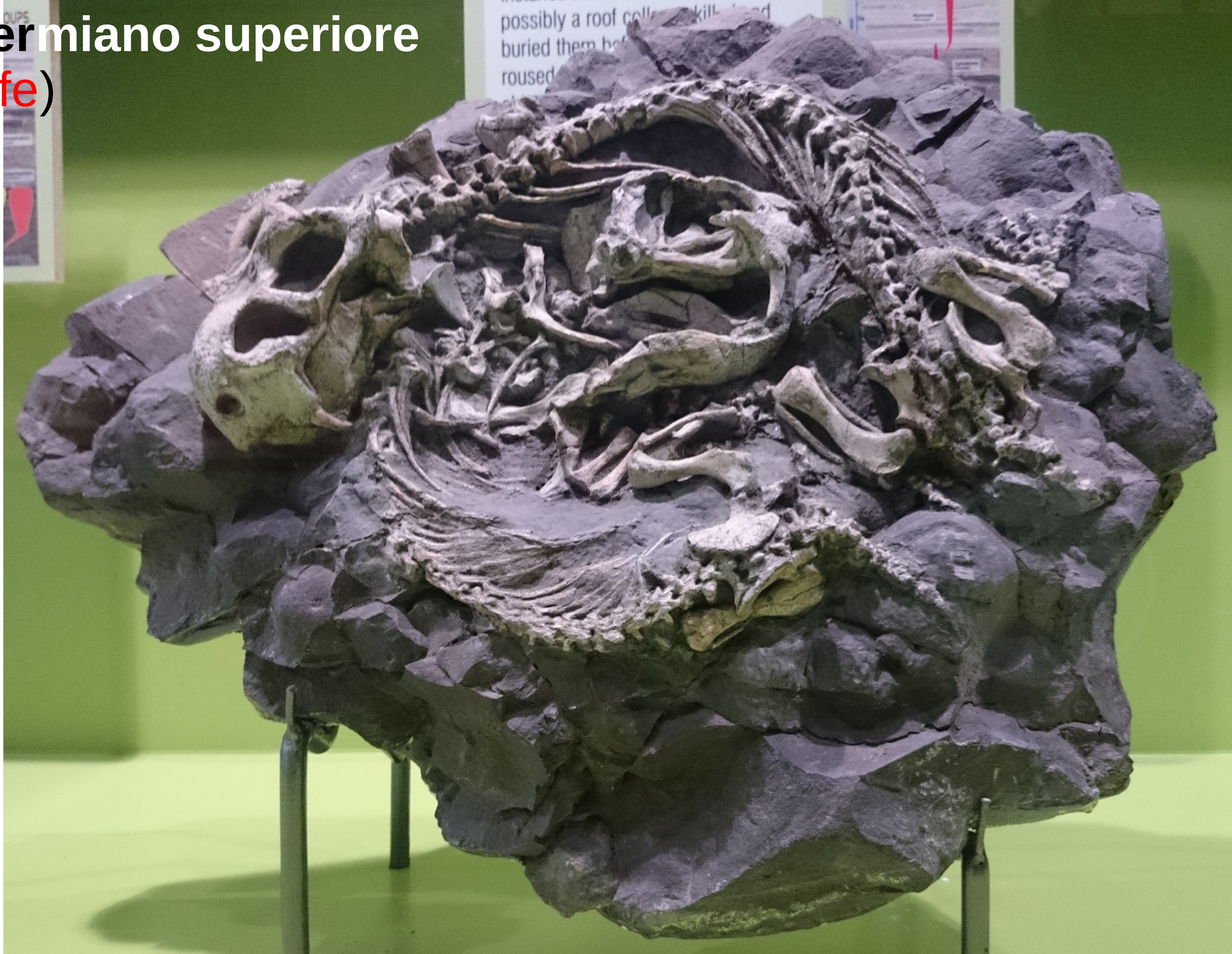
Flora e fauna del Permiano superiore (prima della catastrofe)

- **Dicinodonti**



Flora e fauna del Permiano superiore
(prima della catastrofe)

- **Dicinodonti**

Flora e fauna del Permiano superiore
(prima della catastrofe)

- **Dicinodonti**
  Dicynodontia is an extinct clade of **anomodonts**, an extinct type of non-mammalian therapsid. Dicynodonts were **herbivores** that typically bore a **pair of tusks**, hence their name, which means 'two dog tooth'. Members of the group possessed a horny, **toothless beak**, unique amongst all synapsids.
  Dicynodonts first appeared in Southern Pangaea during the mid-Permian, ca. 270÷260 million years ago, and became globally distributed and the dominant herbivorous animals in the Late Permian, ca. 260÷252 Mya.
  They were devastated by the end-Permian Extinction that wiped out most other therapsids ~ 252 Mya.

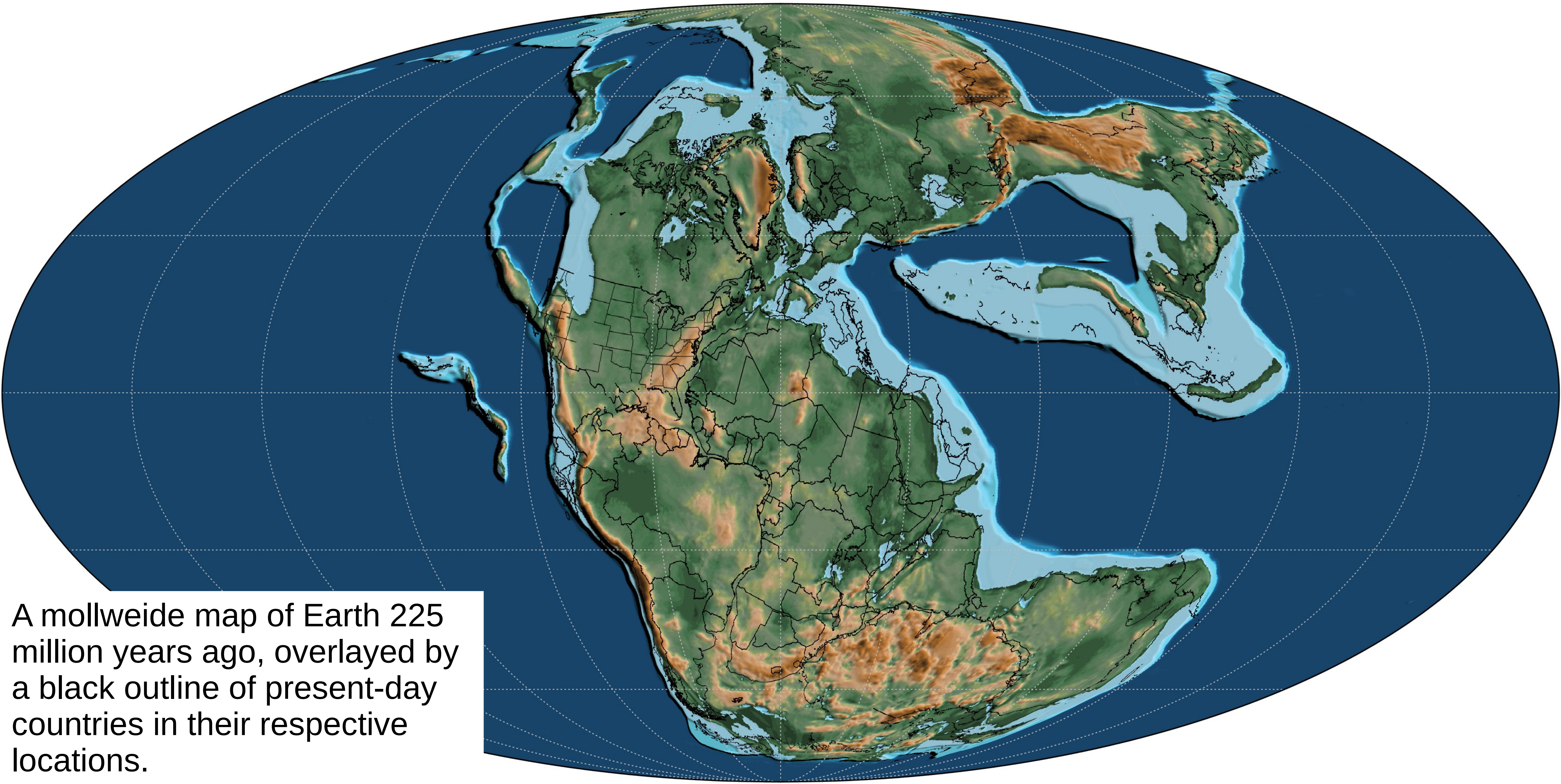
Flora e fauna del Permiano superiore
(prima della catastrofe)

Anomodontia is an extinct group of non-mammalian therapsids from the Permian and Triassic periods. By far the most speciose group are the **dicynodonts**, a clade of **beaked, tusked herbivores**.

Dicynodonts became the most successful and abundant of all herbivores in the Late Permian, filling ecological niches ranging from large browsers down to small burrowers.

Few dicynodont families survived the Permian-Triassic extinction event, but one lineage (Kannemeyeriiformes) evolved into large, stocky forms that became dominant terrestrial herbivores right until the Late Triassic, when changing conditions caused them to decline, finally going extinct during the Triassic-Jurassic extinction event.

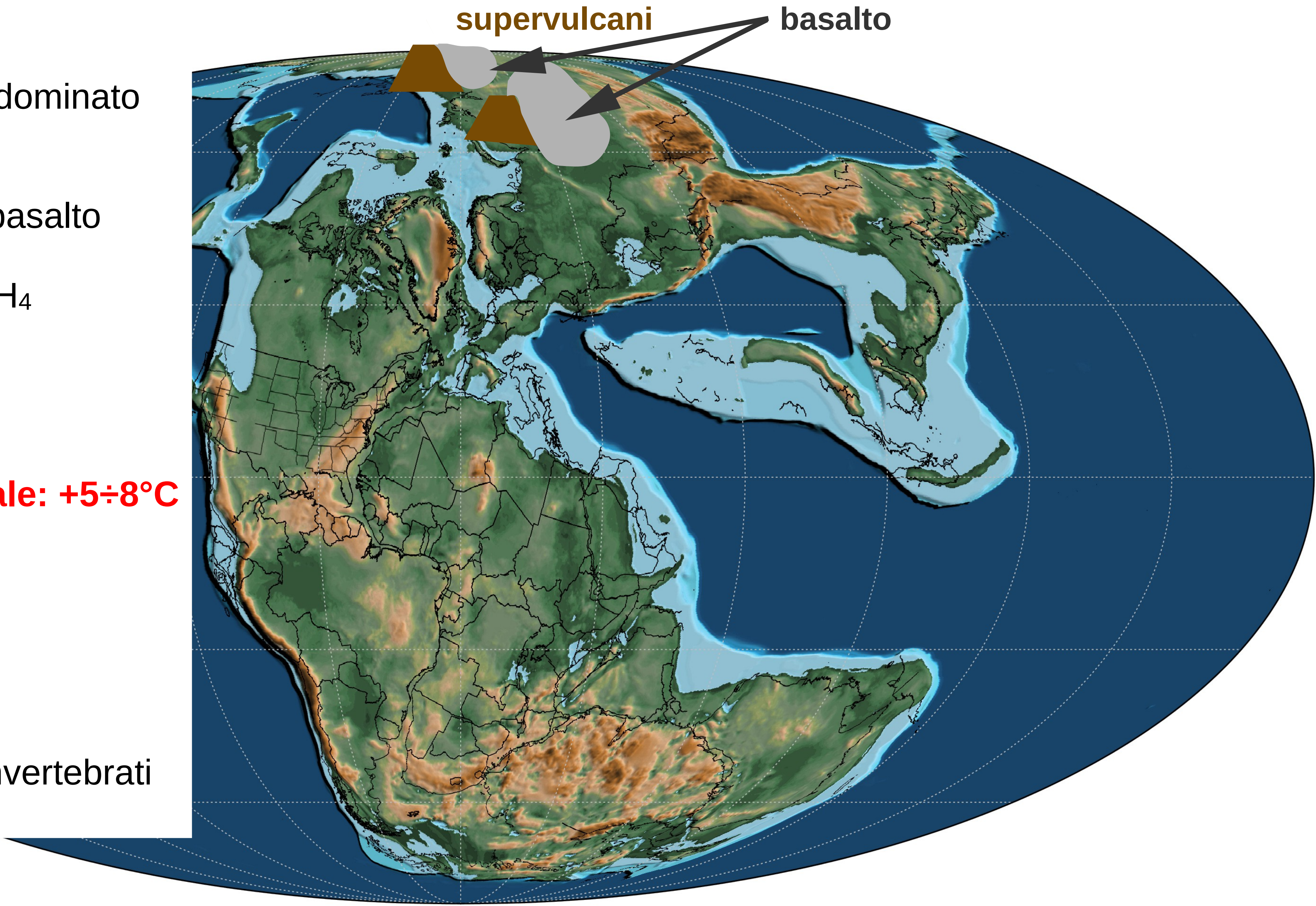
Permian-Triassic extinction event



A mollweide map of Earth 225 million years ago, overlayed by a black outline of present-day countries in their respective locations.

