

7	<b>2/26</b>	Ornithopoda II	Dinosaur behavioral ecology	
	<b>2/28</b>	Sauropods	Carnivorous ancestors to gentle giants	Fastovsky Part 3 & Chpt 8
<b>S7</b>		<b>Sauropods</b>	<b>X</b>	
8	<b>3/5</b>	Prepare for Exam II		
	<b>3/7</b>	Exam II	Good Luck!	
<b>S8</b>		<b>Film: Giants of Patagonia</b>		

7	<b>2/26</b>	Pachycephalosaurs	Fastovsky chapter 11	
	<b>2/28</b>	Ceratopsians	Fastovsky chapter 11	
<b>S7</b>		<b>Sauropods</b>		
8	<b>3/5</b>	Ornithopods	Fastovsky chapter 12	
	<b>3/7</b>	Exam II	Good Luck!	
<b>S8</b>		<b>Film: Giants of Patagonia</b>		

Ornithischia

Genosauria

Ceropoda

## Marginocephalia

Pachycephalosauria: ‘Thick Heads’

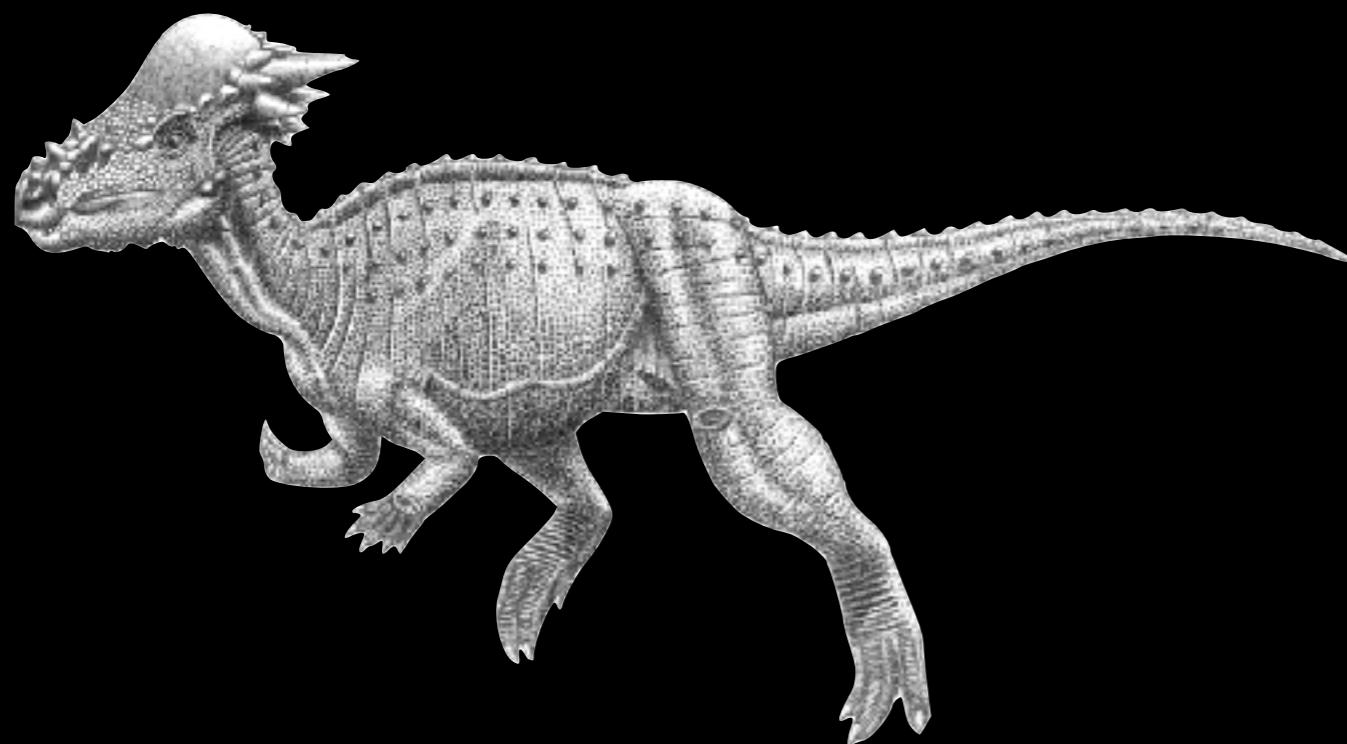
Ceratopsia: ‘Horn Face’

All marginocephalians bear a ridge, or shelf across the back of their skull

Many sizes and shapes

Cretaceous

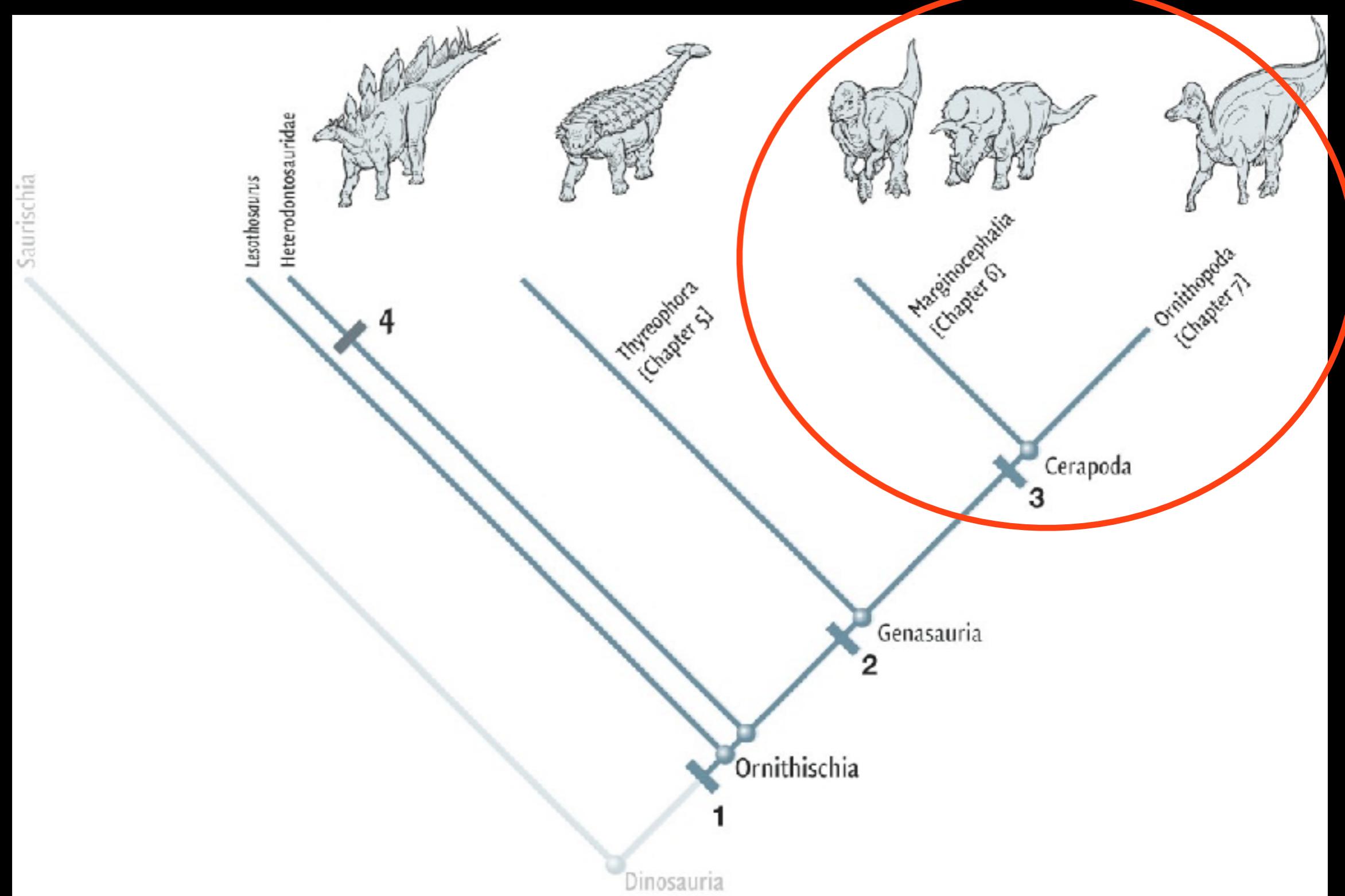
Northern Hemisphere



*Stygimoloch*



*Styracosaurus*



**Gap btw. premaxillary and maxillary teeth**  
**5 or less premaxillary teeth**  
**Finger-like anterior trochanter**

**Cerapoda:**



Ornithopoda



Ceratopsia

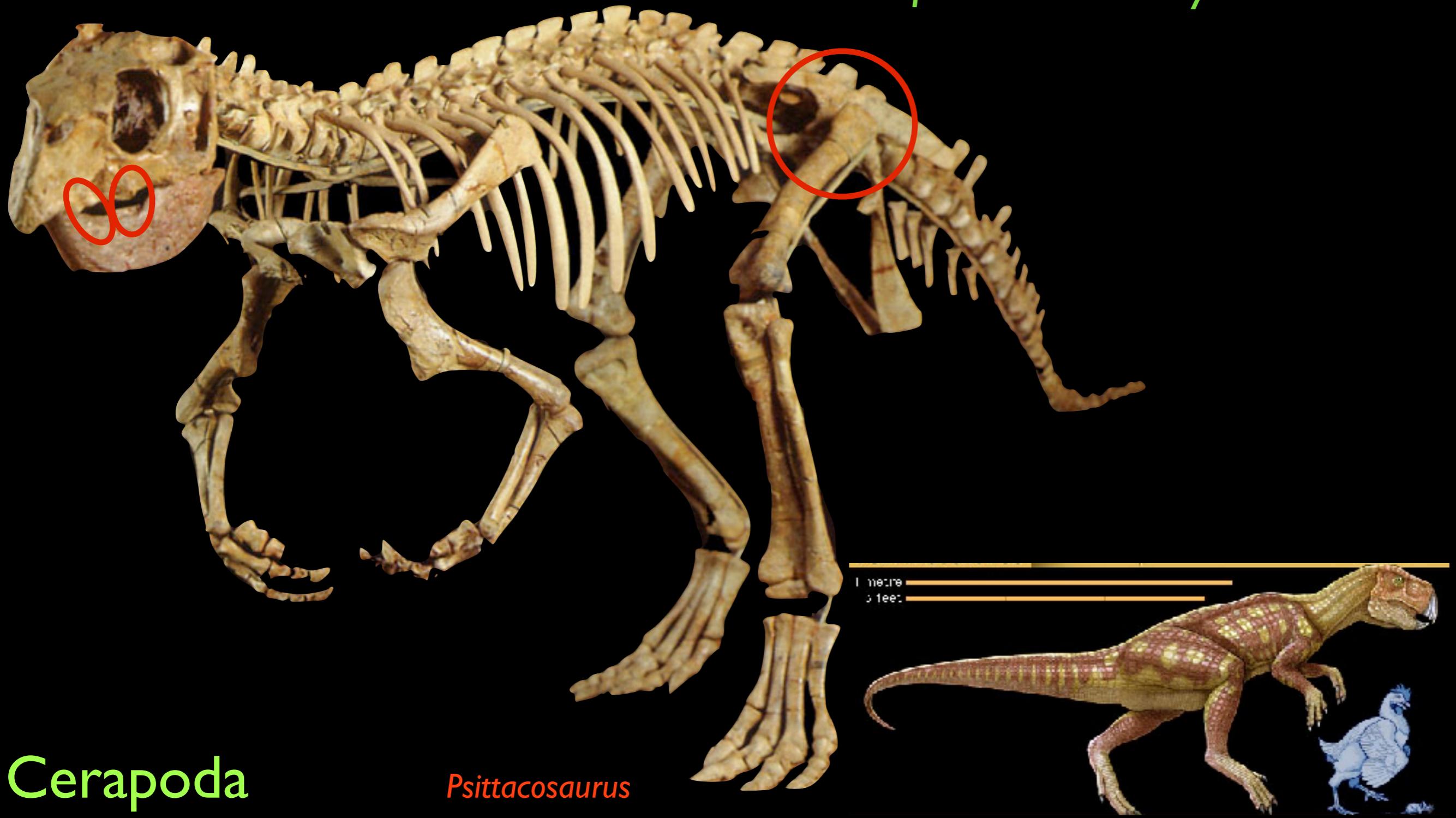


Pachycephalosauria

Marginocephalia

Cerapoda

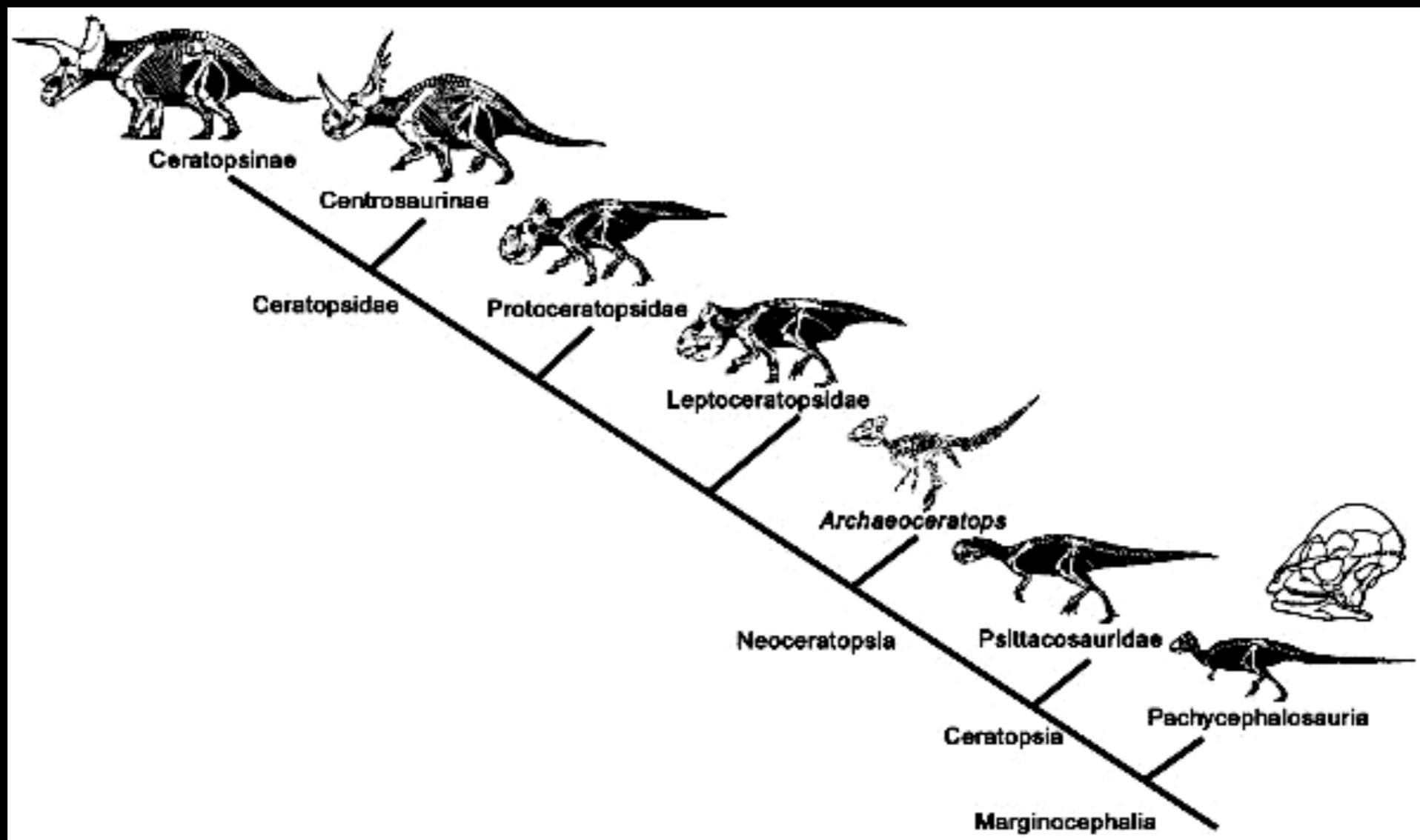
Shared, derived characteristics  
*Significant Diastem*  
*Widely spaced hip sockets*  
*5 or fewer maxillary teeth*





