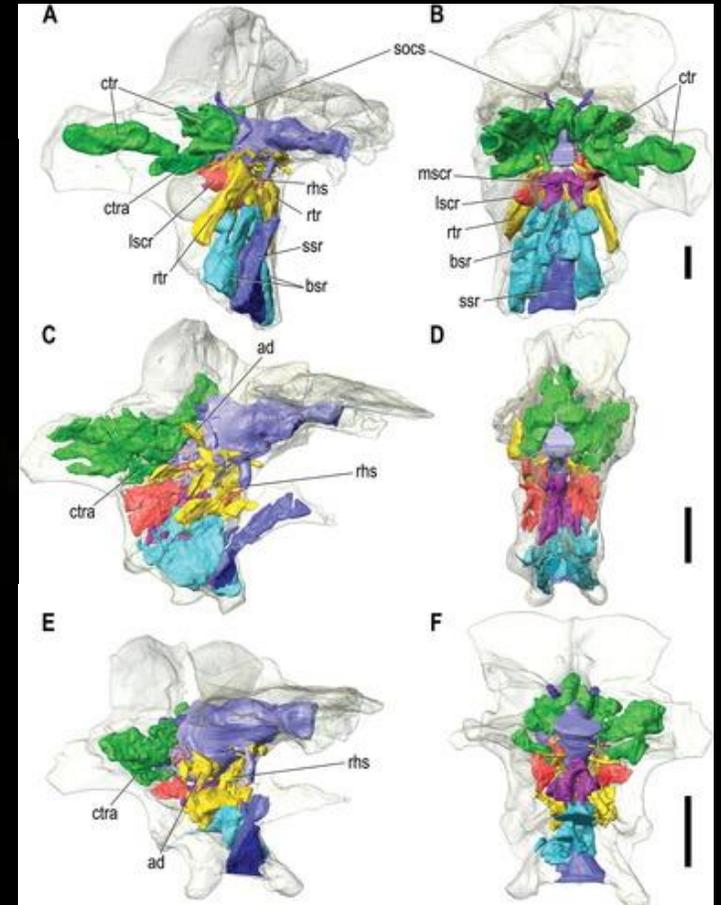
Gleich et al. (2005) hearing estimates *T. rex*: **573Hz best frequency and 2109 Hz max.**

Jurassic Park: ~200Hz
A human male: 120 Hz
African Elephant: 16 Hz



Witmer and Ridgely, 2008b; Witmer et al., 2008

Likely low frequency hearing (pneumatic recesses)



