# Paleontologia 2023 (Aula 8):
# *Terrestrialização*

"All the News That's in the Record"

# Devonian Times

Fourth E.

Fram Formation, Euramerica, Sunday, ~382 MYA

*Tiktaalik,* from the Nunavut Territory, Canada, has dazzled the scientific community and the world media.

## "Fishapod" from the North!

*Gaps in the fossil record are diminishing.*

The dramatic discovery of *Tiktaalik roseae* has ...ded an impressive and informative transitional ...tween lobe-fin fishes and early tetrapods. ..."fishapod", *Tiktaalik* is one of several recent

## Red Hill: Late Devonian Window

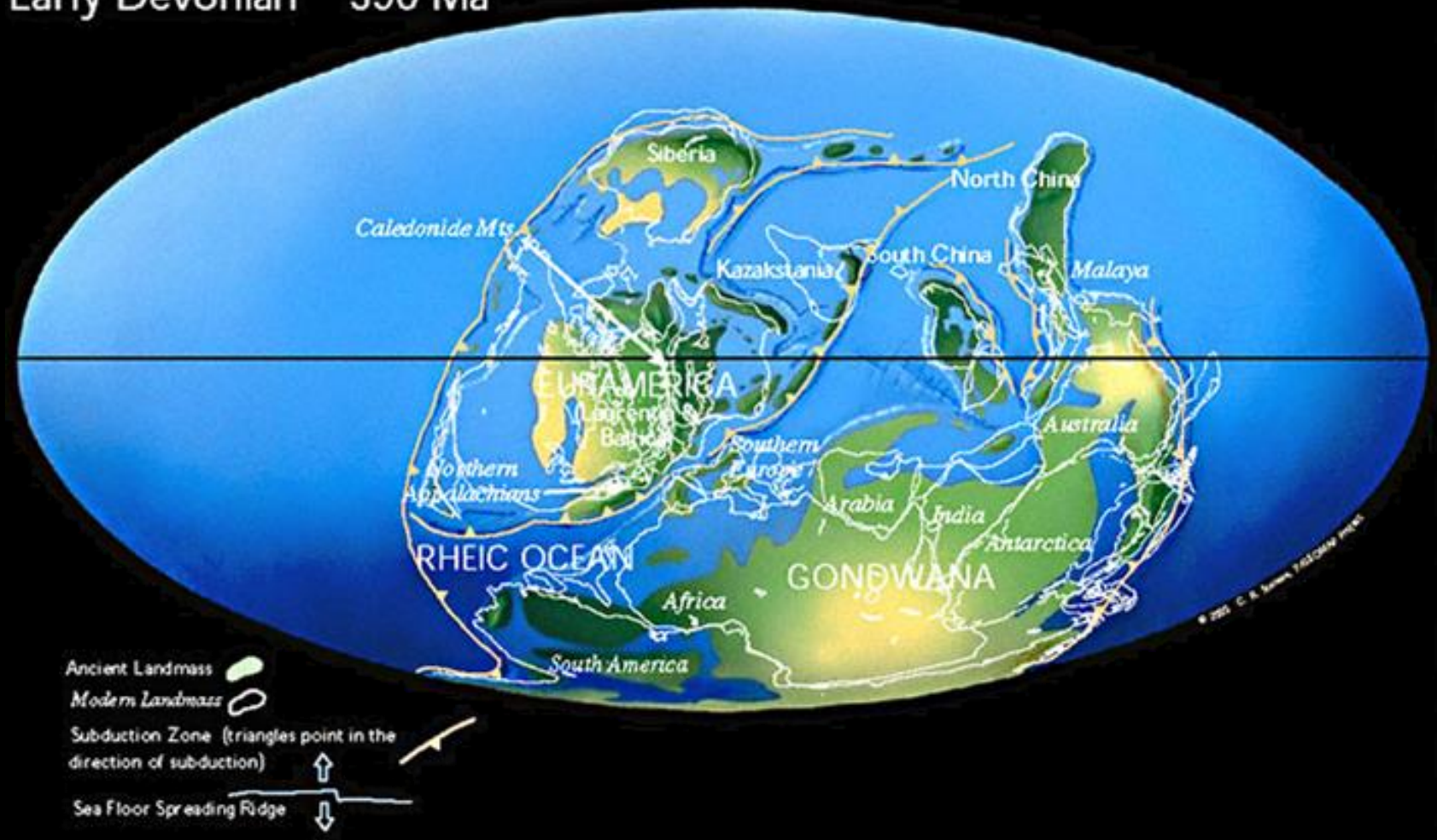
While much attention has been shifted to Late Devonian investigations in the Canadian Arctic, Red Hill continues to provide an exceptional window onto the world of the first tetrapods. This Famennian locality hosts a diverse assemblage of tetrapods, lobe-fin fishes, other fishes, invertebrates and plants

see Who's Who at Red Hill

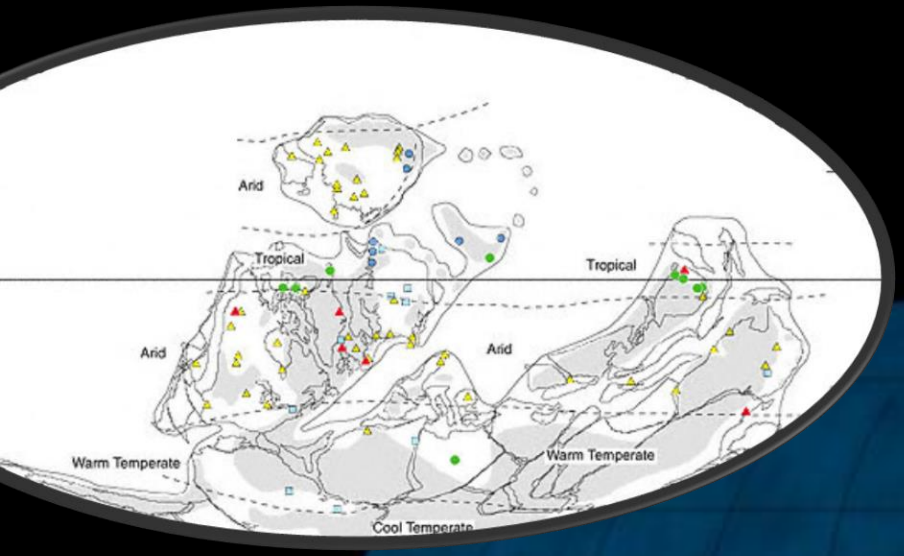
## Opportunity Knocked: Tetrapods Answered

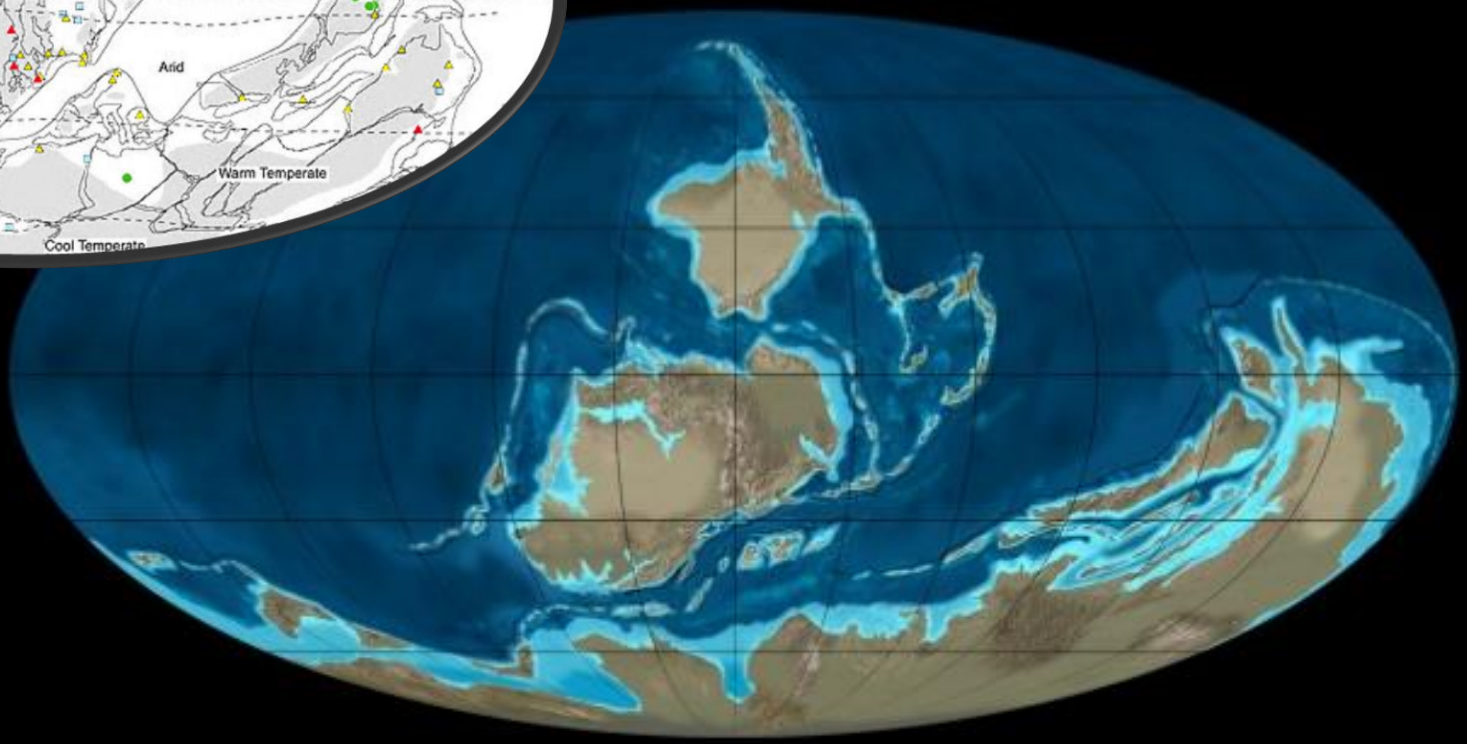
The Devonian Period (417-354 MYA) was a time of profound changes in terrestrial and aquatic ecosystems. These changes set the stage for the evolution of tetrapods and their expansion onto the land.

