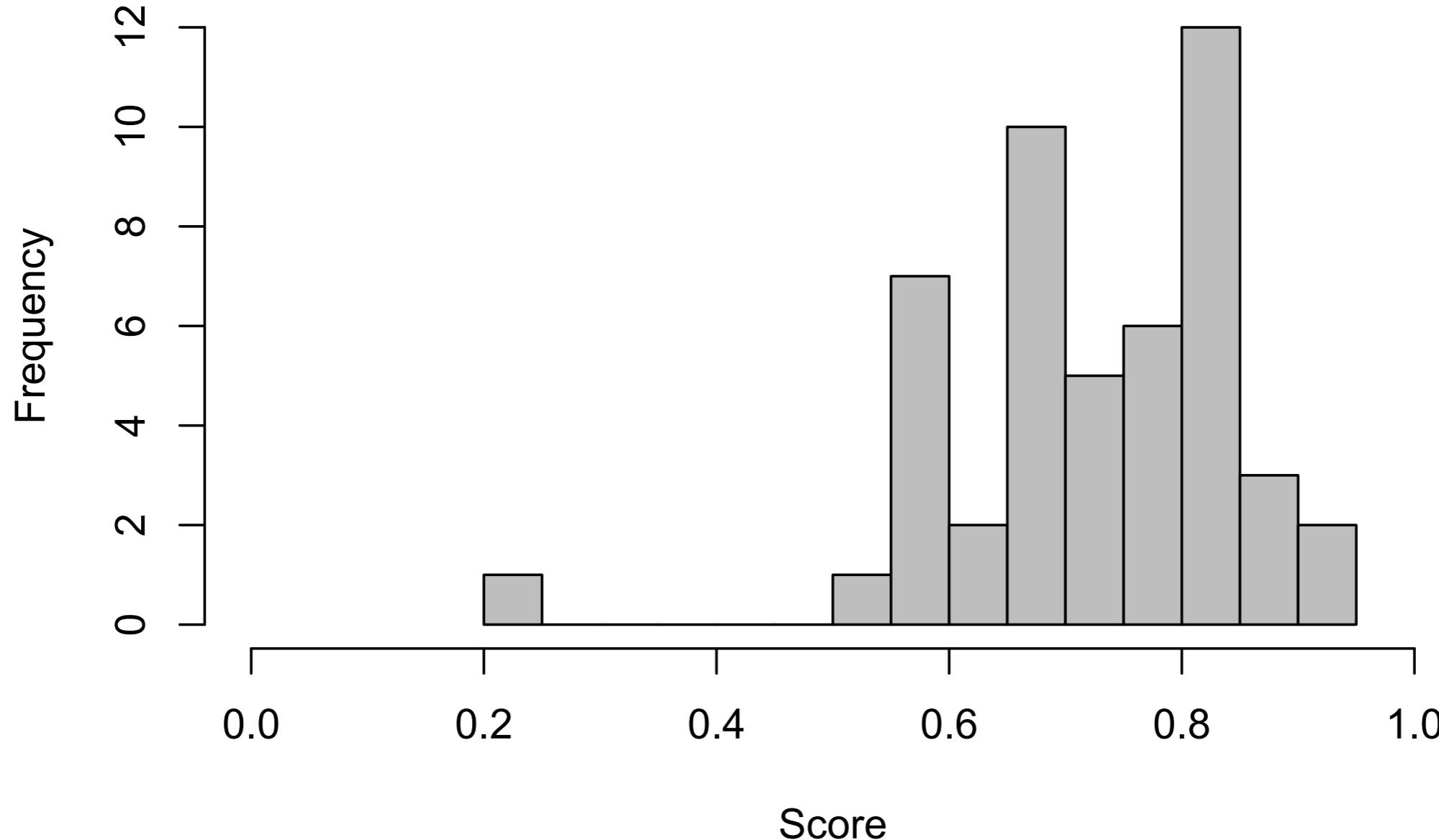


Histogram of x



Mean: 72%

Flying Reptiles of the Mesozoic



Bird Evolution Summary

- Birds are theropod dinosaurs, demonstrated by similarities in osteology, oology, integument, and behavior
- Feathers and arm flapping evolved **before** the animals were capable of powered flight
- Flight likely first evolved in paravian theropods (not in birds), but they were poor fliers
- Further acquisition of flight adaptations (pygostyle, sternum, alula) occurred during Mesozoic bird evolution
- Flying pterosaur reptiles are not related to birds but display convergent evolution of many flight adaptations

Pterosauria



Earliest vertebrates known to evolve
powered flight!

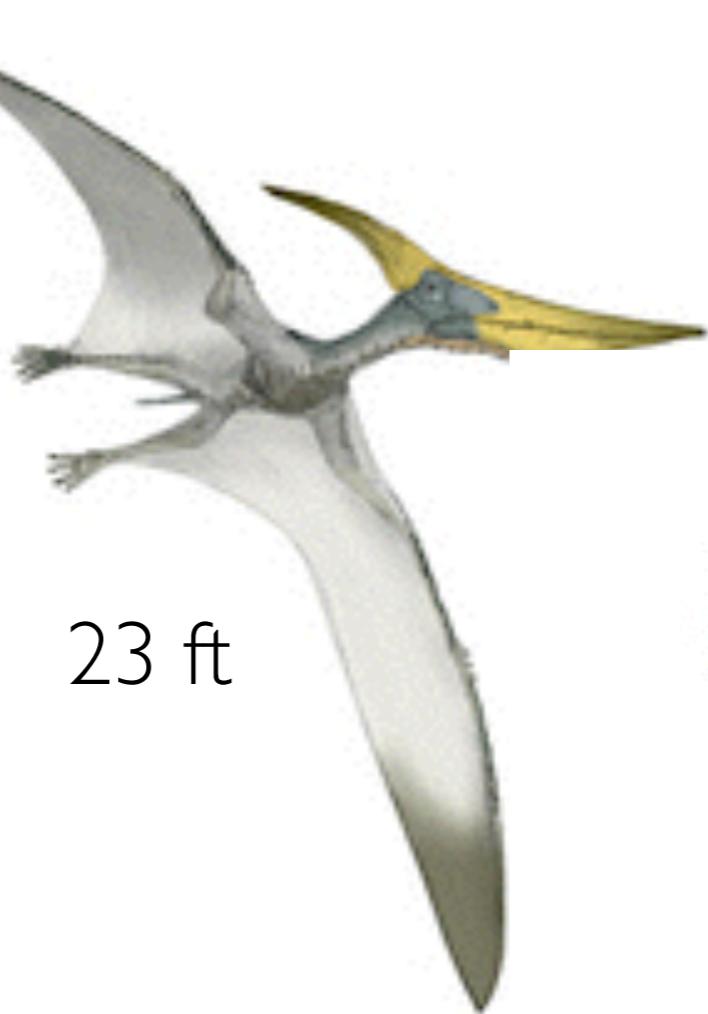
Pterosauria



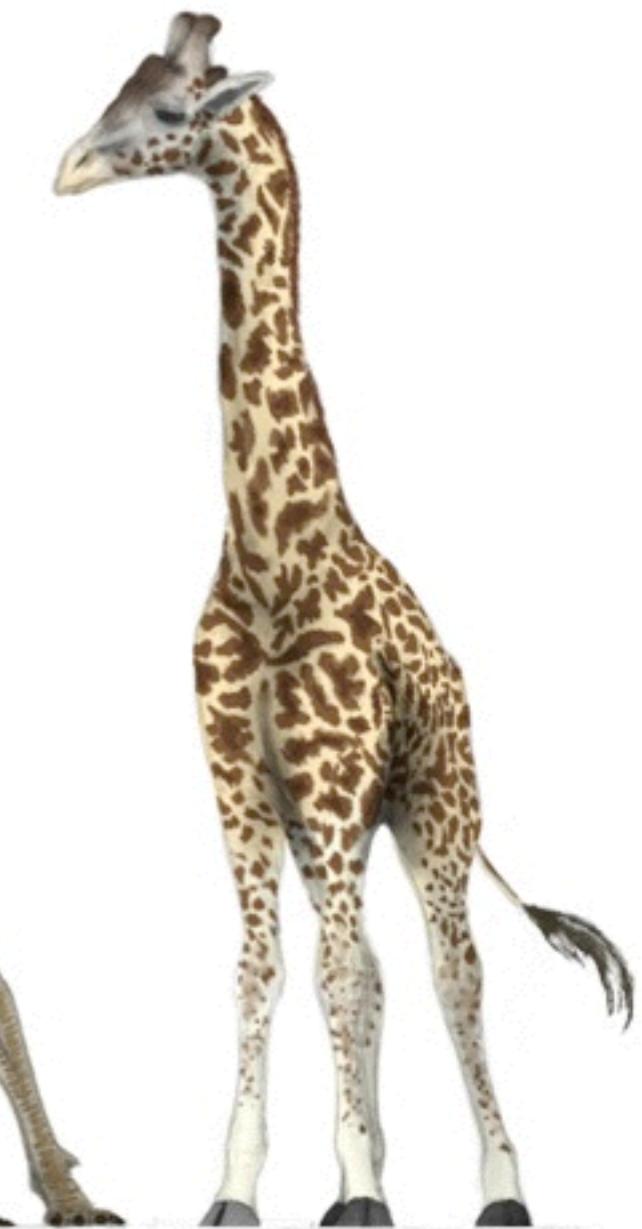
10 in



23 ft



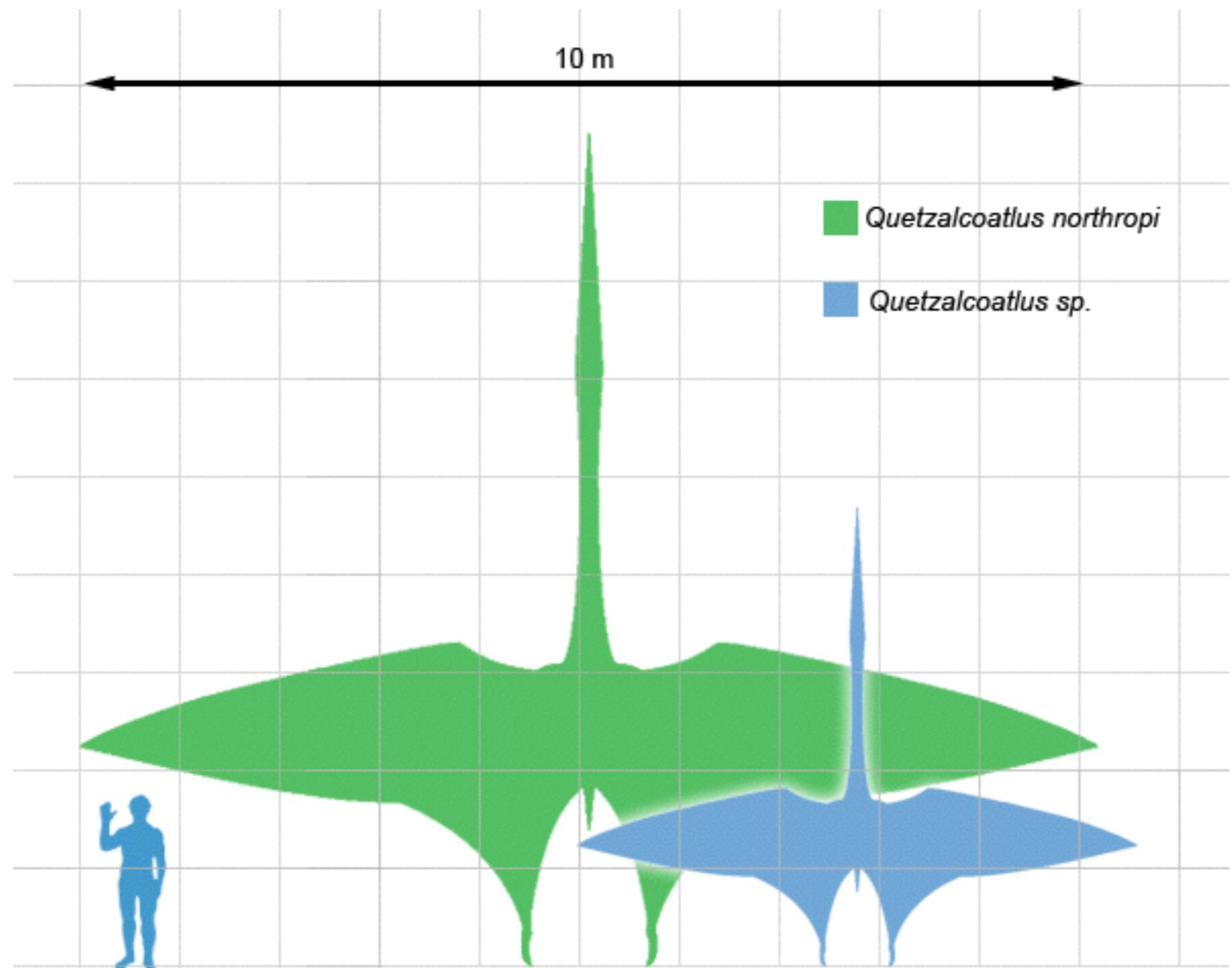
33 ft



Quetzalcoatlus



13 ft



Pterosauria: early forms

Late Triassic - Late Jurassic

Eudimorphodon: (sea gull sized)

Already an advanced flyer

Short body

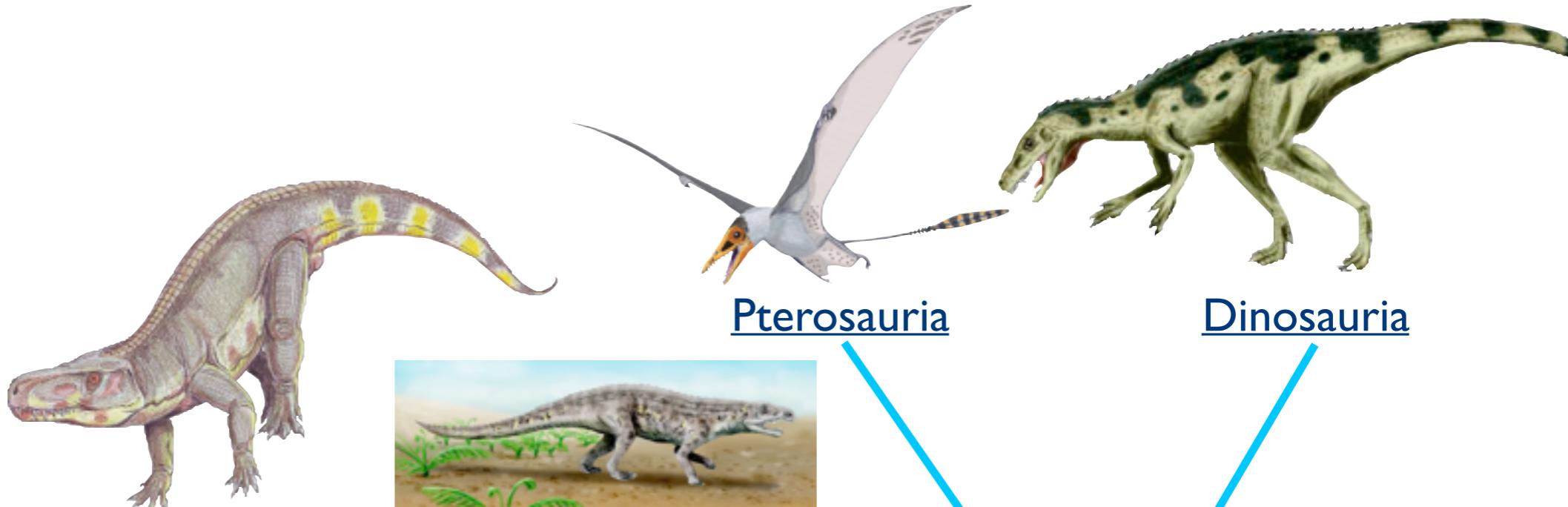
Elongate 4th finger

Pteroid bone





Crocodylomorpha



“Rauisuchia”

Ornithosuchidae

Pterosauria

Dinosauria

Ornithodira

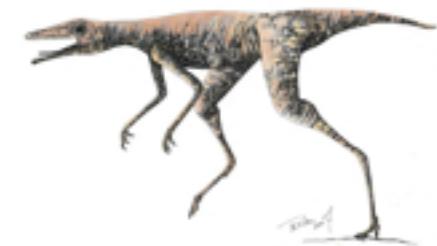
Crurotarsi

Basal archosaurs

Crown-clade Archosauria

Archosauria

Pterosauria



Scleromochlus



Pterosauria



Lagosuchus



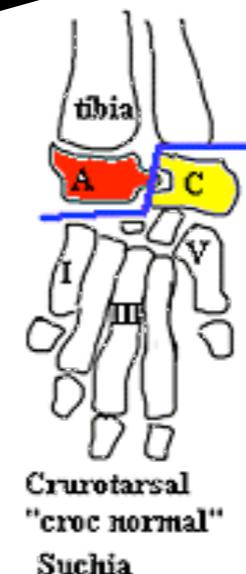
Aves



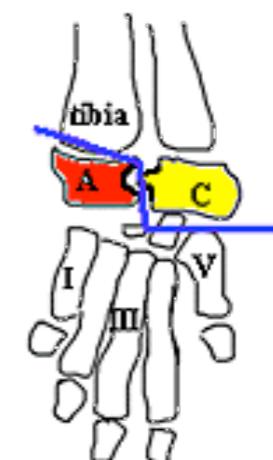
Dinosauria



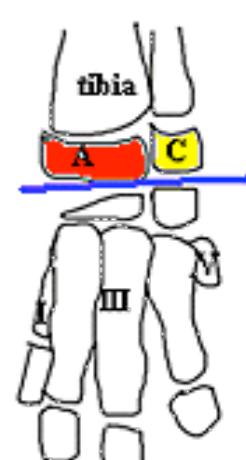
Ornithodira:
Upright gait
S-curved necks
Hinged Ankle



Crurotarsal
"croc normal"
Suchia

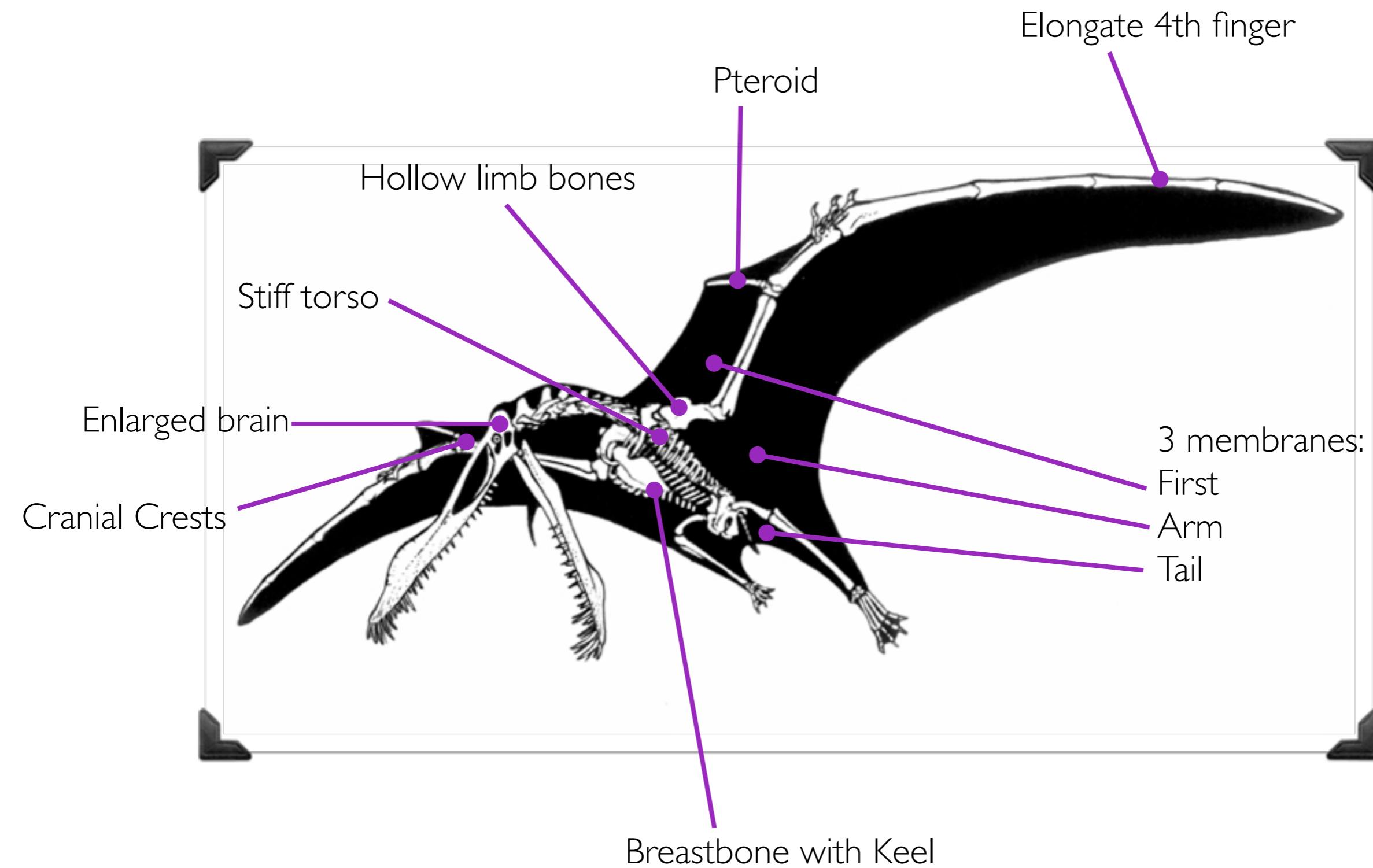


Crurotarsal
"croc reversed"
Ornithosuchia

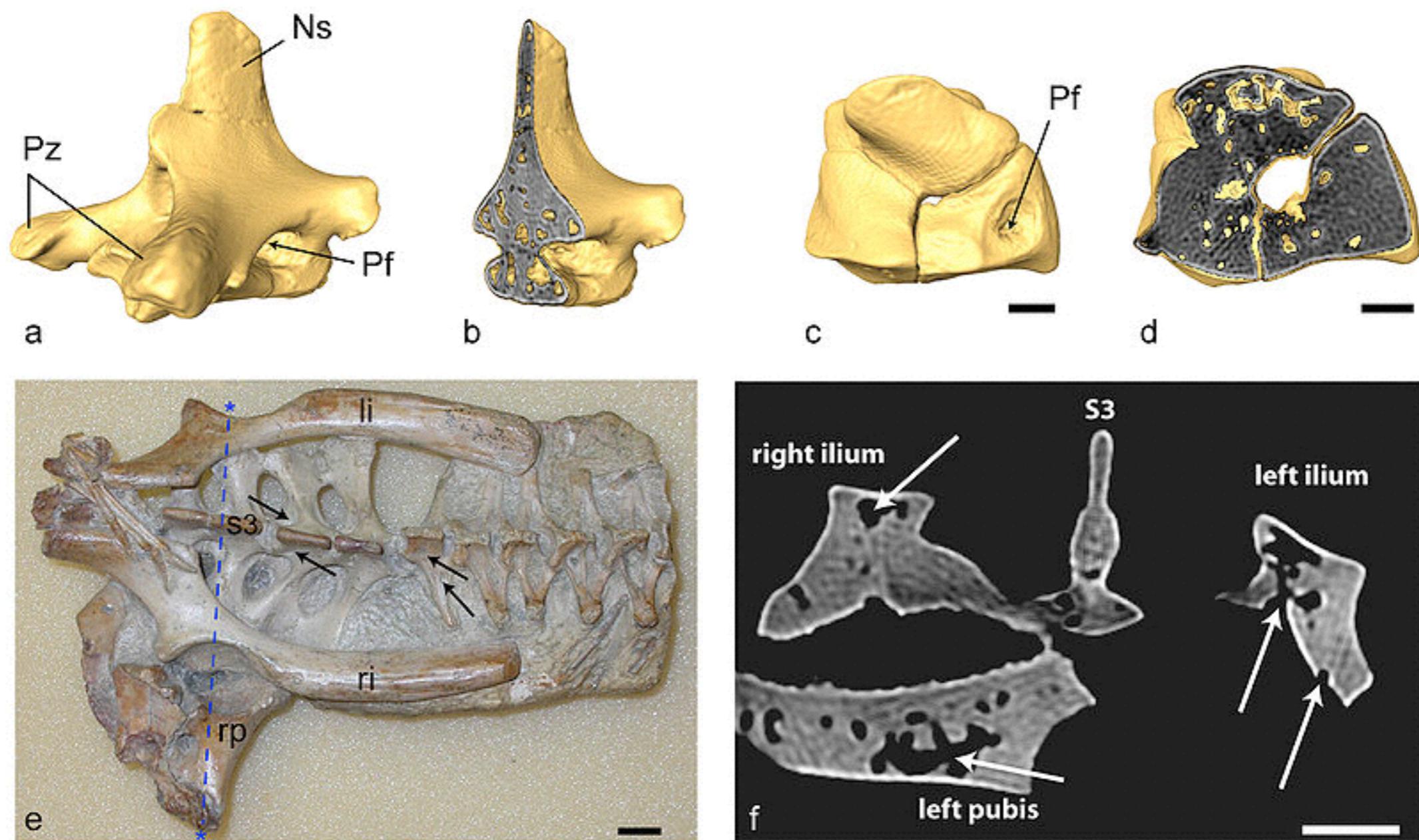


Mesotarsal
Ornithodira

Pterosaur Traits



Pterosaur Traits: pneumatic bones



Pterosaur Traits: air sacs



(c) Mark Witton 2009

Pterosaur Traits: cranial crests Keratinous



Pteranodon



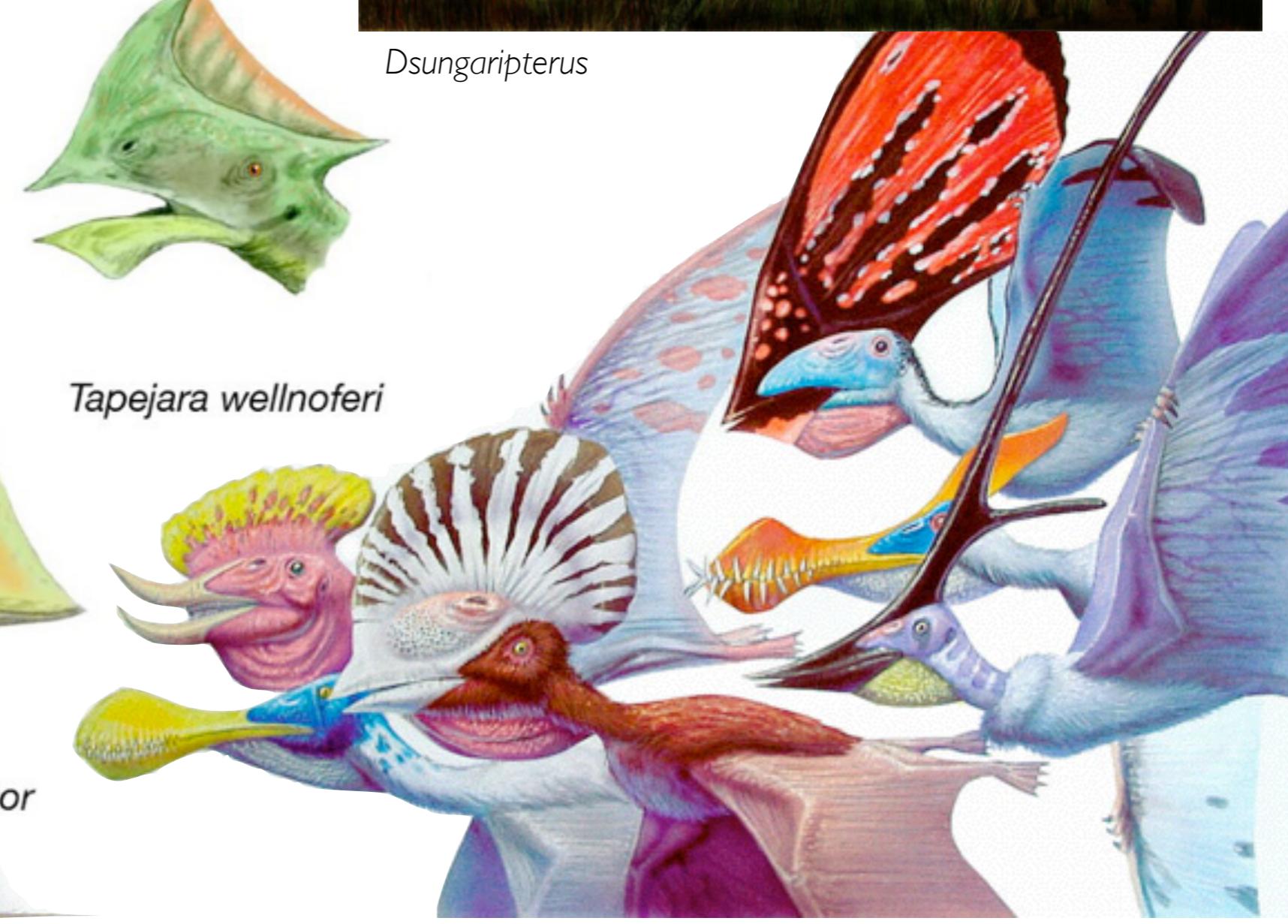
'Ingridia' navigans



Tupandactylus imperator



Tapejara wellnoferi



Dsungaripterus

Pterosaur Traits: cranial crests

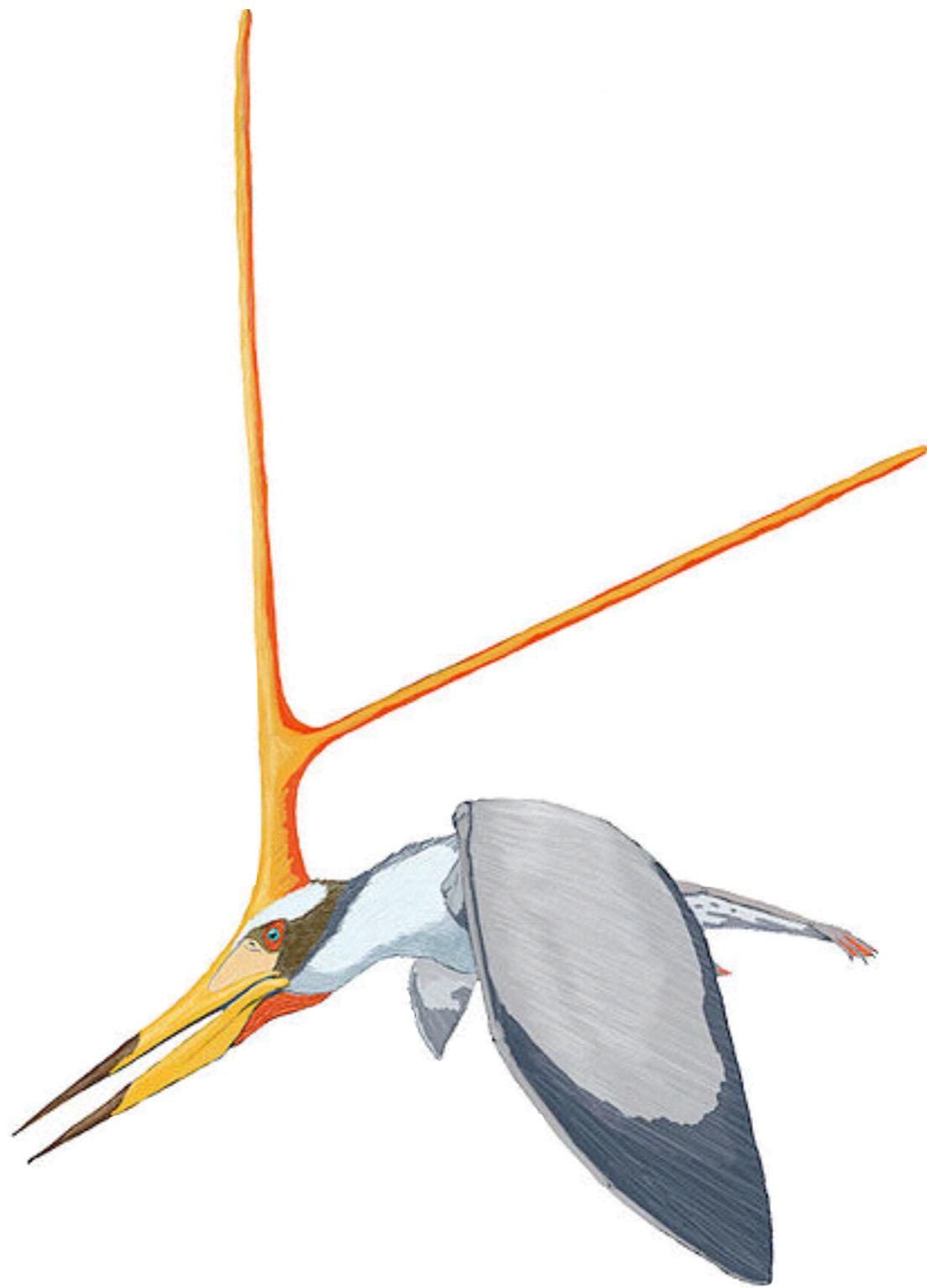
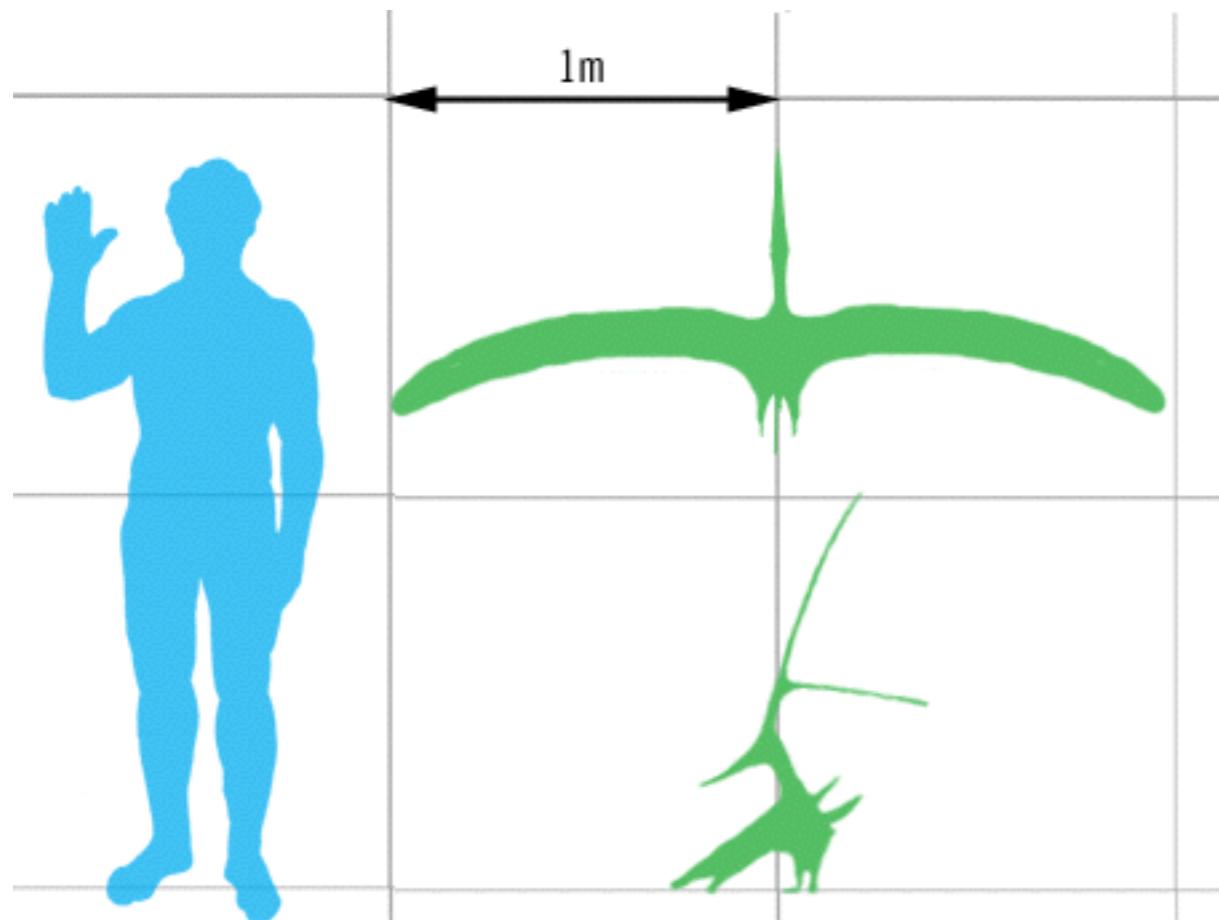
Keratinous



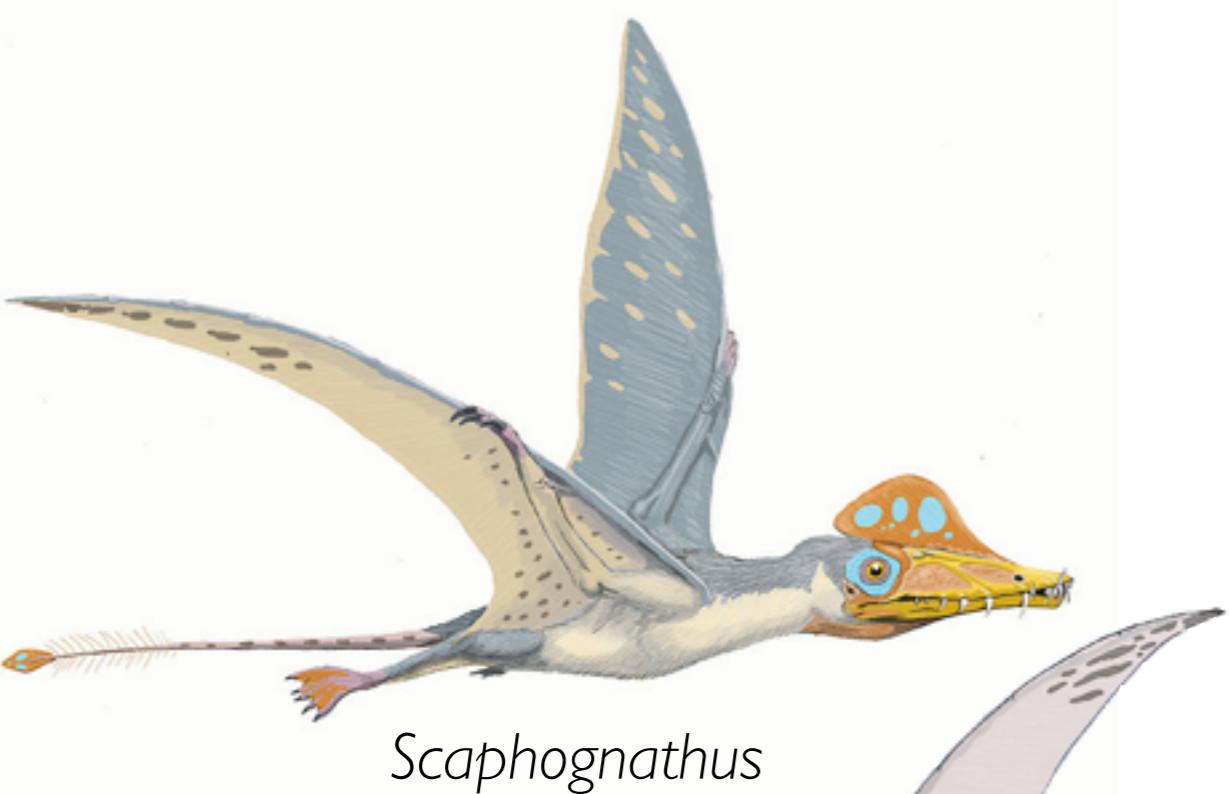
Pterosaur Traits: cranial crests

Nyctosaurus; late Cretaceous

Sometime, ridiculous things happen.