Witmer lab

Fundamental frequency or pitch of sound

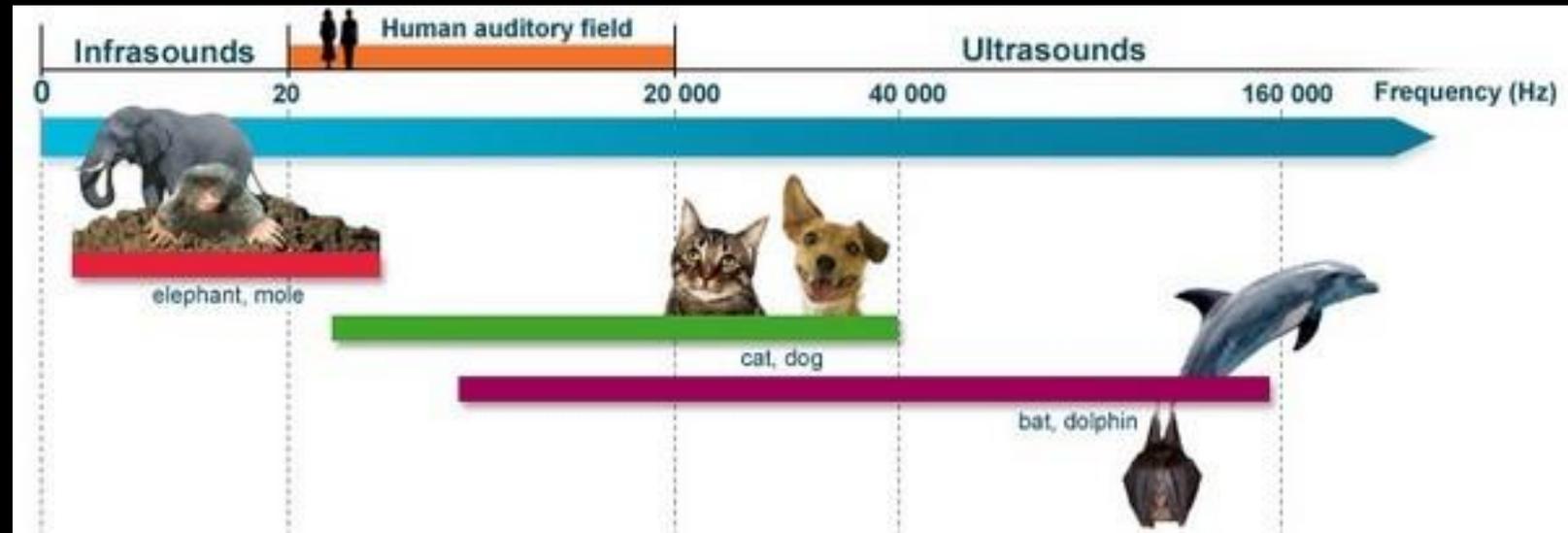
Jurassic Park dino: ~100-200Hz

A human male: 120 Hz

African Elephant: 16 Hz

Infrasounds are sounds not "heard" by us but felt ...

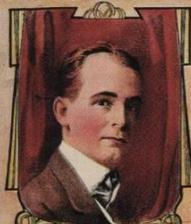
Human hearing in hertz



Are many dinosaurs small or large?

WINSOR McCAY'S "GERTIE"

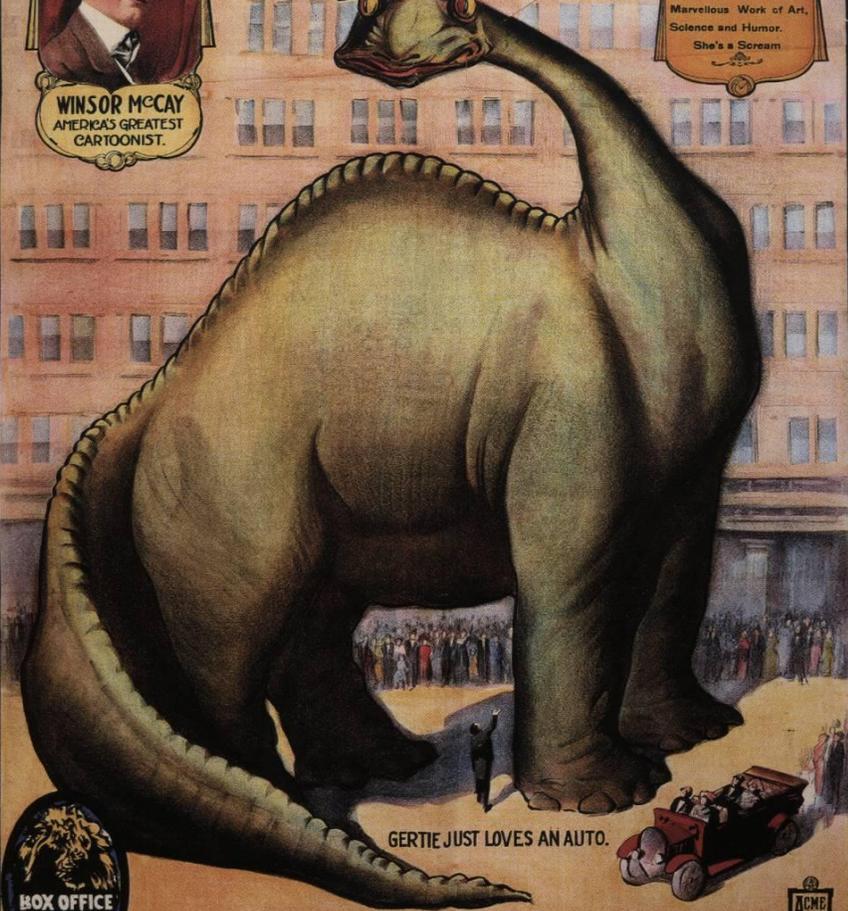
WONDERFULLY TRAINED DINOSAUR



WINSOR McCAY
AMERICA'S GREATEST
CARTOONIST.