# Devonian Times

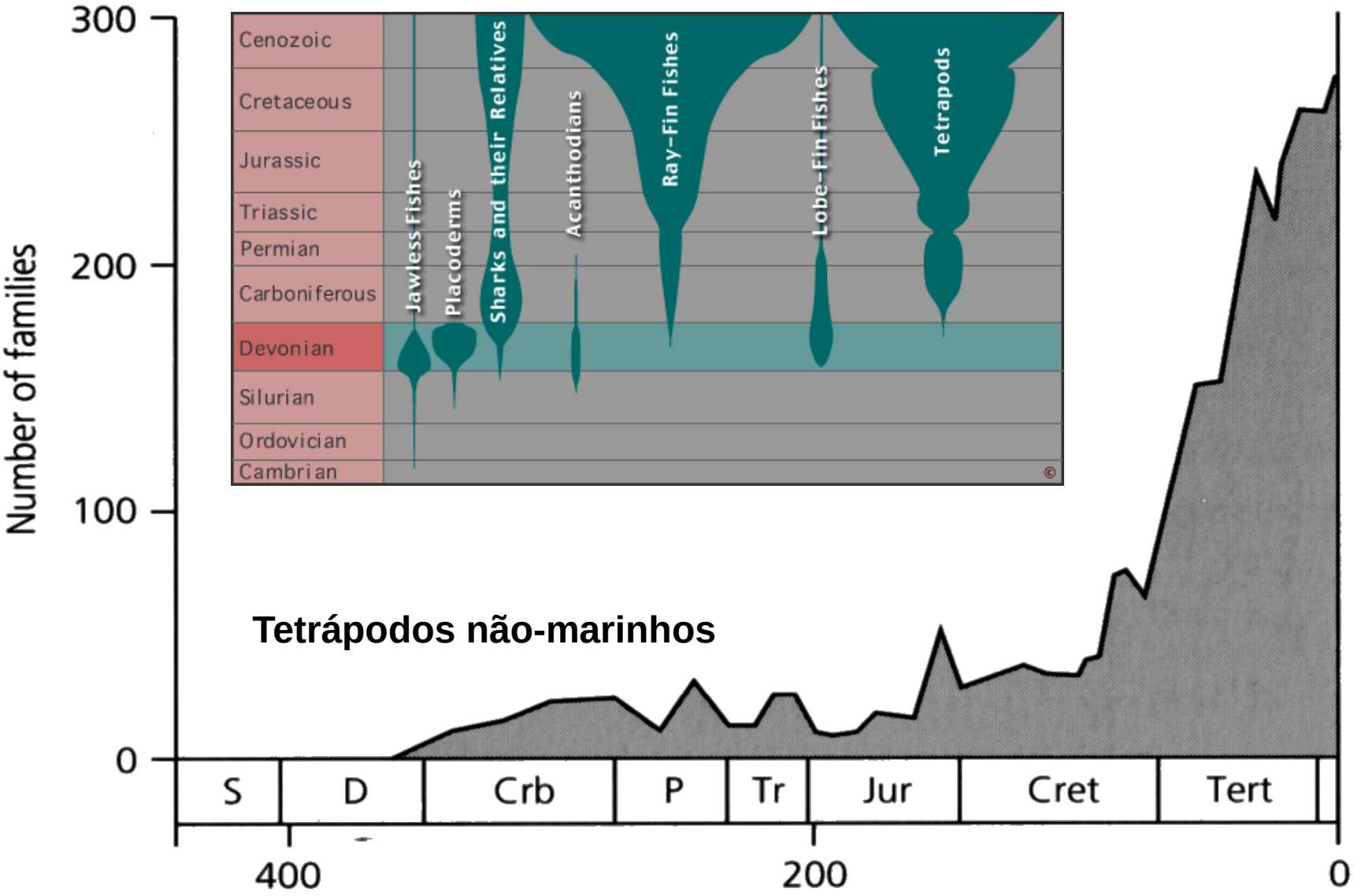


# Devonian Times



# Vertebrados: tetrápodos



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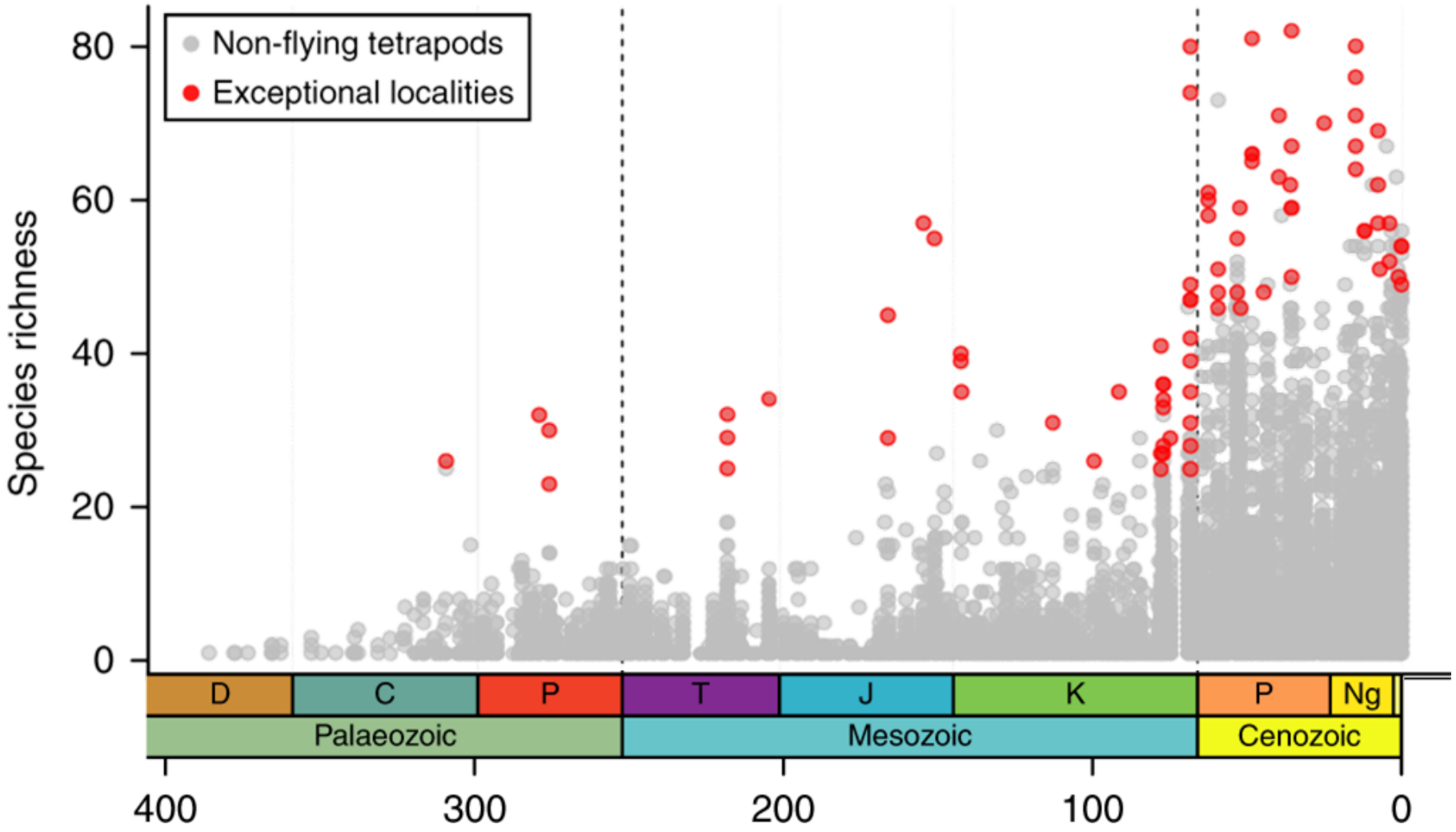
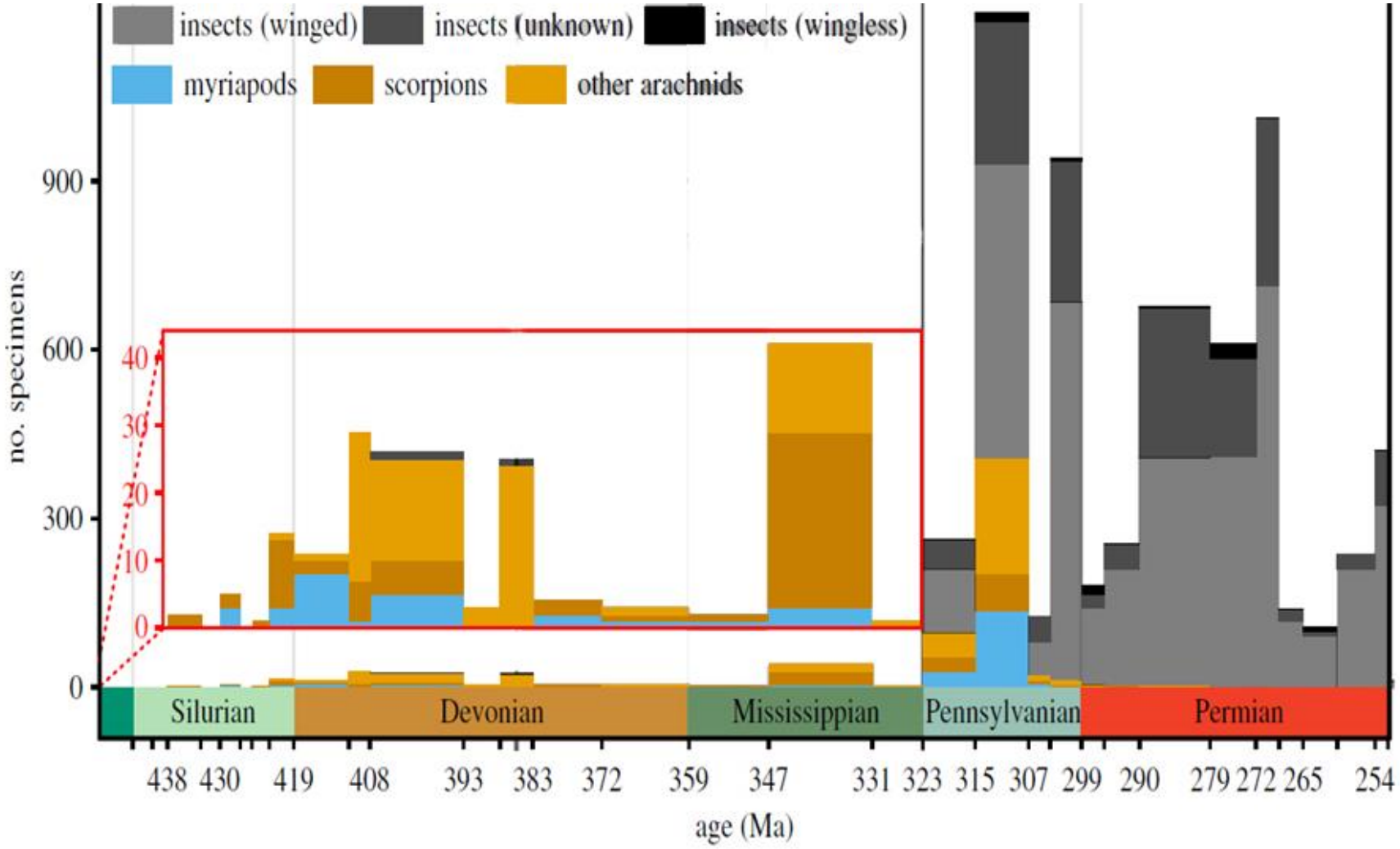
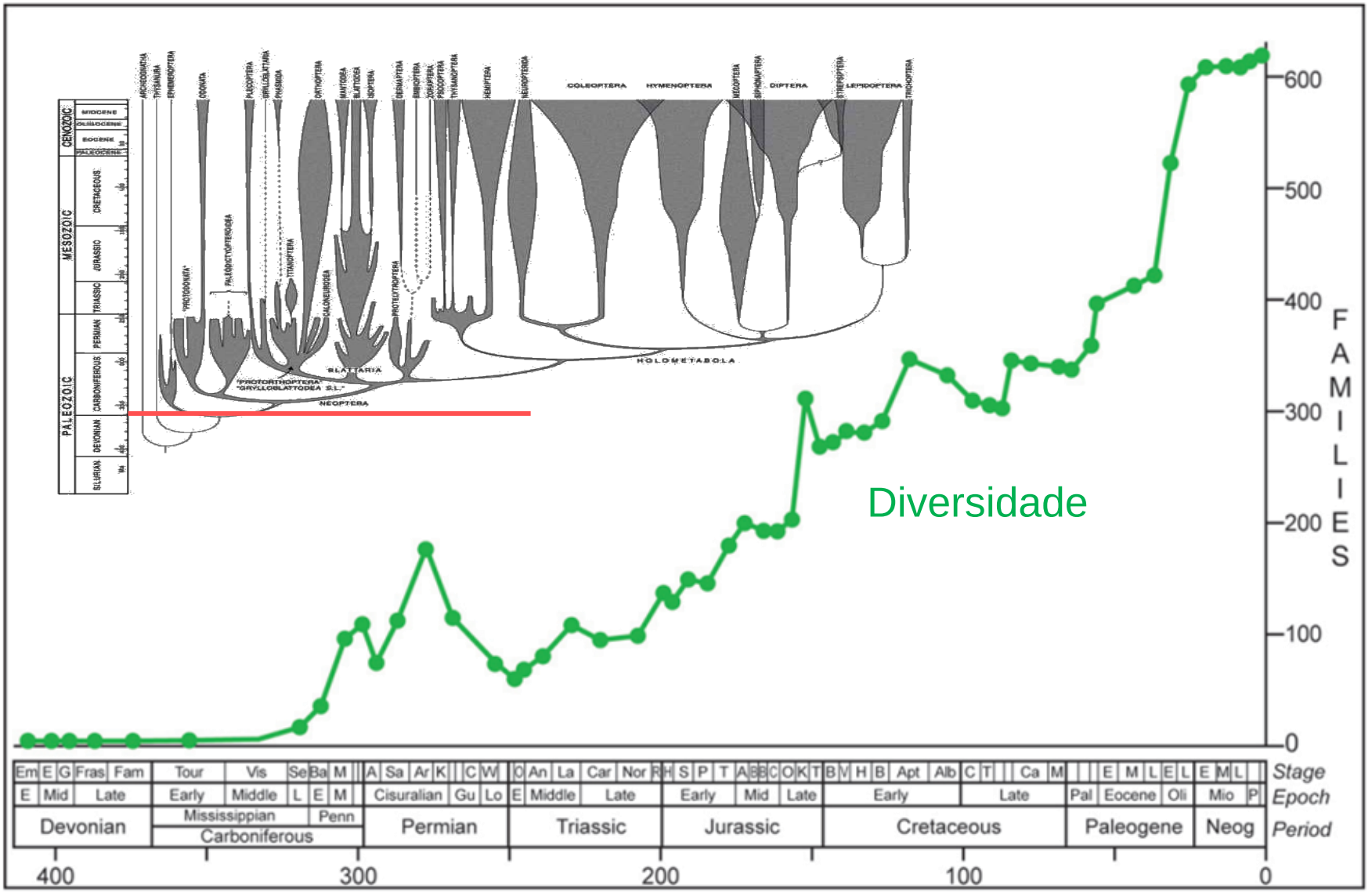


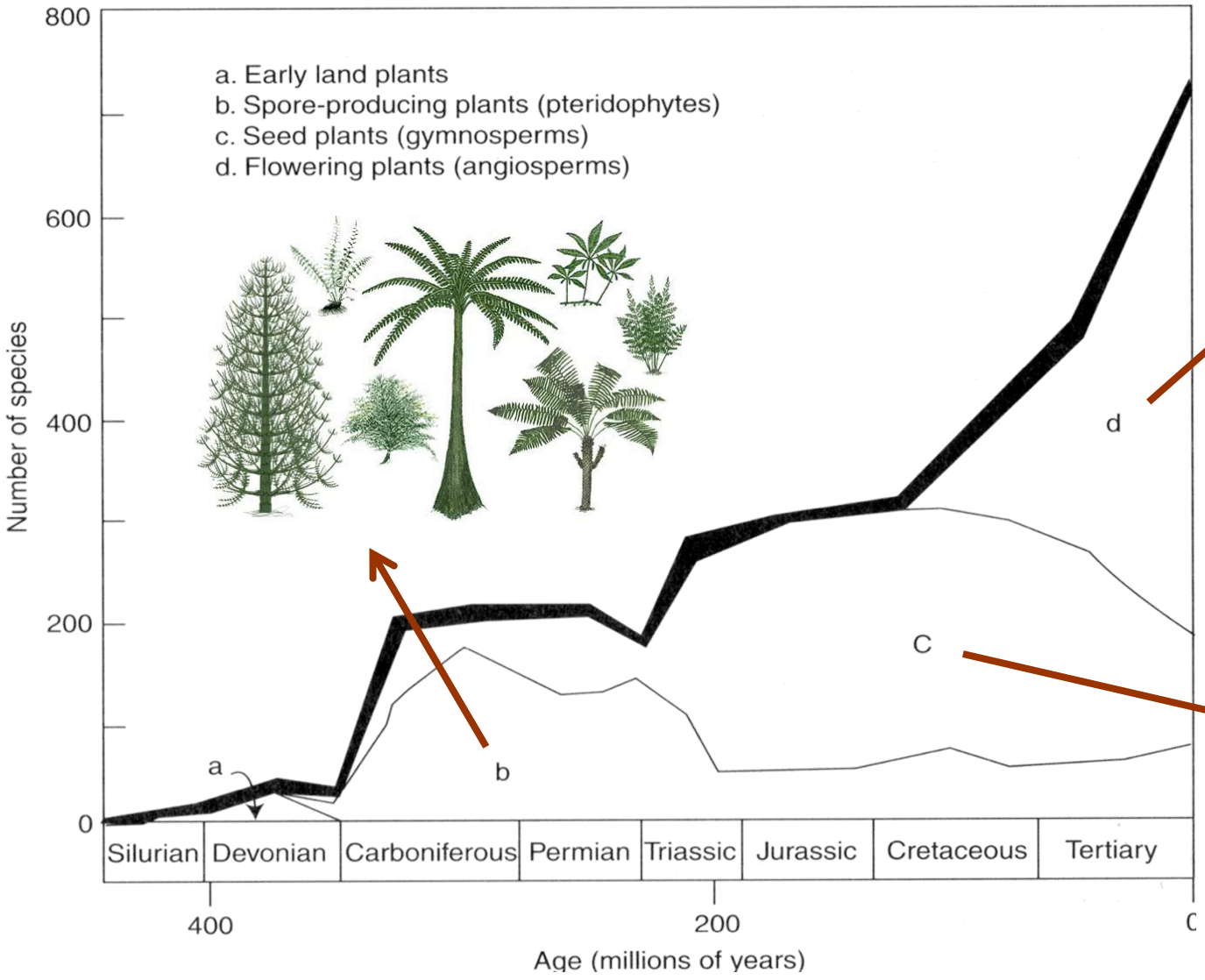
# Artrópodes: miriápodes, insetos e aracnídeos



# Artrópodes: insetos

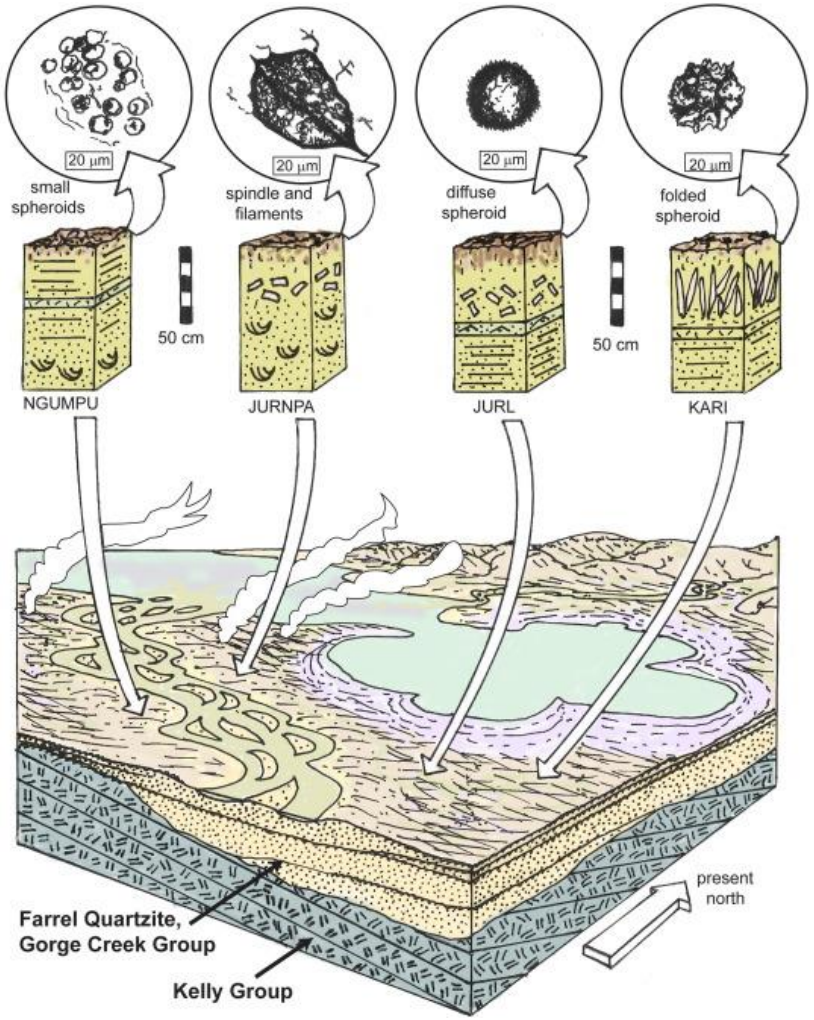


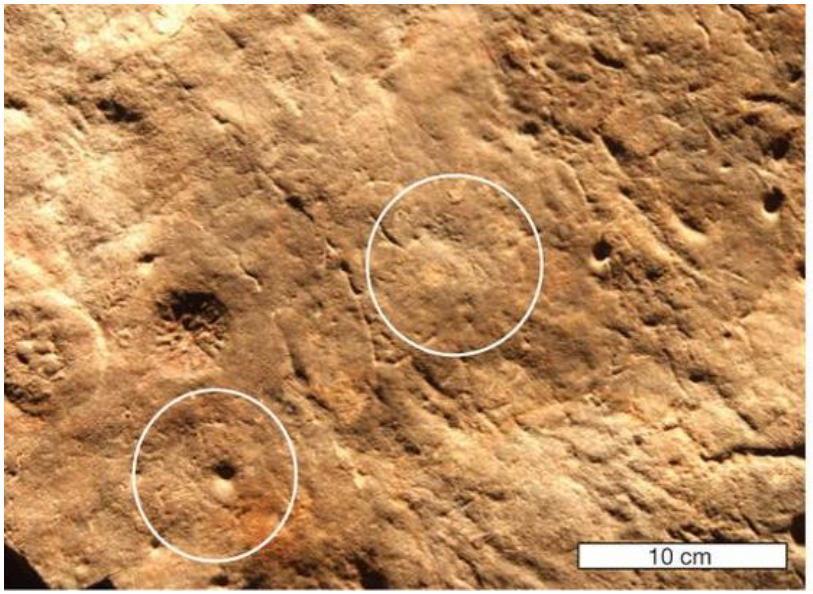
# Plantas: traqueófitas




# Solos pré-devonianos

Alto $CO_2$ atmosférico => chuva ácida
Cianobactérias (paleosolos ricos em carbono) e líquens

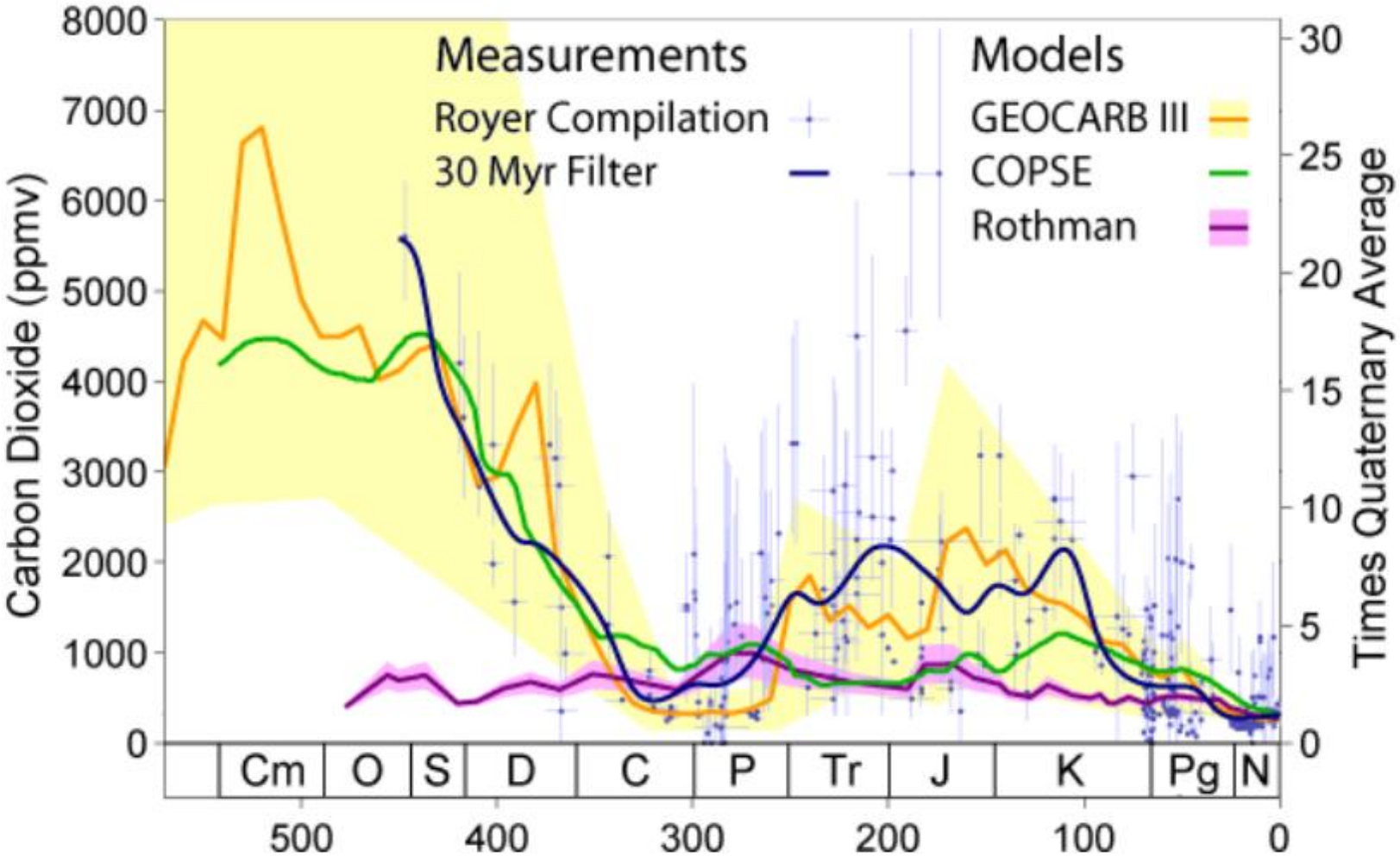



# Solos pré-devonianos

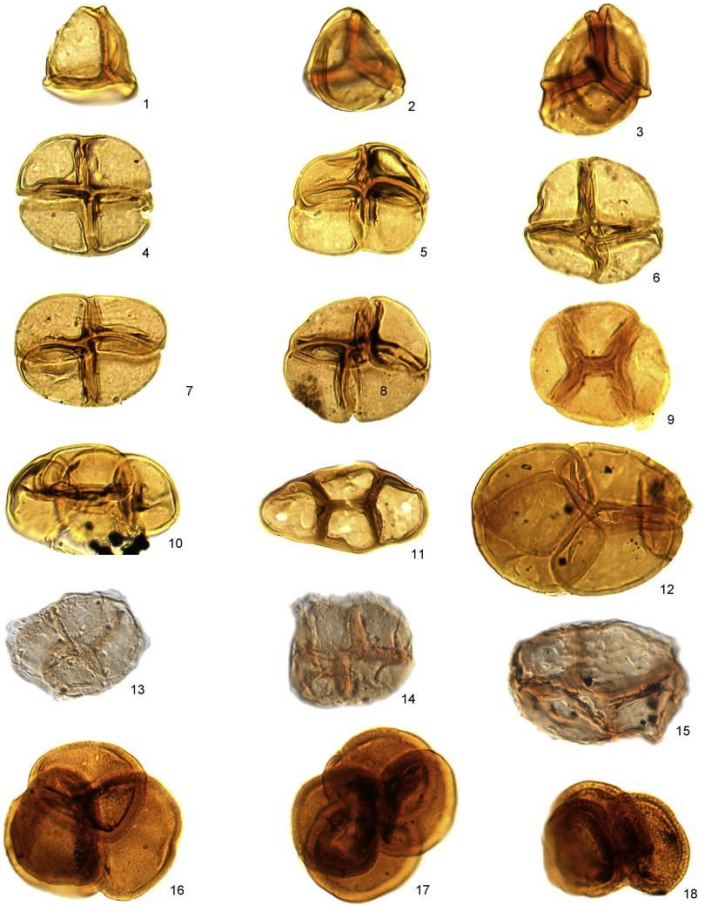
Cianobactérias (paleosolos ricos em carbono) e líquens