Pterosaur Traits: jaw diversity



Scaphognathus



Sordes

Basal Pterosaurs (paraphyletic)
Late Triassic
Long teeth and nails
Most lacked bony crests

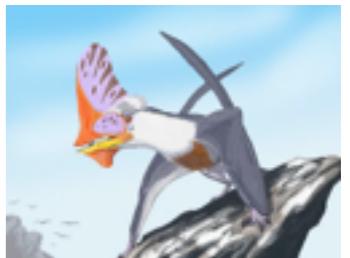


Dorygnathus



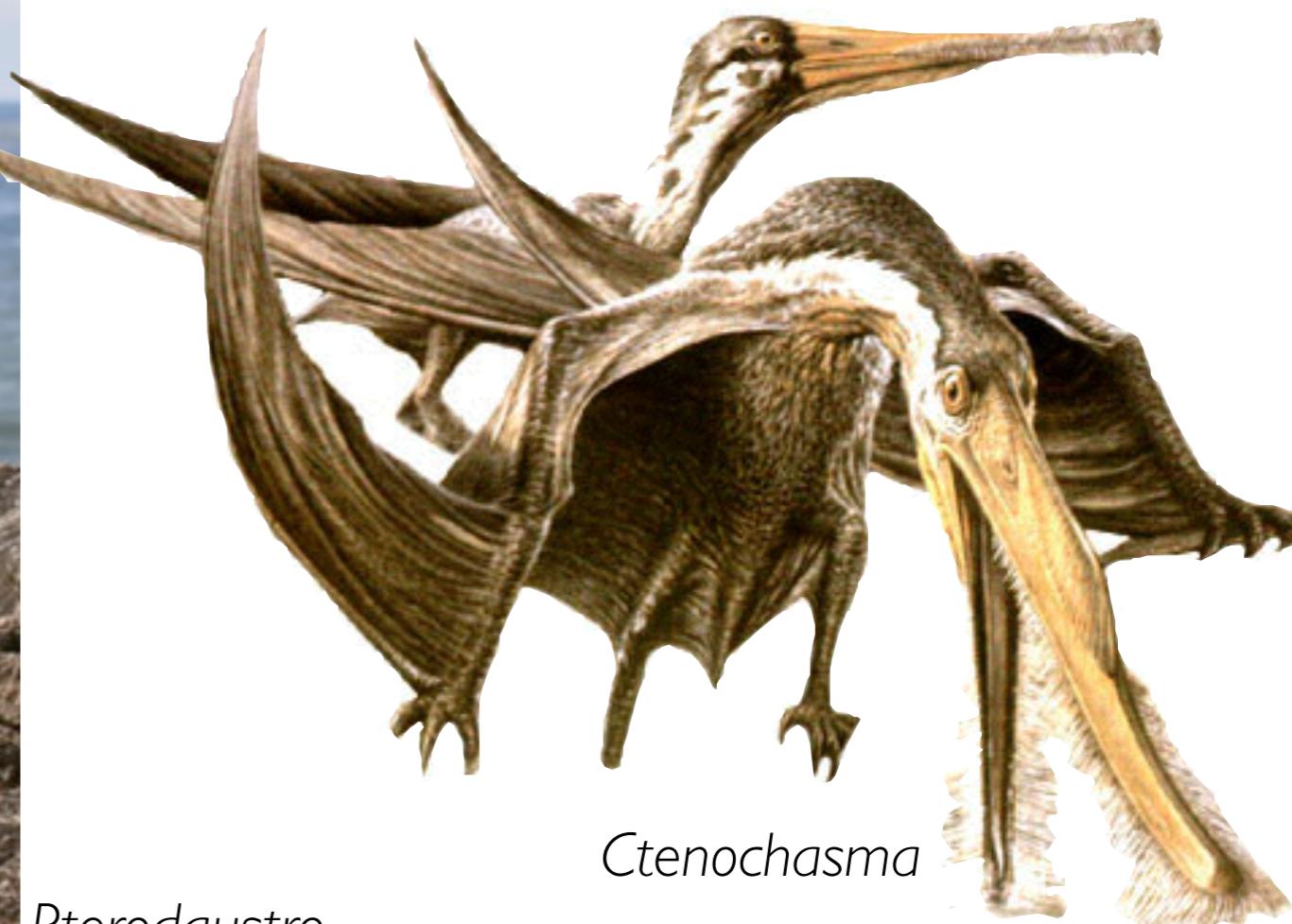
Campylorhynchoides

Ramphorynchids





Dimorphodon



Pterodaustro

Ctenochasma

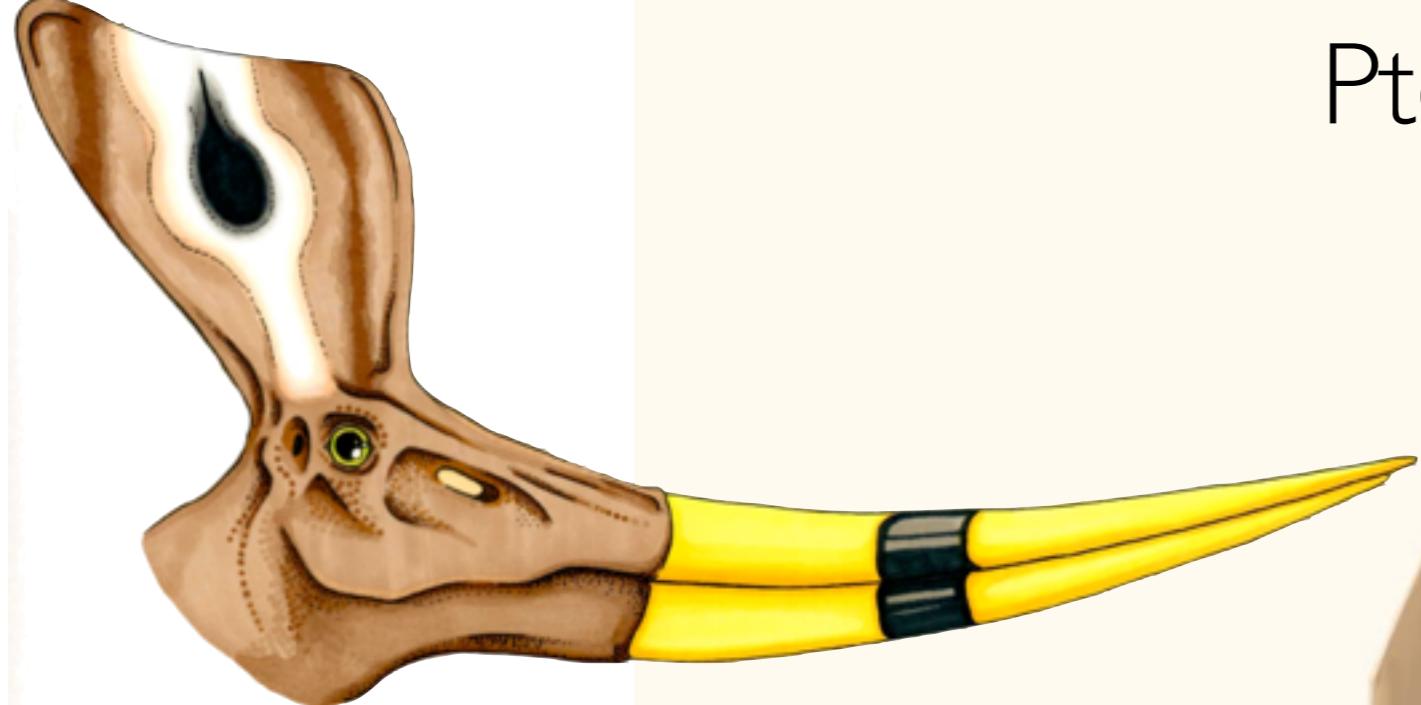


Ornithocheirus

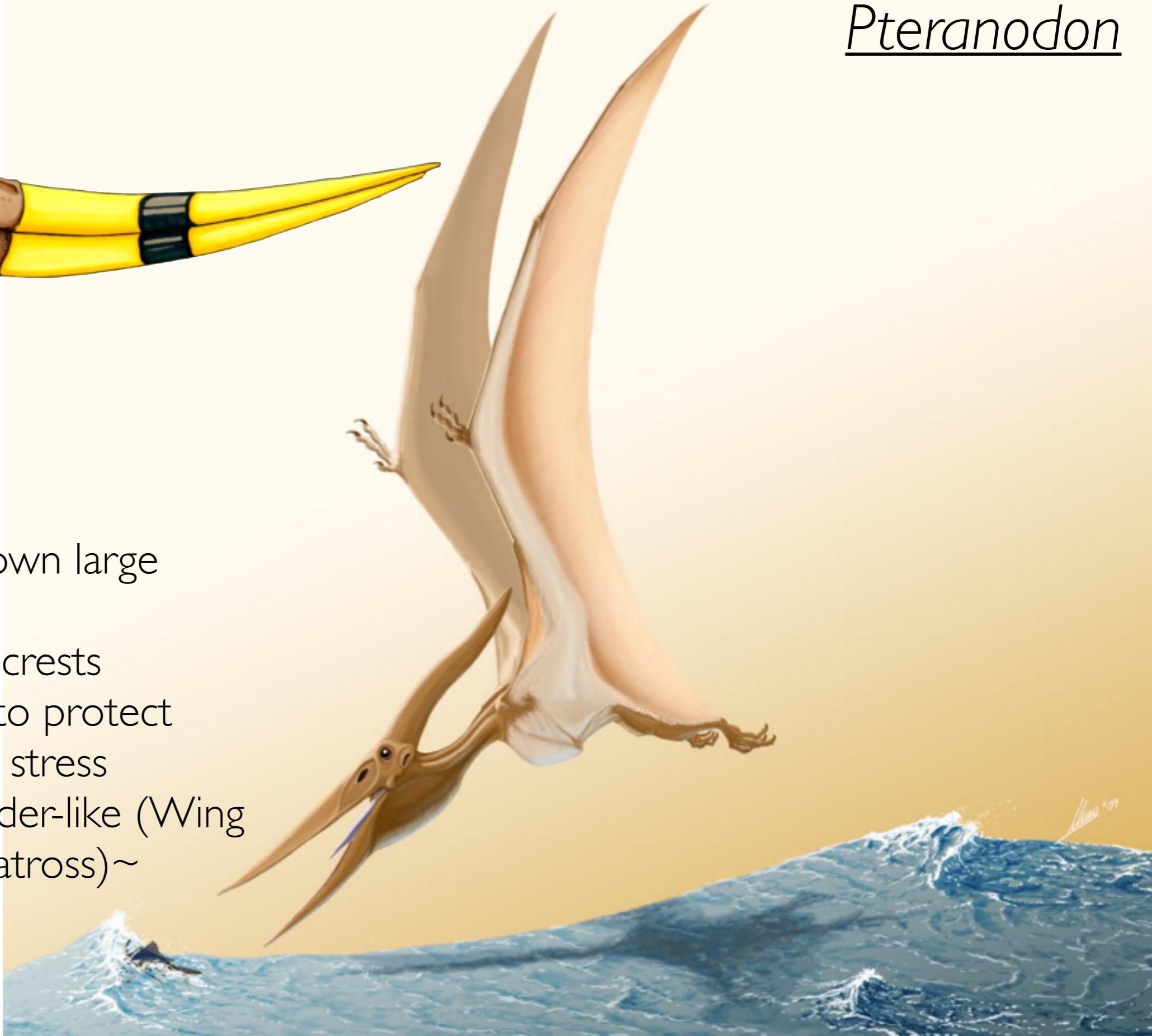
Fisheaters, Filterers

Pterosaur Traits: jaw diversity

Pteranodon



No teeth
Scoop-shaped bill
One of the best known large
Pterosaurs
Sexually Dimorphic crests
Heavily fused body to protect
against flight-related stress
Potentially more Glider-like (Wing
shape similar to Albatross)~
dynamic soaring
Piscivore



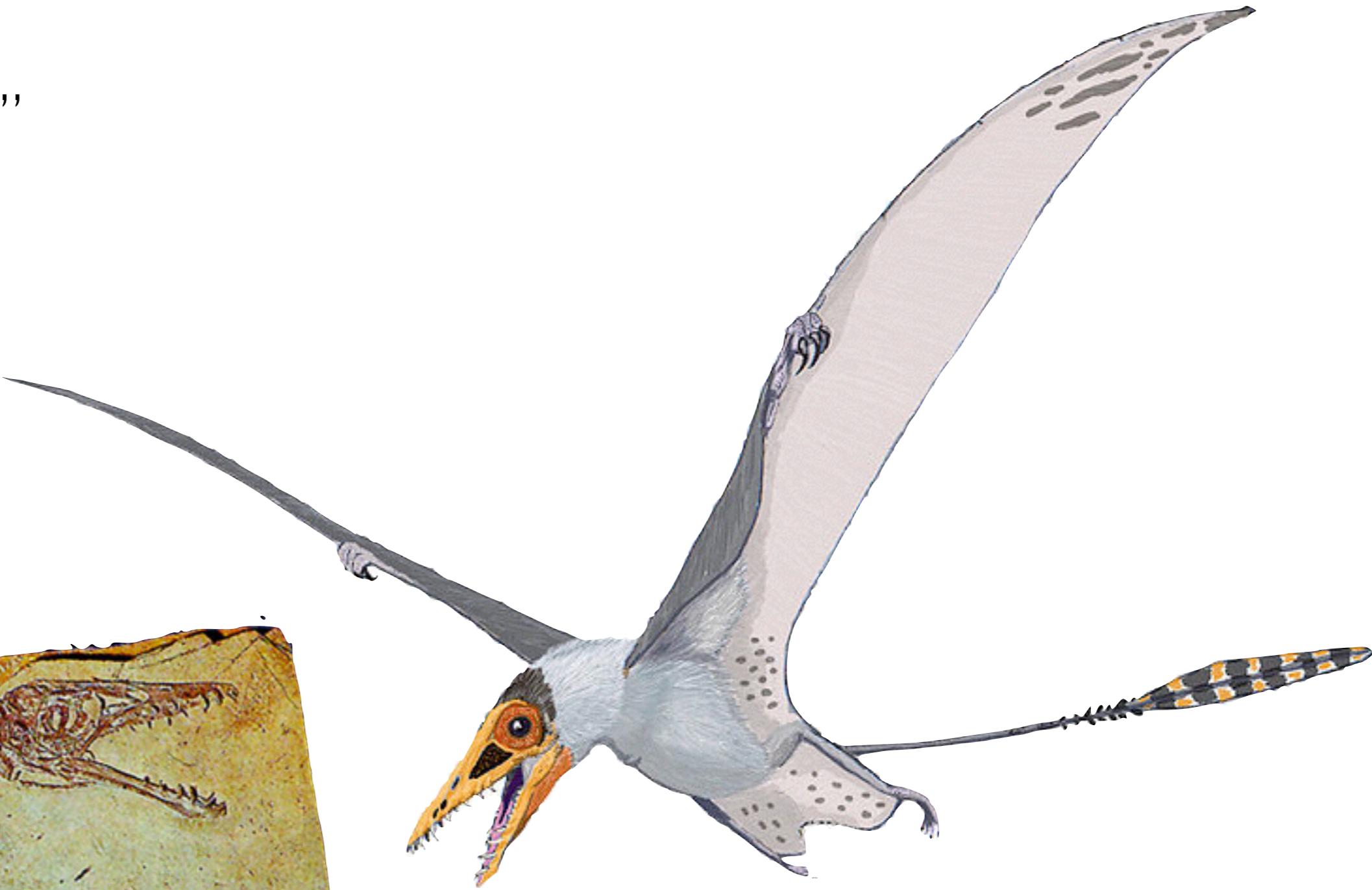


Pterosaur Traits: skin



Covered in hair-like filaments:
Pycnofibres
NOT HAIR
Similar in structure: convergent evolution
Very convincing evidence that these animals were **endothermic**

Sordes pilosus
“Hairy Demon”



Pterosaur Eggs

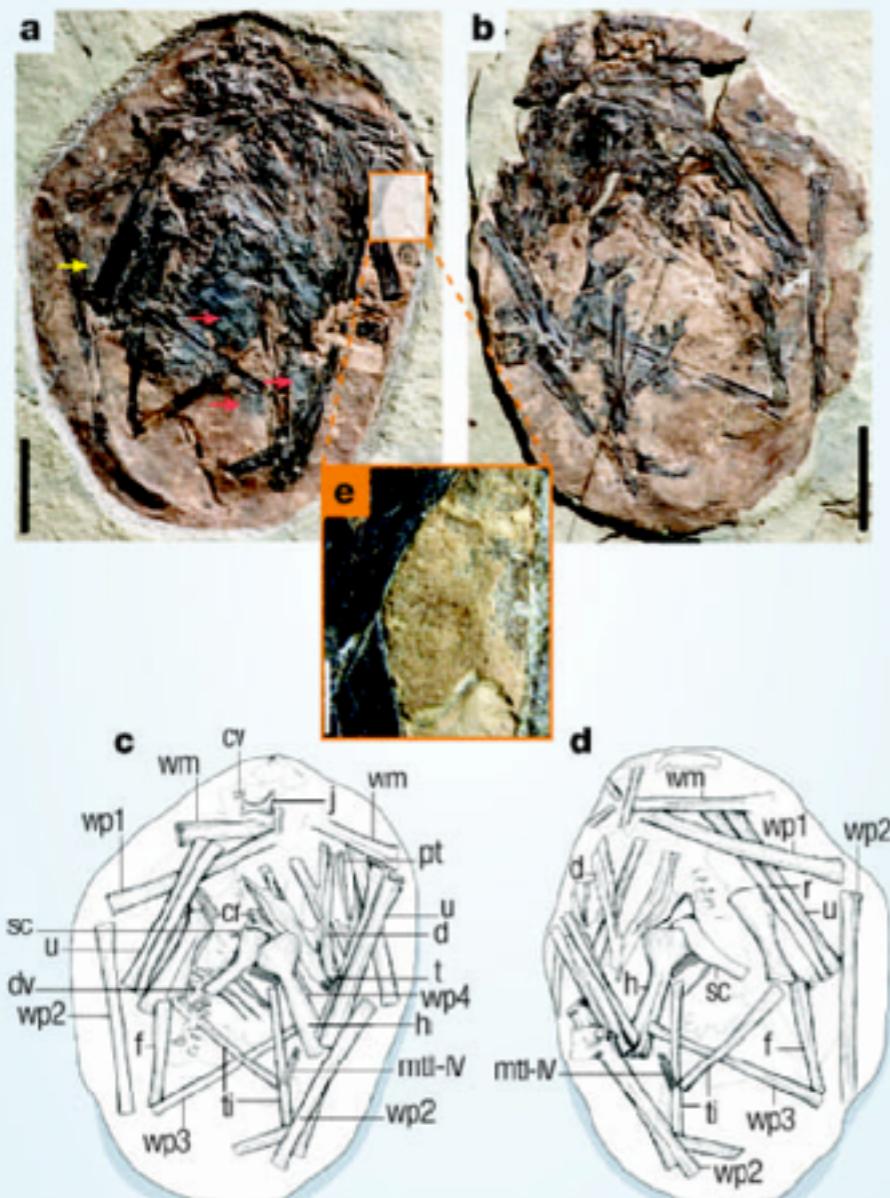


Figure 1 Pterosaur embryo inside an egg from the Early Cretaceous period from Liaoning, China (VPP V13758). **a–d**, Photographs of part (a) and counterpart (b) of the fossil and their corresponding line drawings (c, d; not to scale). Red arrows indicate skin imprints and the yellow arrow indicates the fibres of the wing membrane. Scale bar, 10 mm. **e**, Close-up of the papilla-like ornamentation of the eggshell (corresponding to orange frame in a). Scale bar, 2 mm. Abbreviations in **c, d**: cr, coracoid; cv, cervical vertebra; d, dentary; dv, dorsal vertebra; f, femur; h, humerus; j, jugal; mtI–IV, metatarsals I–IV; pt, pteroid; r, radius; sc, scapula; t, tooth; ti, tibia; u, ulna; wp1–4, first to fourth phalanges of the wing digit; wm, wing metacarpal.

Thin, soft shelled eggs
No evidence of multiple laminar layers

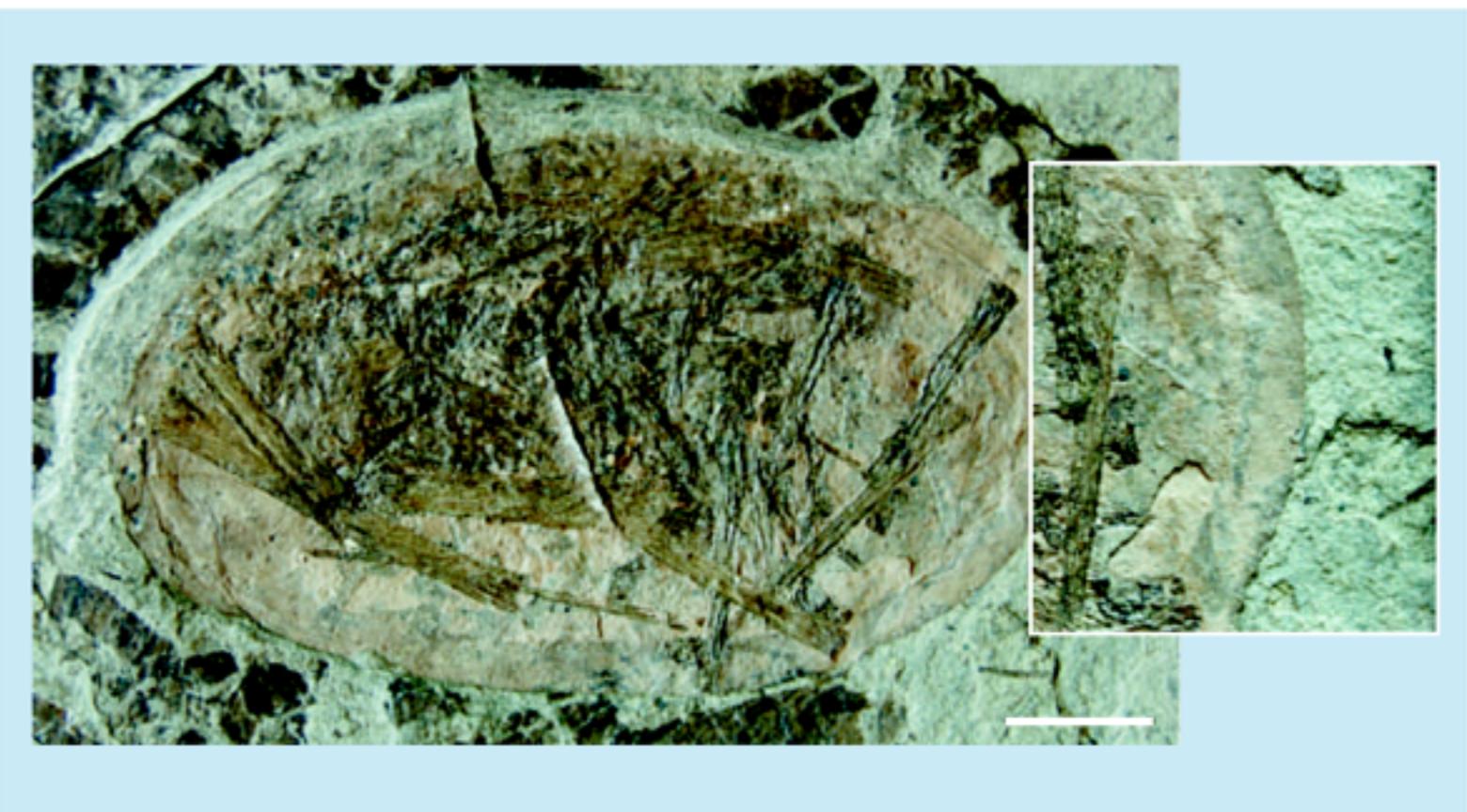
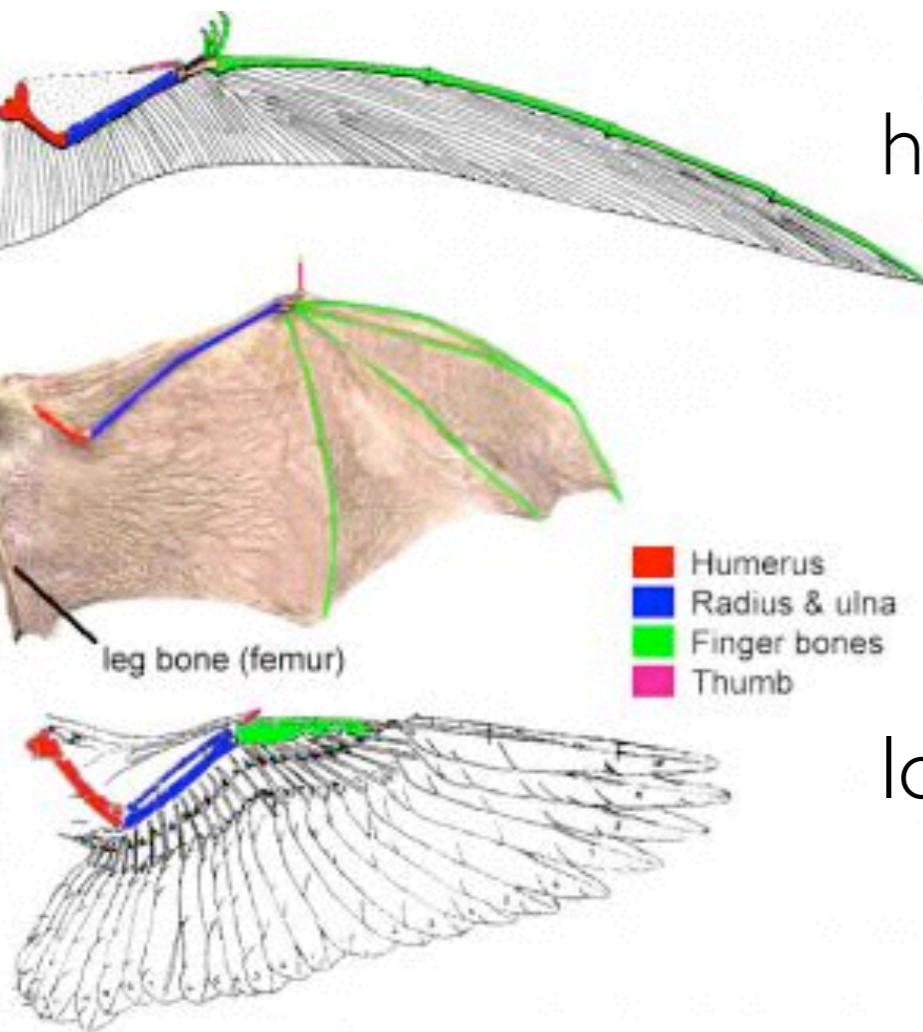


Figure 1 Early Cretaceous pterosaur egg and embryo (JZMP-03-03-2) from the Yixian Formation of Liaoning, China. Scale bar, 1 cm. Inset, magnification of egg boundary (130%) showing the thin, soft shell and no evidence of lamination structures. For composite drawing of the specimen, see supplementary information.

Pterosaur Flight



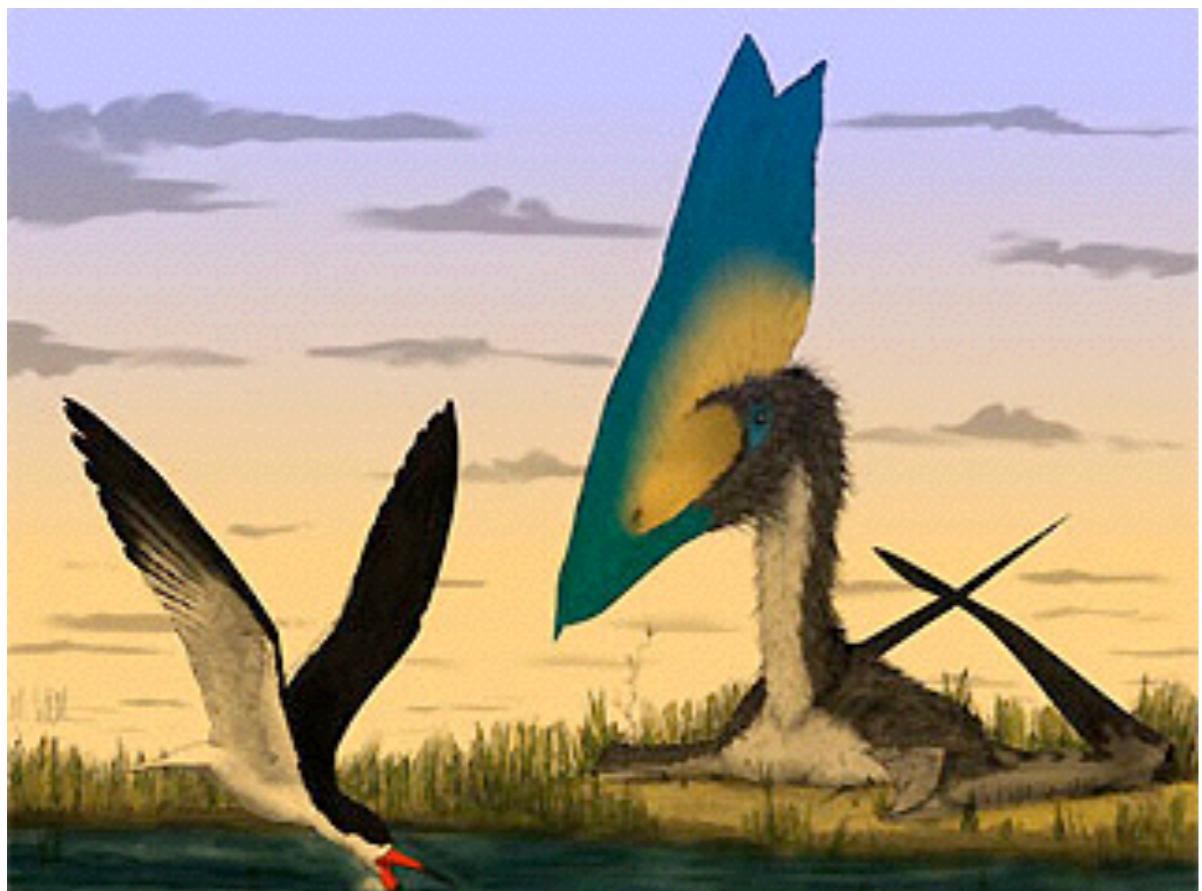


high aspect ratio
(long, slender)

low aspect ratio
(short, squat)



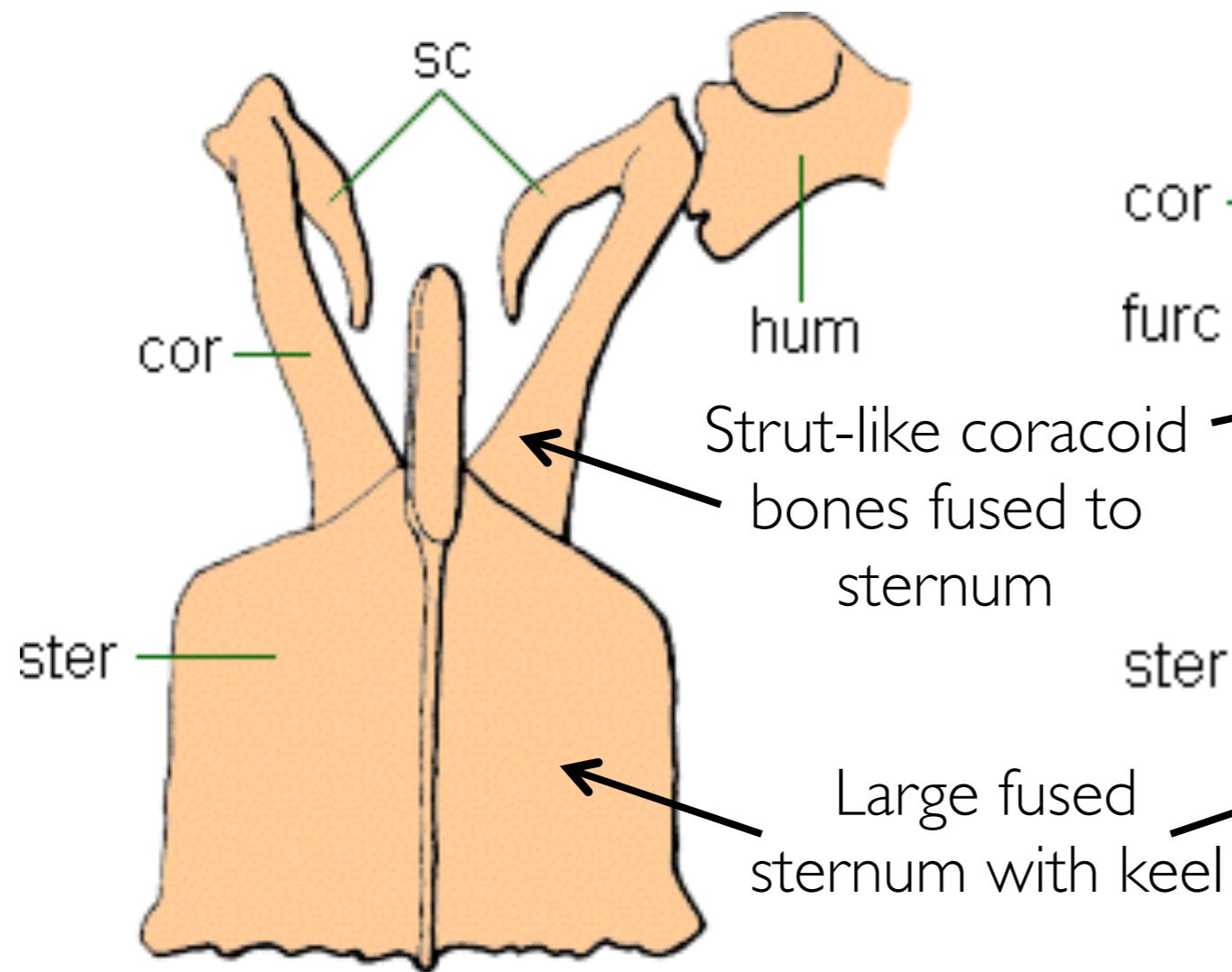
Convergent Flight Adaptations in Pterosaurs



