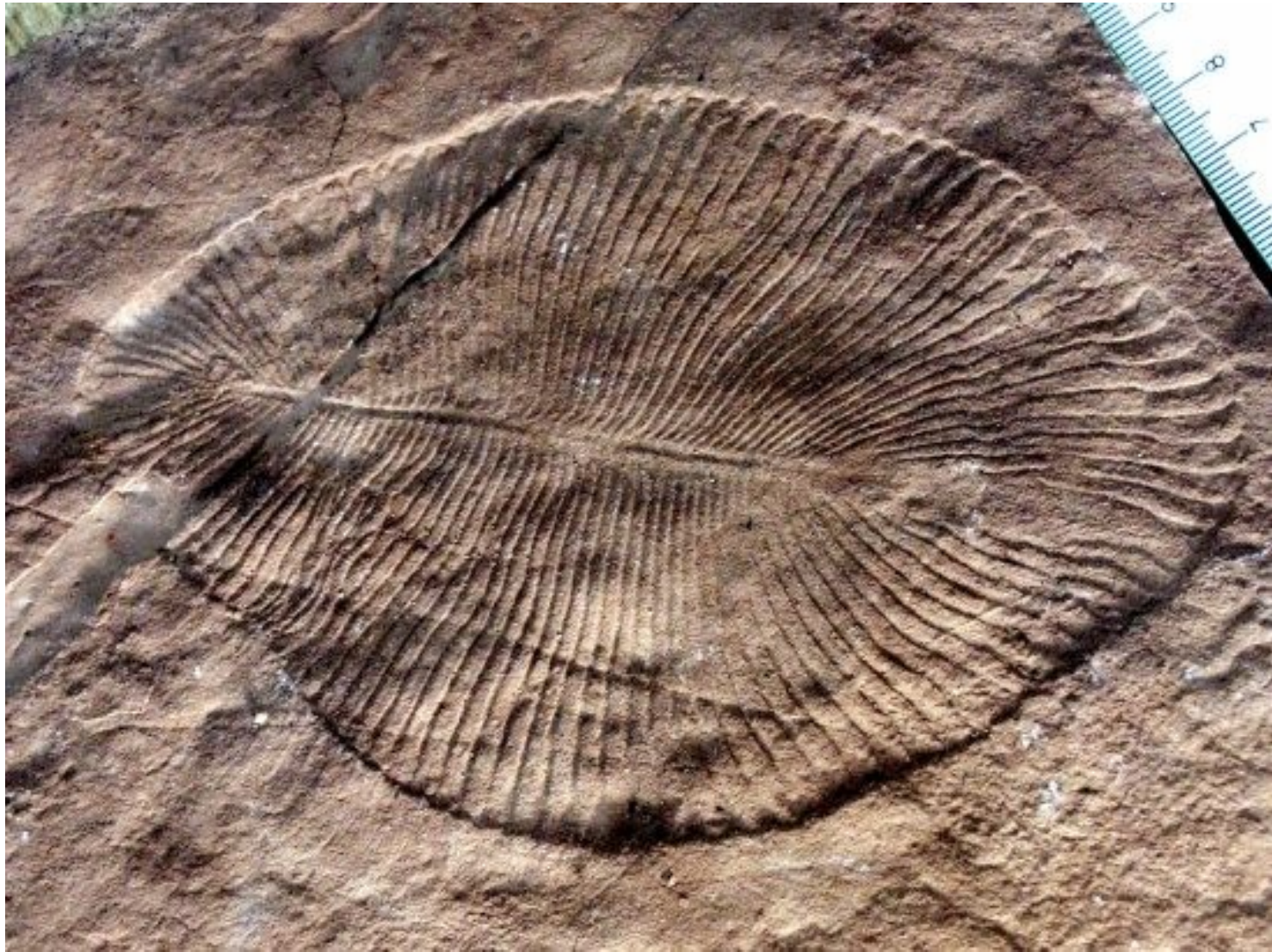
La fauna di Ediacara

The Ediacaran is the period that started 635 My ago (after the Marinoan glaciation) and that ended 542 My ago (with the discover of the earliest widespread complex trace fossil).



Dickinsonia costata fossil. According to its shape, it was probably a bilateral animal (with a ‘head’ and an ‘anus’), and for a long time it was suggested that it was related to some kind of flat worm, some of which could be up to 1 meter long.
In 2018, cholesterol molecules found in *Dickinsonia* fossils confirmed that it was an animal.

La fauna di Ediacara

La fauna di Ediacara

EARLY ANIMALS

Ancient steroids establish the Ediacaran fossil *Dickinsonia* as one of the earliest animals

Ilya Bobrovskiy[1]*, Janet M. Hope[1], Andrey Ivantsov[2], Benjamin J. Nettersheim[3], Christian Hallmann[3,4], Jochen J. Brocks[1]*

The enigmatic Ediacara biota (571 million to 541 million years ago) represents the first macroscopic complex organisms in the geological record and may hold the key to our understanding of the origin of animals. Ediacaran macrofossils are as "strange as life on another planet" and have evaded taxonomic classification, with interpretations ranging from marine animals or giant single-celled protists to terrestrial lichens. Here, we show that lipid biomarkers extracted from organically preserved Ediacaran macrofossils unambiguously clarify their phylogeny. *Dickinsonia* and its relatives solely produced cholesteroids, a hallmark of animals. Our results make these iconic members of the Ediacara biota the oldest confirmed macroscopic animals in the rock record, indicating that the appearance of the Ediacara biota was indeed a prelude to the Cambrian explosion of animal life.

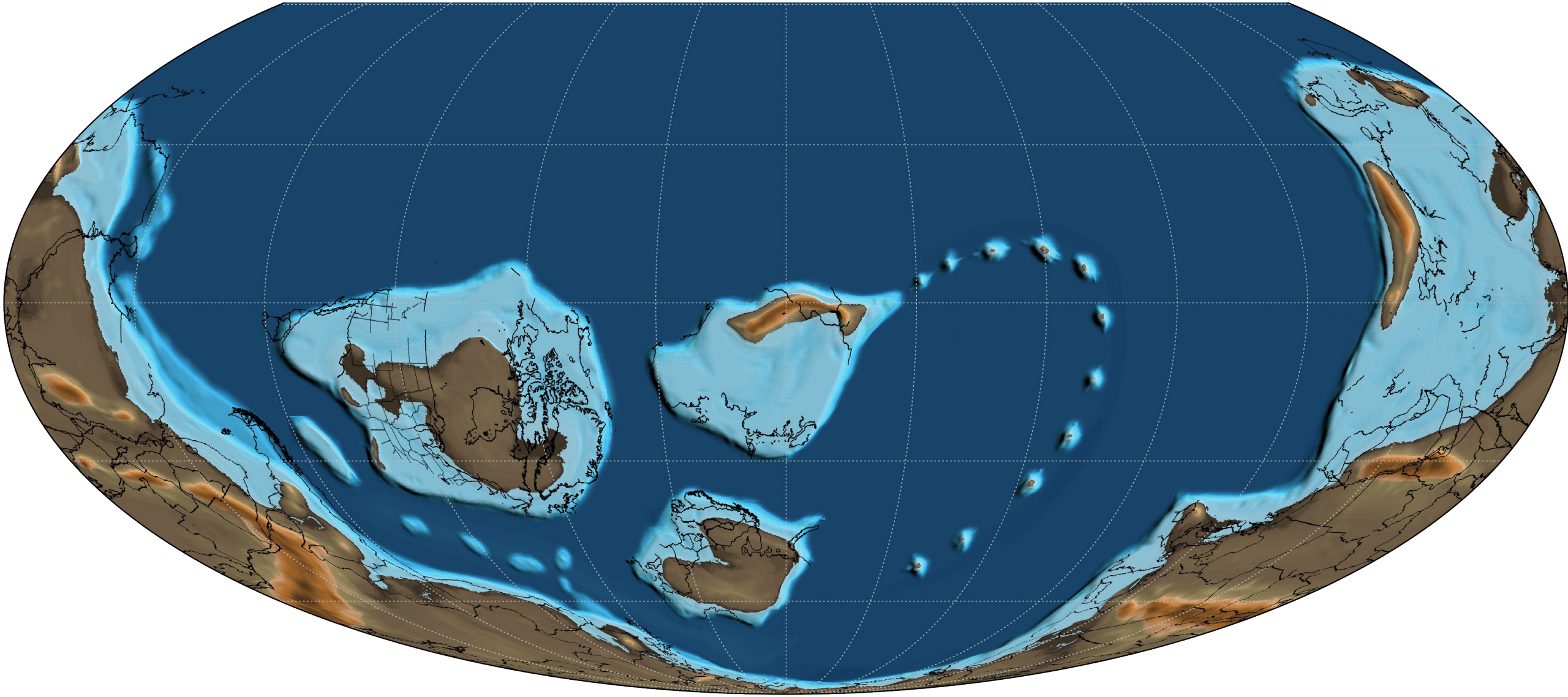
Il Cambriano

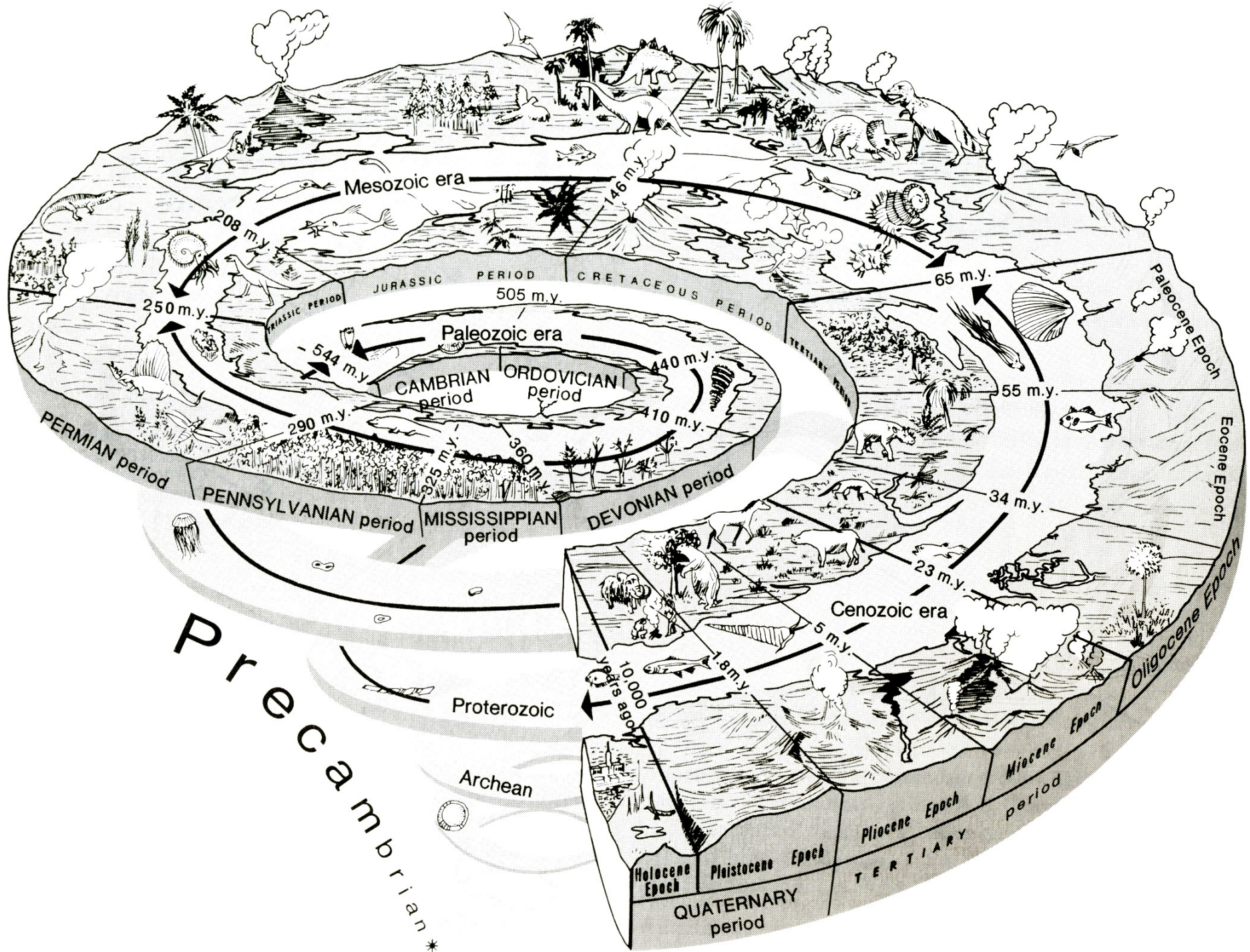
The end of the Precambrian supereon lead to the beginning of the Phanerozoic eon, whose first geological period, the Cambrian, has been traditionally considered to set the origin of all phyla of metazoans (multicellular animals).

All animal phyla were already represented shortly after the beginning of this period; that is, it took place a great diversification of living beings on a global scale in a short span, an evolutive radiation event. This massive evolutive event was named as Cambrian Explosion.

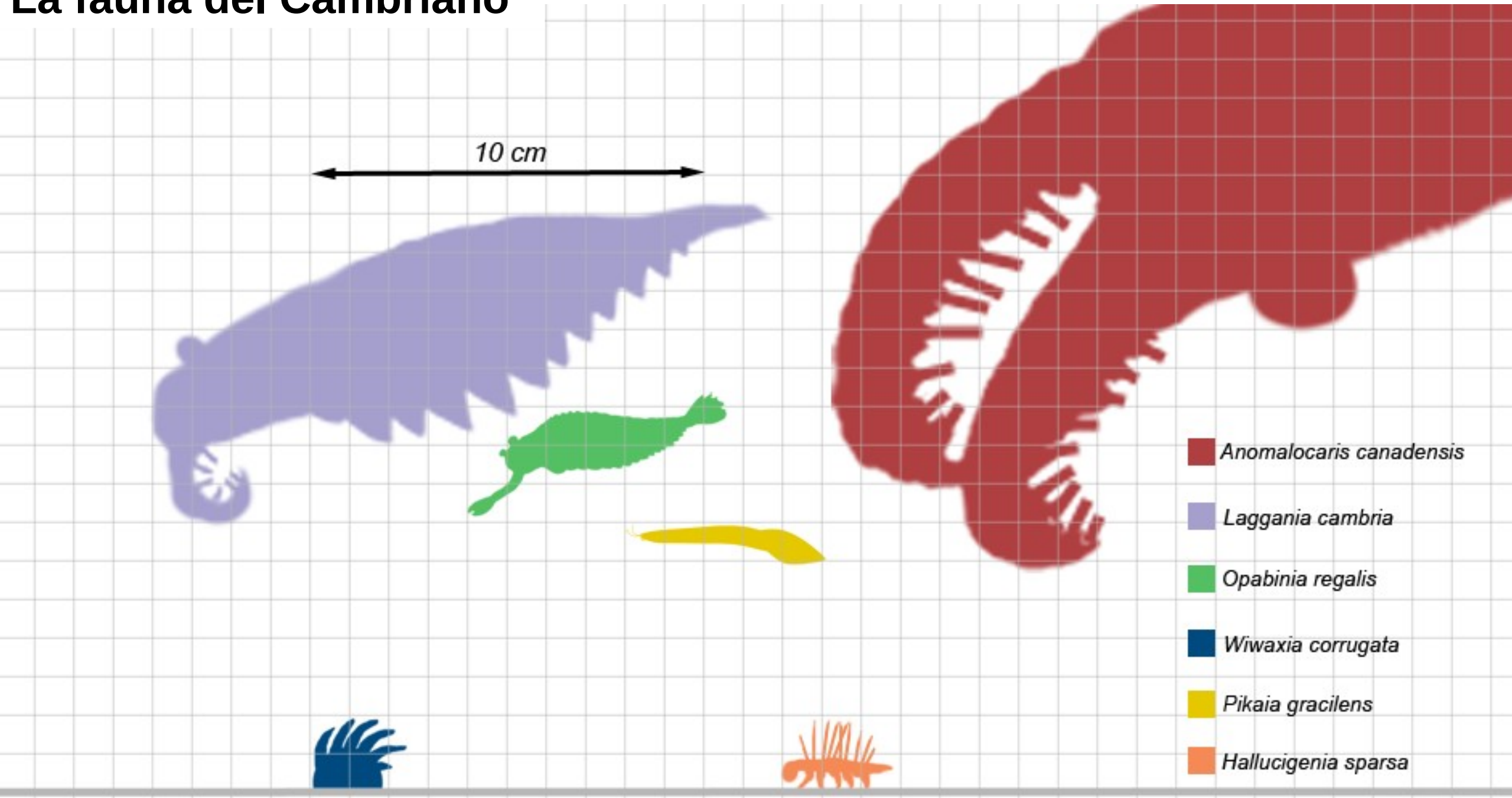
Il Cambriano (538.8 ± 0.2 – 485.4 ± 1.9 Mya)

A map of Earth 510 million years ago, overlayed by a black outline of present-day countries in their respective locations.

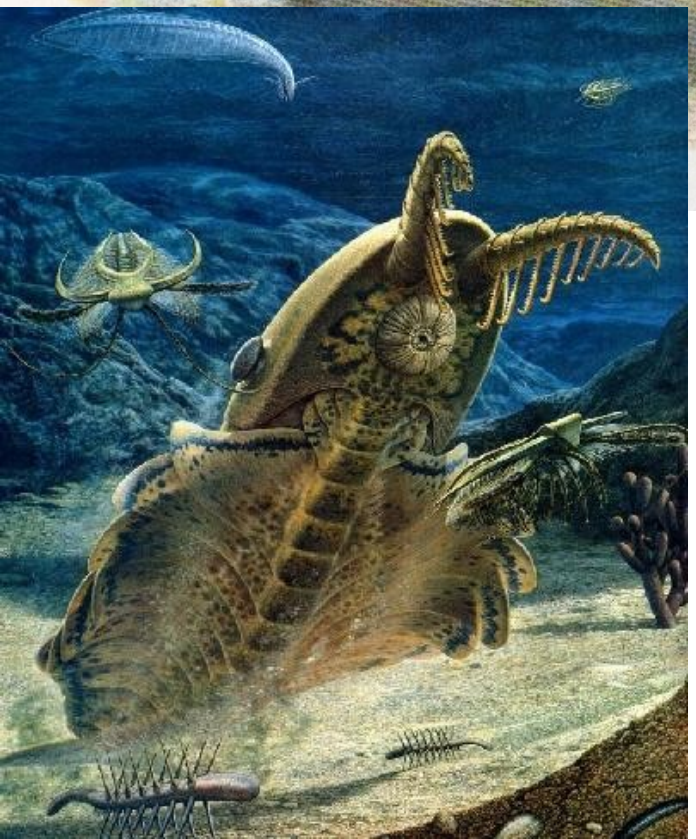



Mesozoic era
208 m.y.
146 m.y.
250 m.y.
TRIASSIC PERIOD
JURASSIC PERIOD
CRETACEOUS PERIOD
TERTIARY PERIOD
65 m.y.
505 m.y.
Paleozoic era
544 m.y.
CAMBRIAN period
ORDOVICIAN period
440 m.y.
410 m.y.
290 m.y.
360 m.y.
325 m.y.
PERMIAN period
PENNSYLVANIAN period
MISSISSIPPIAN period
DEVONIAN period
Paleocene Epoch
55 m.y.
Eocene Epoch
34 m.y.
23 m.y.
Cenozoic era
5 m.y.
1.8 m.y.
10,000 years ago
Oligocene Epoch
Miocene Epoch
Pliocene Epoch
TERTIARY period
Holocene Epoch
Pleistocene Epoch
QUATERNARY period
Precambrian
Proterozoic
Archean

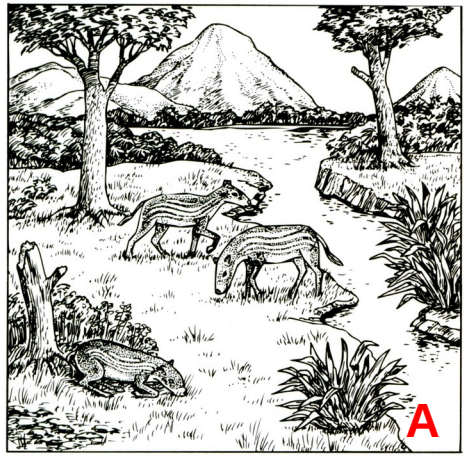
La fauna del Cambriano

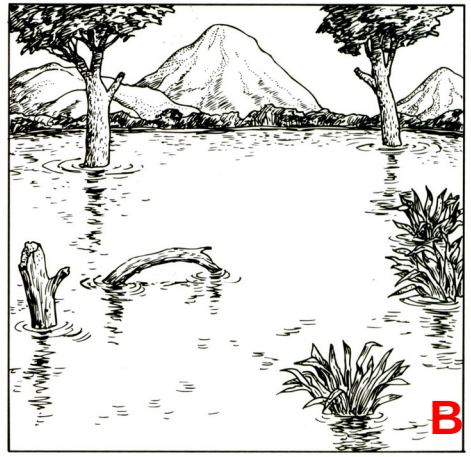


La fauna del Cambriano

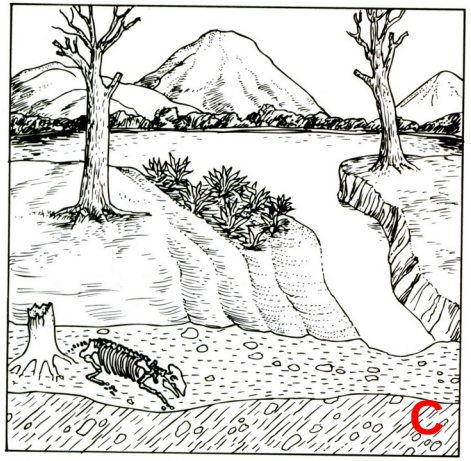


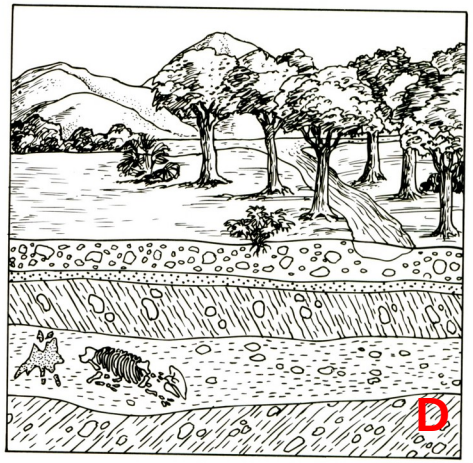
I fossili



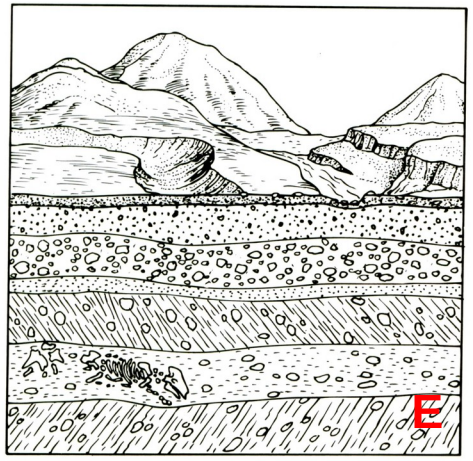


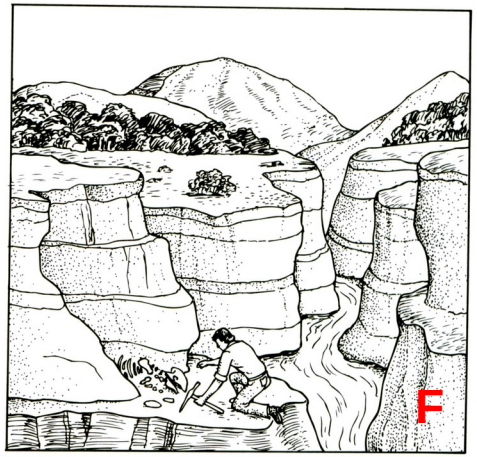
A) I resti di animali estinti possono conservarsi se riescono a sfuggire agli animali consumatori di carogne (*scavengers*), ai decompositori ed al successivo spostamento tettonico delle zolle litosferiche che costituiscono la crosta terrestre della zona in cui essi vivevano.
B) Generalmente, ciò avviene se il sito viene inondato.