Redução do $CO_2$ atmosférico



# Plantas pré-devonianas

Ordoviciano: esporomorfos e cutículas de “briófitas”, bem como de plantas possivelmente mais adpatadas à vida terrestre

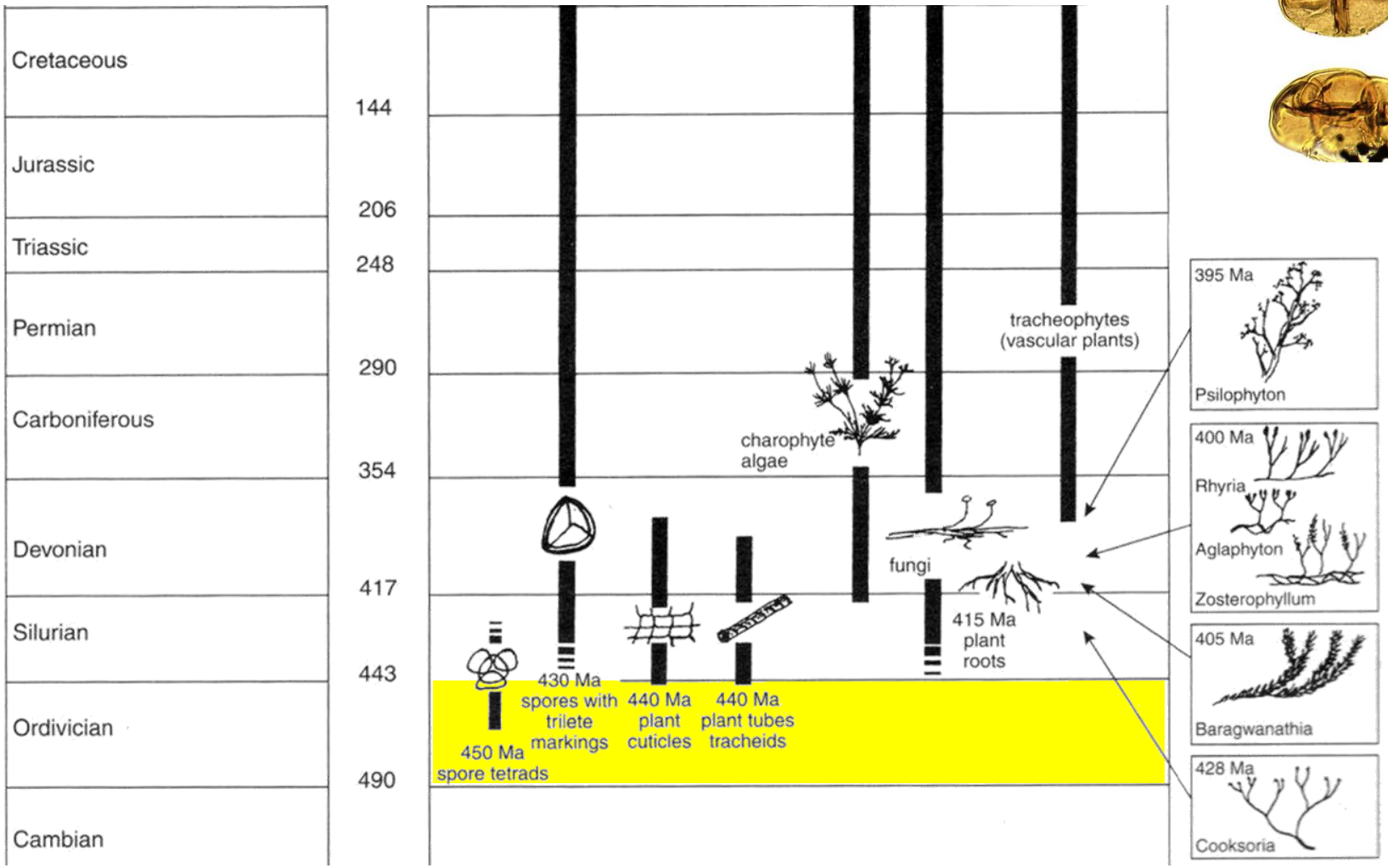



*Nematothallus*, EUA

# Plantas pré-devonianas

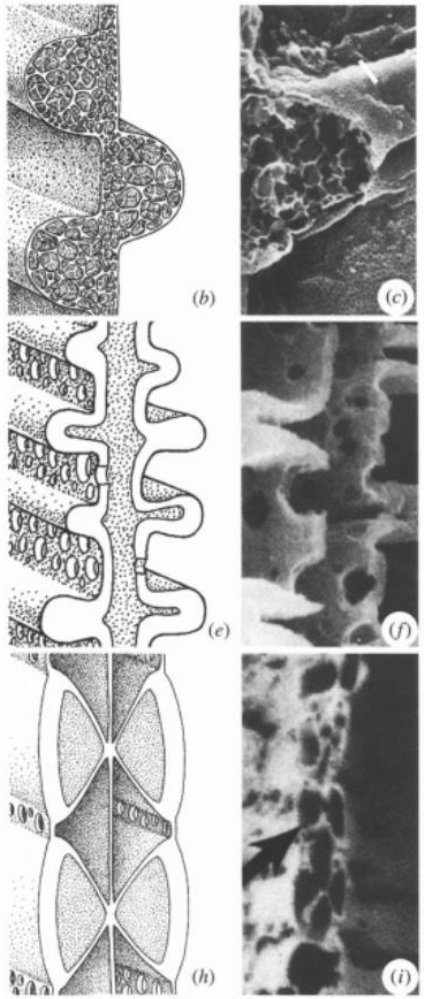
## Ordoviciano: esporomorfos
## Fase vegetativa esporofítica => Tracheophyta

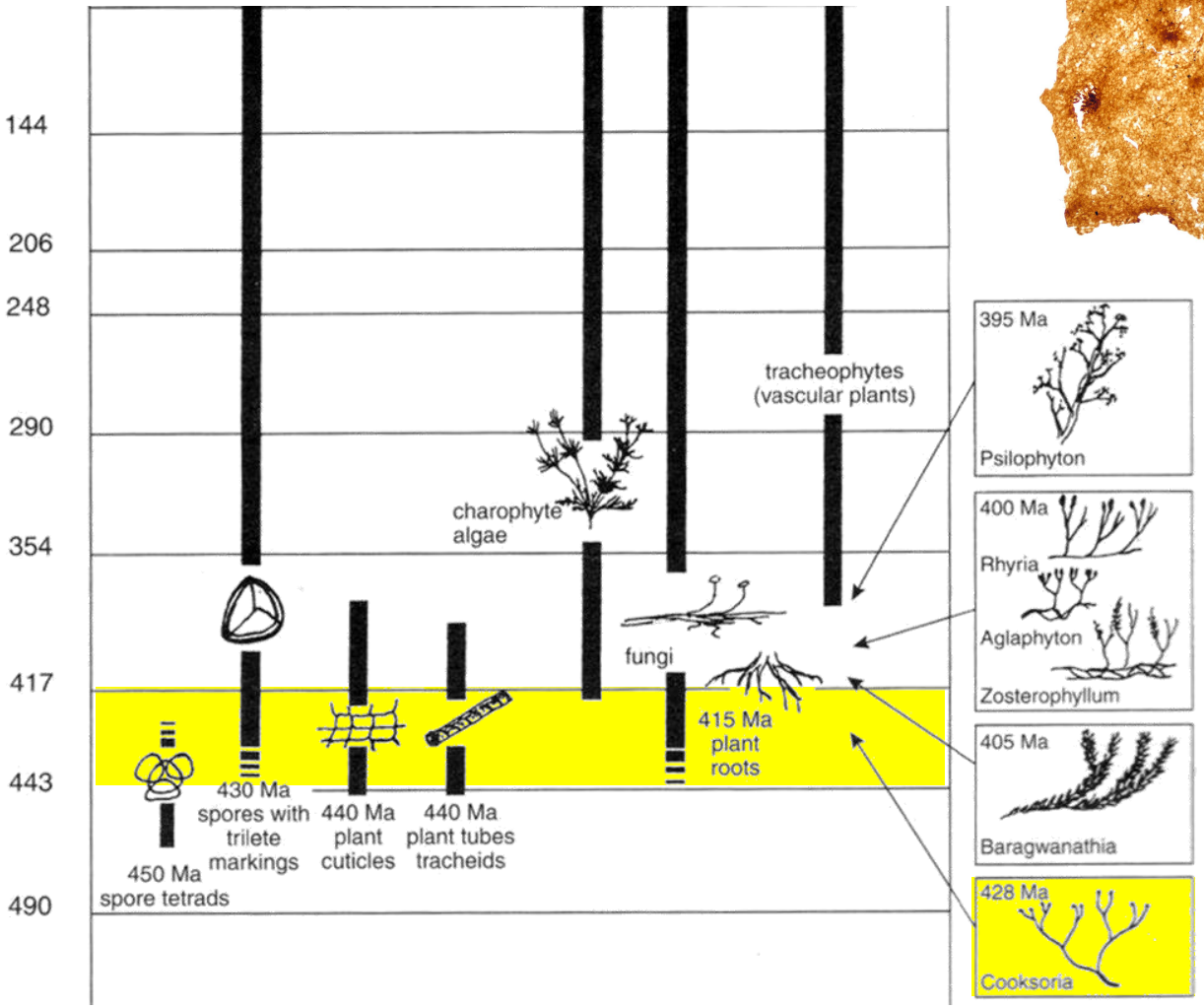


# Plantas pré-devonianas

Siluriano: traqueídeos e mais cutículas => Tracheophyta
Suporte, retenção e transporte de água




# Plantas pré-devonianas

Siluriano: “rhyniofitódes” (Tracheophyta) como *Cooksonia*

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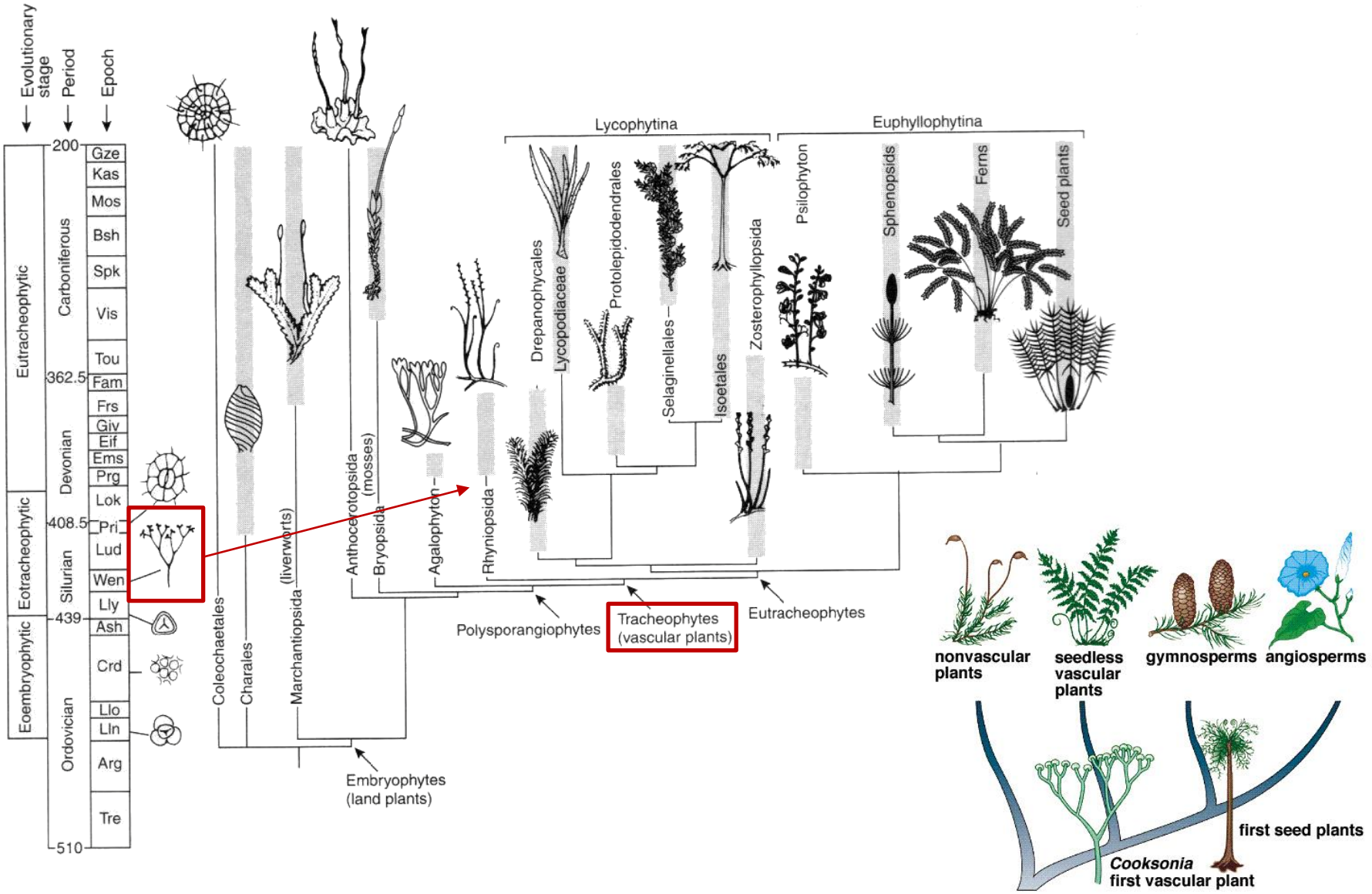
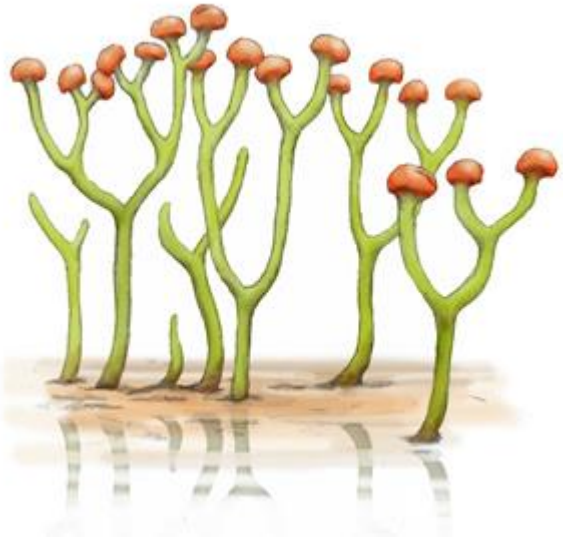
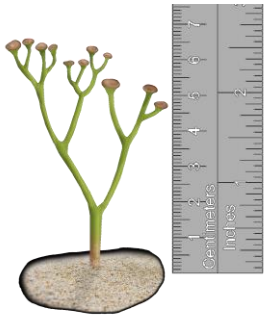
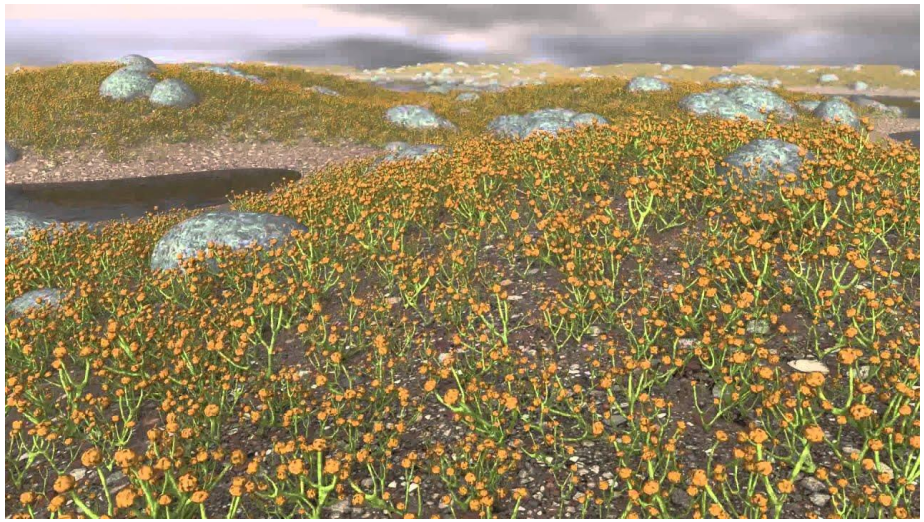


# Plantas pré-devonianas

*Cooksonia*: ramos verticalizados simples bifurcantes e isonômicos
esporângios apical  globular ou discóde