Permian-Triassic extinction event (250 Mya)

- Sconvolge un mondo dominato dai **Terapsidi**
- 10^6 kmq ricoperti di basalto
- Emissione di CO_2 e CH_4
- **Riscaldamento globale: +5÷8°C**
- Acidificazione oceani
- Estinzione di massa invertebrati dotati di conchiglia



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Body Size Reductions in Nonmammalian Eutheriodont Therapsids (Synapsida) during the End-Permian Mass Extinction

Adam K. Huttenlocker

Published: February 3, 2014 • https://doi.org/10.1371/journal.pone.0087553

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Abstract

The extent to which mass extinctions influence body size evolution in major tetrapod clades is inadequately understood. For example, the 'Lilliput effect,' a common feature of mass extinctions, describes a temporary decrease in body sizes of survivor taxa in post-extinction faunas. However, its signature on existing patterns of body size evolution in tetrapods and the persistence of its impacts during post-extinction recoveries are virtually unknown, and rarely

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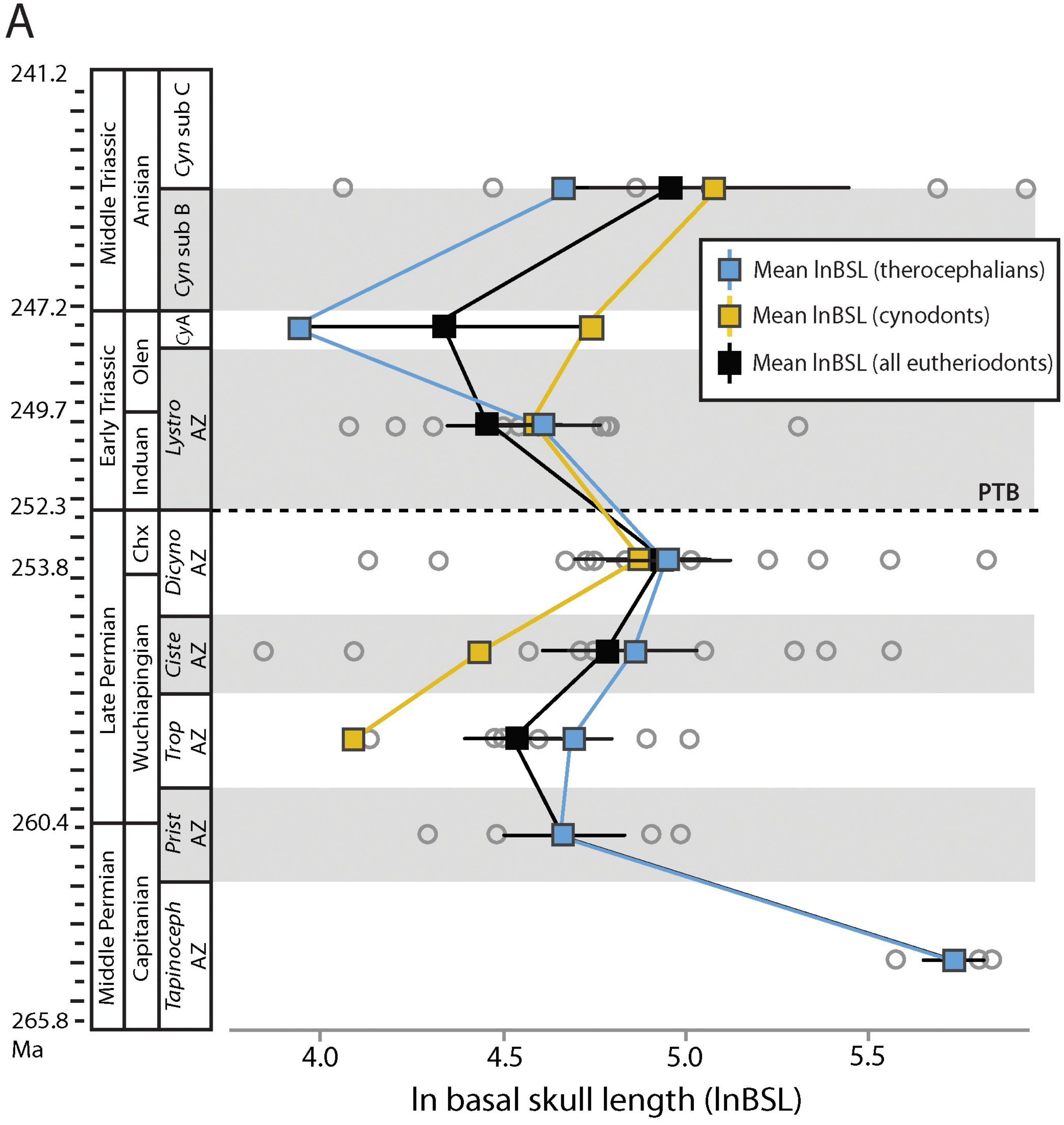
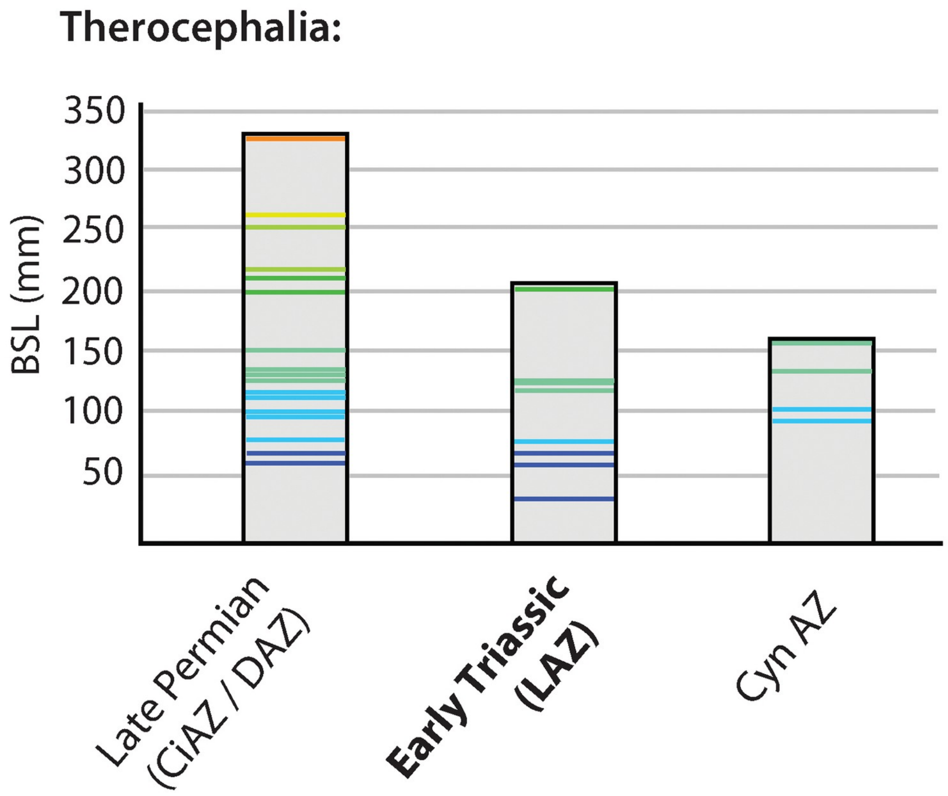
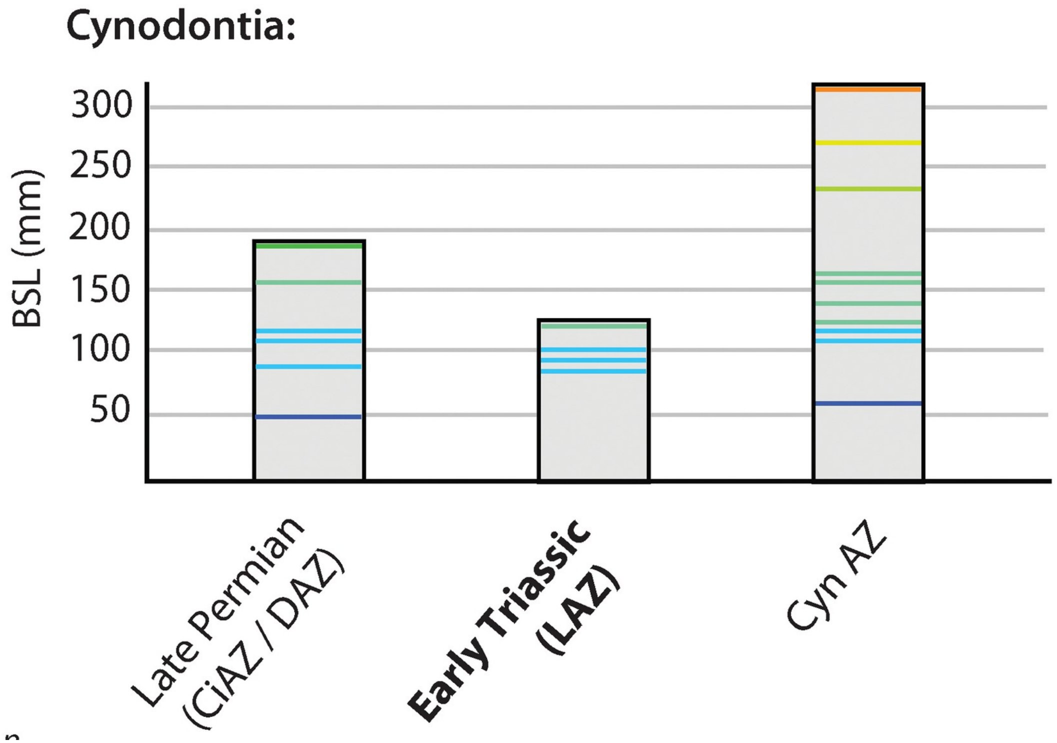
Permian-Triassic extinction event (250 Mya)

- estinzione di massa delle piante
- semplificazione delle reti alimentari
- **sopravvivono i Cinodonti ed i Terocefali più piccoli**
- estivazione



Permian-Triassic extinction event (250 Mya)





Perché essere piccoli era un vantaggio?

Ci si poteva nascondere più facilmente, sottraendosi a condizioni meteo sfavorevoli, agli sbalzi di temperatura ed alle tempeste di sabbia, al riparo nelle tane.
Le rocce del Karoo al di sopra dello strato formatosi con l'estinzione (sedimenti argillosi di pianure alluvionali disseminati di mummie sepolte nella sabbia soffiata dal vento), sono ricche di tane fossilizzate, alcune delle quali contengono resti scheletrici.

Il Triassico

The **Triassic** is a geologic period and system which spans 50.5 million years from the end of the Permian Period 251.902 million years ago (Mya), to the beginning of the Jurassic Period 201.4 Mya.

The Triassic is the first and shortest period of the Mesozoic Era and the seventh period of the Phanerozoic Eon. Both the start and end of the period are marked by major extinction events.

The Triassic Period is subdivided into three epochs: Early Triassic, Middle Triassic and Late Triassic.

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RESEARCH ARTICLE

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Synchrotron Reveals Early Triassic Odd Couple: Injured Amphibian and Aestivating Therapsid Share Burrow

Vincent Fernandez, Fernando Abdala, Kristian J. Carlson, Della Collins Cook, Bruce S. Rubidge, Adam Yates, Paul Tafforeau

Published: June 21, 2013 • https://doi.org/10.1371/journal.pone.0064978

Abstract

Fossorialism is a beneficial adaptation for brooding, predator avoidance and protection from extreme climate. The abundance of fossilised burrow casts from the Early Triassic of southern Africa is viewed as a behavioural response by many tetrapods to the harsh conditions following the Permo-Triassic mass-extinction event. However, scarcity of vertebrate remains associated with these burrows leaves many ecological questions unanswered. Synchrotron scanning of a lithified burrow cast from the Early Triassic of the Karoo unveiled a unique mixed-species association: an injured temnospondyl amphibian (*Broomistega*) that sheltered in a burrow

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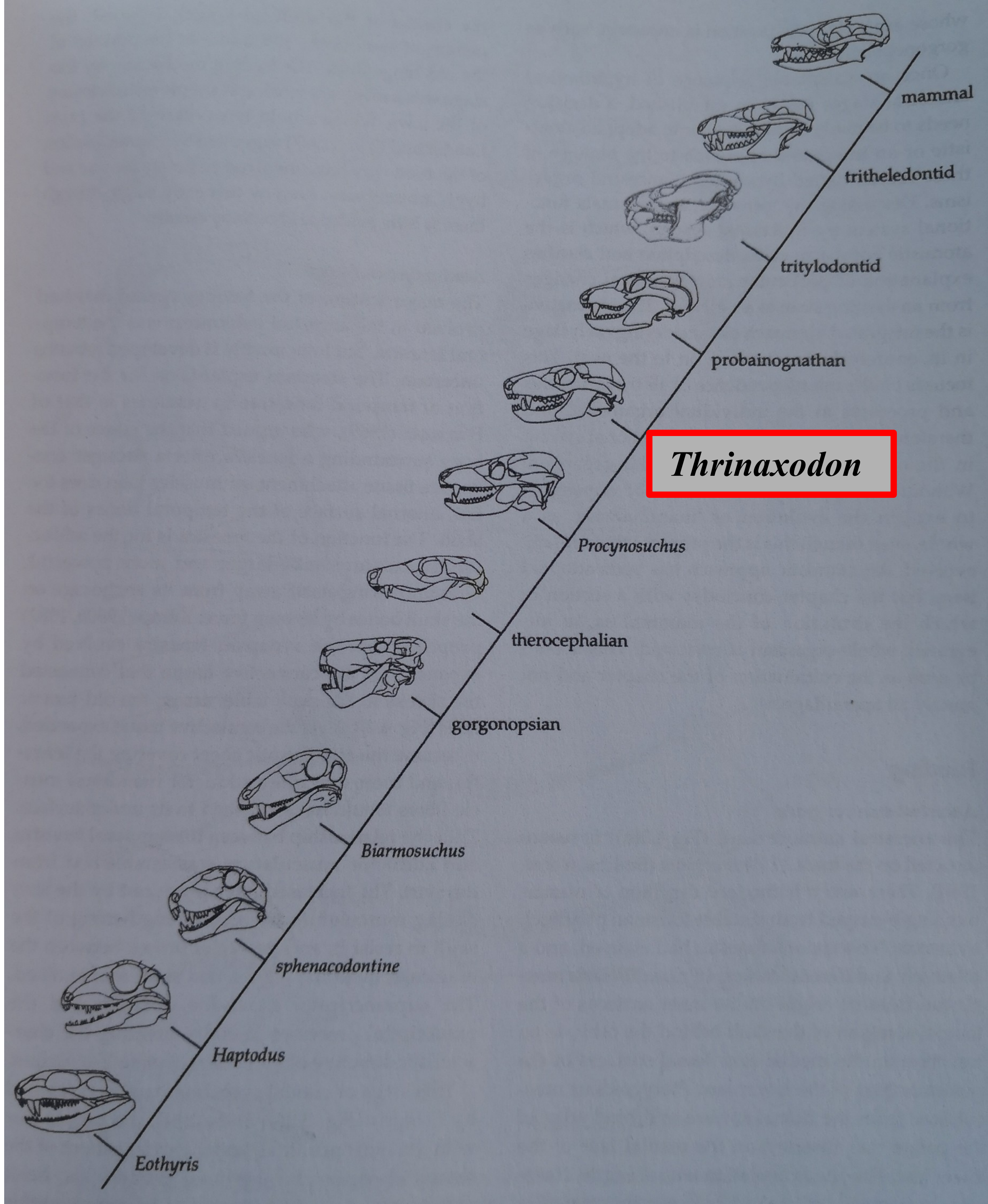
5cm