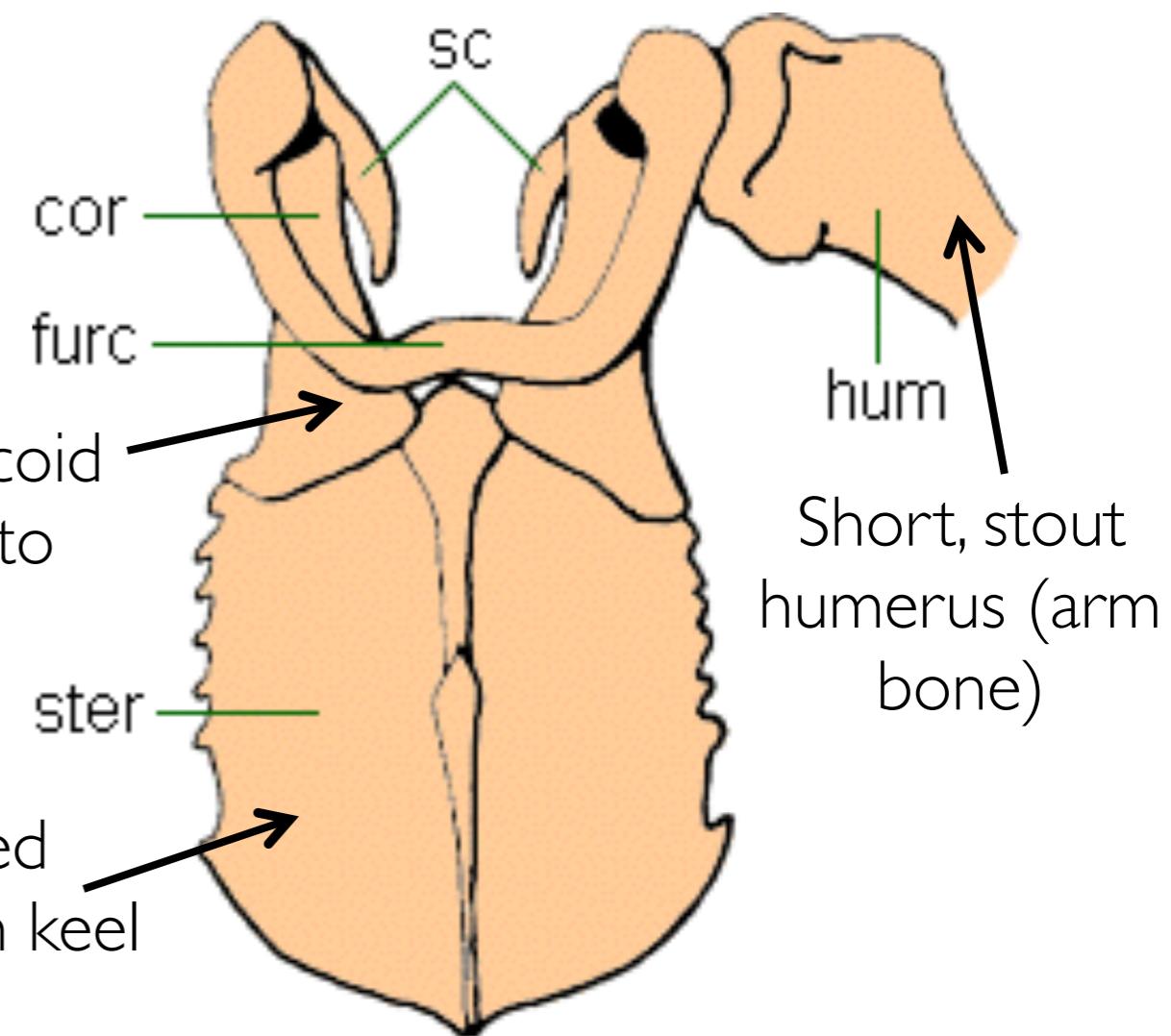
Pectoral Girdle Similarities

Pterosaurs independently evolved a pectoral girdle for supporting flight muscles

Pterosaur pectoral girdle

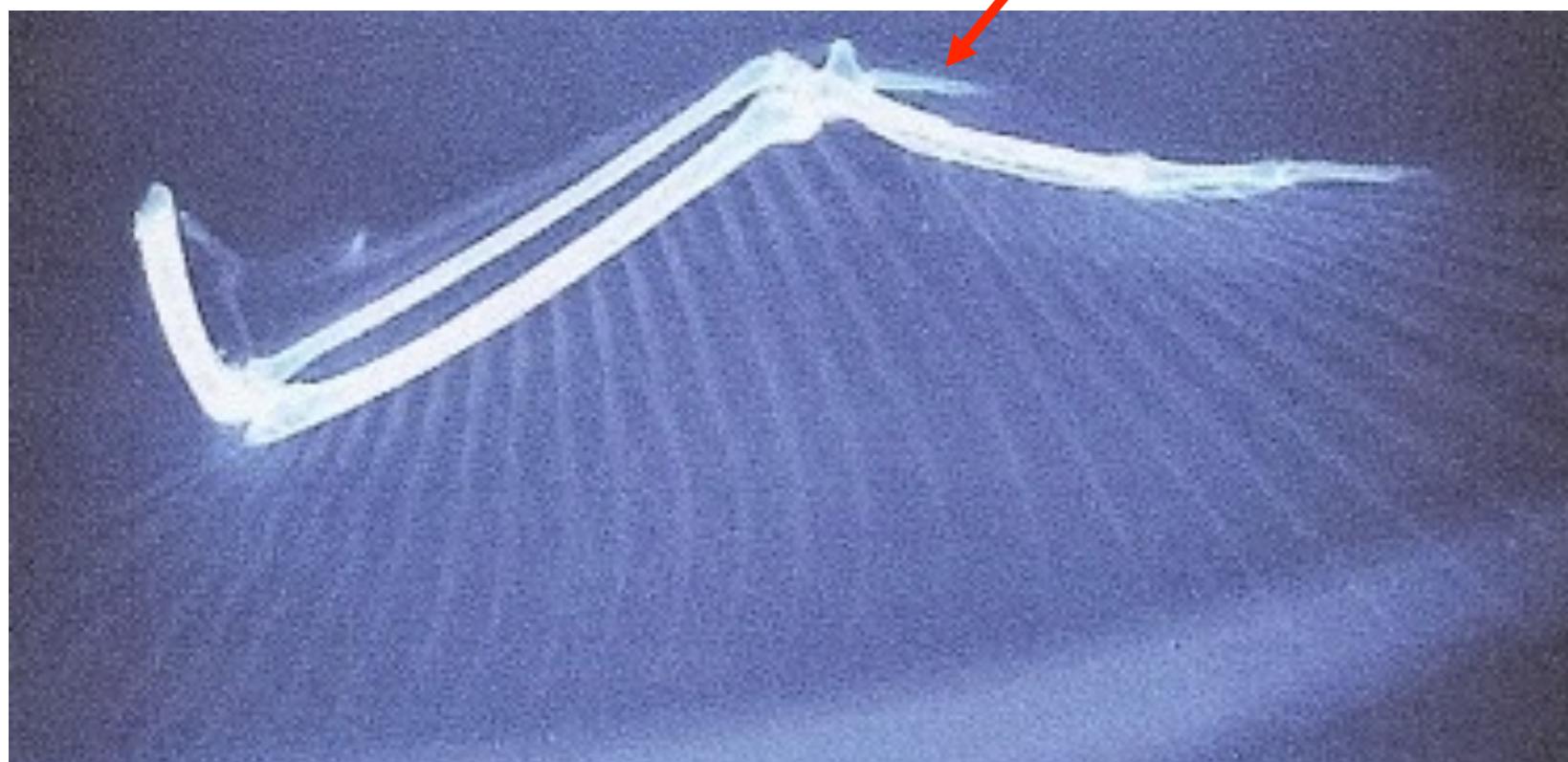
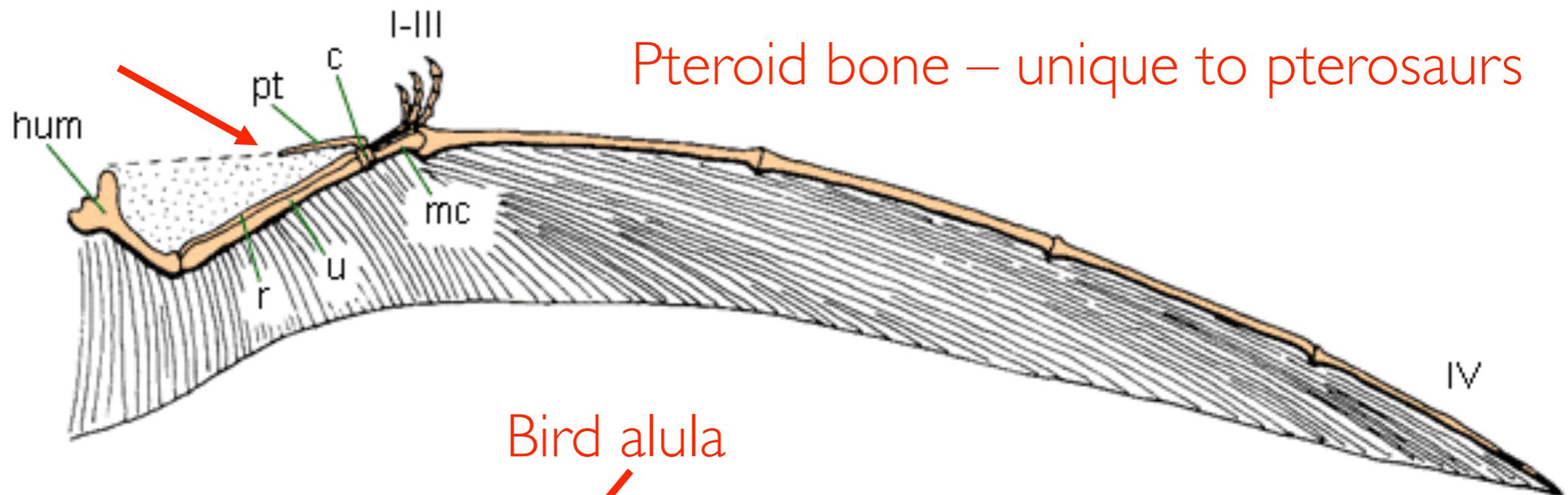


Avian pectoral girdle



No feathers – instead use skin membrane stretched across hand

Wing surface primarily supported by extended finger digit IV



Bird wing: feathers

Wing surface primarily supported by ulna, wrist



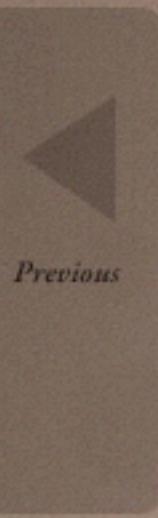
三



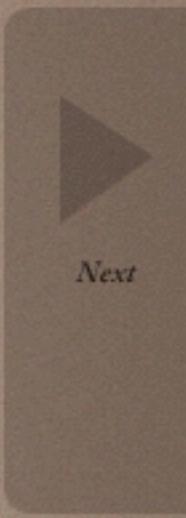
Dissecting
Rhamphorhynchus



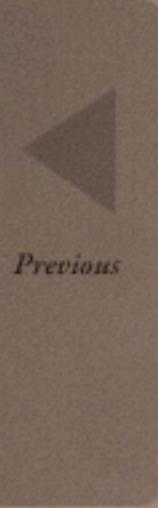
Next



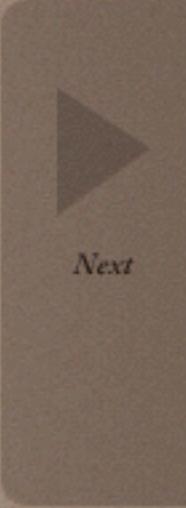
Previous



Next

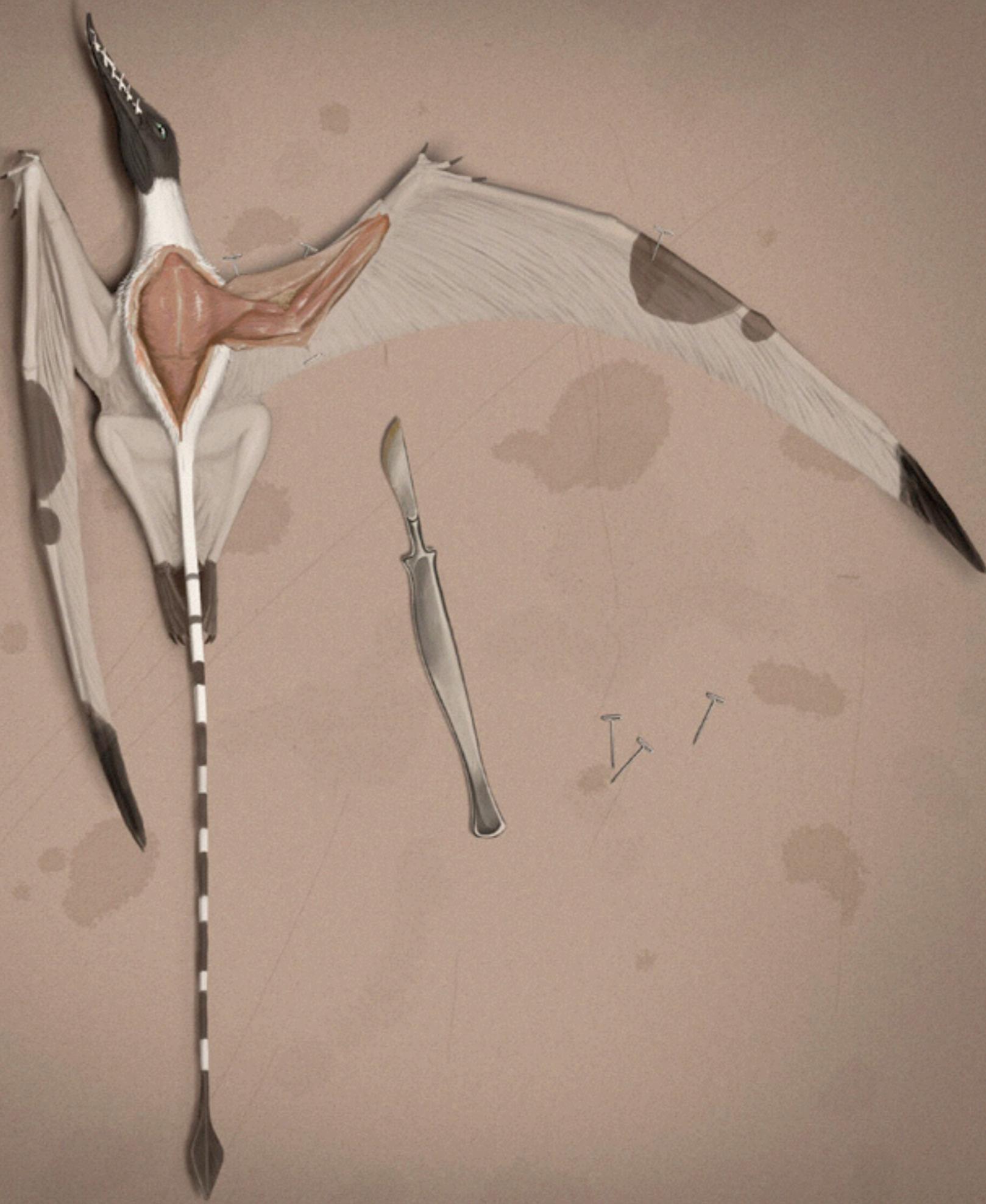


Previous



Next

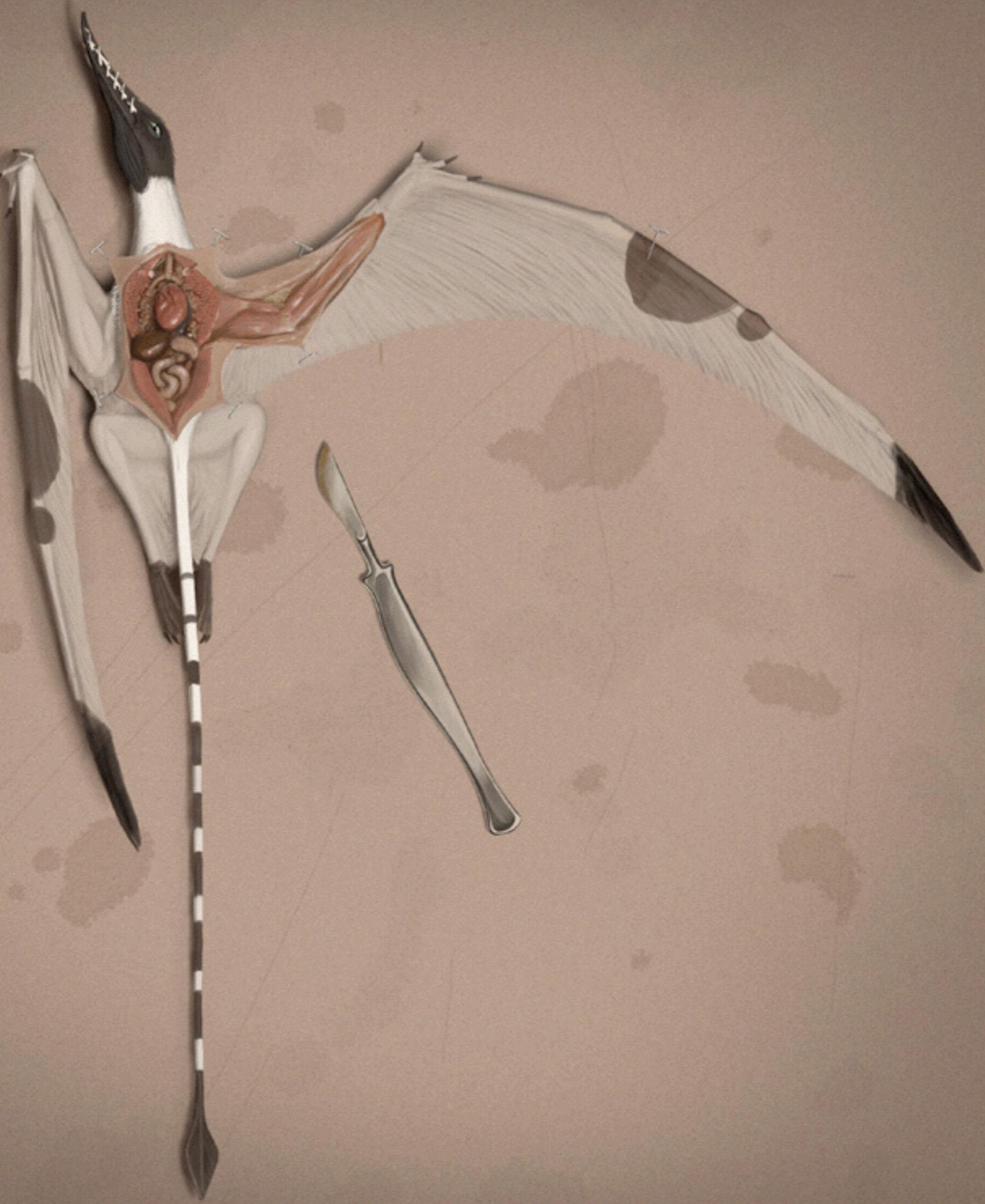
Previous



Next



Previous



Unique Flight Adaptations in Pterosaurs

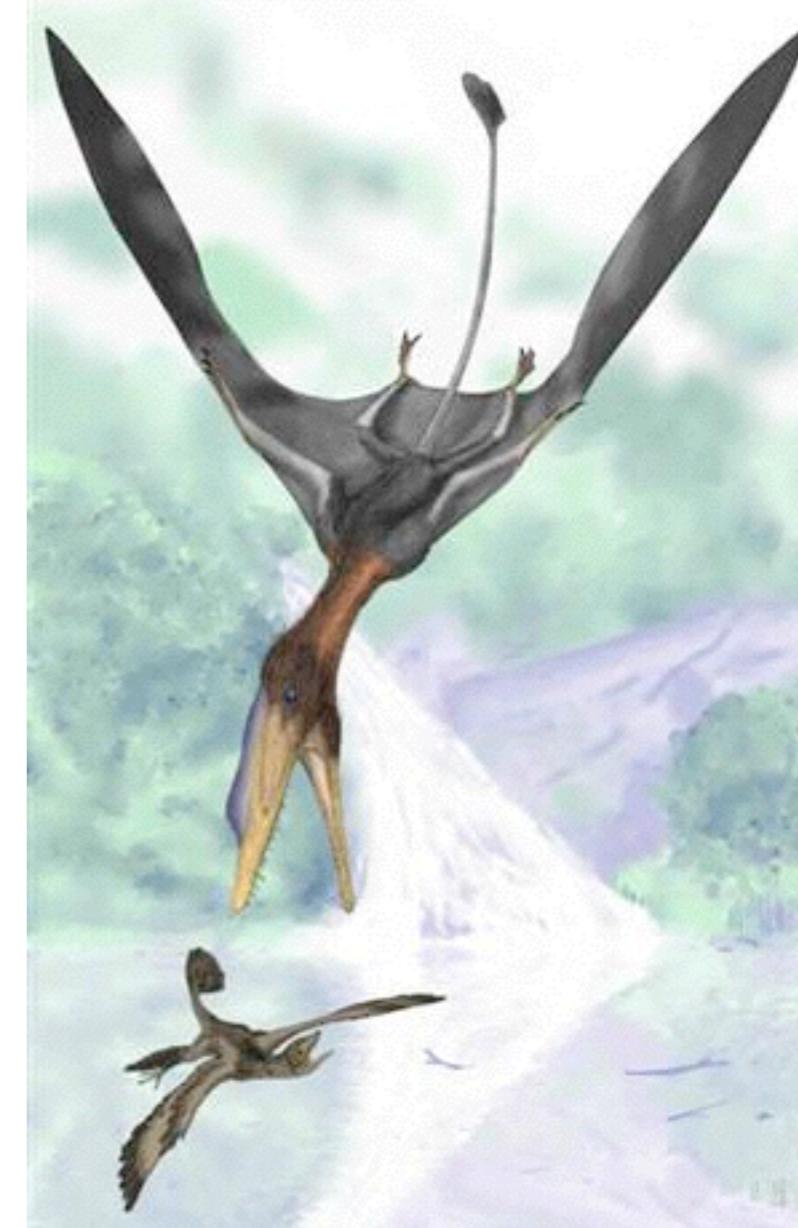
Wing support

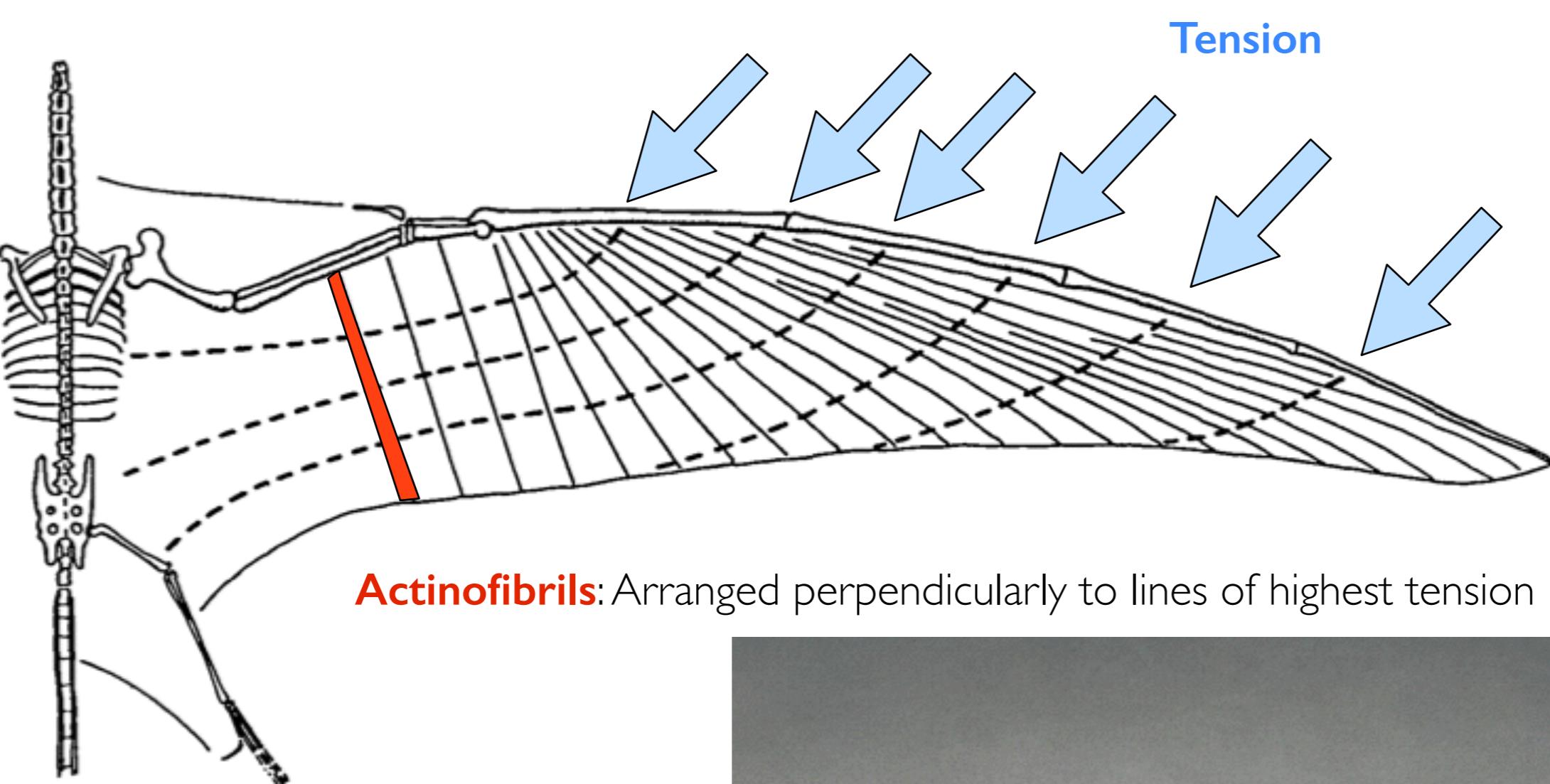
Outer wing supported by **Actinofibrils**

3 distinct layers of criss-crossed fibers

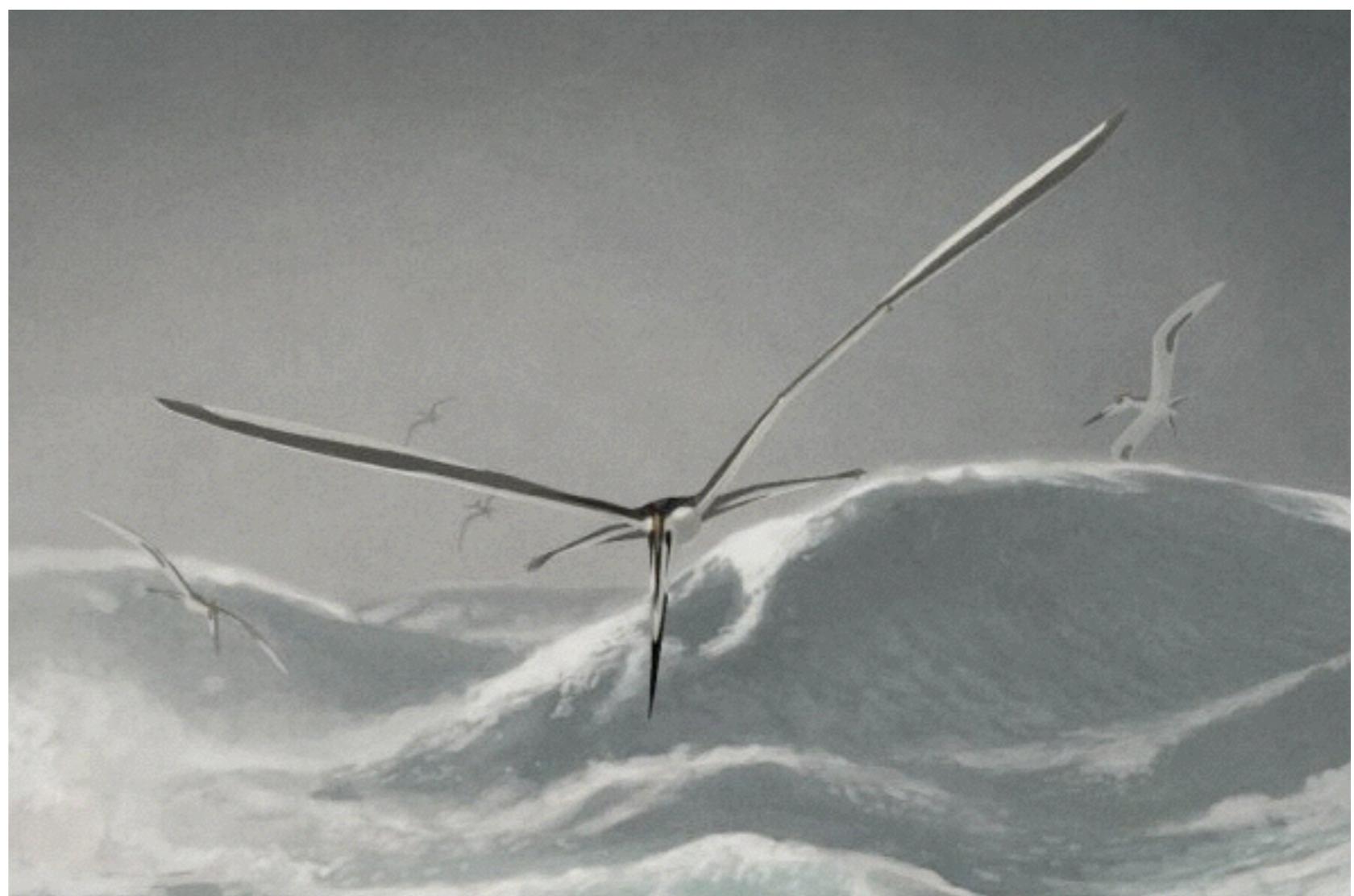
Keratin? Elastin? Unknown.

Oxygenated by looping blood vessels



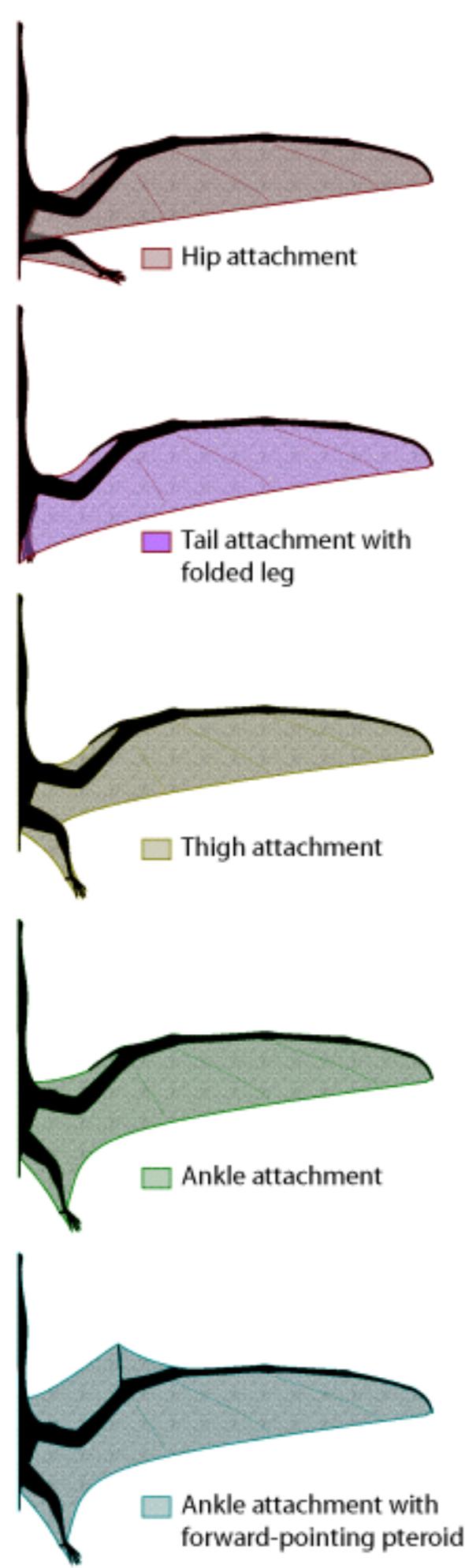


Actinofibrils: Arranged perpendicularly to lines of highest tension in wing

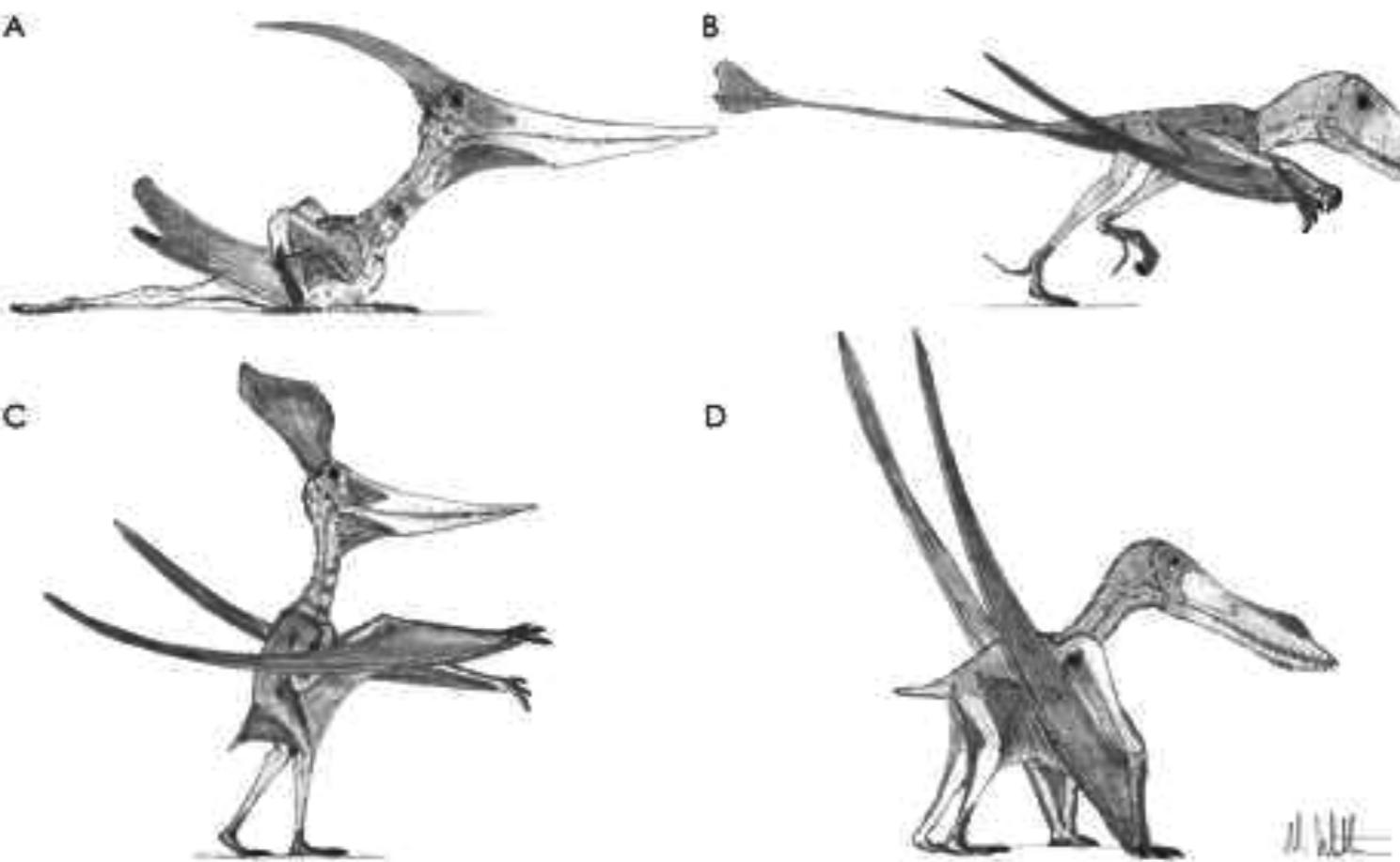


Alternative Wing Structures

Wing structure highly variable in modern animals
Almost certainly was variable among Pterosaurs
There is likely no 'One right answer' here



Pterosaur Walking



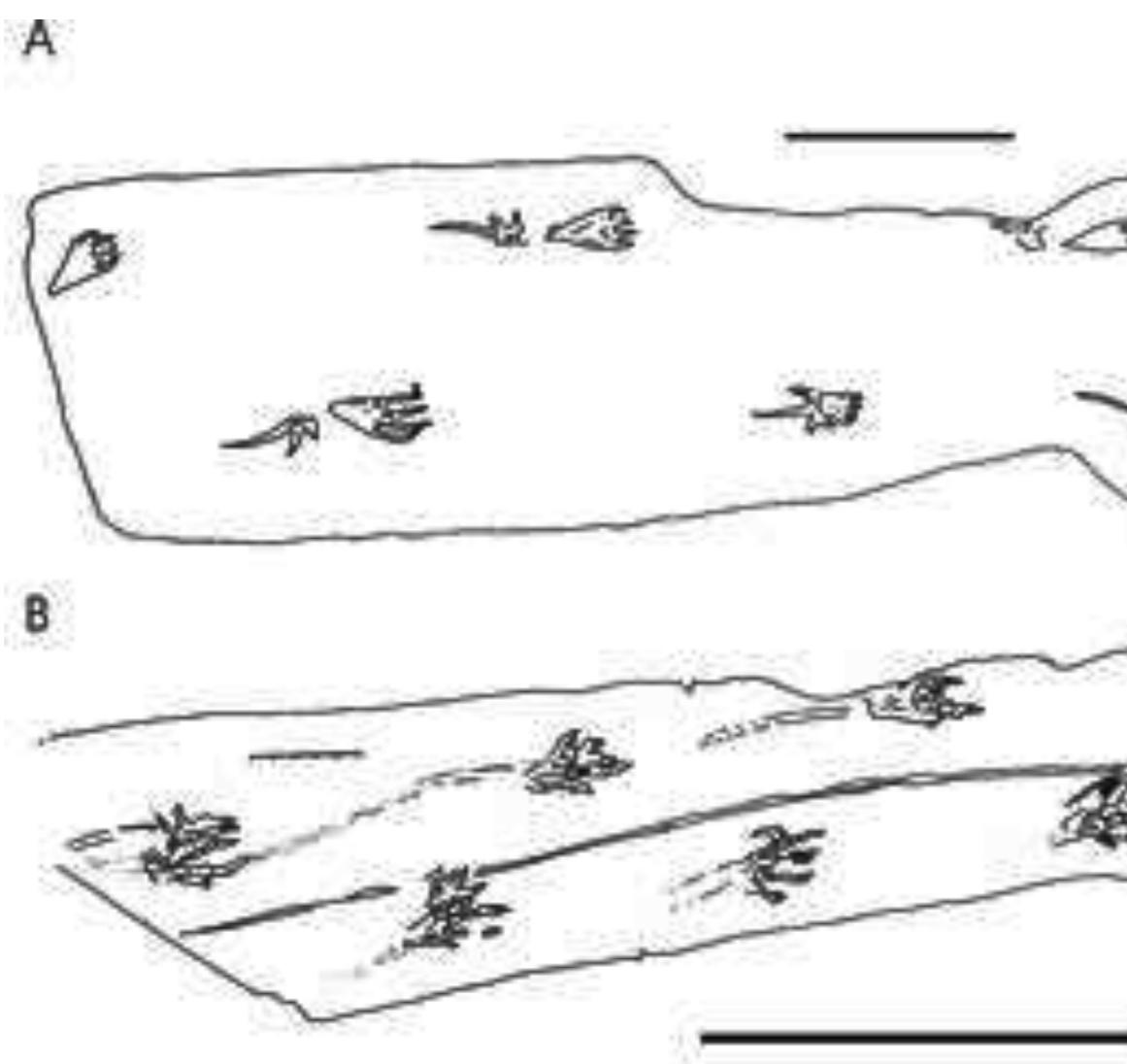
An evolving concept...