C) La carogna che giace sul fondale del corpo idrico viene progressivamente ricoperta di sedimenti cosicché (**D**) viene sepolta sempre più profondamente in un materiale che, nel corso di milioni di anni, si compatta in una dura roccia sedimentaria (**E**).





Affinché il fossile contenuto nella roccia venga esposto, è necessario che si formi una spaccatura del substrato roccioso o che quest'ultimo venga eroso dall'azione abrasiva degli agenti atmosferici o, più frequentemente, dell'acqua di un fiume (**F**).

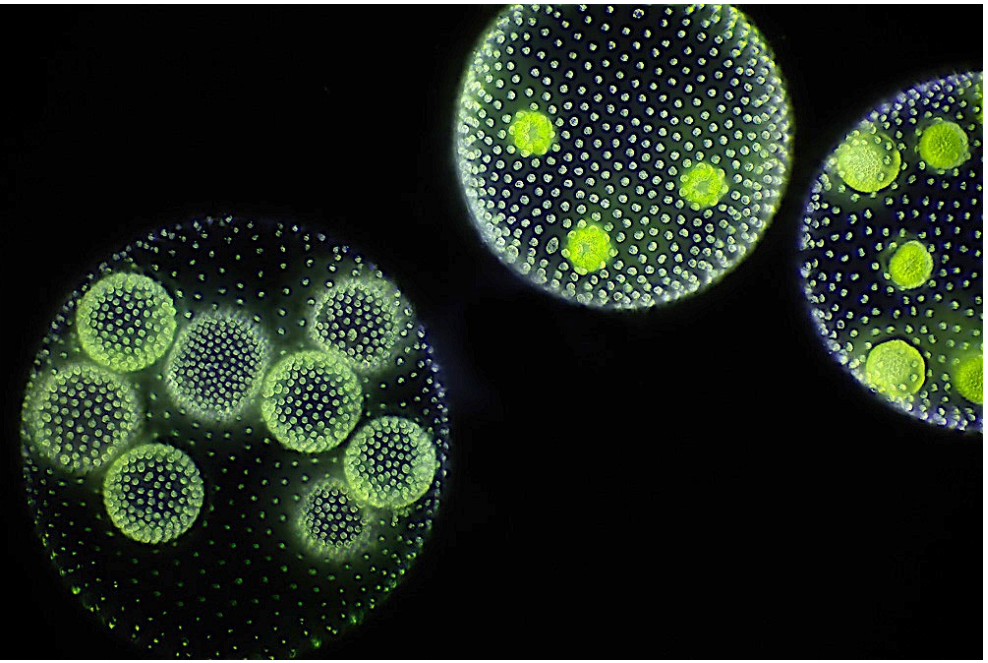
I fossili

La simmetria corporea

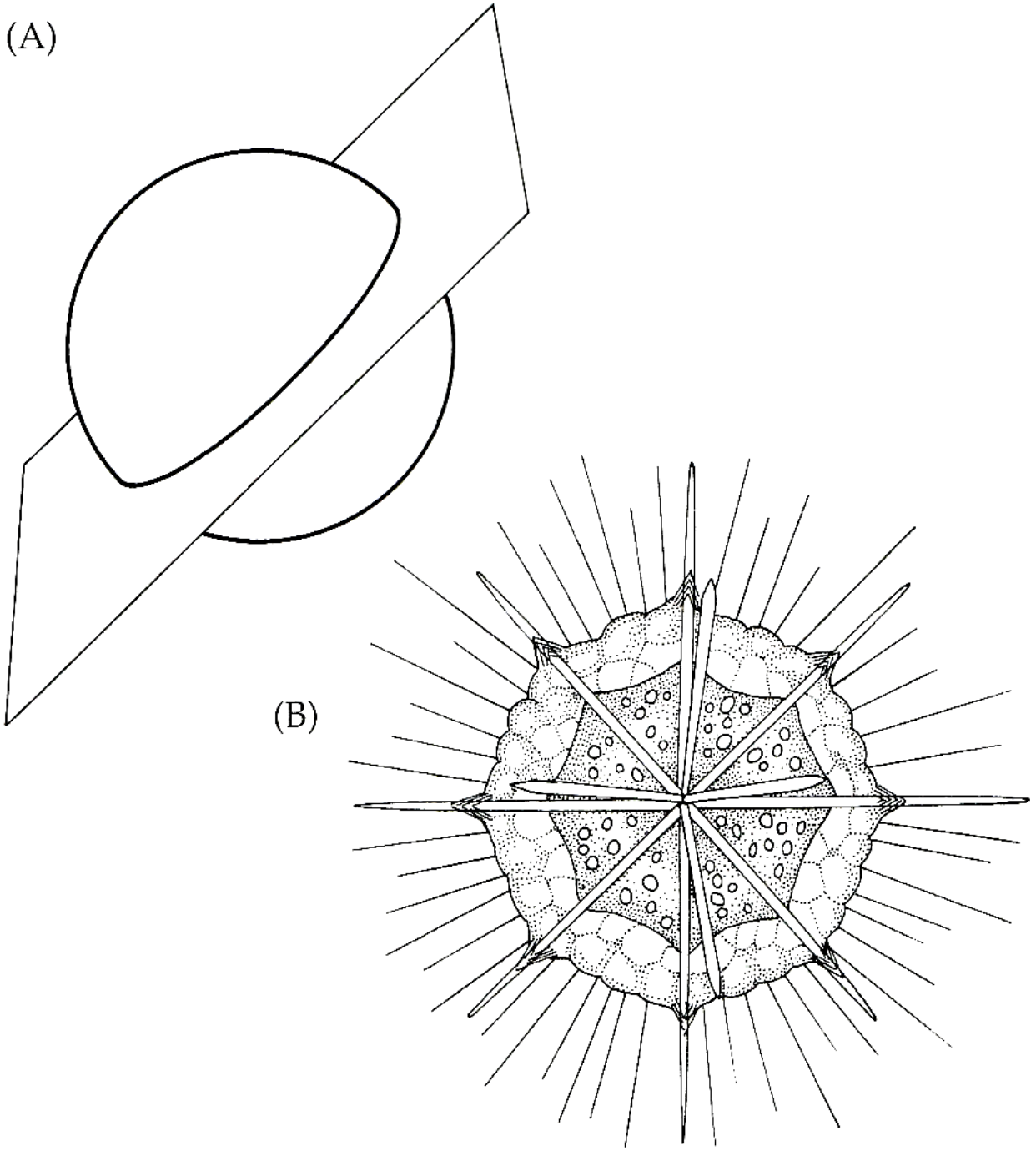
Un aspetto fondamentale del piano strutturale o architettura corporea (Bauplan) di un animale è rappresentato dalla sua forma o geometria complessiva.

A propria volta, l'architettura corporea riconosce nella simmetria una proprietà basilare della forma degli organismi, dove per simmetria si intende la disposizione regolare delle strutture somatiche rispetto all'asse del corpo.

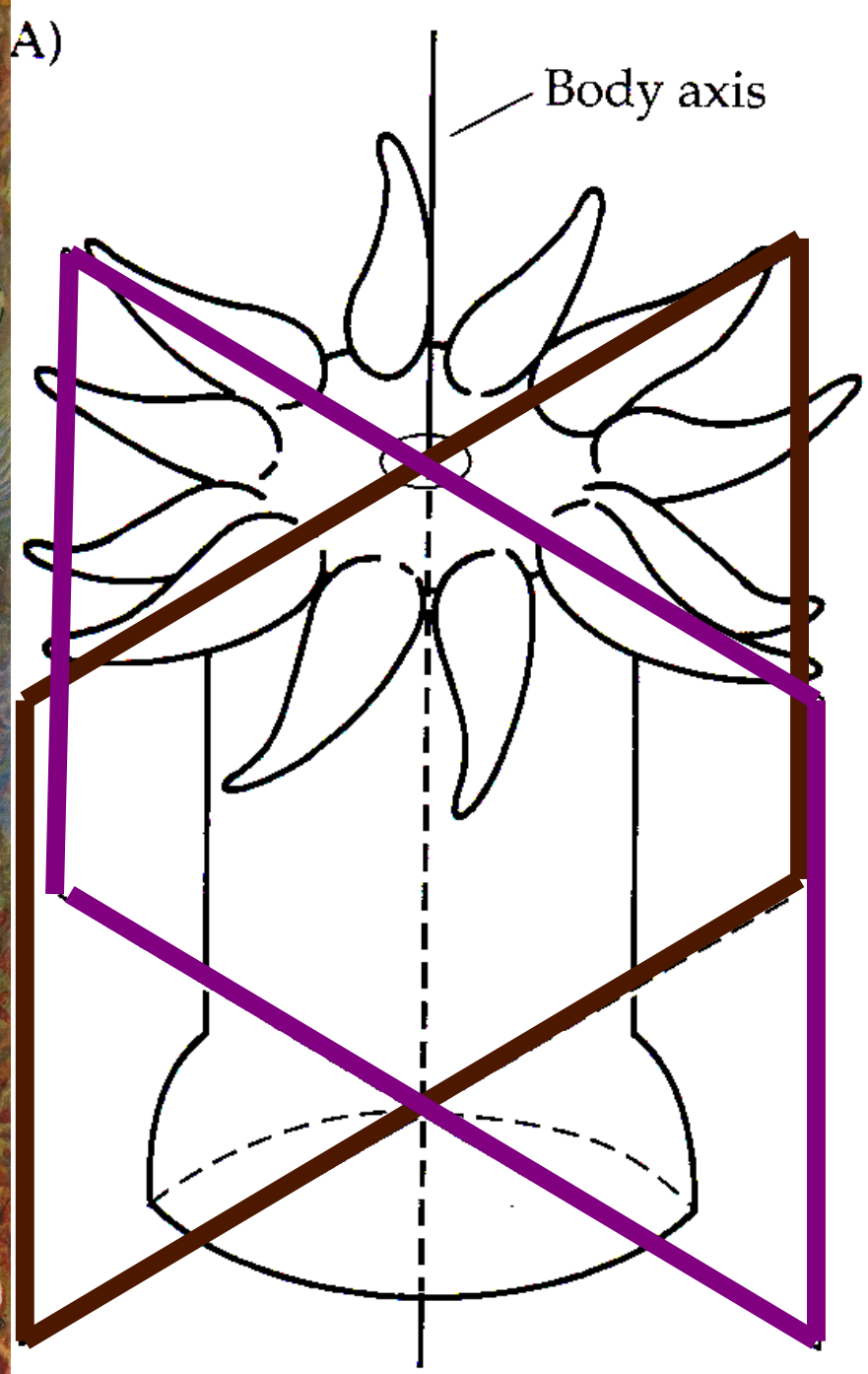
Simmetria sferica



Volvox is a microscopic green freshwater alga with spherical symmetry. Young colonies can be seen inside the larger ones.

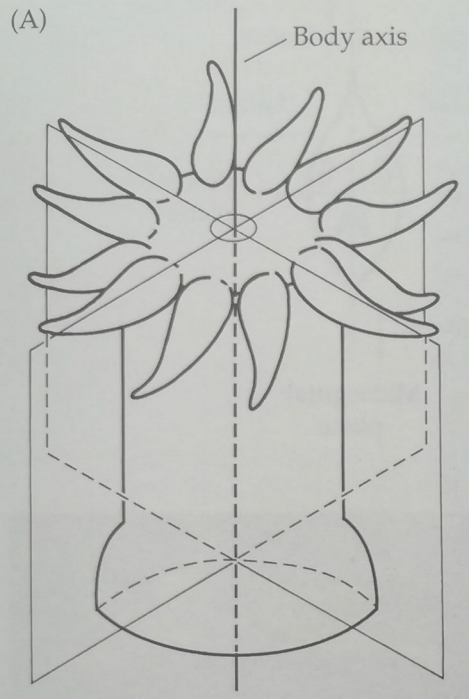


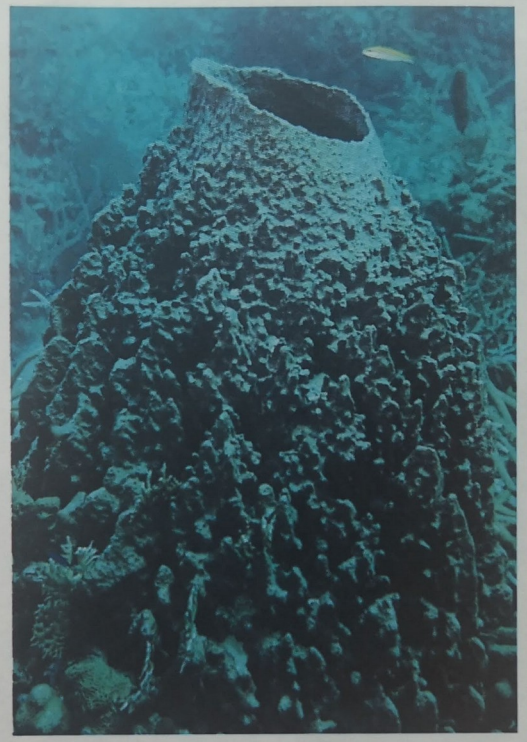
Simmetria radiale

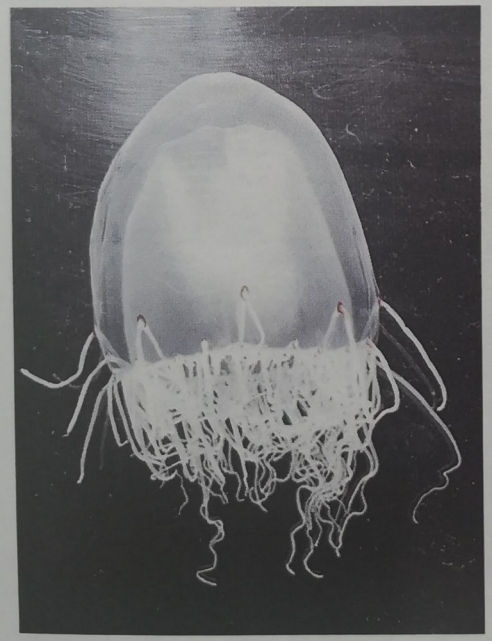


These sea anemones have been painted to emphasize their radial symmetry.
(Plate from Ernst Haeckel's *Kunstformen der Natur*).