Shared, derived characteristics  
*Overhanging shelf, or MARGIN*  
*Short Pubis*

Marginocephalia



Ornithischia  
Genosauria  
Ceropoda  
Marginocephalia  
Pachycephalosauria

Shared, derived characteristics  
*Thickened skull roof*  
*Ornamentation of ext. skull*  
*Ridges/Grooves on vertebrae*  
*Ossified tendons at end of tail*

Primitive characteristics:

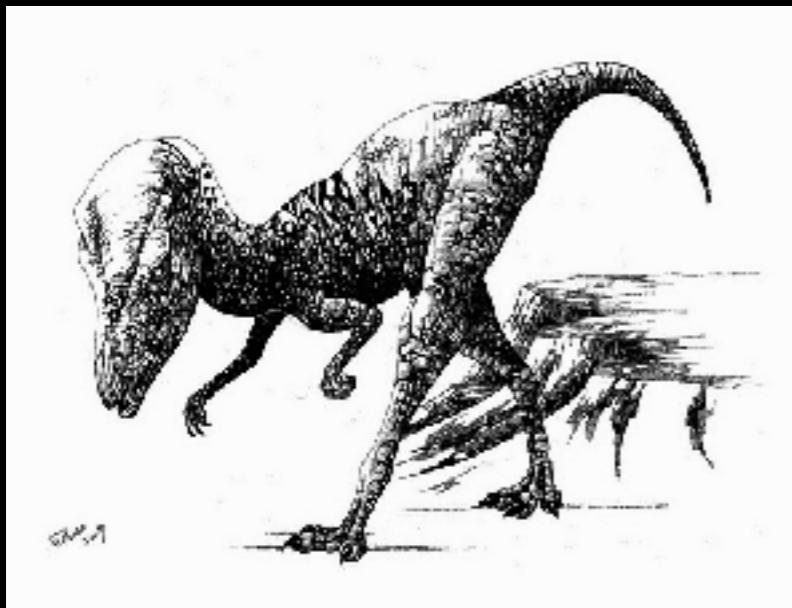
*Pronounced diastem*  
*Expanded skull Margin*



Stegoceras

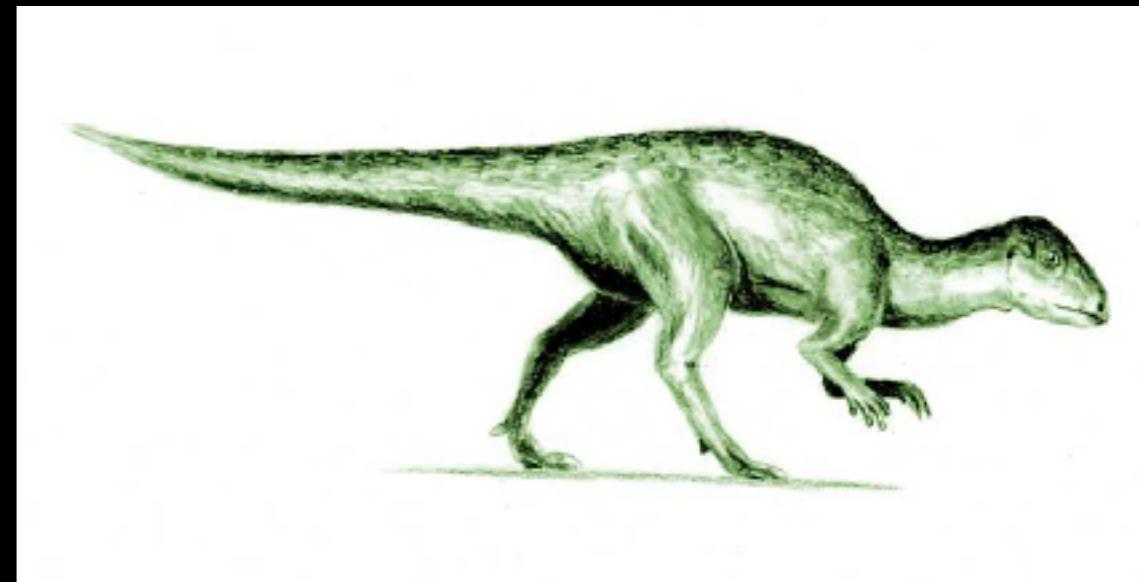
# Primitive Pachycephalosaurs

*Yaverlandia?*      *Stenopelix*



*Yaverlandia*

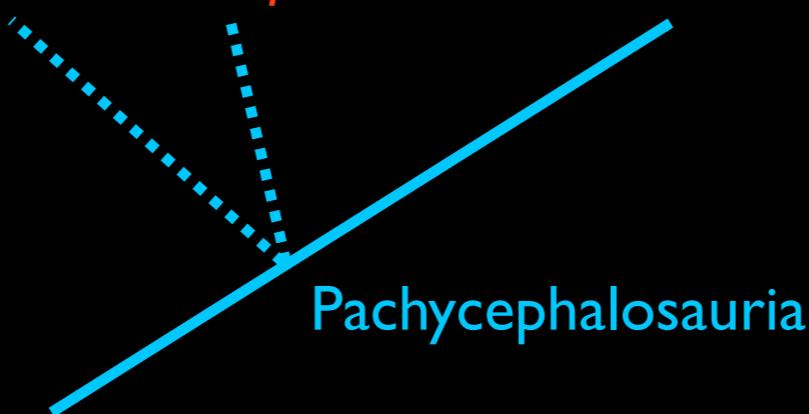
Early Cretaceous  
Partial skull



*Stenopelix*

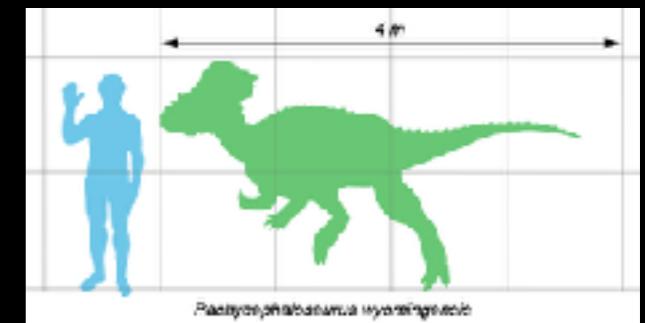
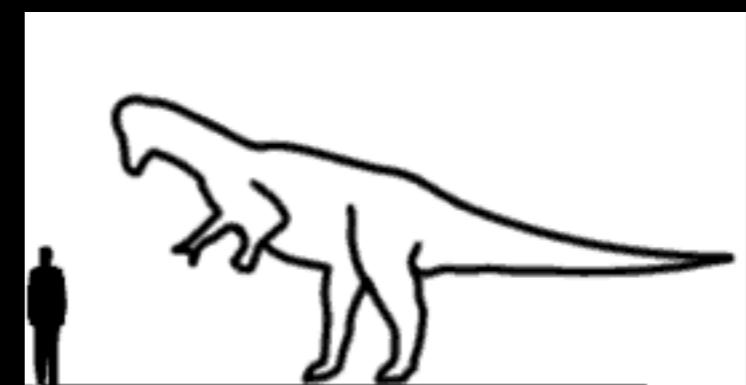
Early Cretaceous  
Lacked skull  
Doubt regarding it's classification

*Yaverlandia*      *Stenopelix*



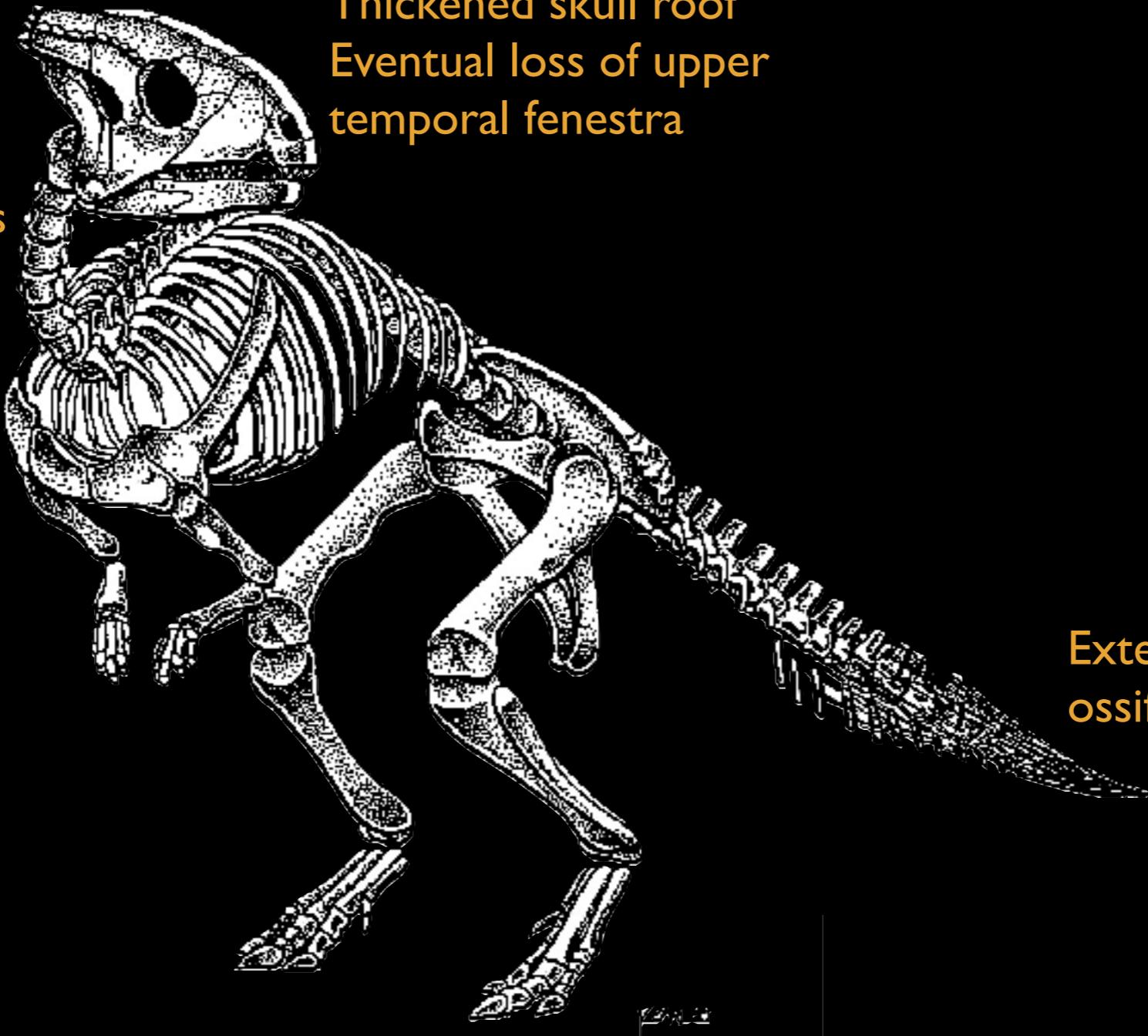
# Derived Pachycephalosaurs

## *Pachycephalosaurus*



# Derived Pachycephalosaurs

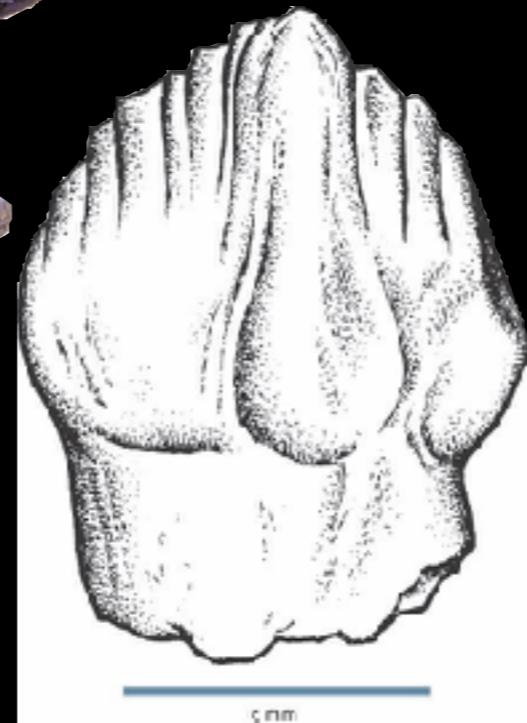
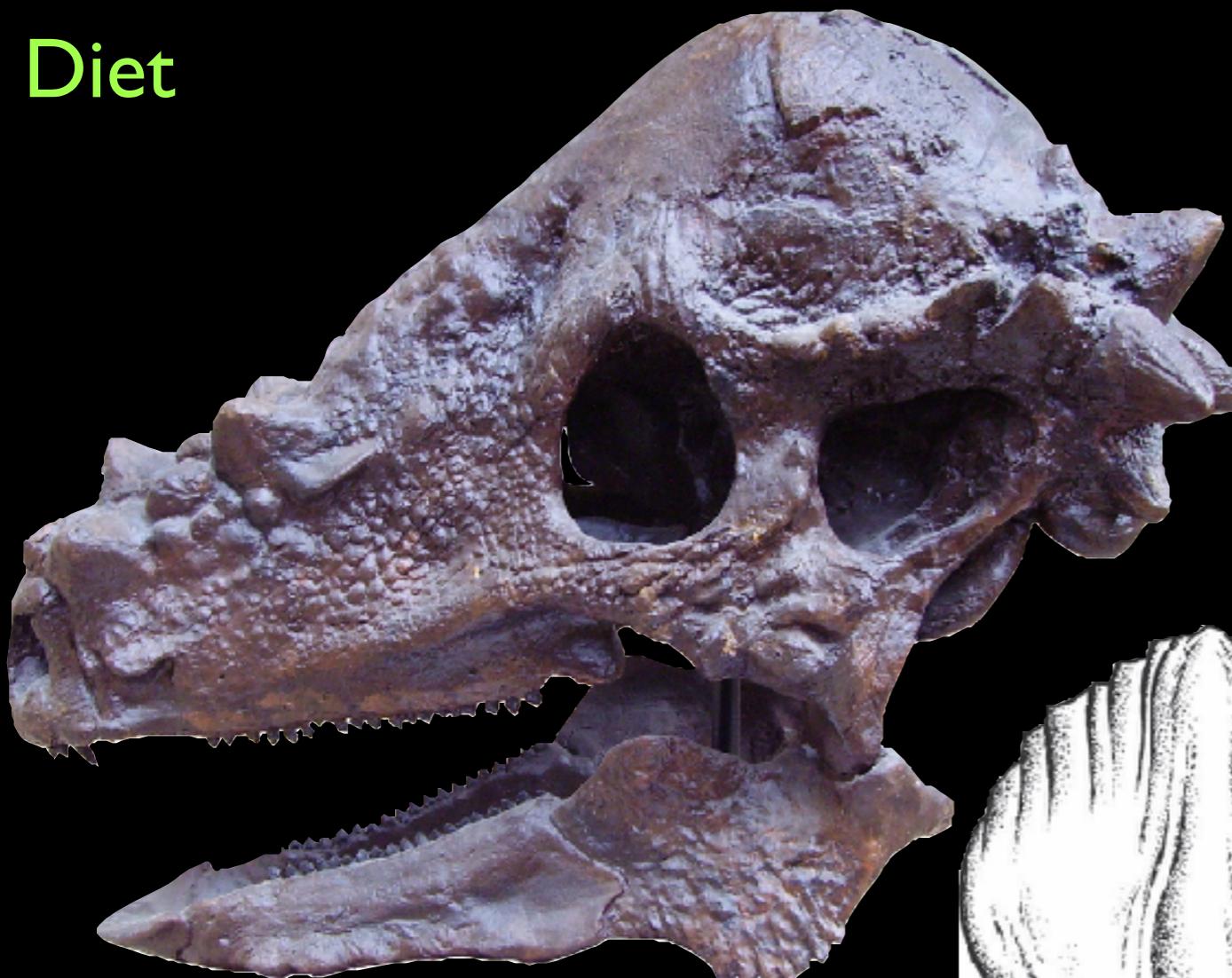
Expanded cheek bones