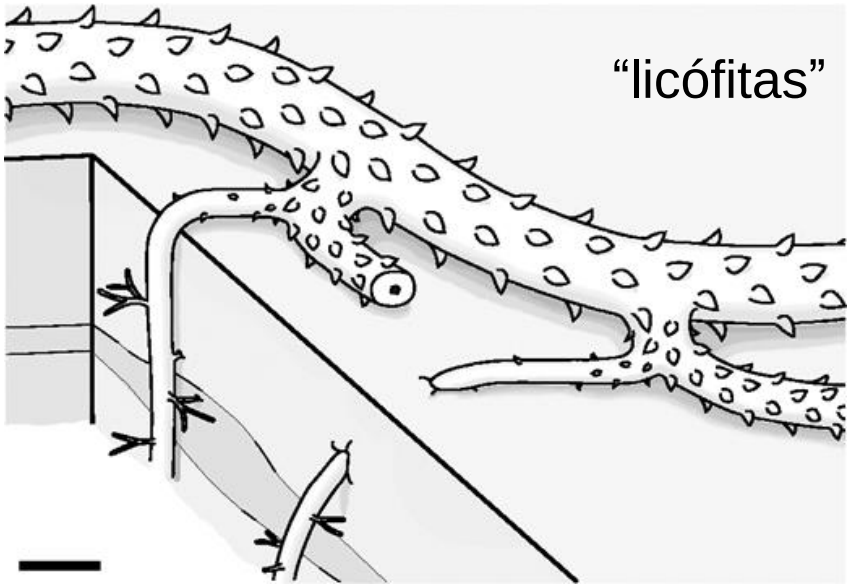


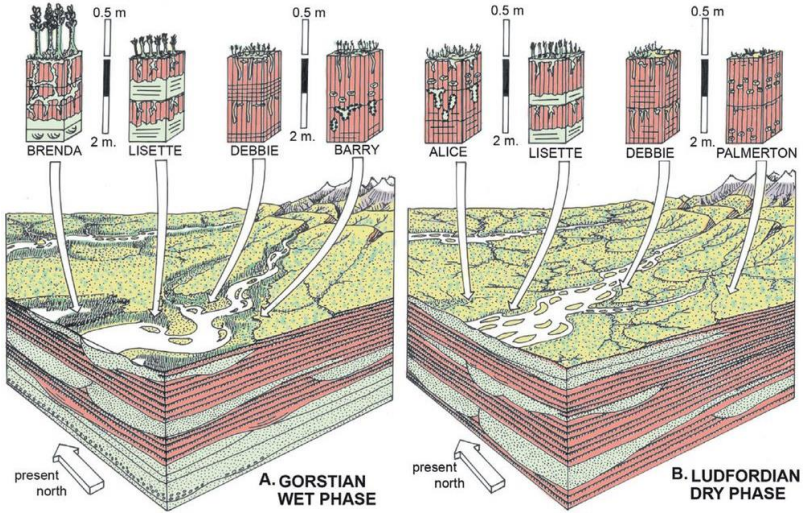




# Plantas pré-devonianas

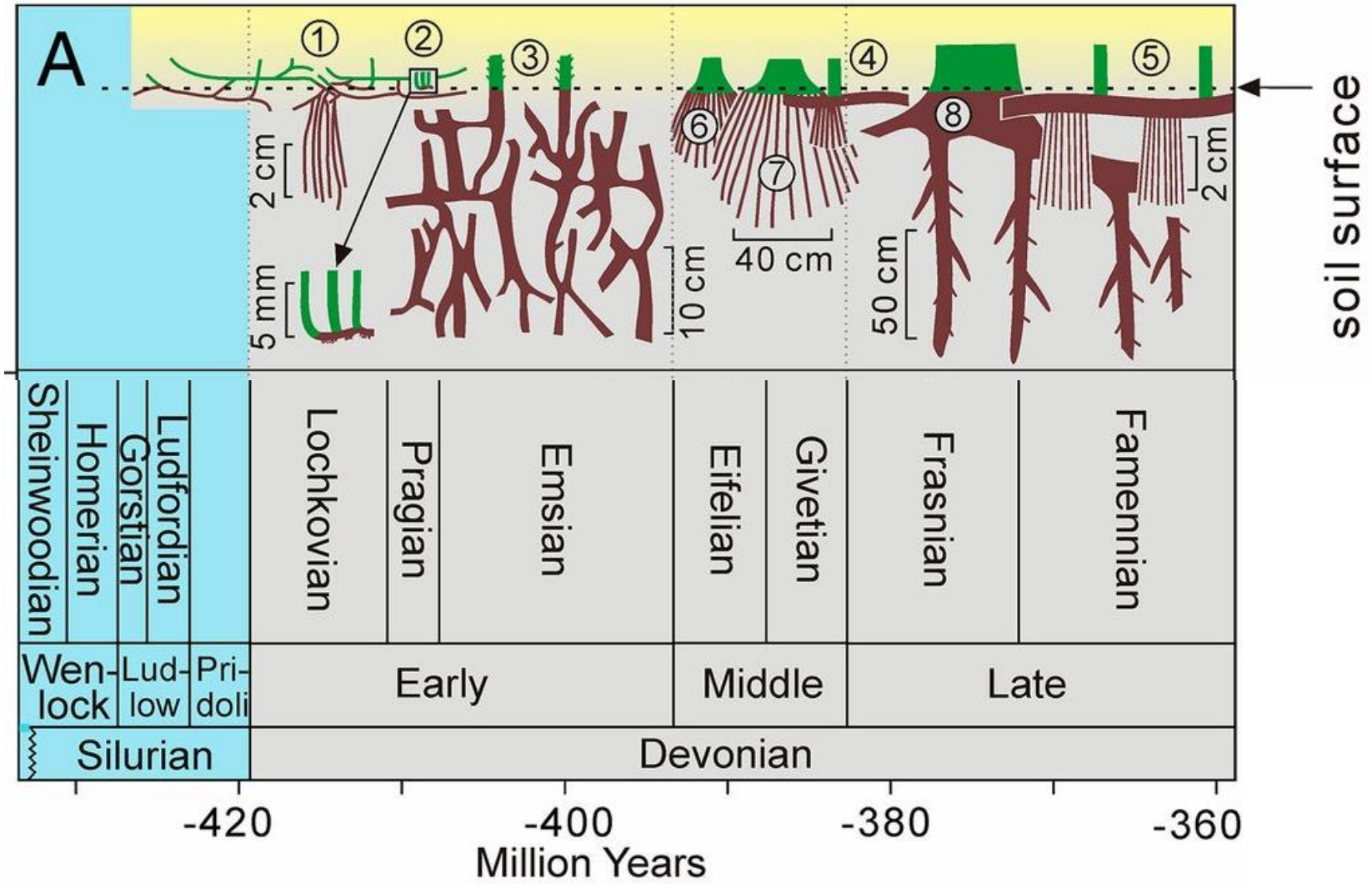
## Siluriano: primeiras evidências de raízes (EUA)

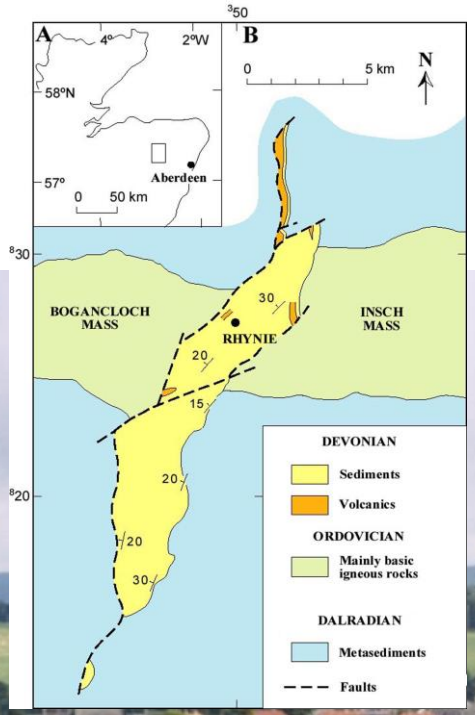

# A revolução devoniana

## Raízes e solos (segunda “Revolução Agronômica”)



# A revolução devoniana

## Rhynie Chert

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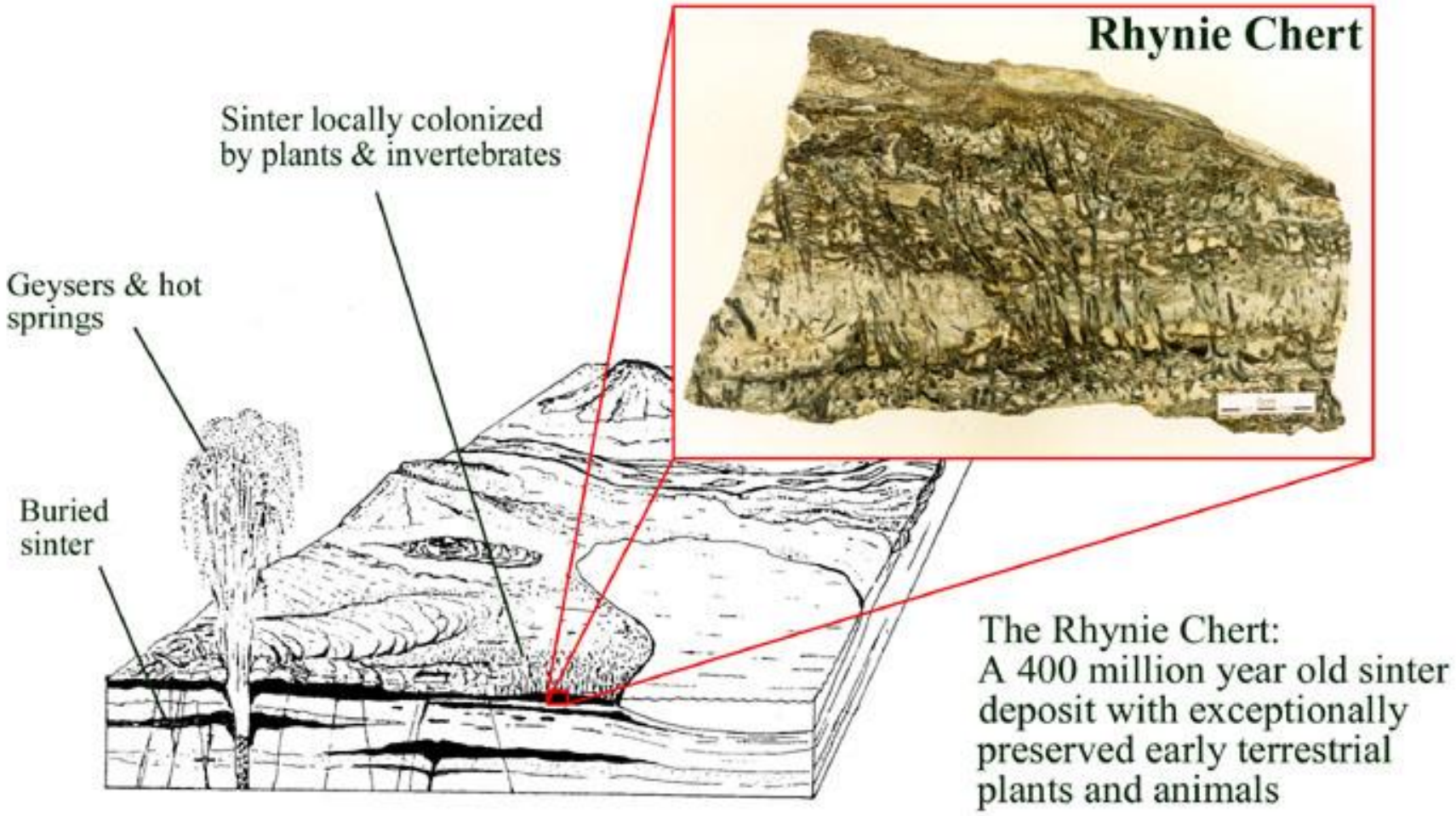

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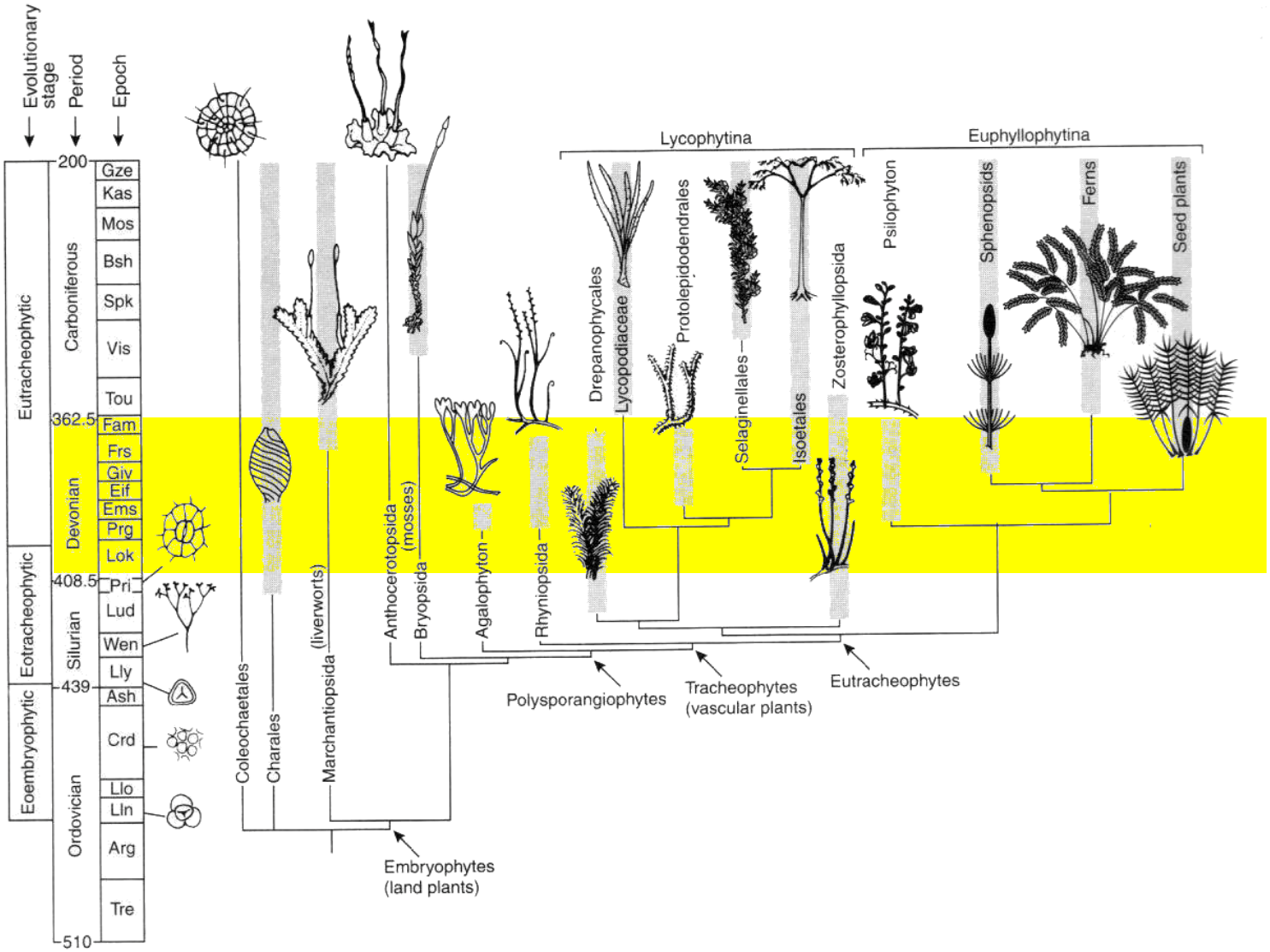
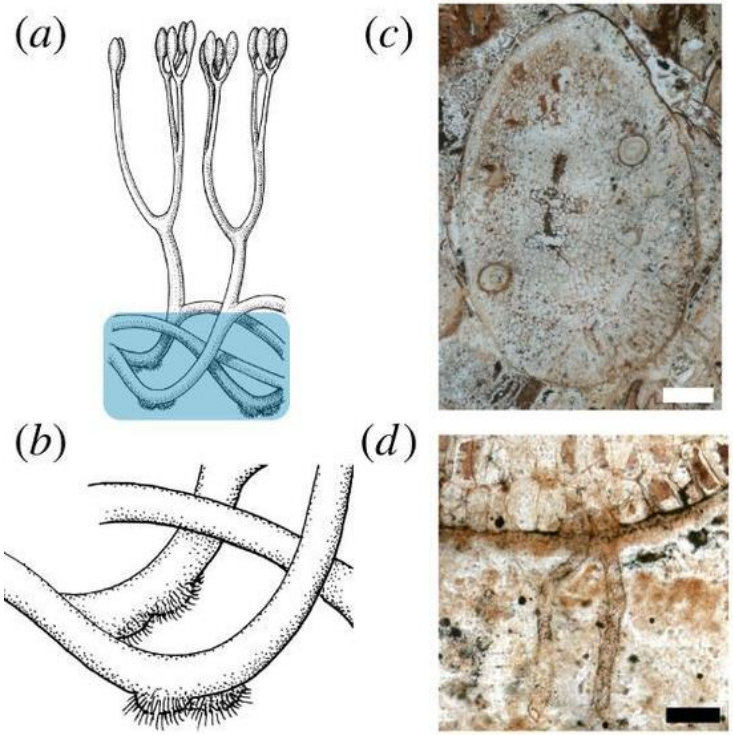
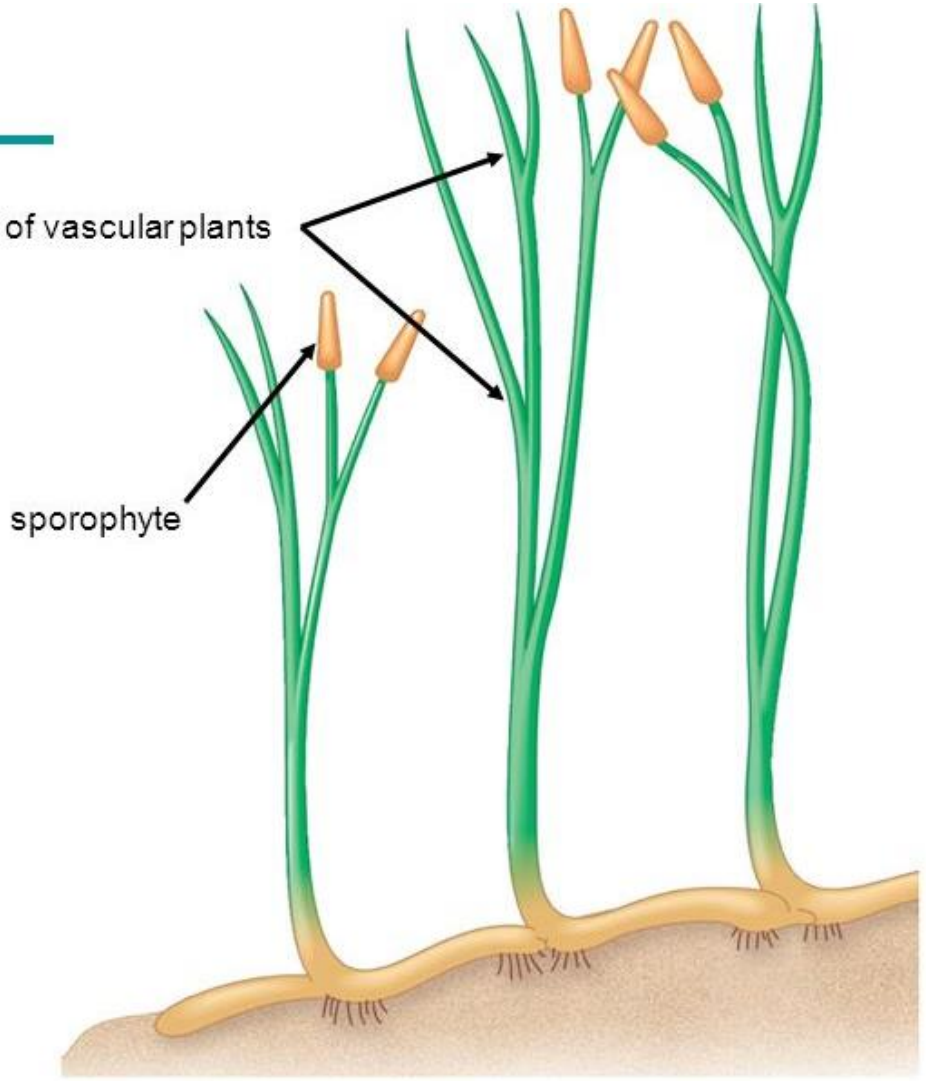