A Prehistoric Animal
that Lived Thirteen Mil-
lion Years Ago, Brought
Back to Life. A Most
Marvellous Work of Art,
Science and Humor.
She's a Scream.



GERTIE JUST LOVES AN AUTO.



Released through **BOX OFFICE ATTRACTION CO.**
WILLIAM FOX, President. EXCHANGES IN ALL PRINCIPAL CITIES.



1874

Fundamental frequency scales with body size

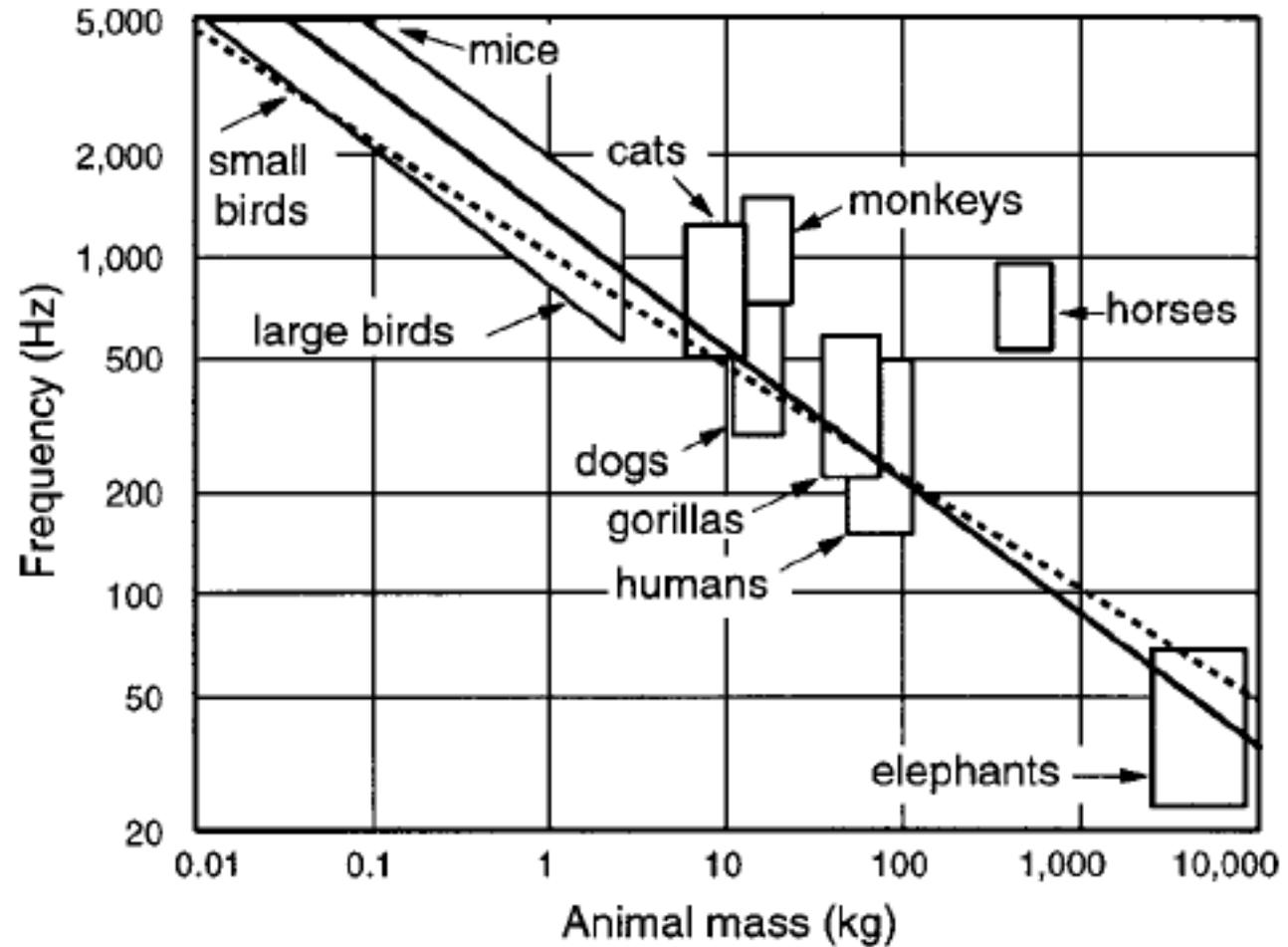
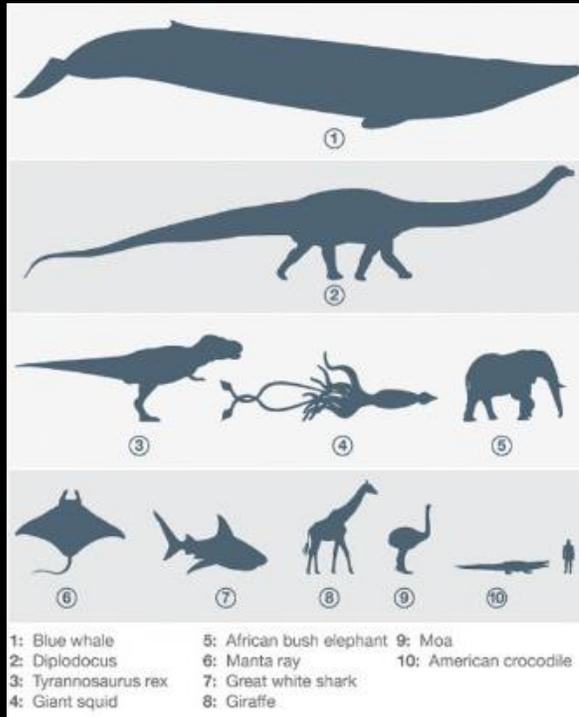
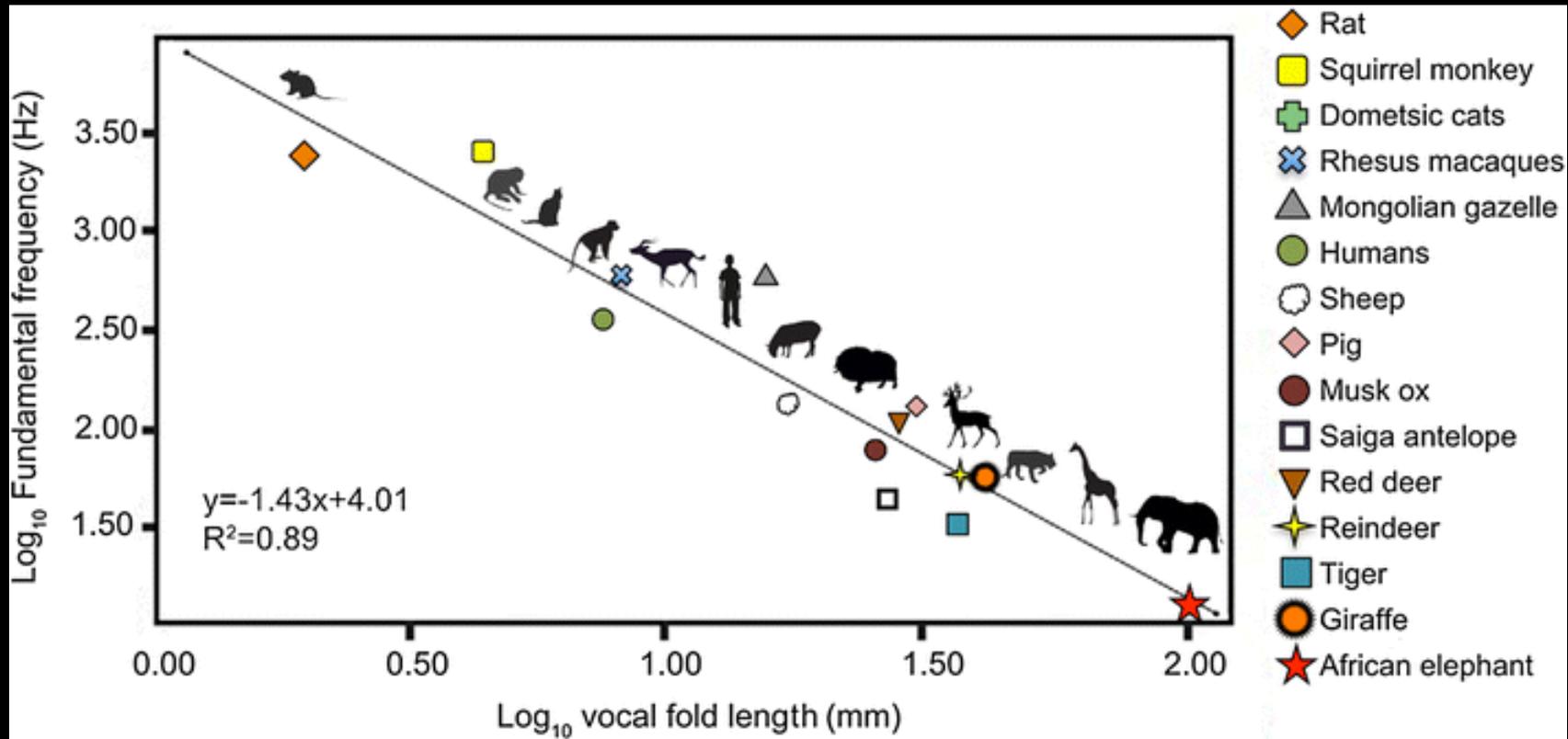