- A) 1970s: Belly dragging
- B) 1980s: Bipedality
- C) 1990: Semi-erect
- D) 1990s: Sprawling

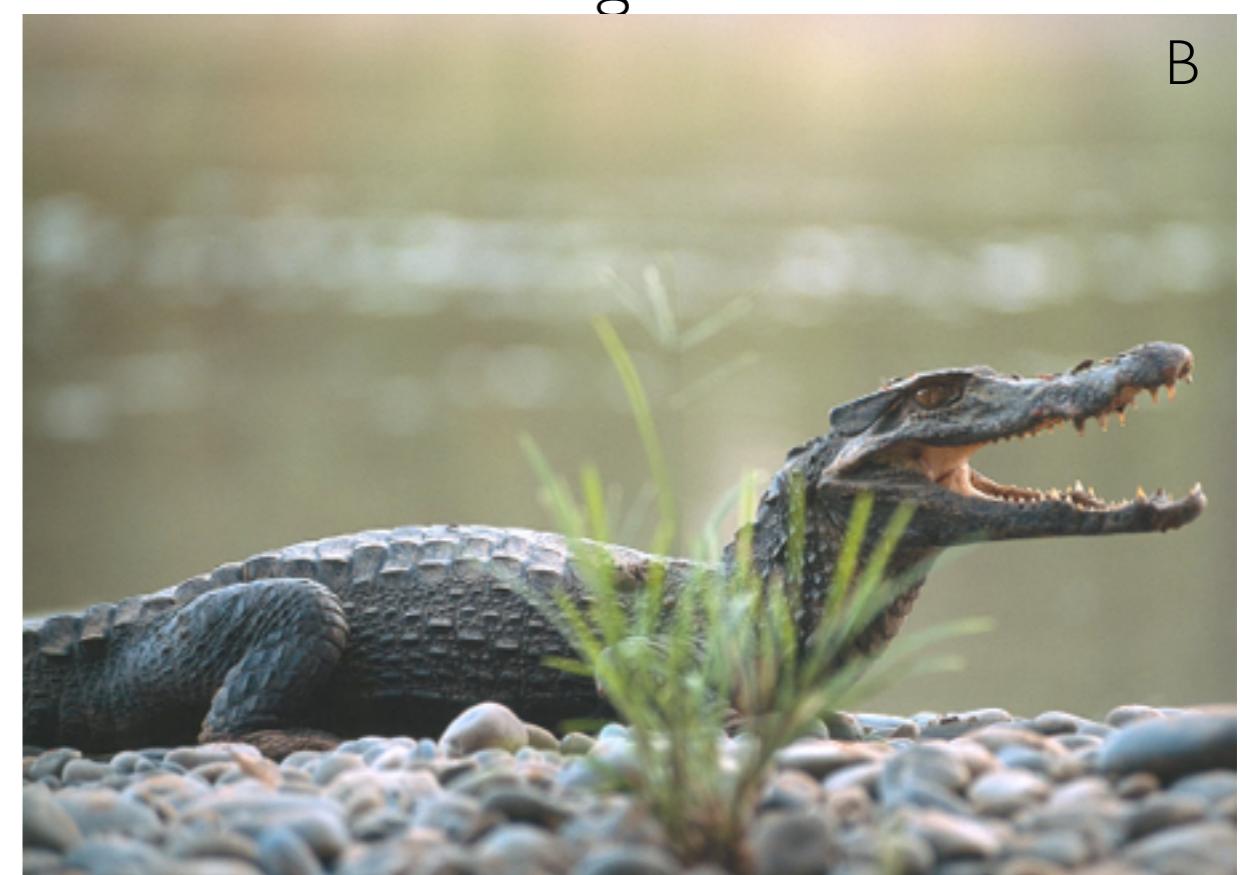
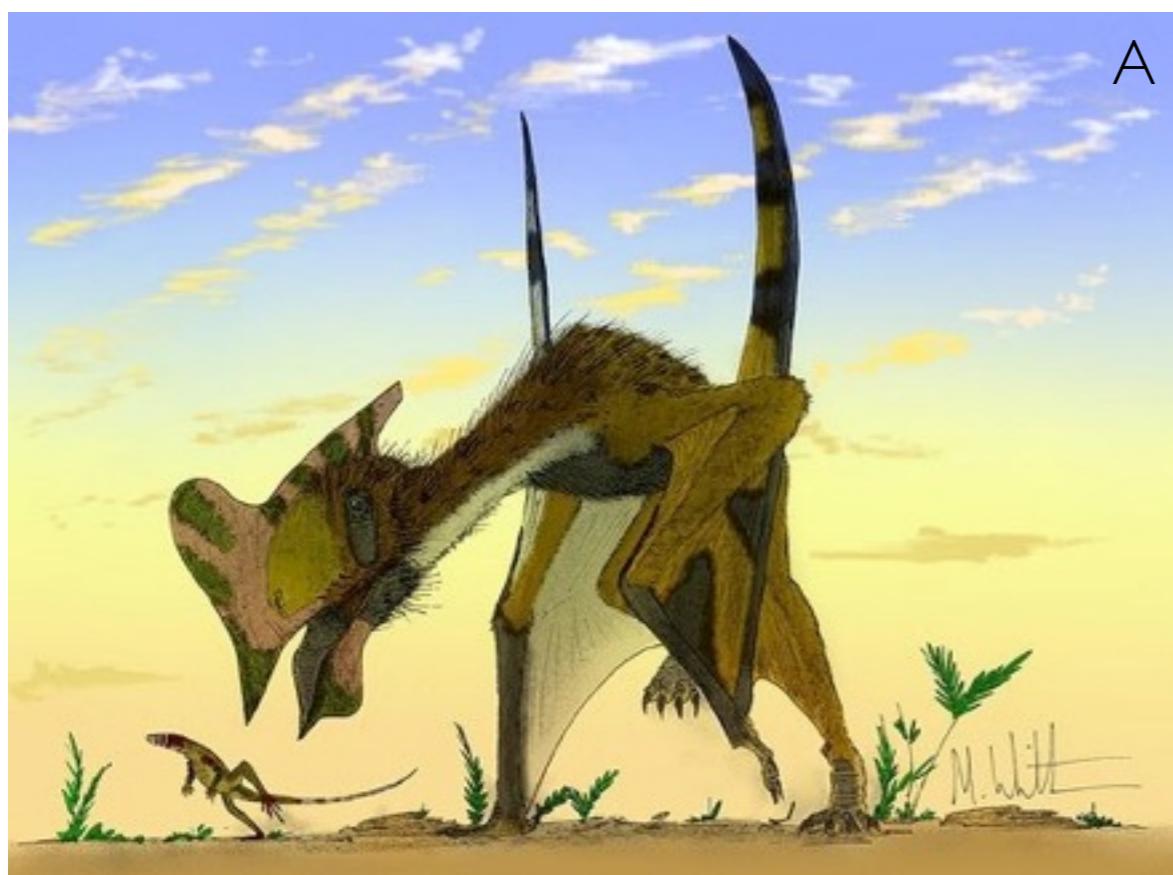


Still a source of contention!

Pterosaur Walking



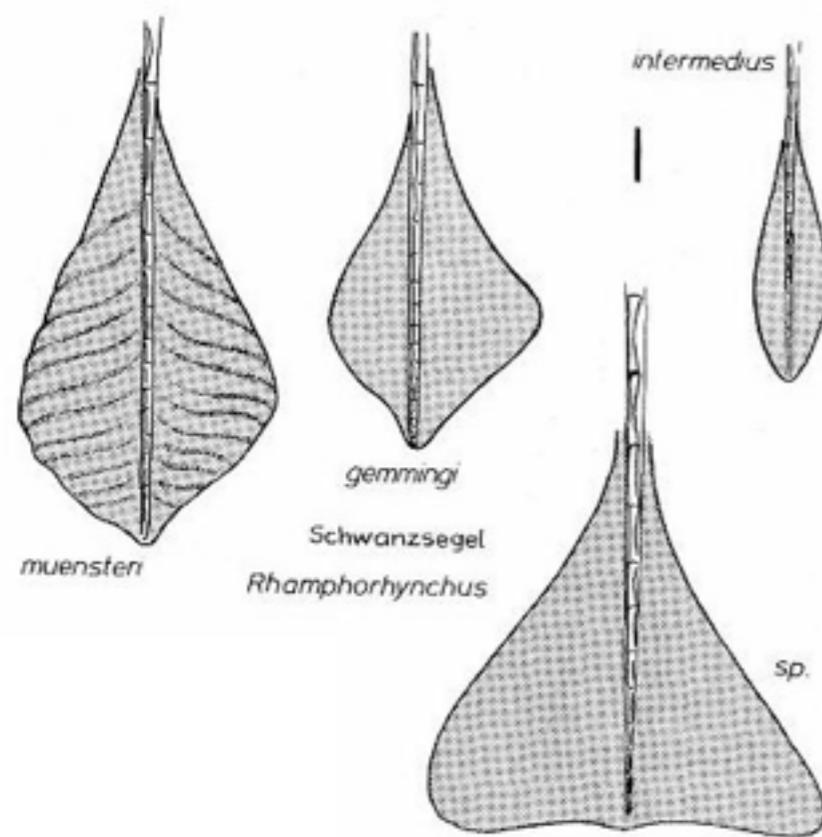
Top: Pteraichnus
Bottom: Running Caiman



Tail Vanes



Present among early Pterosaurs; particularly *Ramphorhynchus*
Much reduced among derived Pterosaurs
Probably a stabilizing feature
More diamond-shaped among older animals



Unique Flight Adaptations in Pterosaurs



Laser Beam eyes

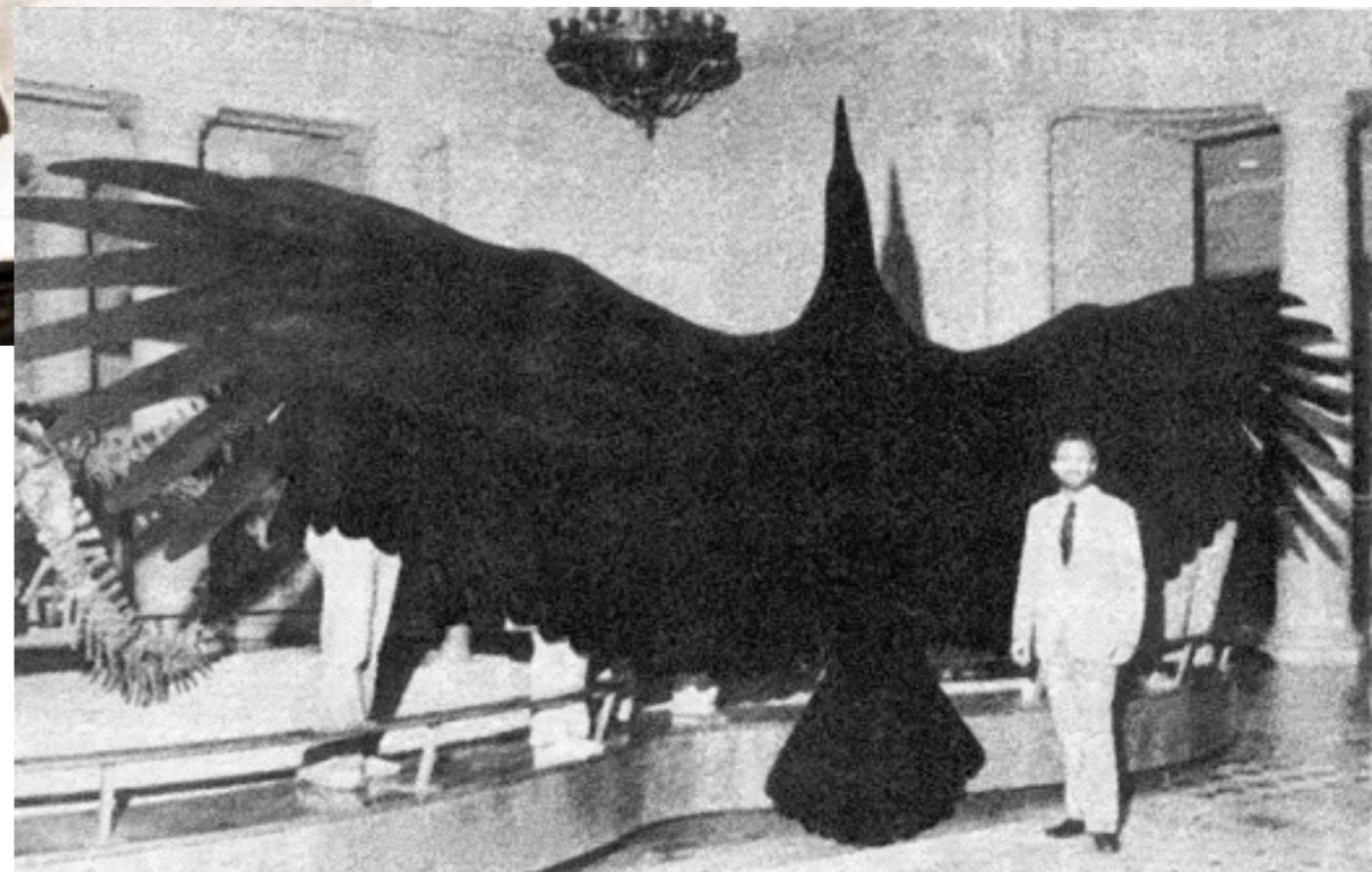
Convergently evolved in Kryptonian humanoids



Giant Flying Animals



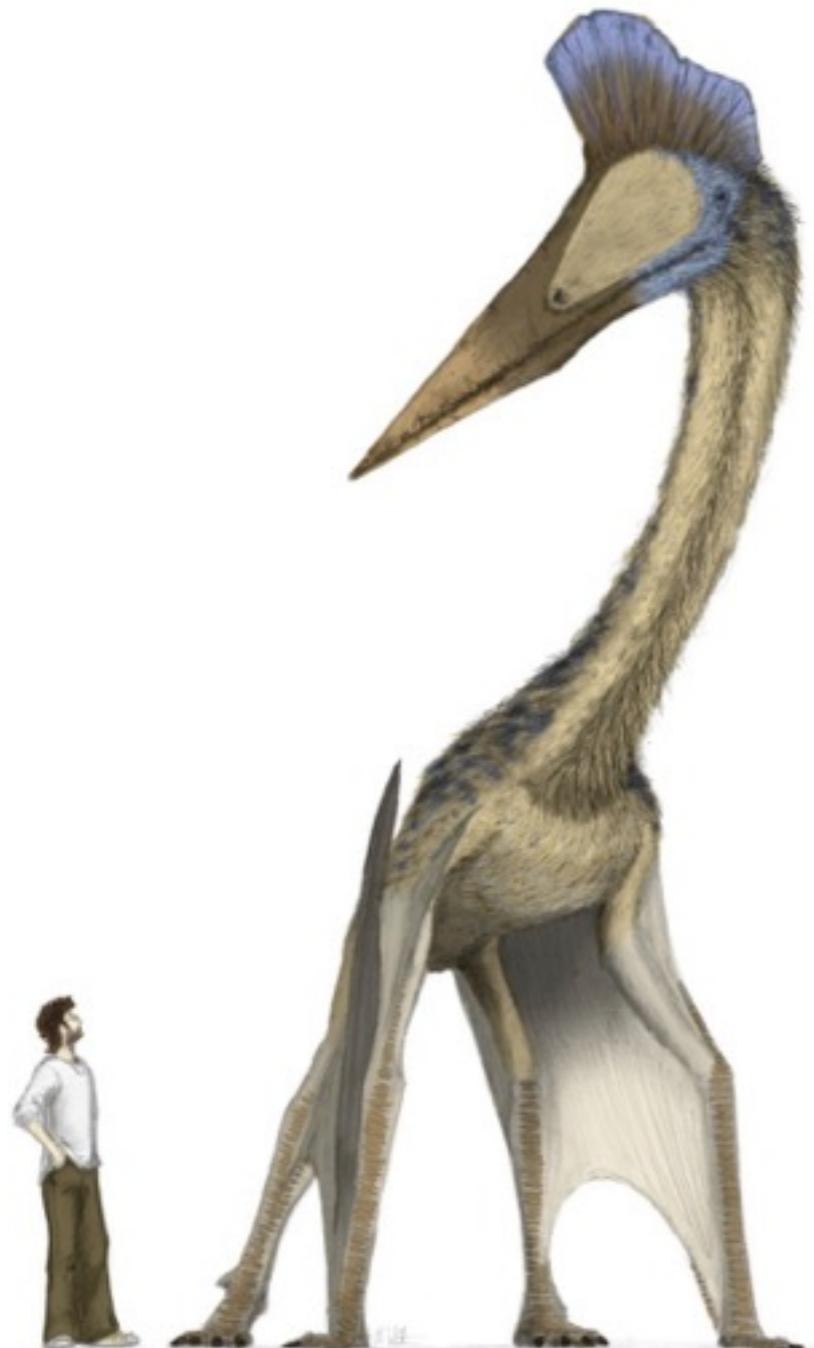
Largest pterosaur (*Quetzalcoatlus*, from the latest Cretaceous) had a 12 m wingspan and weighed 100 kg



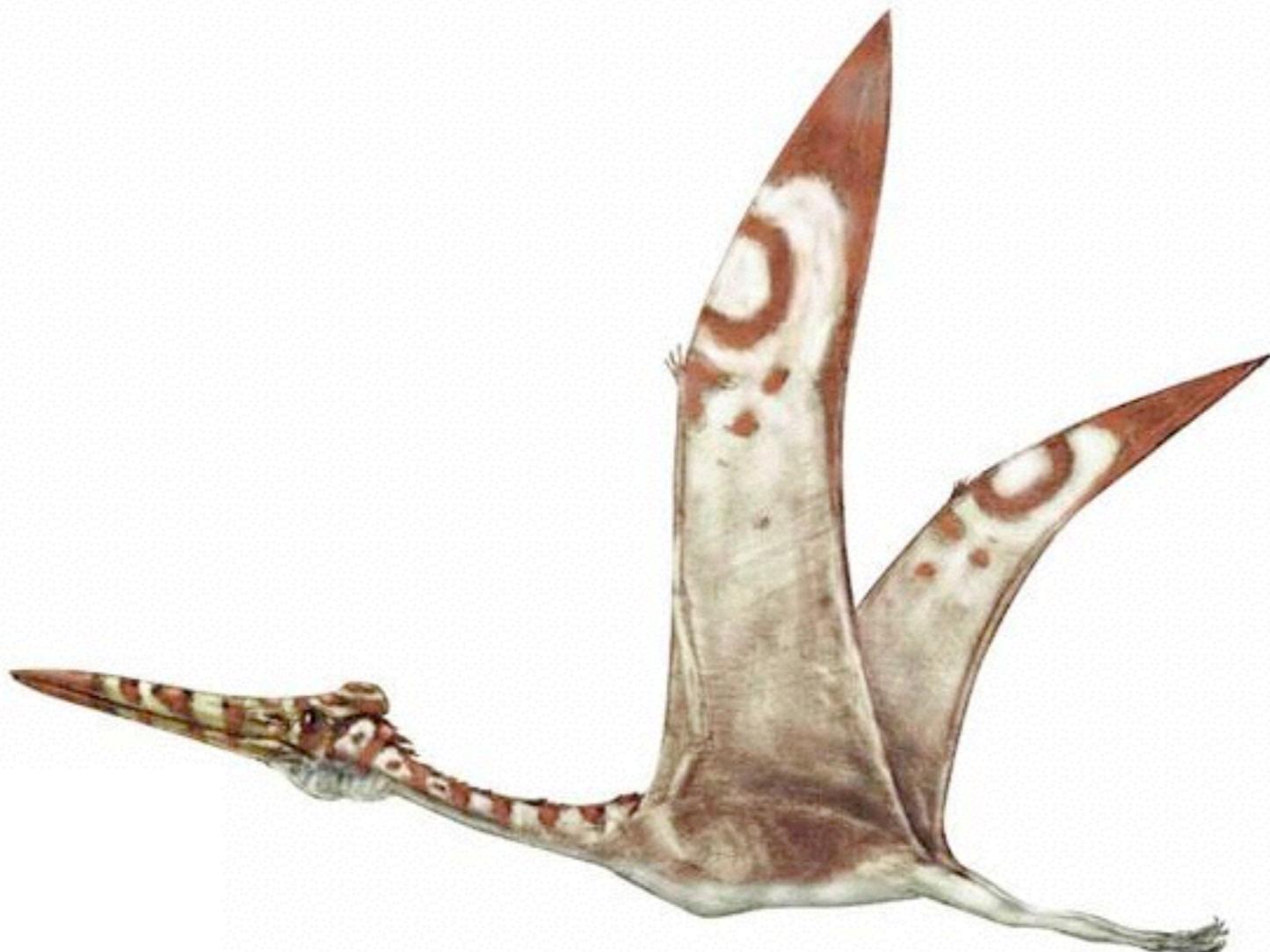
Largest bird (*Argentavis*, Miocene) had 7 m wingspan and weighed 80 kg

Giant Pterosaurs

Largest pterosaurs were probably excellent gliders but would have had difficult reaching takeoff velocity

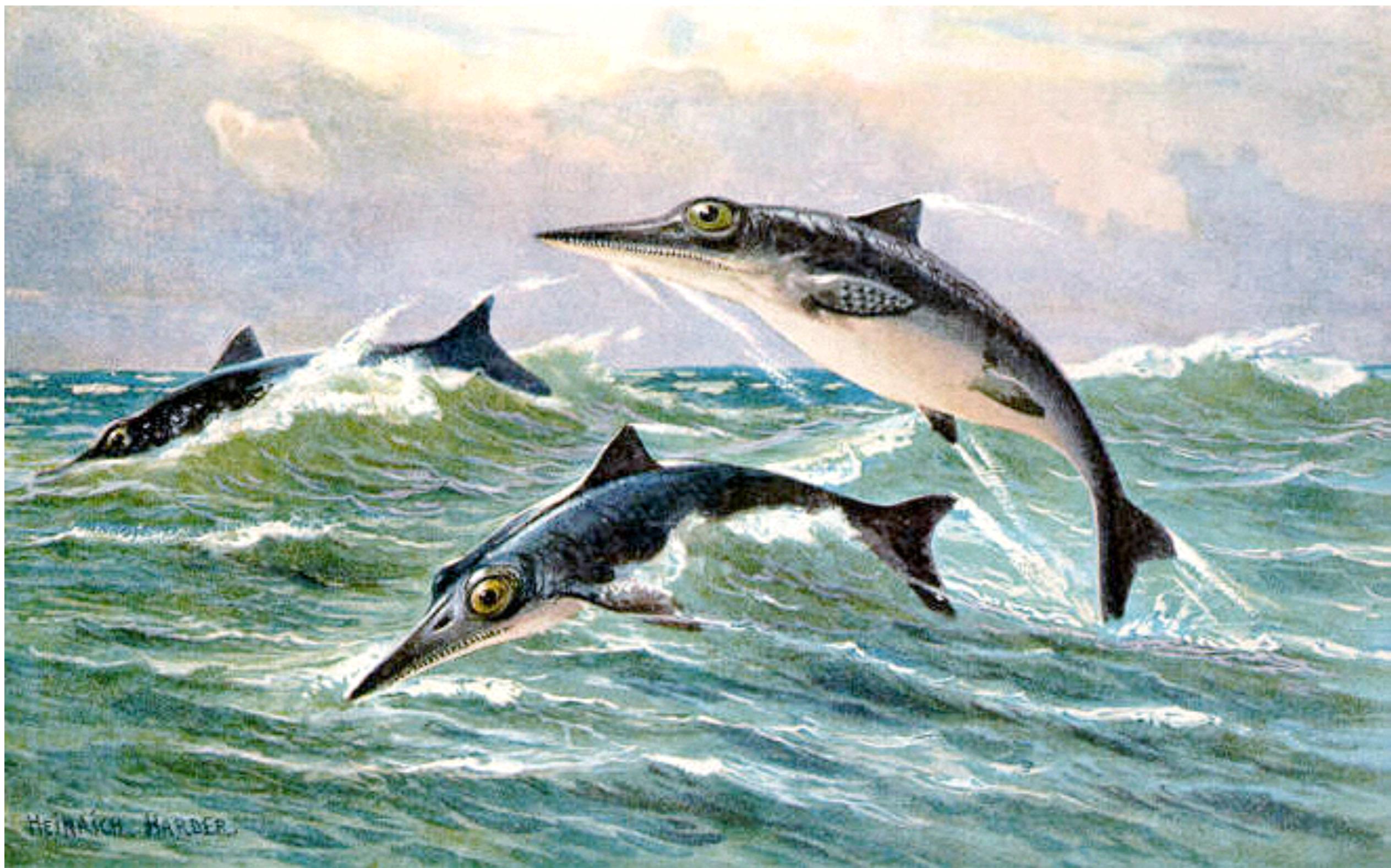


Pterosaur documentary 10:13





Aquatic Reptiles of the Mesozoic





Mosasaurus

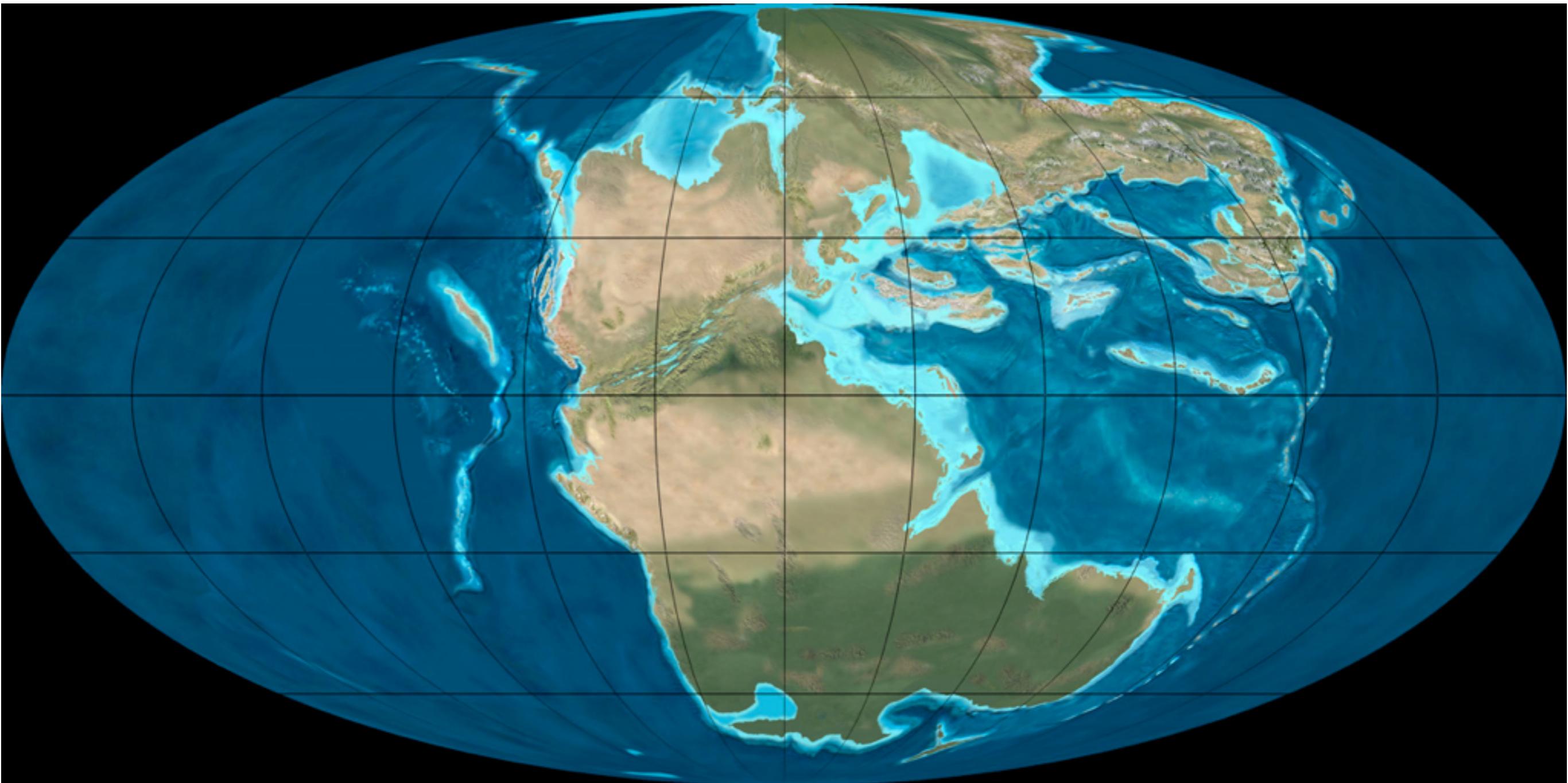
Preceded any dinosaur discoveries: unearthed in 1764 by quarry workers in the Dutch city, Maastrich

French Revolutionary Forces obtained the fossil after paying a 600 bottle of wine reward

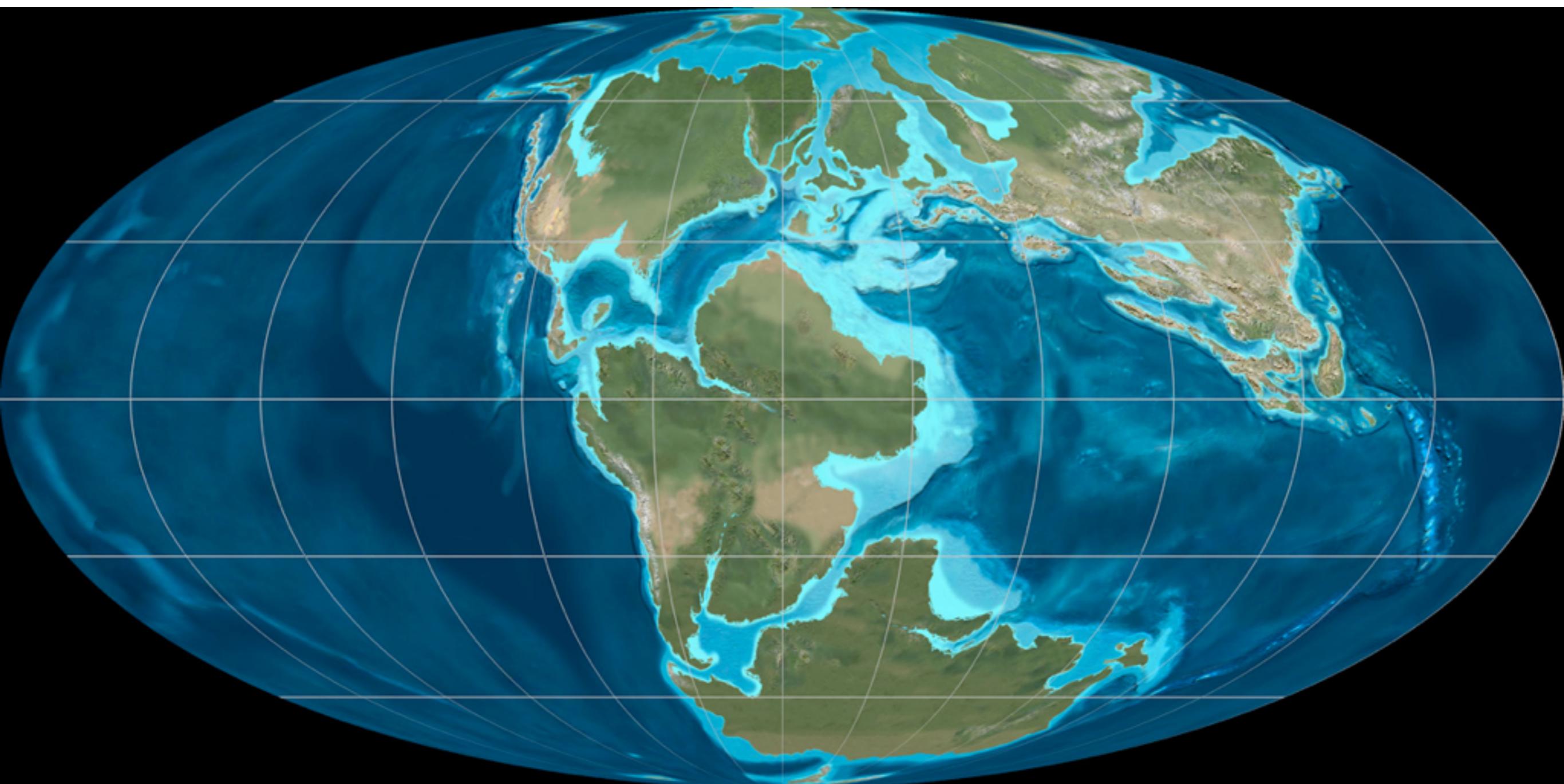
Wasn't recognized as reptilian until 1799



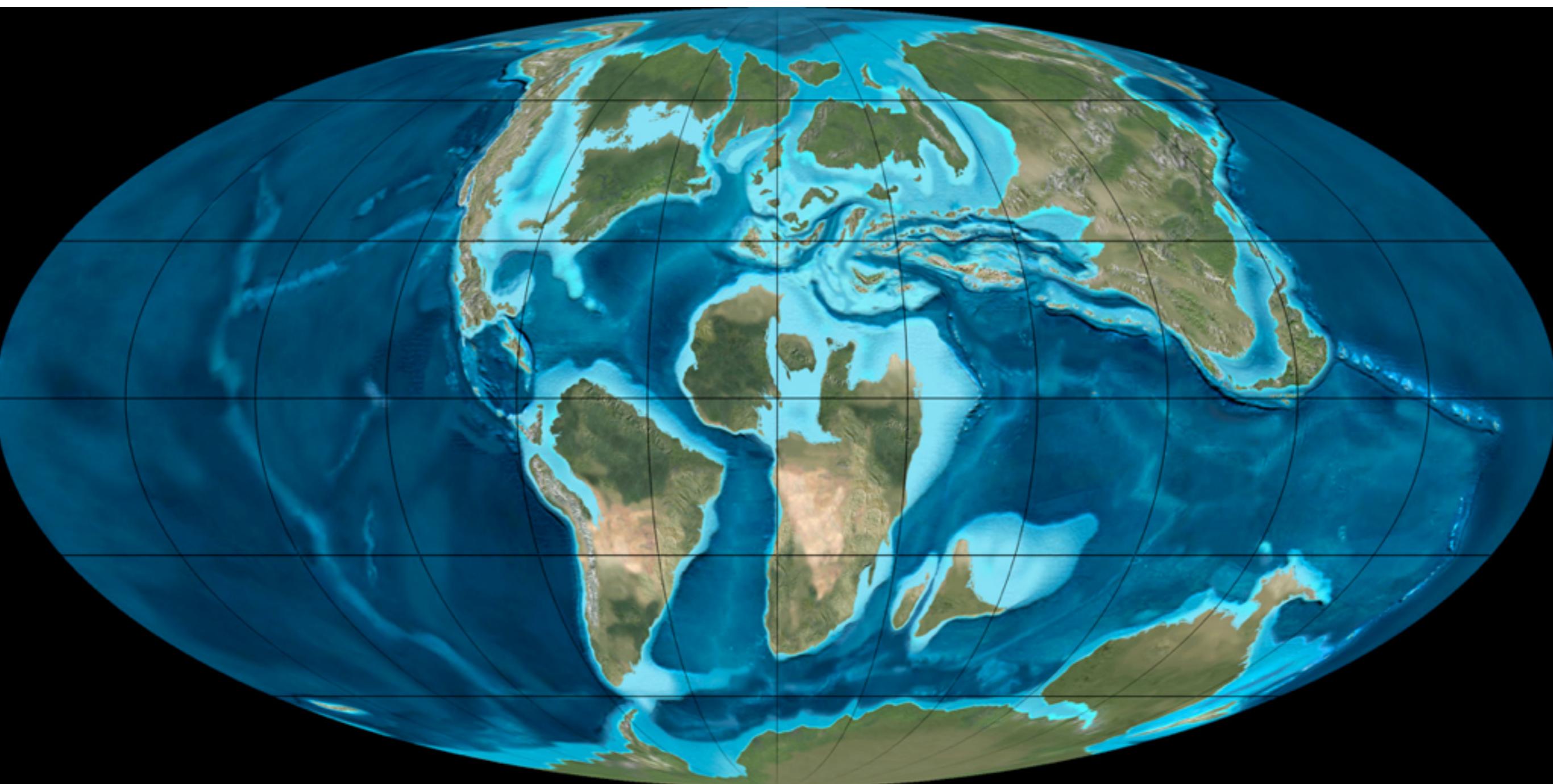
Triassic Oceans

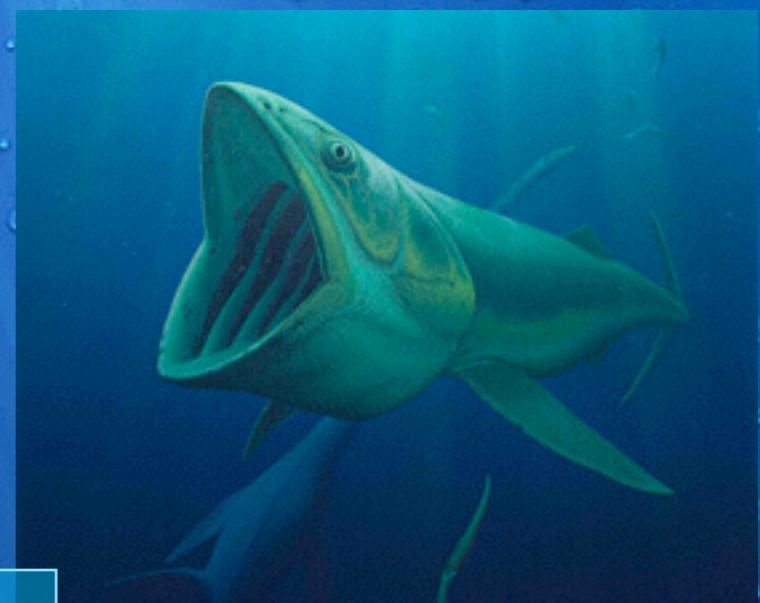
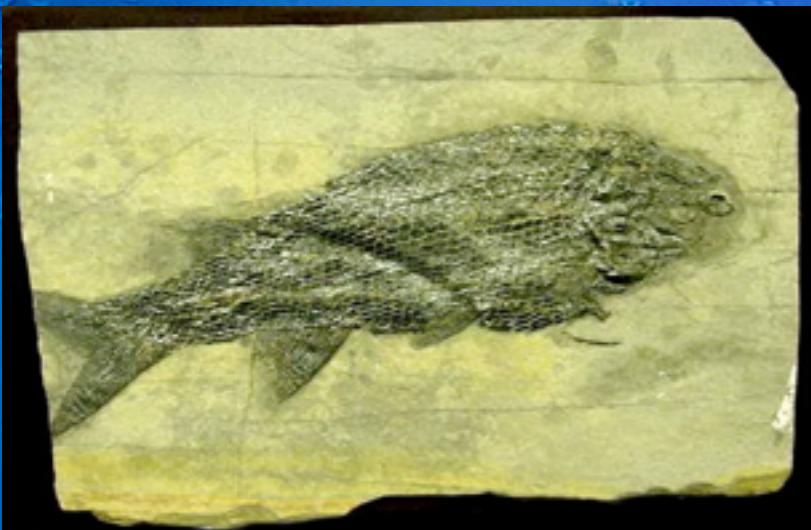