Simmetria radiale



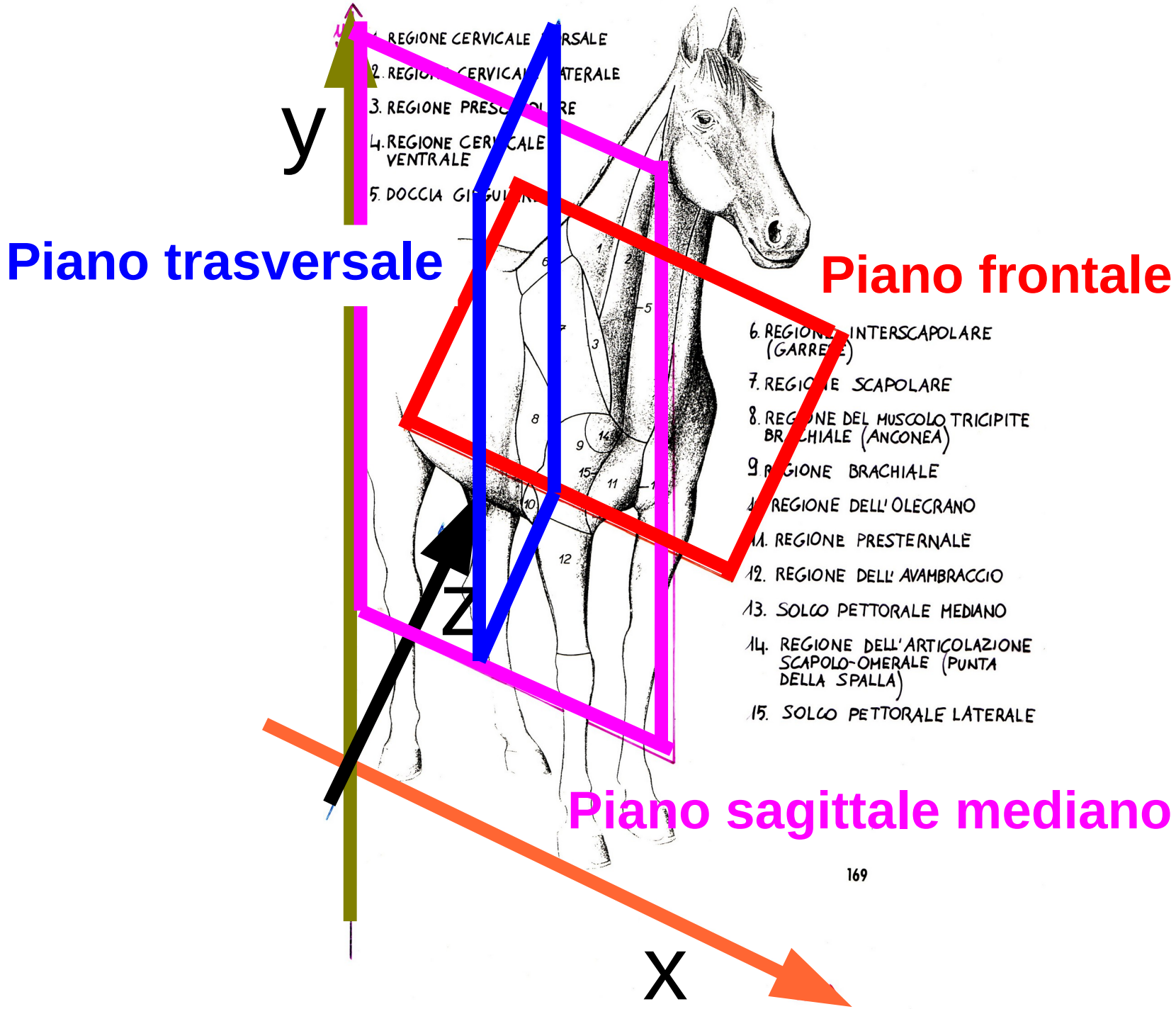


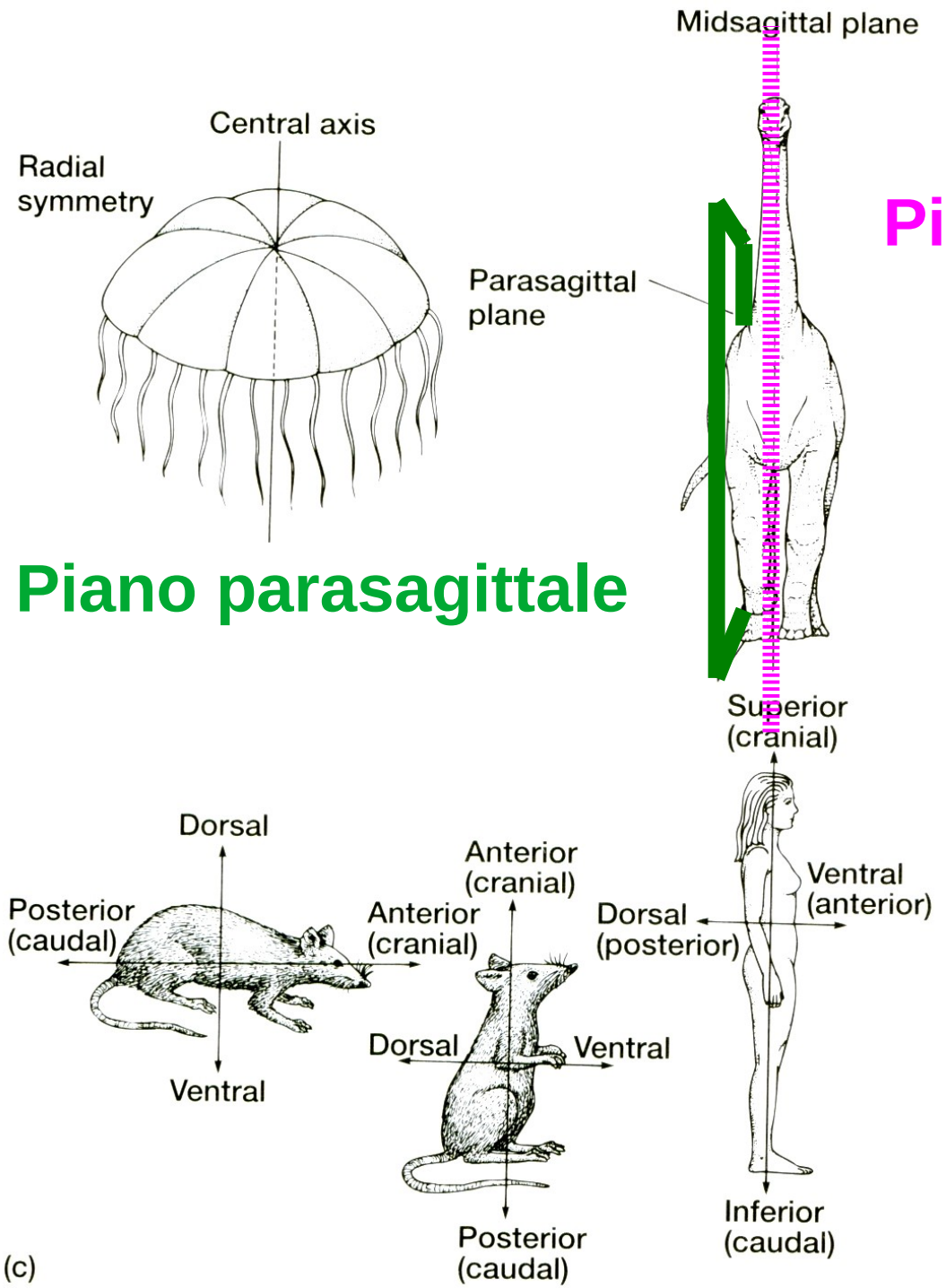


Simmetria bilaterale

Simmetria bilaterale

Simmetria bilaterale

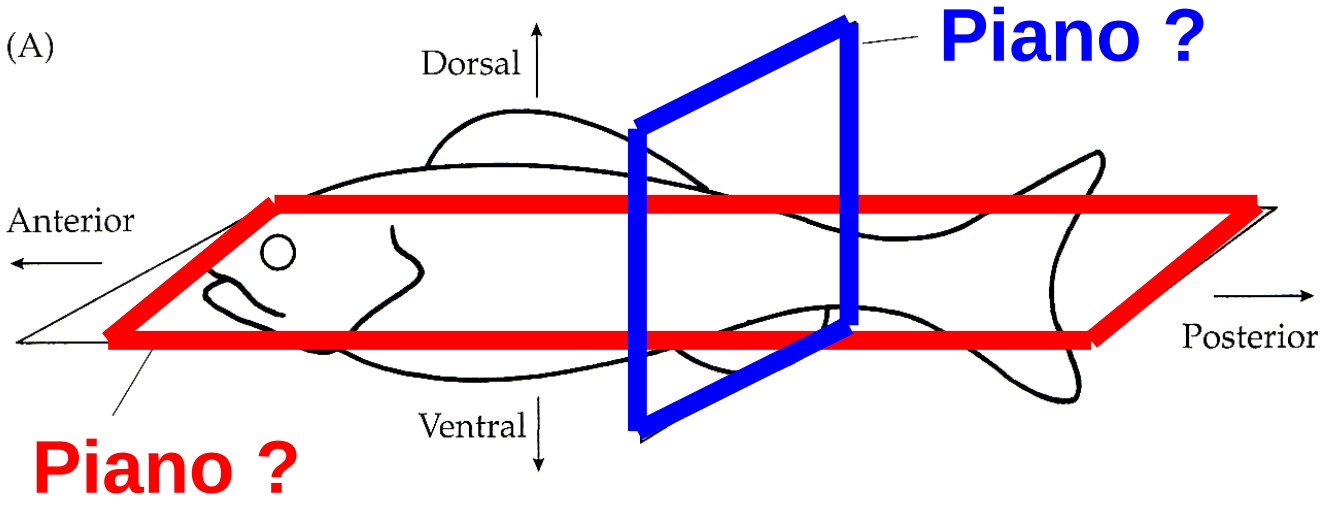


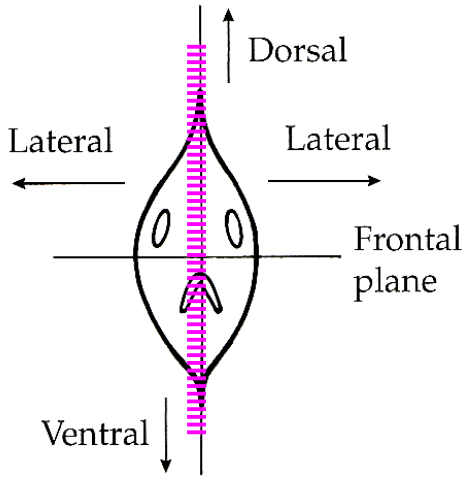


Piano parasagittale

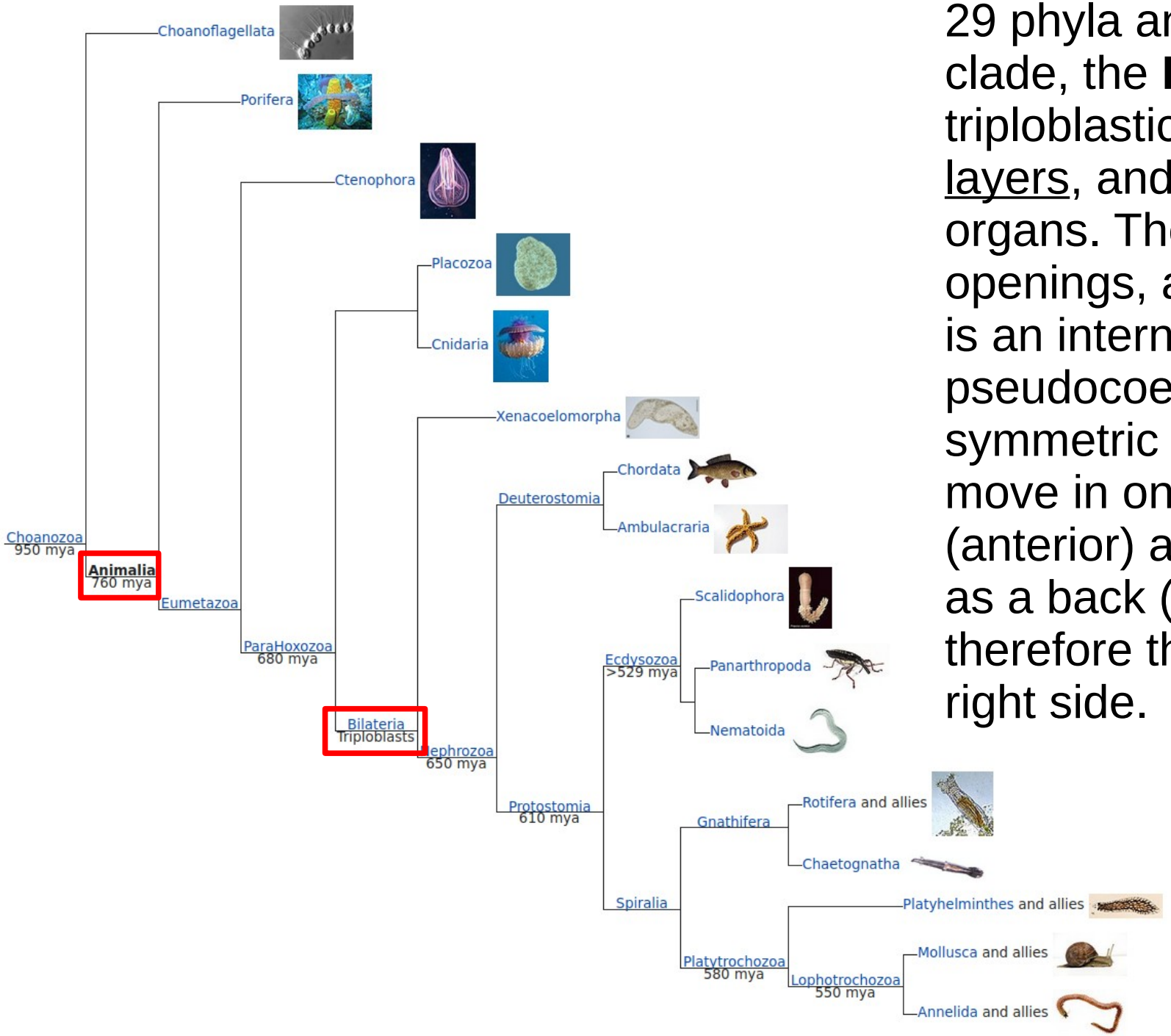
Piano sagittale mediano

Simmetria bilaterale



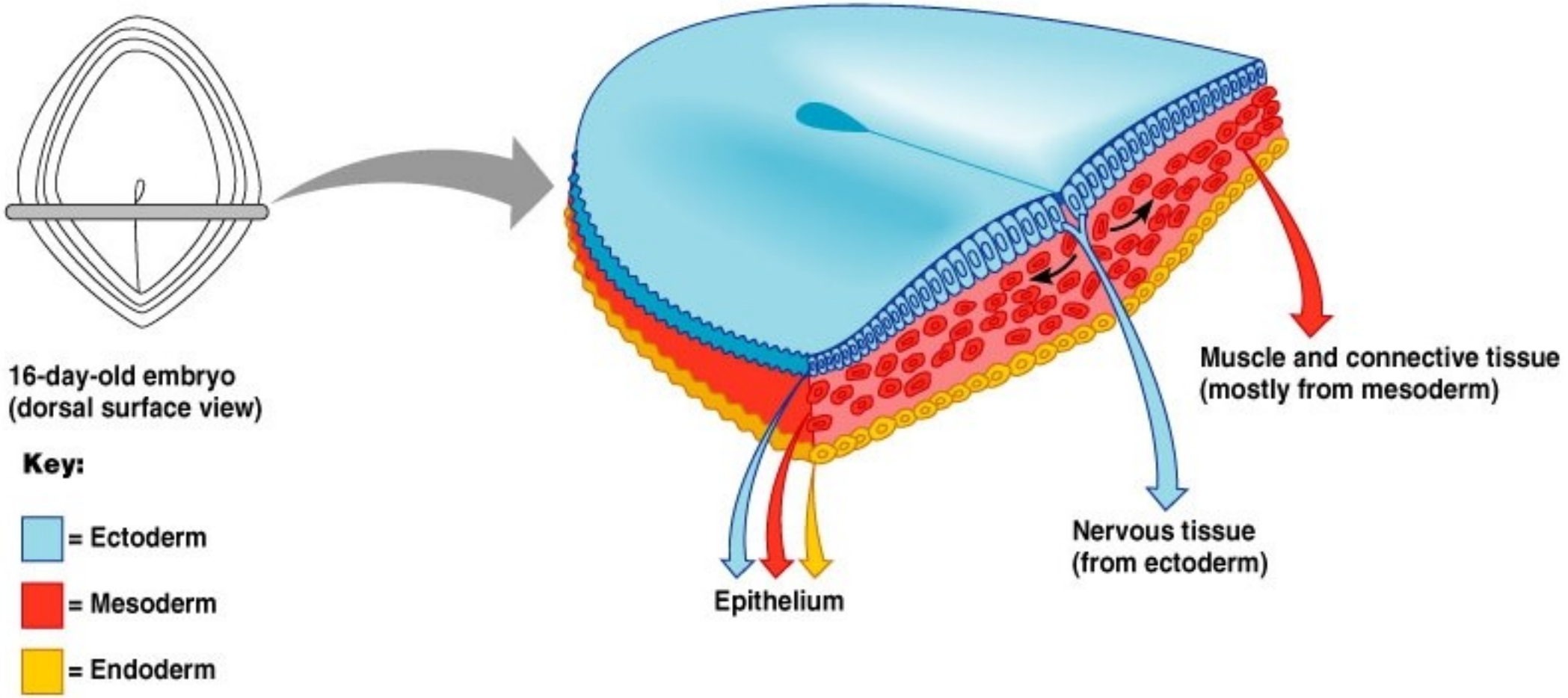


Piano ?



29 phyla and over a million species form a clade, the **Bilateria**. The body is triploblastic, with three well-developed germ layers, and their tissues form distinct organs. The digestive chamber has two openings, a mouth and an anus, and there is an internal body cavity, a coelom or pseudocoelom. Animals with this bilaterally symmetric body plan and a tendency to move in one direction have a head end (anterior) and a tail end (posterior) as well as a back (dorsal) and a belly (ventral); therefore they also have a left side and a right side.

Stadio tridermico



... poco dopo, per proliferazione delle cellule dell'ectoderma, si forma un terzo foglietto, il **mesoderma** o mesoblasto

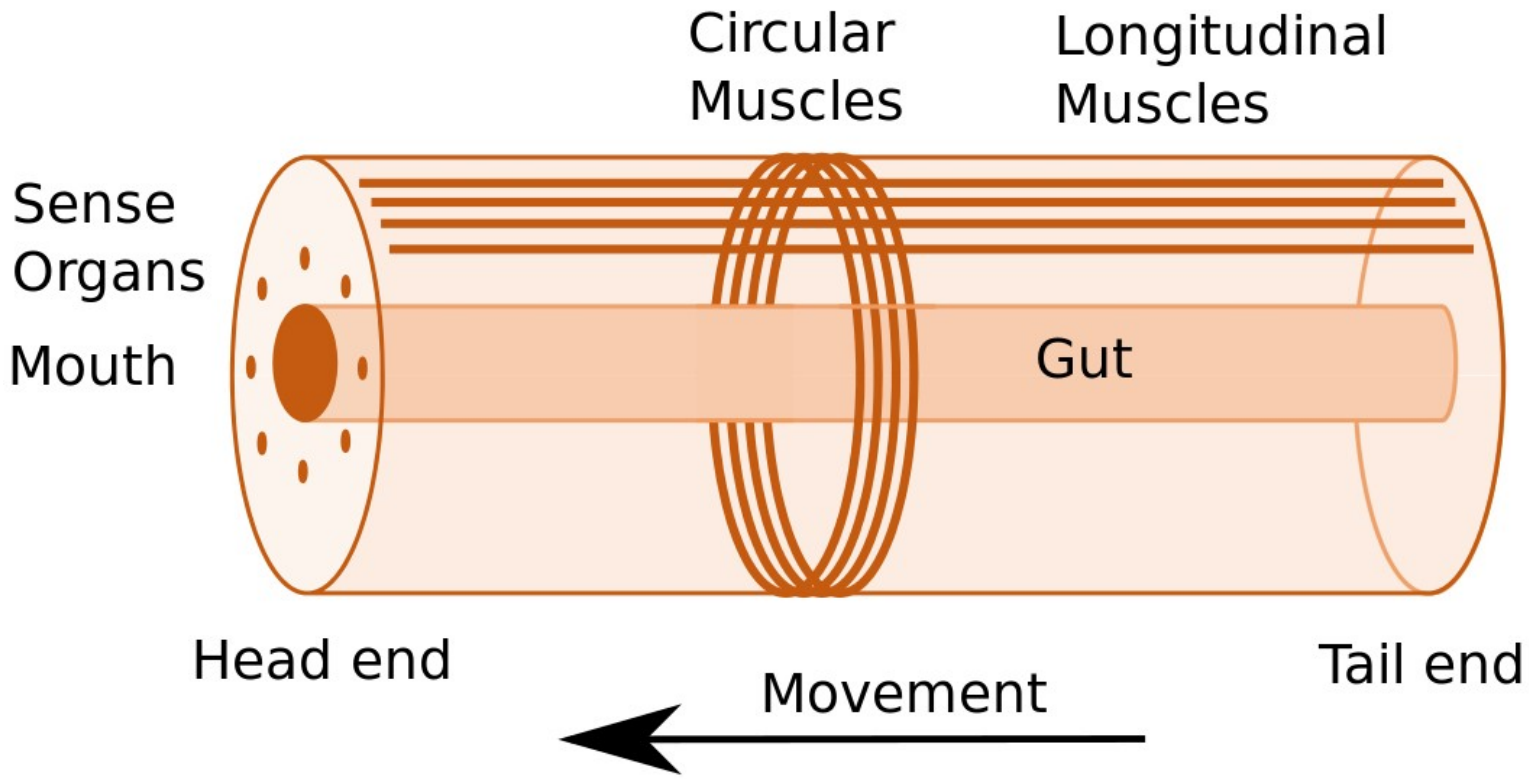
Polarità corporea e simmetria bilaterale

Having a front end means that this part of the body encounters stimuli, such as food, favouring cephalisation, the development of a head with sense organs and a mouth.

Many bilaterians have a combination of circular muscles that constrict the body, making it longer, and an opposing set of longitudinal muscles, that shorten the body; these enable soft-bodied animals with a hydrostatic skeleton to move by **peristalsis**. They also have a gut that extends through the basically cylindrical body from mouth to anus.

Many bilaterian phyla have primary larvae which swim with cilia and have an apical organ containing sensory cells. However, there are exceptions to each of these characteristics; for example, **adult echinoderms are radially symmetric** (unlike their larvae).

Polarità corporea e simmetria bilaterale



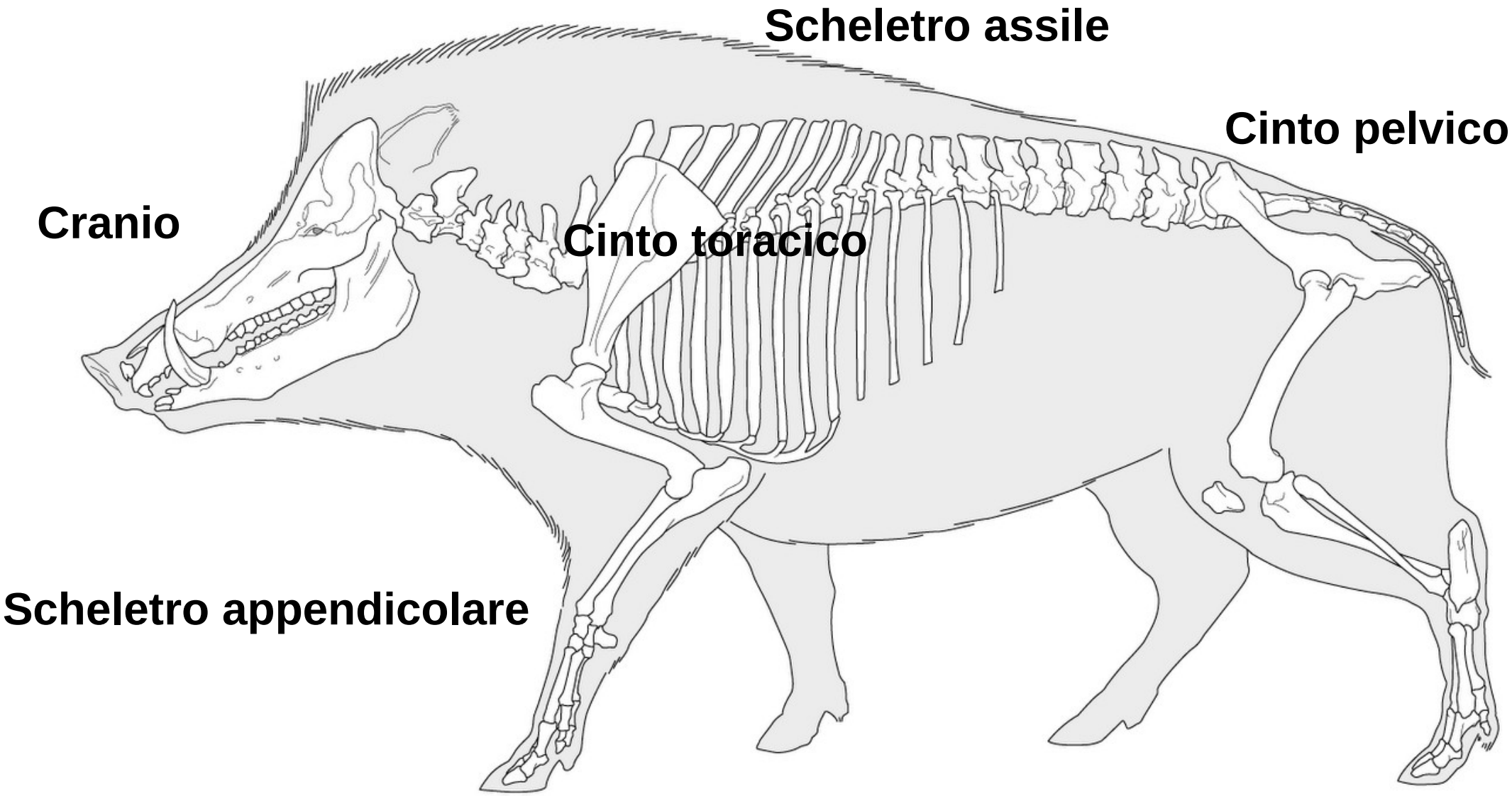
Idealised bilaterian body plan. With an elongated body and a direction of movement the animal has head and tail ends. Sense organs and mouth form the basis of the head. Opposed circular and longitudinal muscles enable peristaltic motion.

Stabilità morfologica degli organismi (nonostante l'evoluzione)

=

piano corporeo

Esempio di piano corporeo: i Tetrapodi



Il Devoniano

The Devonian is a geologic period and system of the Paleozoic, spanning 60.3 million years from the end of the Silurian, 419.2 million years ago (Mya), to the beginning of the Carboniferous, 358.9 Mya.

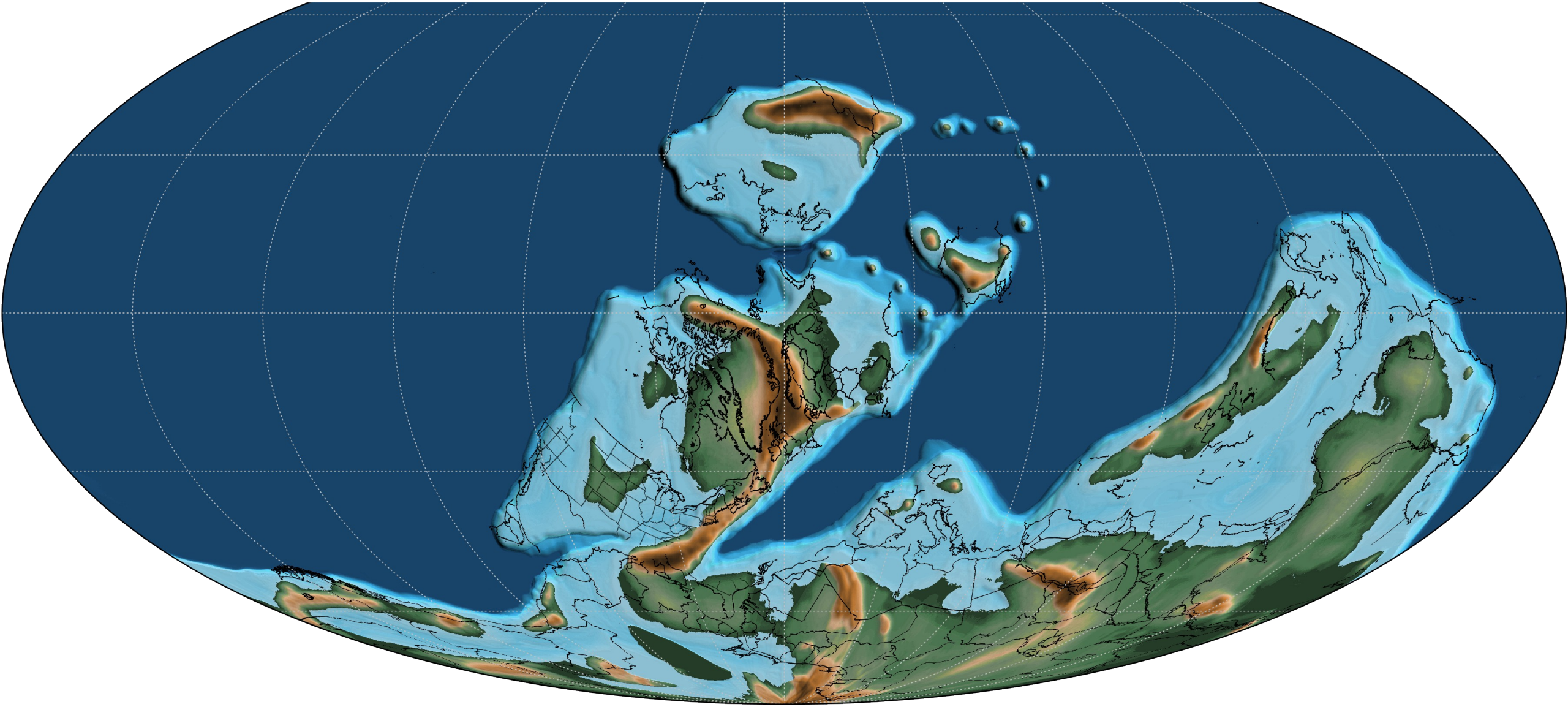
It is named after Devon, England, where rocks from this period were first studied.

The first significant adaptive radiation of life on dry land occurred during the Devonian. Free-sporing vascular plants began to spread across dry land, forming extensive forests which covered the continents.

The Devonian Period marks the beginning of **extensive land colonisation by plants**. With large land-dwelling herbivores not yet present, large forests grew and shaped the landscape.