# A revolução devoniana

*Aglaophyton*

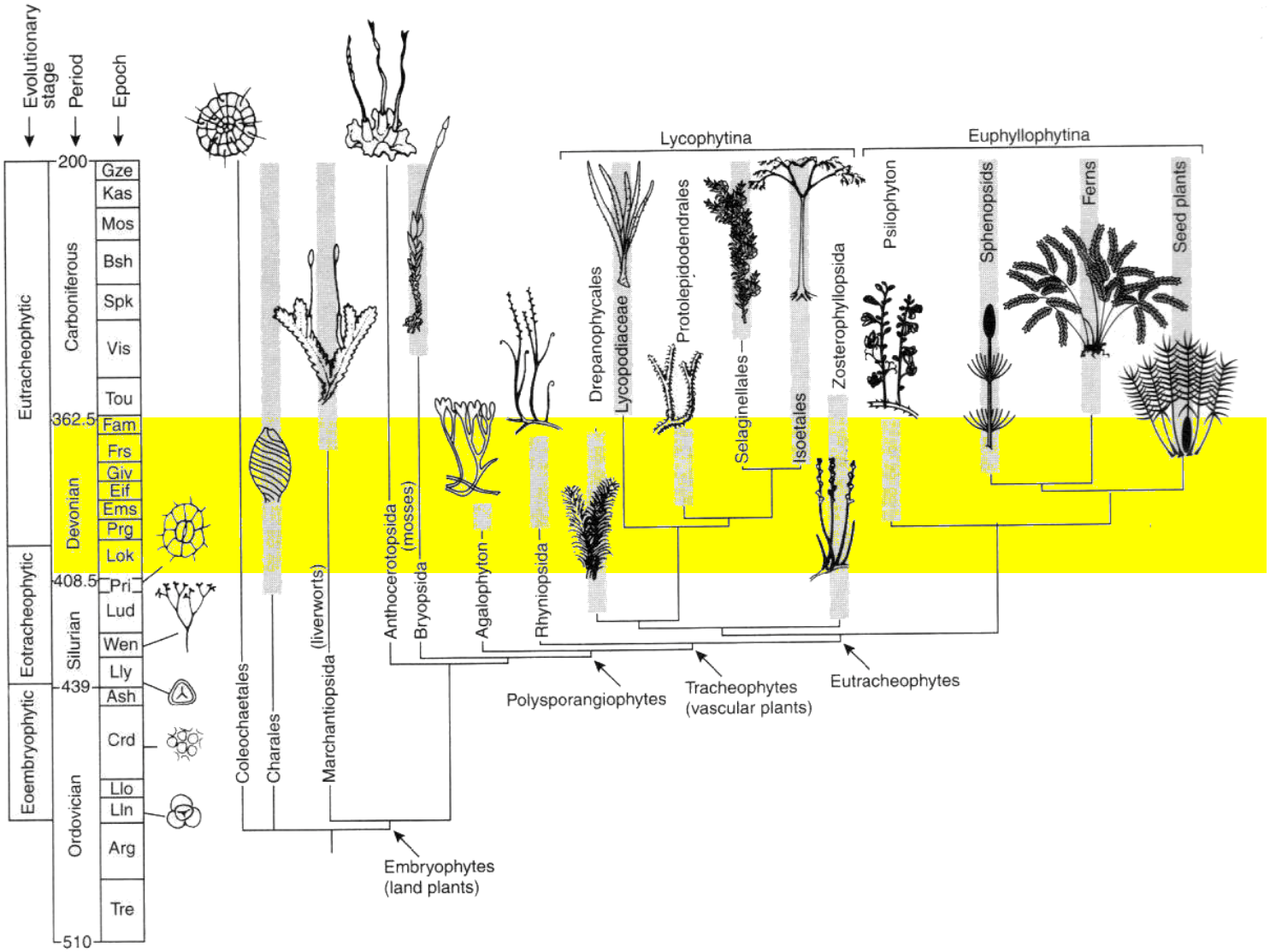
## *Aglaophyton major*



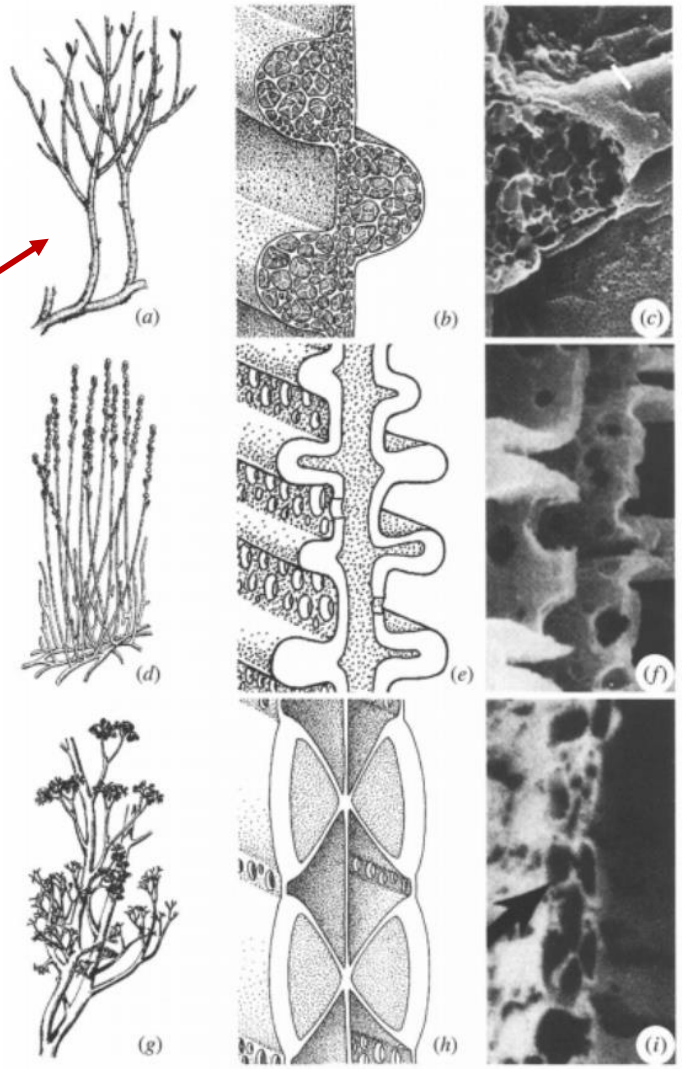
# A revolução devoniana

## Tracheophyta: traqueídeos “verdadeiros”



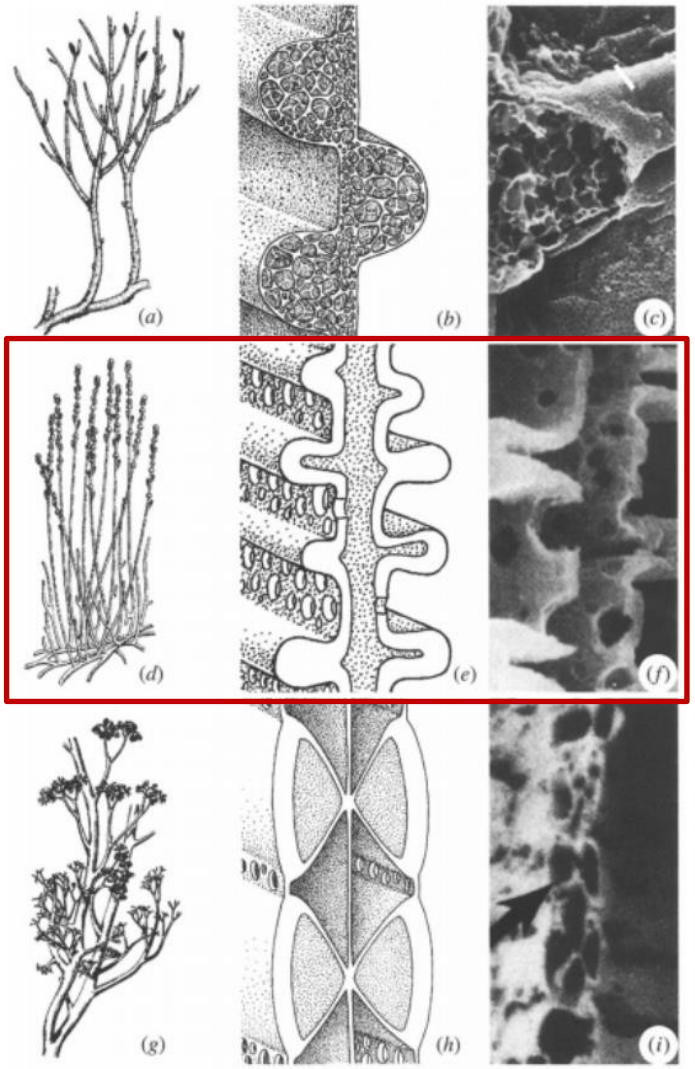
# A revolução devoniana

## Tracheophyta – Rhyniopsida – *Rhynia*



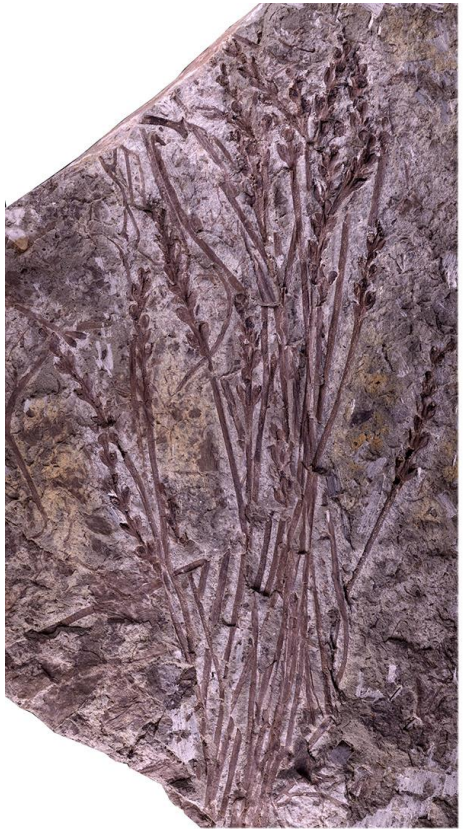
# A revolução devoniana

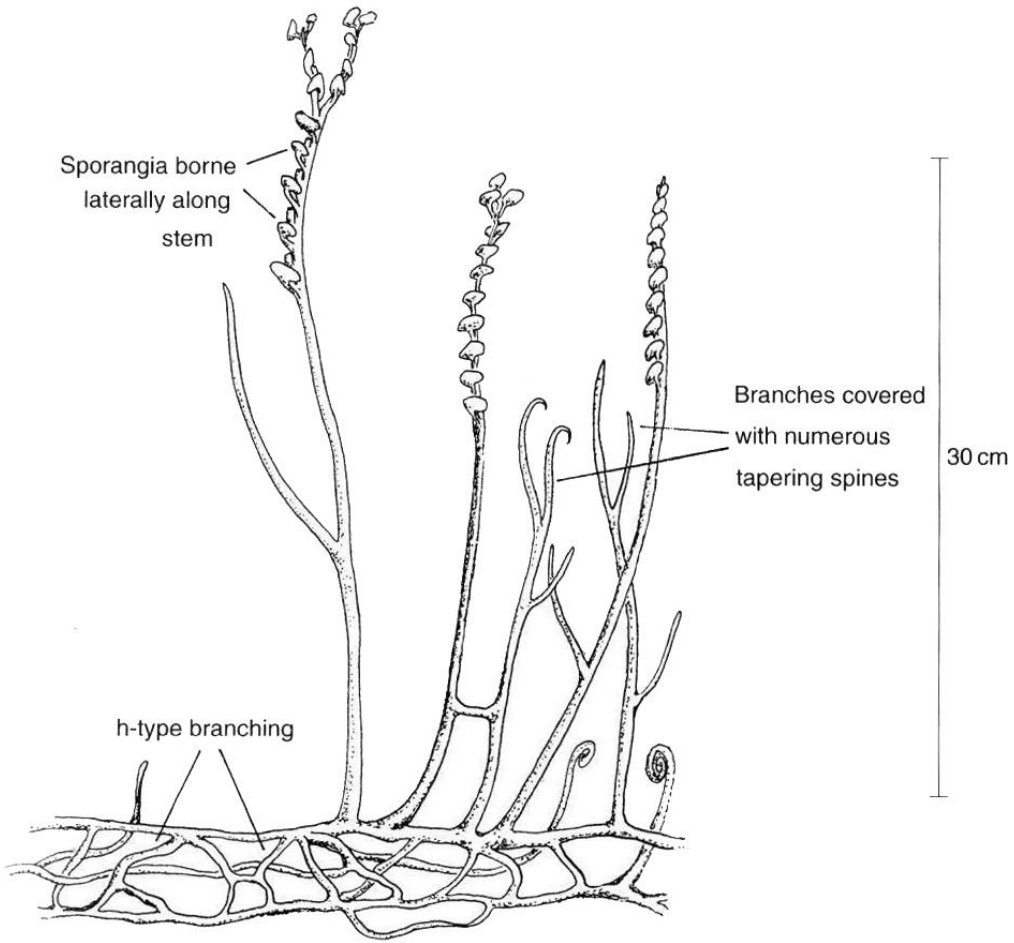
## Eutracheophyta – Lycophytina – *Zosterophyllum*



# A revolução devoniana

Eutracheophyta – Lycophytina – *Zosterophyllum*
Esporângios laterais, ramos não-reprodutivos e rizomas complexos





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Eutracheophyta – Lycophytina – *Zosterophyllum*
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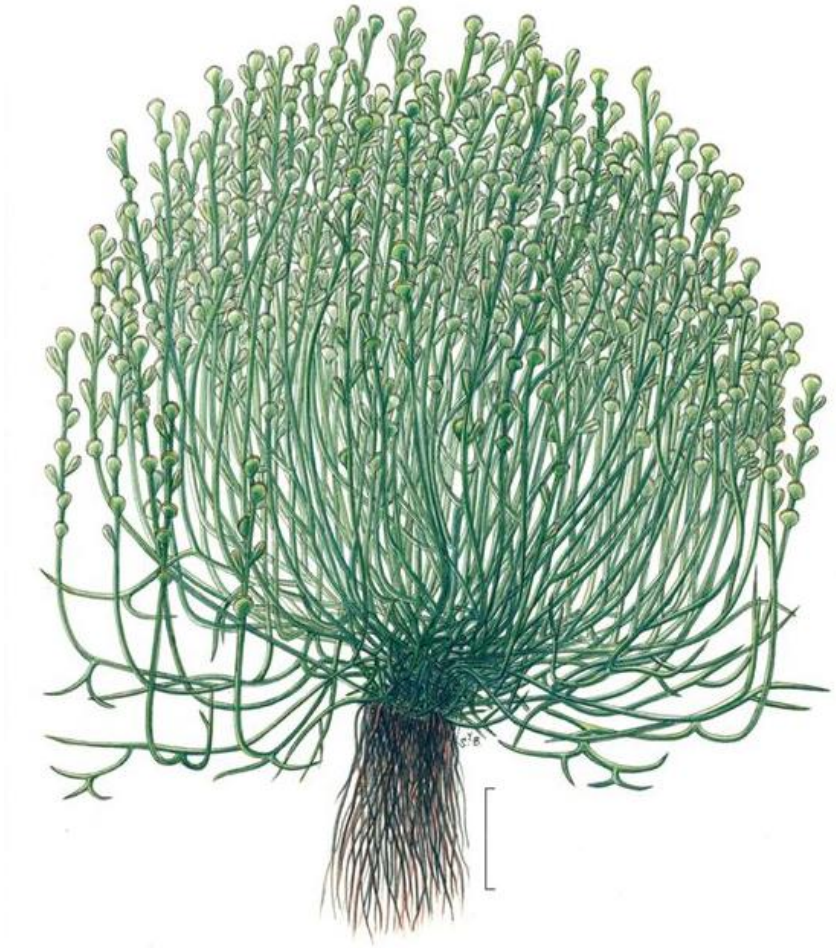
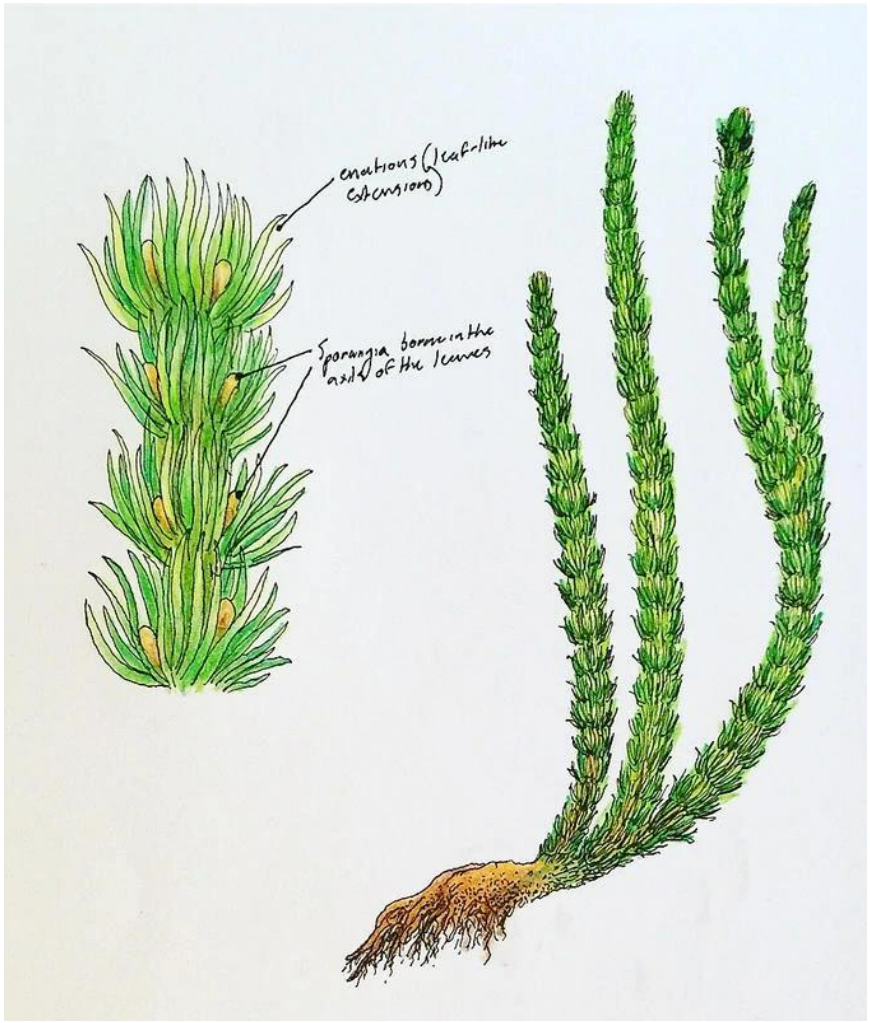