Permian-Triassic extinction event (250 Mya)

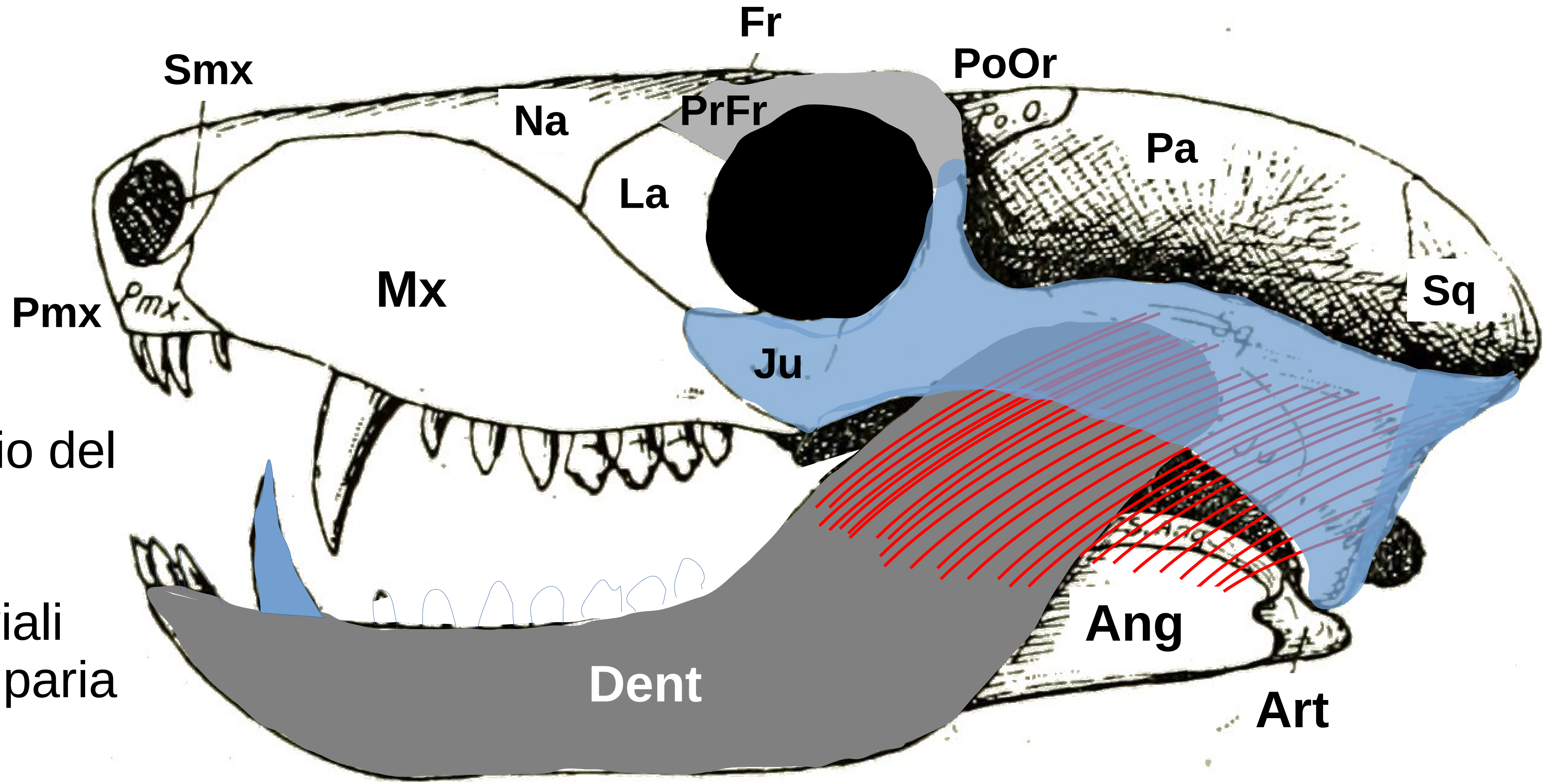
Fossorialism is a beneficial adaptation for brooding (cova), predator avoidance and protection from extreme climate. The abundance of fossilised burrow casts from the Early Triassic of southern Africa is viewed as a behavioural response by many tetrapods to the **harsh conditions following the Permo-Triassic mass-extinction event**. However, scarcity of vertebrate remains associated with these burrows leaves many ecological questions unanswered. Synchrotron scanning of a lithified burrow cast from the Early Triassic of the Karoo unveiled a unique mixed-species association: an injured temnospondyl amphibian (*Broomistega*) that sheltered in a burrow occupied by an aestivating therapsid (***Thrinaxodon***). The discovery of this rare rhinesuchid represents the first occurrence in the fossil record of a temnospondyl in a burrow. The amphibian skeleton shows signs of a crushing trauma with partially healed fractures on several consecutive ribs. The presence of a relatively large intruder in what is interpreted to be a *Thrinaxodon* burrow implies that the therapsid tolerated the amphibian's presence. Among possible explanations for such unlikely cohabitation, ***Thrinaxodon* aestivation** is most plausible, an interpretation supported by the numerous *Thrinaxodon* specimens fossilised in curled-up postures. Recent advances in synchrotron imaging have enabled visualization of the contents of burrow casts, thus providing a novel tool to elucidate not only anatomy but also ecology and biology of ancient tetrapods.

Il cladogramma dei Sinapsidi



Evoluzione dell'anatomia craniale: grado epicinodonti primitivi

Es. *Thrinaxodon*



Cinodonte vissuto ~ 251 Mya, all'inizio del Triassico

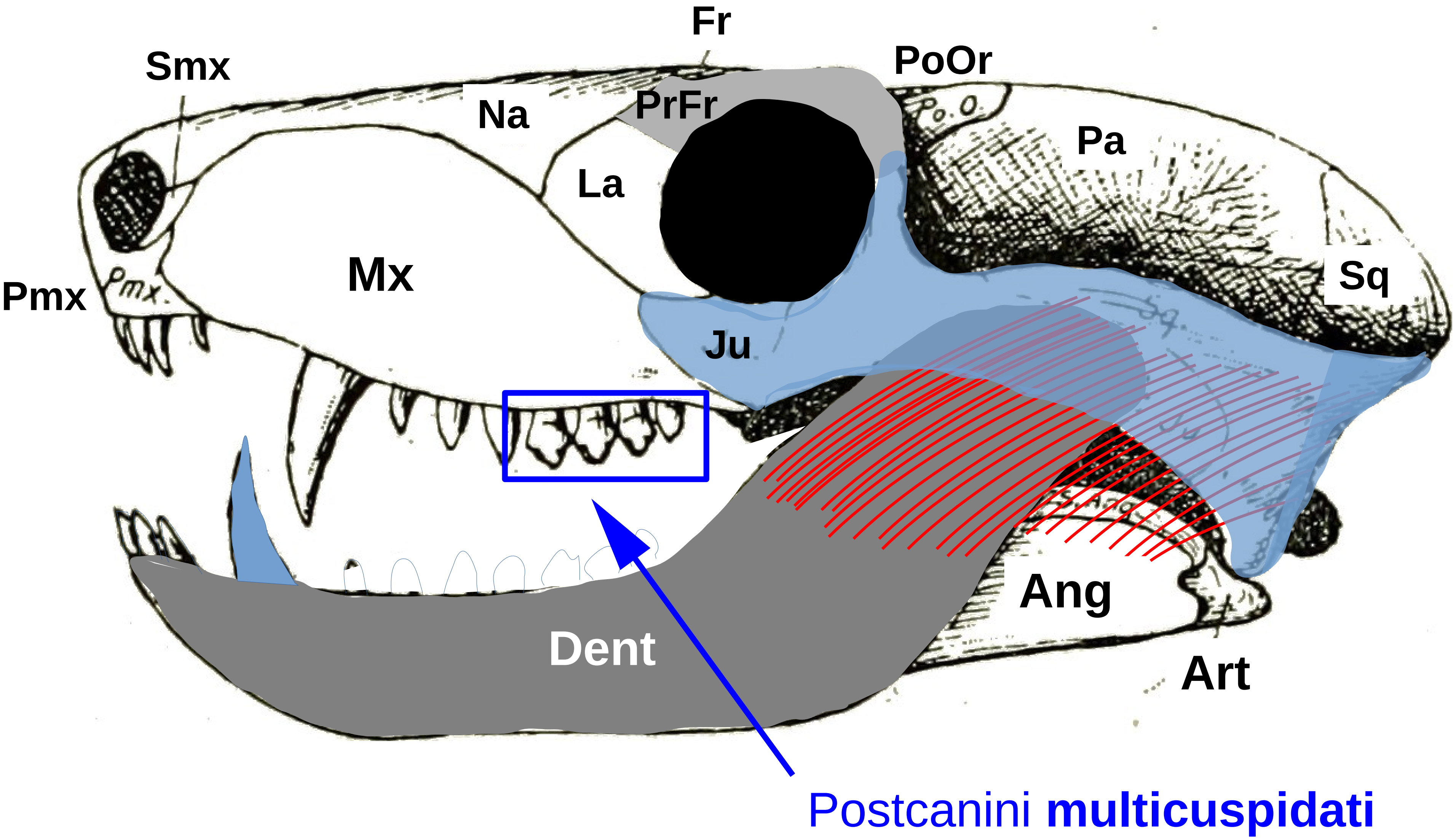
HABITAT: valli fluviali con vegetazione riparia a felci e licopodi

Clima tropicale: stagione secca e stagione umida, con piogge monsoniche

Estivazione in letargia (metabolismo rallentato) in tane sotterranee

Evoluzione dell'anatomia craniale: grado epicinodonti primitivi

Es. *Thrinaxodon*

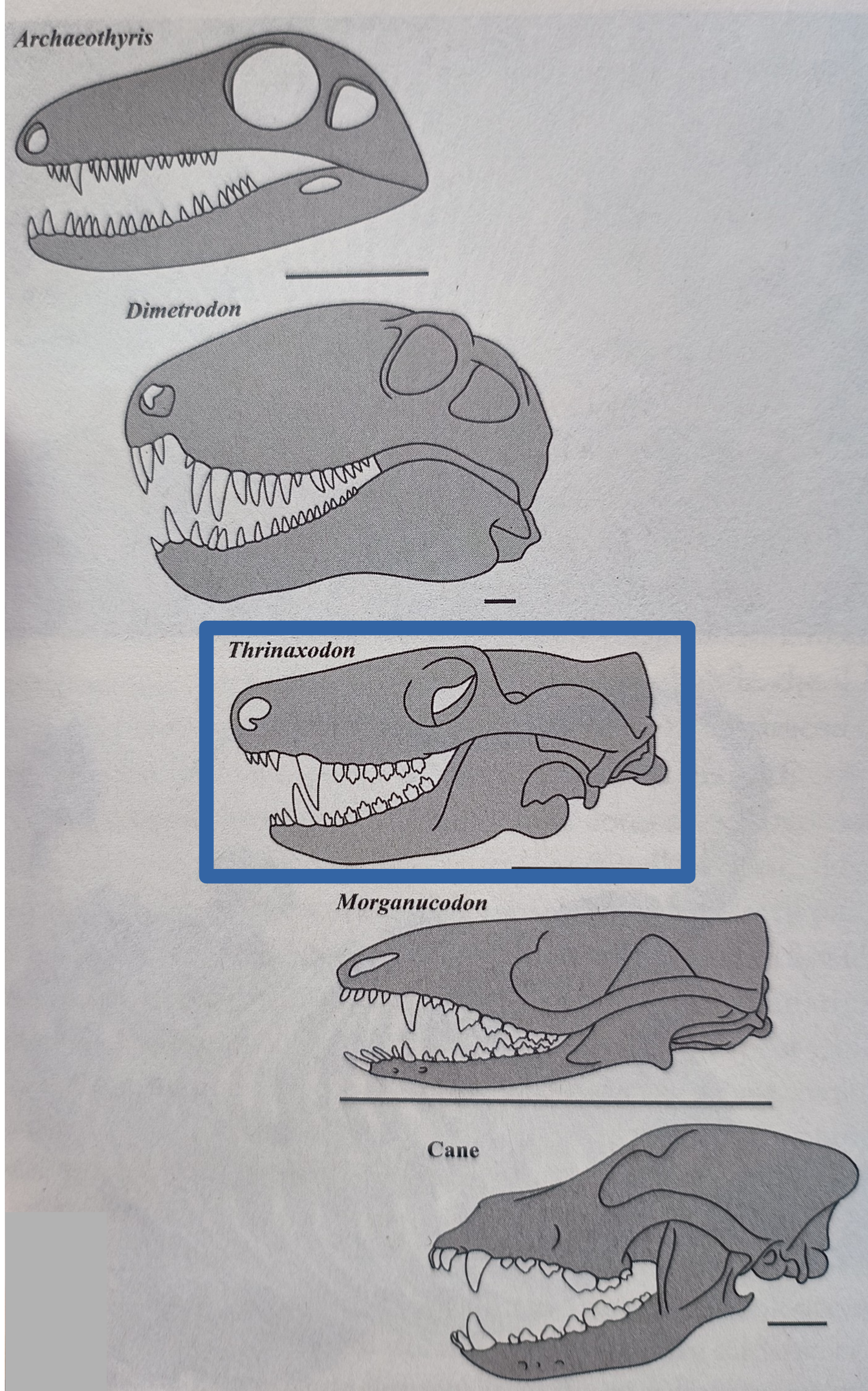


Scavatore, si nutriva di insetti e piccoli anfibi che masticava con i suoi **denti postcanini multicuspidati**