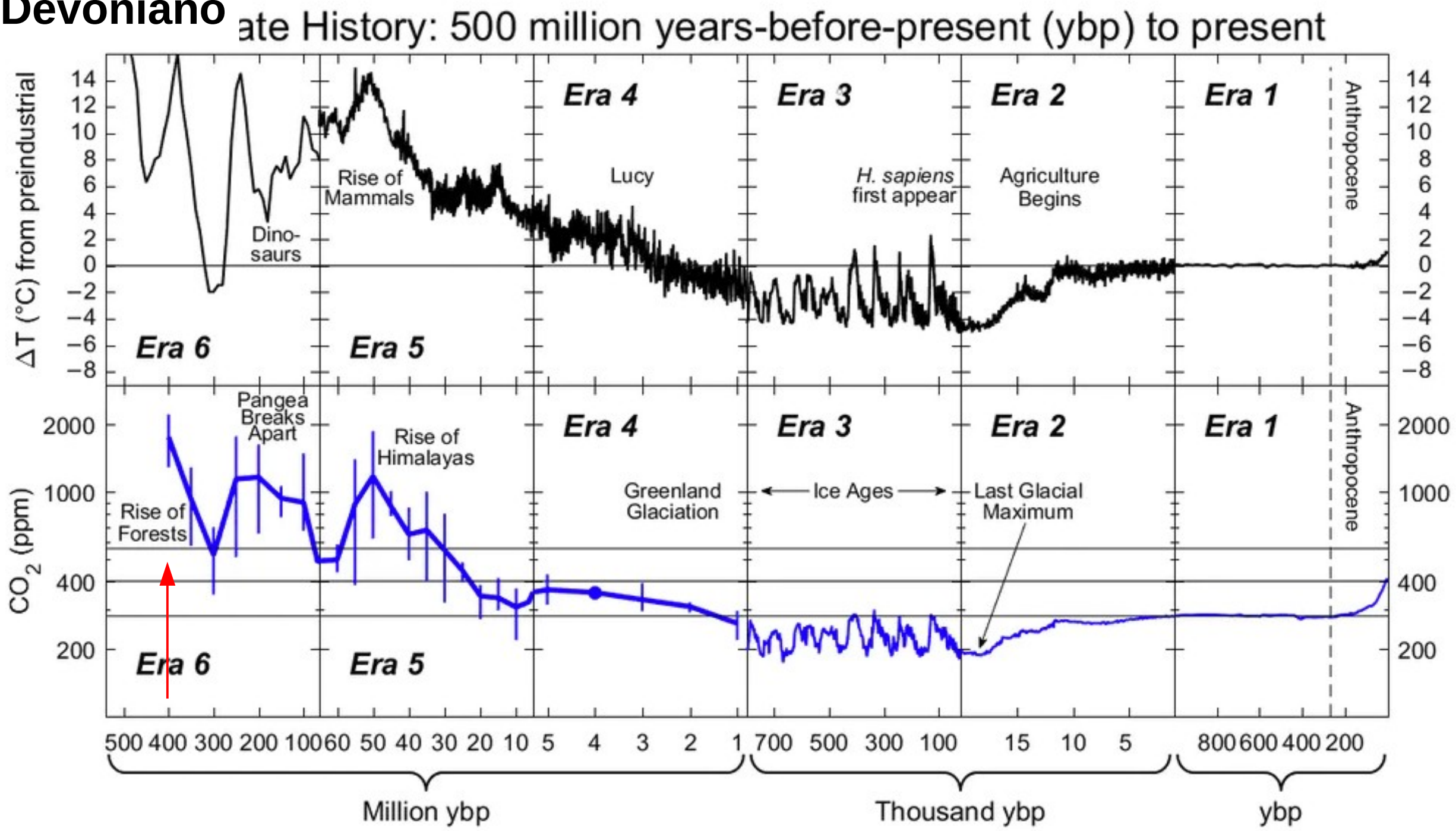
Il Devoniano

A map of Earth 390 million years ago, overlayed by a black outline of present-day countries in their respective locations.



Il Devoniano

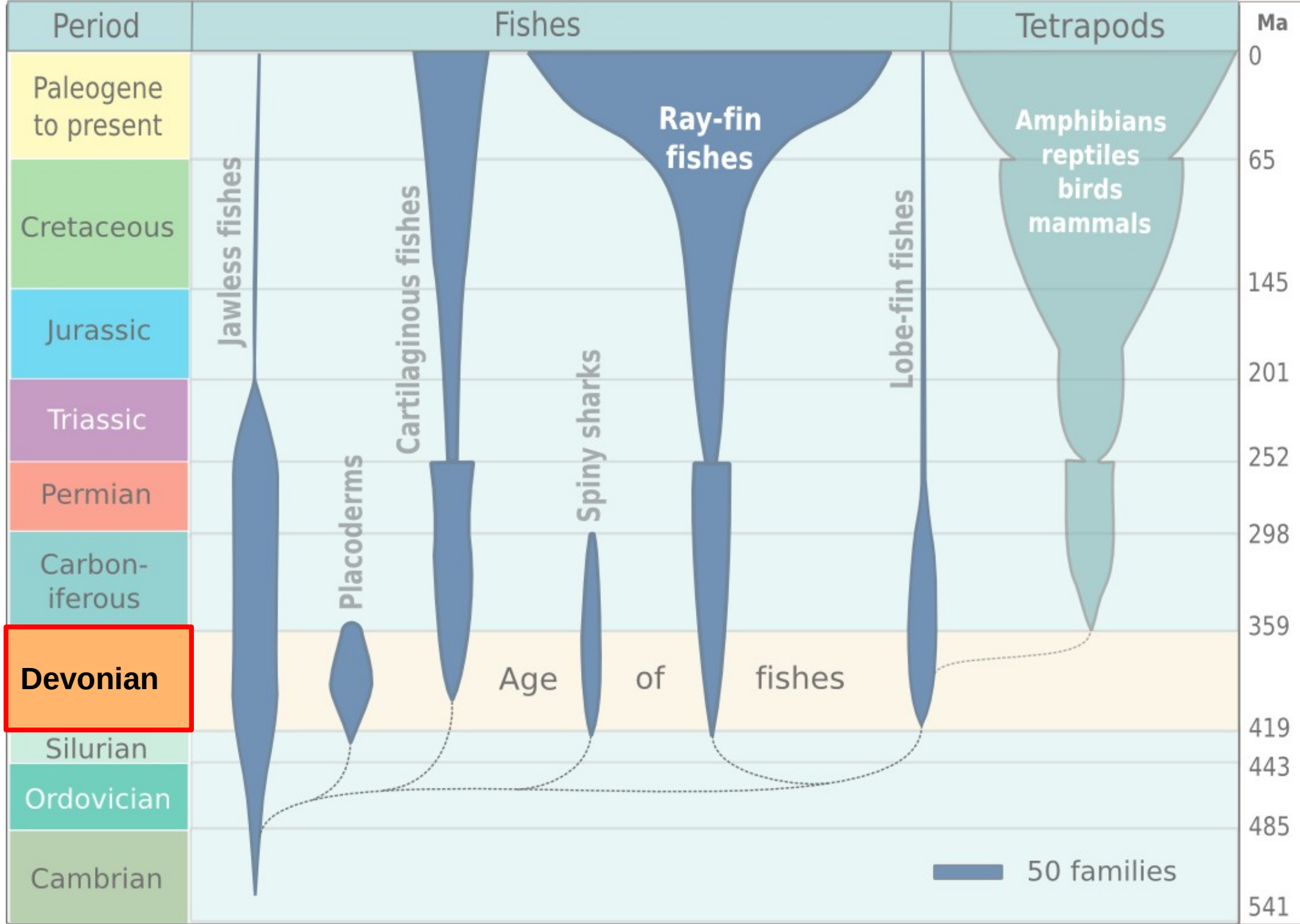
Il Devoniano

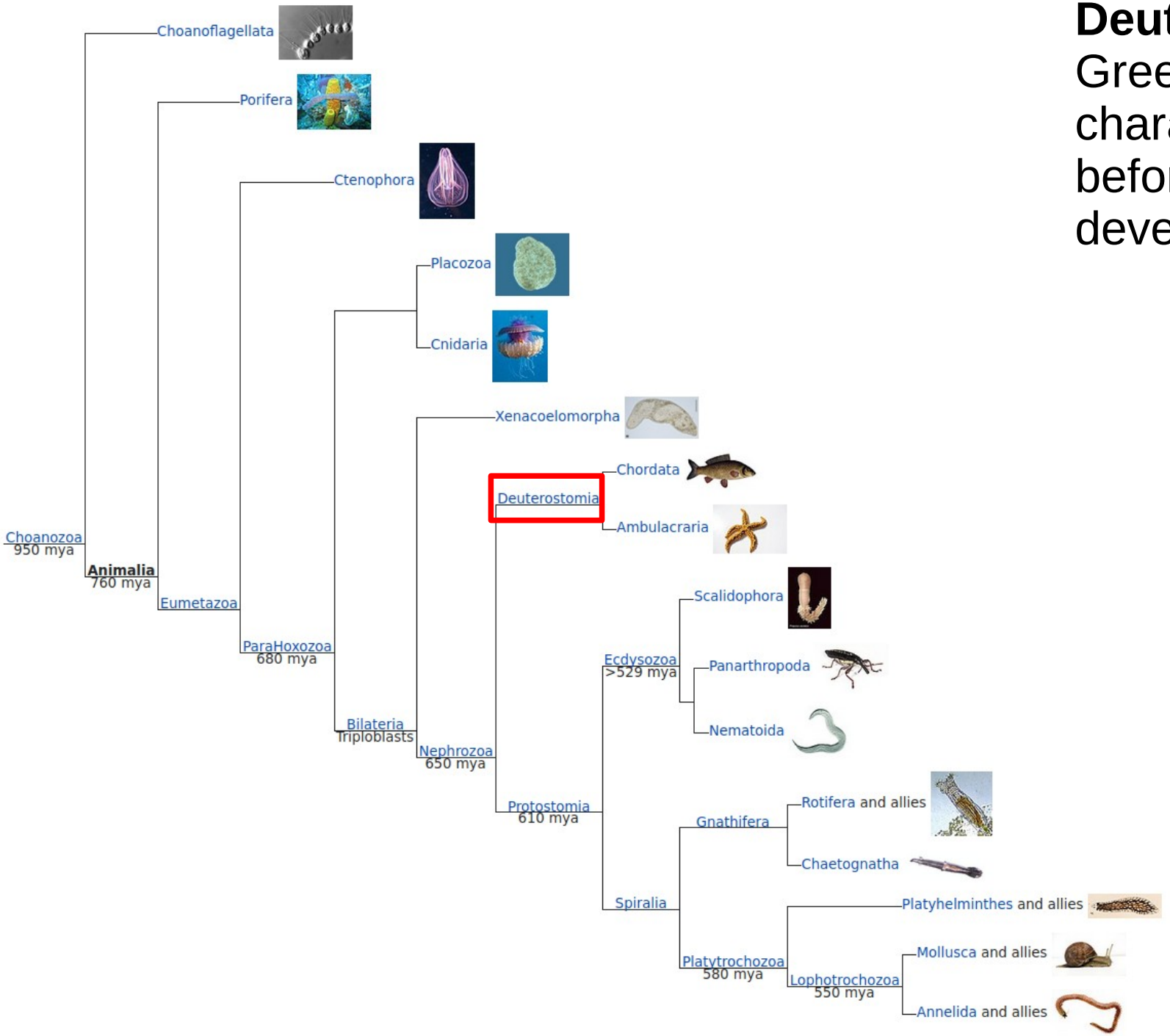


Il Devoniano

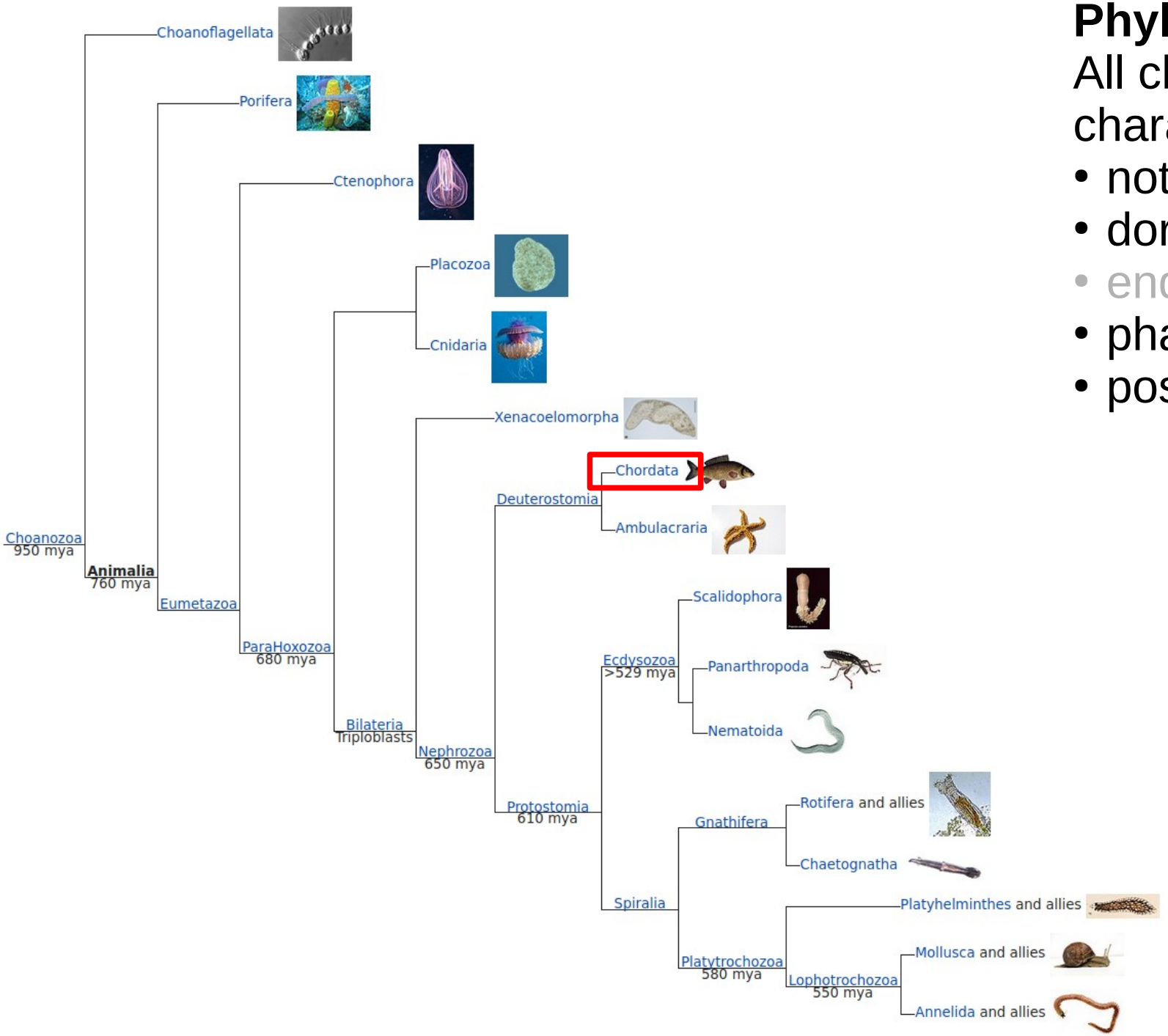
By the middle of the Devonian, several groups of plants had evolved leaves and true roots, and by the end of the period the first seed-bearing plants appeared. Various terrestrial arthropods also became well-established.

Fish reached substantial diversity during this time, leading the Devonian to often be dubbed the **Age of Fishes**.





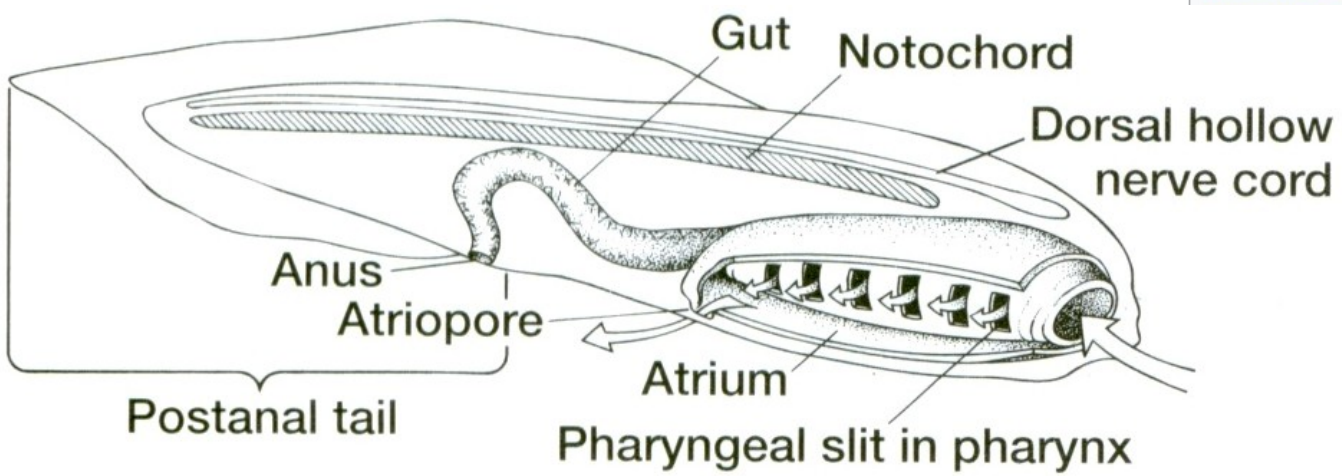
Deuterostomia ('second mouth' in Greek) are animals typically characterized by their anus forming before their mouth during embryonic development.



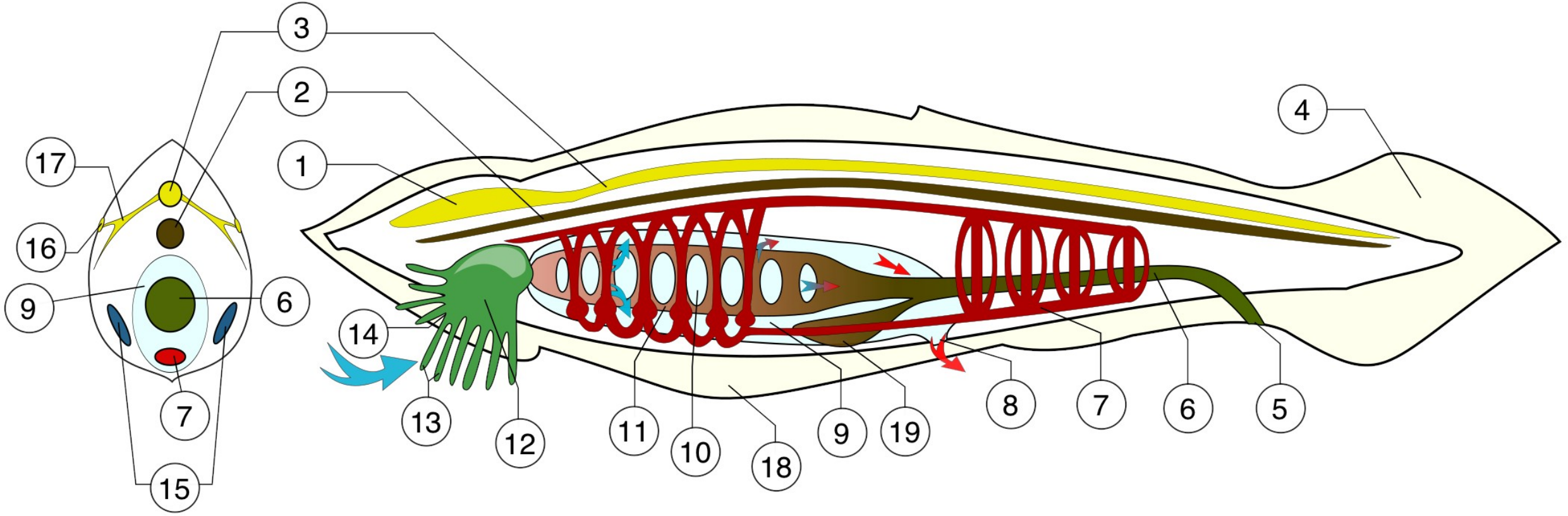
Phylum: Cordata

All chordates possess 5 characteristics:

- notochord
- dorsal hollow nerve cord
- endostyle or thyroid
- pharyngeal slits
- post-anal tail



Phylum	Example	No. of Species	Land	Sea	Fresh water	Free-living	Parasitic
Annelids		17,000[60]	Yes (soil)[62]	Yes[62]	1,750[61]	Yes	400[63]
Arthropods		1,257,000[60]	1,000,000 (insects)[68]	>40,000 (Malac-ostraca)[69]	94,000[61]	Yes[62]	>45,000[b][63]
Bryozoa		6,000[60]		Yes[62]	60–80[61]	Yes	
Chordates		>70,000[60][70]	23,000[71]	13,000[71]	18,000[61] 9,000[71]	Yes	40 (catfish)[72][63]
Cnidaria		16,000[60]		Yes[62]	Yes (few)[62]	Yes[62]	>1,350 (Myxozoa)[63]
Echinoderms		7,500[60]		7,500[60]		Yes[62]	
Molluscs		85,000[60] 107,000[73]	35,000[73]	60,000[73]	5,000[61] 12,000[73]	Yes[62]	>5,600[63]
Nematodes		25,000[60]	Yes (soil)[62]	4,000[64]	2,000[61]	11,000[64]	14,000[64]
hes		29,500[60]	Yes[74]	Yes[62]	1,300[61]	Yes[62] 3,000–6,500[75]	>40,000[63] 4,000–25,000[75]
		2,000[60]		>400[76]	2,000[61]	Yes	
		10,800[60]		Yes[62]	200-300[61]	Yes	Yes[77]
Total number of described extant species as of 2013: 1,525,728[60]							

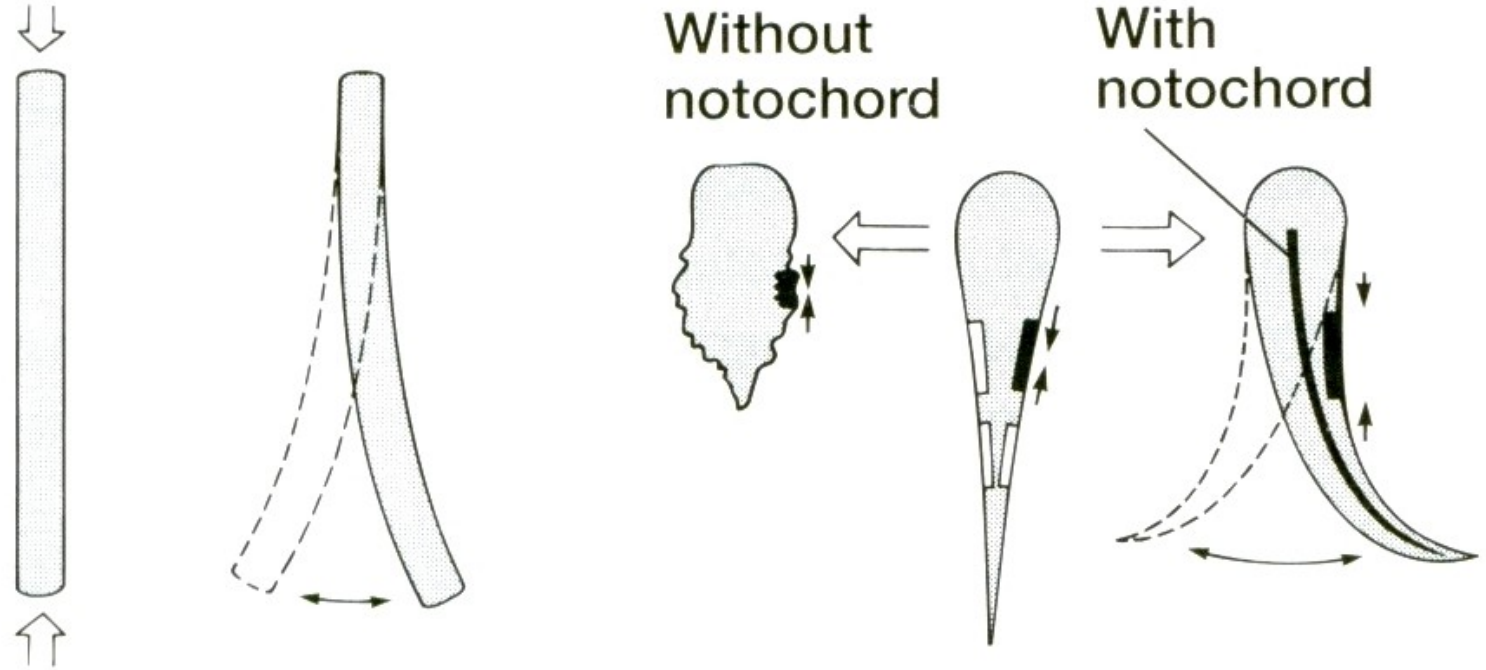


1 = bulge in spinal cord ("**brain**")
2 = **notochord**
3 = **dorsal nerve cord**
4 = **post-anal tail**
5 = **anus**
6 = **digestive canal**
7 = **circulatory system**
8 = **atriopore**
9 = space above pharynx
10 = pharyngeal slit (**gill**)
11 = **pharynx**
12 = vestibule
13 = oral cirri
14 = **mouth opening**
15 = **gonads** (ovary / testicle)
16 = light sensor
17 = nerves
18 = metapleural fold
19 = hepatic caecum (liver-like sack)

I Cordati

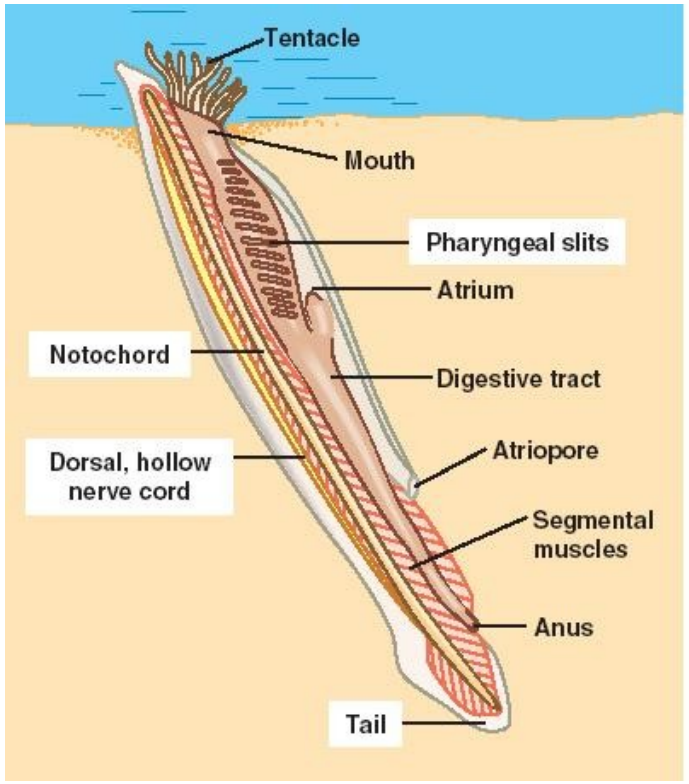
La corda dorsale possiede le *proprietà meccaniche di una fune statica*: può flettersi lateralmente ma non può allungarsi o accorciarsi a telescopio; essa è, infatti, un organo idrostatico, ossia una struttura in cui una parete esterna racchiude un nucleo fluido

I Cordati



Conseguenze (vista dall'alto) della contrazione muscolare in un corpo senza (a *sinistra*) e con (a *destra*) una notocorda: se mancasse quest'organo idrostatico, la contrazione dei muscoli provocherebbe l'accorciamento del corpo a telescopio; la presenza della notocorda impedisce al corpo di collassare e la contrazione alternata dei muscoli laterali flette la coda, mentre quando i muscoli si rilassano la notocorda, con la propria elasticità, distende il corpo. La coda quindi, esercitando una compressione laterale alternata sul mezzo circostante, imprime un movimento avanzante al corpo dell'animale.