Jurassic Oceans

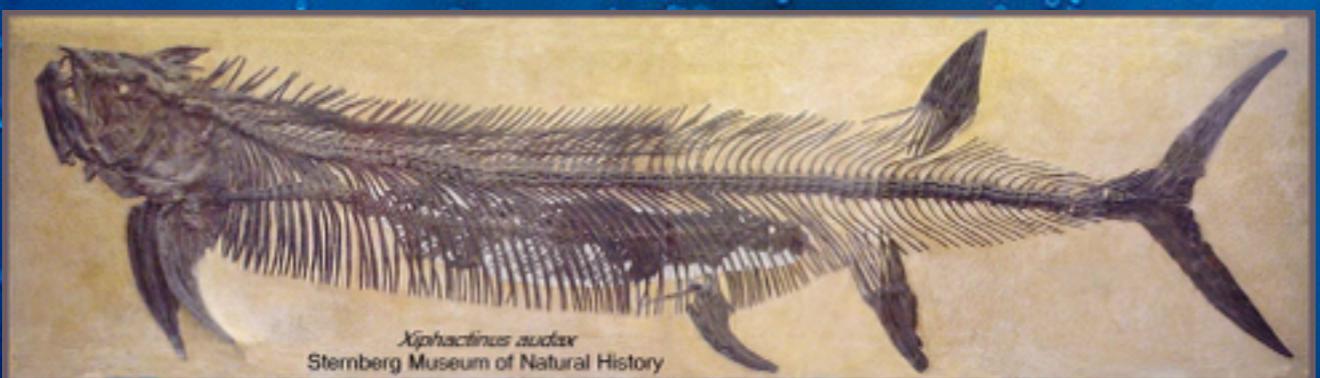


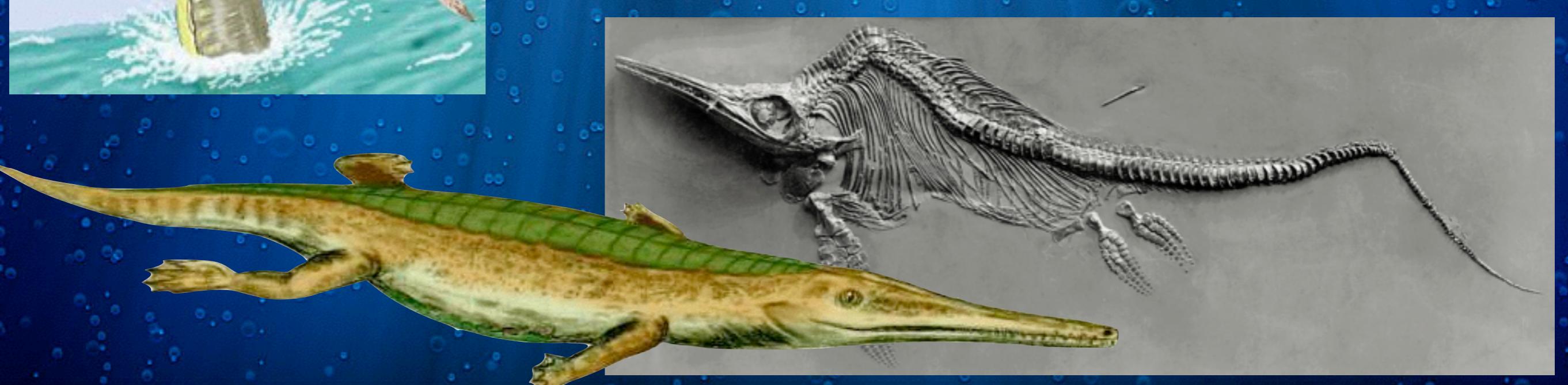
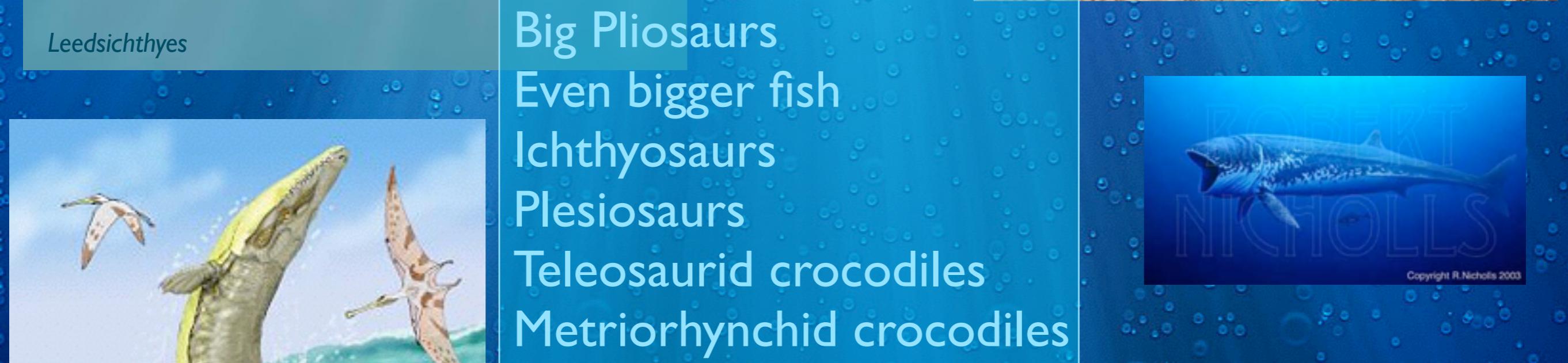
Cretaceous Oceans





Fish of various sizes
Enormous filter-feeding fish
Rays
Neoselachian sharks
Ammonites
Squid





Aquatic Reptiles of the Mesozoic

Major Groups:

Sauroptrygians

Nothosaurs and Placodonts

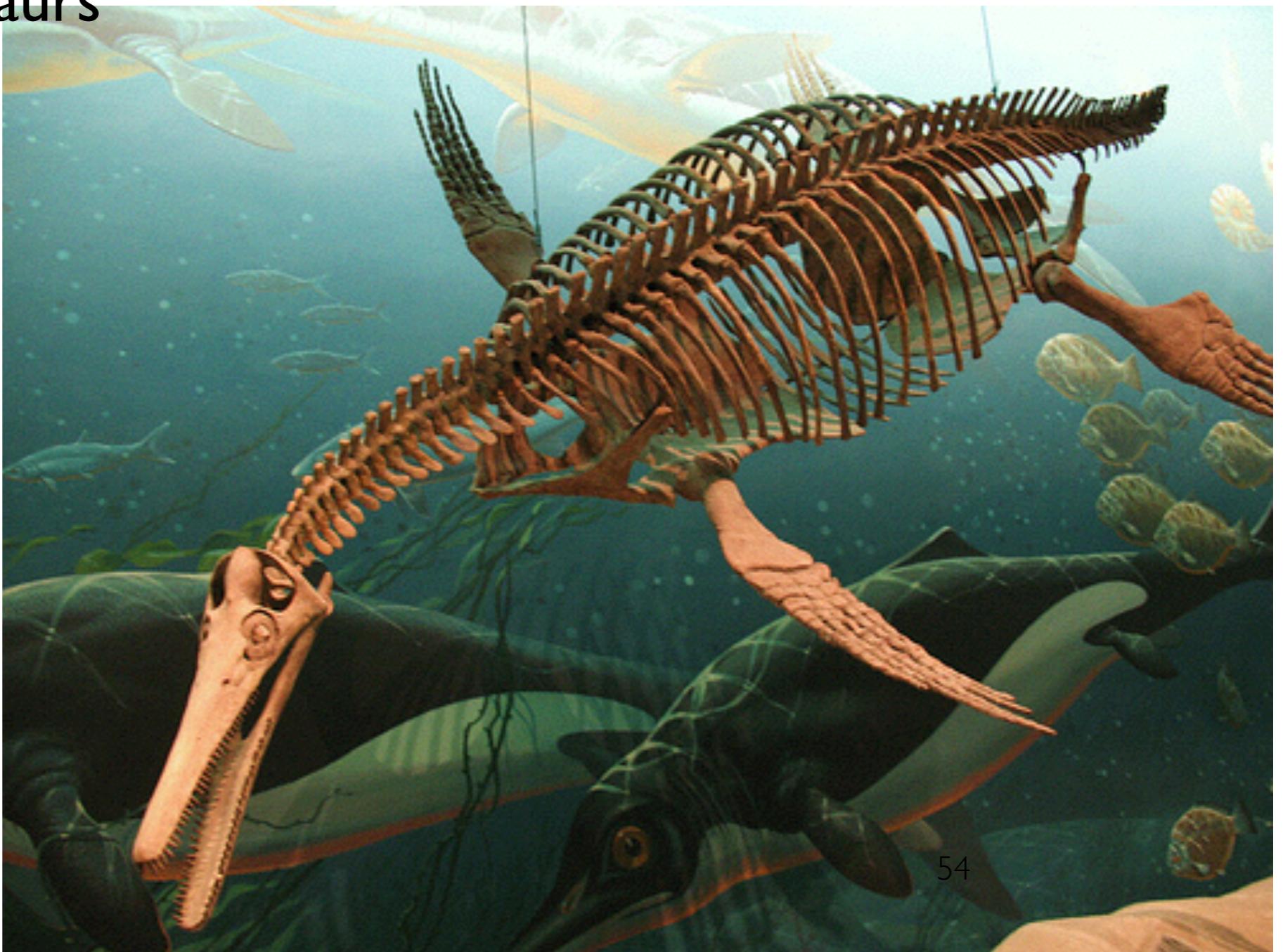
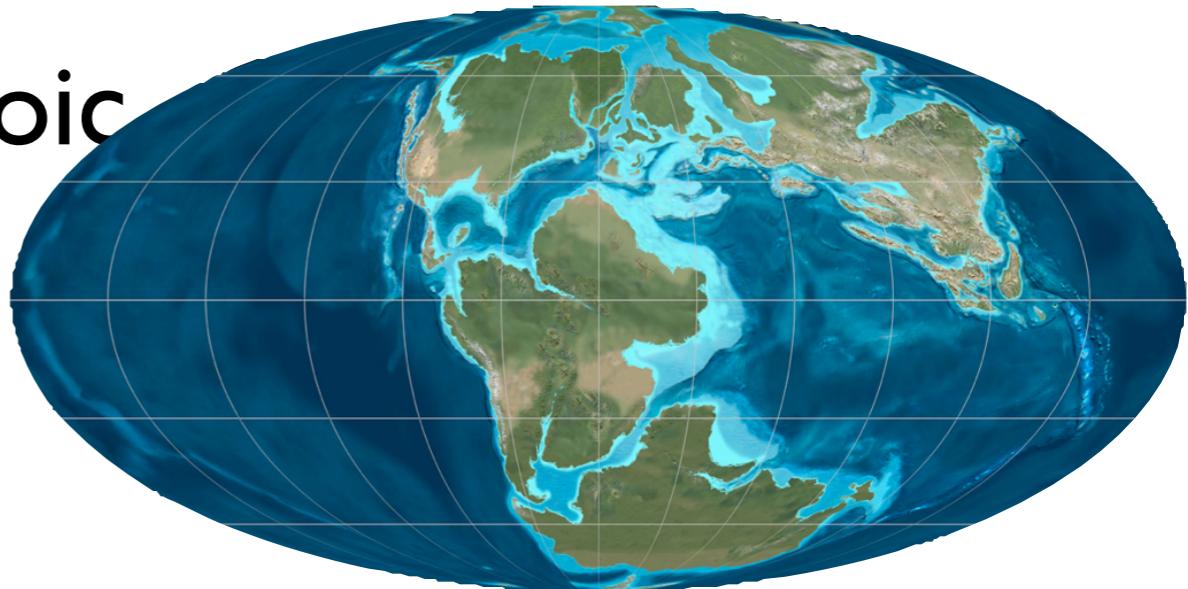
Plesiosaurs and Pliosaurs

Ictyosaurs

Mosasaurs

Turtles

Crocodiles



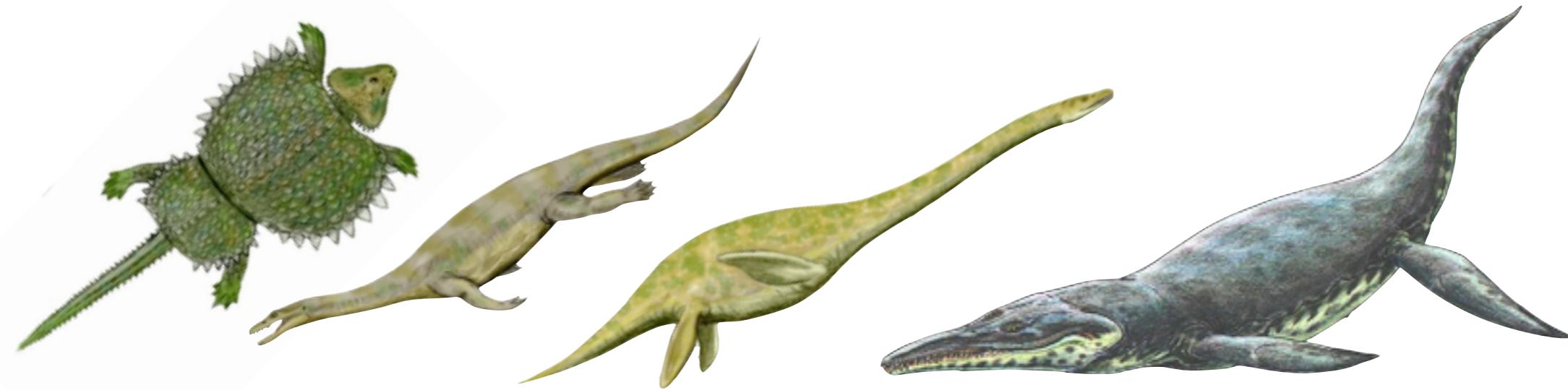
Sauroptrygians: Basal Diapsids

Diversified in the Triassic

Lepidosauria
Sauropterygia



(Basal to Archosaurs)



Placodons

Nothosaurs

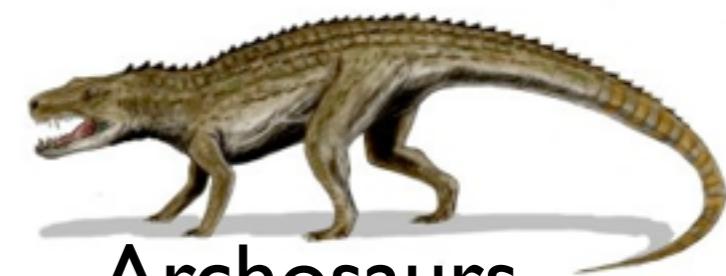
Plesiosaurs

Pliosaurs

Icthyopterygia

Sauroptrygia

Lepidosauramorpha



Archosaurs



Synapsida



Anapsida



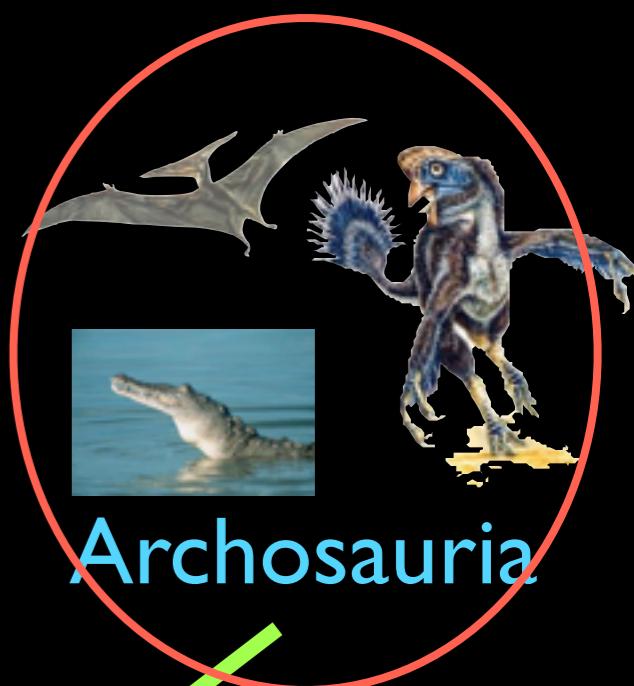
Lepidosauria



Diapsida

Eureptilia

Amniotes



Archosauria

Archosauromorpha

Placodonts = “Tablet Teeth”

Mid to late Triassic
Several continents
Shallow, coastal environments
1-3 ft long
Turtle shape, long tail

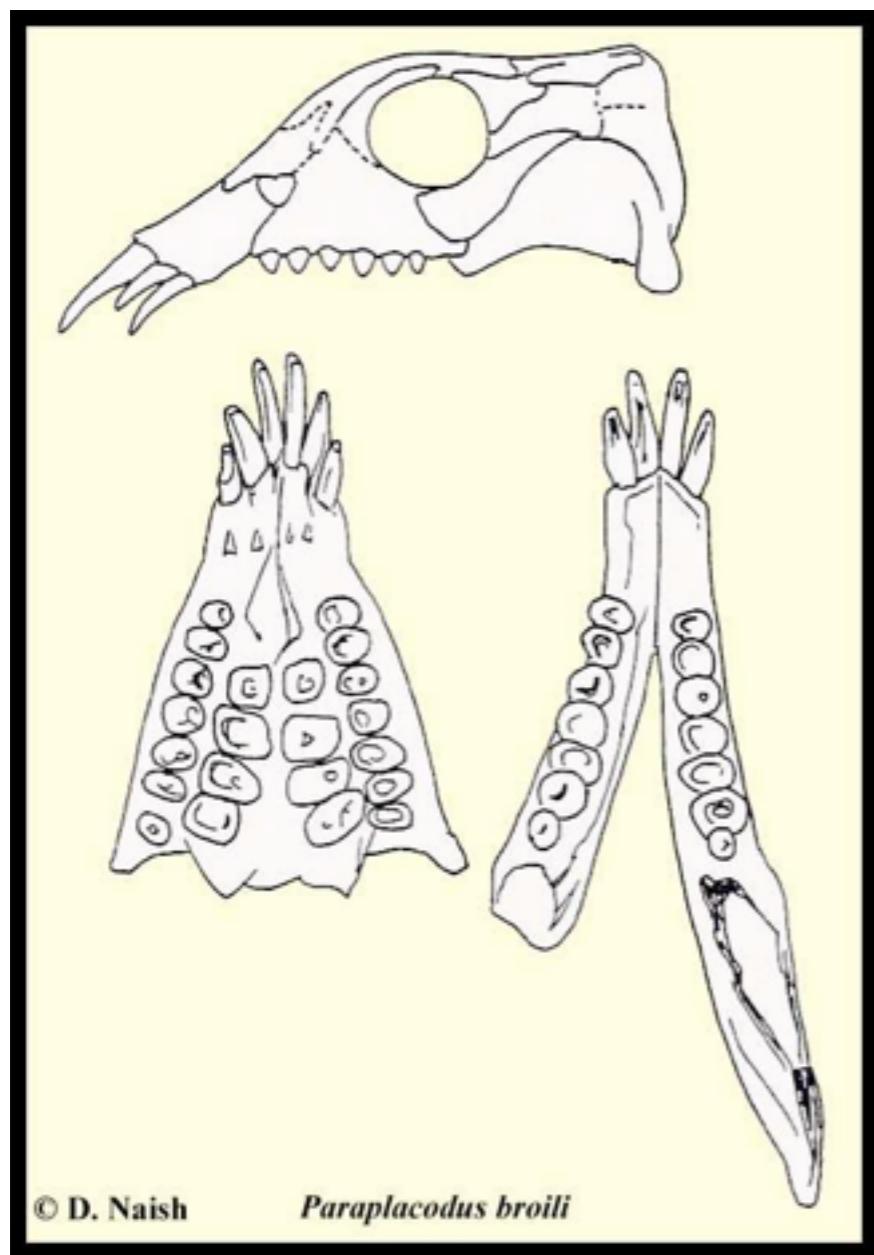


Placodonts

Boxy skull

Tooth comb, crushing teeth

Mollusk-strainer?

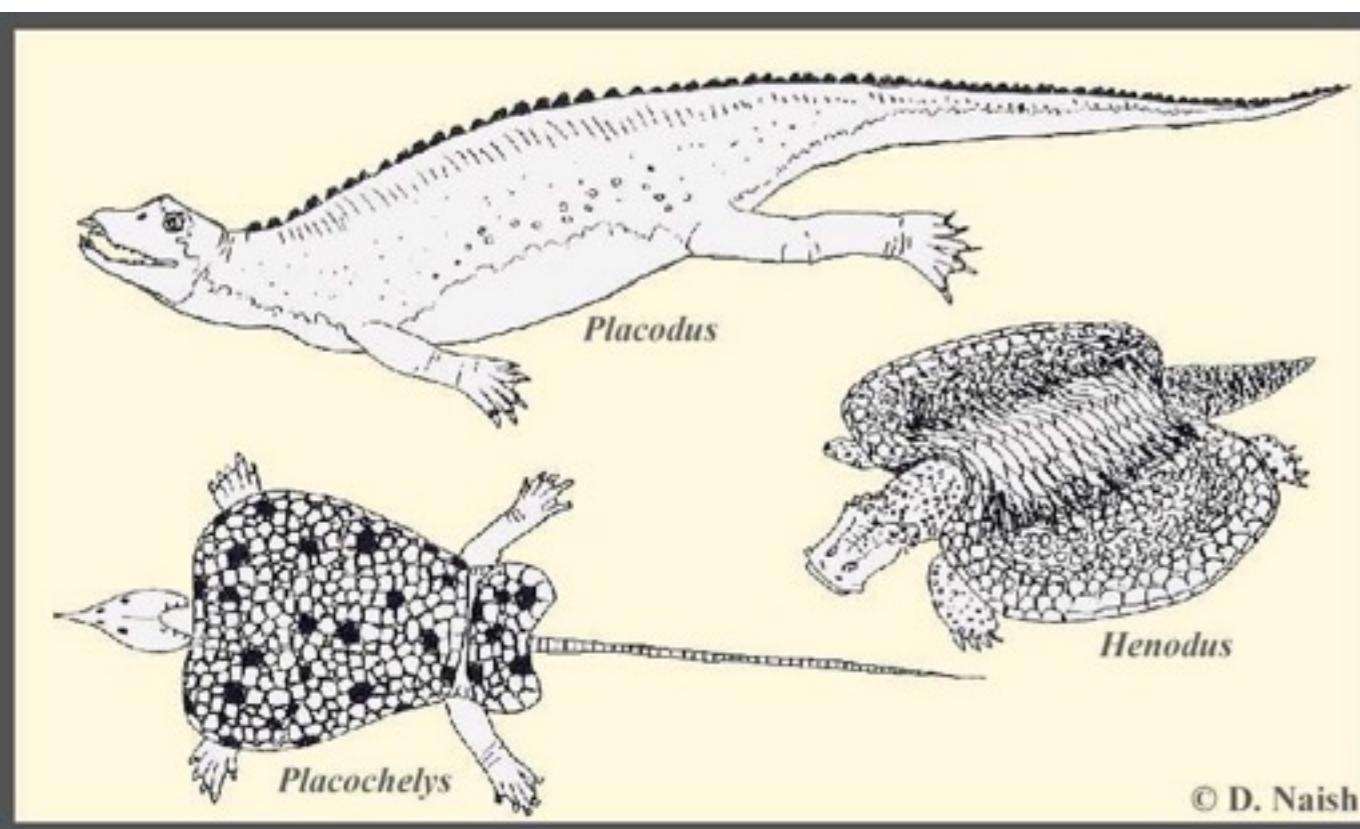


Placodonts

2 Major groups:

Placodontoids: unarmored

Cyamodontoids: armored



Nothosaurs

Triassic SEALS



Attributes:

Mid Triassic of Eurasia

Coastal environments

~ 12 ft long as adults

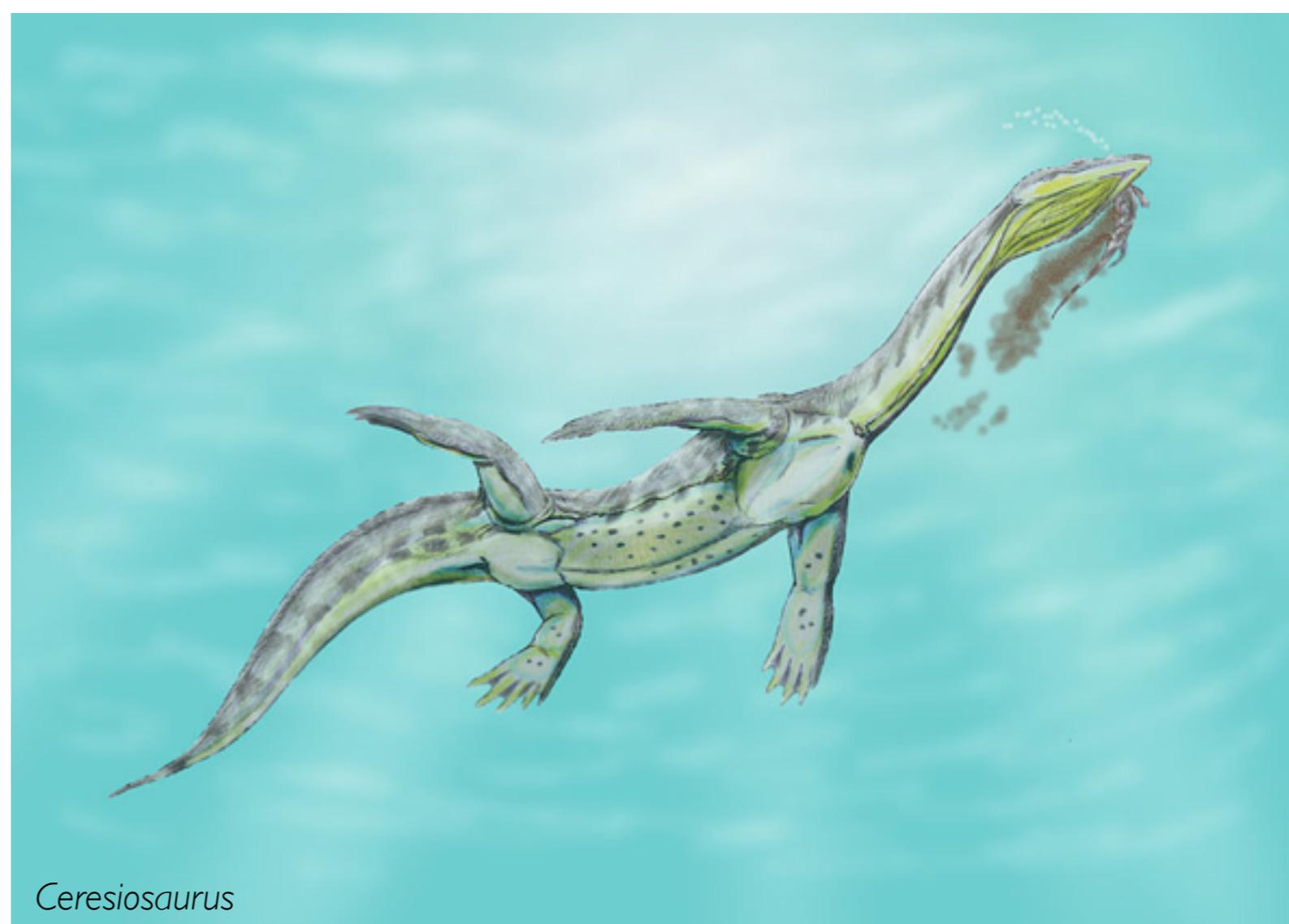
Long neck, streamlined body

Paddlelike forelimbs

Reduced hindlimbs

Webbed feet

Small pointy teeth



Nothosaurs

Triassic SEALS

Ecology:

Fish/squid-specialists

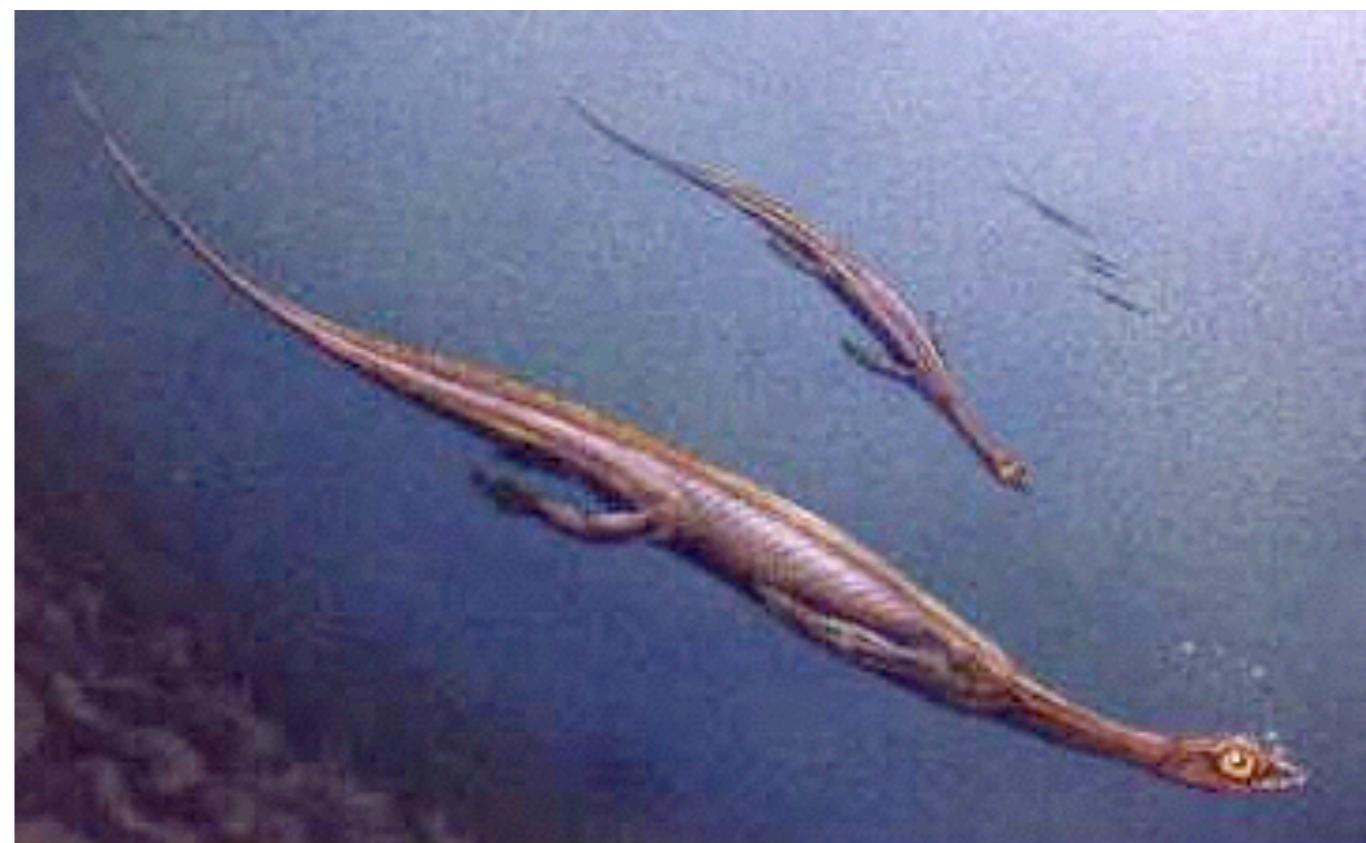
Foraged in water, but were dependent on rocks/beaches



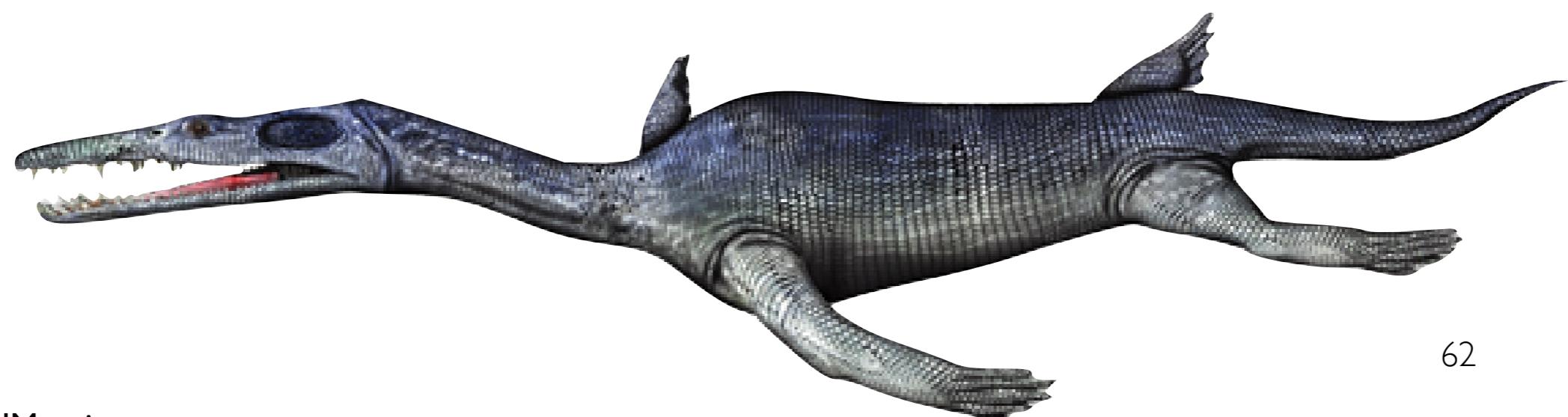
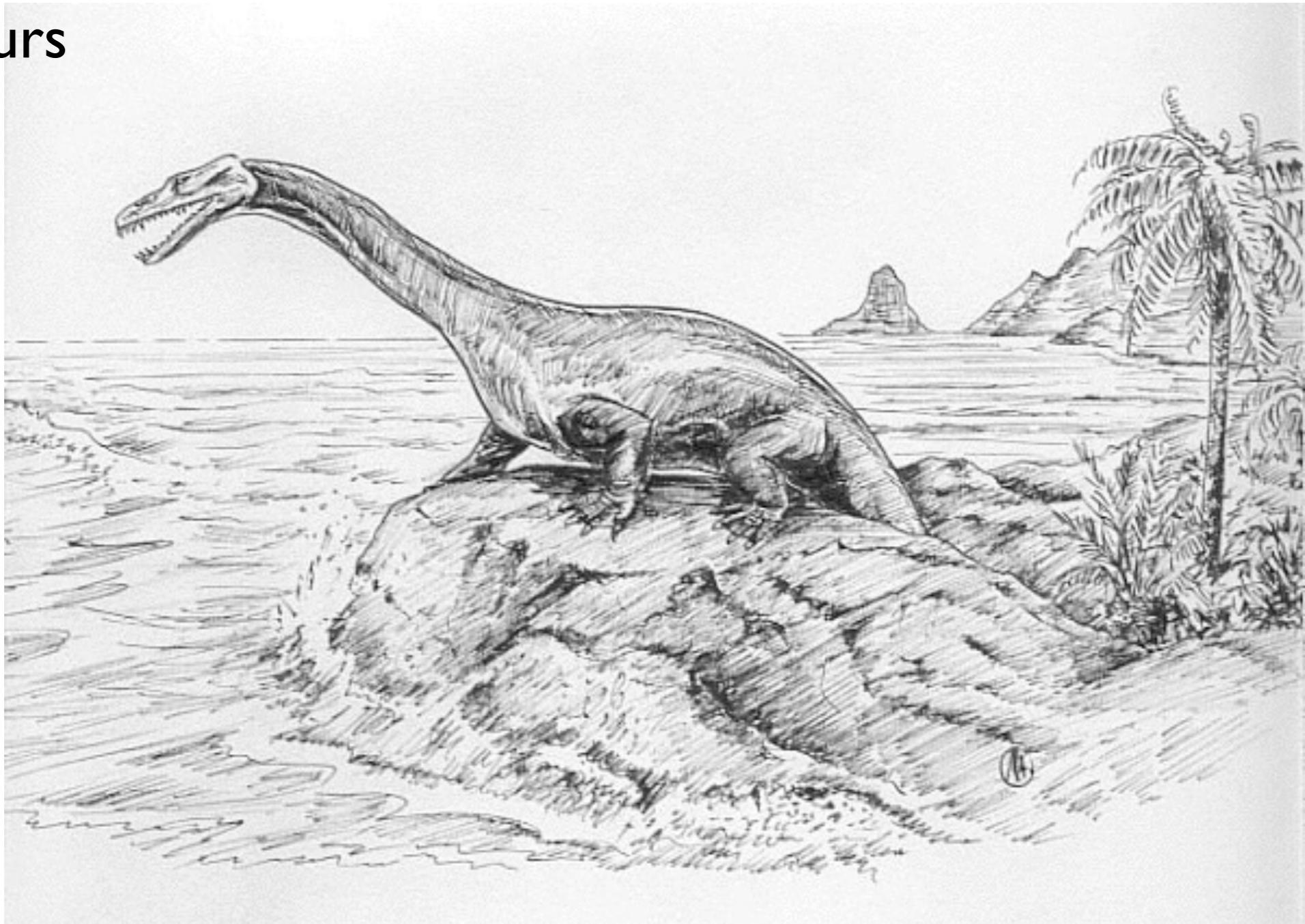
Lariosaurus