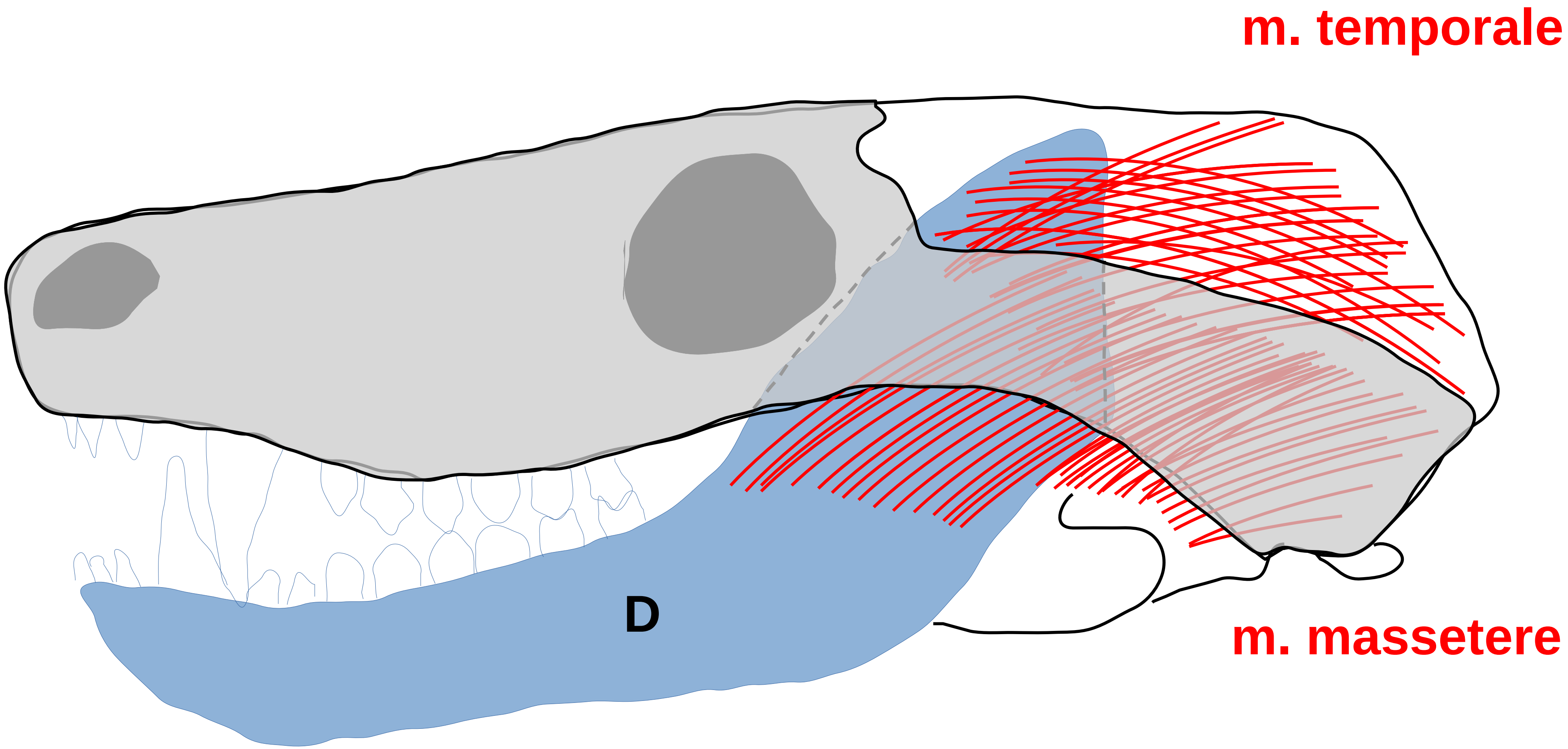
L'evoluzione dei denti: il *Thrinaxodon*

- *Thrinaxodon* is an extinct genus of cynodonts, including the species *T. liorhinus* which lived in what are now South Africa and Antarctica during the Late Permian - Early Triassic

- *Thrinaxodon* **lived just after the Permian-Triassic mass extinction event**, its survival during the extinction may have been due to its burrowing habits



Evoluzione dei muscoli mandibolari: grado epicinodonti primitivi
Es. *Thrinaxodon*



Evoluzione dei muscoli mandibolari: grado epicinodonti primitivi
Es. *Thrinaxodon*

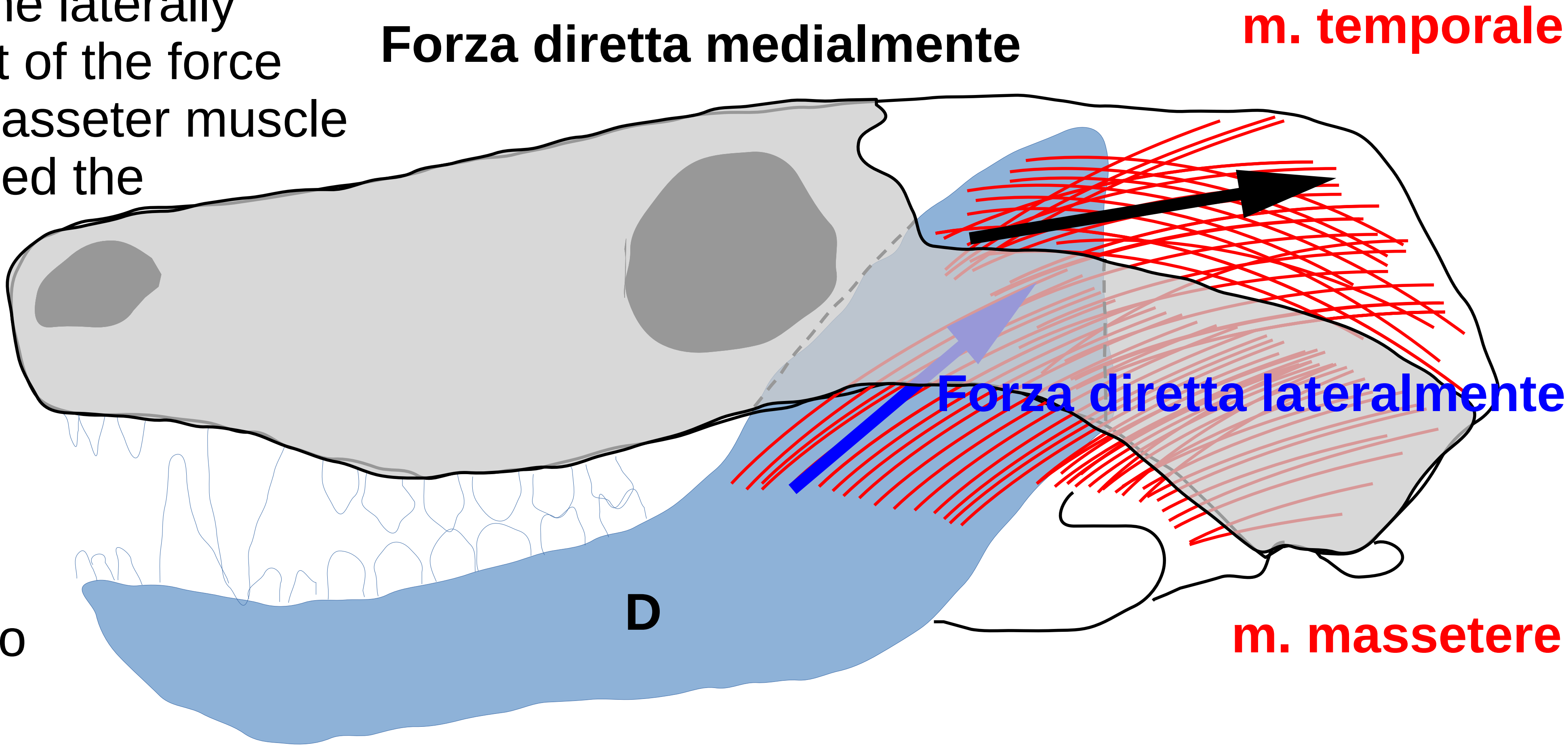
- The **temporal fenestra** is larger, having expanded posteriorly and laterally
- The **sagittal crest** is deeper
- There is attachment for a much larger **temporalis muscle**
- The **coronoid process** extends up into the temporal fenestra, almost to the height of the skull itself; **the medial** and lateral surfaces of the process were both available for the muscle's insertion
- The increase in size of the **masseter muscle** was even more impressive
- The **zygomatic arch** has expanded to form a broad, dorsally arched sheet of bone, providing origin for masseter muscle fibres all along its length

Evoluzione dei muscoli mandibolari: grado epicinodonti primitivi

Es. *Thrinaxodon*

The magnitude of the laterally directed component of the force generated by the masseter muscle more closely matched the medially directed component of the temporalis

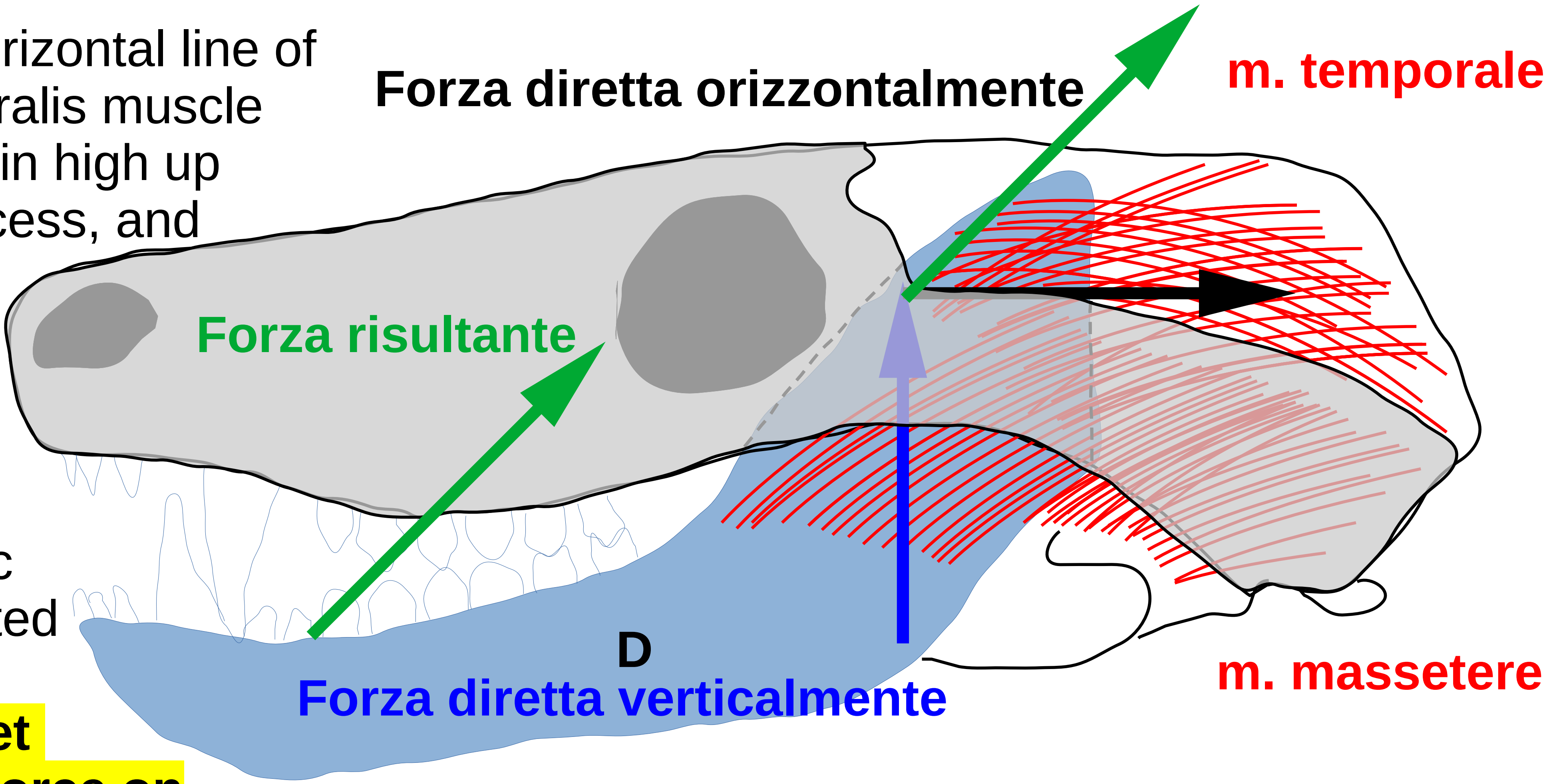
A closer approach to an actual balance between these two forces was achieved