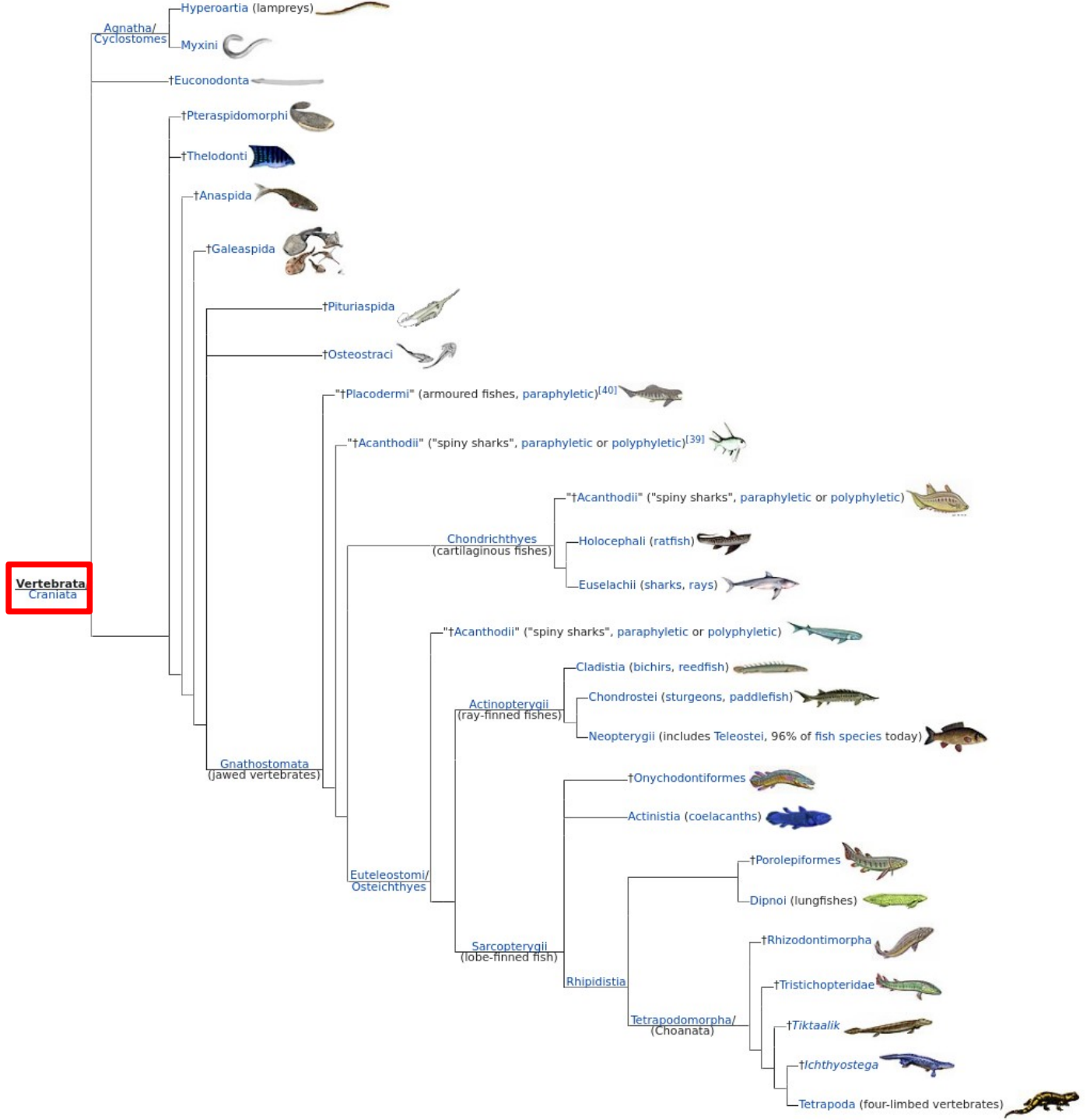
I Cordati



Esempio di <u>cordati primitivi recenti</u> (non estinti): **cefalocordati** o anfiossi (un paio di dozzine di specie di piccoli animali ≈ pesci che raramente superano i 5 cm di lunghezza, cosmopoliti in acque marine e salmastre poco profonde dove vivono sepolti nella sabbia del fondale con solo la testa che sporge sui sedimenti)

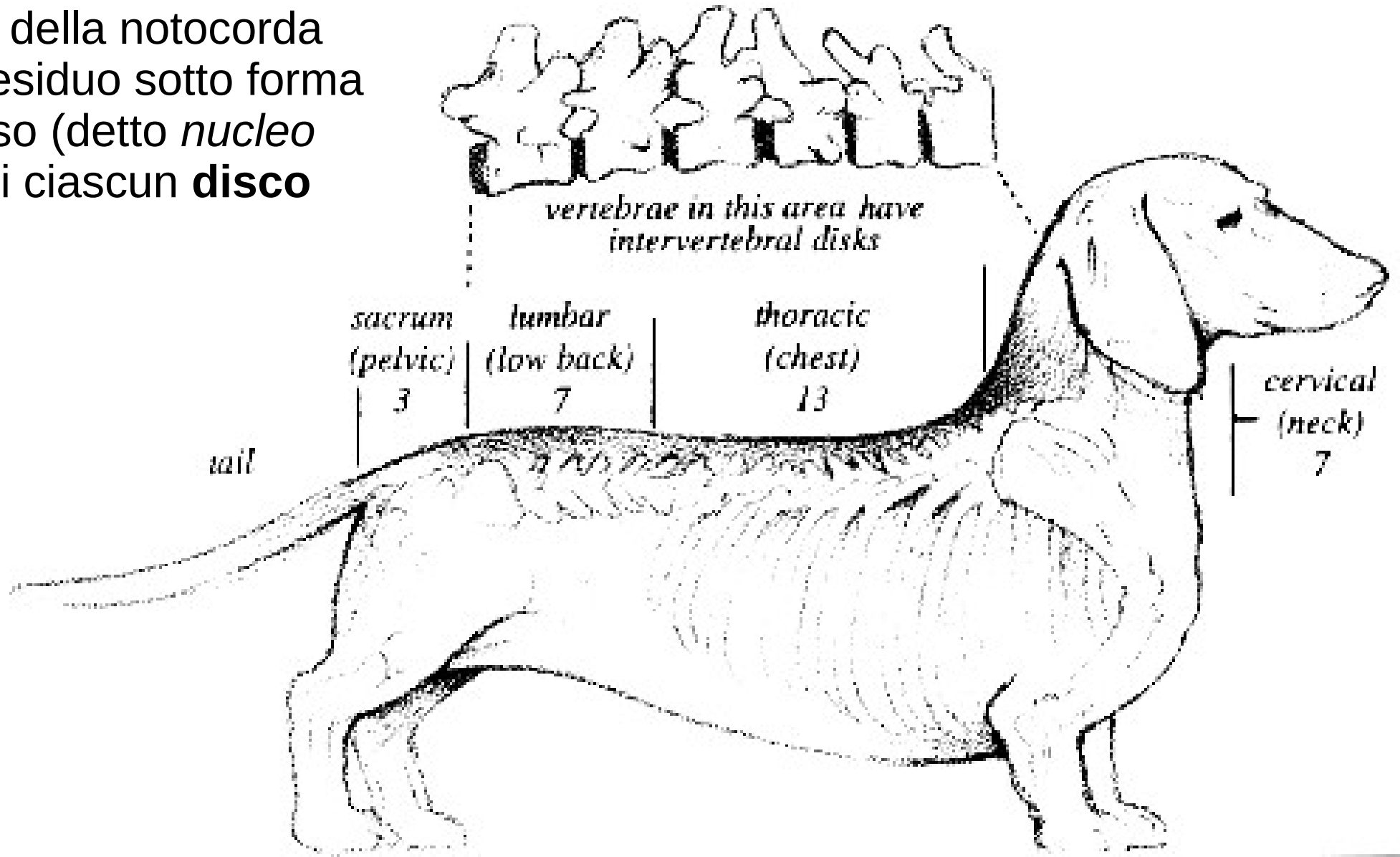
I Cordati

Subphylum:
Vertebrata o Craniata (vertebrati)

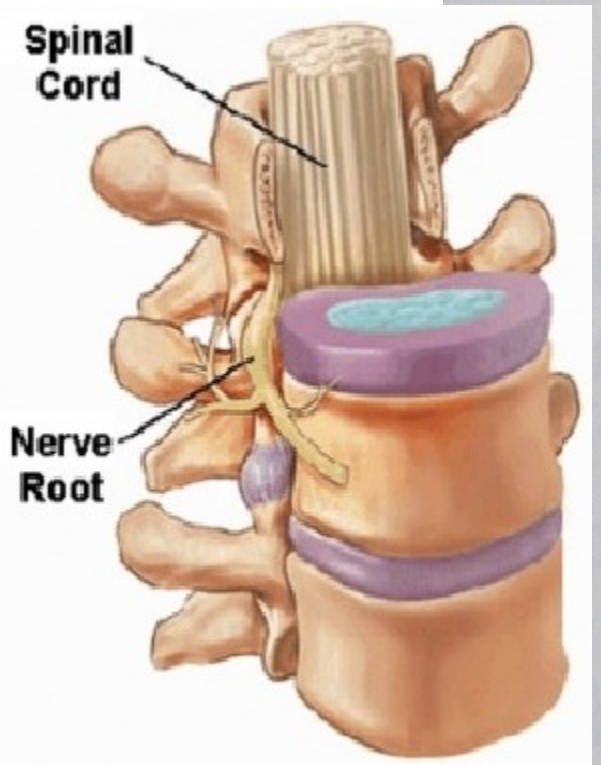


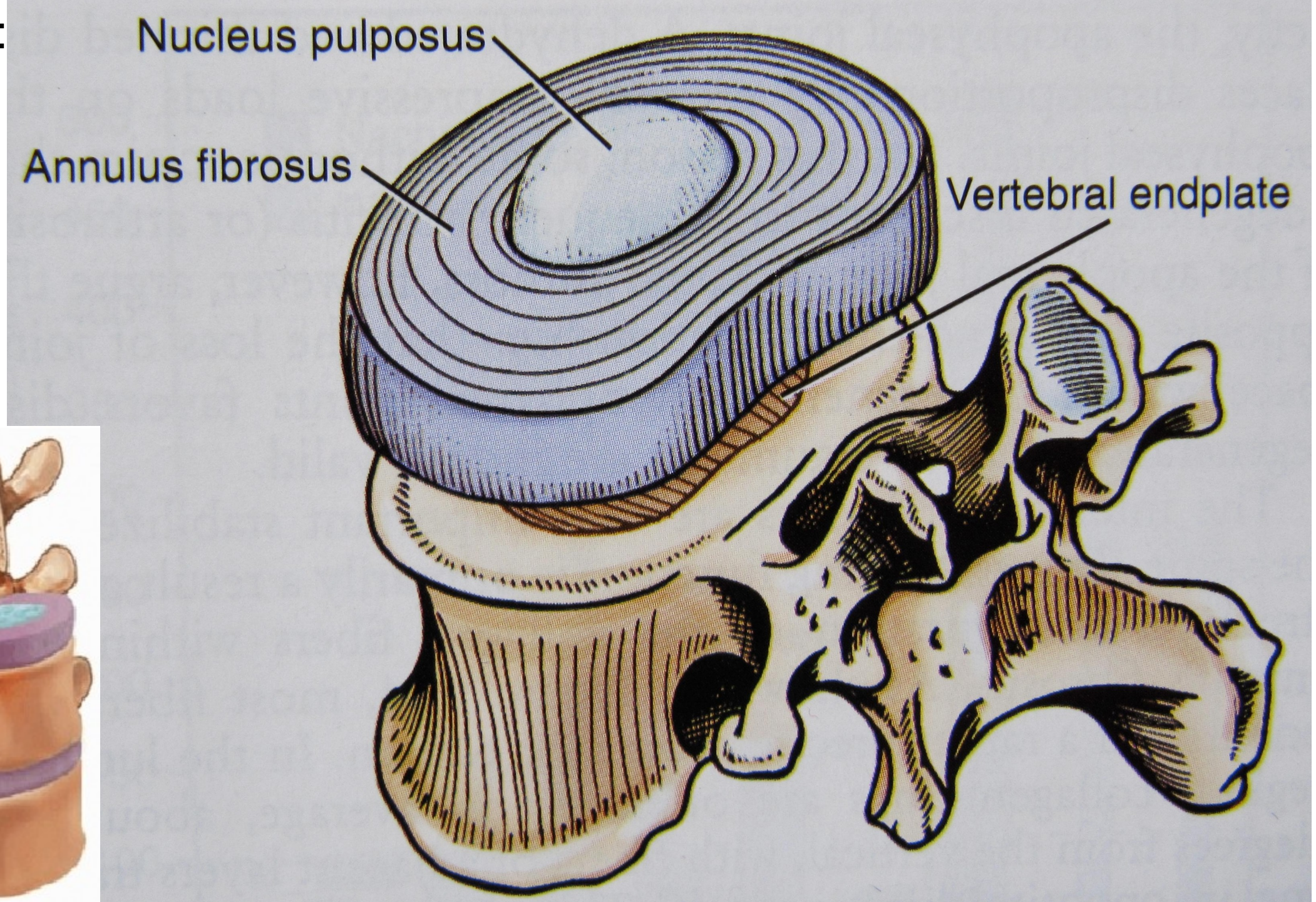
Subphylum:
Vertebrata o Craniata (vertebrati)

Nei mammiferi adulti della notocorda persiste un piccolo residuo sotto forma di materiale gelatinoso (detto *nucleo polposo*) all'interno di ciascun **disco intervertebrale**