Thickened skull roof  
Eventual loss of upper  
temporal fenestra

Extensive network of  
ossified tendons

# Diet

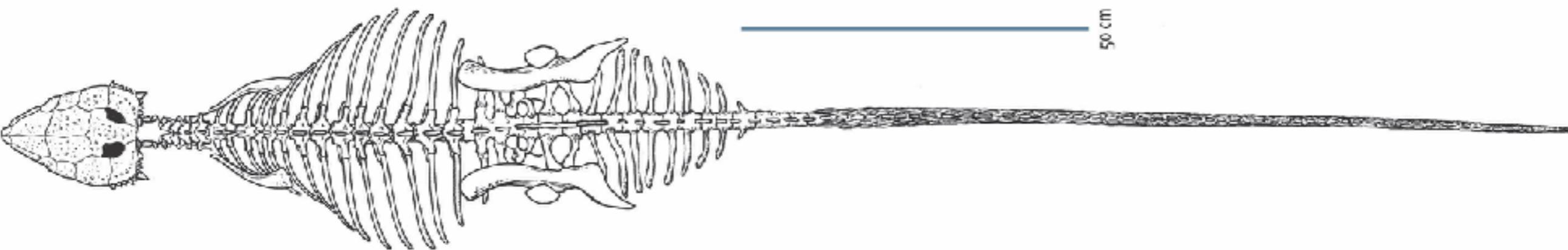


Typical Ornithischian teeth: herbivore  
Front jaws: peg-like gripping teeth surrounded by small beak  
Small, canine-type teeth in front  
Diastem is emphasized  
Cheek teeth uniformly shaped

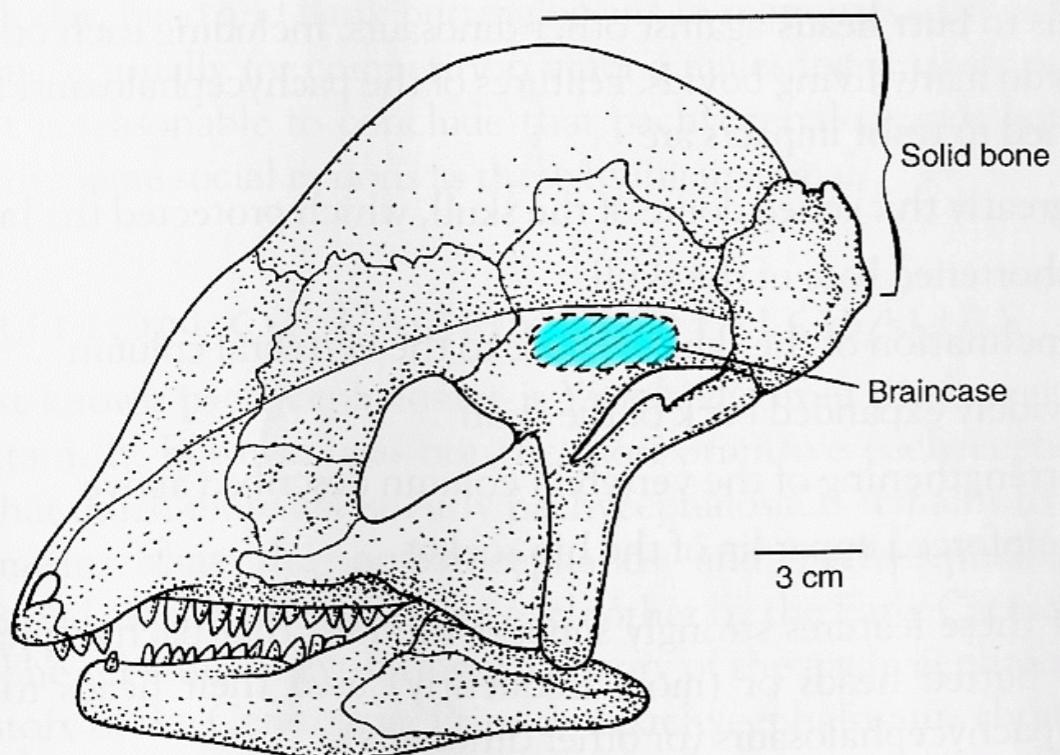
BROAD rib cage  
Extended to base of tail  
Indicates that the digestive organs were positioned around the hind legs  
Food digested less by chewing, more by fermentation (similar to Thyreophorans)



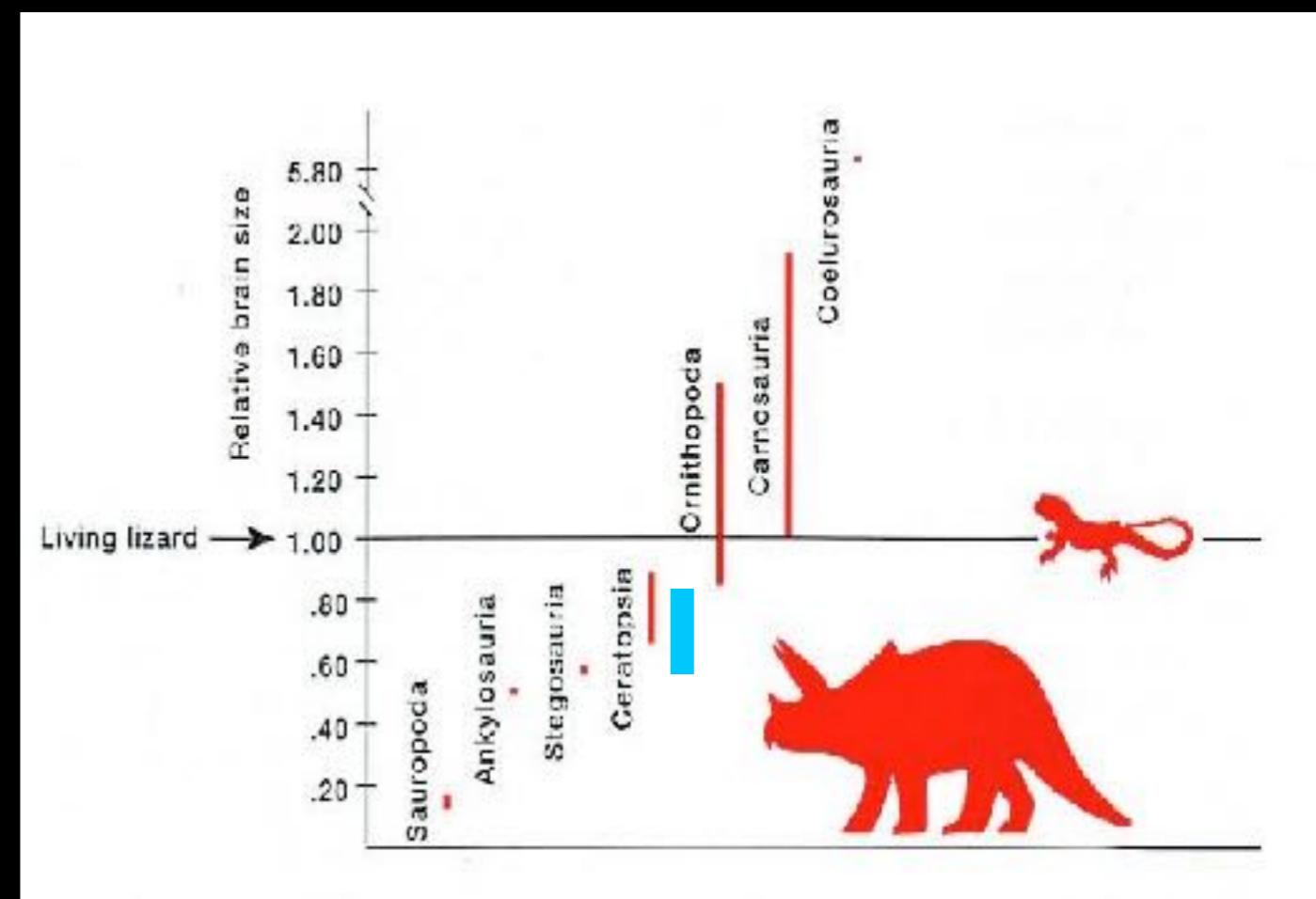
*Homalocephale*

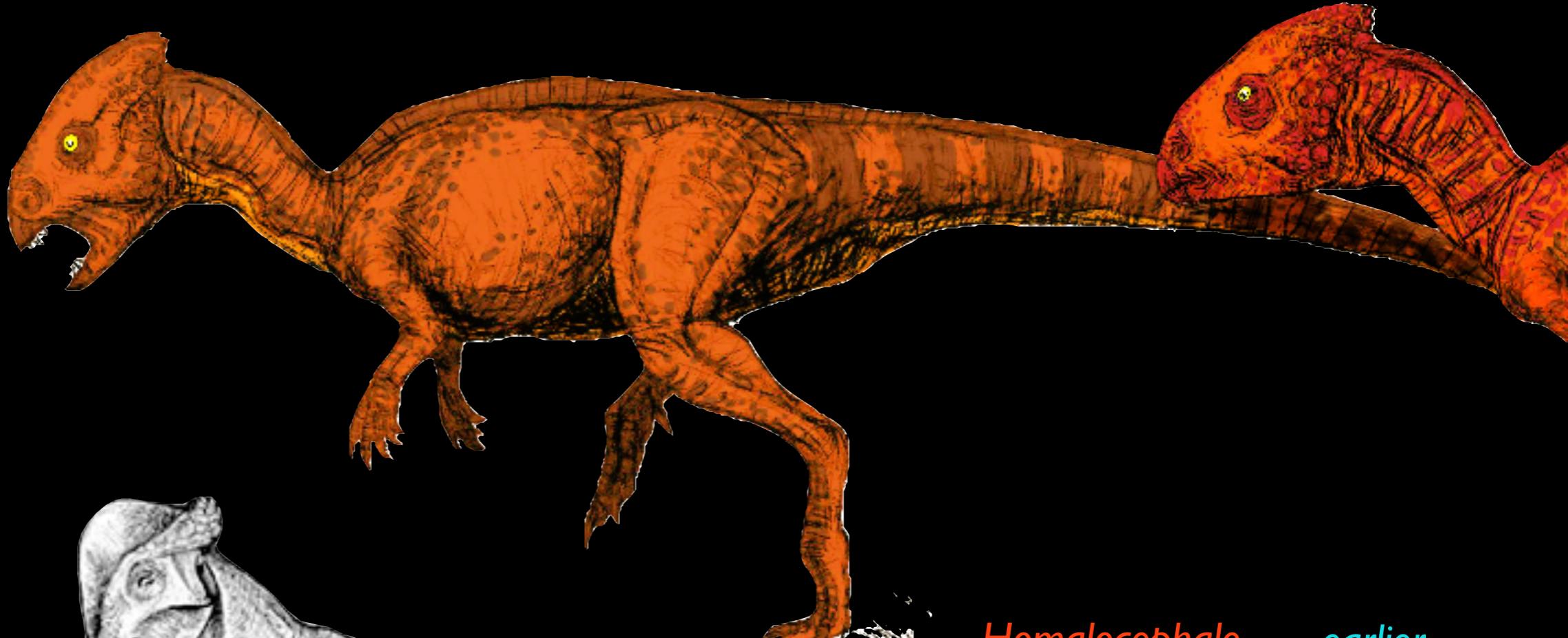


# Brain Size



*Moderate/small braincase  
Enlarged Olfactory Lobes  
Large groove indicating thick optic nerve  
Indicates good eyesight*