Evoluzione dei muscoli mandibolari: grado epicinodonti primitivi

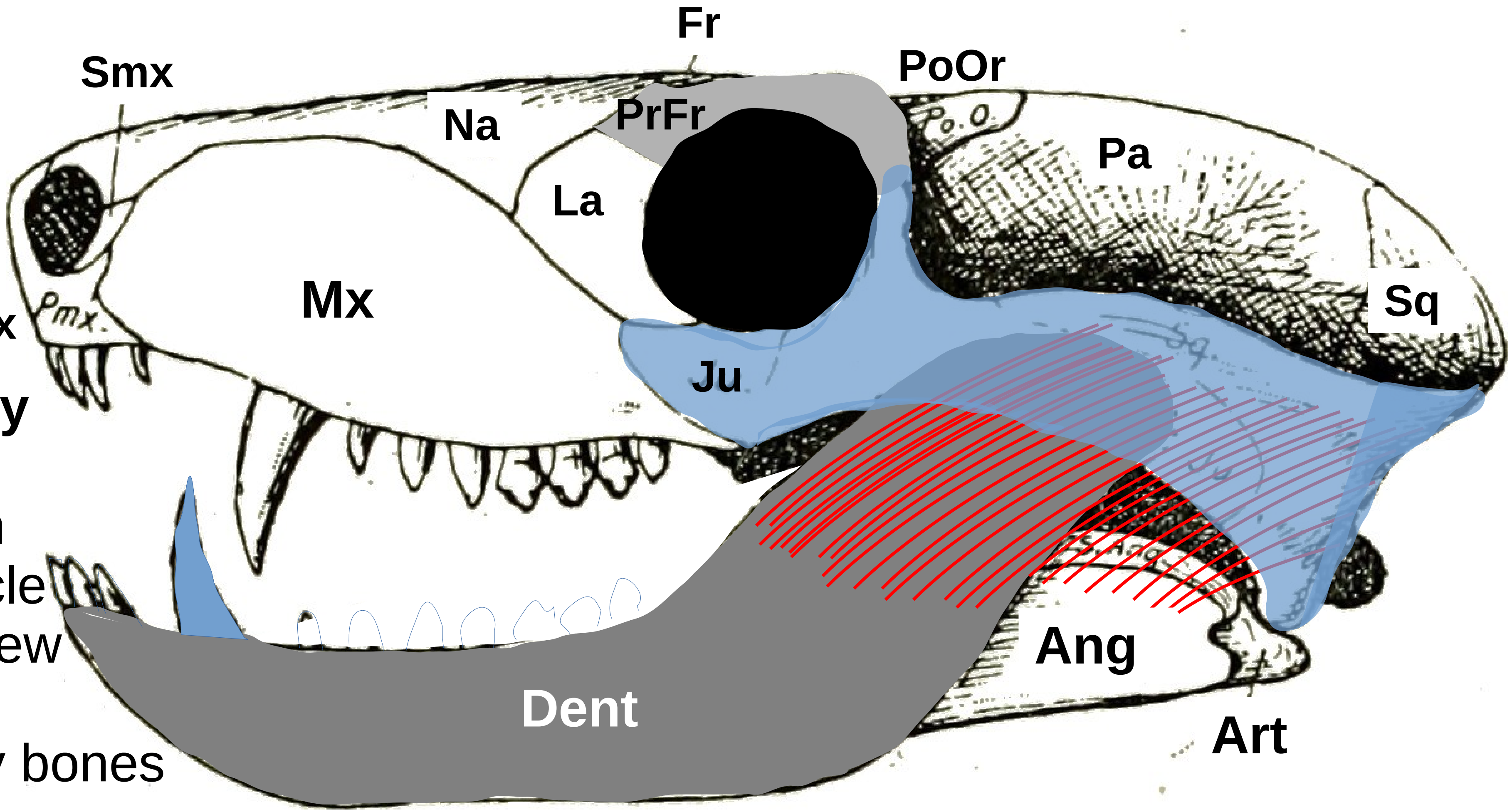
Es. *Thrinaxodon*

The increasingly horizontal line of action of the temporalis muscle from its area of origin high up in the coronoid process, and the increasingly vertical orientation of the masseter muscle as it expanded forwards along the zygomatic arch, together created a tendency to **concentrate the net adductor muscle force on the teeth**, and away from the jaw articulation



Evoluzione dell'anatomia craniale: grado epicinodonti primitivi

Es. *Thrinaxodon*

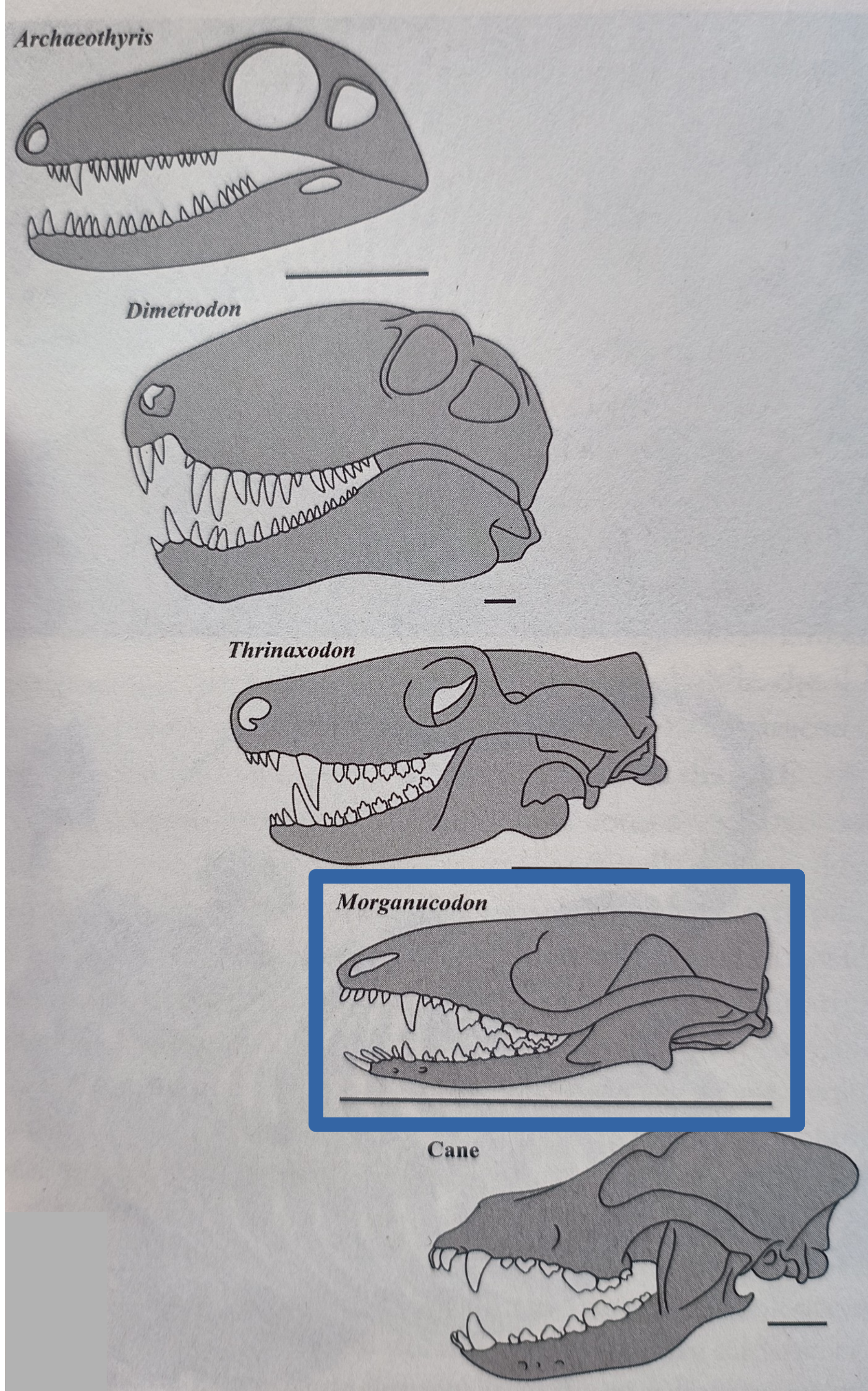


- An **enlarged dentary bone** captured an increased proportion of the total jaw muscle fibers, leaving very few still inserted on the reduced postdentary bones

- Stresses across the sutures between the the dentary on the one hand and the attached postdentary bones on the other were reduced, permitting the latter to be **less firmly attached**

L'evoluzione dei denti: il *Morganucodon*

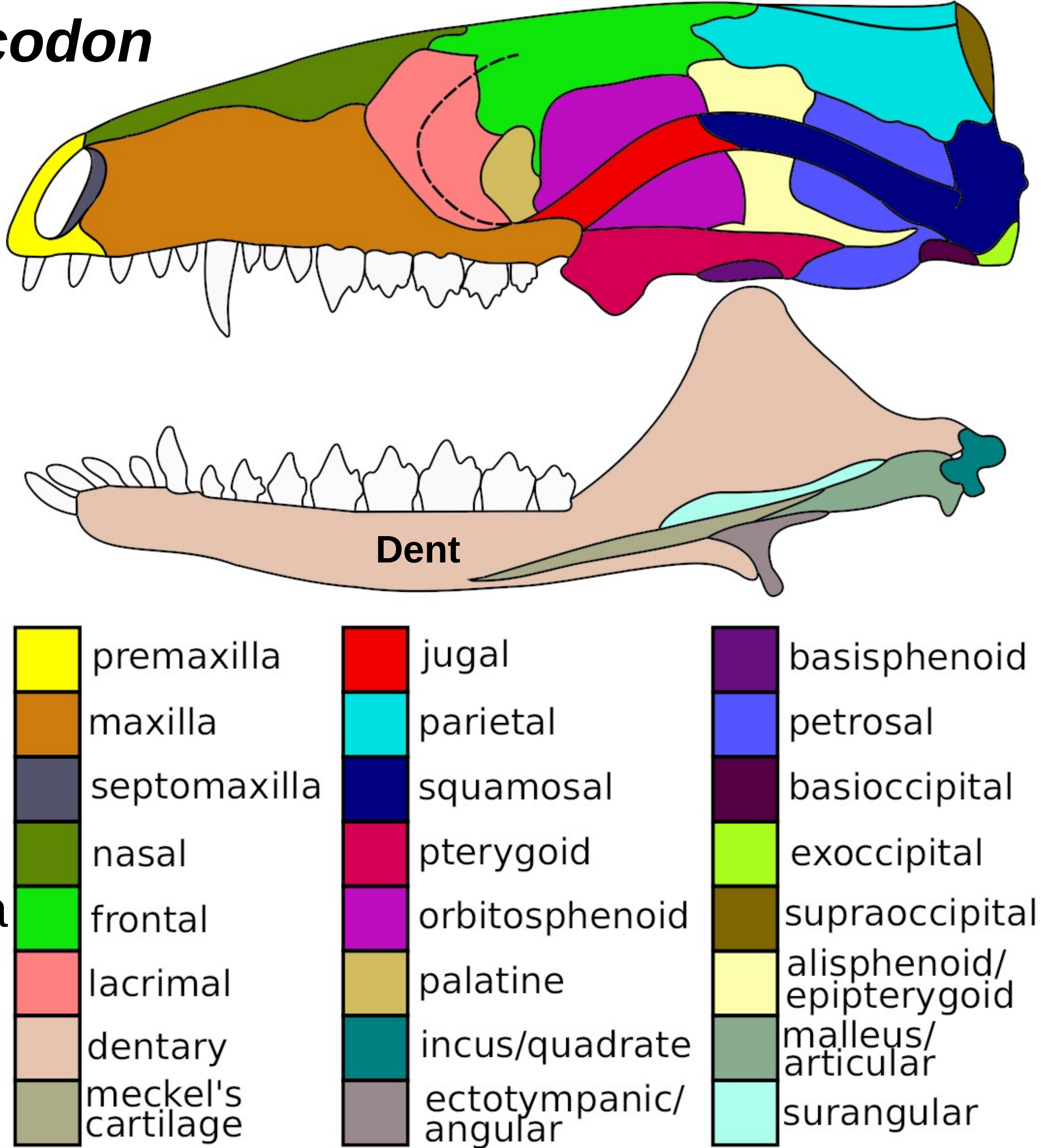
- Durante il Triassico superiore l'osso dentario in *Morganucodon* ed in altri Cinodonti diventò sempre più grande, fino ad entrare in contatto con il cranio. Si formò, così, una **giuntura ad incastro tra il dentario stesso e l'osso squamoso** del cranio.