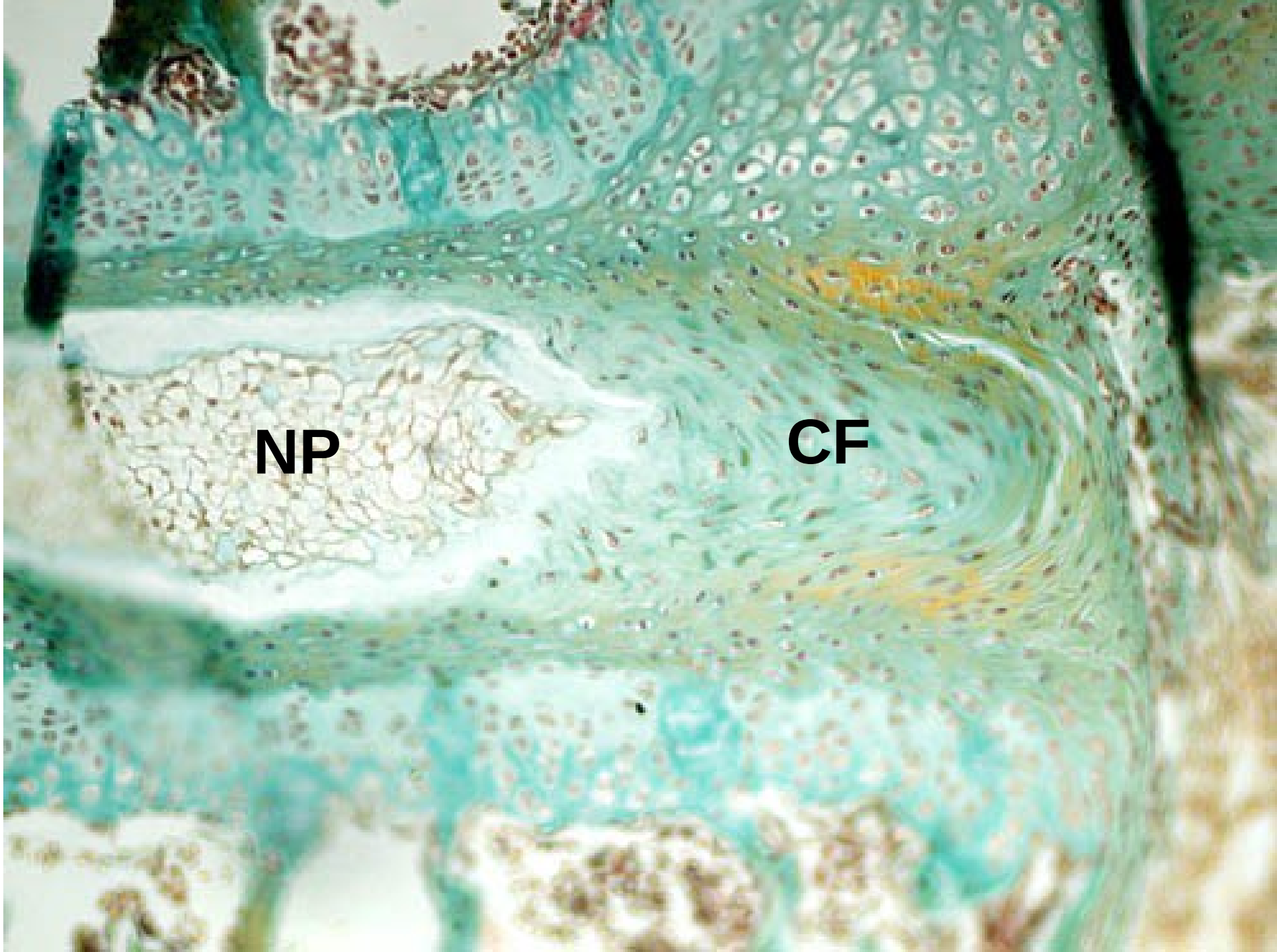


Subphylum:
Vertebrata

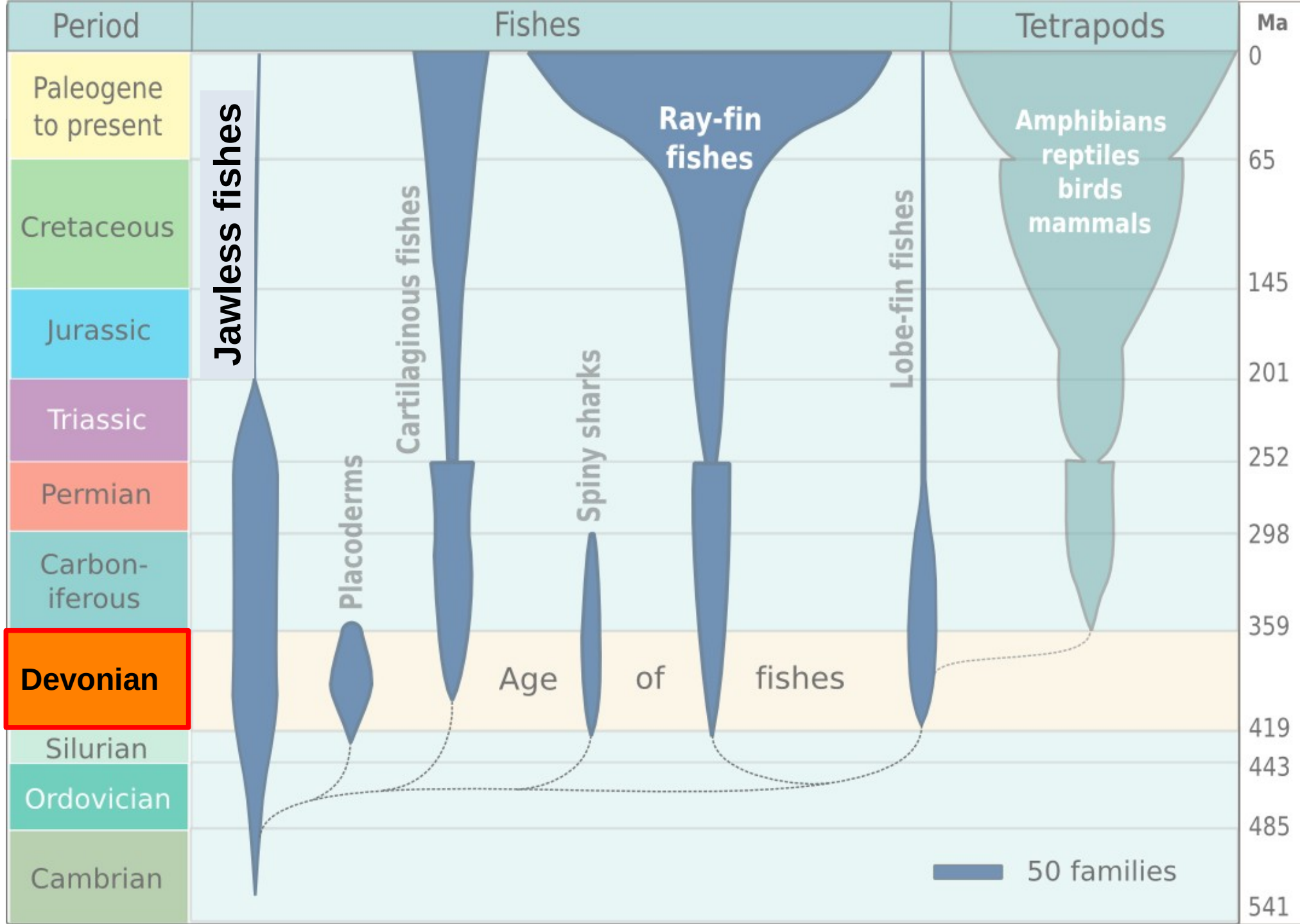




Subphylum:
Vertebrata

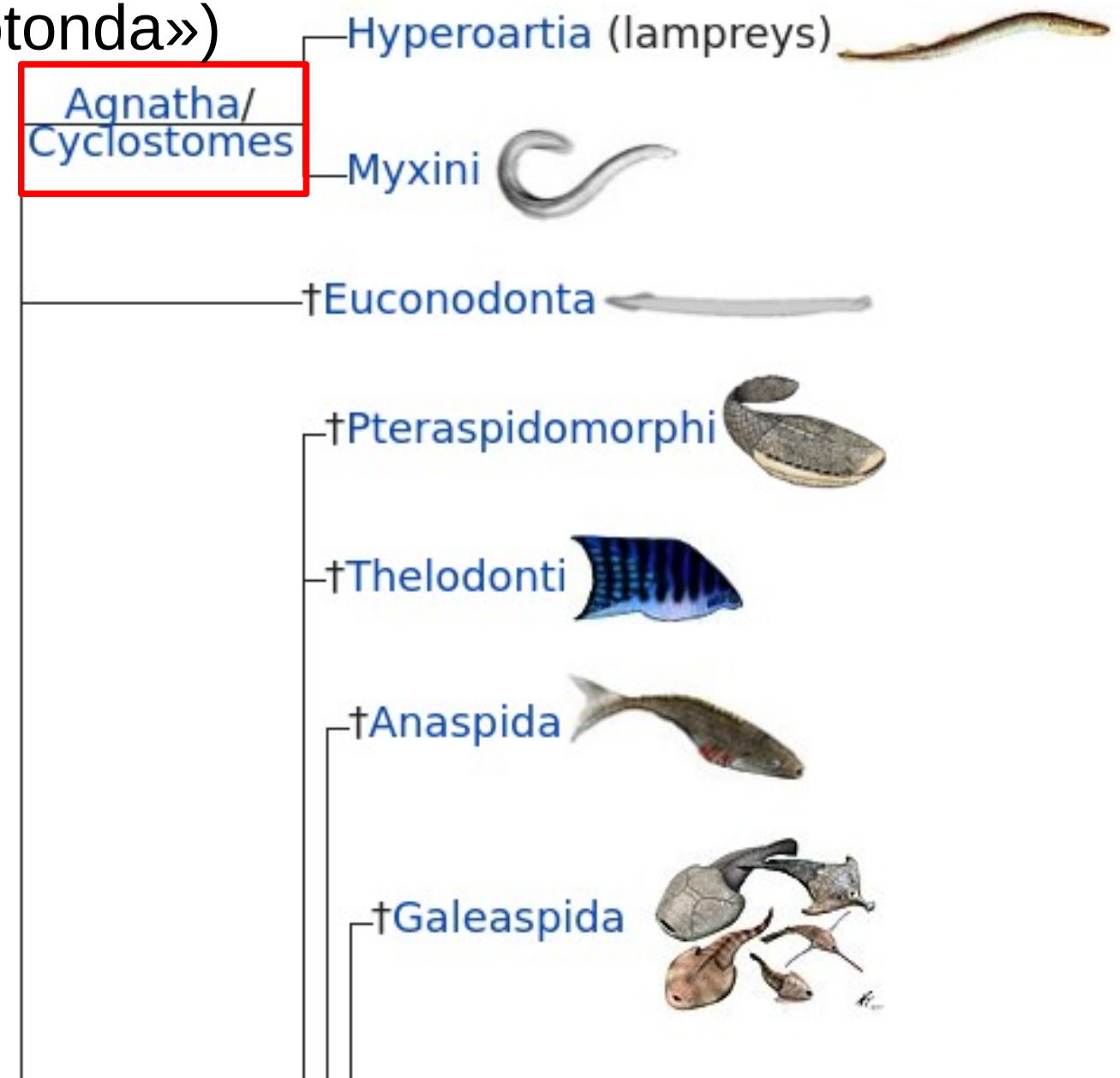


Gli animali del Devoniano

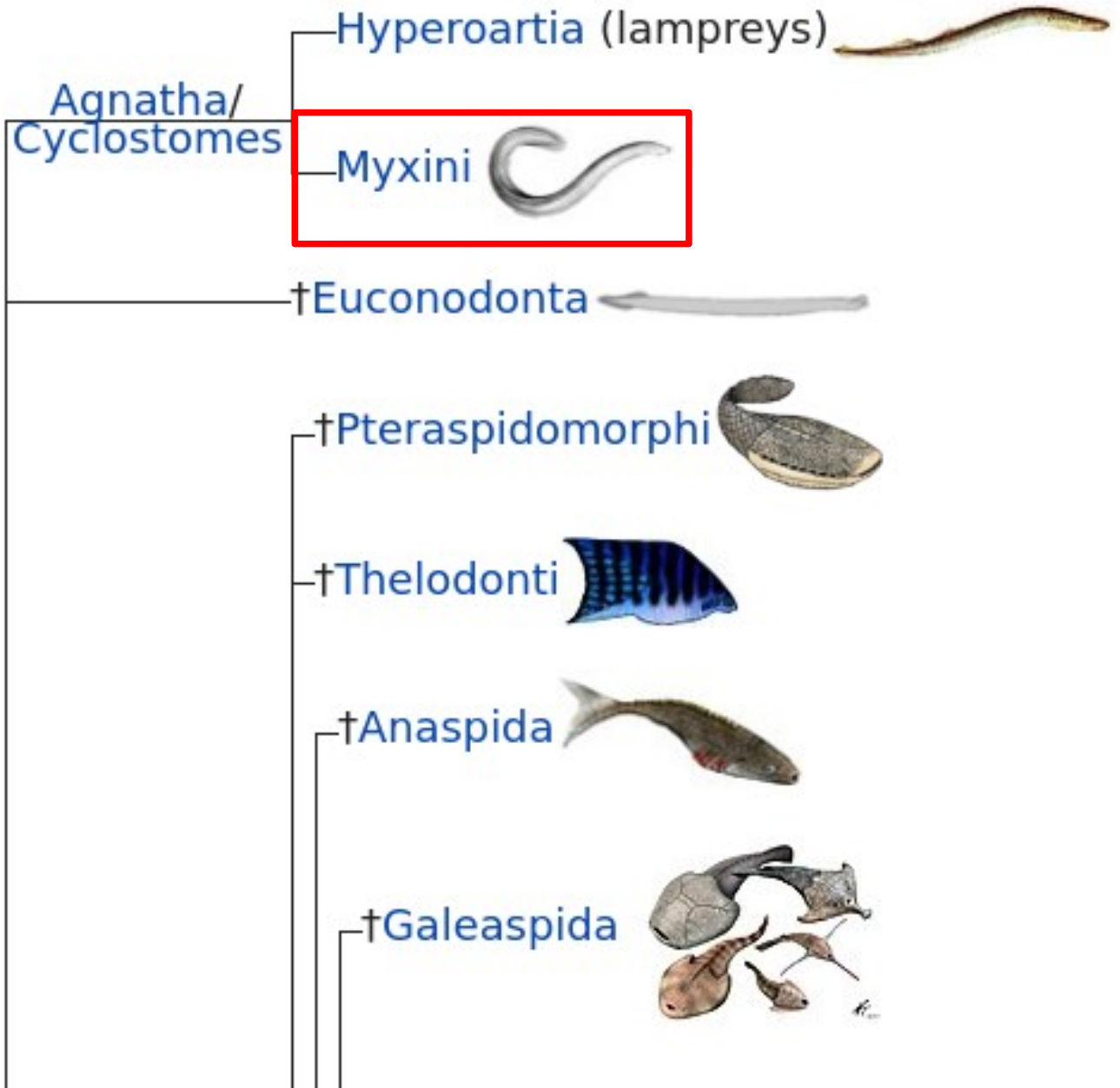


Myr B.P.	EVENTI GEOLOGICI	ORGANISMI
2000	formazione O_3	
1400		eucarioti (acritarchi)
1000		**comparsa del sesso e conseguente esplosione evolutiva**
> 700		vegetali
> 600		animali pluricellulari rinvenuti in Australia (**fauna di Ediacara**)
600		esplosione forme viventi: **≈ 20 classi di Echinodermi**
		Lobopoda, parenti dei moderni Onicofori (*Hallucigenia*, *Anomalocaris*, *Opabinia*) scoperti negli scisti di Burgess, in Canada
510		*Cothurnocystis*, ≈ a echinodermi con piastre di calcite e coda
		vertebrati agnati
500	frammentazione Pangea I	
	formazione Oceano Giapetico (proto-atlantico) NW-SE	
438	**OROGENESI CALEDONIANA**	organismi terrestri
410	arenarie rosse antiche per erosione Catena caledoniana in clima desertico	**insetti** e pesci
		celacanti (pesci sarcopterigi a pinne lobate, ≈ 200 m grotte sottomarine, polmone invaso da tessuto adiposo, pinne pettorali con omero, radio e ulna, pelviche con femore, tibia e fibula e ventaglio di ossa "radiali")
400	formazione Pangea II	
		Pteraspidi (agnati ≈ lamprede)
360		Säve-Södebergh e Jarvik scoprono tetrapodi primitivi in Groenlandia (*Ichtyostega*, 7 dita)
		Oleg Lebenev descrive *Tulerpeton*, con 6 dita
		Clack e Coates descrivono *Acanthostega* (osso io-mandibolare, ioide e branchie interne, arti laterali, 8 dita). Pozze poco profonde

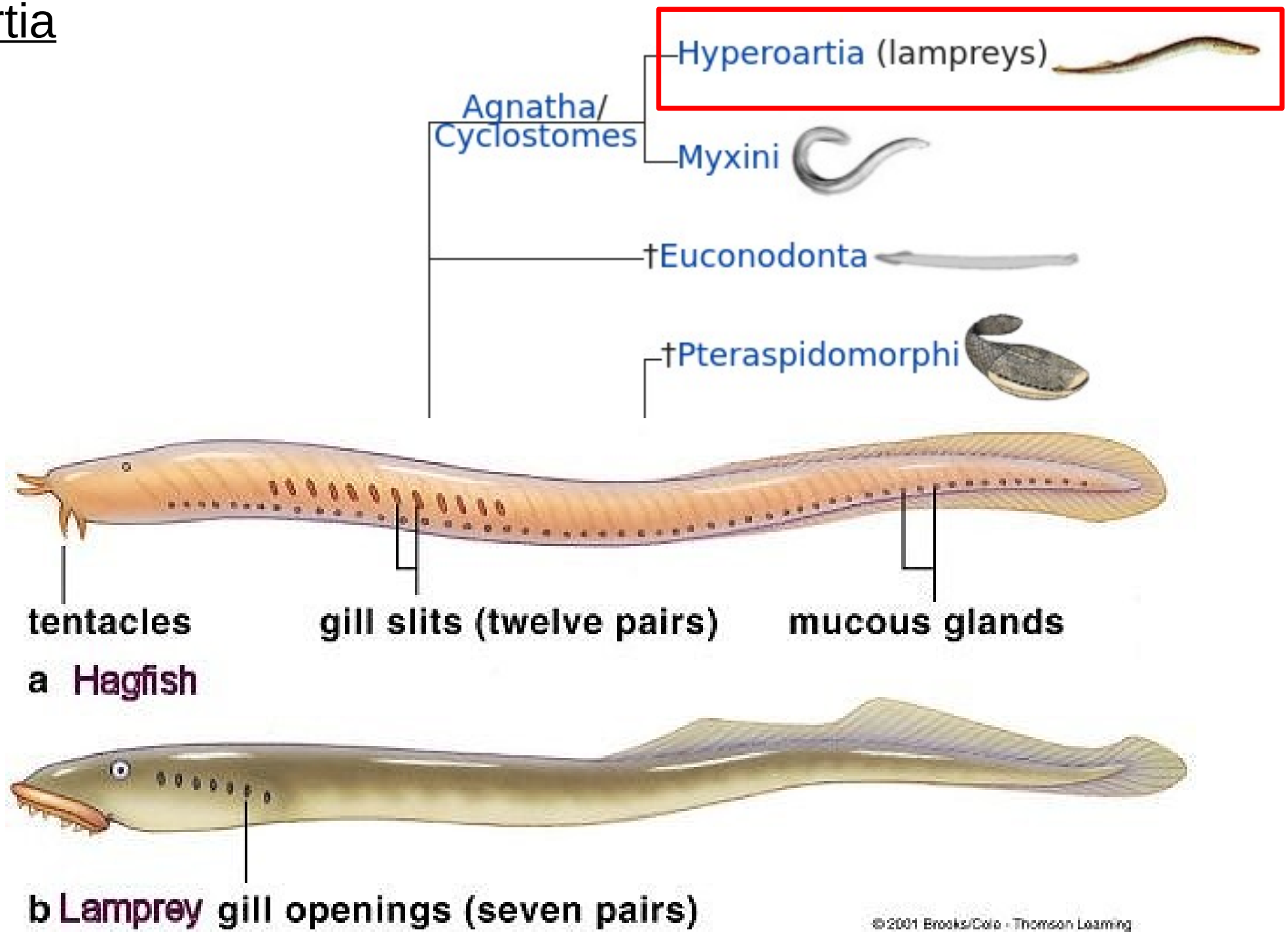
Subphylum: Vertebrata o Craniata
Infraphylum: Agnati («privi di mandibole»)
Superclasse: Ciclostomi («bocca rotonda»)



Classe:Myxini o *hagfishes*
(cranio ma privi di colonna vertebrale)



Classe:<u>Hyperoartia</u>
(lamprede)



Ordine: Petromyzontiformes
Famiglia: Petromyzontidae
Genere e **specie**: *Petromyzon marinus*
(lampreda di mare)

Distribuzione geografica e biologia della lampreda di mare

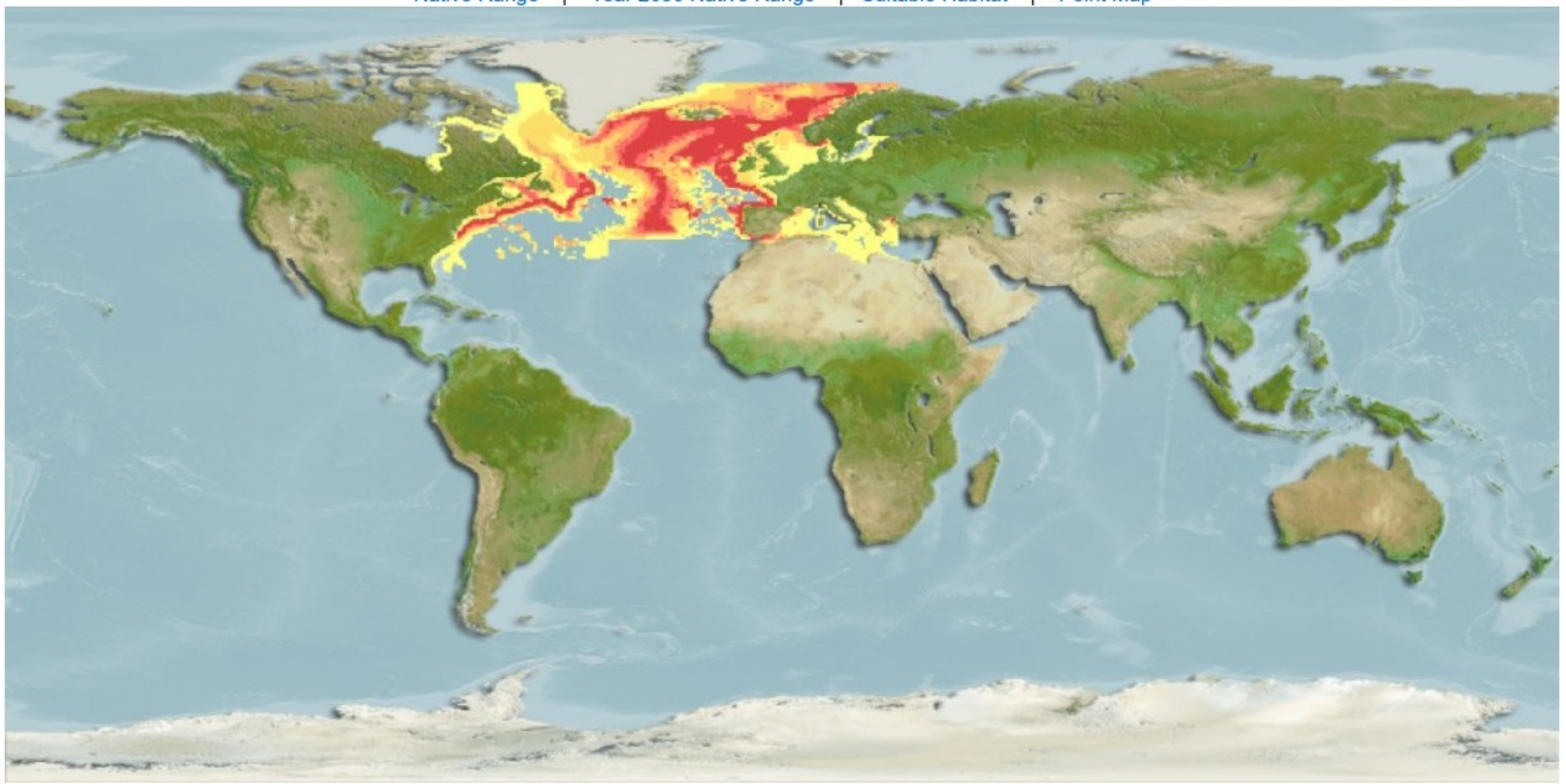
L max 90 cm (fino a 120 cm e 2 kg di peso)

Migratrice anadroma (mare -> fiumi per riprodursi su fondo ghiaioso o ciottoloso); cessano di alimentarsi -> atrofia intestinale. ♂♂ e ♀♀ scavano una buca nel fondo in cui depongono spermatozoi e uova (a 17÷19°C), poi muoiono. Larve (ammoceti) si lasciano trasportare dalla corrente fino al tratto di pianura del fiume, con fondo fangoso: qui vivono infossati per alcuni anni, nutrendosi di microrganismi per filtrazione.

Computer Generated Native Distribution Map for *Petromyzon marinus* (Sea lamprey), with modelled year 2050 native range map based on IPCC RCP8.5 emissions scenario

Currently known distribution: Northeast Atlantic: Norway including Iceland and the Barents Sea, south to northern Africa. Throughout the western and central Mediterranean but absent from eastern Mediterranean and the Black Sea (Ref. 59043). Western Atlantic: Labrador, Canada to Gulf of Mexico in Florida, USA. Landlocked in Great Lakes, Finger Lakes, Oneida Lake and Lake Champlain, Canada/USA (Ref. 12269). Gulf of St. Lawrence to St. Jonhs River in Florida, St. Lawrence-Great Lakes basin; 1 record for Florida panhandle (Ref. 86798). Appendix III of the Bern Convention (2002). Annex II (excluding Swedish population) of the EC Habitats Directive (2007).

Native Range | Year 2050 Native Range | Suitable Habitat | Point Map

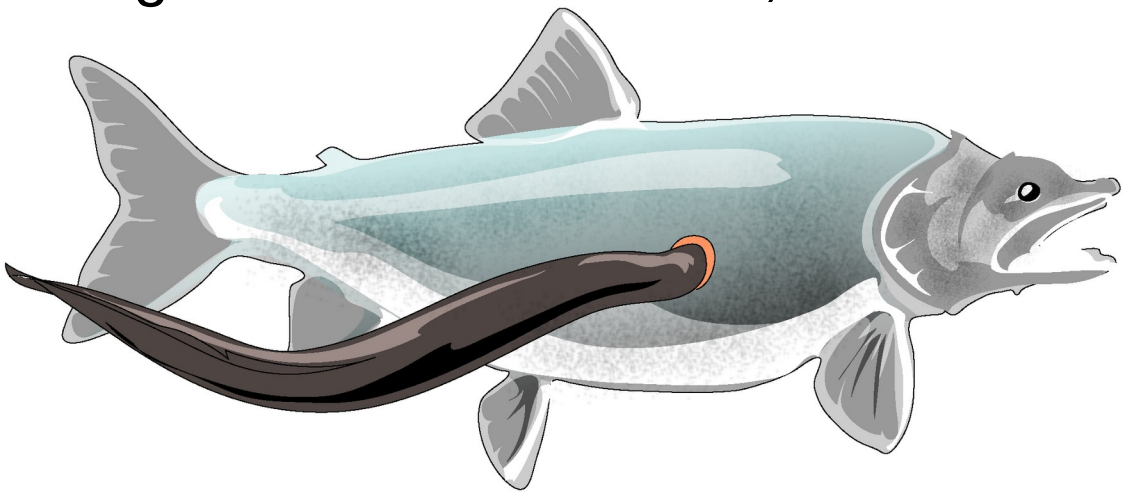


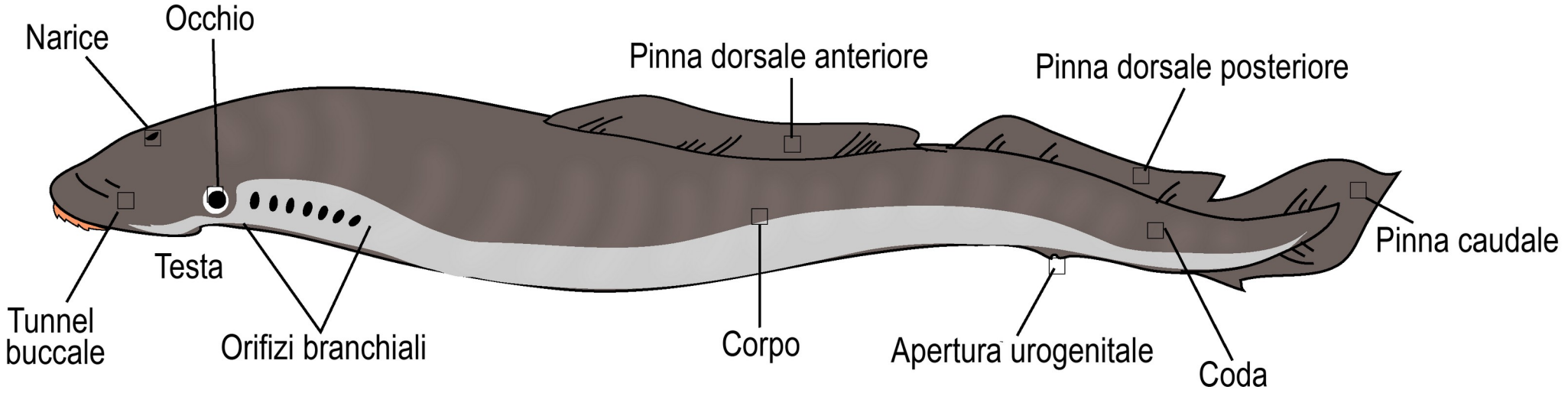
Note: Distribution range colours indicate degree of suitability of habitat which can be interpreted as probabilities of occurrence.