*Stegoceras*

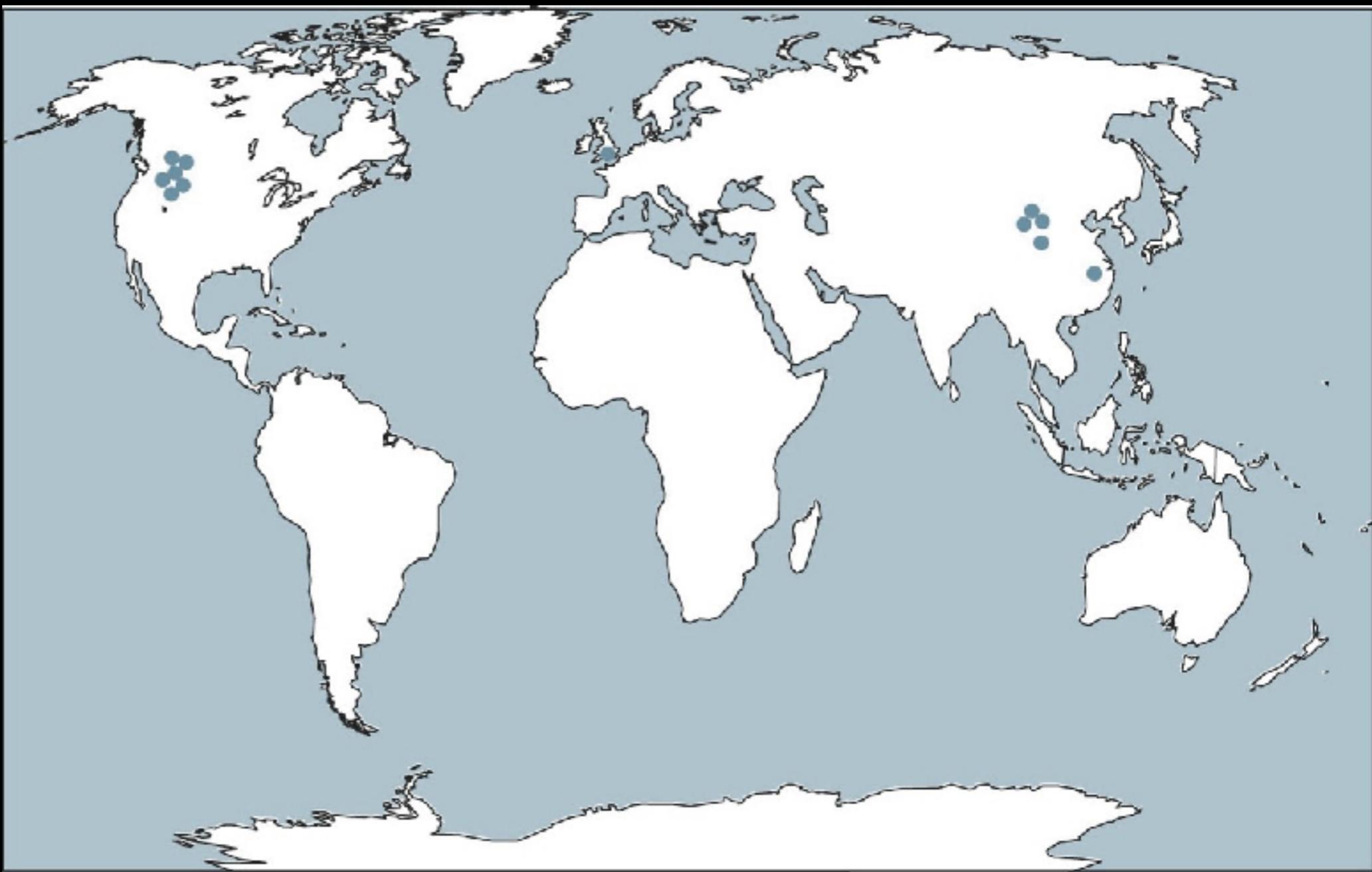
*Homalocephale*

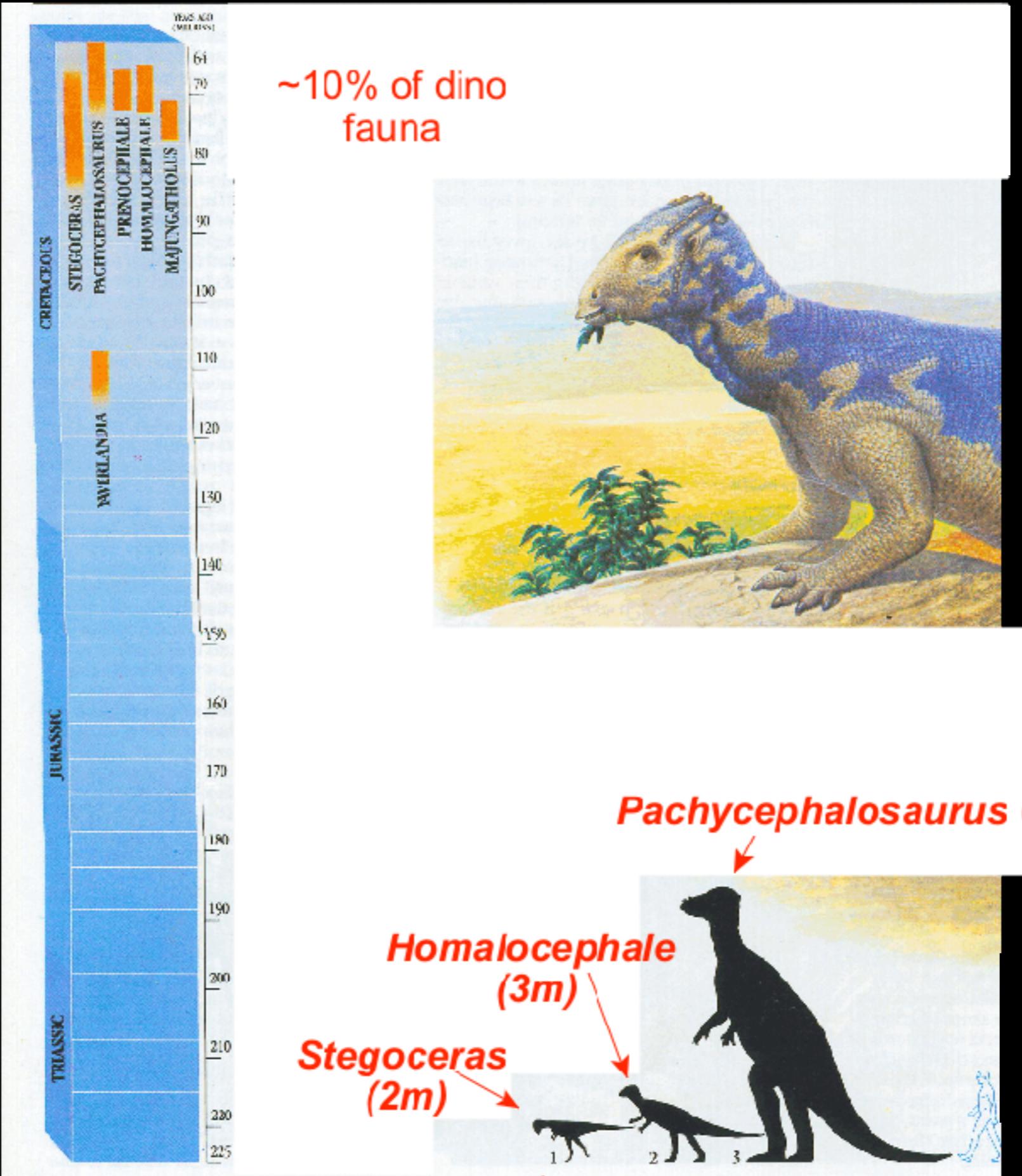
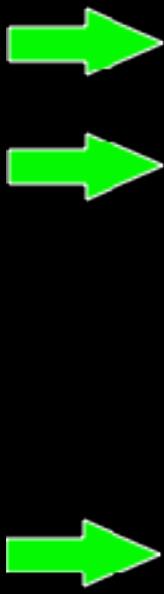
earlier  
'flat'

derived  
'round'