L'evoluzione dei denti: il *Morganucodon*

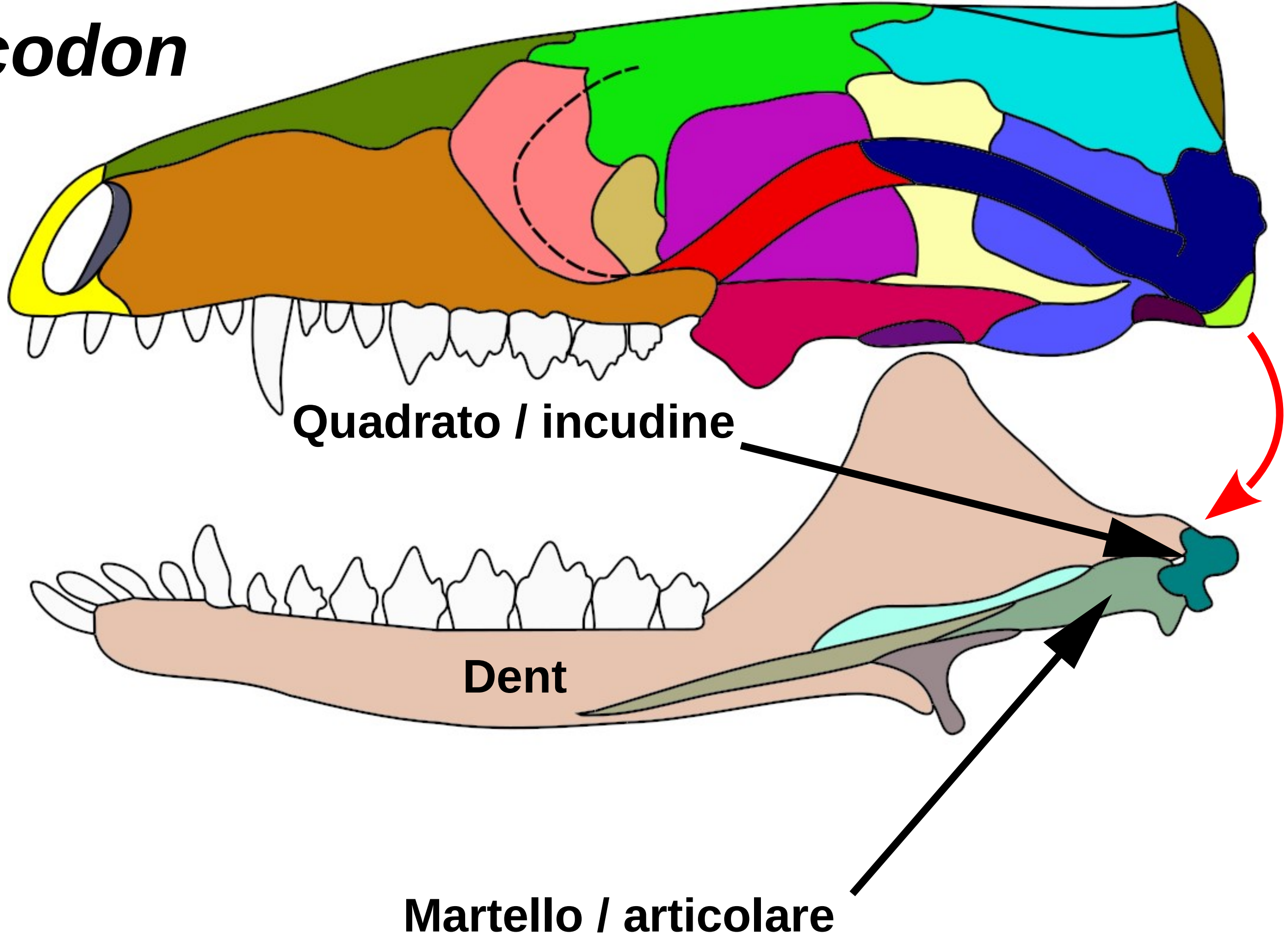
Mentre i loro antenati avevano mandibole formate da molte ossa, **nei Mammiferi rimane solo il dentario**, grazie al fatto che nei Cinodonti del Triassico i muscoli mandibolari, a mano a mano che si sviluppavano, si ancorarono in misura crescente a quest'osso.

Ciò implicò un innegabile vantaggio: il dentario è l'unico osso provvisto di denti, e redistribuire le inserzioni muscolari su di esso aumenta la potenza del morso e la precisione con la quale viene distribuita lungo la dentatura durante le varie fasi della masticazione.

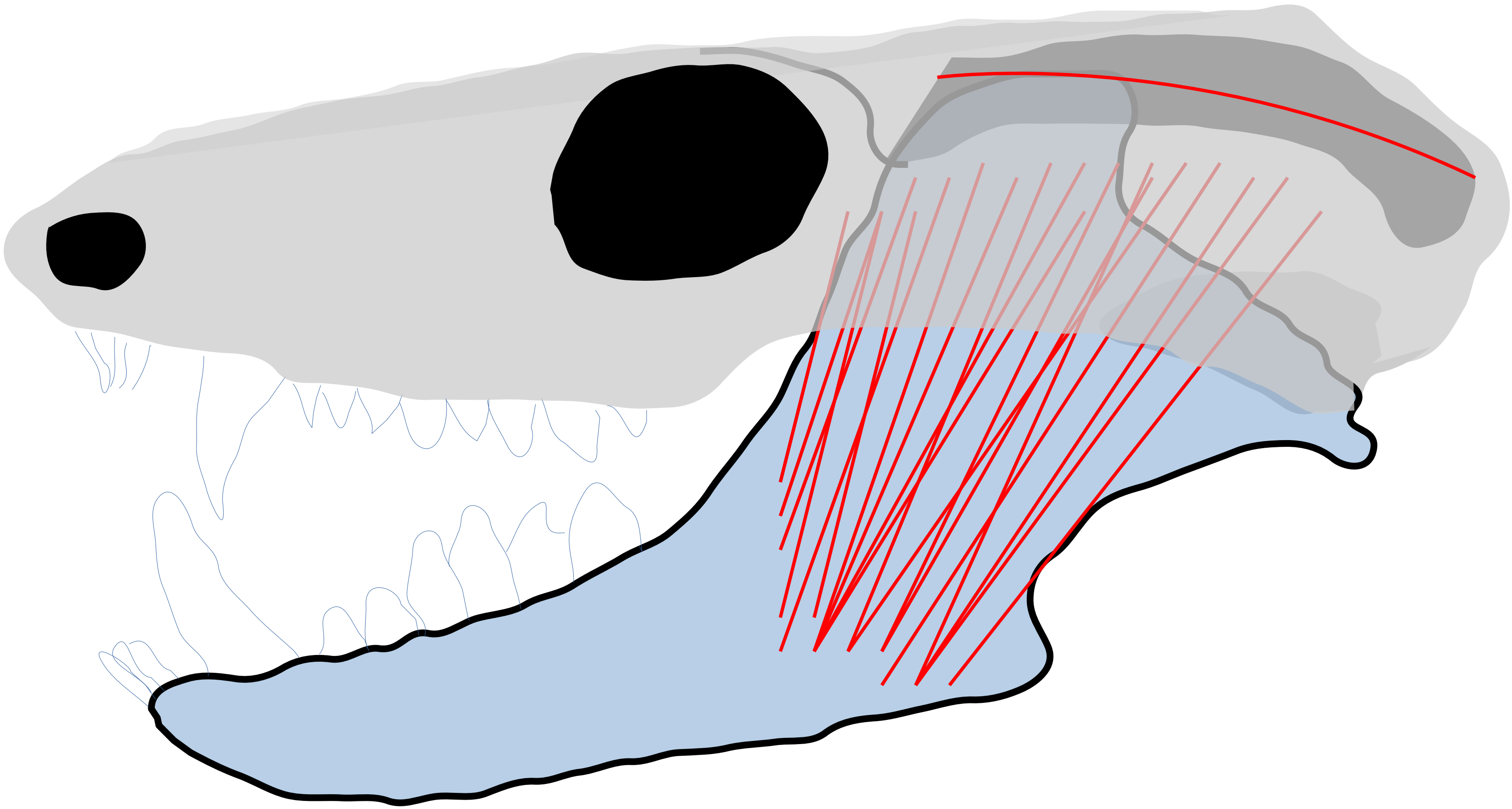


L'evoluzione dei denti: il *Morganucodon*

Il **quadrato** si separò dal cranio e diventò l'**incudine**, mentre dall'**articolare**, staccatosi dalla mandibola, si sviluppò il **martello**



L'evoluzione dei denti: il *Chiniquodon*



JEZ-B MOLECULAR AND DEVELOPMENTAL EVOLUTION

Volume 314B, Issue 6
15 September 2010
Pages 417-433

Review Article

History of studies on mammalian middle ear evolution: A comparative morphological and developmental biology perspective

Masaki Takechi, Shigeru Kuratani

First published: 04 August 2010 | https://doi.org/10.1002/jez.b.21347 | Citations: 66

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References Related Information

Abstract

The mammalian middle ear represents one of the most fundamental morphological features that define this class of vertebrates. Its skeletal pattern differs conspicuously from those of other amniotes and has attracted the attention of comparative zoologists for about 200 years. To reconcile this morphological inconsistency, early comparative morphologists suggested that the mammalian middle ear was derived from elements of the jaw joint of nonmammalian amniotes. Fossils of mammalian ancestors also implied a transition in skeletal morphology that resulted in the mammalian state. During

Recommended

Evolution of the mammalian middle ear: a historical review
Wolfgang Maier, Irina Ruf
Journal of Anatomy

Evolution of the mammalian middle ear
Edgar F. Allin
Journal of Morphology

Ear ossicle morphology of the Jurassic euharamiyidan

L'evoluzione dell'orecchio medio

Unlike nonmammalian amniotes, which have only one ossicle, the columella auris, the mammalian middle ear has three ossicles, the malleus, incus, and stapes.
The evolutionary origins of this complex and its homology is one of the most formidable conundrums in vertebrate comparative morphology.

Why is a difference in the number of the ossicles a problem?

It is problematic because **animals are usually unable to generate entirely new anatomical elements de novo in evolution**.

L'evoluzione dell'orecchio medio

Geoffroy Saint-Hilaire, a French anatomist, pointed out in 1818 that:

- **equivalent sets of skeletal elements are connected in an identical order in all animals**

- **every animal skeletal type is derived from changes to a common skeletal pattern**.

This *principe des connexions* is one of the simplest definitions for **morphological homology**

Two of the three ossicles in the mammalian middle ear must have their homologues in the nonmammalian skull, a phenomenon that has puzzled morphologists for many years

Developmental and evolutionary origins of the pharyngeal apparatus

Review | Open access | Published: 01 October 2012

Volume 3, article number 24, (2012) Cite this article

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Anthony Graham & Jo Richardson

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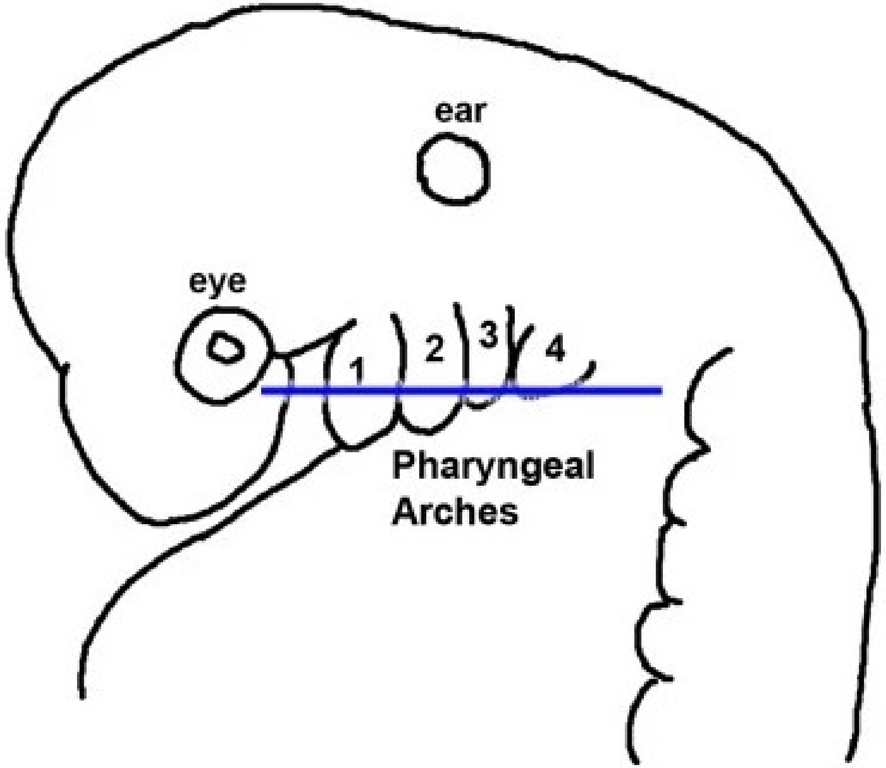
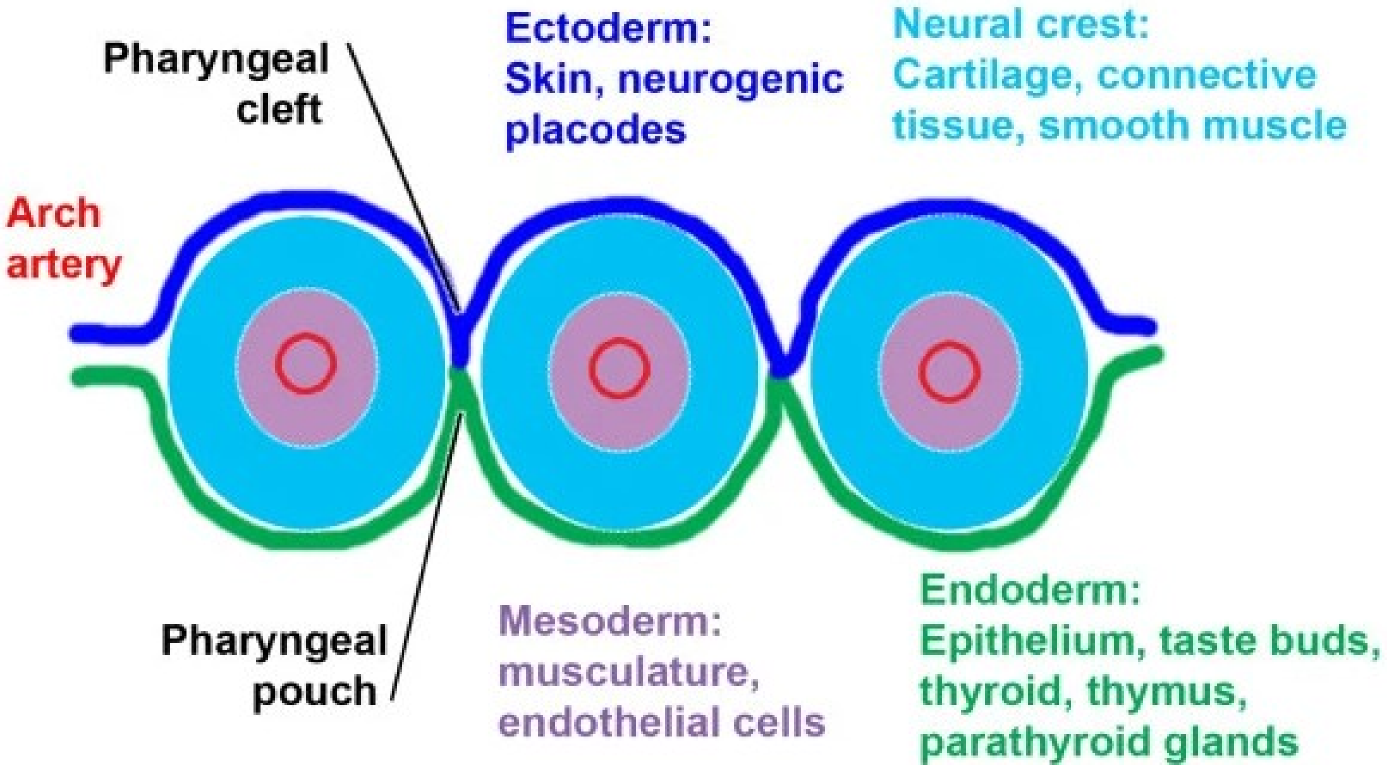
Abstract