Relative probabilities of occurrence	**Explore:**	**Download native range data:**	**More species info:**	**Session no. 10**
0.80 - 1.00	Native range map	csv format	List of countries	-Close window-
0.60 - 0.79	Suitable habitat map	NetCDF (view in Godiva)	List of FAO areas	*Please use -Close window- link just above to exit instead of the browser's X button.*
0.40 - 0.59	Point map	About AquaMaps	List of ecosystems	
0.20 - 0.39	Show mapping parameters	Proper map citation	Comments & Corrections	
0.01 - 0.19	Create your own map			

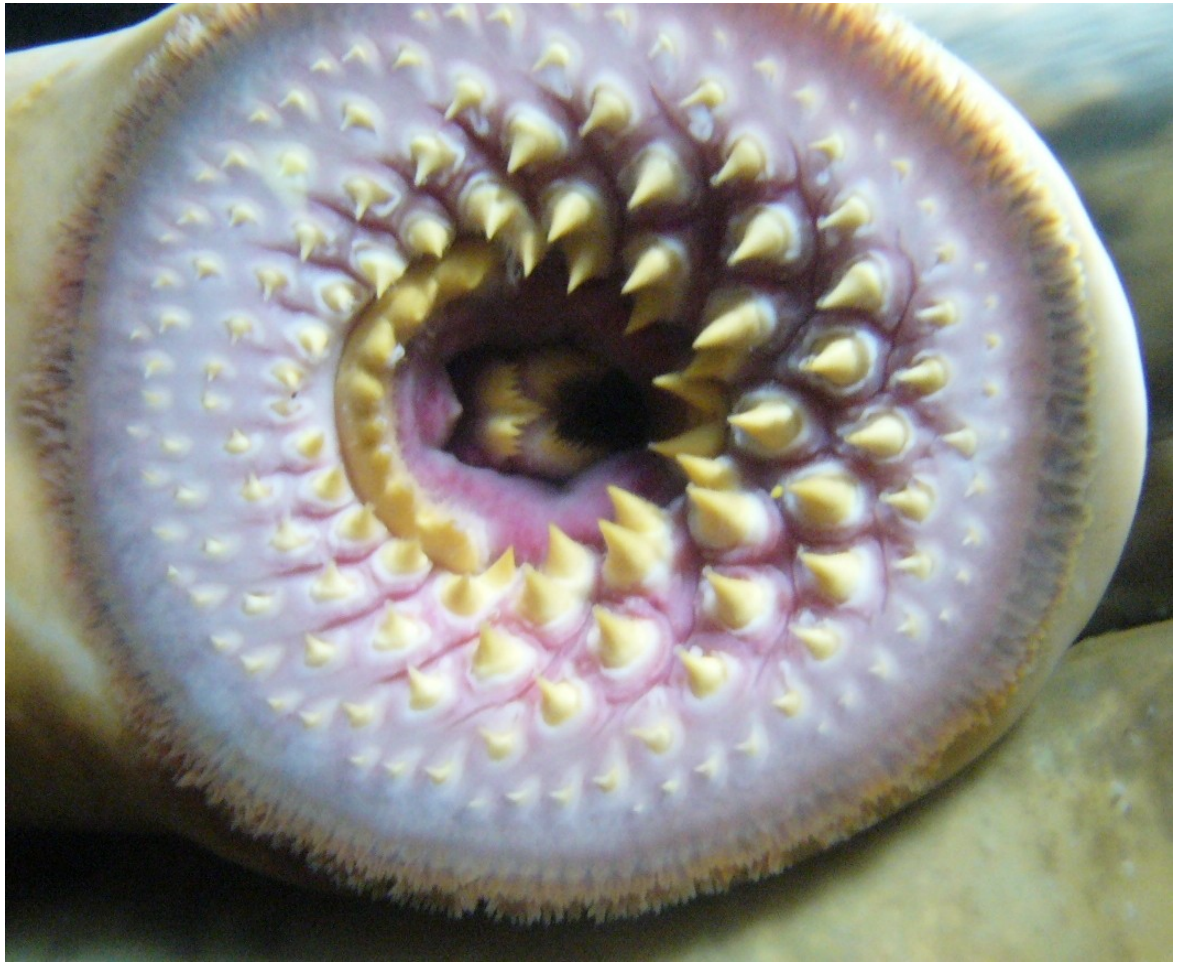
Distribuzione geografica e biologia della lampreda di mare

A 12÷15 cm -> metamorfosi e migrazione verso il mare;
<u>adulti ectoparassiti di pesci</u>

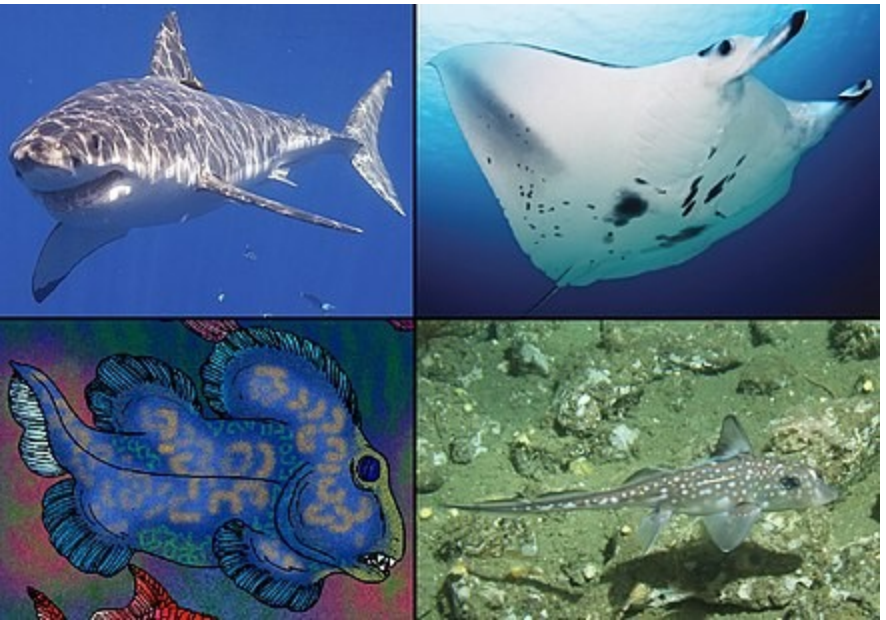


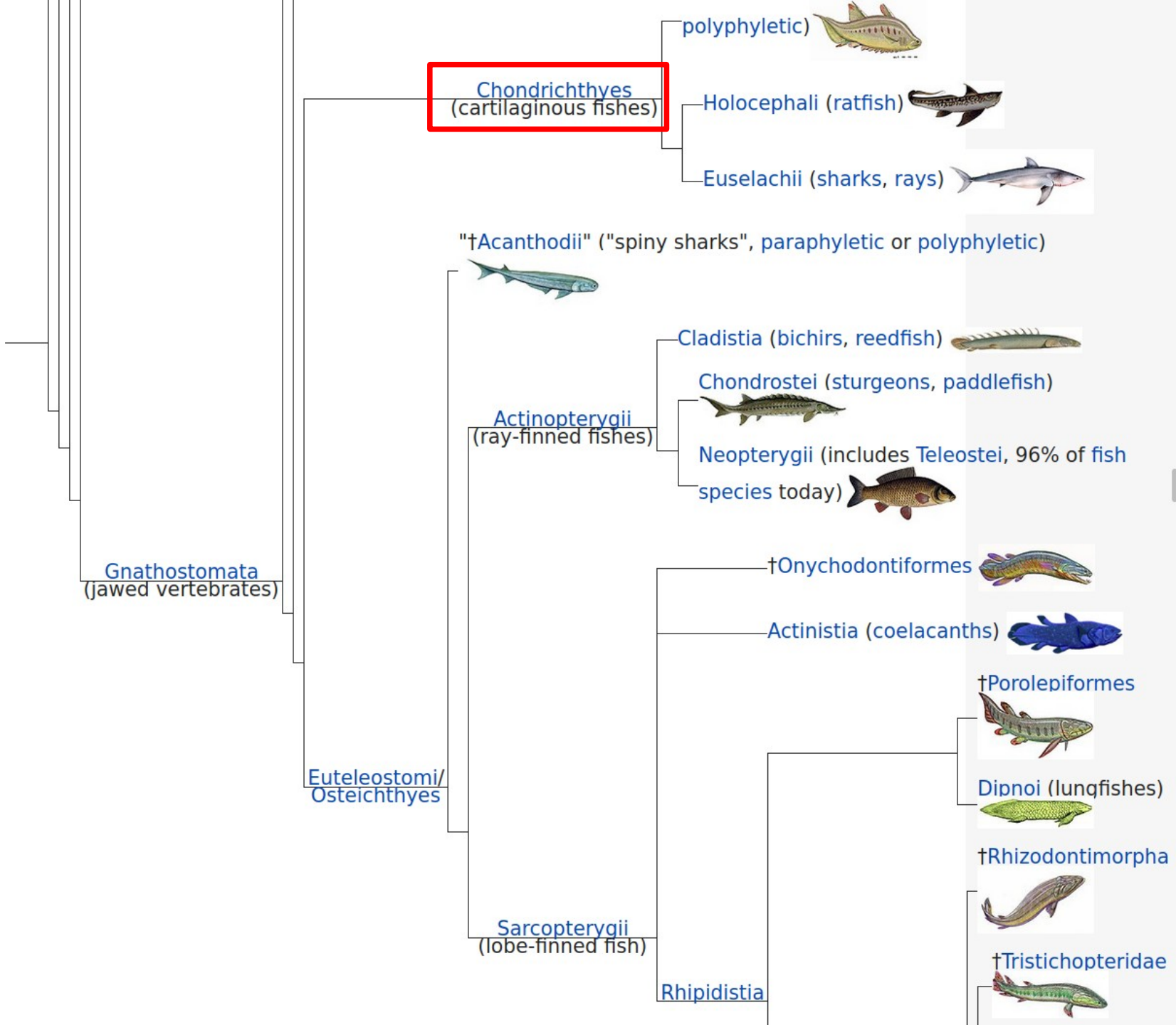


L'apparato boccale di una lampreda funziona come una ventosa, grazie alla quale si possono attaccare ai sassi e, per nutrirsi, ai pesci, dei quali succhiano il sangue dopo aver raschiato la carne mediante movimenti della lingua, lasciando un’impronta circolare sulla pelle delle vittime.
Per inghiottire più facilmente il sangue delle vittime, le lamprede secernono una saliva anticoagulante.

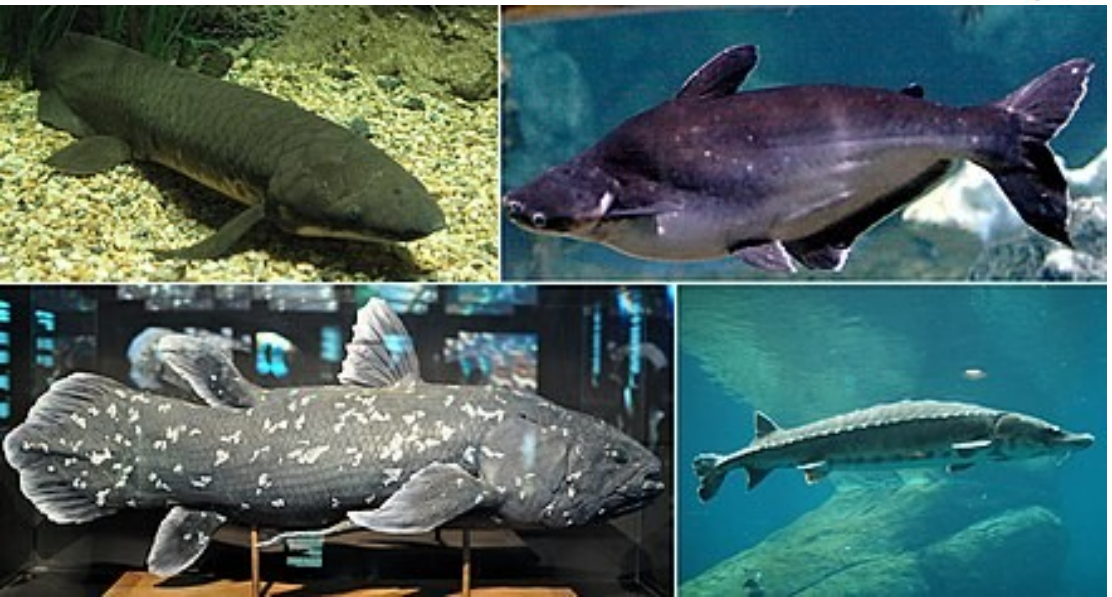


Regno: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Infraphylum: Gnathostomata
Clade: Eugnathostomata
Classe: *Chondrichthyes*





Regno: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Infraphylum: Gnathostomata
Clade: Eugnathostomata
Superclasse: *Osteichthyes*



Gnathostomata
(jawed vertebrates)

Chondrichthyes
(cartilaginous fishes)

polyphyletic)

Holocephali (ratfish)

Euselachii (sharks, rays)

"†Acanthodii" ("spiny sharks", paraphyletic or polyphyletic)

Euteleostomi/
Osteichthyes

Actinopterygii
(ray-finned fishes)

Cladistia (bichirs, reedfish)

Chondrostei (sturgeons, paddlefish)

Neopterygii (includes Teleostei, 96% of fish species today)

Sarcopterygii
(lobe-finned fish)

†Onychodontiformes

Actinistia (coelacanths)

†Porolepiformes

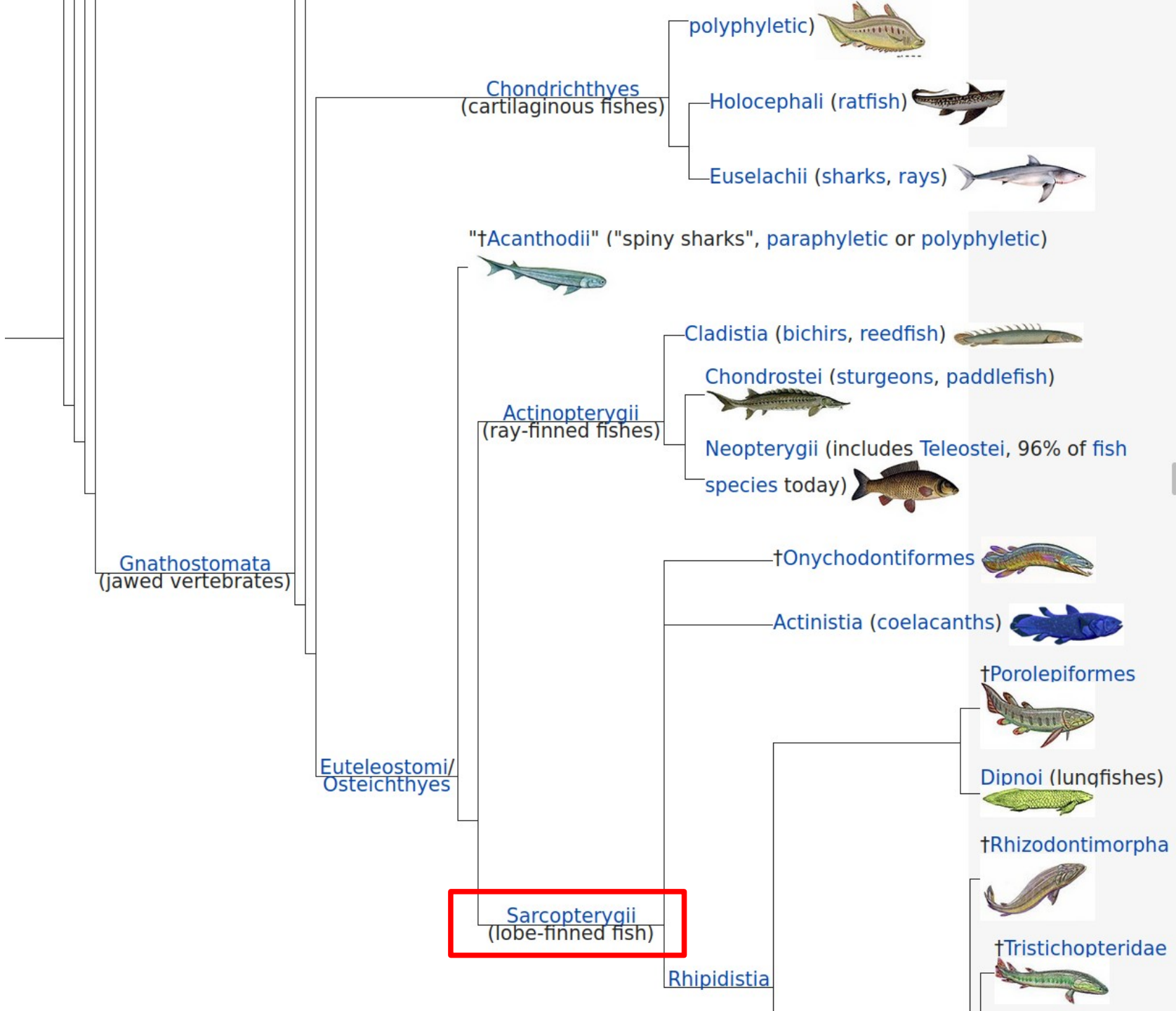
Dipnoi (lungfishes)

†Rhizodontimorpha

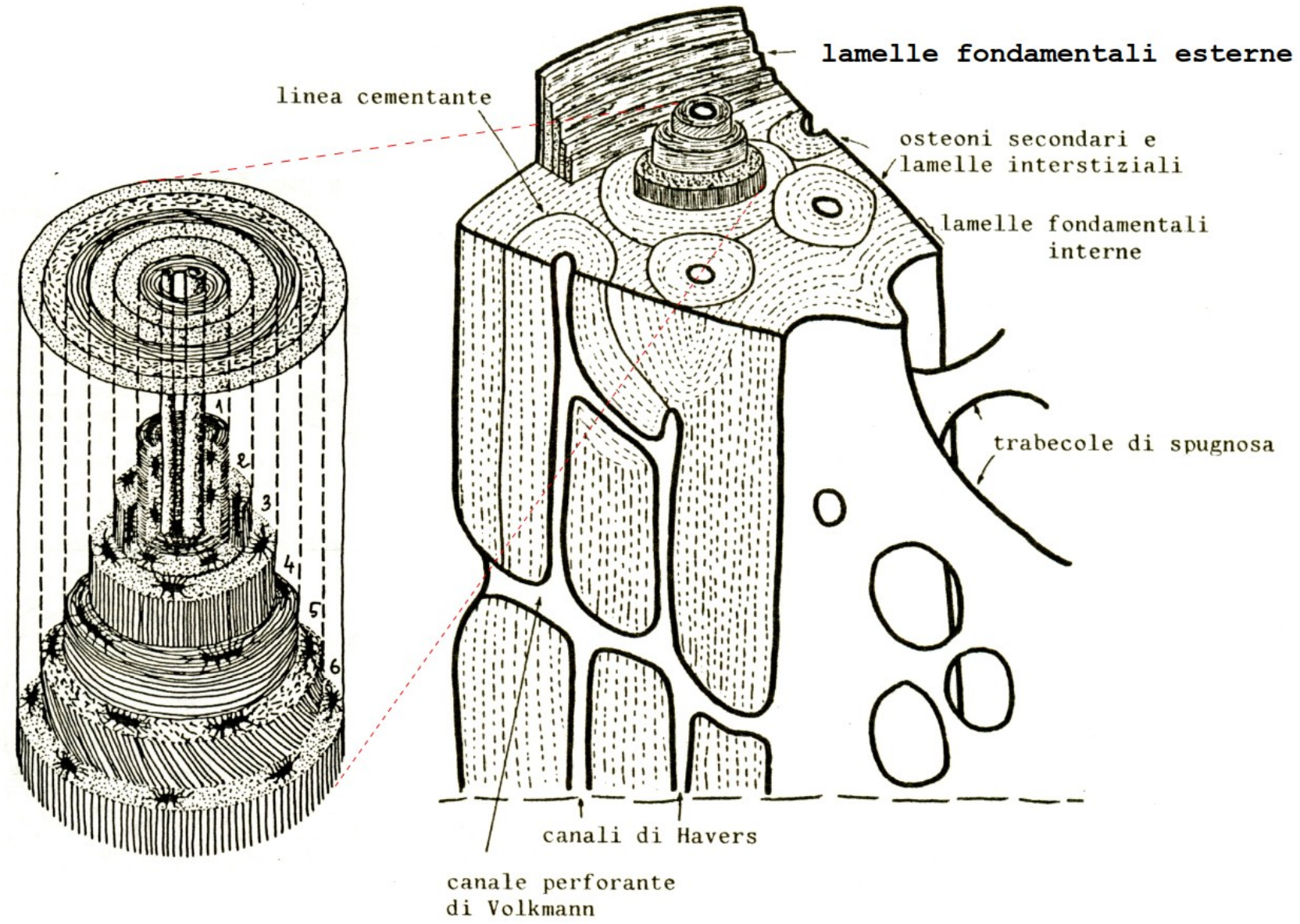
Rhipidistia

†Tristichopteridae

Classe: *Sarcopterygii*
(pesci a pinne lobate)
Early lobe-finned fishes are bony fish with fleshy, lobed, paired fins, which are joined to the body by a single bone. The fins of lobe-finned fishes differ from those of all other fish in that each is borne on a fleshy, lobelike, scaly stalk (*fusto squamoso*) extending from the body. The scales of sarcopterygians are true scaloids, consisting of **lamellar bone** surrounded by layers of vascular bone, dentine-like cosmine, and external keratin.



Struttura di un osso lungo



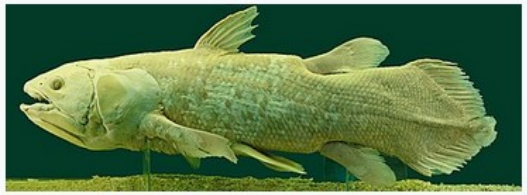
Il Celacanto

Il Celacanto

The coelacanths are members of a now-rare order of fish (*Coelacanthiformes*) that includes two extant species in the genus *Latimeria*: the West Indian Ocean coelacanth (*Latimeria chalumnae*), primarily found near the Comoro Islands off the east coast of Africa, and the Indonesian coelacanth (*Latimeria menadoensis*). The name originates from the Permian genus *Coelacanthus*, which was the first scientifically named coelacanth.

Coelacanths follow the oldest-known living lineage of **Sarcopterygii** (lobe-finned fish and tetrapods), which means they are more closely related to **lungfish** and tetrapods (which includes amphibians, reptiles, birds and mammals) than to ray-finned fish. They are found along the coastline of Indonesia and in the Indian Ocean. The West Indian Ocean coelacanth is a critically endangered species.

Coelacanthiformes



Latimeria chalumnae

Intervallo geologico

Devoniano–Cretacico

Pre Є O S D C P T J K P N

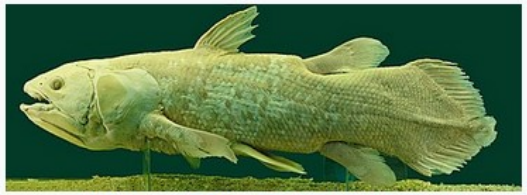
Classificazione scientifica

Dominio	Eukaryota
Regno	Animalia
Sottoregno	Eumetazoa
Ramo	Bilateria
Superphylum	Deuterostomia
Phylum	Chordata
Subphylum	Vertebrata
Infraphylum	Gnathostomata
Superclasse	Osteichthyes
Classe	Sarcopterygii
Sottoclasse	Crossopterygii
Ordine	**Coelacanthiformes**

Il Celacanto

The oldest known coelacanth fossils are over 410 million years old. Coelacanths were thought to have become extinct in the Late Cretaceous, around 66 million years ago, but were rediscovered in 1938 off the coast of South Africa.