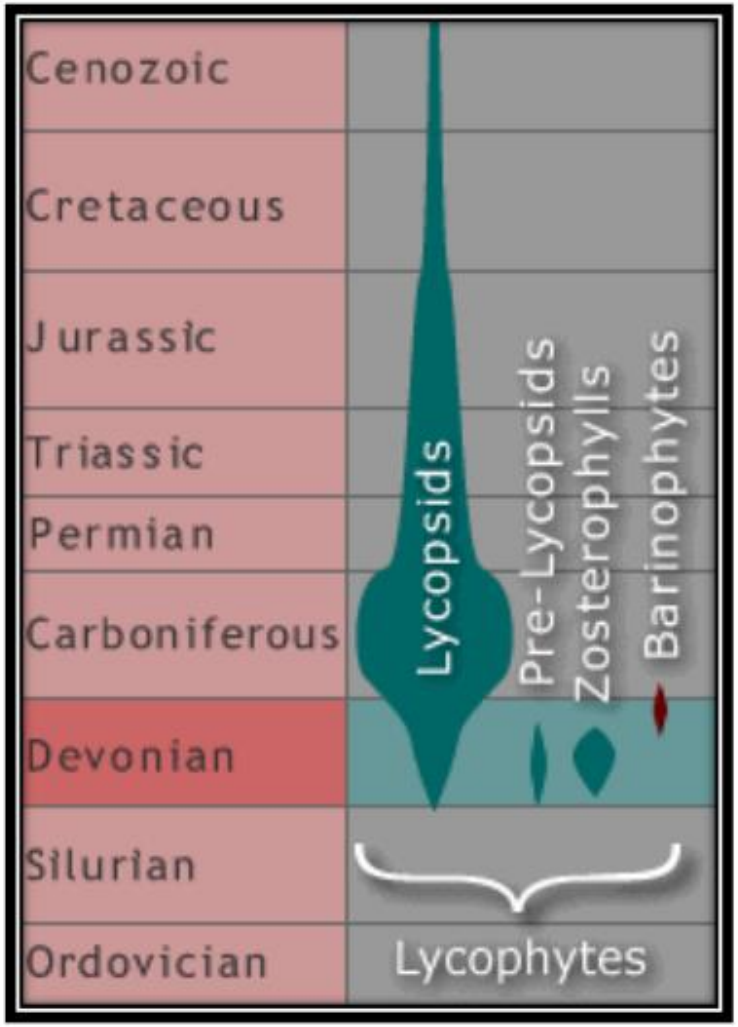
# A revolução devoniana

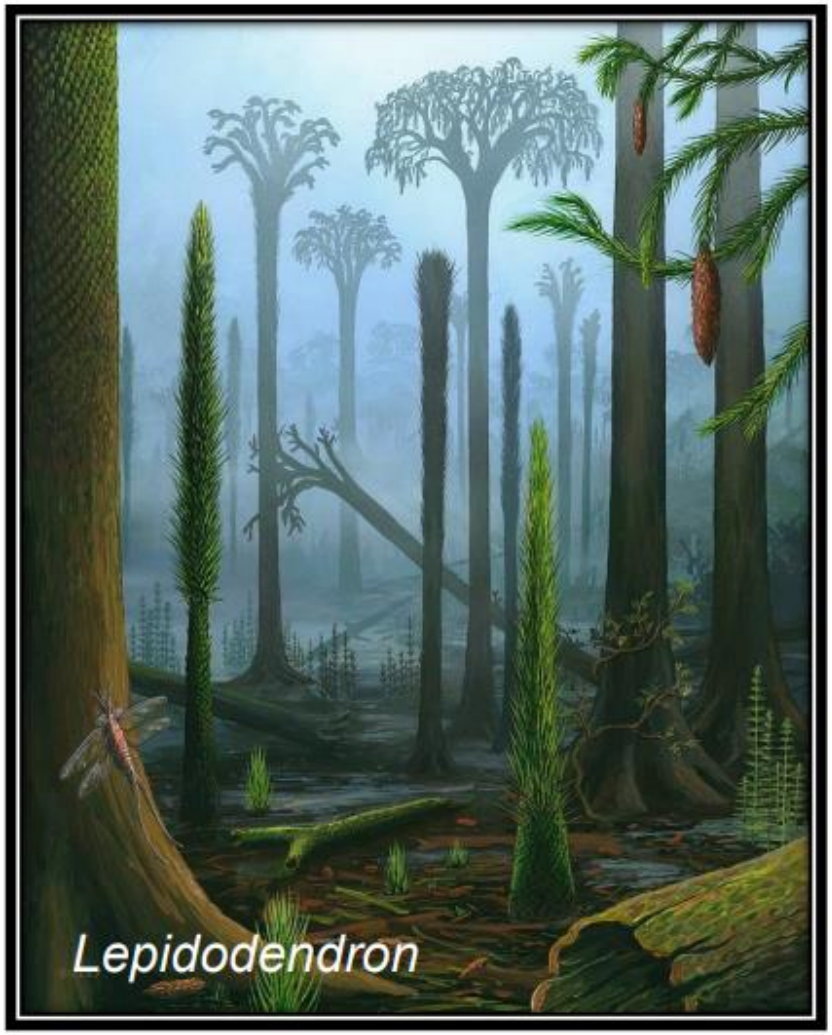
Eutracheophyta – Lycophytina – *Baragwanathia*
Micrófilas verdadeiras (Austrália, China, Canadá e Rep. Checa)




# A revolução devoniana

## Eutracheophyta (Lycophytina)



# A revolução devoniana

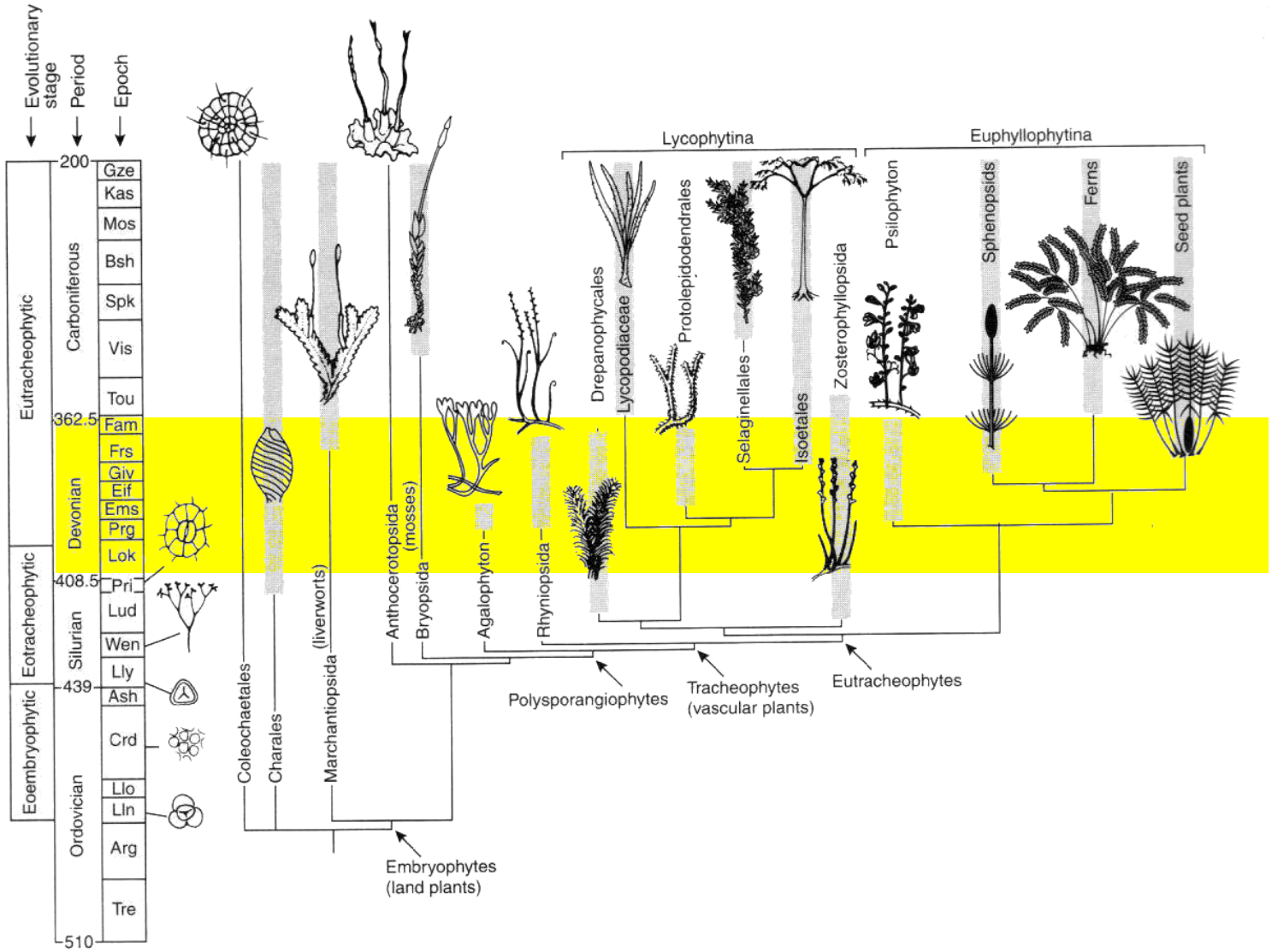
## Eutracheophyta (Lycophytina)