The vertebrate pharyngeal apparatus, serving the dual functions of feeding and respiration, has its embryonic origin in a series of bulges found on the lateral surface of the head, the pharyngeal arches. Developmental studies have been able to discern how these structures are constructed and this has opened the way for an analysis of how the



ear
eye
1
2
3
4
Pharyngeal
Arches



Pharyngeal
cleft
Ectoderm:
Skin, neurogenic
placodes
Neural crest:
Cartilage, connective
tissue, smooth muscle
Arch
artery
Pharyngeal
pouch
Mesoderm:
musculature,
endothelial cells
Endoderm:
Epithelium, taste buds,
thyroid, thymus,
parathyroid glands

Journal of Anatomy

Volume 243, Issue 4
October 2023
Pages 564-569

REVIEW ARTICLE | Open Access

A revised terminology for the pharyngeal arches and the arch arteries

Anthony Graham, Jill P. J. M. Hikspoors, Robert H. Anderson, Wouter H. Lamers, Simon D. Bamforth

First published: 29 May 2023 | https://doi.org/10.1111/joa.13890 | Citations: 2

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Key separable events in the remodelling of the pharyngeal arches

Subathra Poopalasundaram, Jo Richardson, Anthony Graham

Journal of Anatomy

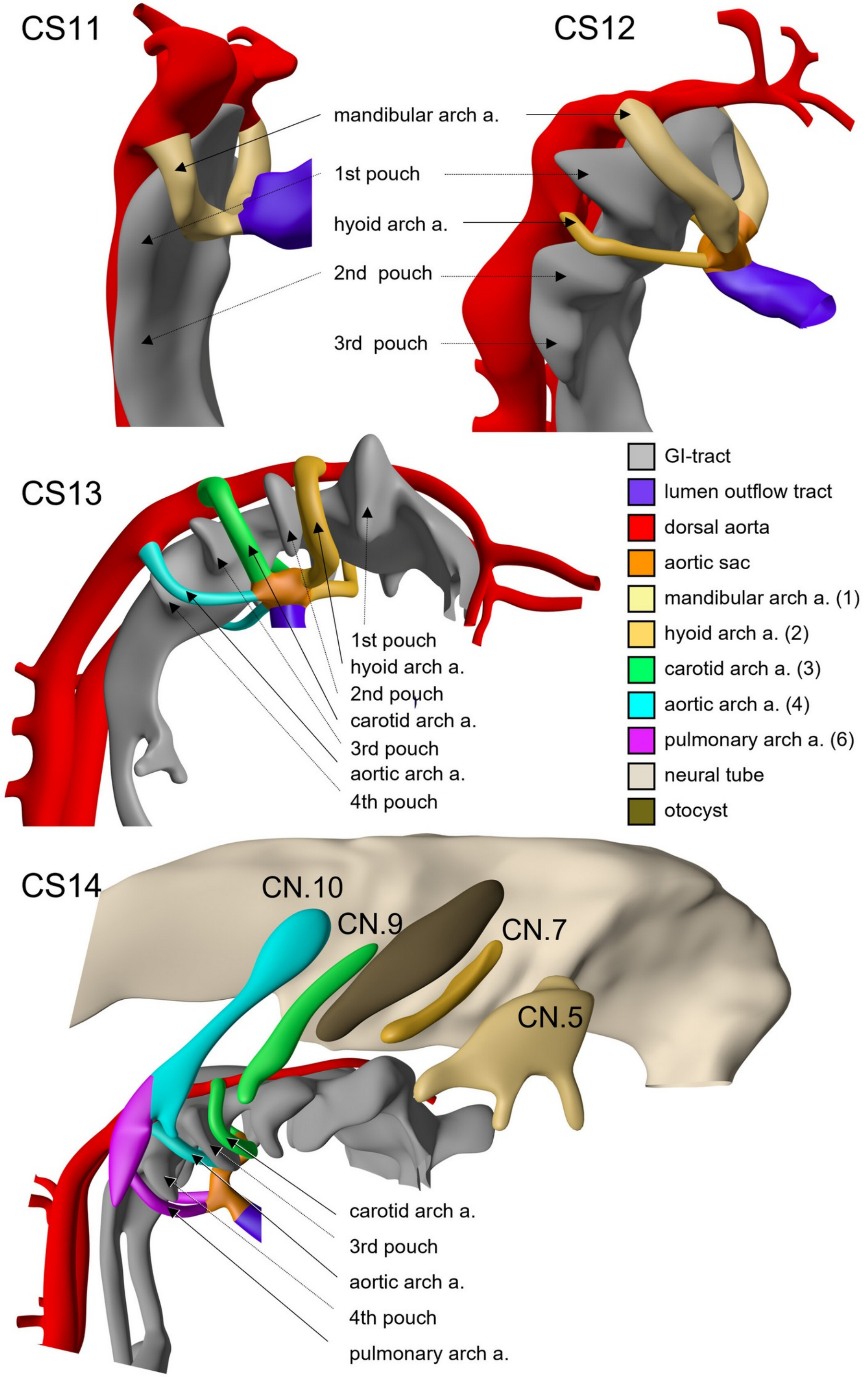
A reappraisal and revision of the numbering of the pharyngeal arches

Anthony Graham, Subathra Poopalasundaram, Victoria Shone, Clemens Kiecker

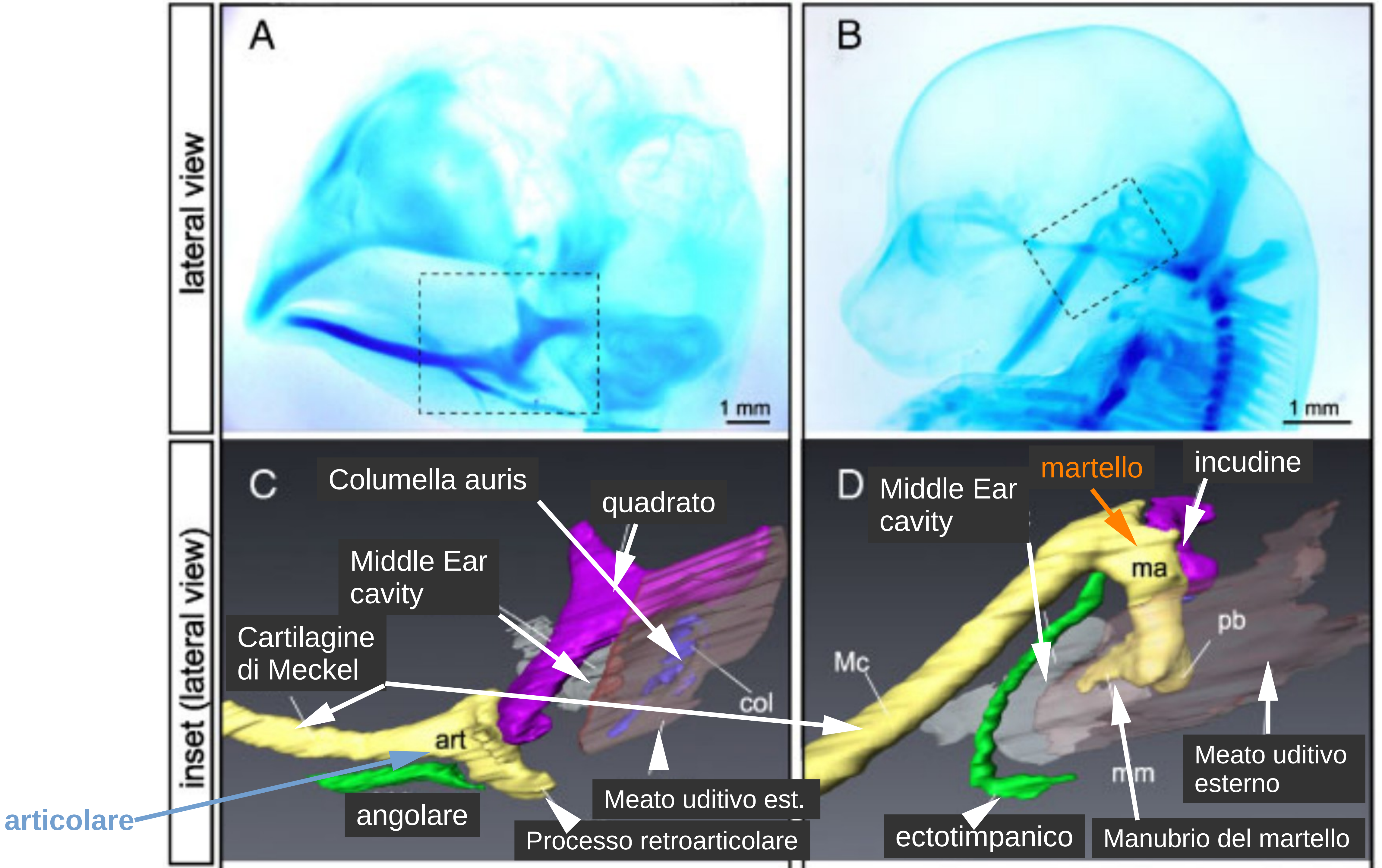
Journal of Anatomy

Abstract

The pharyngeal arches are a series of bulges found on the lateral surface of the head of vertebrate embryos. In humans, and other amniotes, there are five pharyngeal arches and traditionally these have been labelled from cranial to caudal—1, 2, 3, 4 and 6. This numbering is odd—there is no ‘5’. Two reasons have been given for this. One is that during development, a ‘fifth’ arch forms transiently but is not fully realised. The second is that this numbering fits with the evolutionary history of the pharyngeal arches. Recent studies, however, have shown that neither of these justifications have basis. The



CS11
CS12
mandibular arch a.
1st pouch
hyoid arch a.
2nd pouch
3rd pouch
CS13
1st pouch
hyoid arch a.
2nd pouch
carotid arch a.
3rd pouch
aortic arch a.
4th pouch
GI-tract
lumen outflow tract
dorsal aorta
aortic sac
mandibular arch a. (1)
hyoid arch a. (2)
carotid arch a. (3)
aortic arch a. (4)
pulmonary arch a. (6)
neural tube
otocyst
CS14
CN.10
CN.9
CN.7
CN.5
carotid arch a.
3rd pouch
aortic arch a.
4th pouch
pulmonary arch a.



lateral view
inset (lateral view)
A
1 mm
B
1 mm
C
Columella auris
quadrato
Middle Ear cavity
Cartilagine di Meckel
art
col
angolare
articolare
Meato uditivo est.
Processo retroarticolare
D
Middle Ear cavity
martello
incudine
ma
pb
Mc
mm
Meato uditivo esterno
ectotimpanico
Manubrio del martello