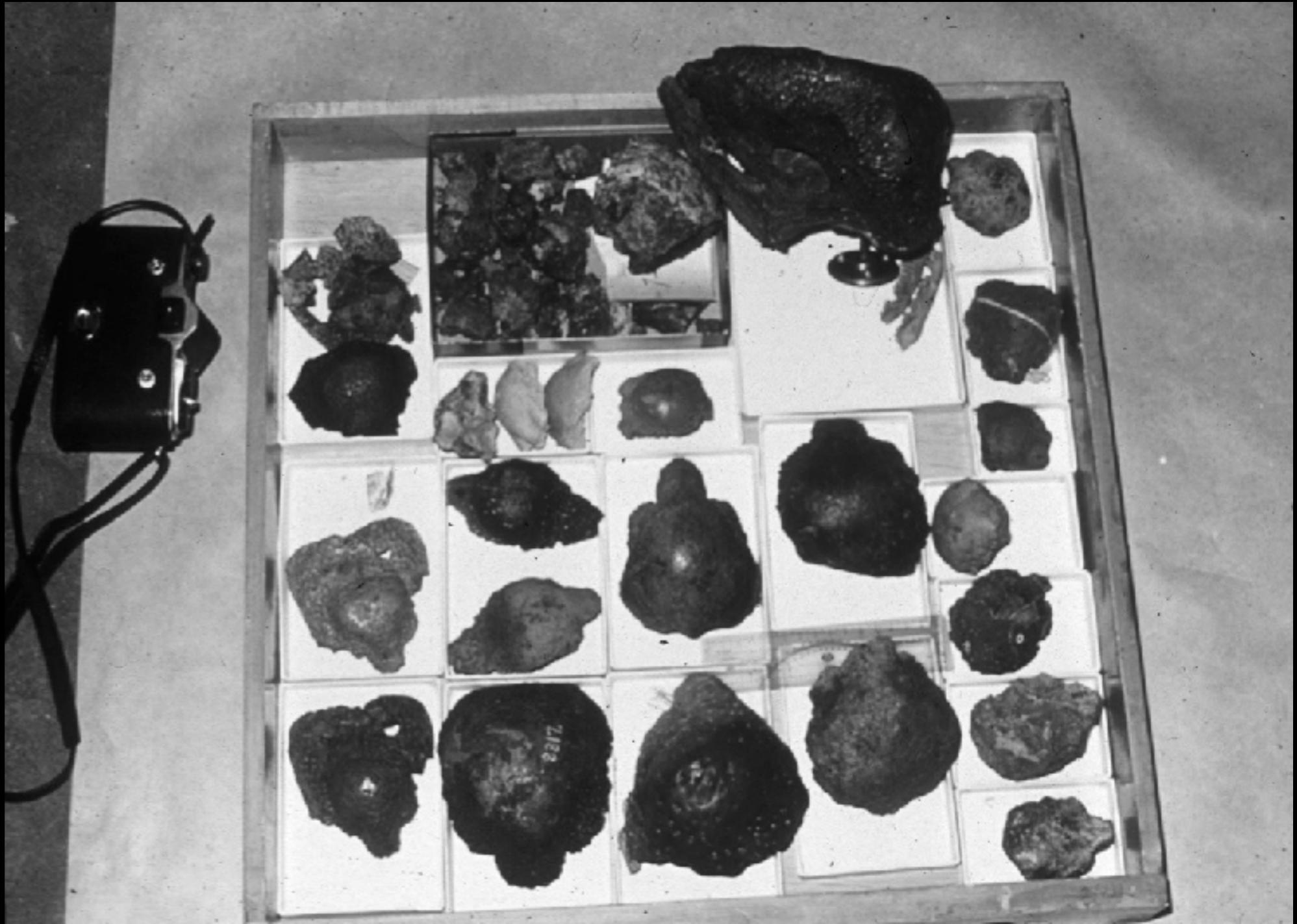


# Distribution in Space and Time



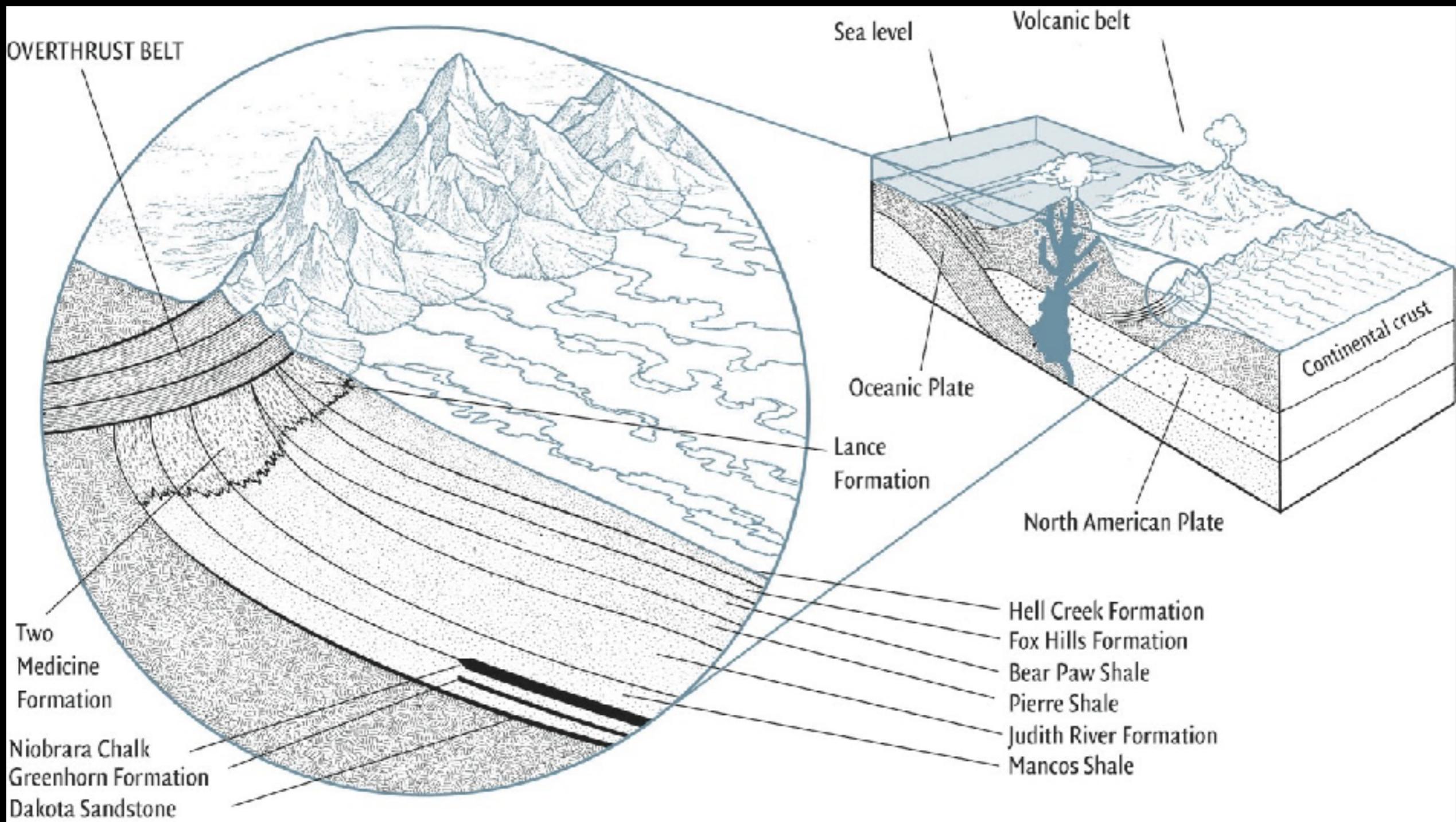


# Taphonomy

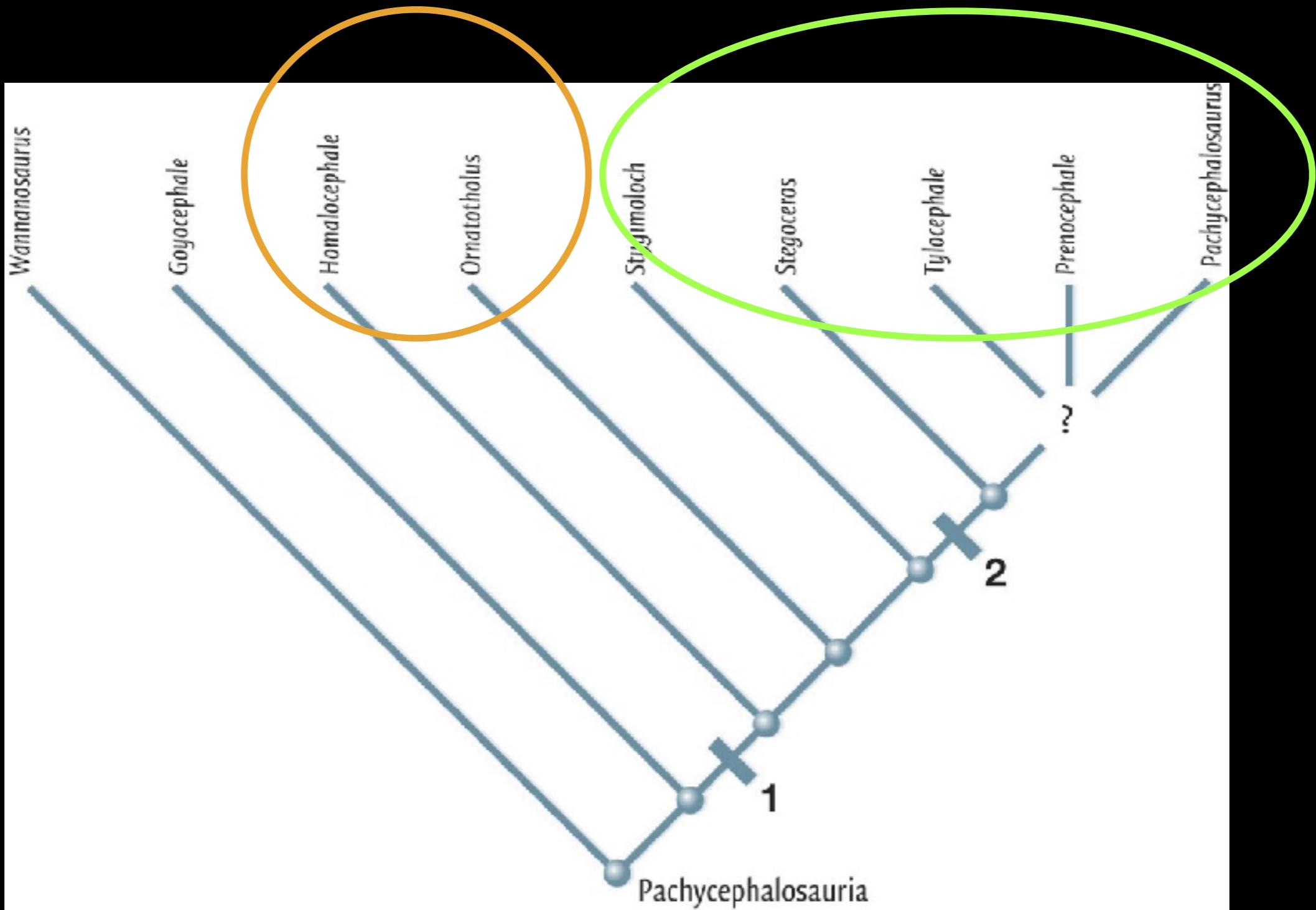


North America: Skull Caps  
Asia: Some skeletal remains: no complete!

# Taphonomy



Why are there no skeletal remains other than skull caps found in North America? *Allochthonous*



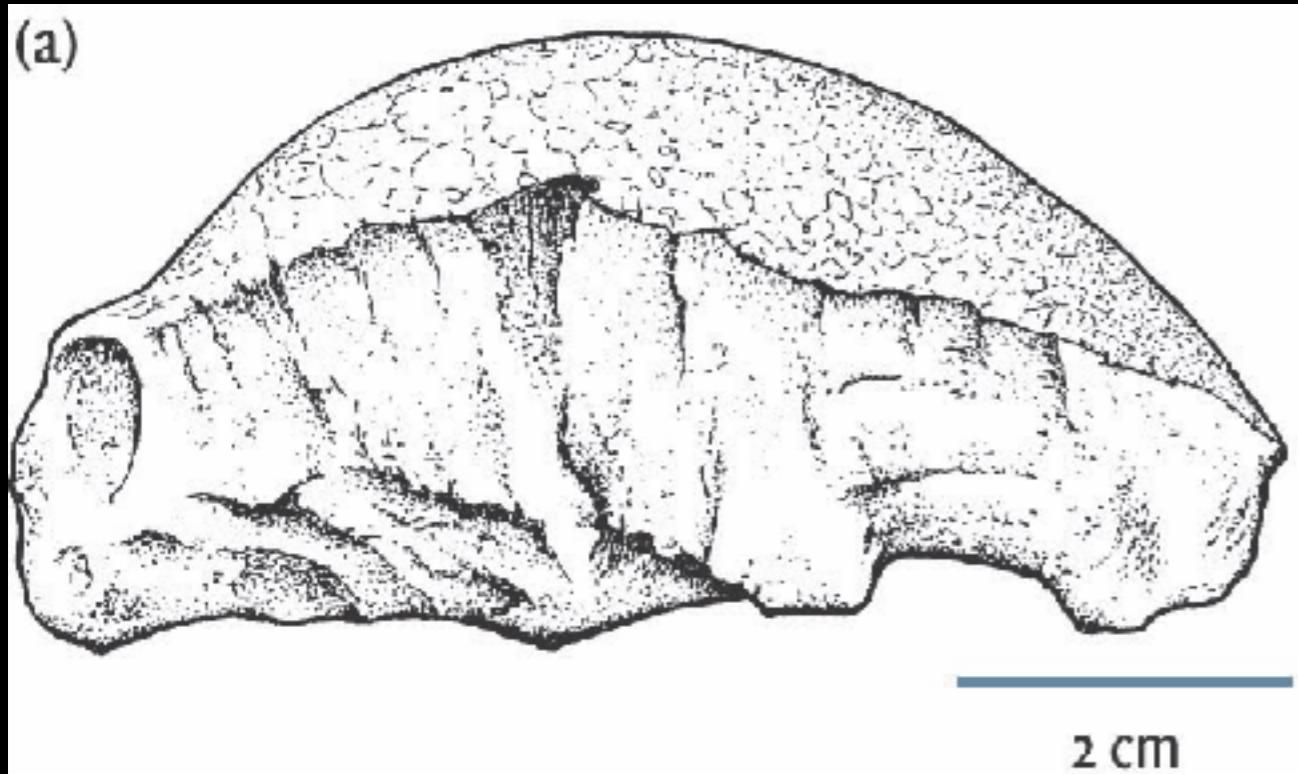
## Flat Heads

Basal Homalocephaloids  
2 temporal fenestrae  
Asia  
Up to 1.5 m long

## Fat Heads

Pachycephalosaurids  
1 temporal fenestra  
Asia & N.America  
Up to 8 m long

# A Battering Ram?



Pachycephalosaurs: Bone Cap

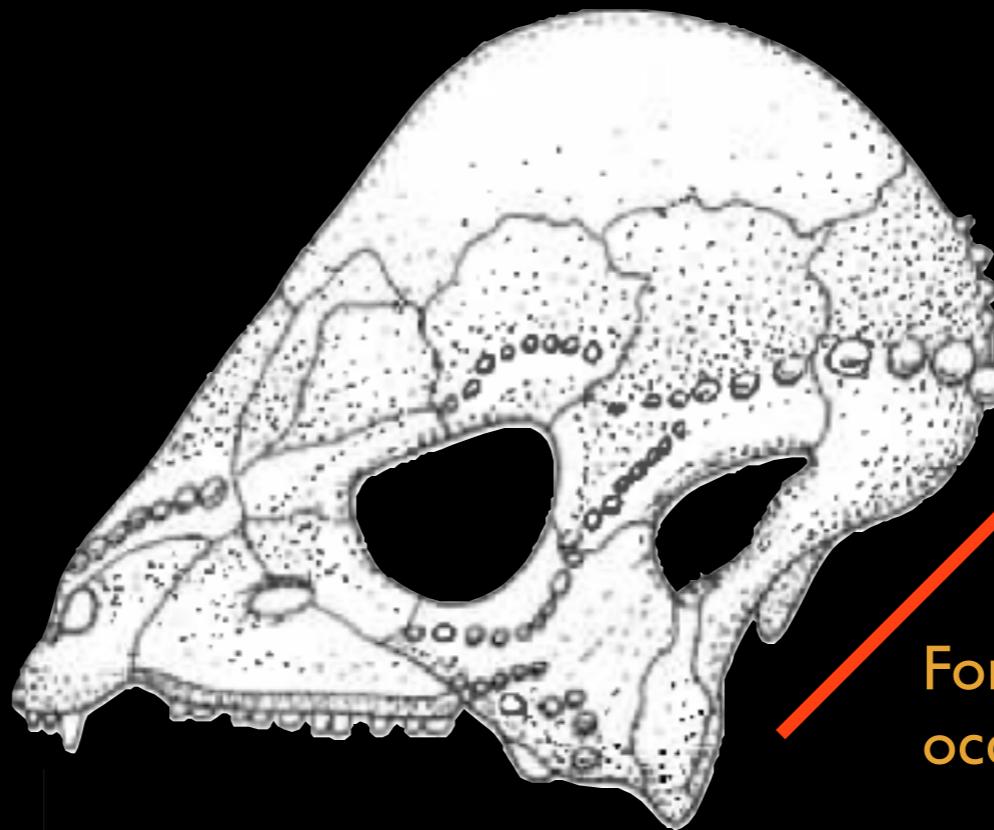
Up to 9 inches of bone

Composed of two primary bones; FRONTAL, PARIETAL

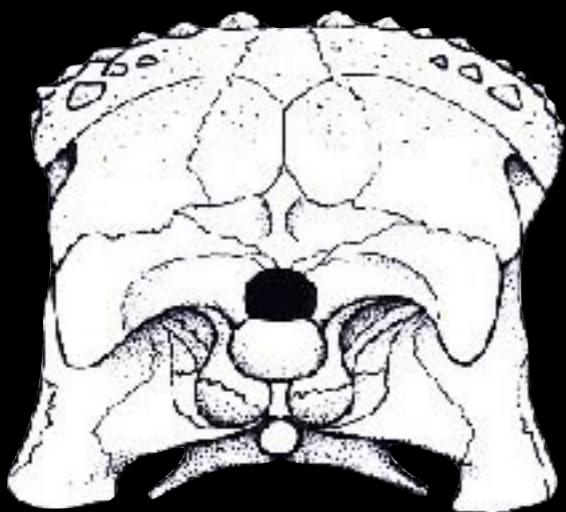
Adjacent bones often form prominent tubercles



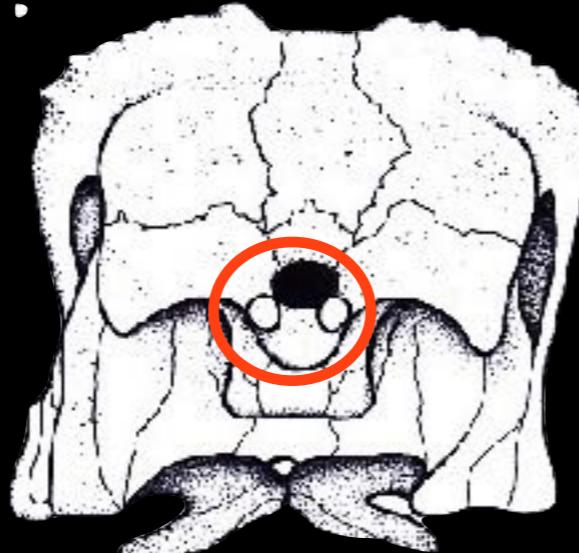
# A Battering Ram?