# A revolução devoniana

## Eutracheophyta (Lycophytina)

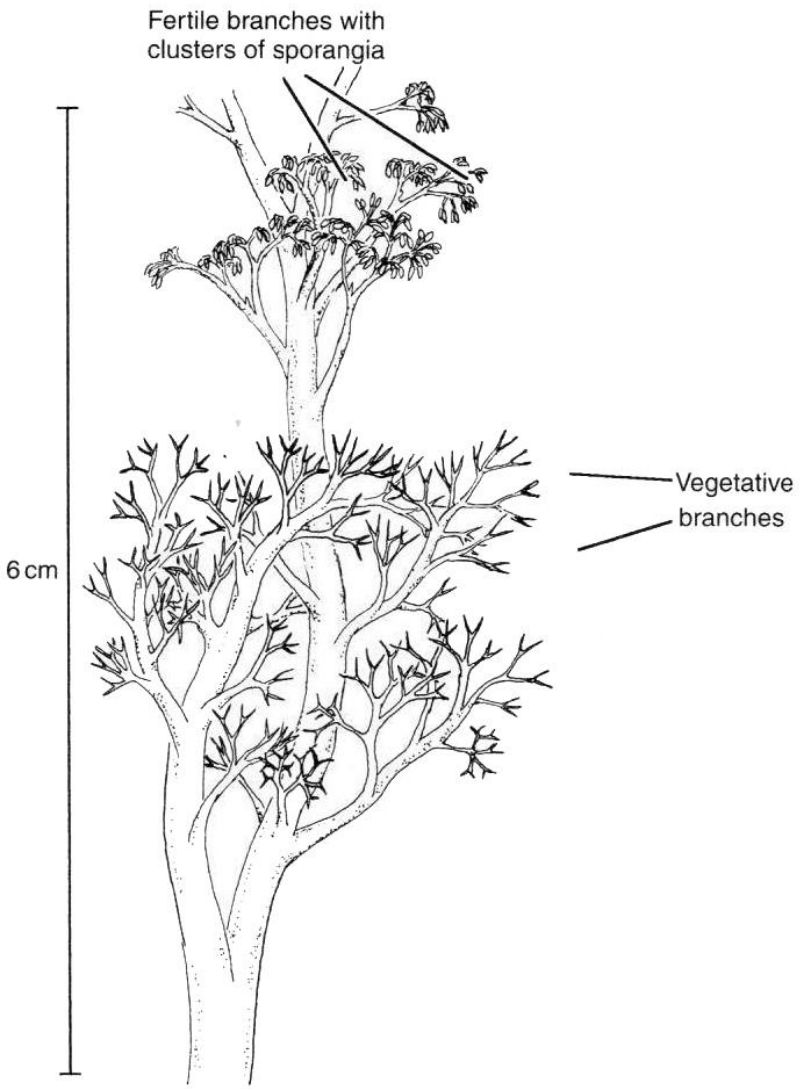
# A revolução devoniana

## Euphyllophytina: samabaias, esfenófitas e espermatófitas



# A revolução devoniana

## Eutracheophyta – Euphyllophytina – *Psilophyton*

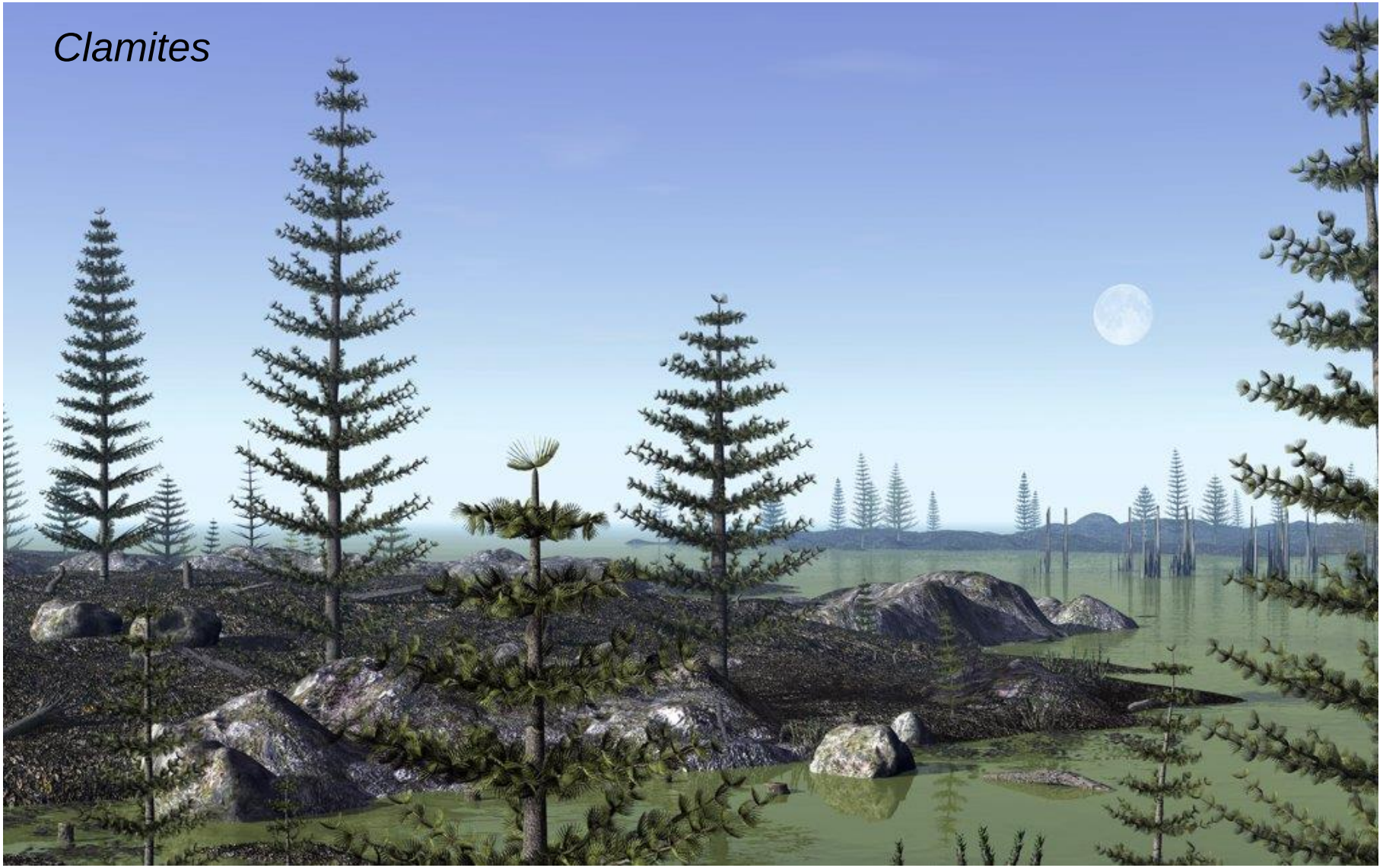



# A revolução devoniana

## Eutracheophyta – Euphyllophytina – Sphenopsida

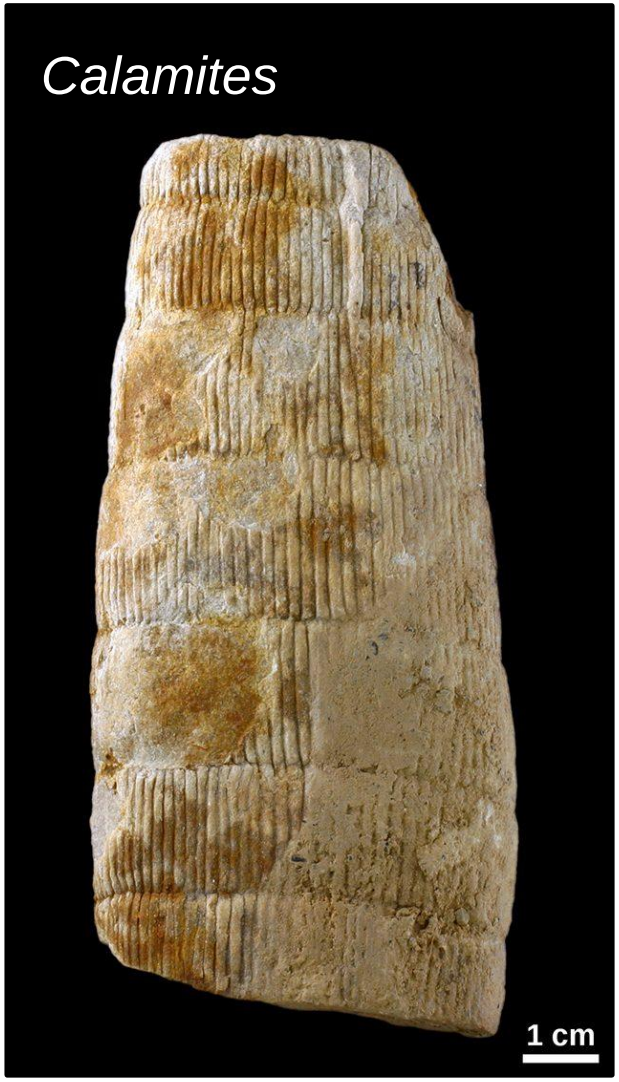
# A revolução devoniana

## Eutracheophyta – Euphyllophytina – Sphenopsida



# A revolução devoniana

## Eutracheophyta – Euphyllophytina – Sphenopsida

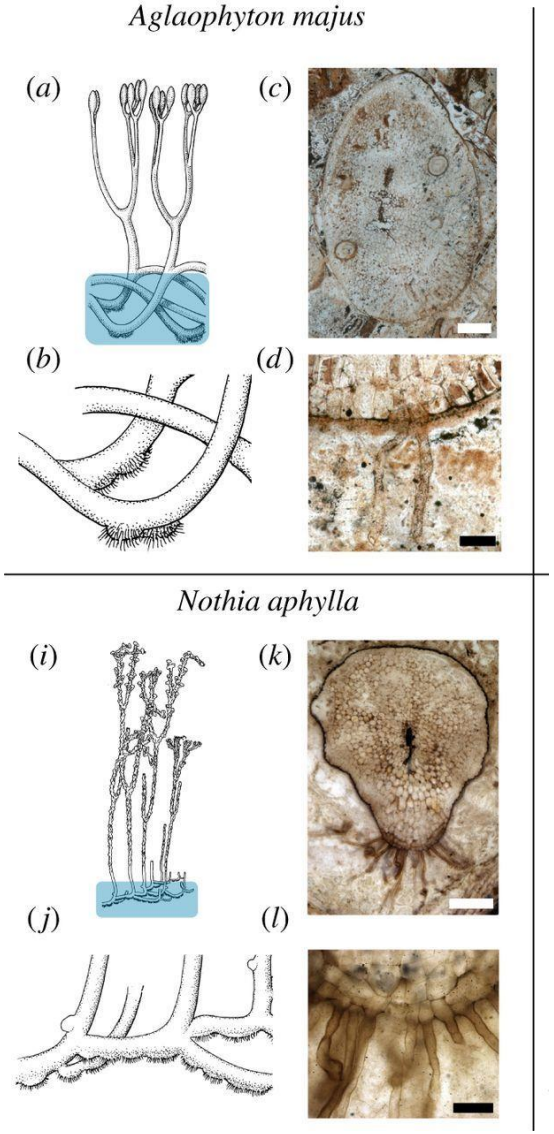


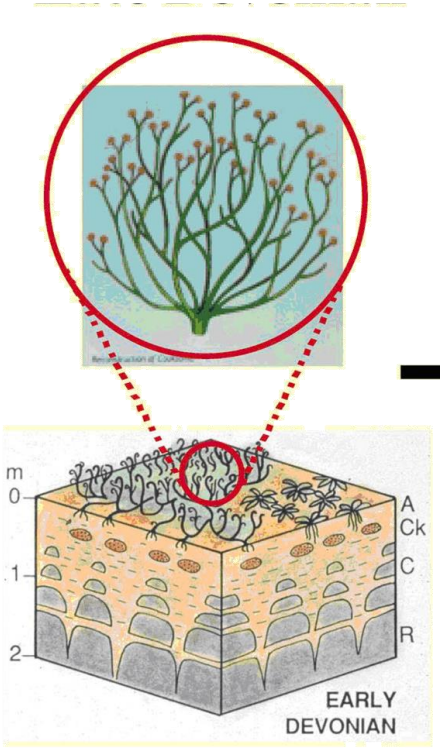
# A revolução devoniana

Florestas Devoniano Superior: licófitas e esfenófitas arborescentes

# A revolução devoniana

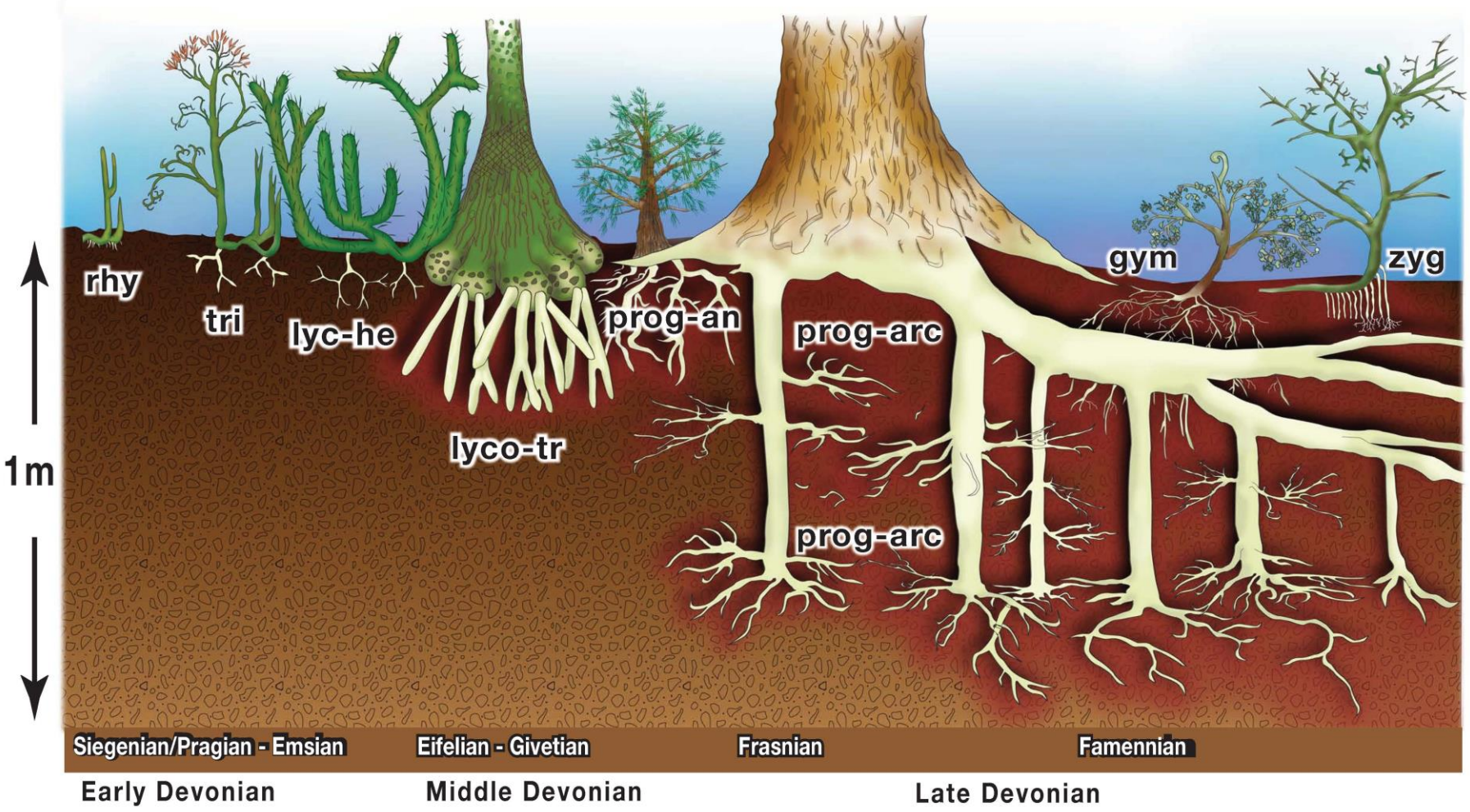
## Raízes e solos



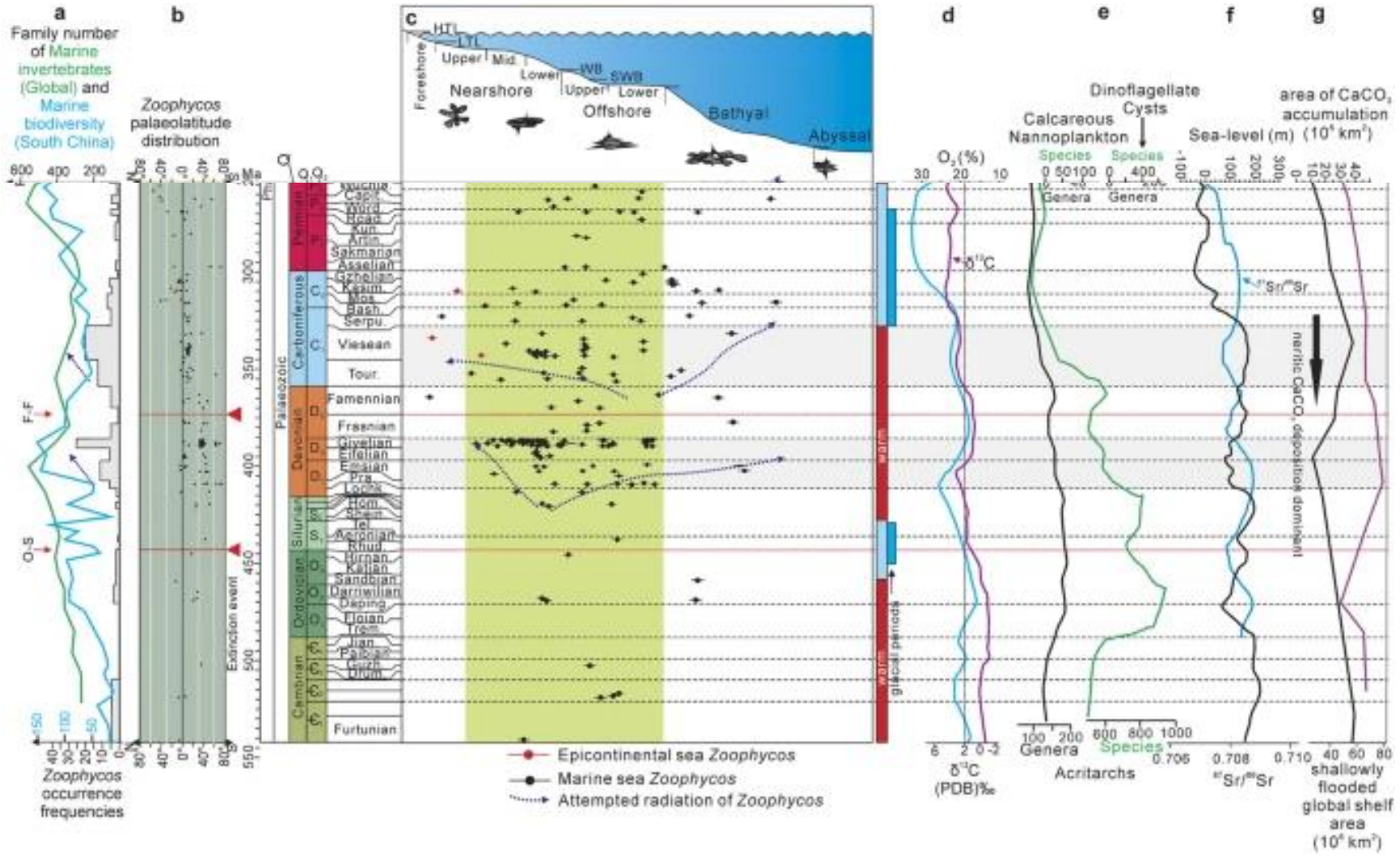

# A revolução devoniana

## Raízes e solos



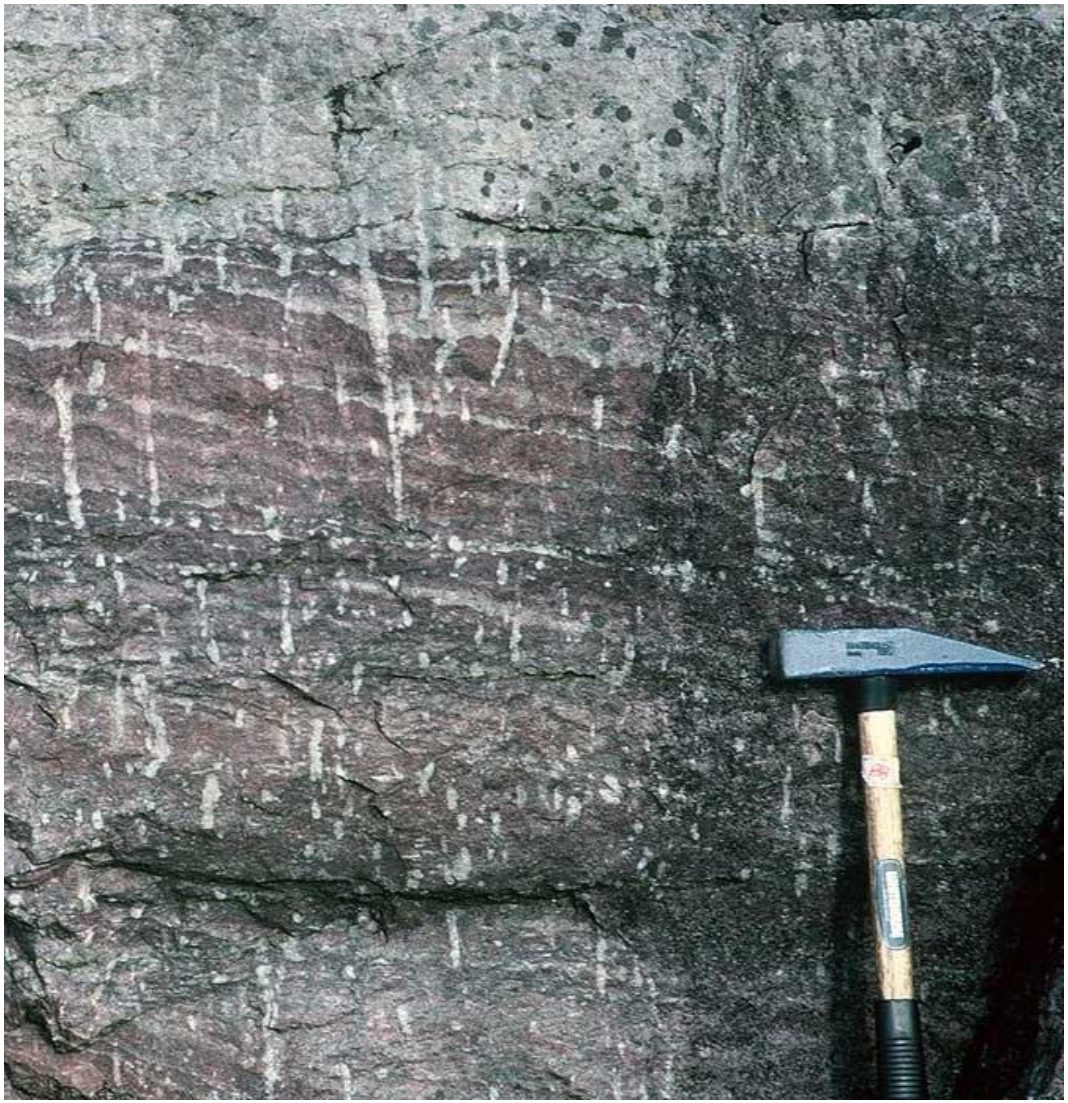
# A revolução devoniana

Mais nutrients => *Zoophycos* se torna offshore



# Invertebrados terrestres

## Ordoviciano: *Skolithos* e criptobiose



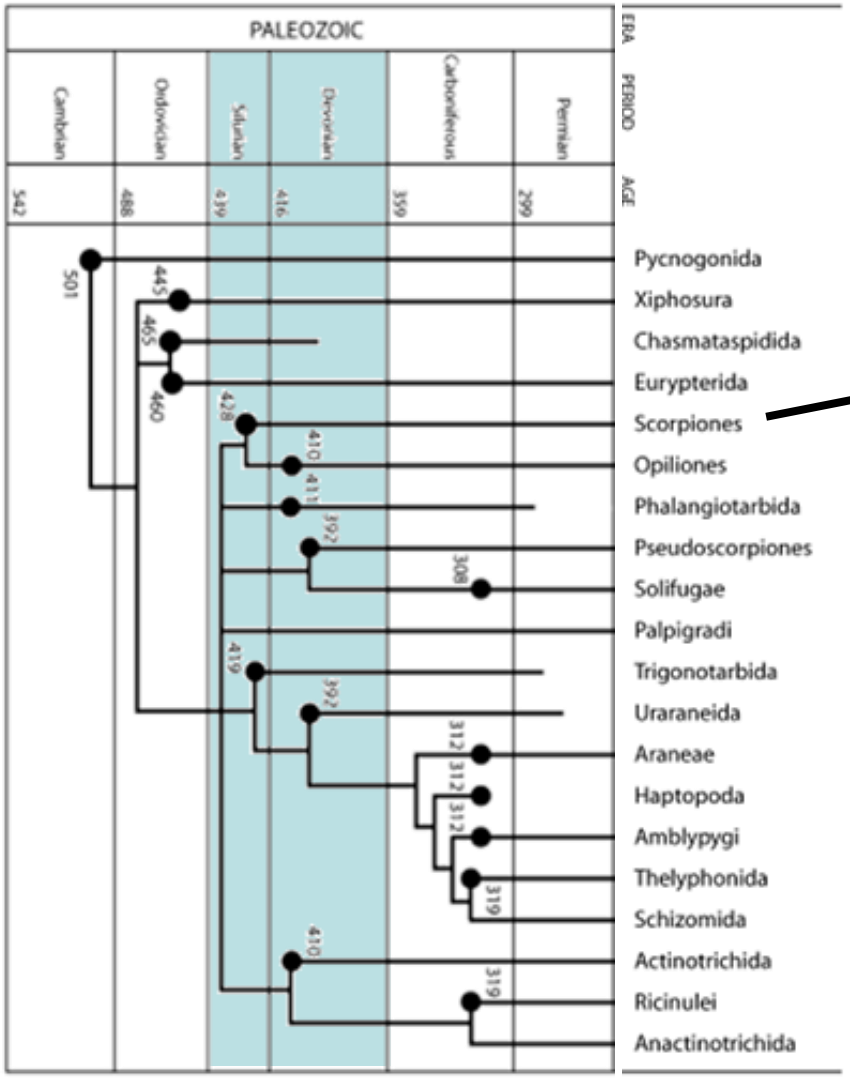