Keichousaurus

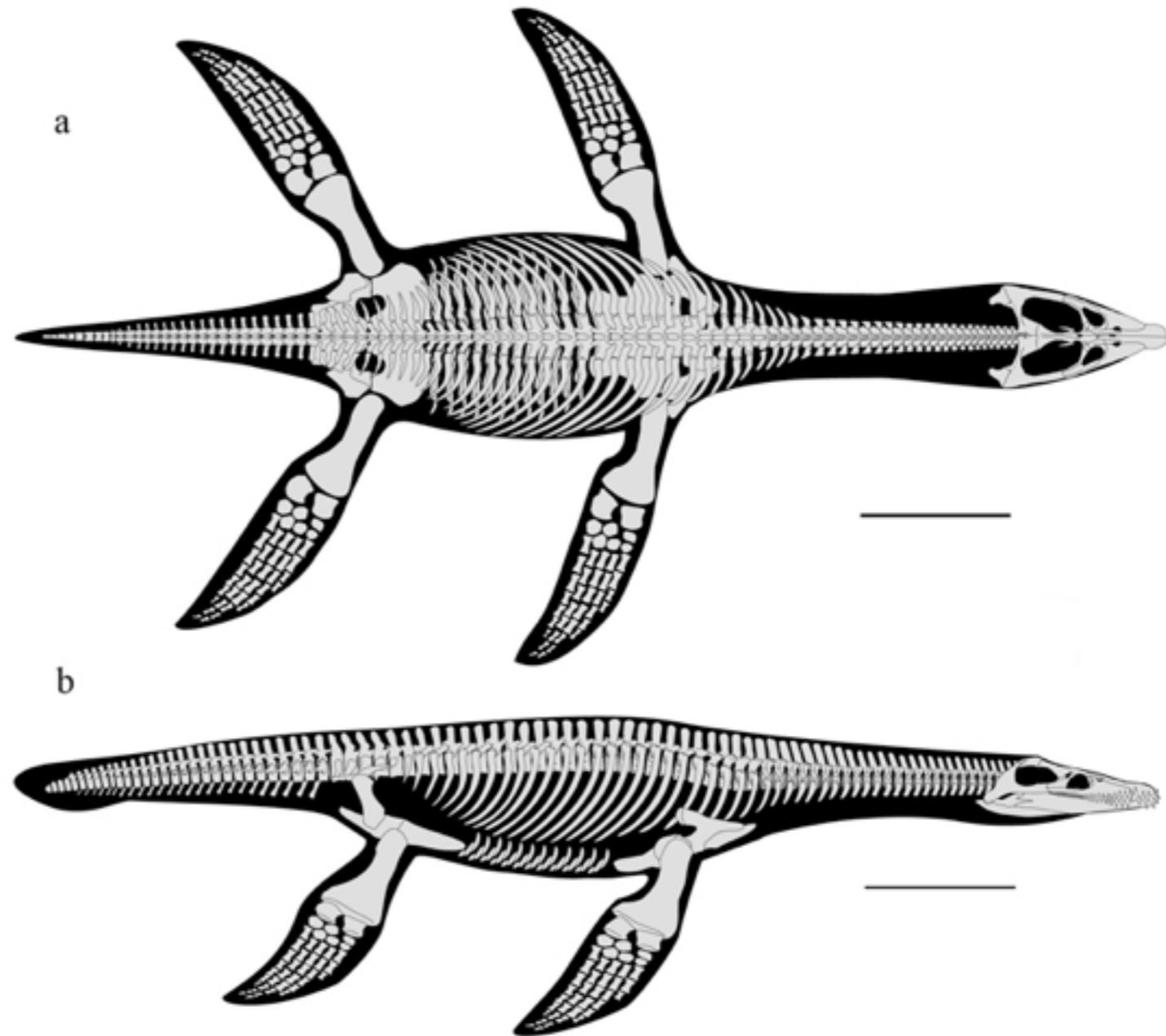


Nothosaurs



62

Plesiosaurs



Attributes:

Early Jurassic to Late Cretaceous

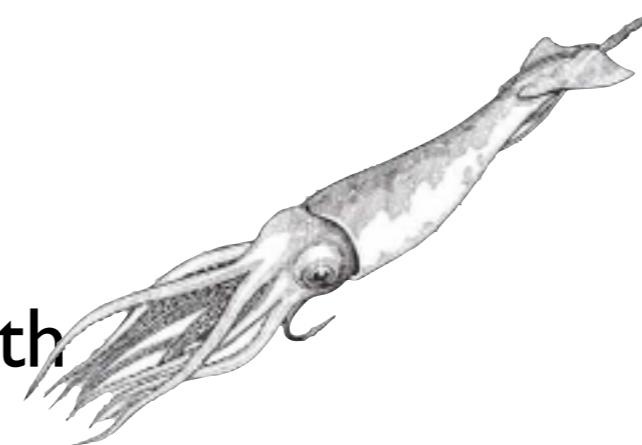
Several Continents

Front and hind limbs modified to flippers

Stiff trunk, strong pectoral and pelvic girdles

Short, boxy body with massive ventral ribs

Long necks, short tails, small head, sharp teeth

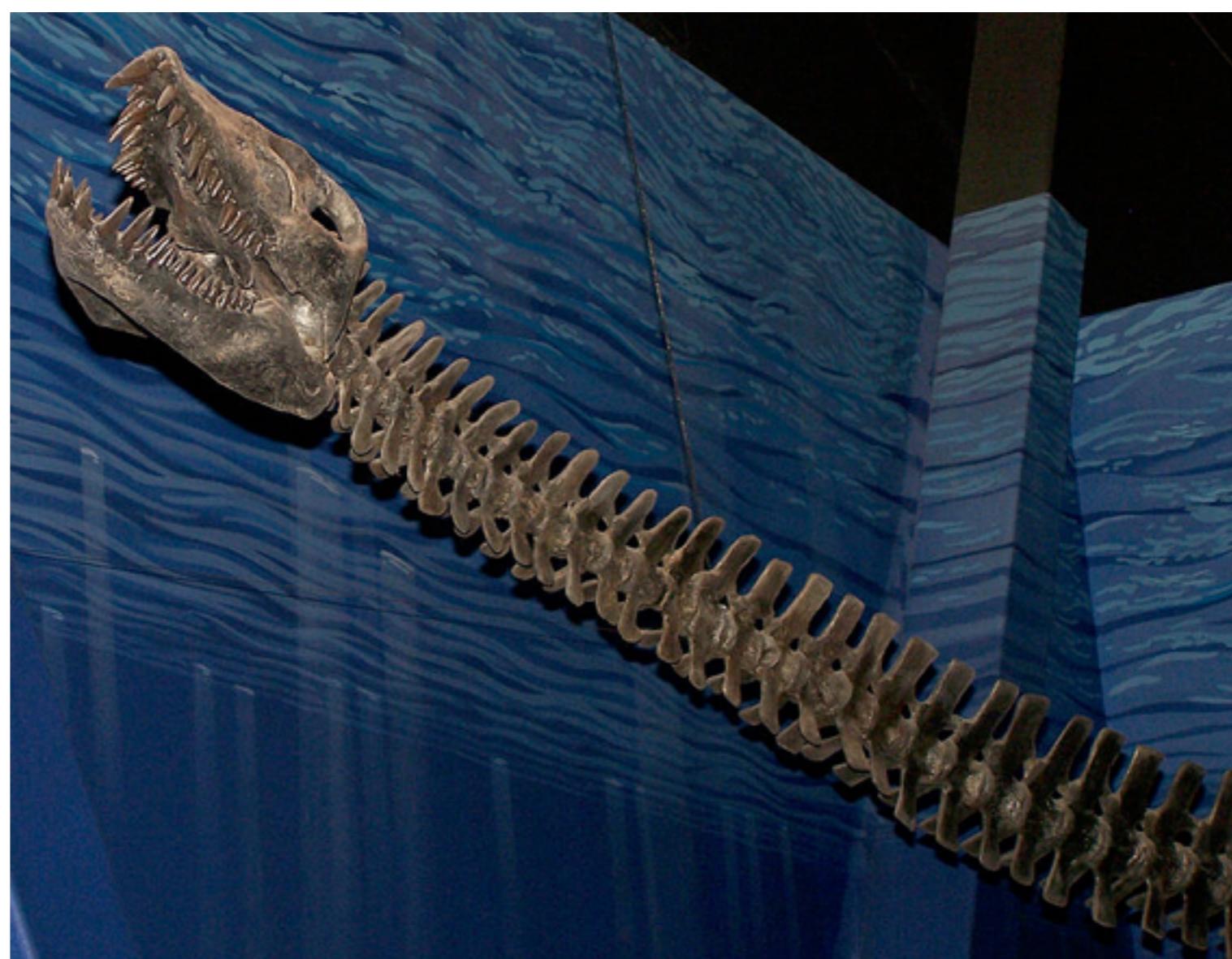


Plesiosaurs

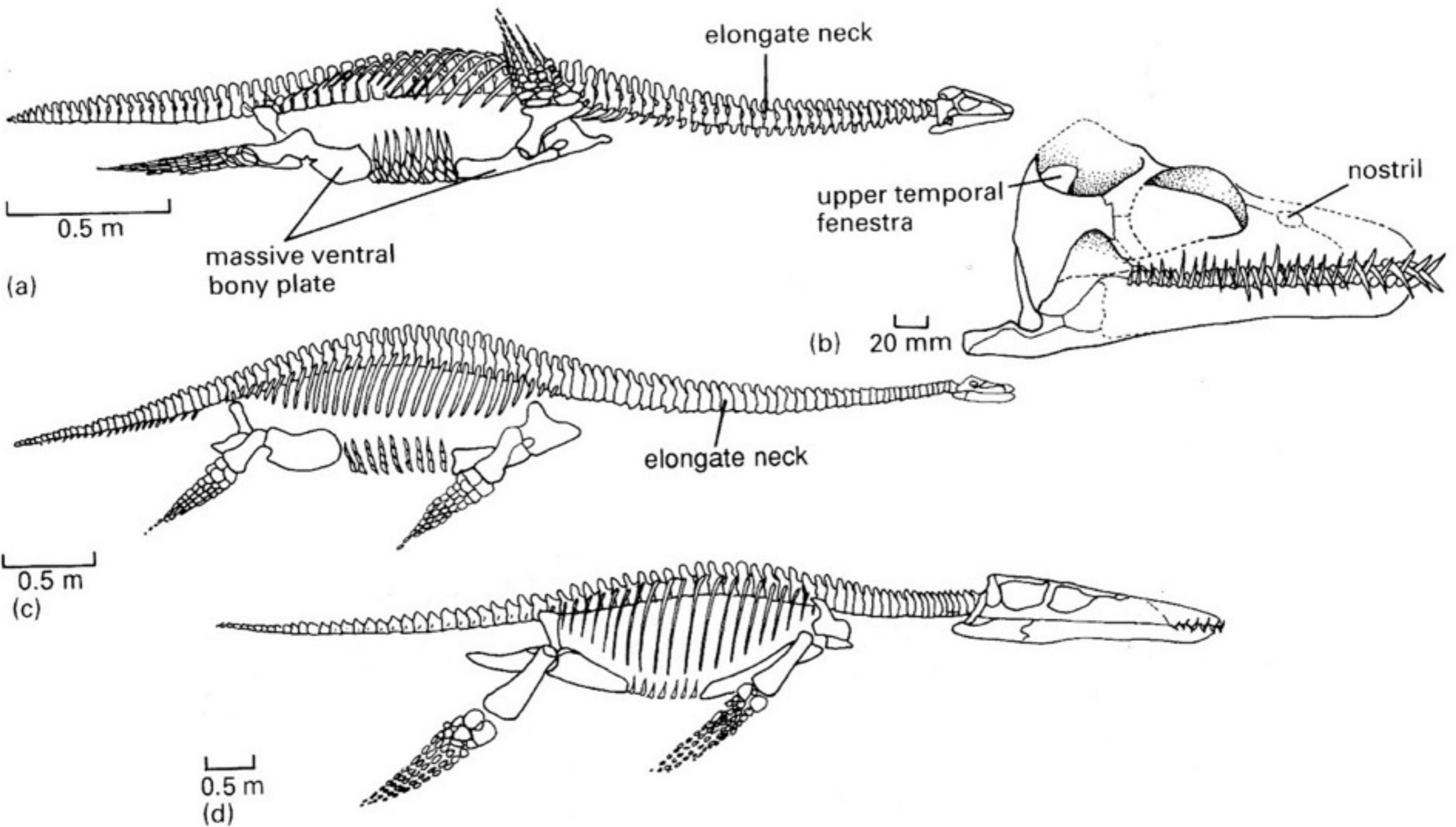
Ecology:

Fully marine and deep water habitats

Fish/cephalopod specialists



Elasmosaurus



Plesiosaurs

Locomotion

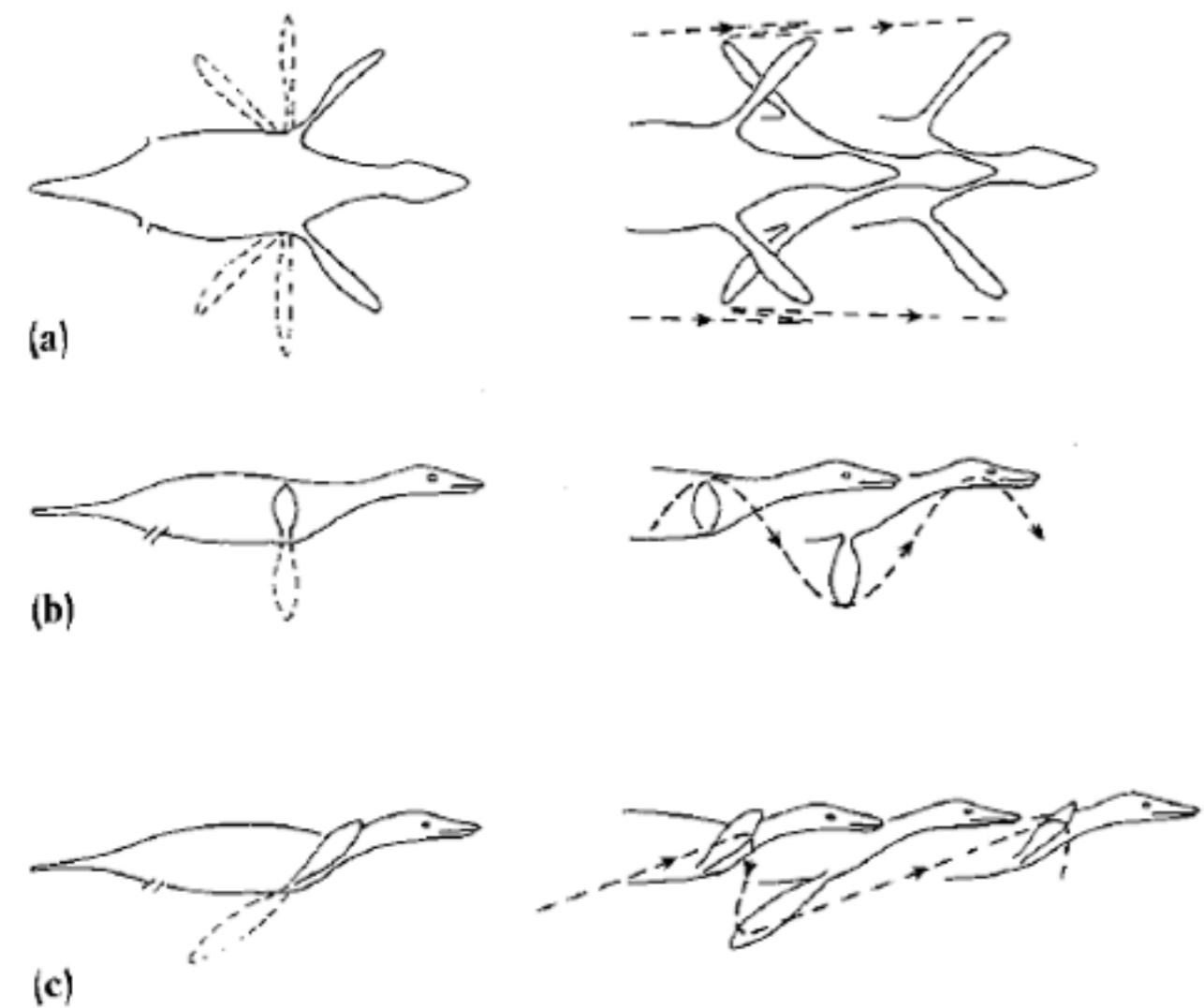


FIGURE 9.6 Three possible swimming techniques for plesiosaurs: (a) rowing; and (b) and (c) underwater flight. The diagrams on the left show how the flippers would have been moved relative to the body and those on the right show successive positions of the animal moving through the water. Only the foreflippers are shown.

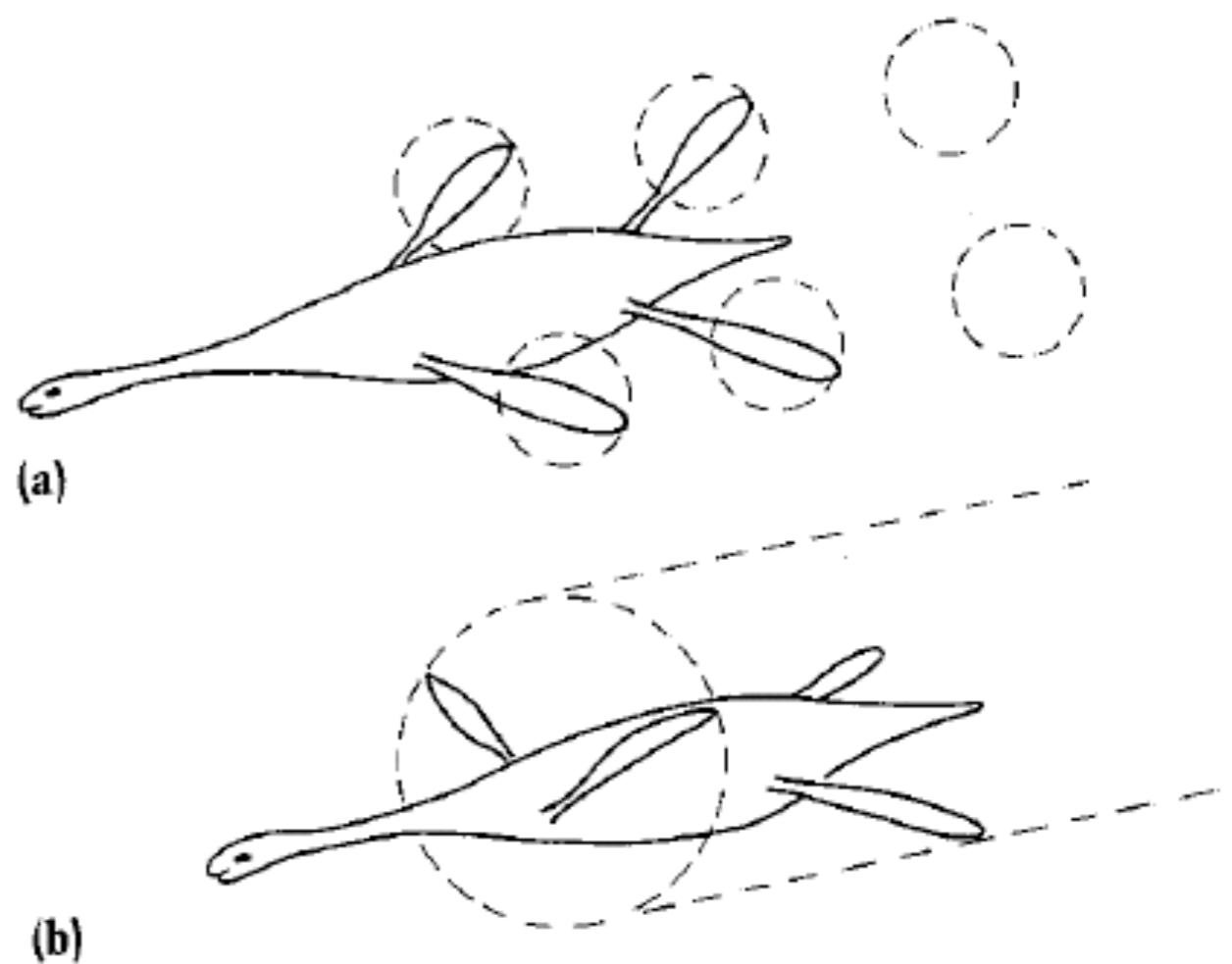
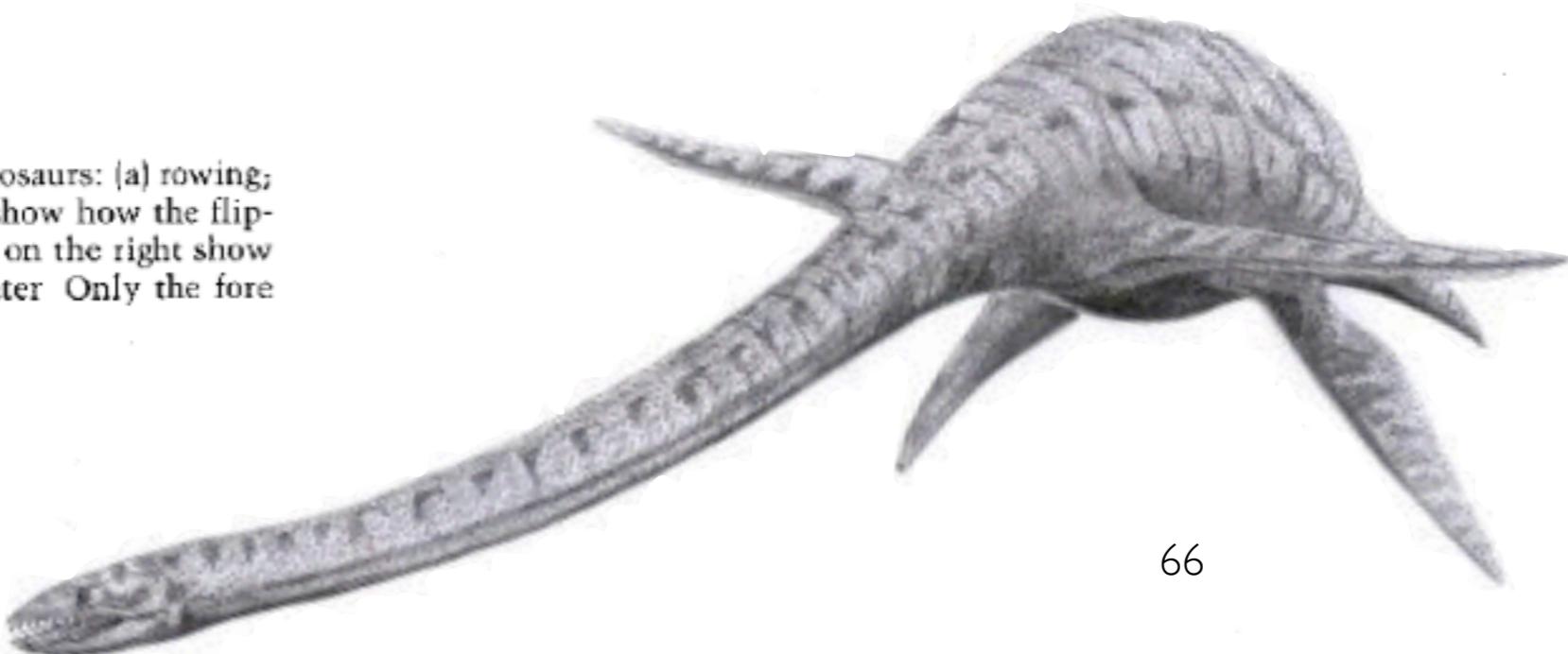
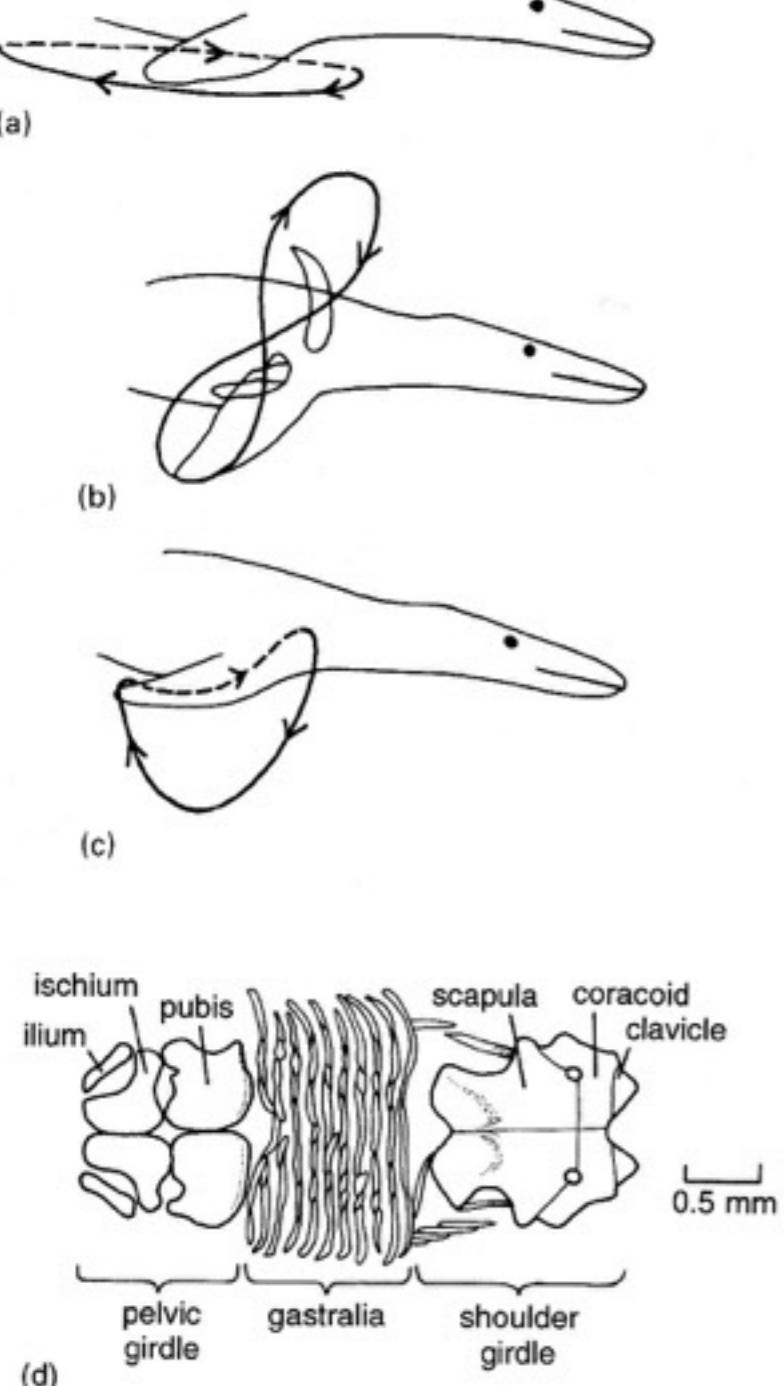
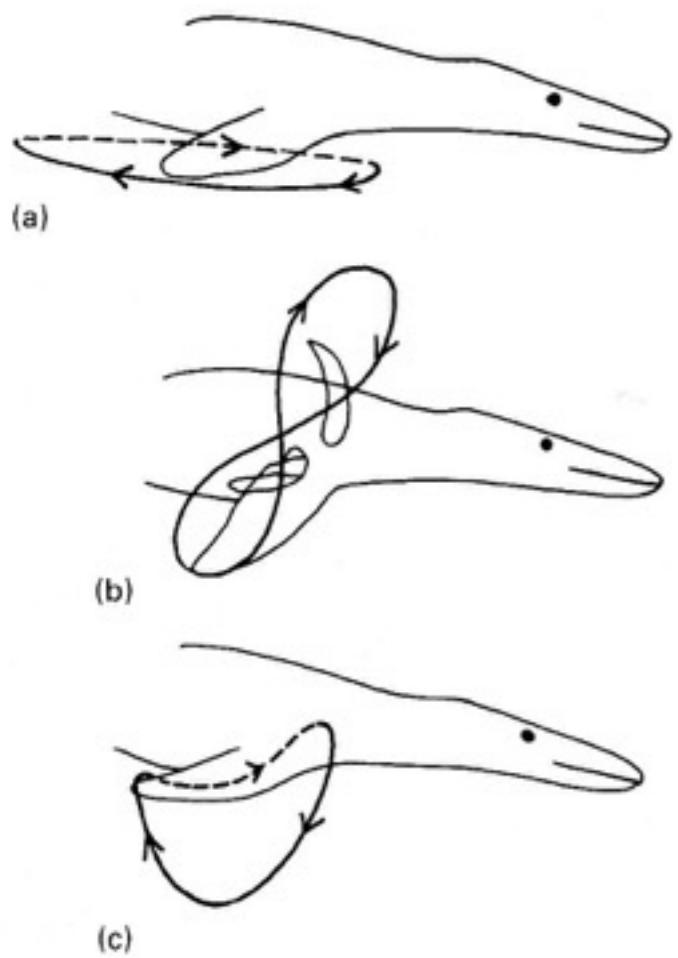


FIGURE 9.8. A plesiosaur (a) rowing and (b) "flying" under water. Broken out lines show the water driven backward by the swimming movements.





Plesiosaur locomotion: (a–c) three hypotheses: (a) rowing underwater like a duck, (b) flying underwater like a penguin, and (c) an intermediate style like a sealion; (d) ventral view of the heavy bony covering of the plesiosaur belly. [Figures (a–c) after Taylor 1986, copyright © 1986 Macmillan Magazines Ltd; (d) after Robinson, 1975.]

Birds

<http://www.youtube.com/watch?v=EahSpvyiFmw&feature=related>

Penguins

<http://www.youtube.com/watch?v=ErIhvelMk0k>

Sea Lions

<http://www.youtube.com/watch?v=br4IPNmfrOY&feature=related>



Plesiosaurs

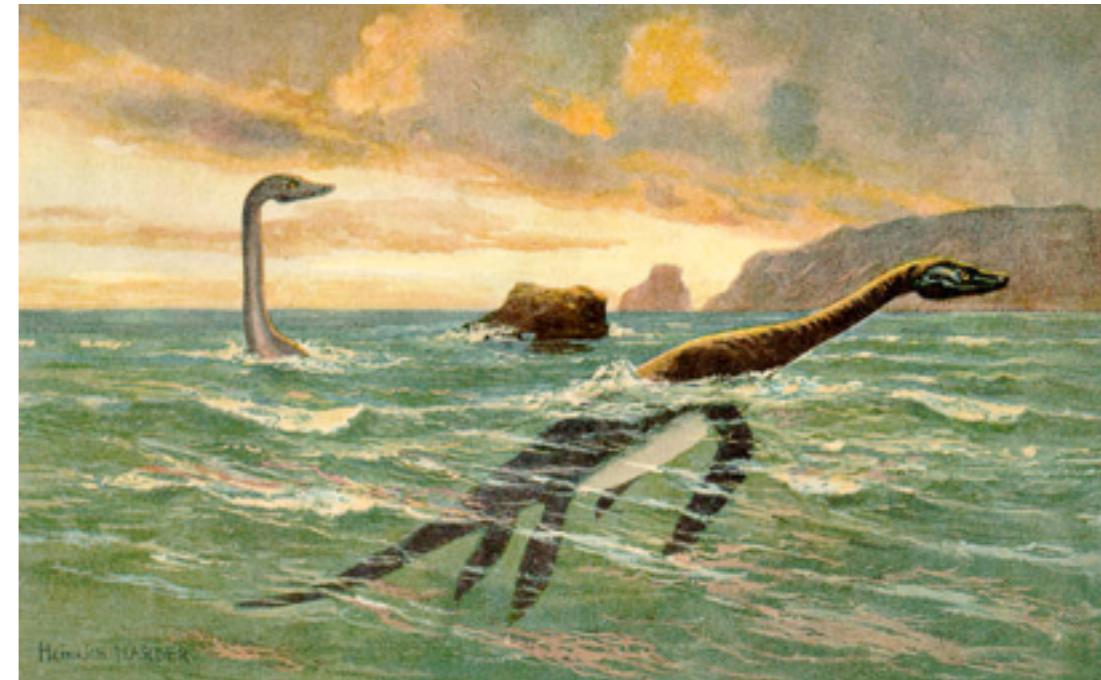
Locomotion

Likely slow swimmers

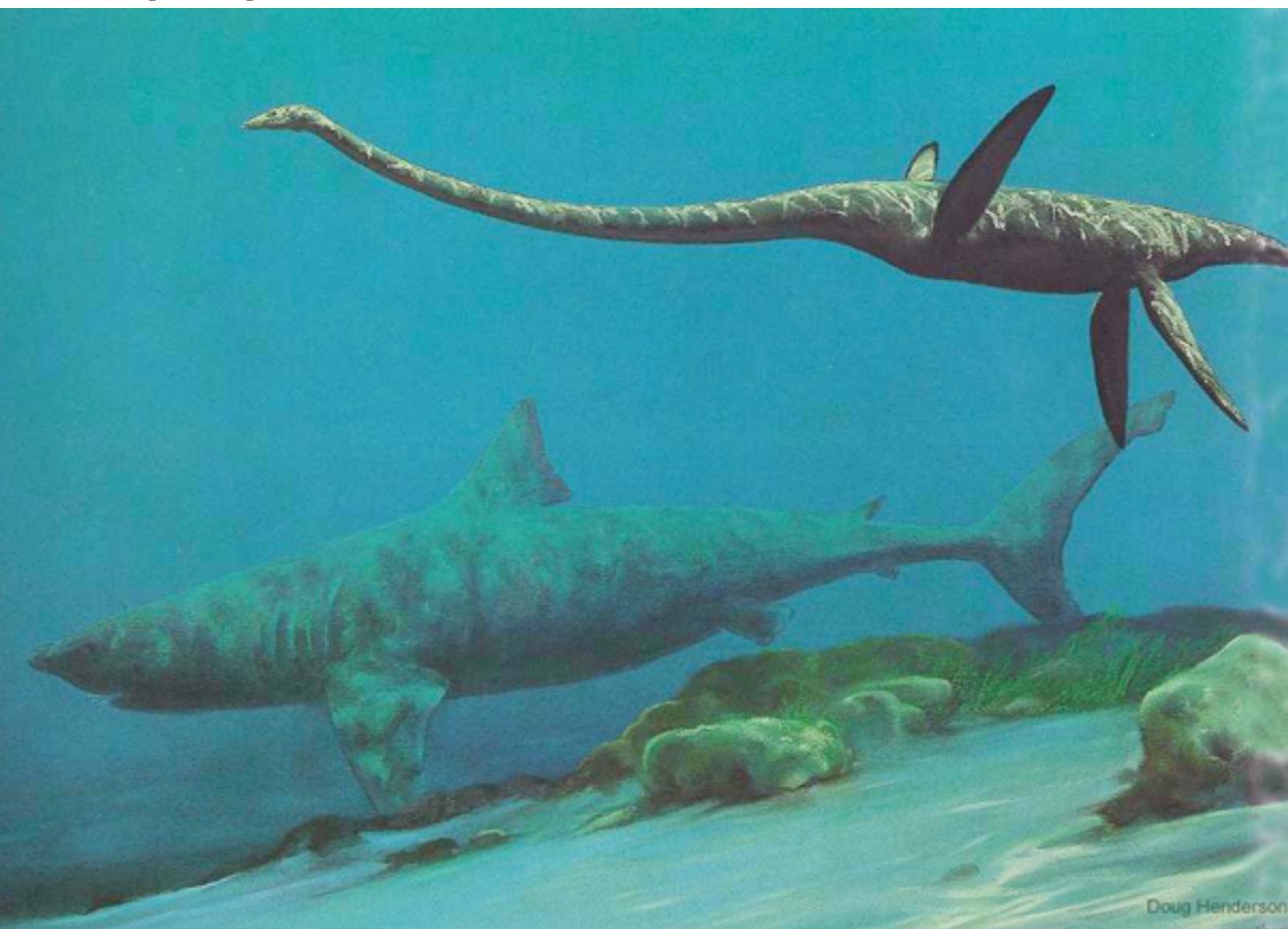
Cruised below the water surface and used long neck to grab prey from below

4-flipper setup would give them an amazing amount of maneuverability

Fins: propulsion

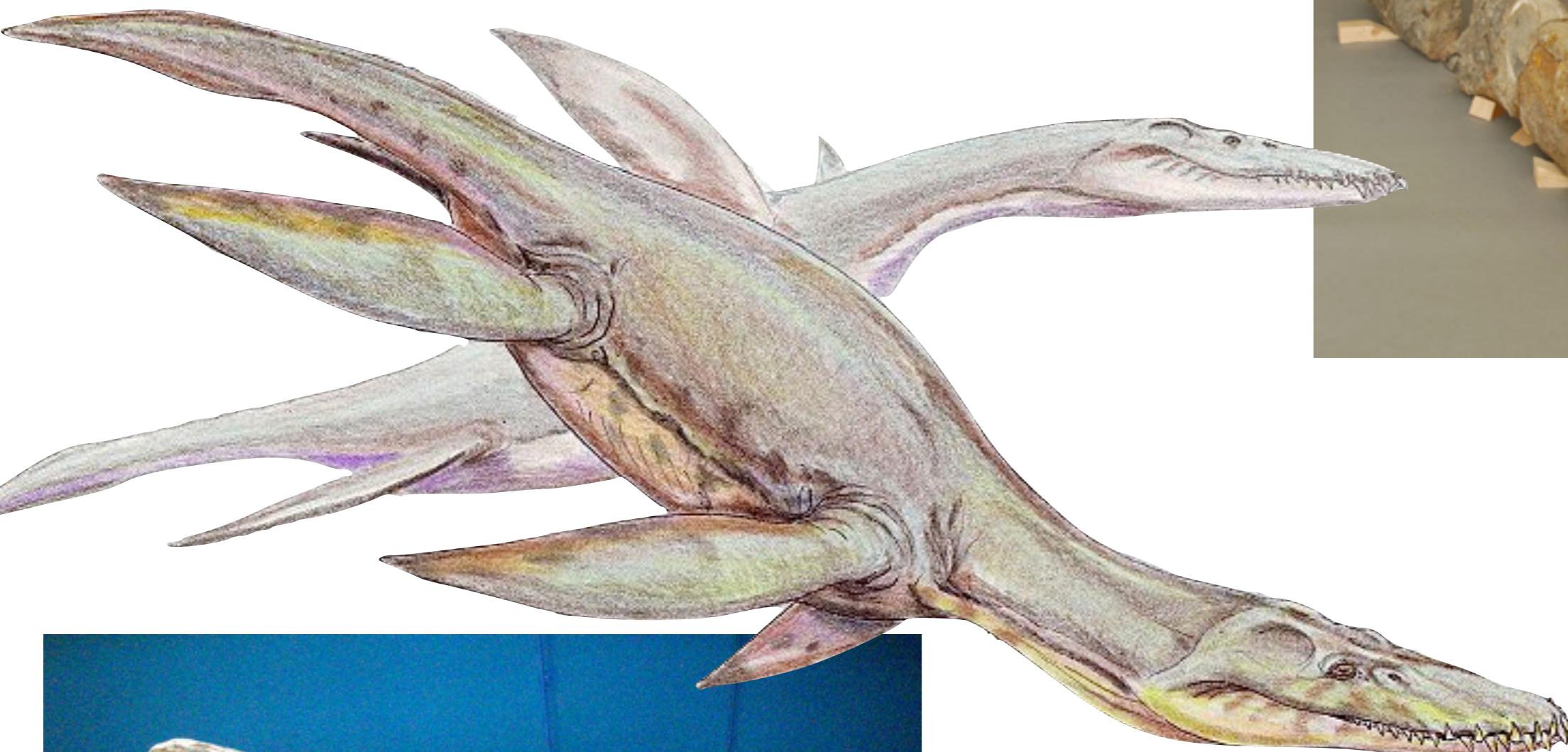


This would have been impossible

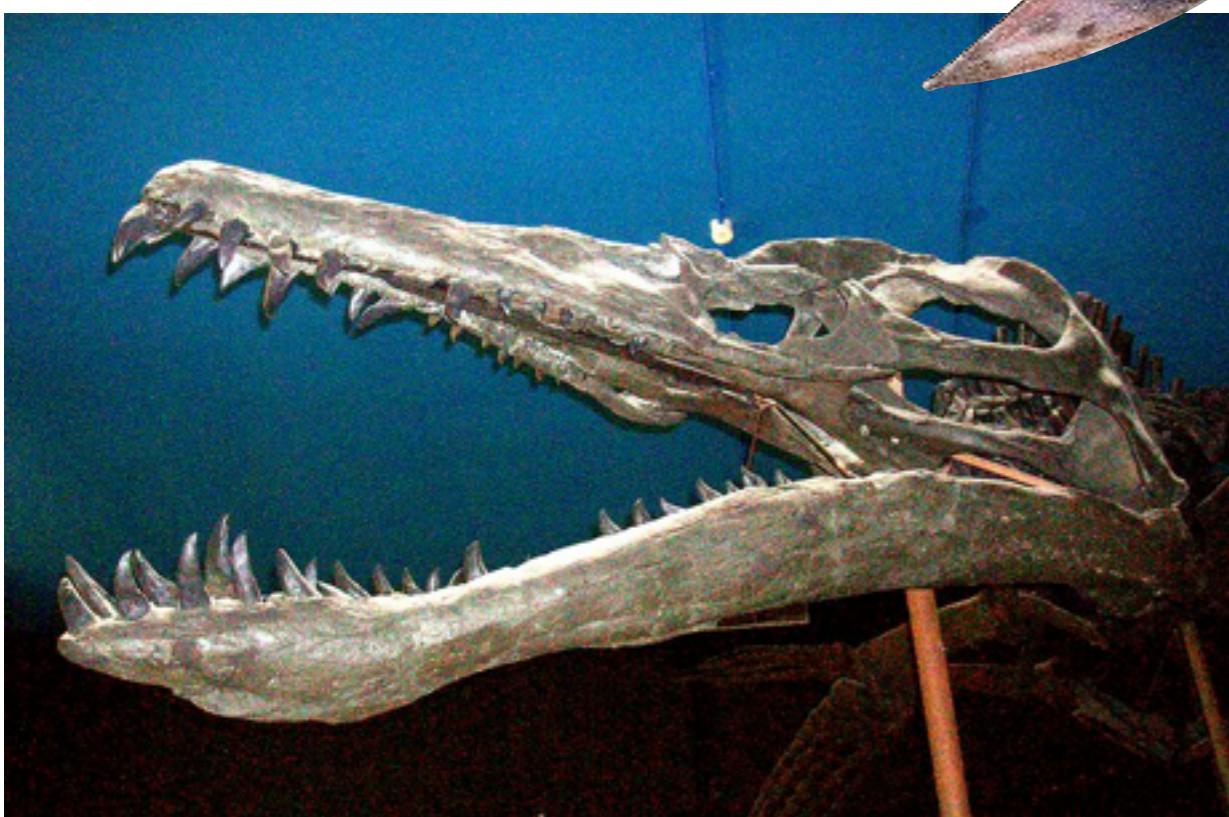


Pliosaurs

APEX predators



A Pliosaur jaw



Pliosaurs

Whales of the Mesozoic!