Forward rotation of  
occipital region



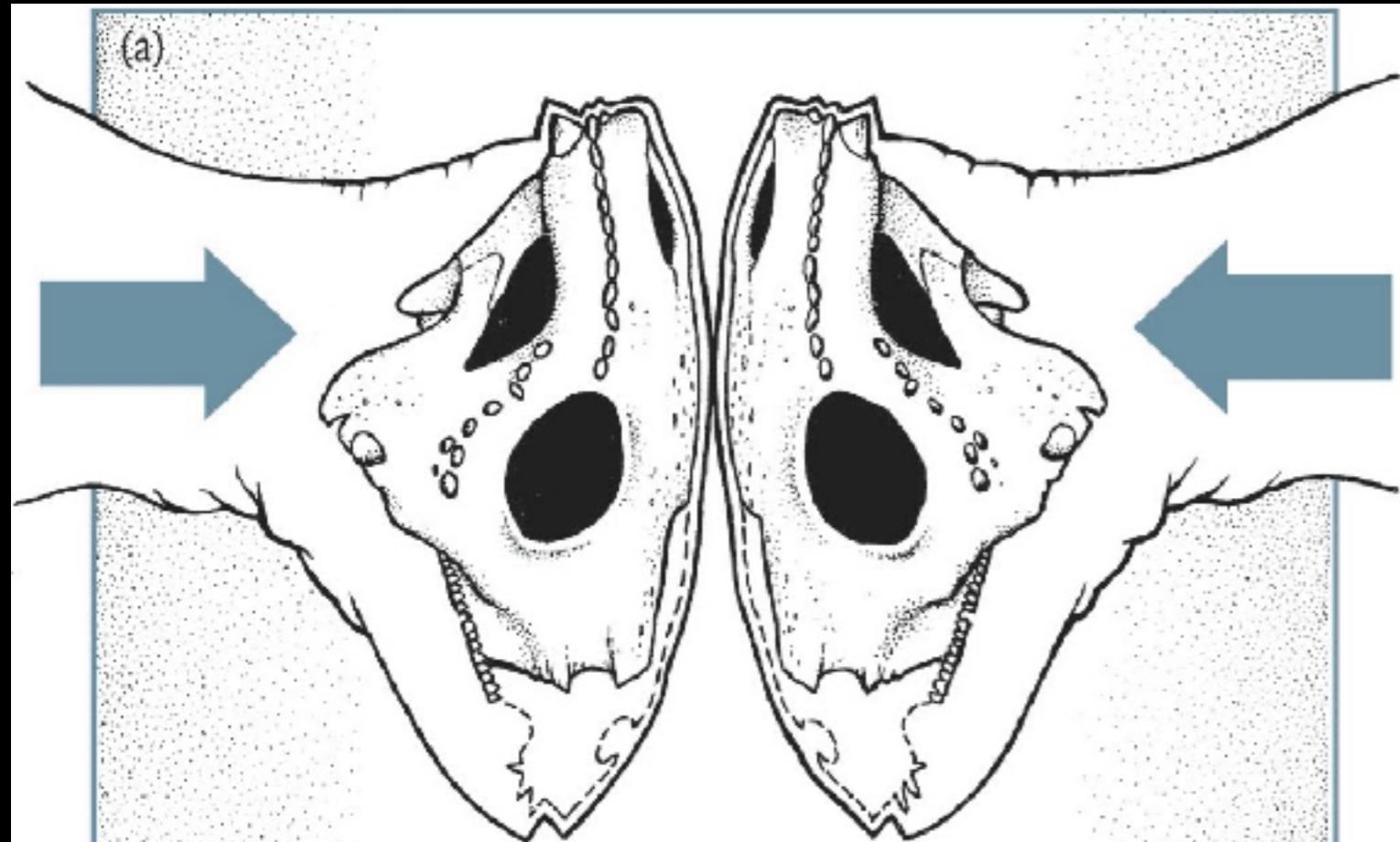
*Homalocephale*



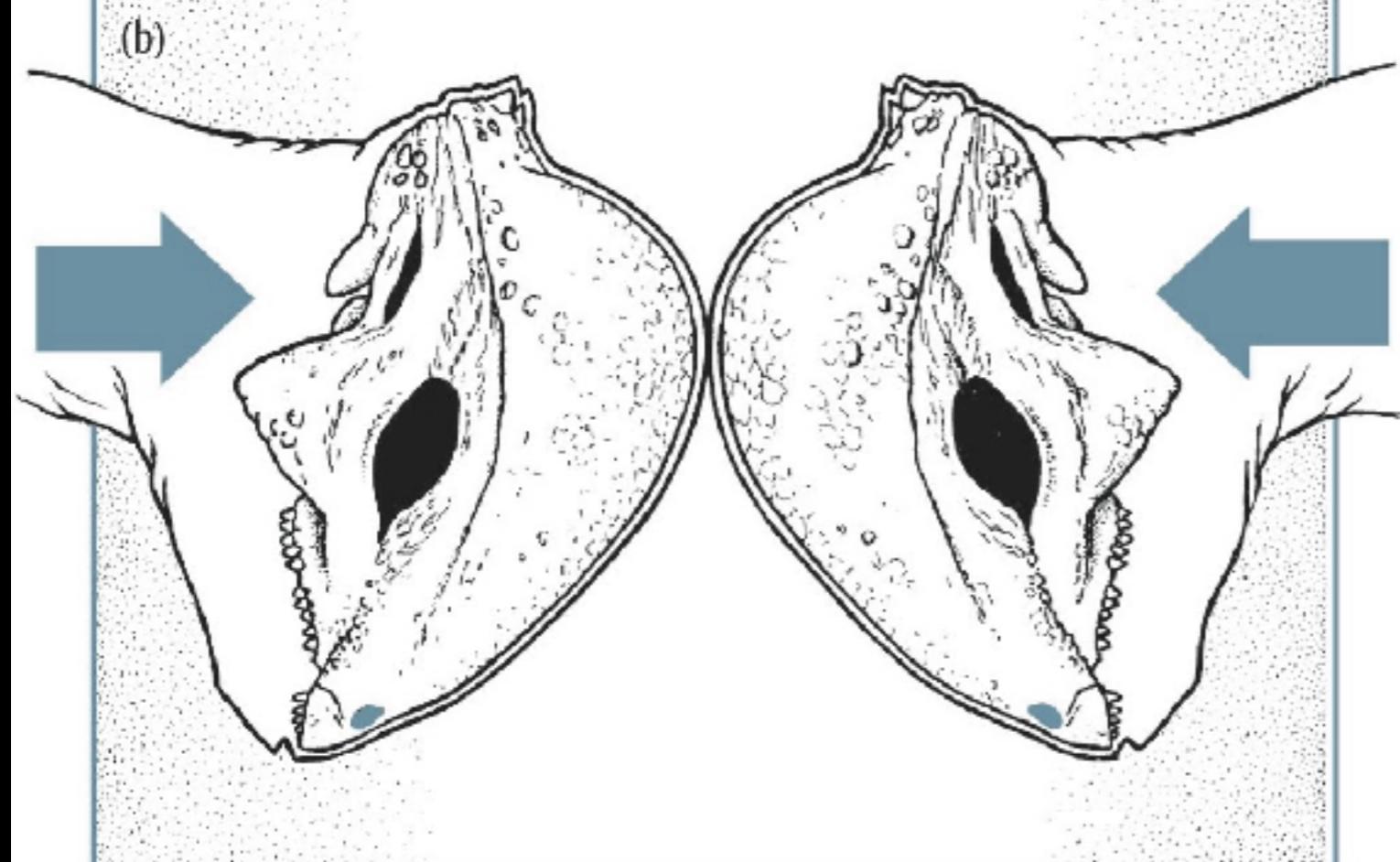
*Stegoceras*

V-shaped articulation with spinal column  
Why? Limit side-to-side motions

# Linear transfer of force

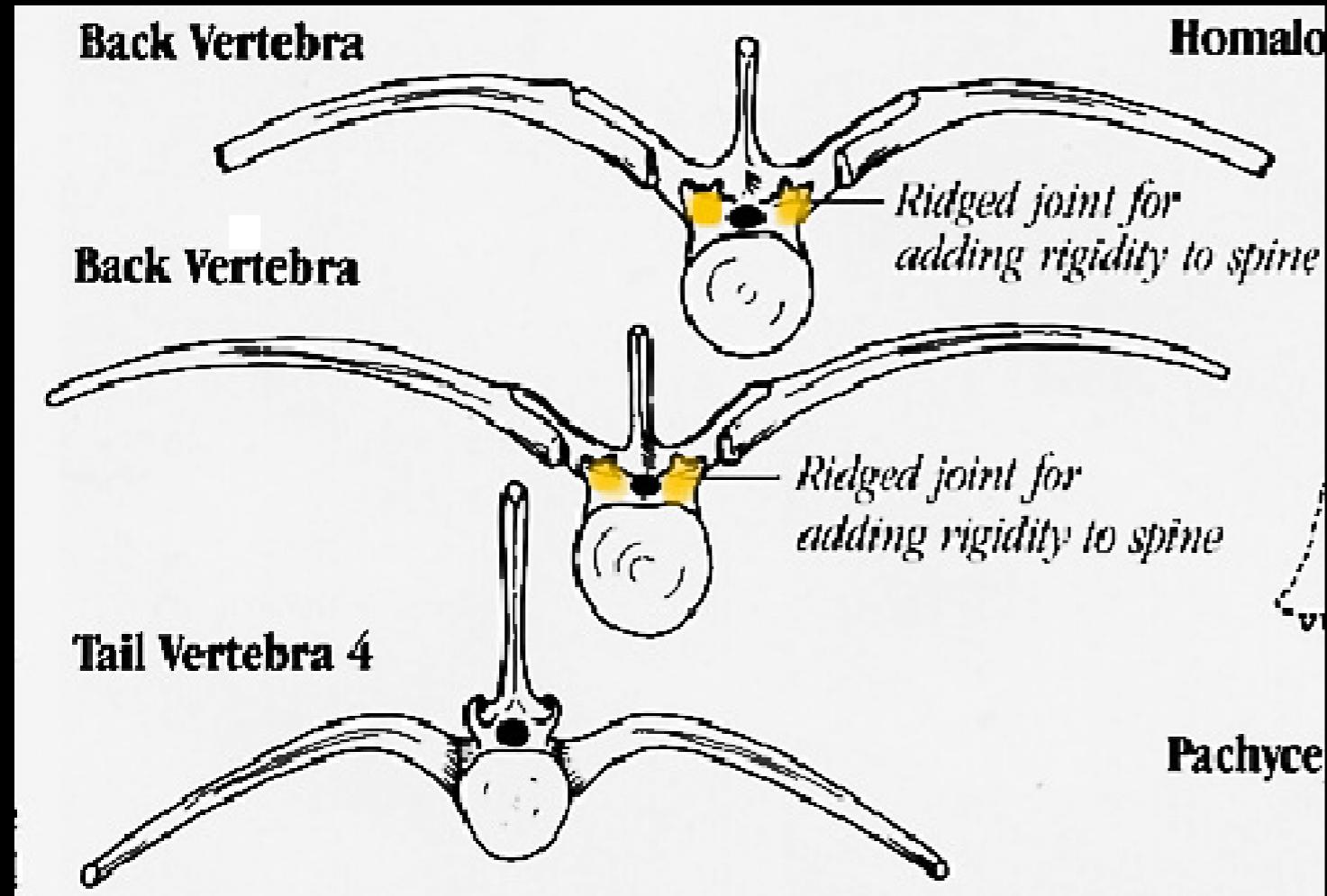


*Homalocephale*  
(Flat head)



*Stegoceras*  
(Fat head)

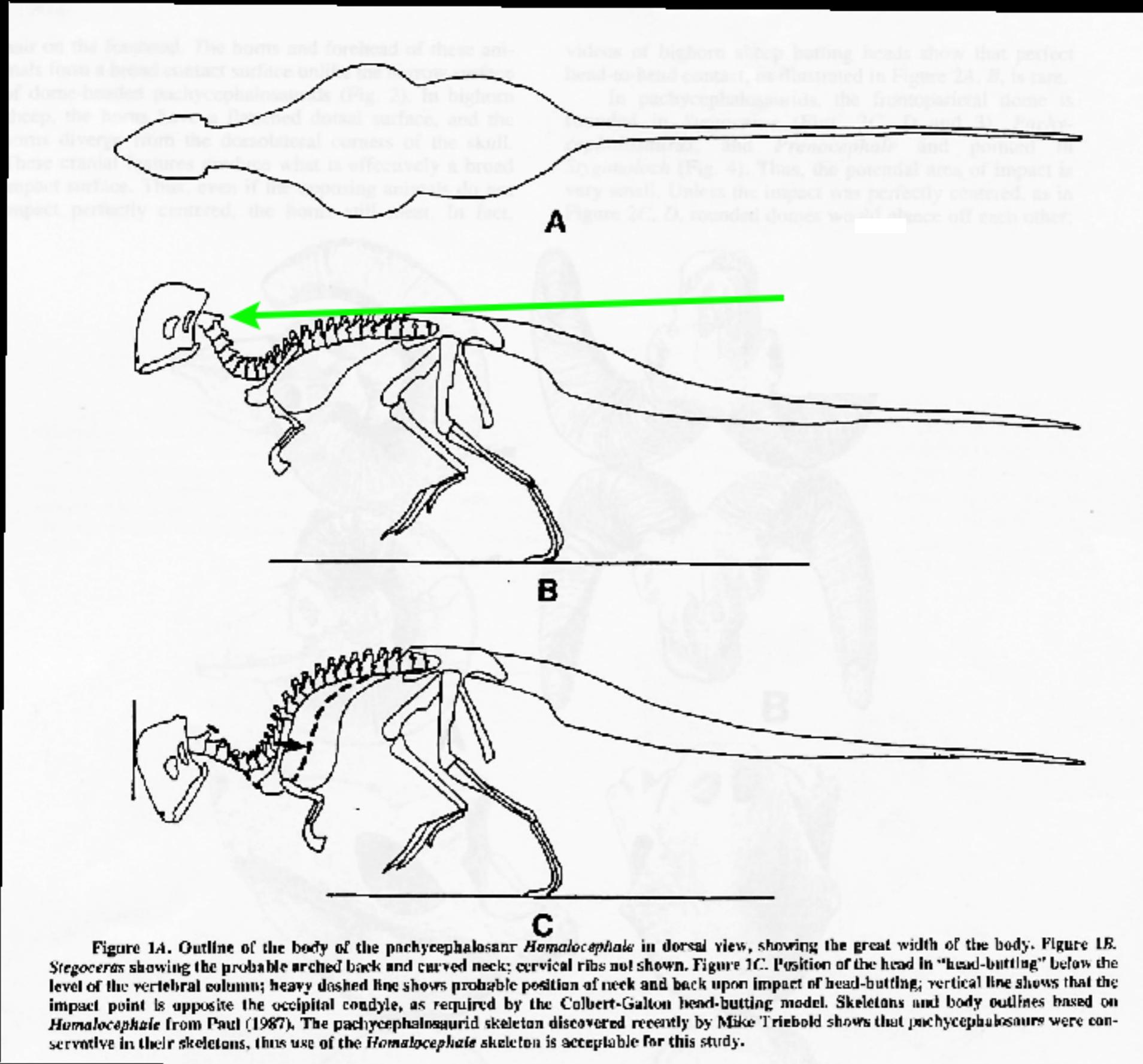
# A Battering Ram?



Tongue and Groove morphology of  
Back and Tail vertebrae  
Ridged joint for adding rigidity to spine