FIG. 3. Correlation between body mass and vocalization frequency for the animals shown. The full line shows the $M^{-0.4}$ power relationship predicted in the text and the dashed line the $M^{-0.33}$ relationship derived from simple linear size scaling.

Fundamental frequency (F0; “pitch”) and vocal fold (sound maker proportions)



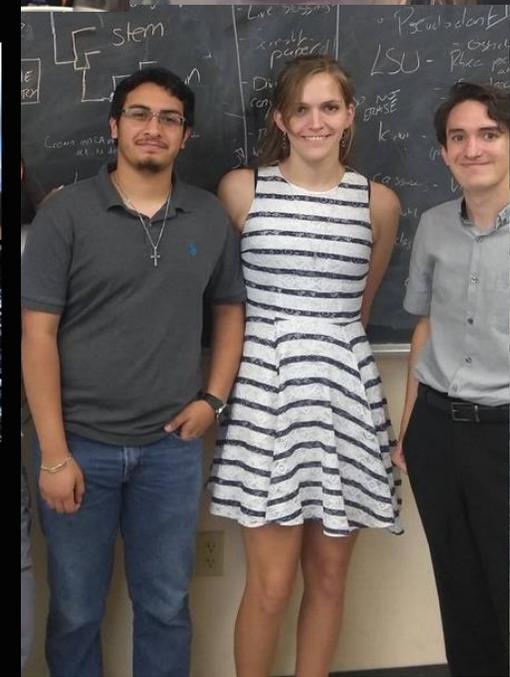


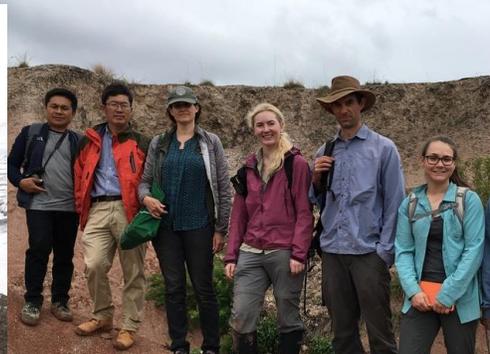
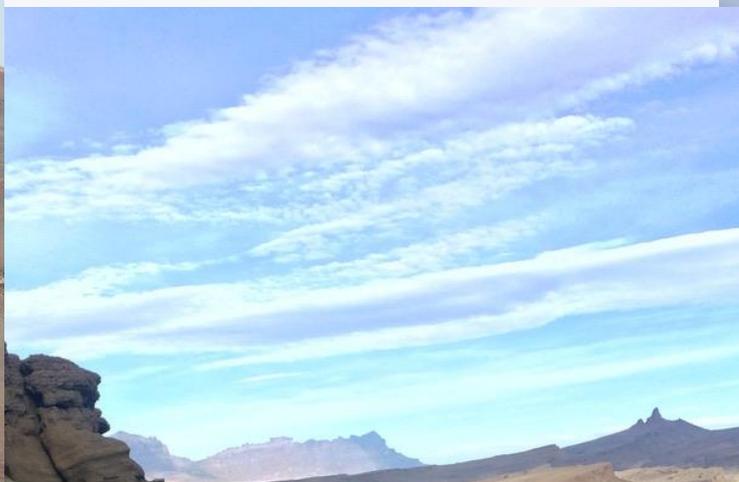
The dinosaurs' ~~roar~~