Up to 40 feet in body length

The skull was 1/3 of this length!

Large and faster than Plesiosaurs

Large, conical teeth

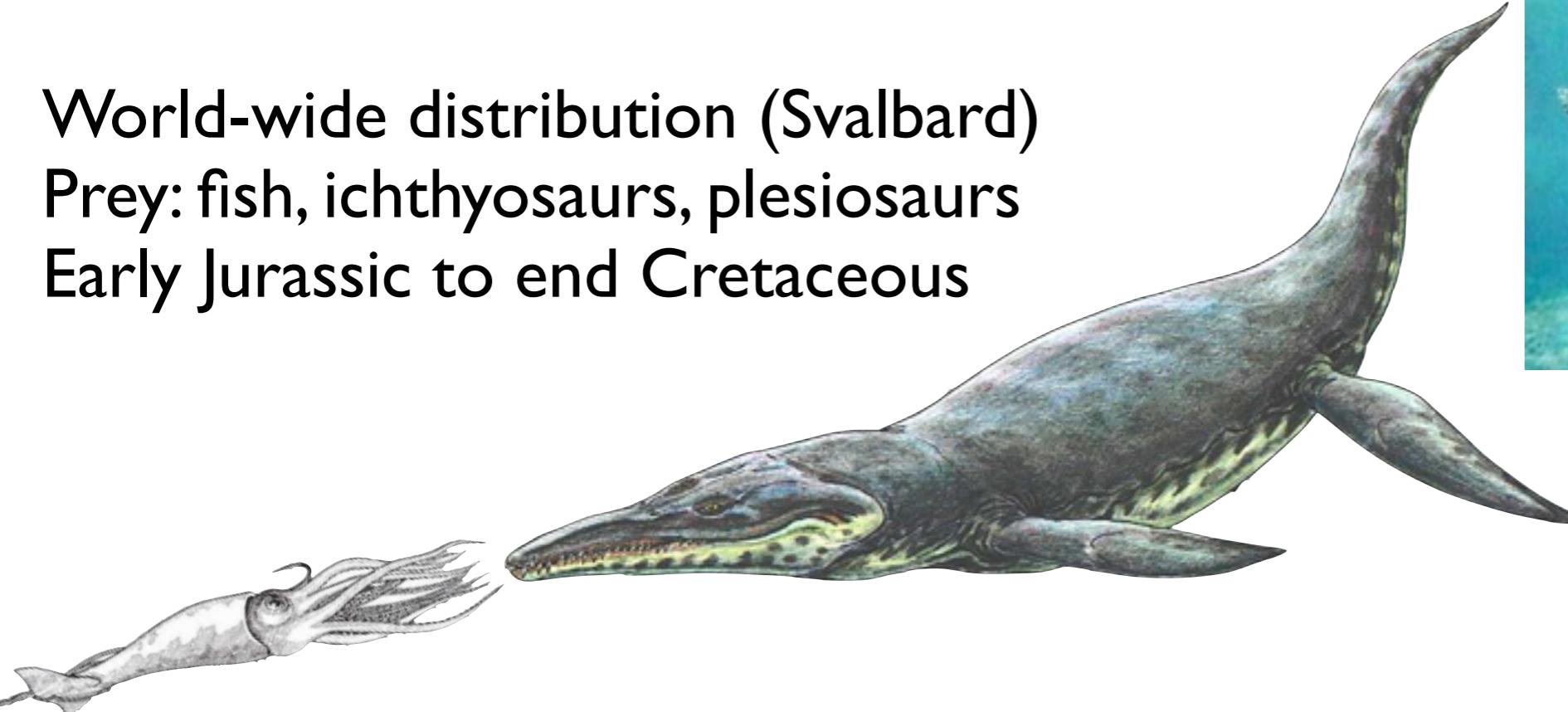
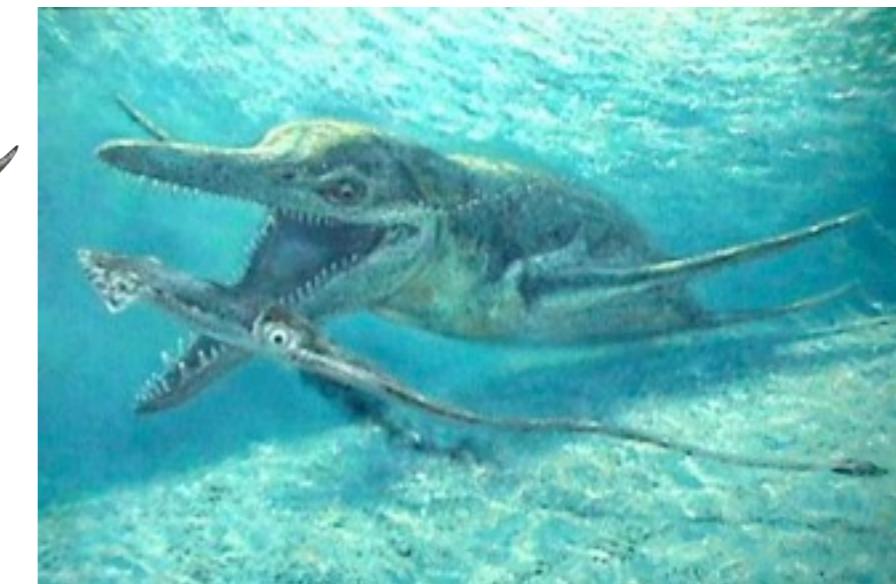


Pliosaurs

World-wide distribution (Svalbard)

Prey: fish, ichthyosaurs, plesiosaurs

Early Jurassic to end Cretaceous



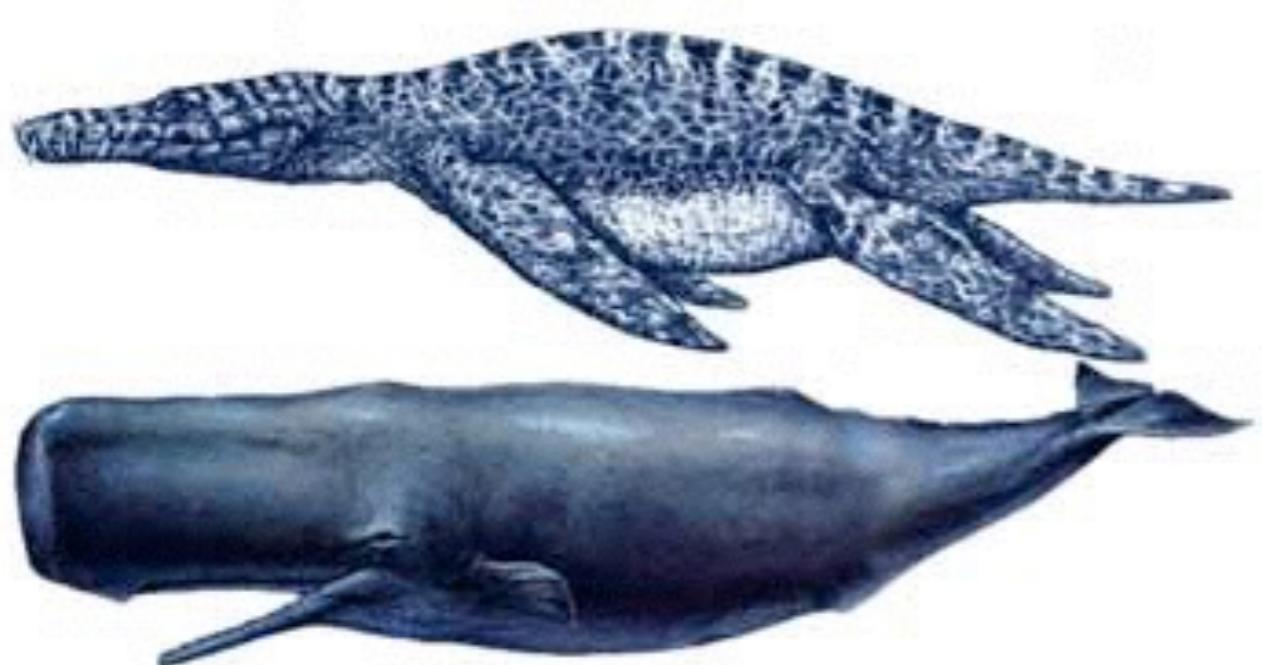
Pliosaurs



Liopleurodon



Serrated Portion.





Art by NGM Art

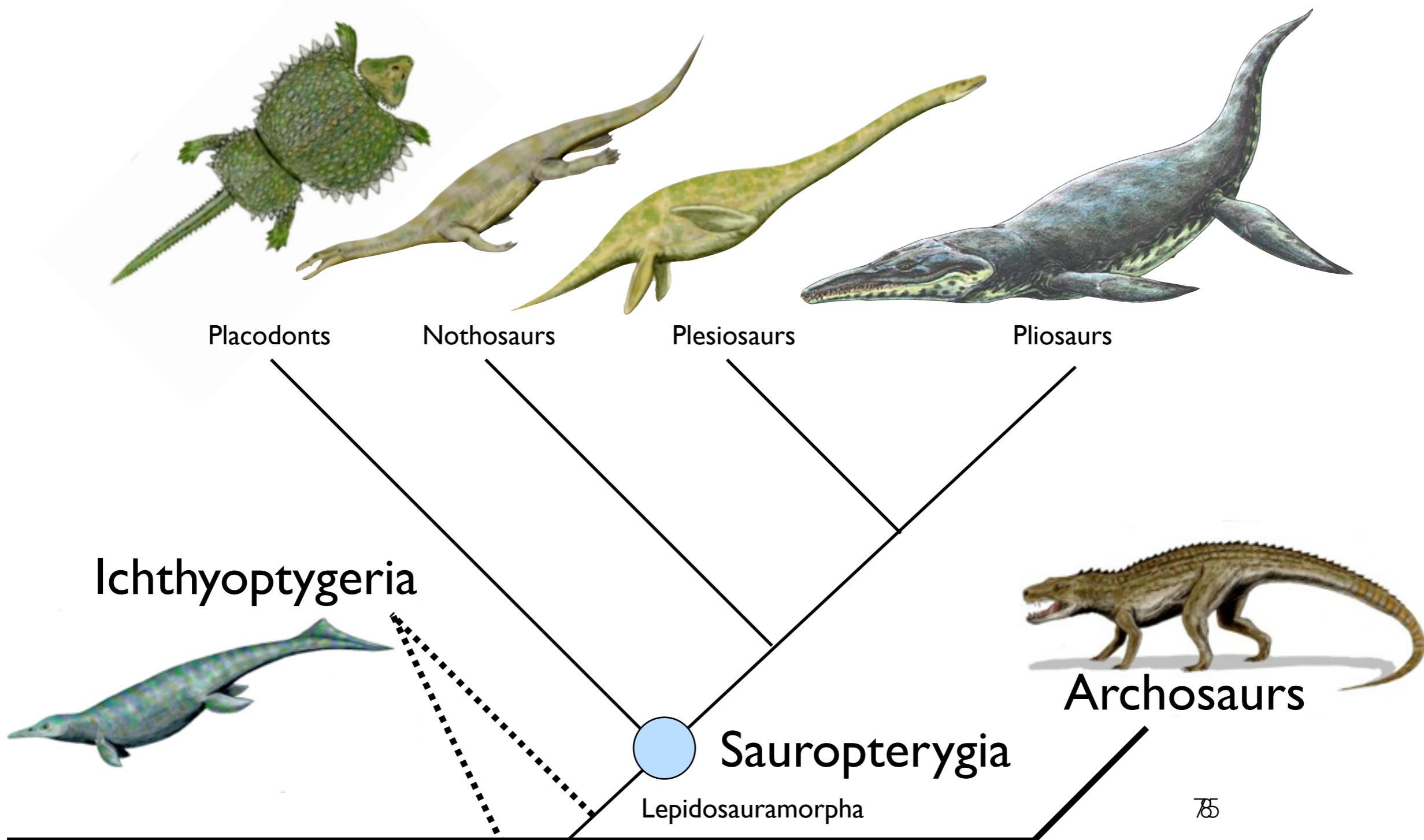
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Ichthyosaurs: Basal Lepidosaurs or sister taxa?

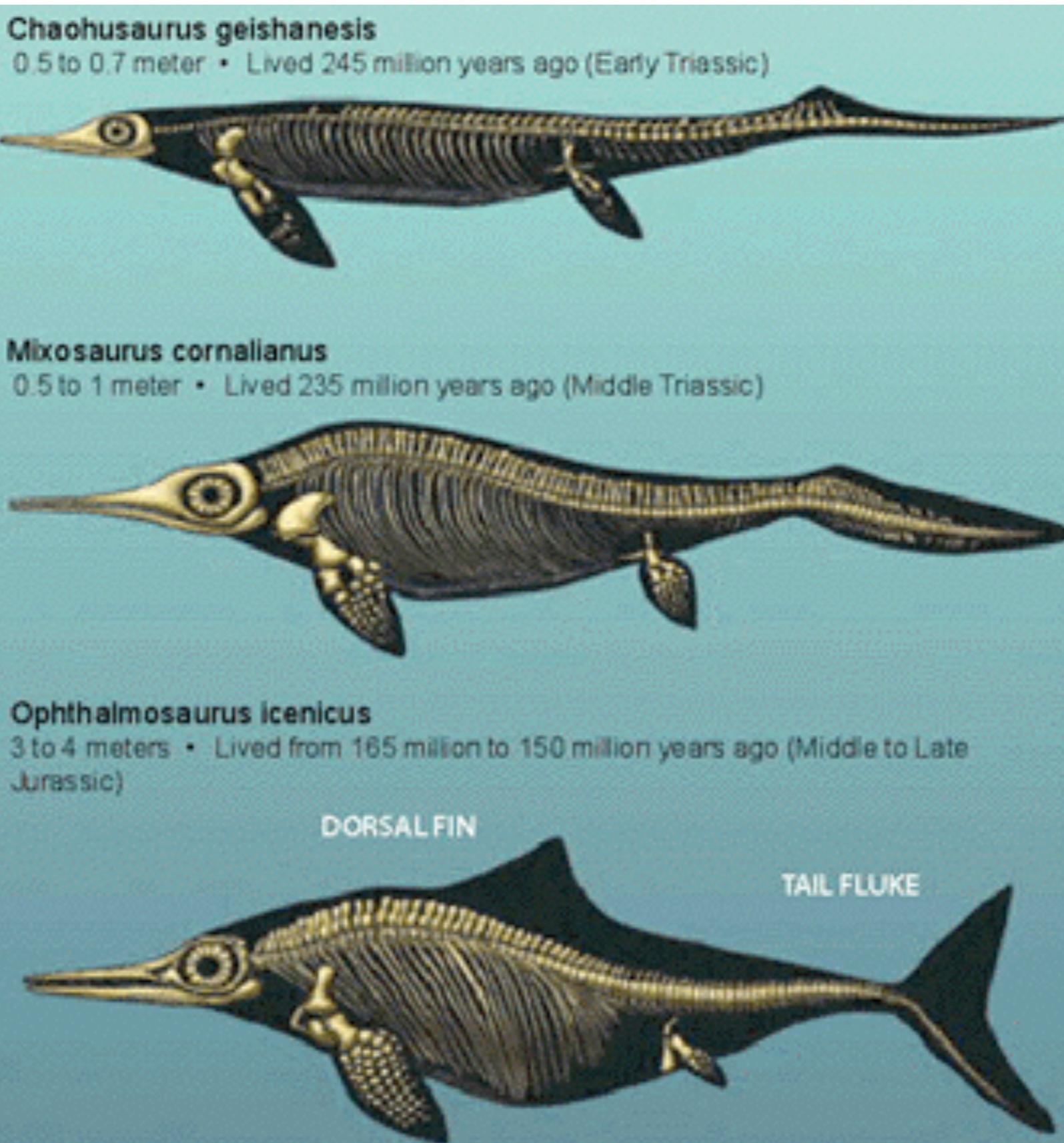
Lepidosaurs

Lepidosauria

Sauroptrygia

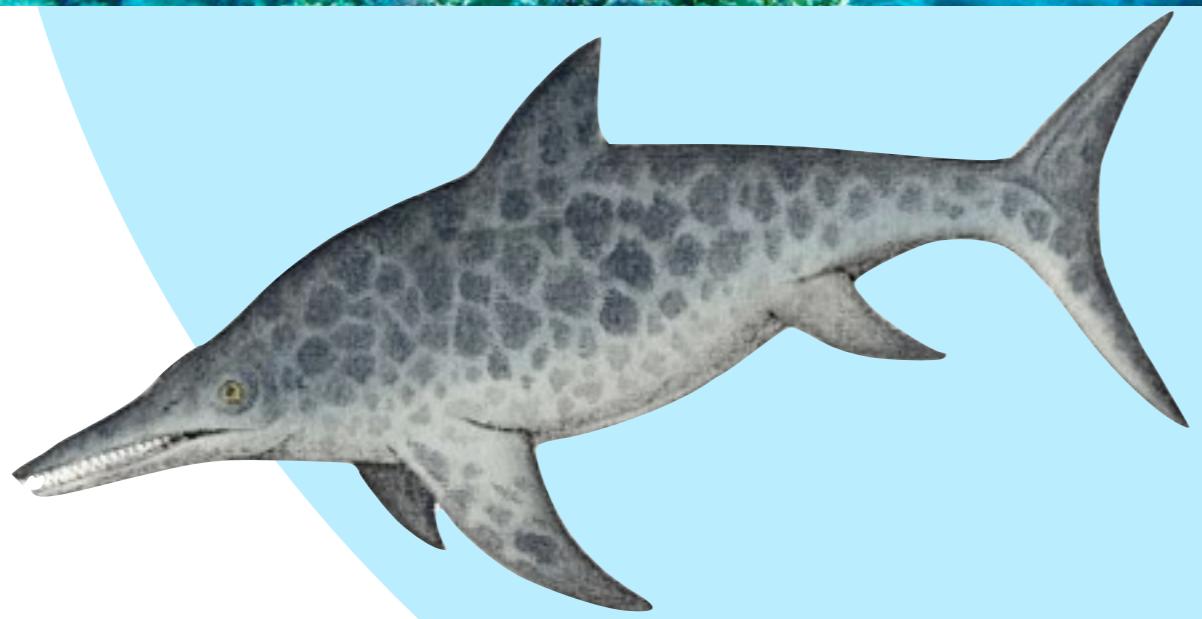
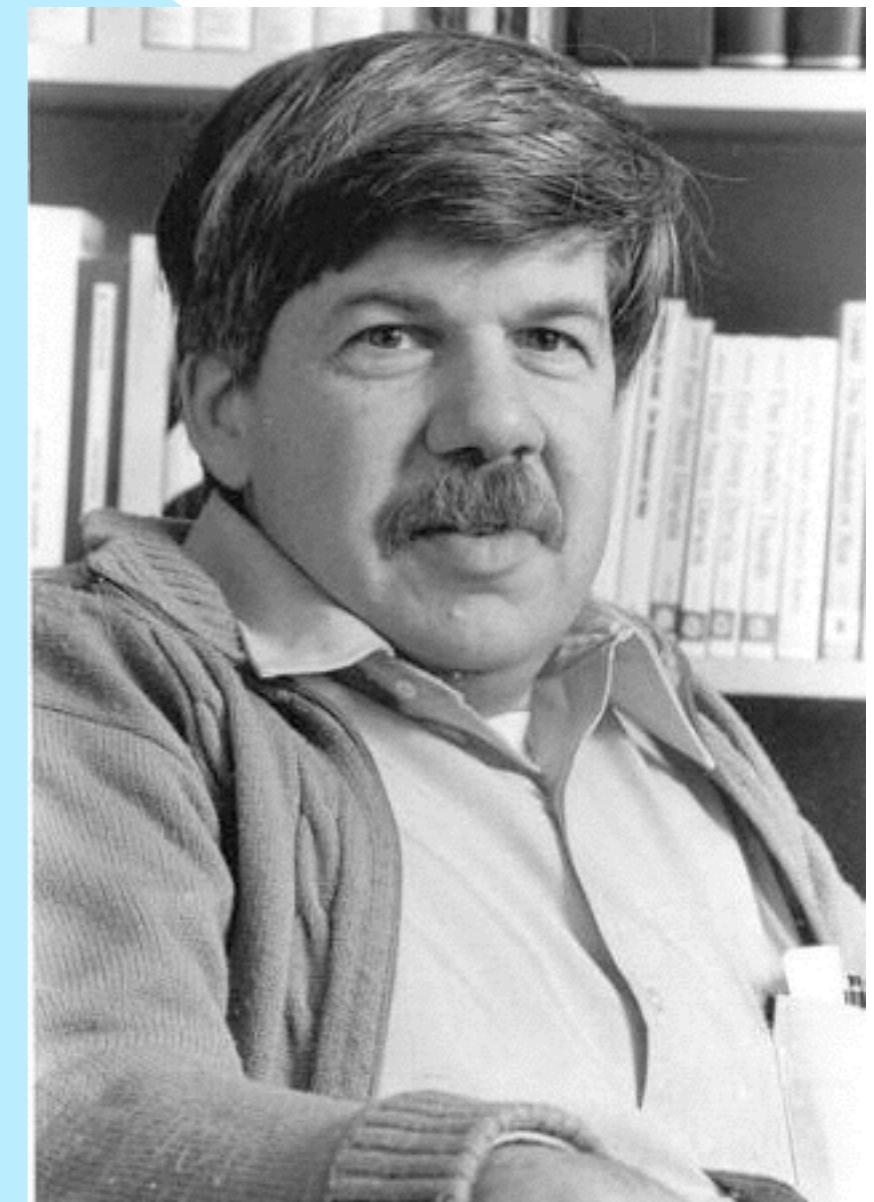


Ichthyosaurs





©2009 Tahoe Art on Demand



Convergent Evolution!

The dorsal fin evolved in exactly the right place for maximal hydrodynamic efficiency in fish, ichthyosaurs, & dolphins... the power of selection

Ichthyosaurs

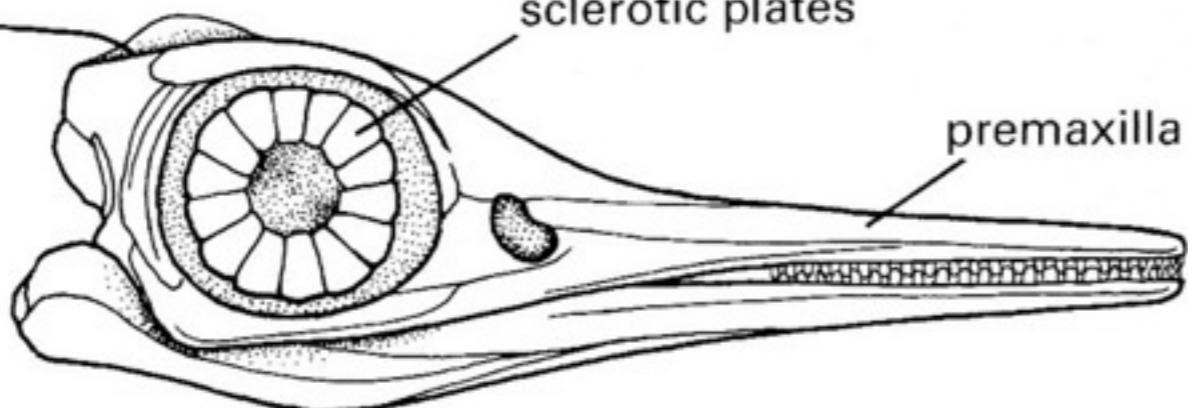
upper
temporal
opening

sclerotic plates

premaxilla

100 mm

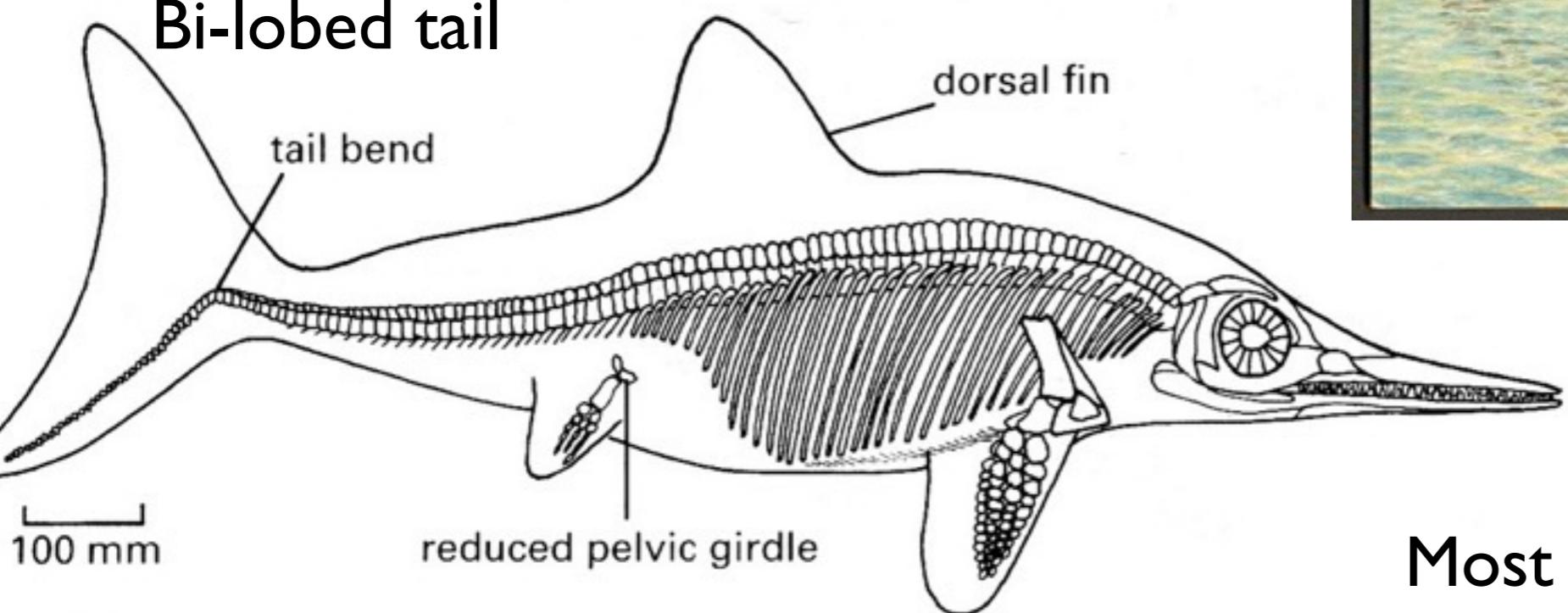
(a)



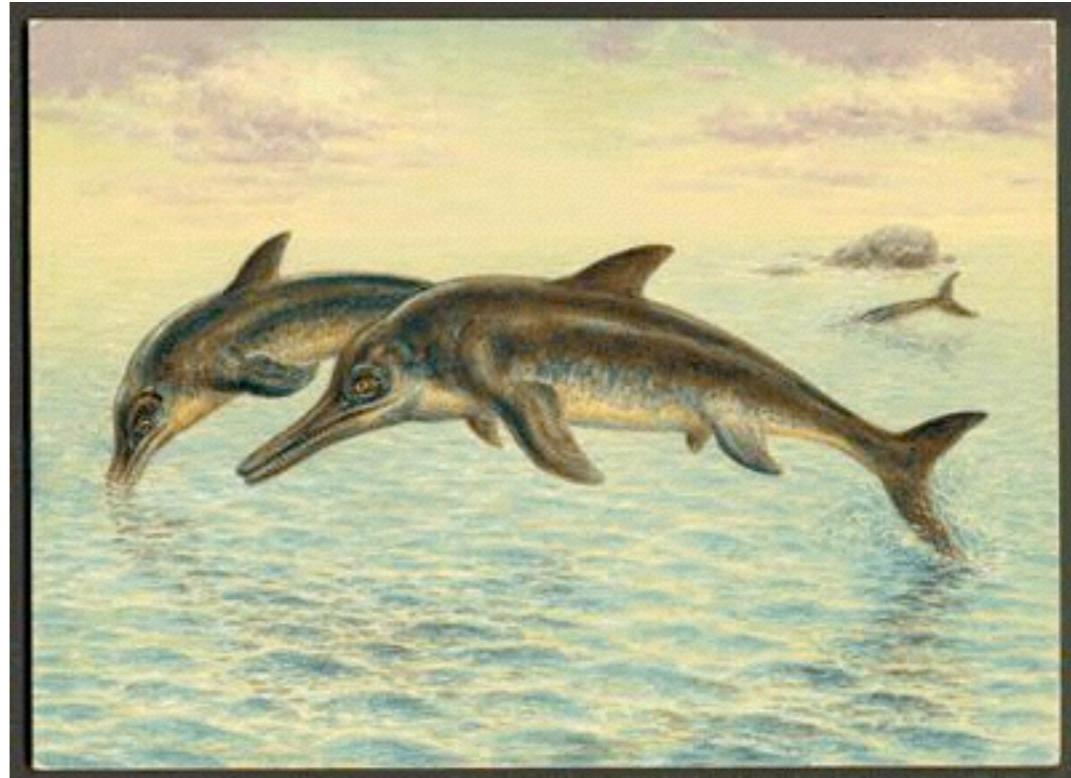
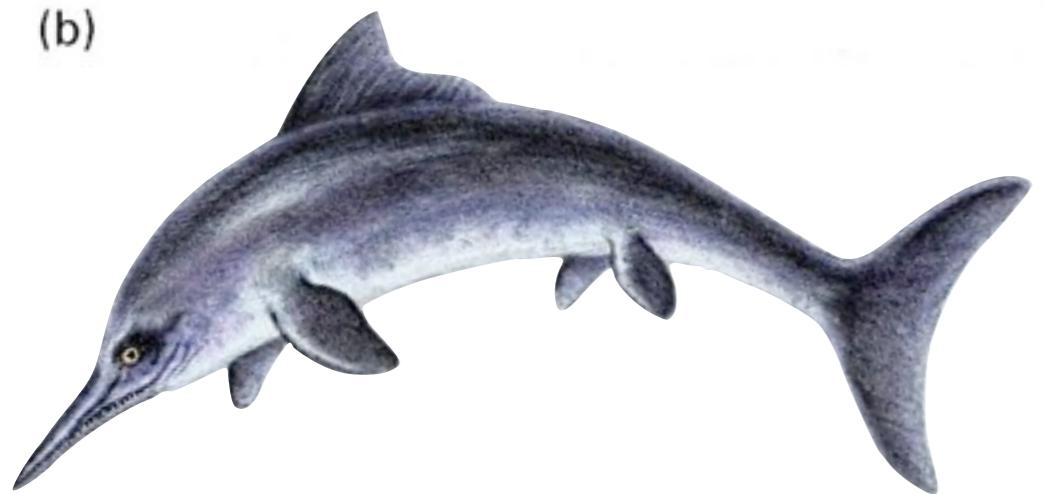
Bi-lobed tail

tail bend

dorsal fin



(b)



Attributes:

Most ‘fish-like’ marine reptile

Earlier forms had longer bodies

Cretaceous forms are more dolphin-like

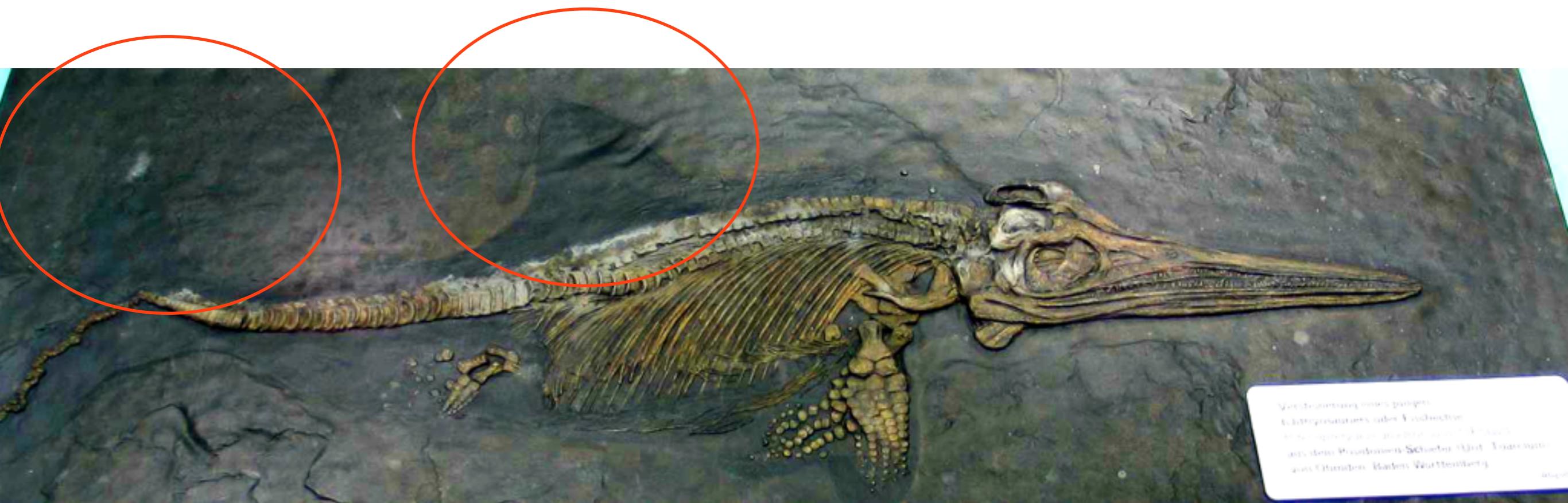
Up to 50 ft in length!

Forelimbs modified into flippers

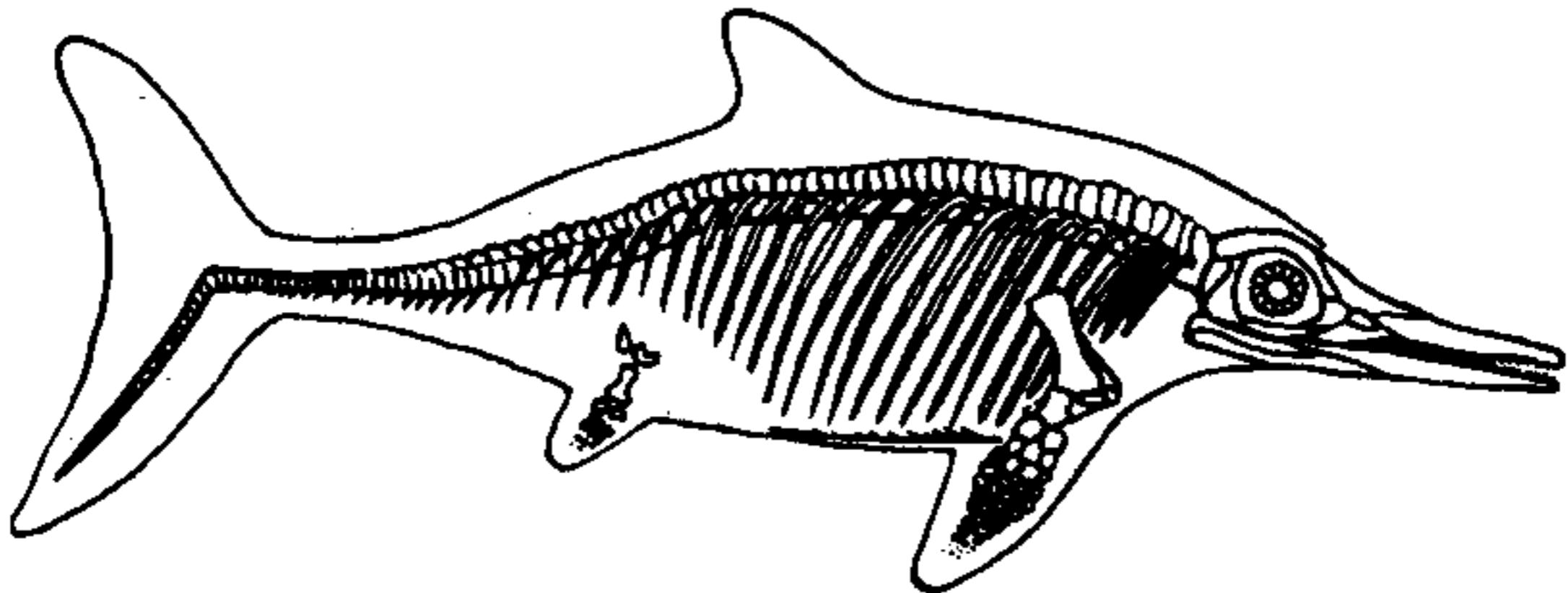
Reduced hindlimbs, reduced pelvic girdle⁷⁹

Ventrally-tipped tail and dorsal fin

Fossil evidence for soft anatomy: Germany



Mit dem Fund eines präzisen
Kontroversien über die Evolution
der Knochenfische ist ein neuer
und sehr wichtiger Schritt auf der
Wissenschaftlichen Karriere von
Hans-Dieter Suttner.