Coelacanthiformes



Latimeria chalumnae

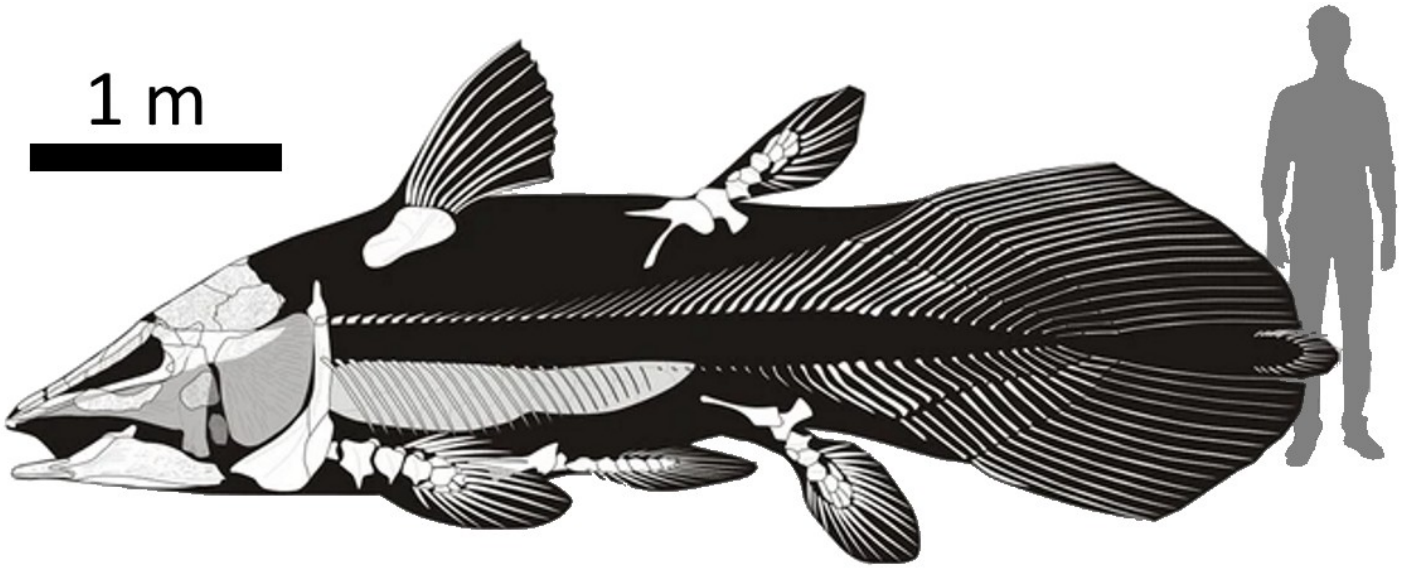
Intervallo geologico

Devoniano–Cretacico

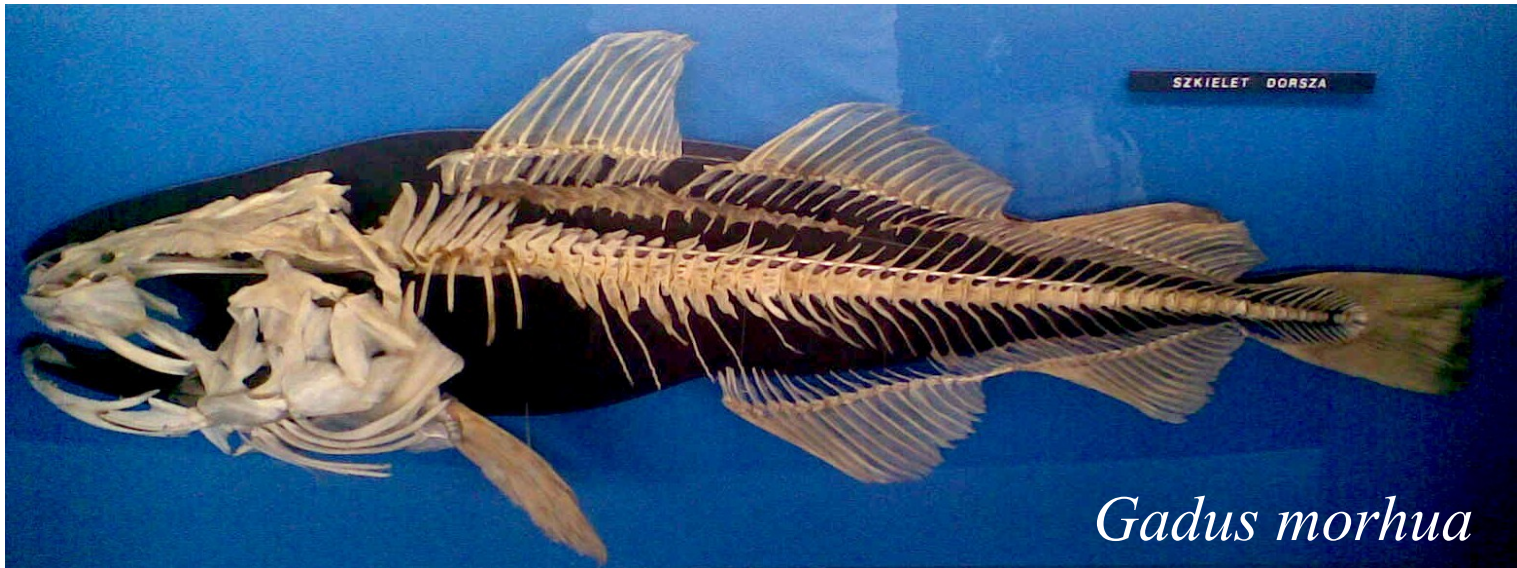
Classificazione scientifica

Dominio	Eukaryota
Regno	Animalia
Sottoregno	Eumetazoa
Ramo	Bilateria
Superphylum	Deuterostomia
Phylum	Chordata
Subphylum	Vertebrata
Infraphylum	Gnathostomata
Superclasse	Osteichthyes
Classe	Sarcopterygii
Sottoclasse	Crossopterygii
Ordine	**Coelacanthiformes**

I pesci a pinne lobate sono gli antenati dei Tetrapodi!



Mawsonia gigas



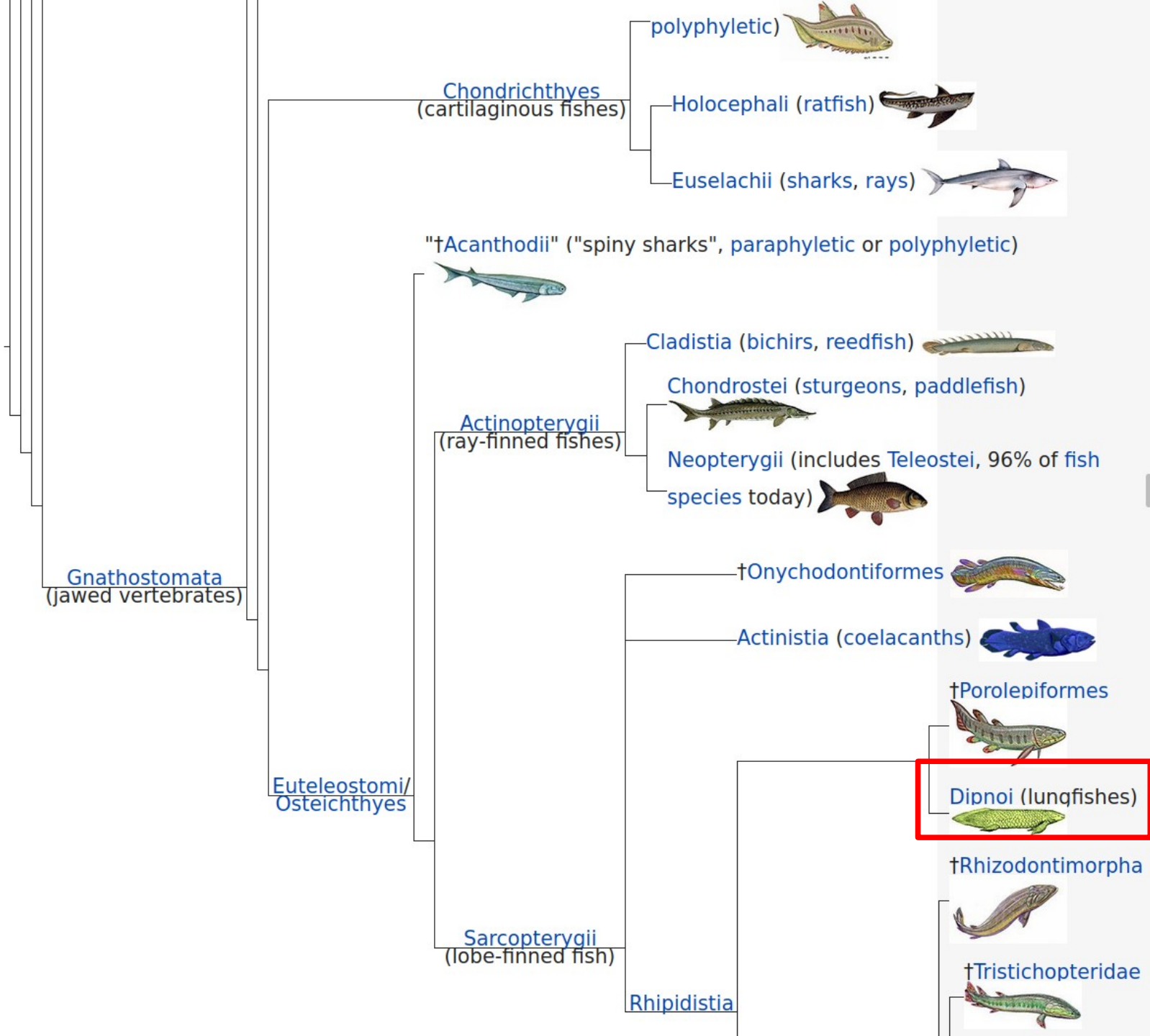
Gadus morhua

Ordine: Dipnoi (lungfishes)

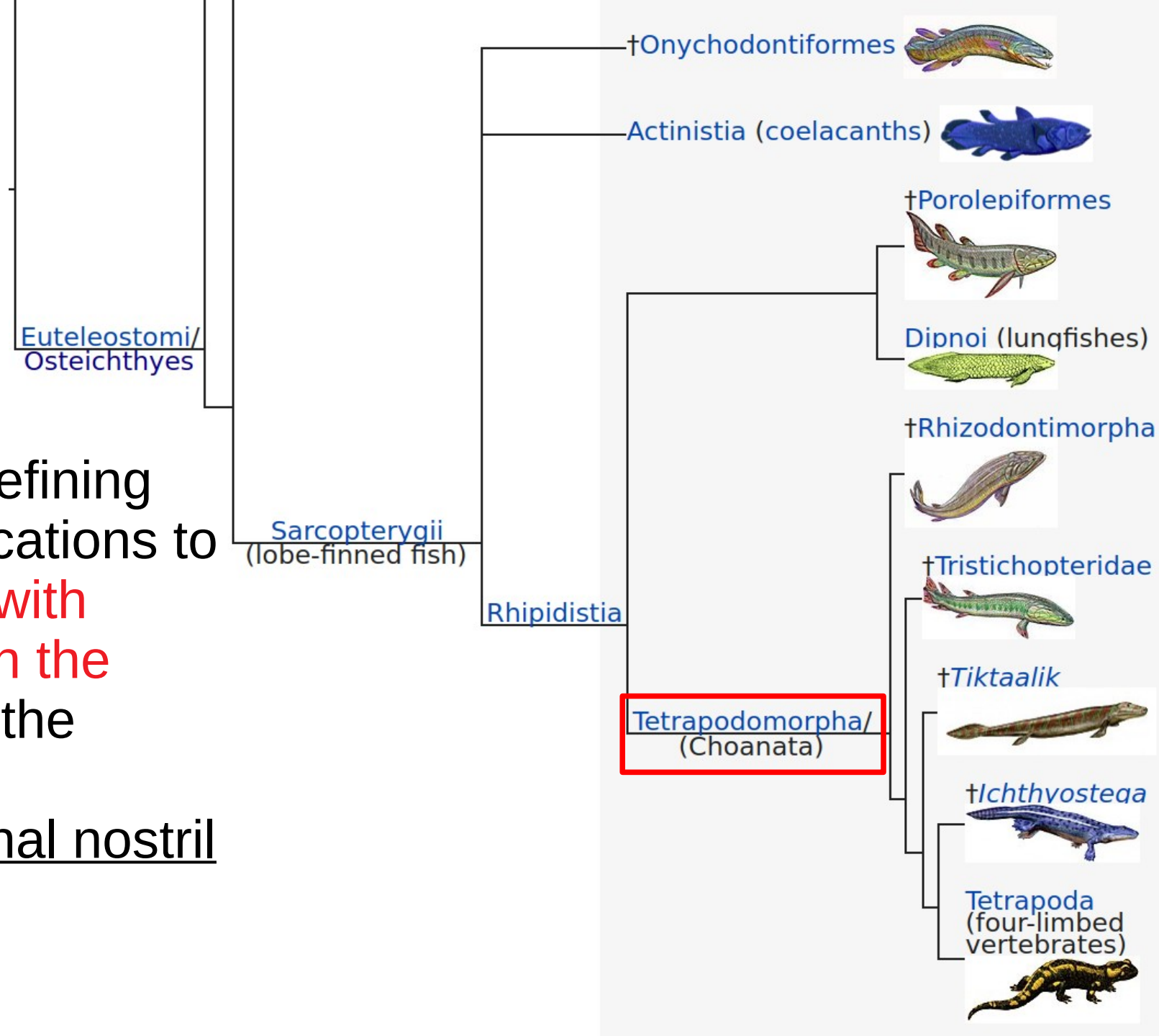
Lungfish are freshwater rhipidistian vertebrates belonging to the order Dipnoi.

Lungfish are best known for retaining ancestral characteristics within the Osteichthyes, including the ability to breathe air, and ancestral structures within Sarcopterygii, including the presence of lobed fins with a well-developed internal skeleton.

Lungfish represent the closest living relatives of the tetrapods.



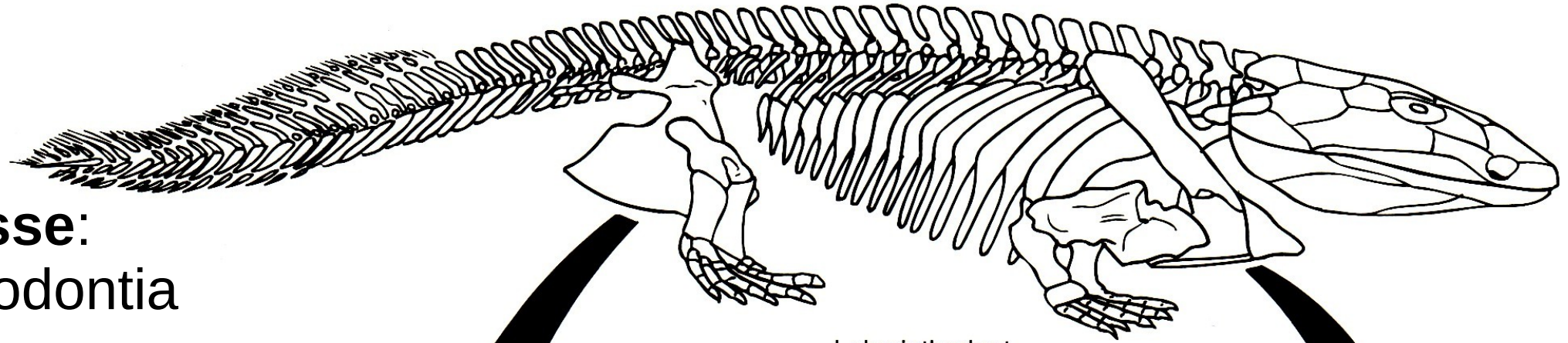
Regno: Animalia
Phylum: Chordata
Clade: Tetrapodomorpha



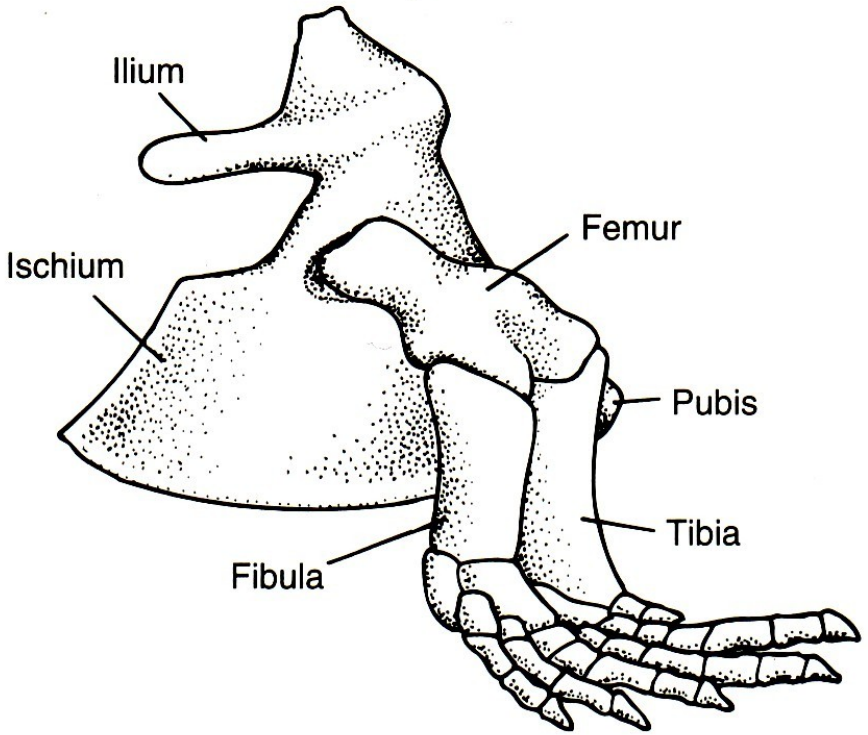
Among the characteristics defining tetrapodomorphs are modifications to the fins, notably a humerus with convex head articulating with the glenoid fossa (the socket of the shoulder joint).
Another key trait is the internal nostril or *choana*.

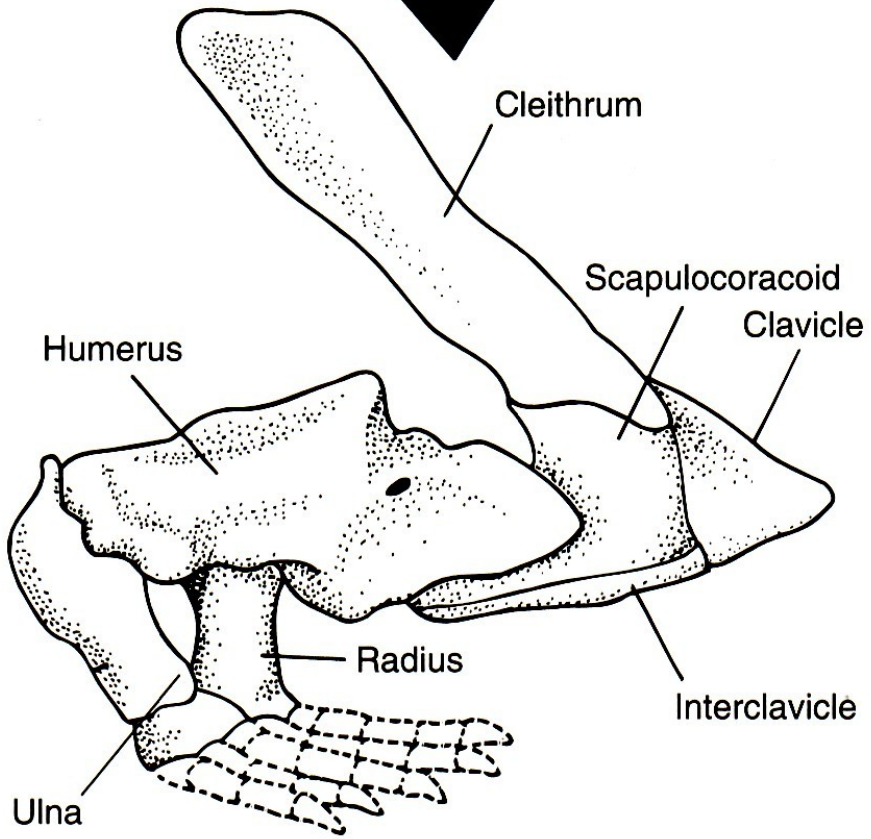
Classe:
Amphibia

Sottoclasse:
Labyrinthodontia



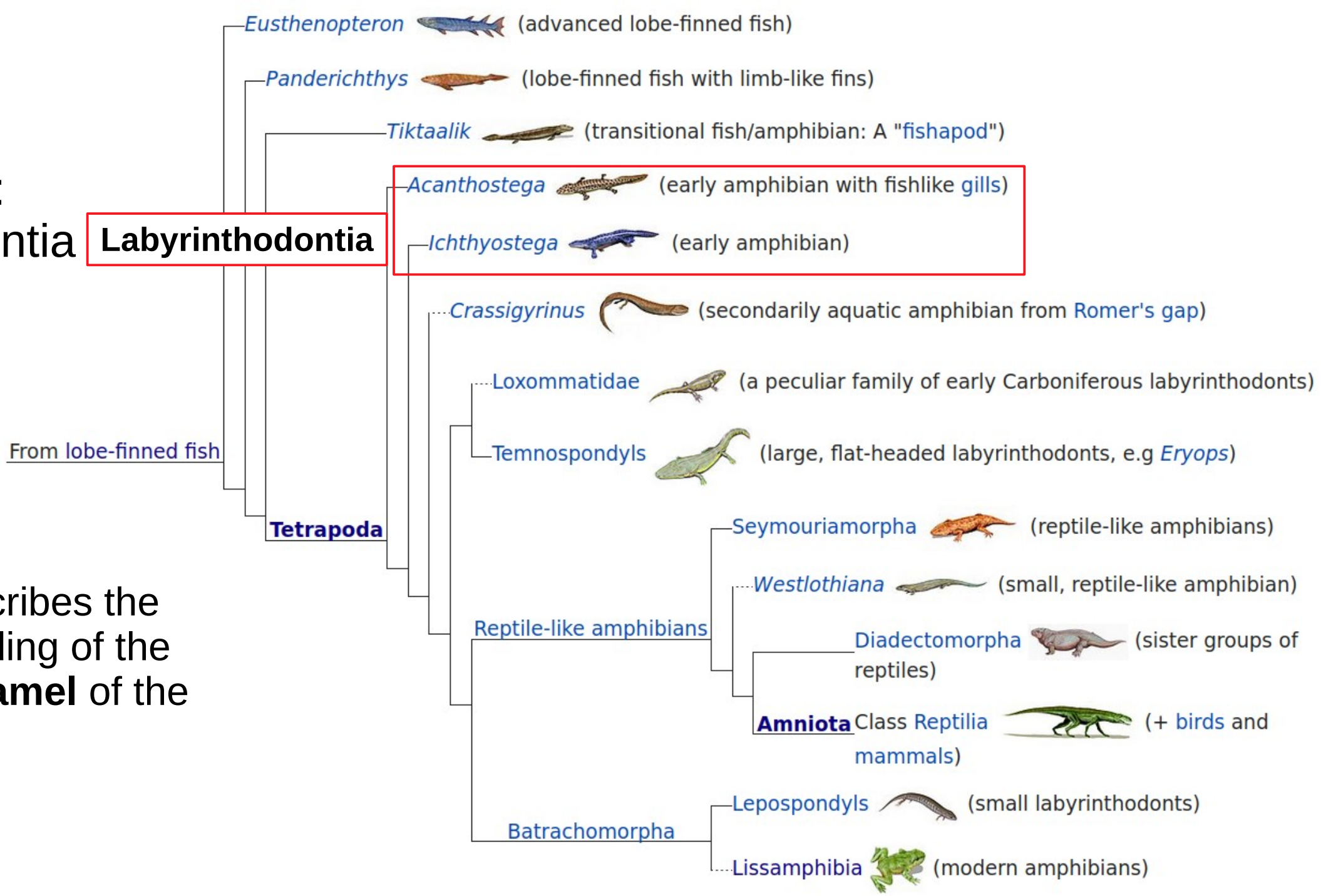
Labyrinthodont
Ichthyostega





Classe:
Amphibia

Sottoclasse:
Labyrinthodontia



The name describes the pattern of infolding of the **dentin** and **enamel** of the teeth.

Smalto e dentina