# A Battering Ram?

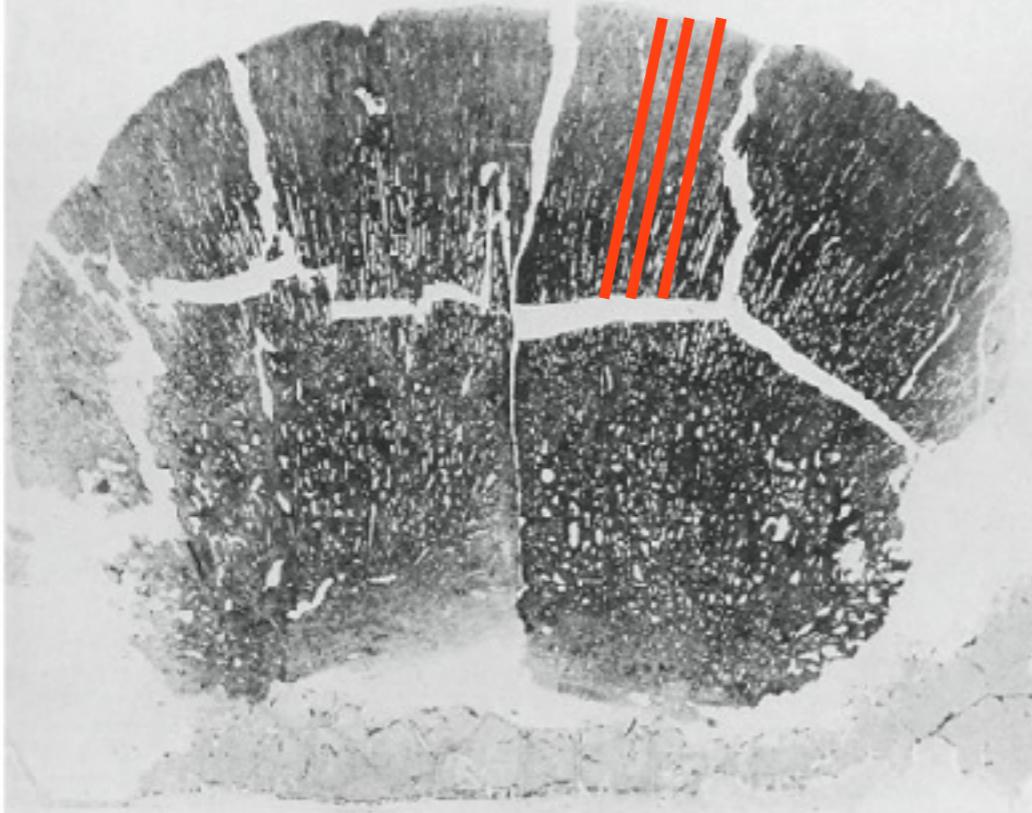


S-shaped shock absorbing  
vertebral column

# A Battering Ram?

Internal bone: radial organization

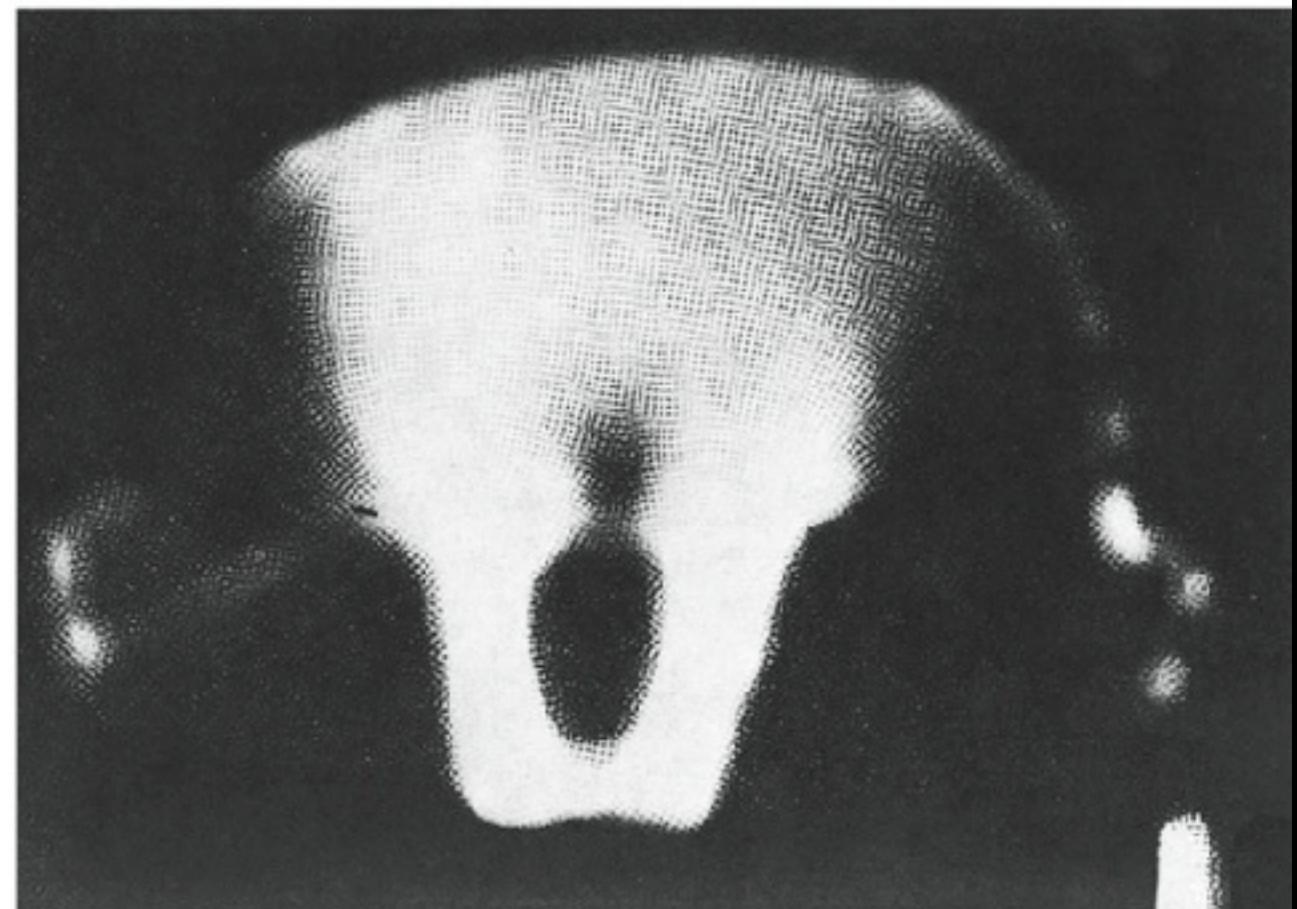
(a)



(b)



(c)



# A Battering Ram?

All evidence suggests that Pachycephalosaur skulls were built to withstand extreme forces

9 inches of solid bone

Bone organized in a radial arrangement- structural support

Articulation btw back of skull and vertebrae oriented to transfer forces linearly

Articulation btw back of skull and vertebral column built to withstand sideways forces

Vertebral column has tongue and groove articulations

Spinal column is an S-shaped shock absorber

BUT

There is no 'locking' mechanism on skull to keep battering heads aligned

Some Pachycephalosaurs have imprinted blood vessels on dome

These factors suggests that head-butting may not be likely



# Intraspecies Competition (typically male-male)

Females are typically choosy

Why?

Because they have more to lose

Common rule in biology: Females are expensive to lose, males are cheap (e.g. deer hunting)

Females choose the male most likely to provide the most successful offspring



Males compete with each other for access to female vs. female chooses the strongest male

Choosey females // Strong males have more offspring => SEXUAL selection

Many ways to do this...

But: In general, maximize competition and minimize accidental deaths (= no fitness)

<http://www.youtube.com/watch?v=PontCxFgs0M>



[http://www.metacafe.com/watch/1941236/giraffe\\_fight/](http://www.metacafe.com/watch/1941236/giraffe_fight/)



<http://www.youtube.com/watch?v=DYDxIy38vGw>





They dont show you this on the TV



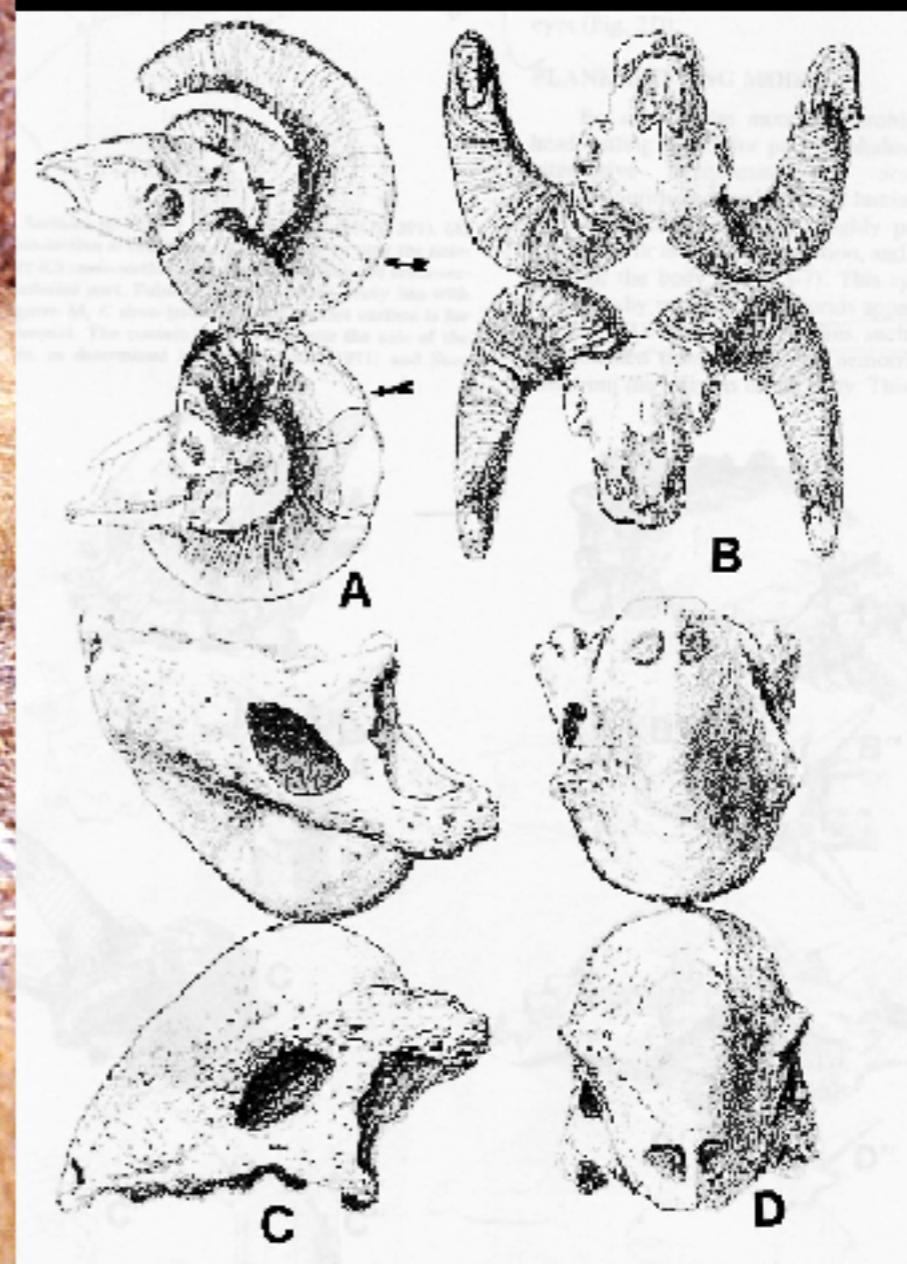
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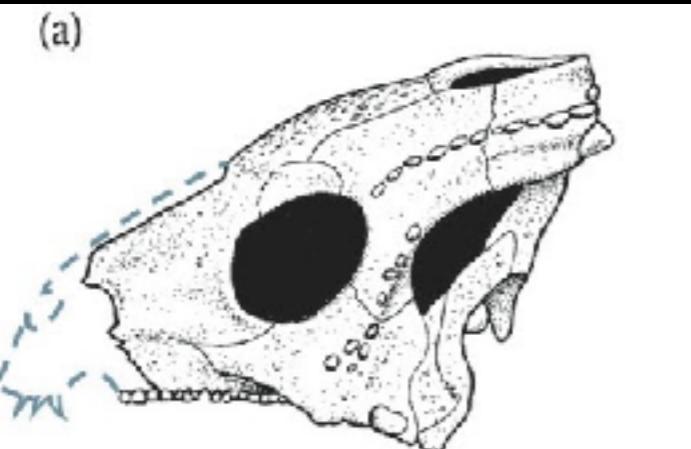


<http://www.youtube.com/watch?v=ULRtdk-3Yh4>





*Homalocephale*



10 cm

*Prenocephale*

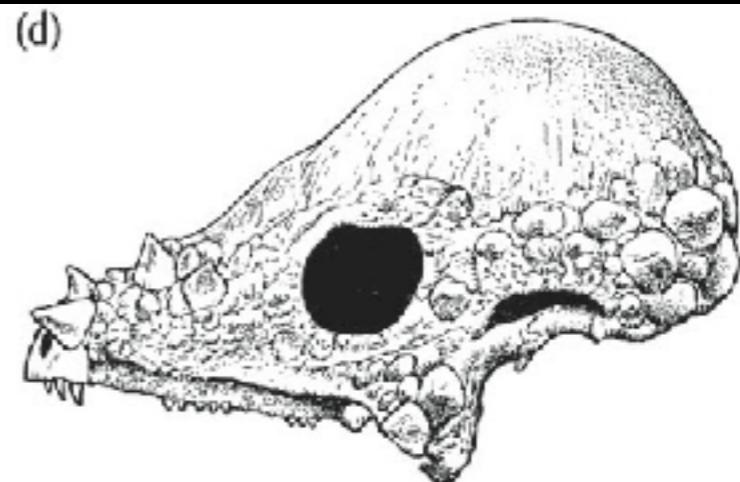


10 cm

*Stegoceras*

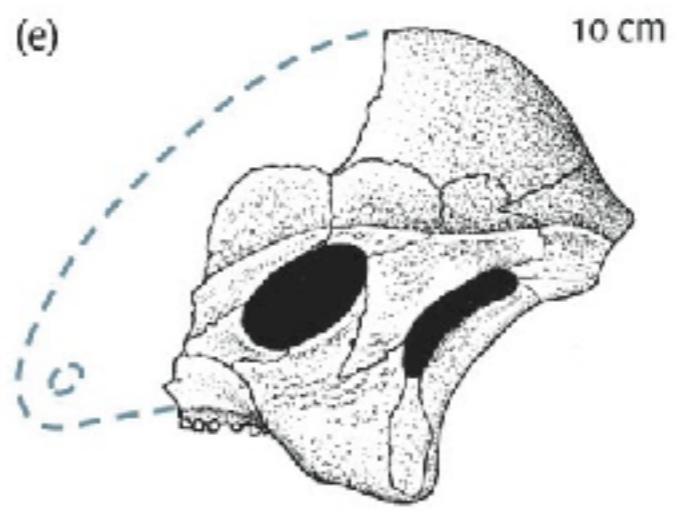


10 cm



10 cm

*Pachycephalosaurus*



10 cm

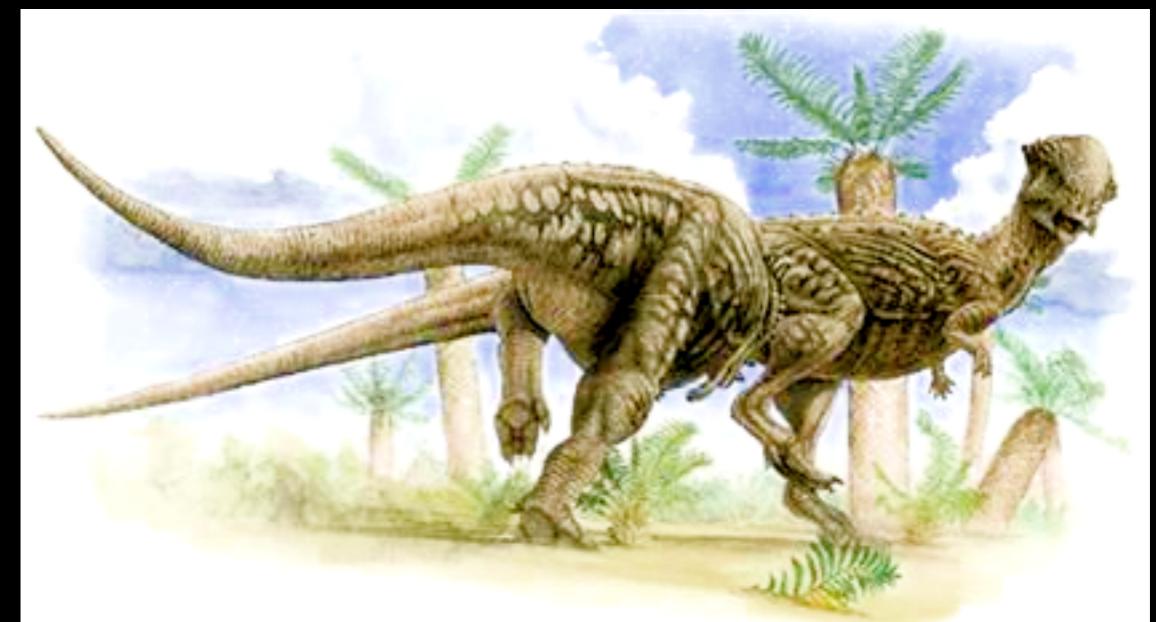
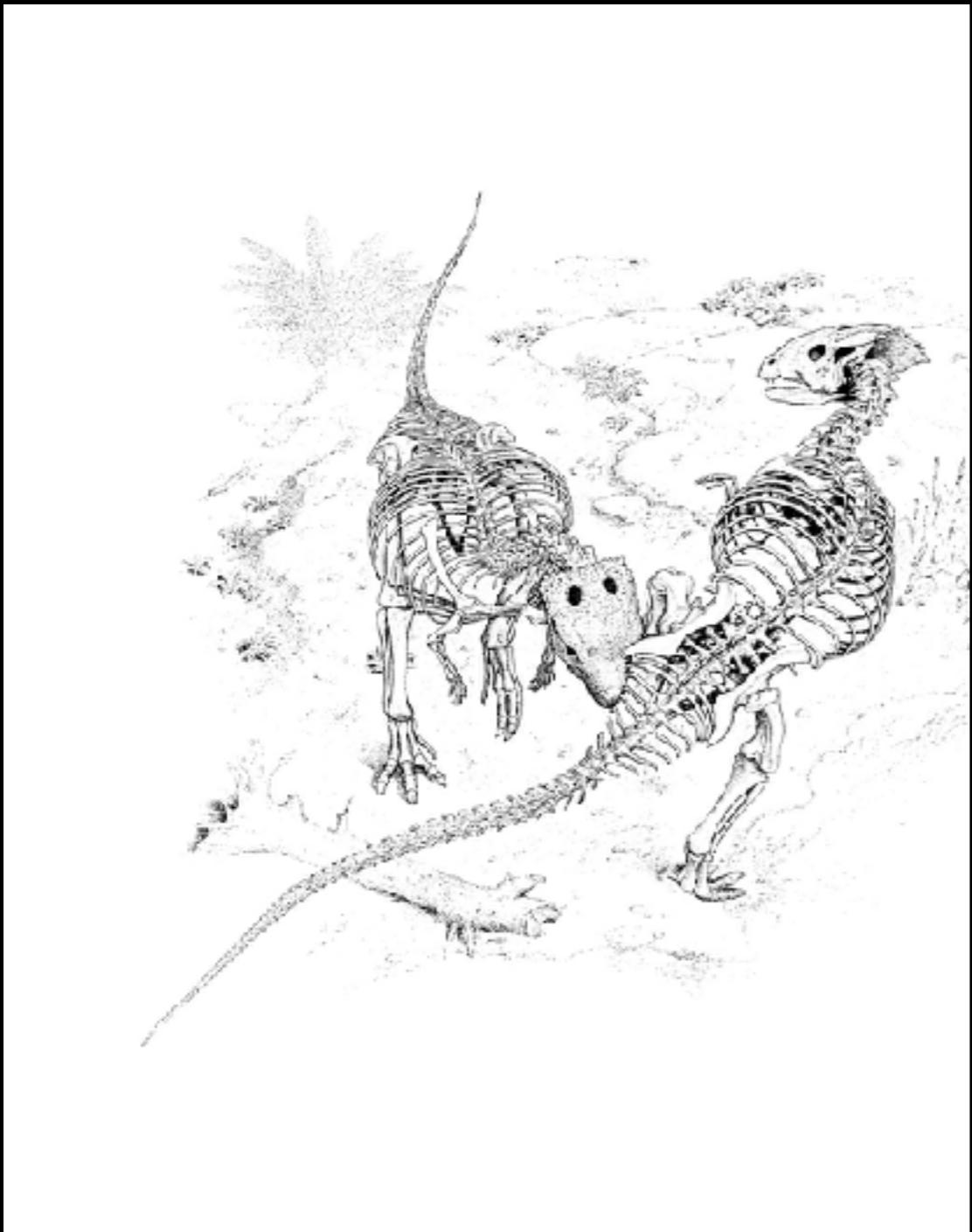
*Tylocephale*