Attributes:

World-wide distribution

Specialized pursuit predators

Likely a very similar ecology as modern dolphins

Fins were not used for propulsion, but for directional control & stability



2 main styles of locomotion:

I. Slow-moving, ambush predators

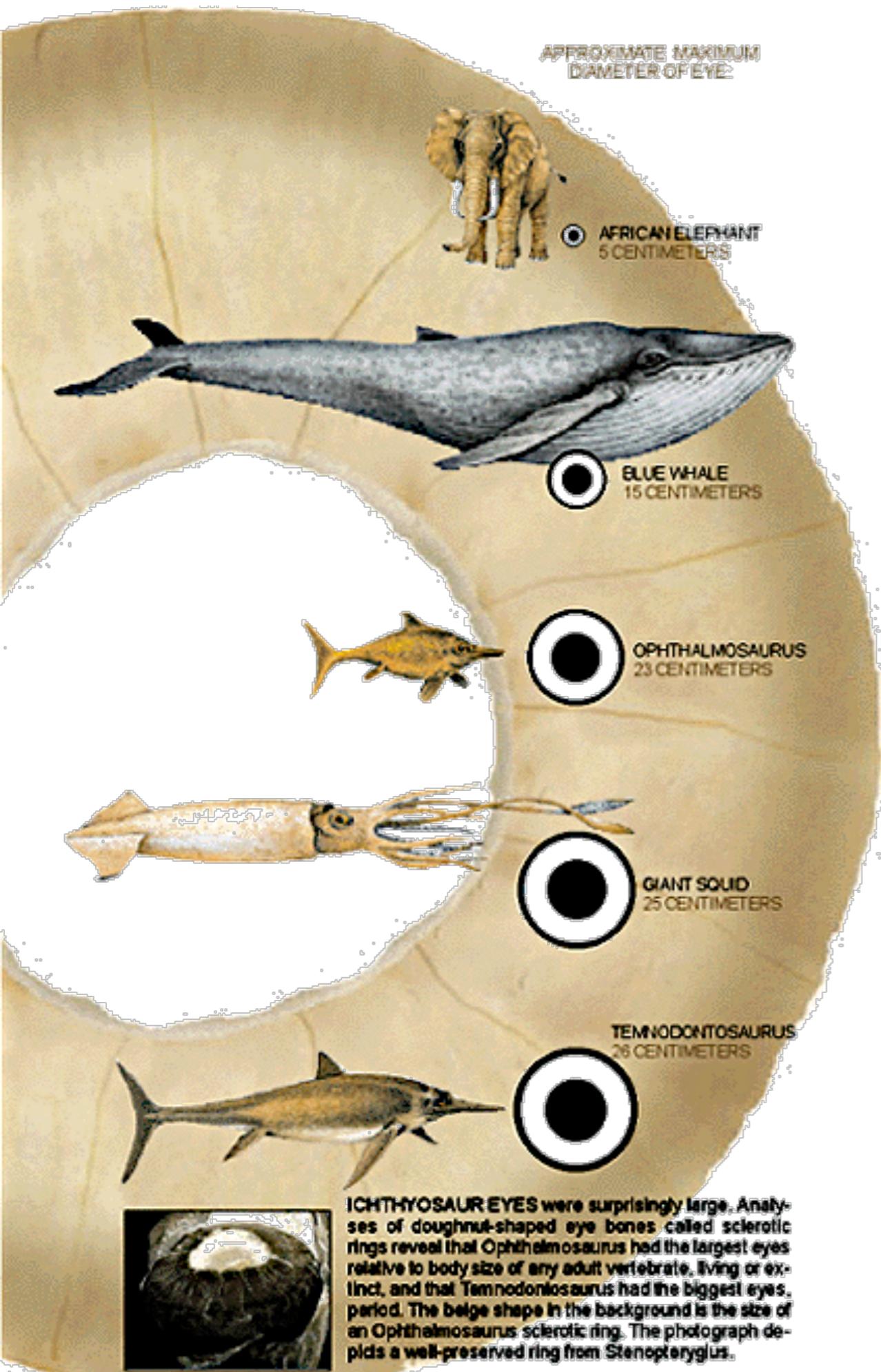


2. Fast-moving pursuit predators
up to 25 mph





Their similarity with tuna, dolphins, suggests that they occupied a similar ecological niche. This has led some people to believe that they could have been endothermic (Tuna are also endothermic)



Ichthyosaur EYES

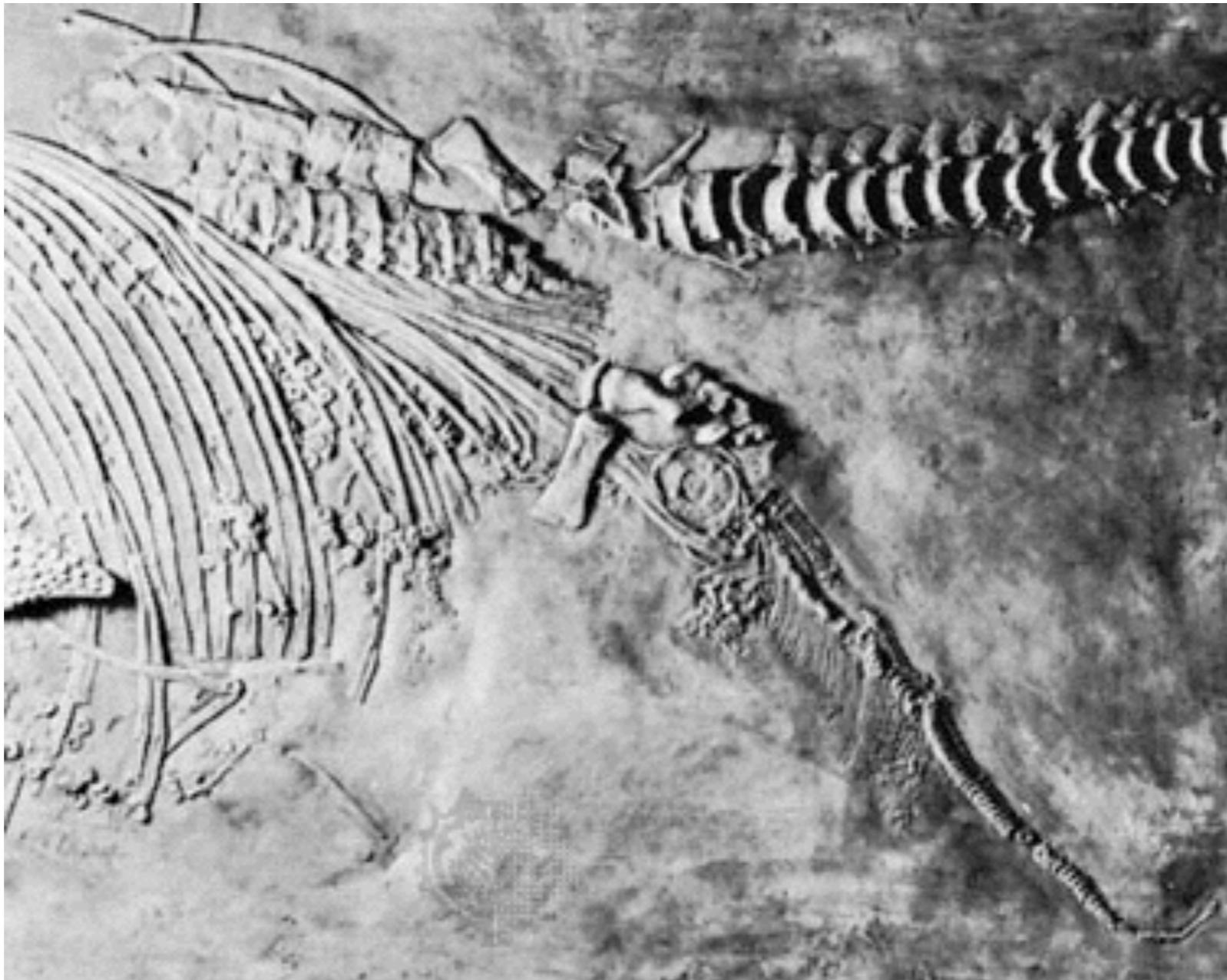
- Largest eyes of any animal
- Eyes are sized by measuring the sclerotic rings
- Large eyes are needed for hunting prey at great depths~ probably similar to elephant seals and sperm whales



Ichthyosaur Reproduction

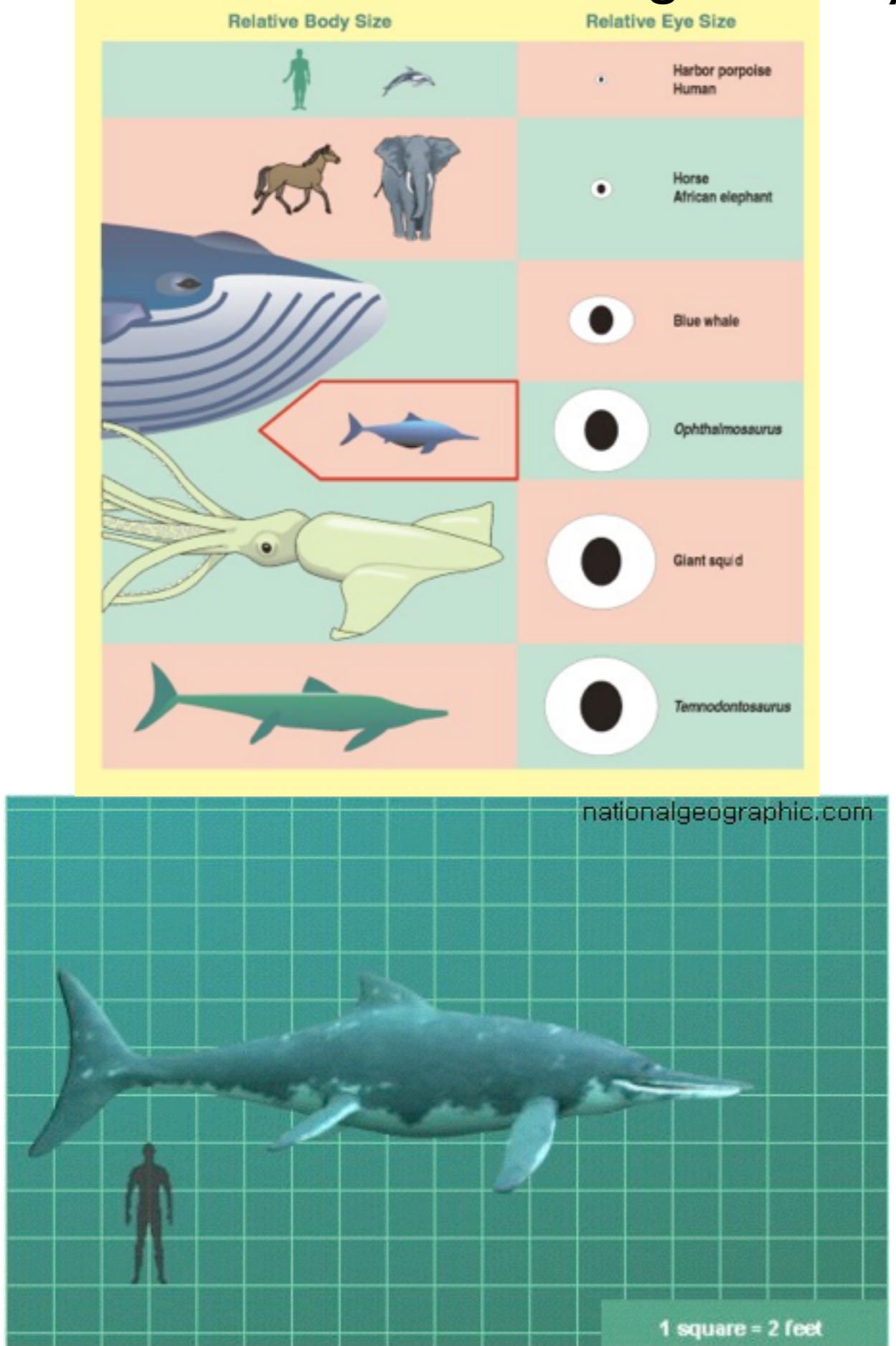
Although they evolved from egg-laying ancestors, Ichthyosaurs were **Viviporous** (gave birth to live young)

A divorce from the mainland was inevitable, given their marine adaptations

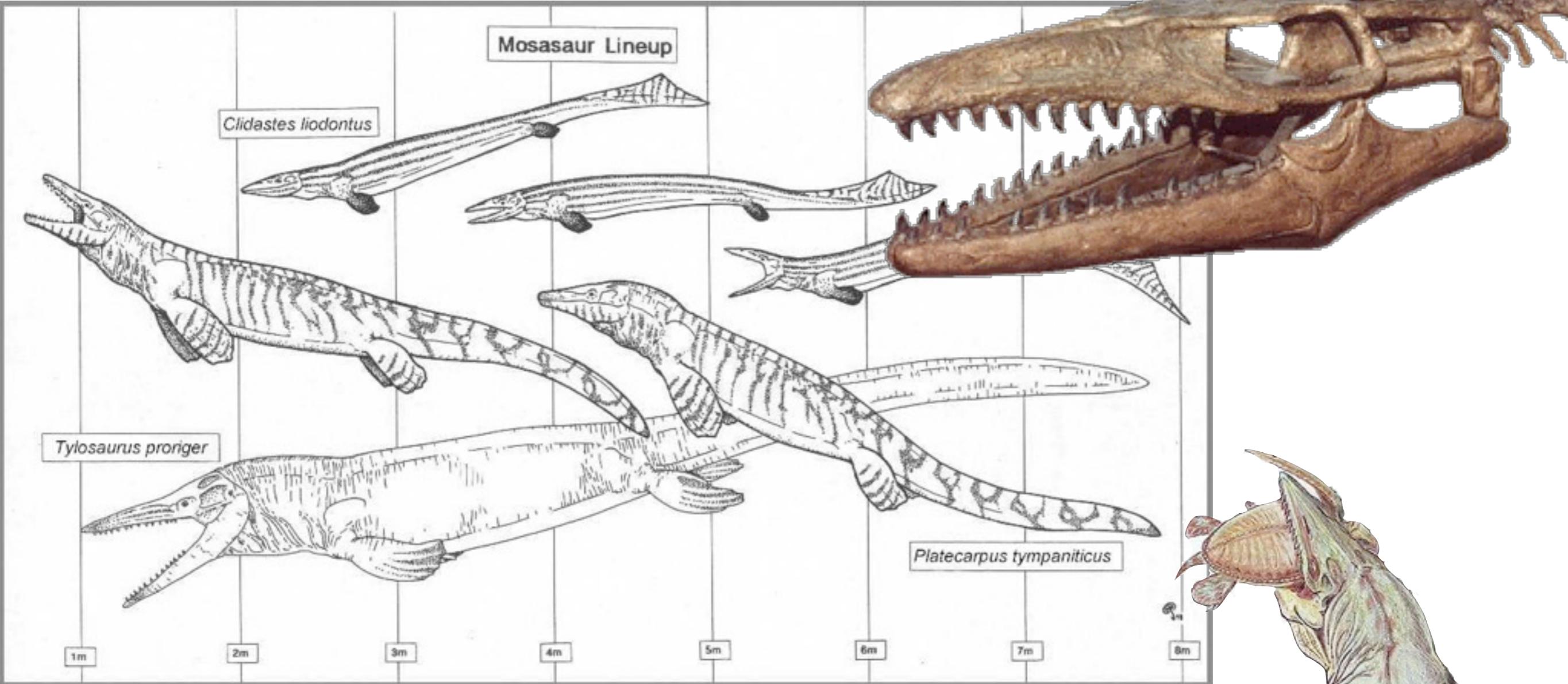


Young were born tail-first, similar to modern whales!

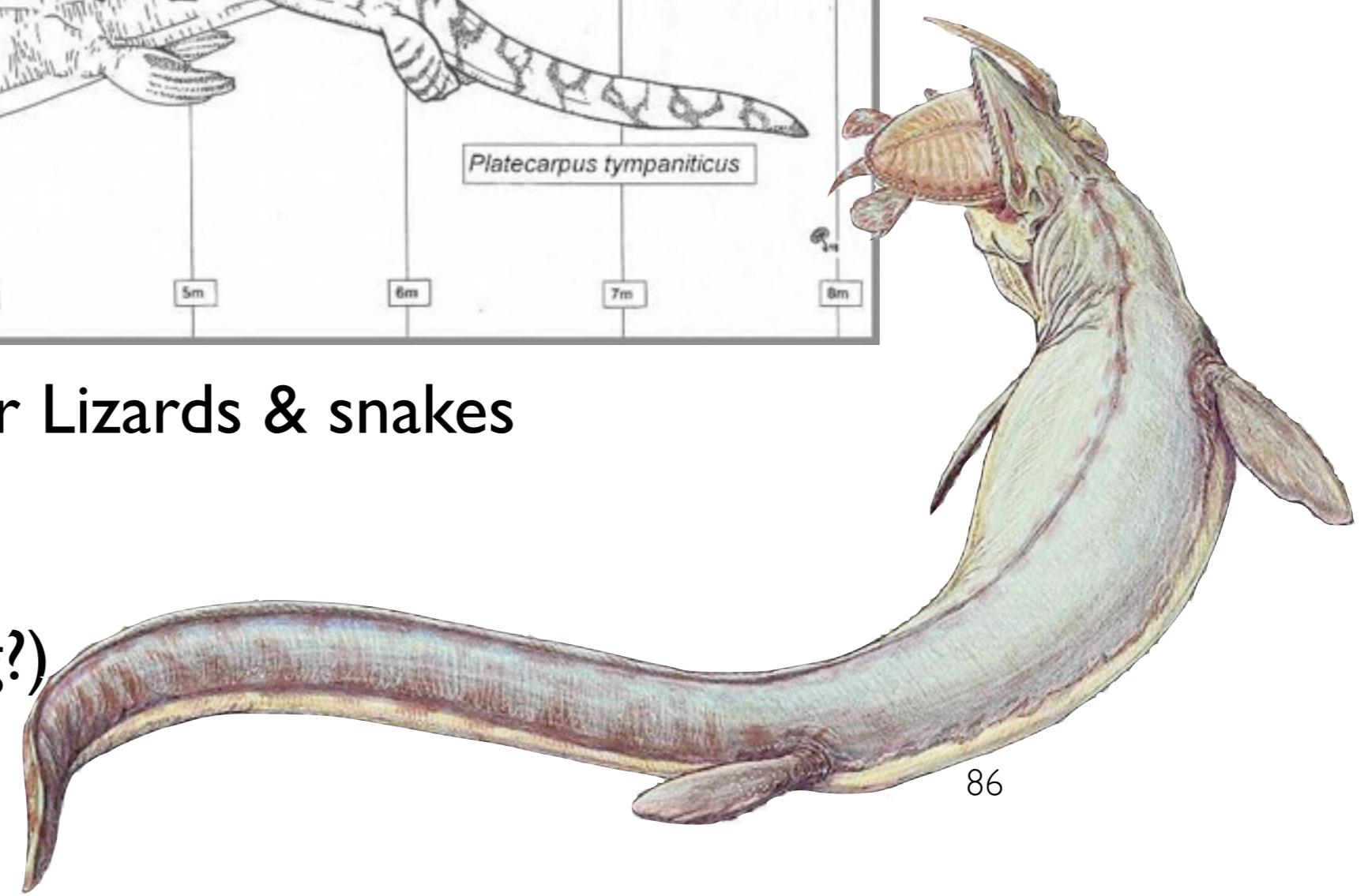
Temnodontosaurus: the largest Ichthyosaur



Mosasaur!



Closely related to Monitor Lizards & snakes
5 to 45 feet long
Long and slender
Blunt snouts (for ramming?)
Large eyes, stout teeth
APEX predator

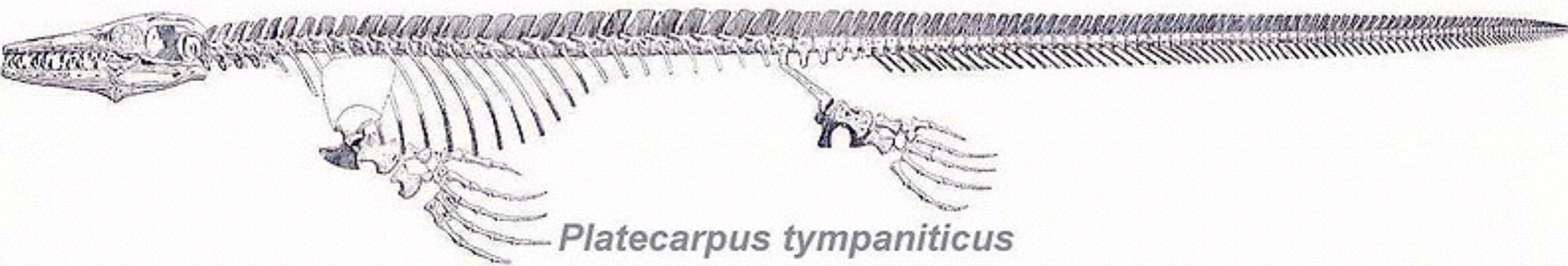


Mosasaurs!

Early to late Cretaceous
Superseded Ichthyosaurs and Pliosaurs as the
dominant Apex Predators



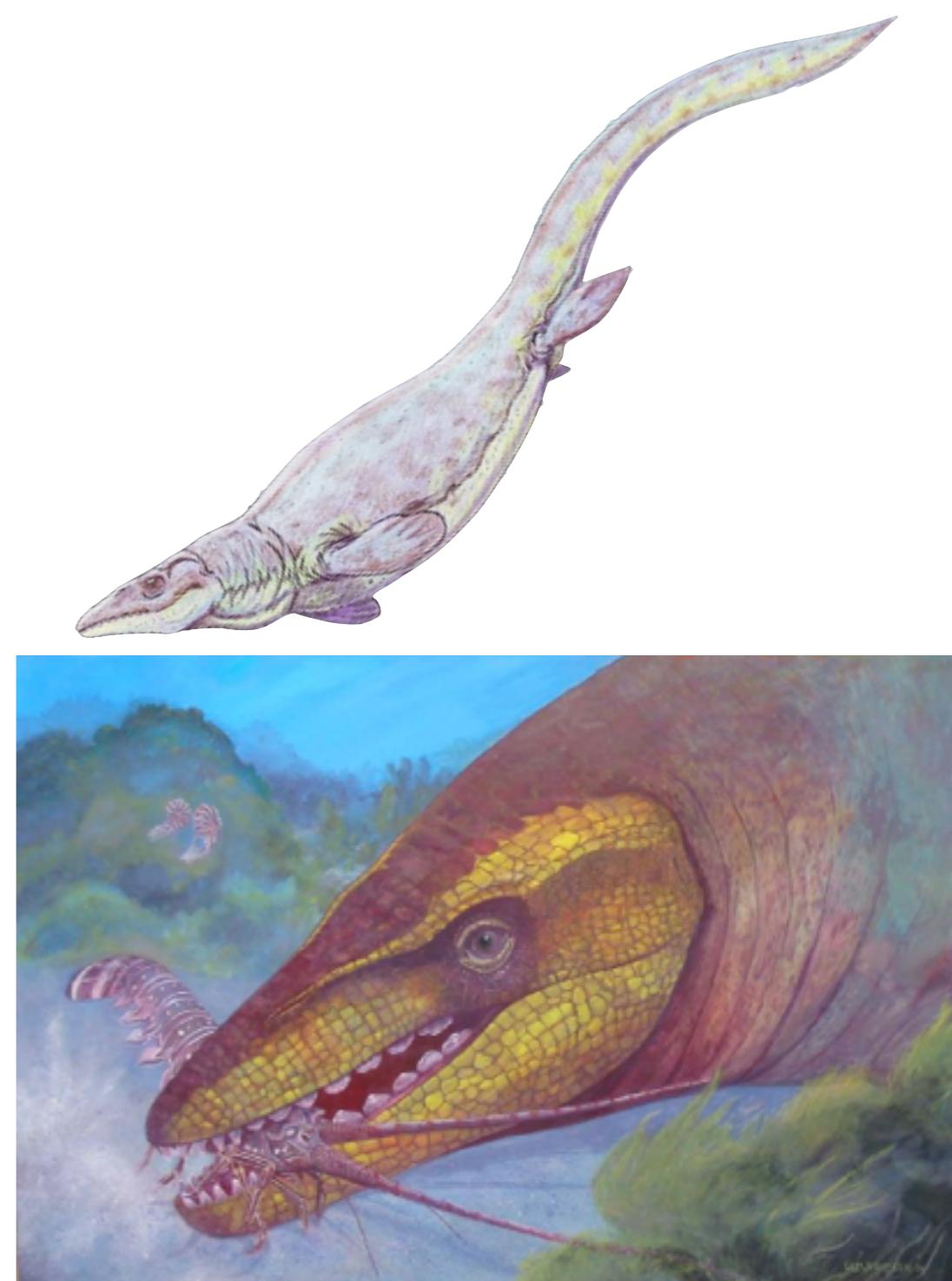
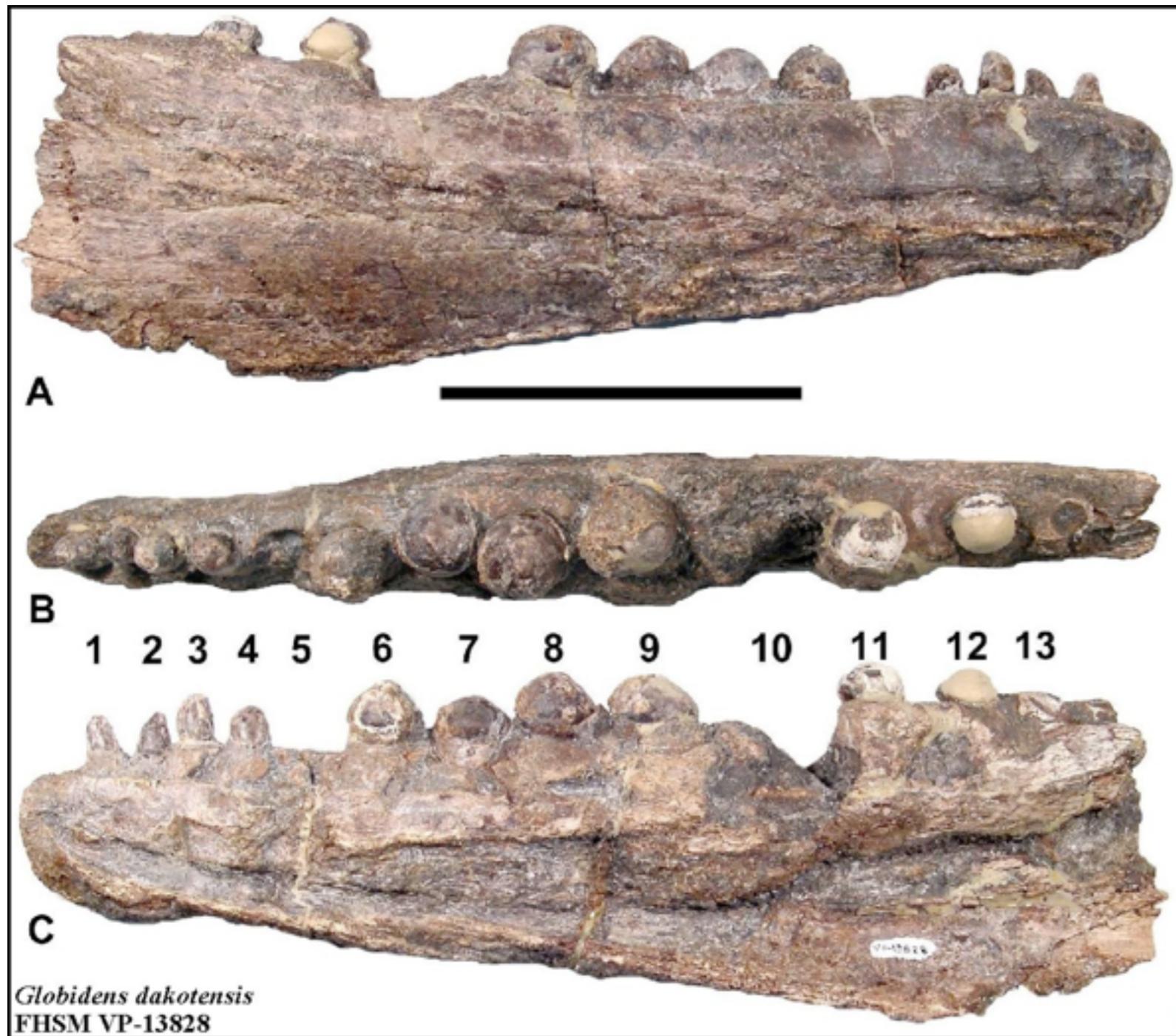
Clidastes propython



Platecarpus tympaniticus



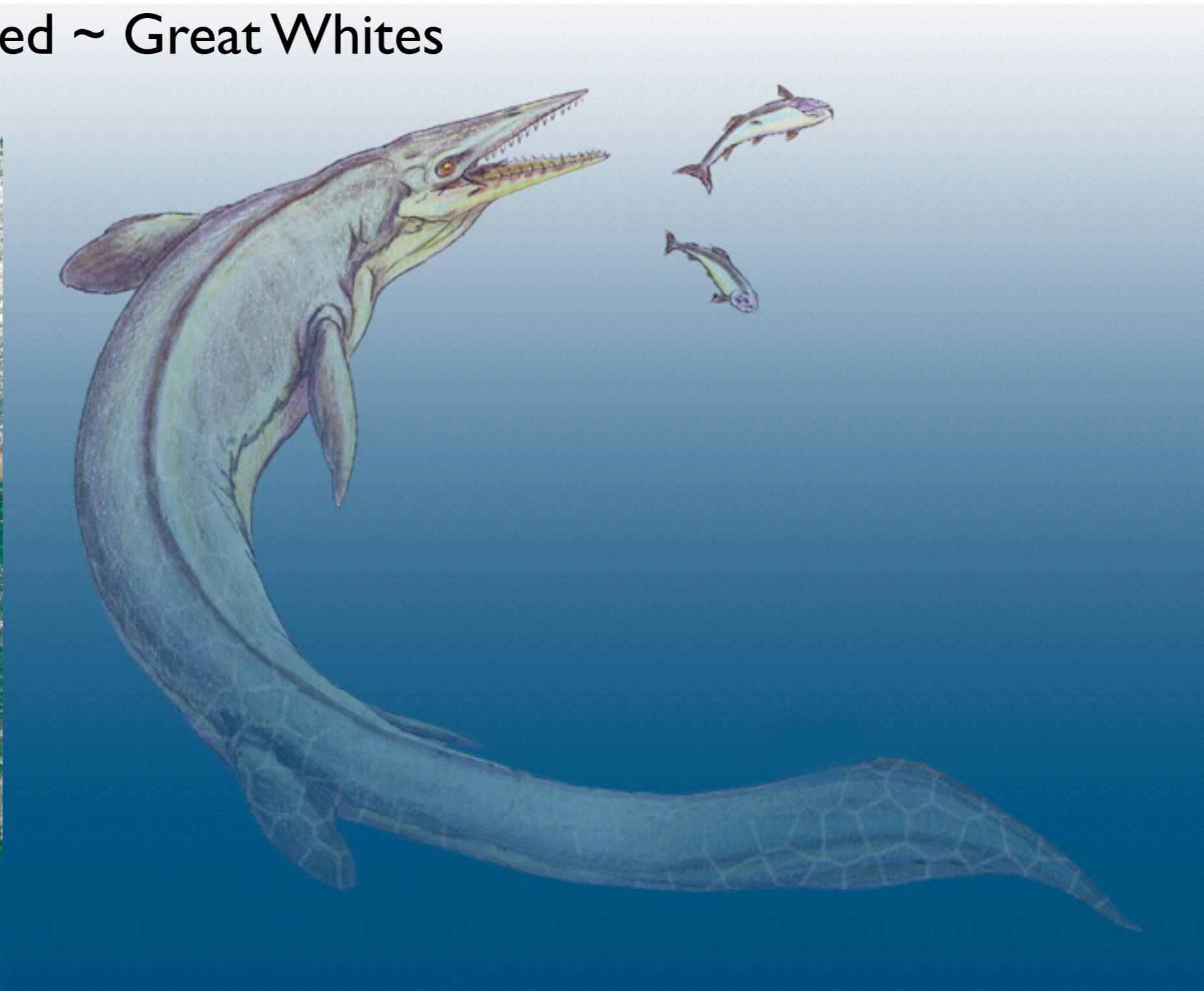
Tylosaurus proriger



Carinodens & *Globidens*: smallest, earliest mosasaurs (11 ft)
 Likely ate mollusks, small to medium arthropods
 ~ Shell crackers (blunt teeth)

Mosasaurs!

It's body plan suggests that it stalked prey, attacking in short, powerful bursts of speed ~ Great Whites

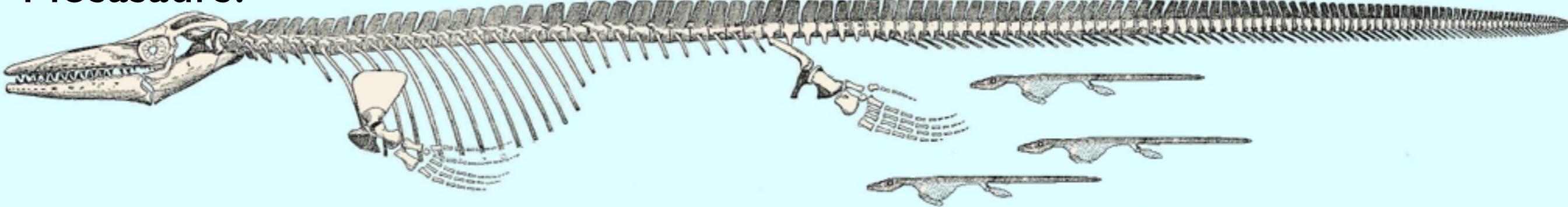


Mosasaurs!



Sitting in a 3.8-metre sea kayak and watching a four-metre great white approach you is a fairly tense experience

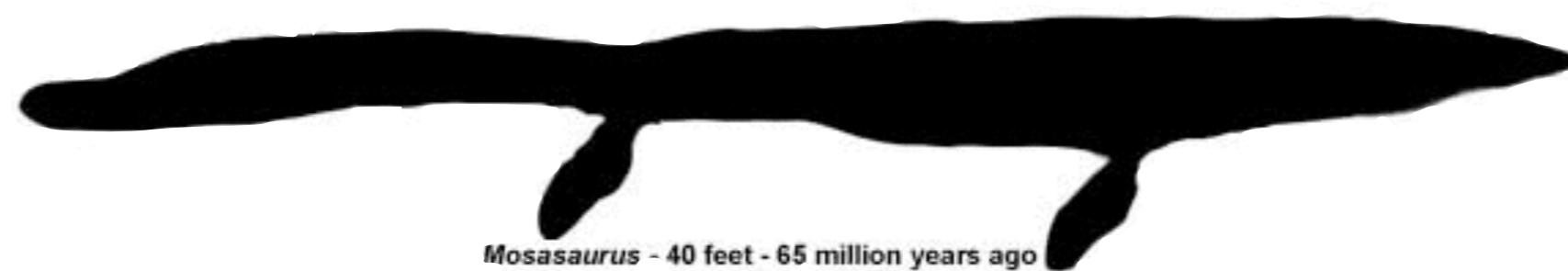
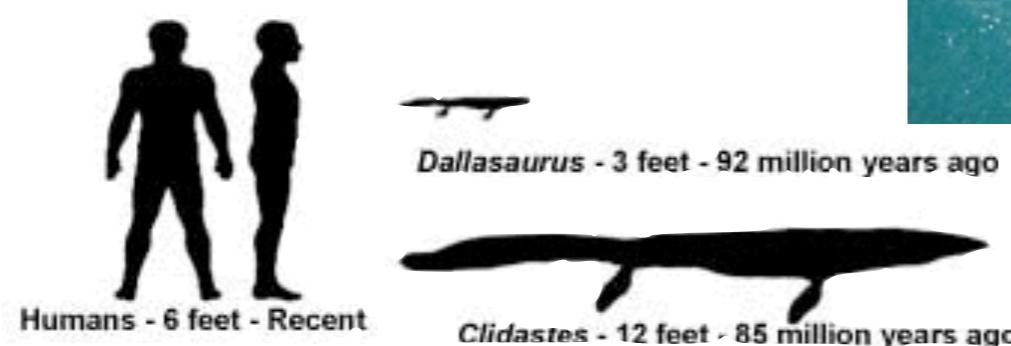
Mosasaur!



Derived Mosasaurs had double-hinged jaws ~ allowed them to swallow prey whole

Mosasaur have been found with large sharks in their 'stomachs'

Covered in overlapping scales; keeled scales on the upper body and smooth scales on the lower body



Mosasaurs!