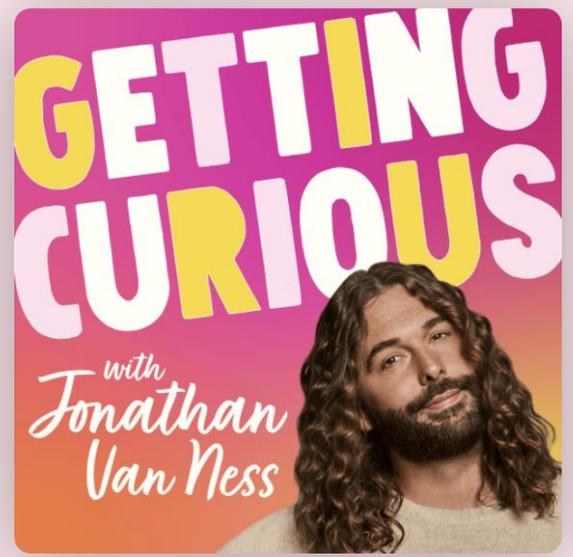
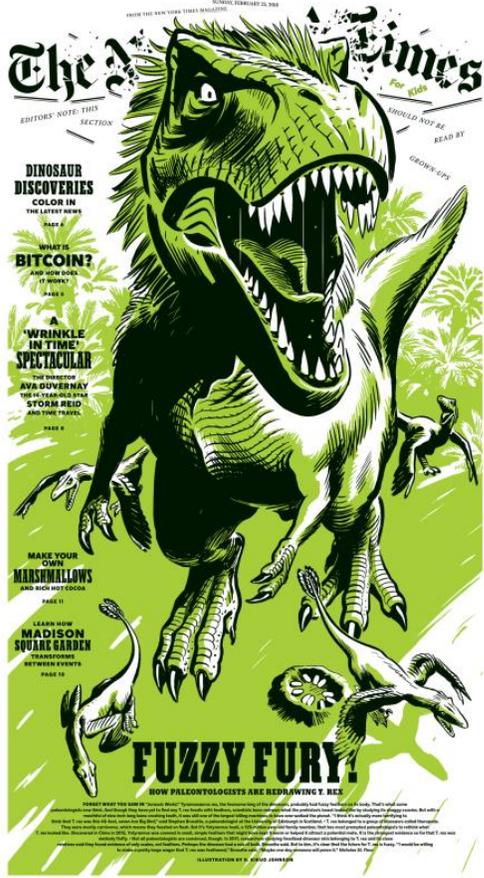




The Valley of Gwanji, 1969
Ray Harryhausen





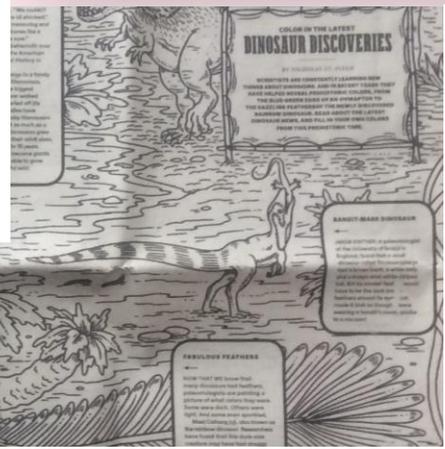


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MAY 27, 2020 | 00:45:07



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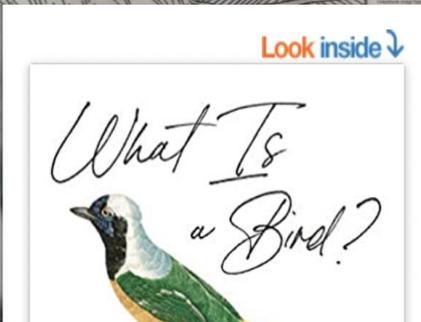


Natural history

Birds of a feather

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