# Head butting Pachycephalosaurs

Bone structure was probably strong enough to withstand collision

Convex nature would favor glancing blows

Instead, dome and spines seem better suited for “flank butting”



So... if head butting is the result of male-male competition, what should we expect to find?

Sexual dimorphism...

if males are primarily using their domes to headbutt, male domes will be under strong selective forces, while female domes will not.

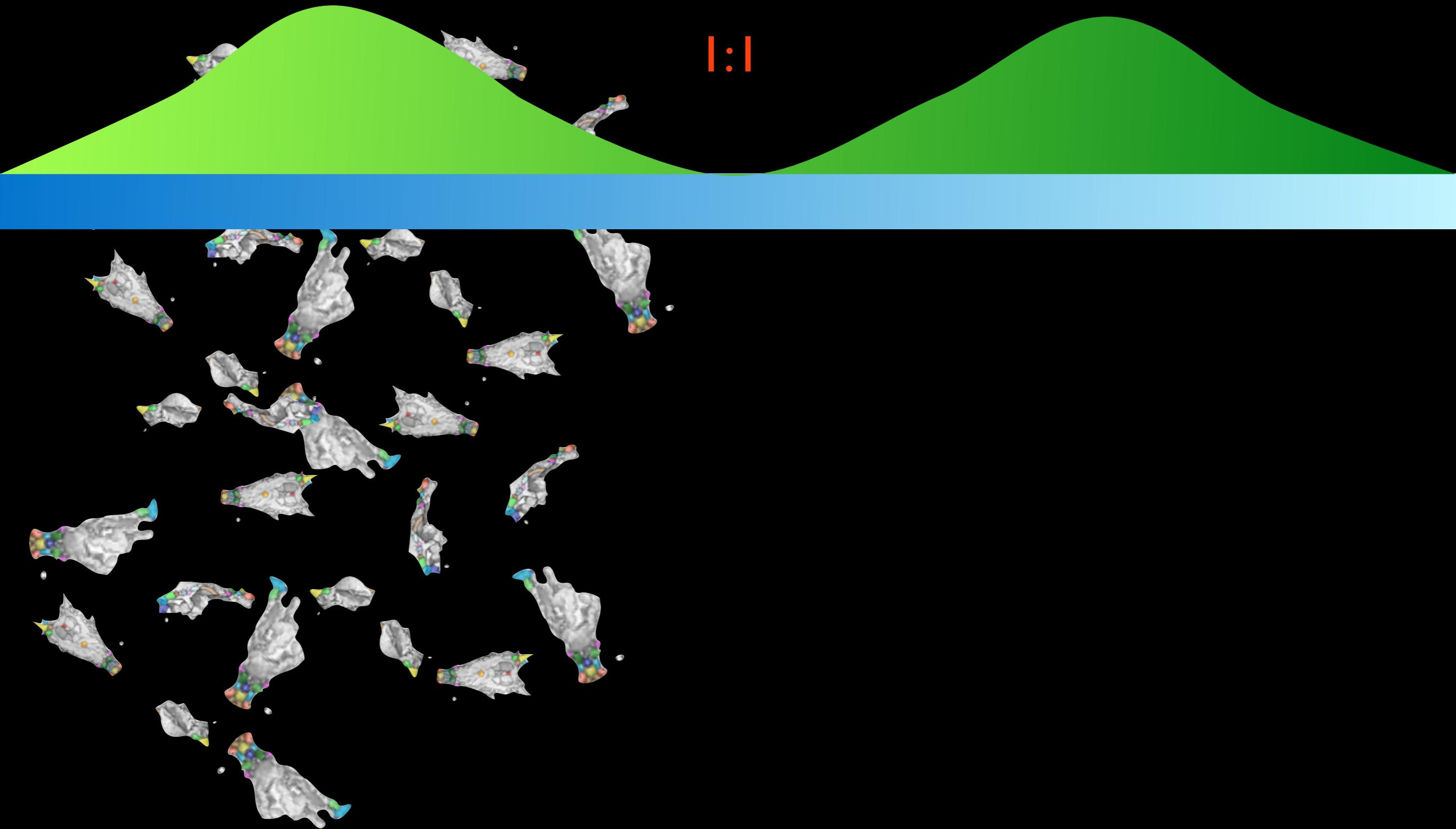




Smaller

Larger

|:|



# The strange case of Hell's Creek.





Hell Creek formation, Montana (Upper Cretaceous)



*Pachycephalosaurus*



*Stygimoloch*



*Dracorex*



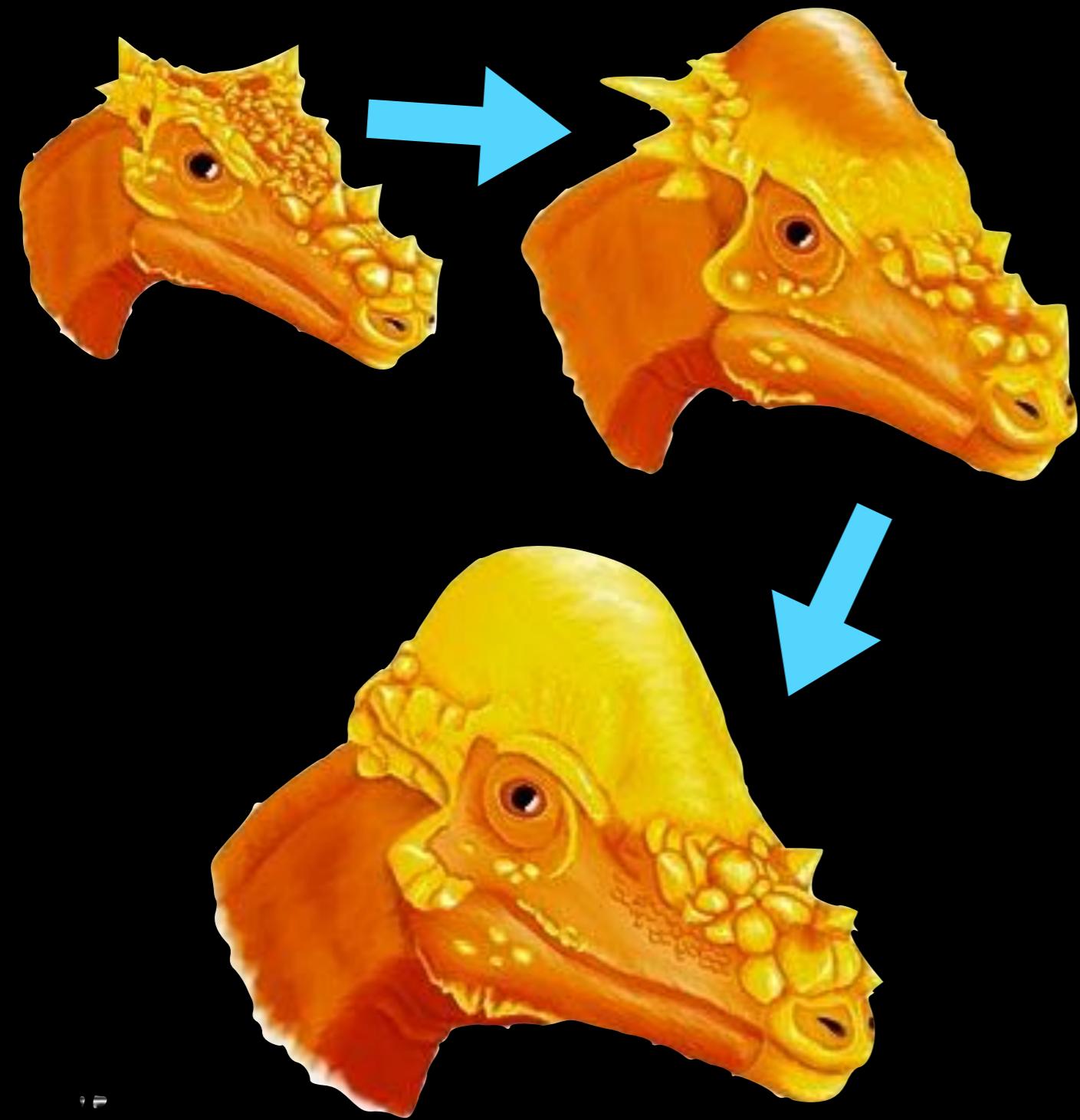
*Dracorex  
hogwartsia*



*Dracorex  
hogwartsia*



# A Modern Day Dinosaur Extinction

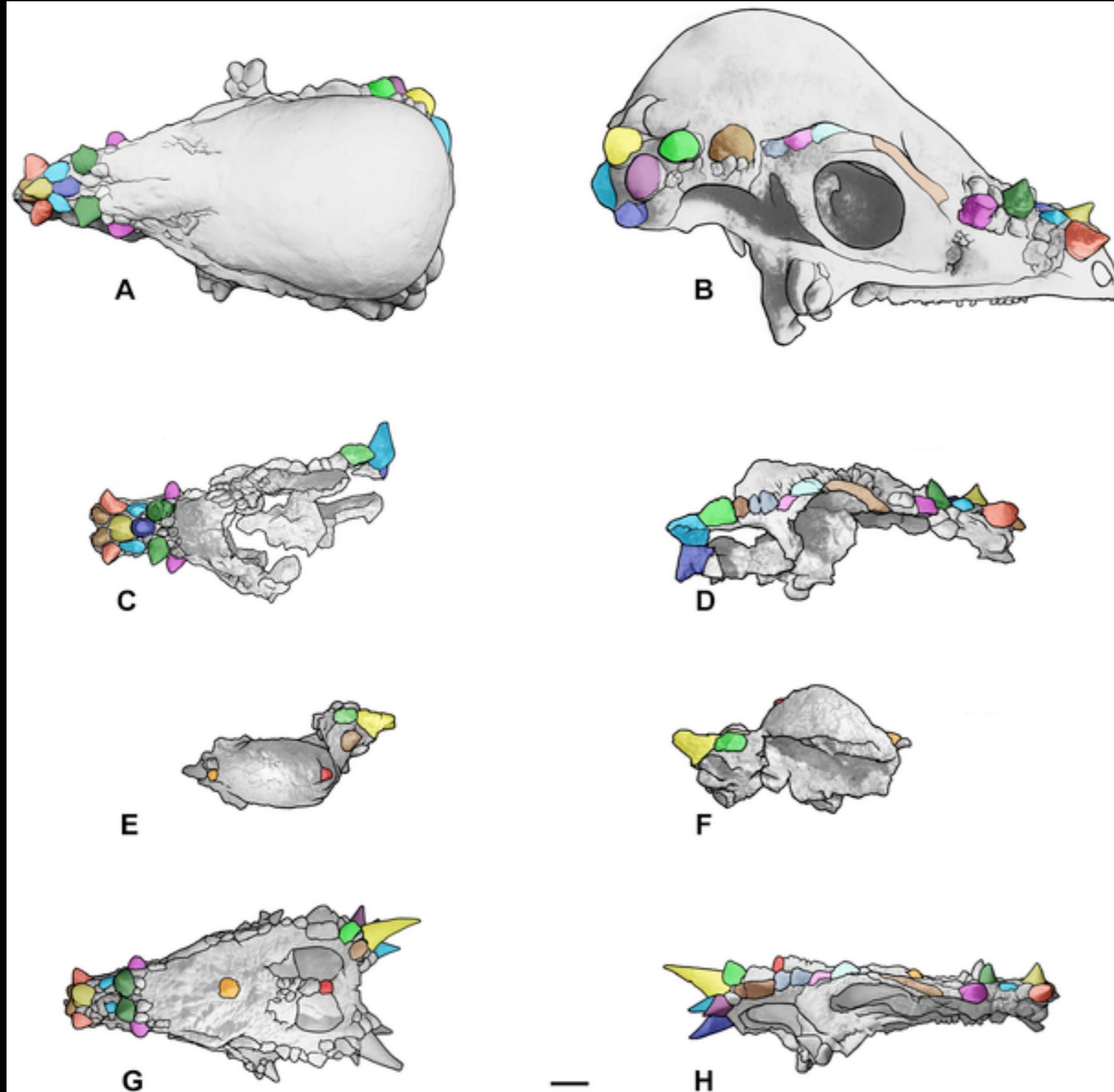


Two Hypotheses:

1. These animals are independent species
2. These animals are an ontogenetic series

GROWTH

# *Ontogeny of Pachycephalosaurus wyomingensis*



*Oldest adult*

*Youngest adult*

*Subadult (Stygimoloch)*

*Youngest growth Stage (Dracorex)*

[http://www.youtube.com/watch?](http://www.youtube.com/watch?v=GcZnupsB5Ps&feature=PlayList&p=B109C00BD252F27D&playnext_from=PL&playnext=1&index=43)

v=GcZnupsB5Ps&feature=PlayList&p=B109C00BD252F27D&playnext\_from=PL&playnext=1&index=43



4-6  
months



11-13  
months



13-17  
months



17-20  
months



3.5  
years



Horns Go Wild