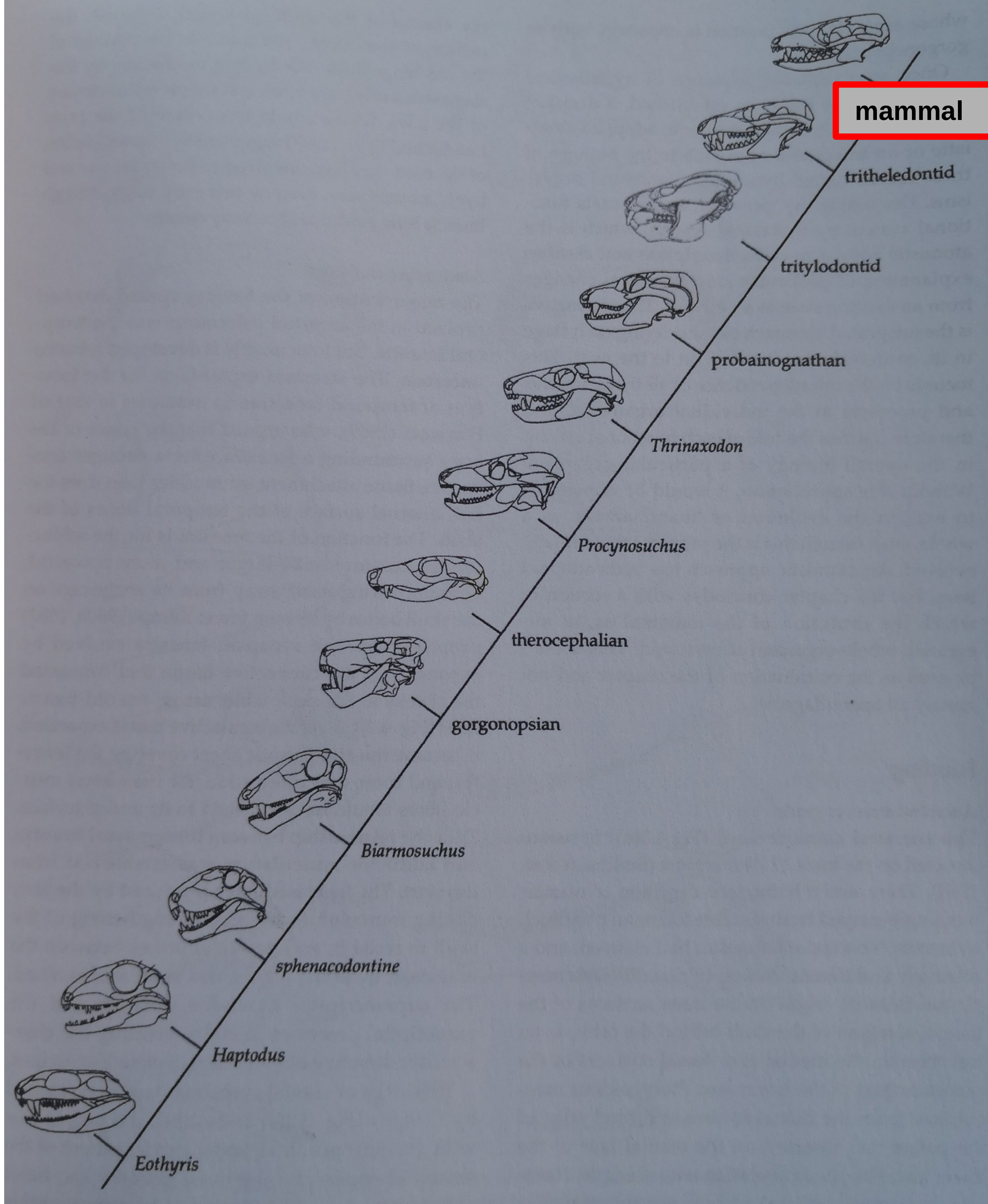
Il Giurassico

The

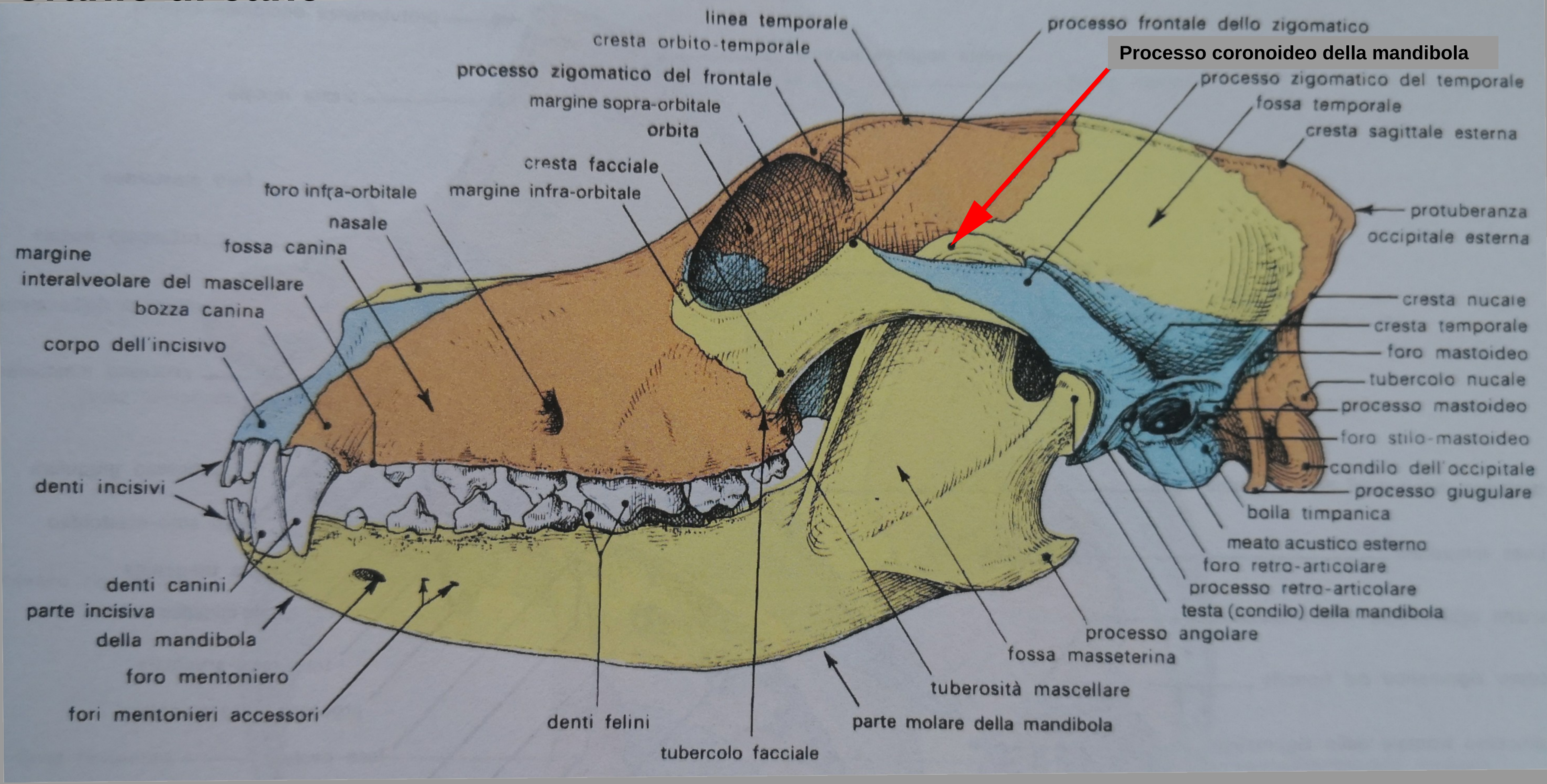
Il Giurassico

By the Mesozoic, 150 million years ago, **sauropsids** included the largest animals anywhere. Shown are some late Jurassic dinosaurs, including the early bird *Archaeopteryx* perched on a tree stump.

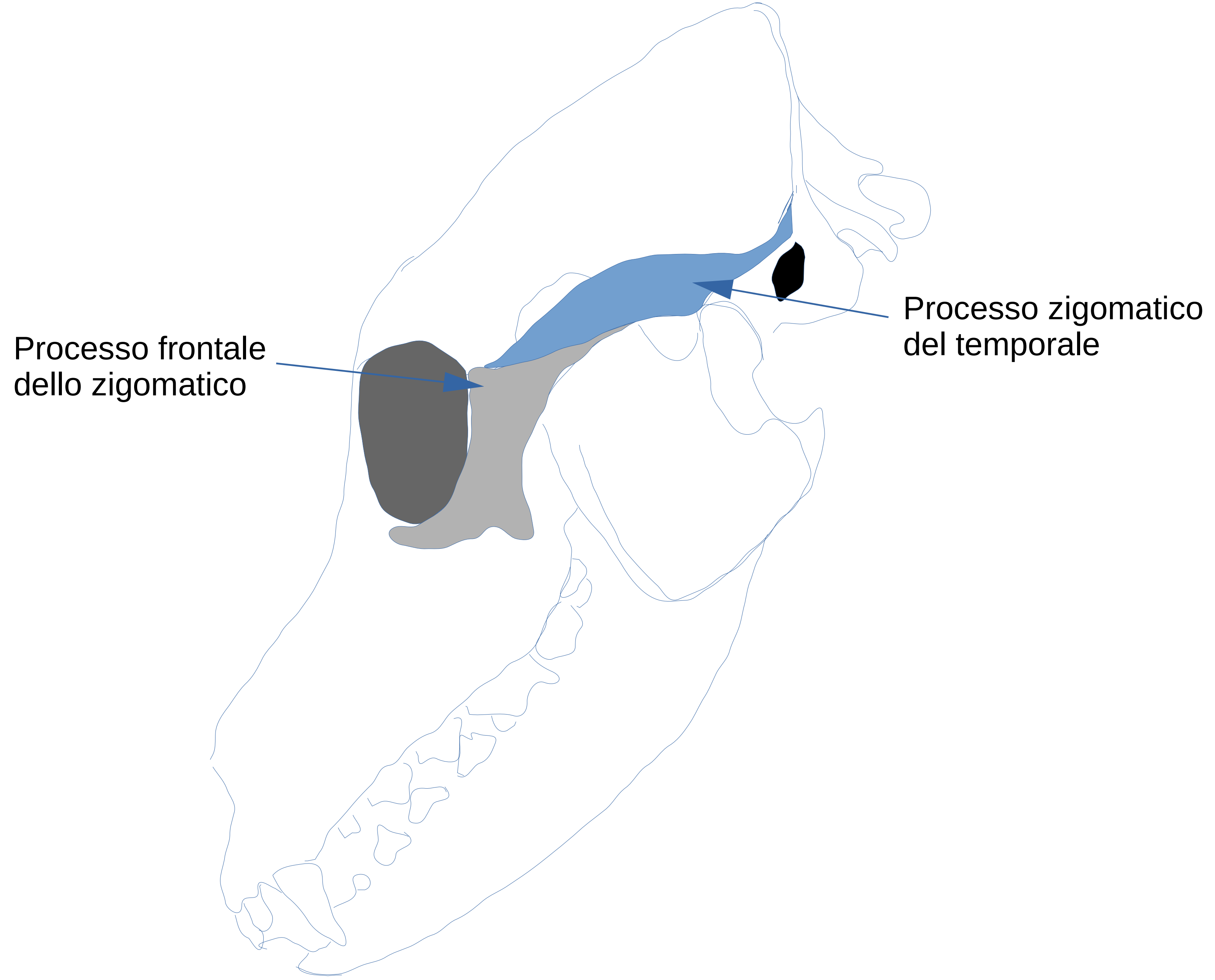
Il cladogramma dei Sinapsidi



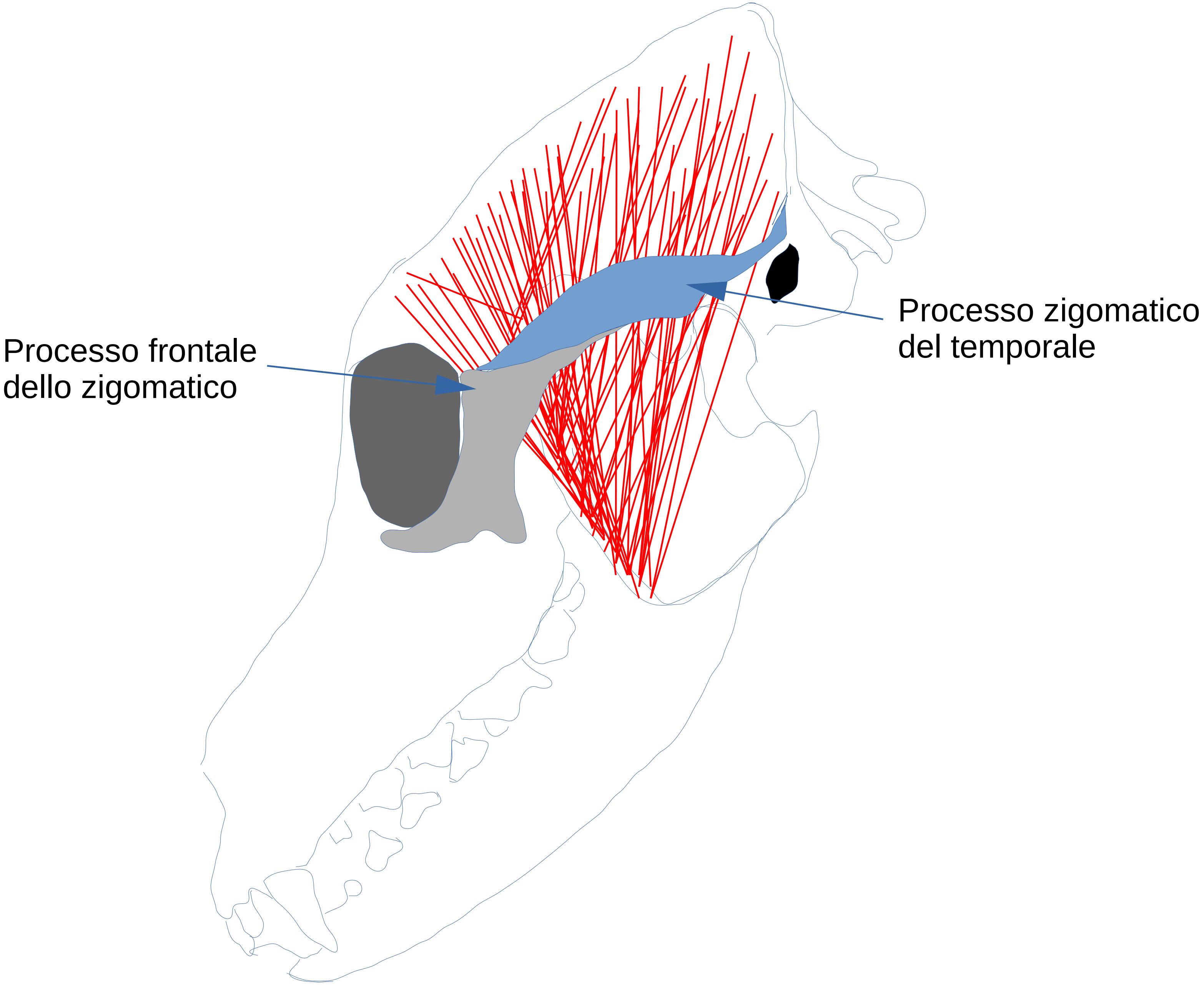
Cranio di cane



Cranio di cane



Il muscolo temporale



Il muscolo massetere

Il m. massetere è la componente laterale dell'adduttore della mandibola; origina dall'arcata zigomatica, che delimita lateralmente la finestra temporale