# Invertebrados terrestres

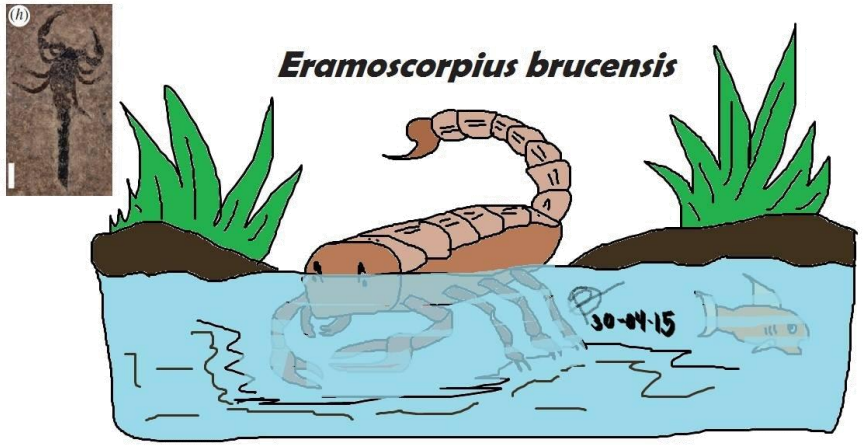
## Siluriano - Miriapoda

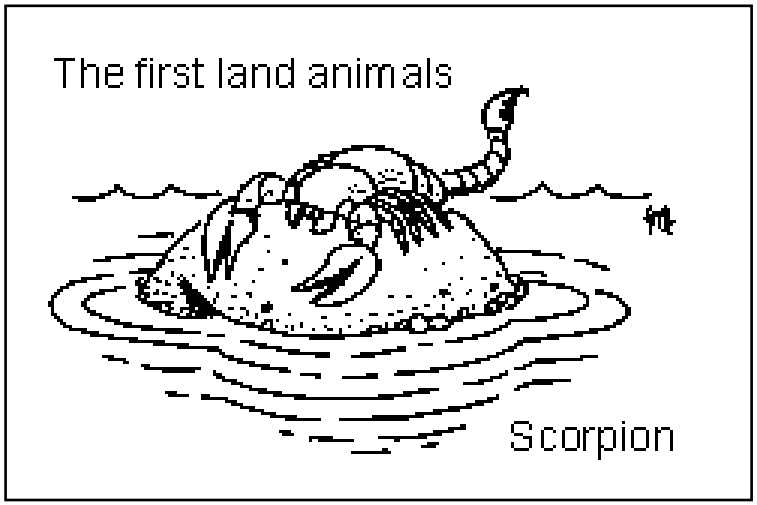
*Pneumodesmus*
Siluriano da Escócia

# Invertebrados terrestres

## Siluriano - Scorpiones

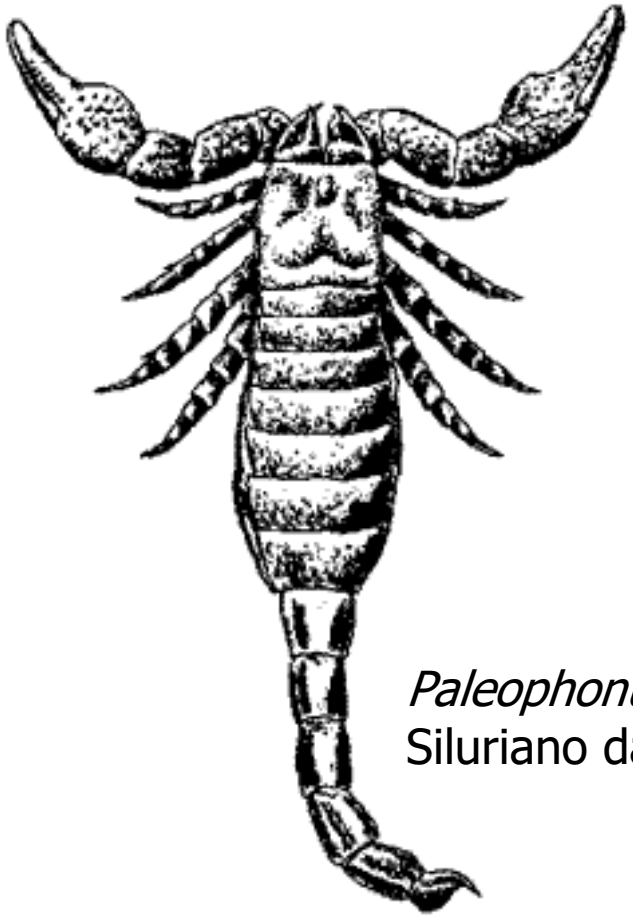


# Invertebrados terrestres

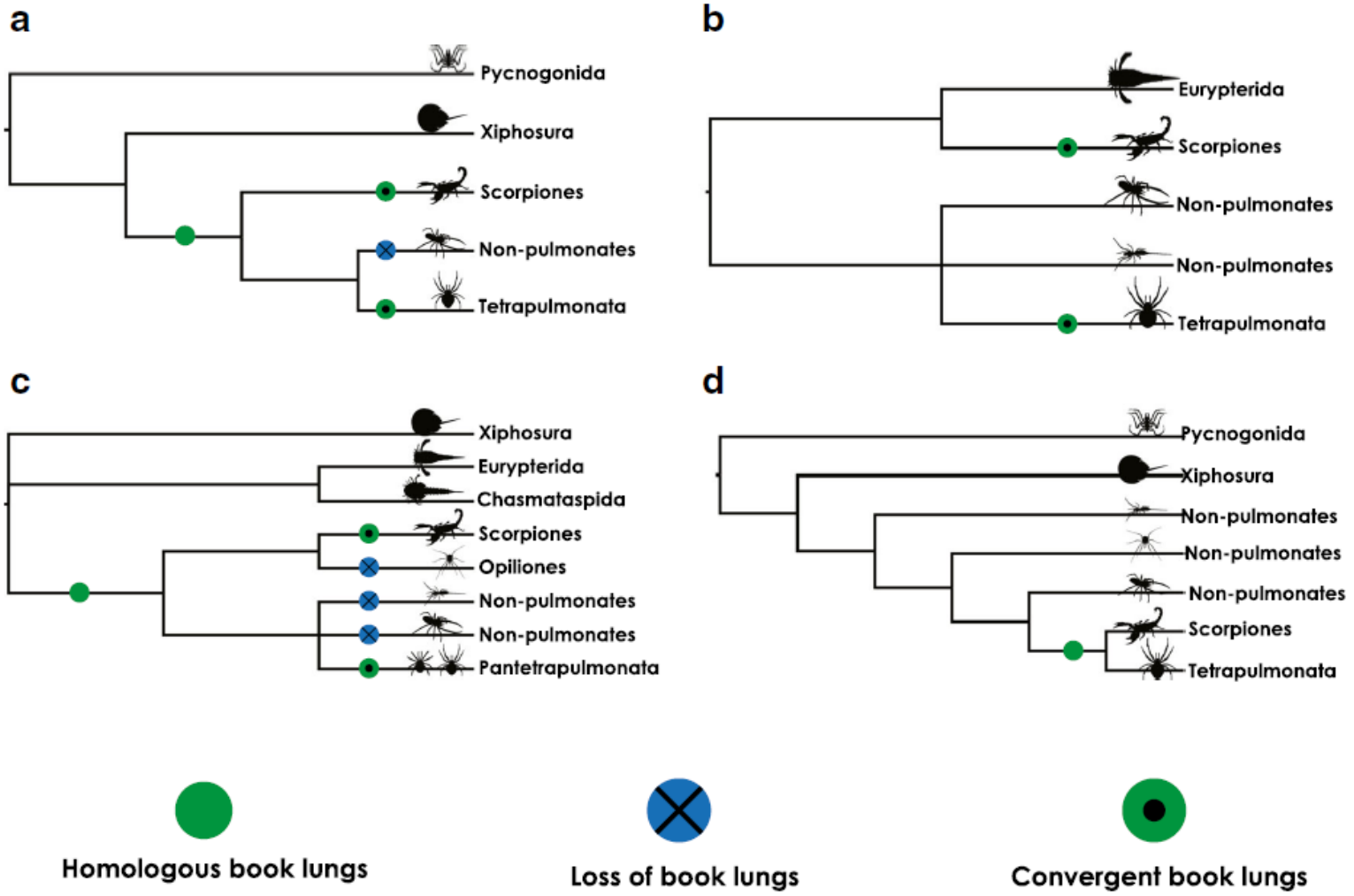
A partir do Devoniano, os escorpiões colonizam o meio terrestre
No Carbonífero as formas com brânquias desaparecem e
os escorpiões se tornam exclusivamente terrestres



*Paleophonus*
Siluriano da Suécia

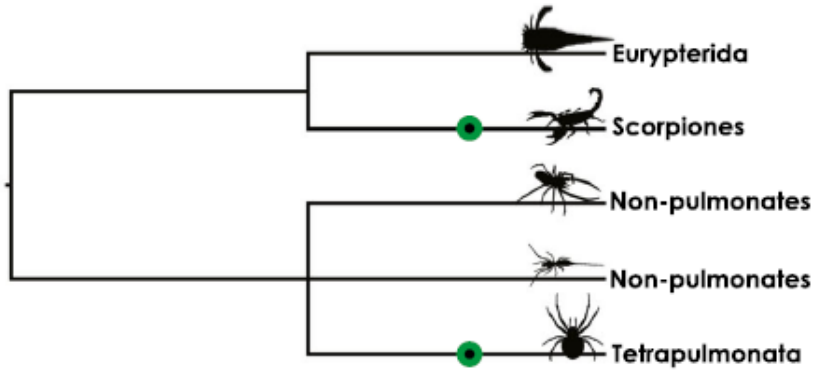
# Invertebrados terrestres

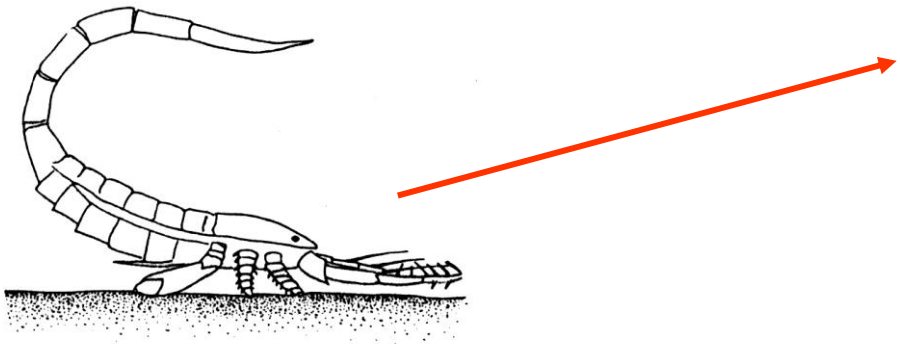
## Afinidade com os Eurypterida

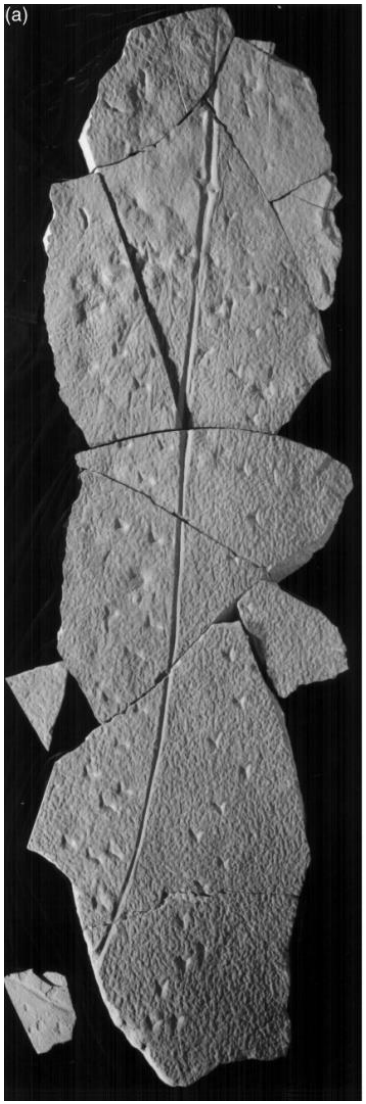


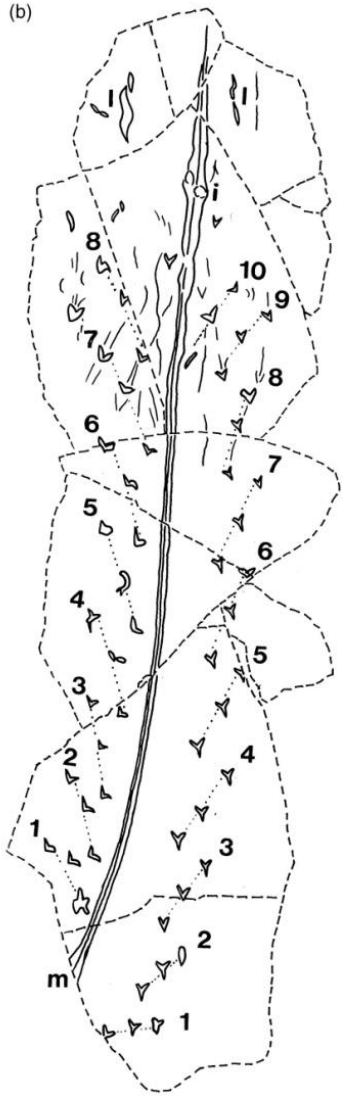
# Invertebrados terrestres

## Afinidade com os Eurypterida



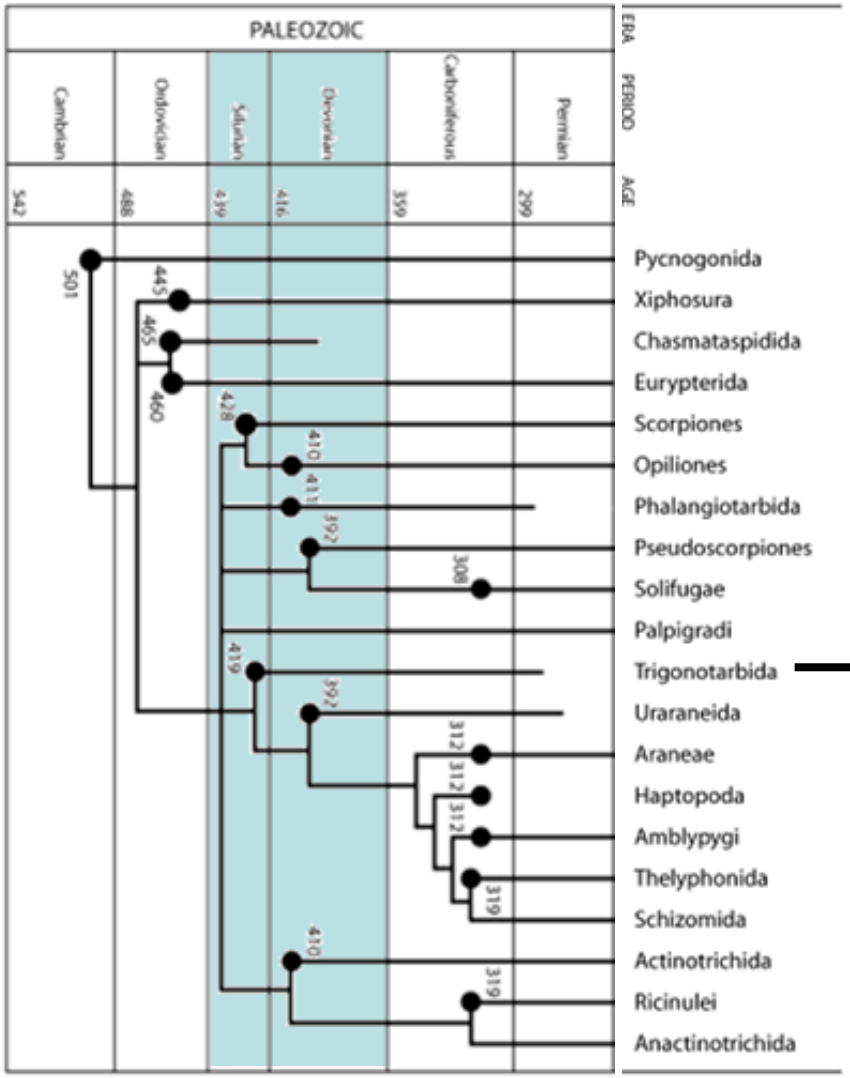


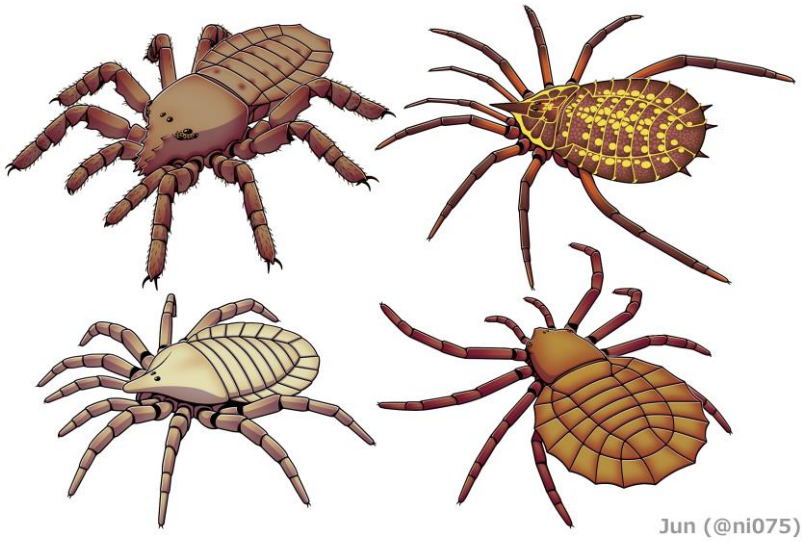



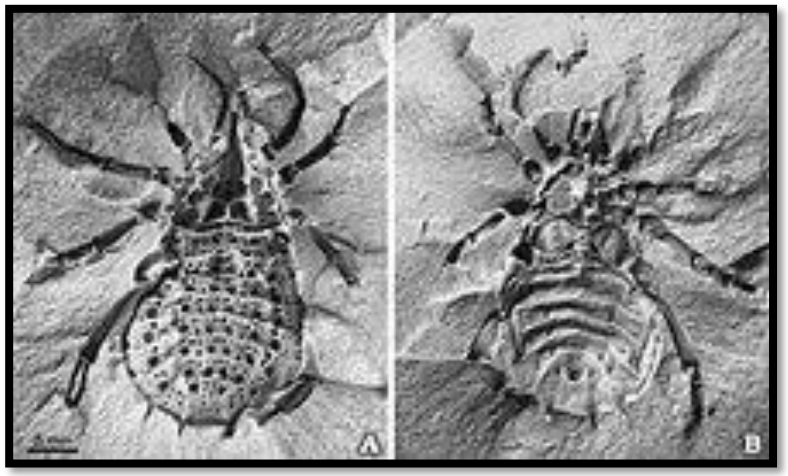

Traços de euriptérido terrestre do Devoniano do Candá

# Invertebrados terrestres

## Invertebrados terrestres - Chelicerata

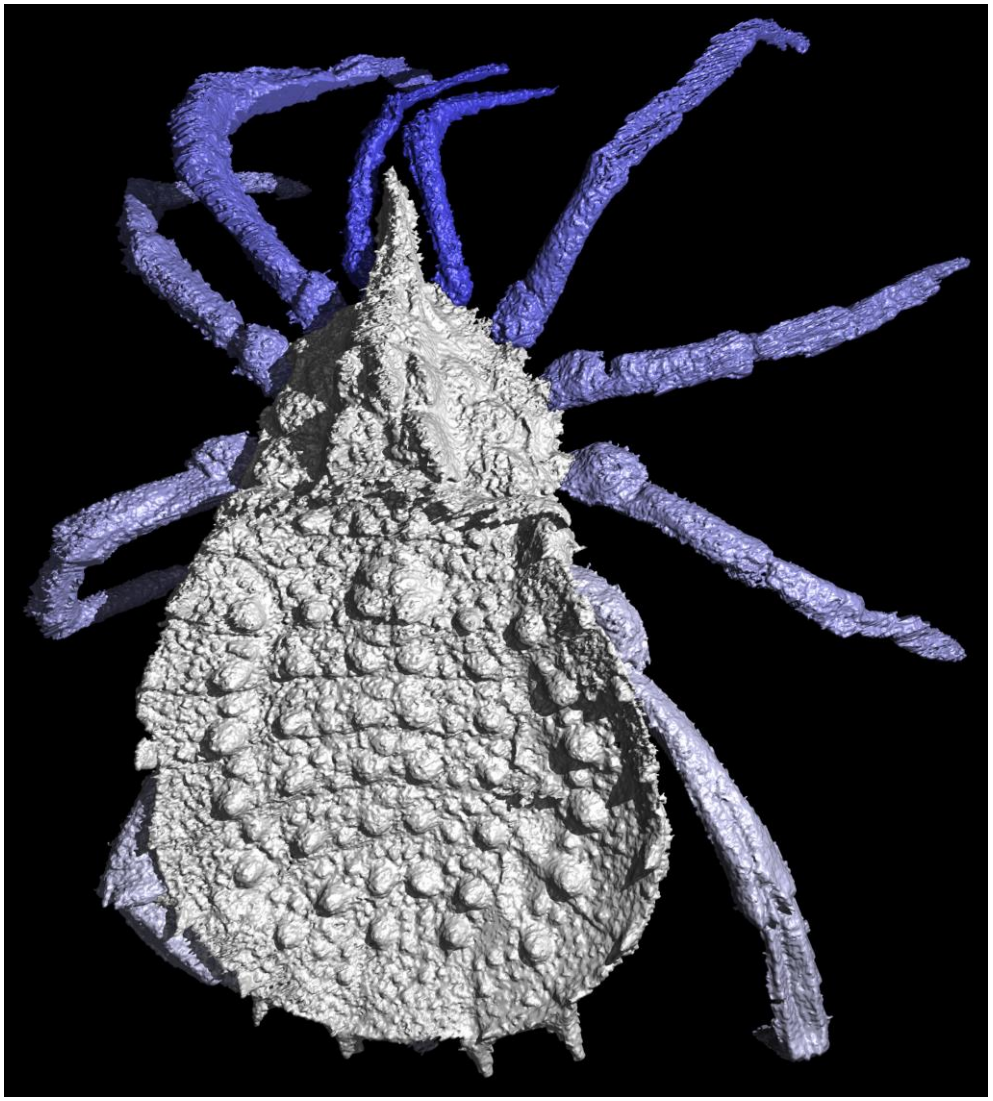


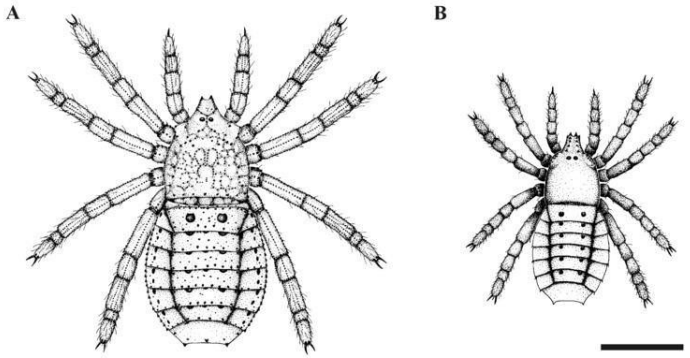



# Invertebrados terrestres

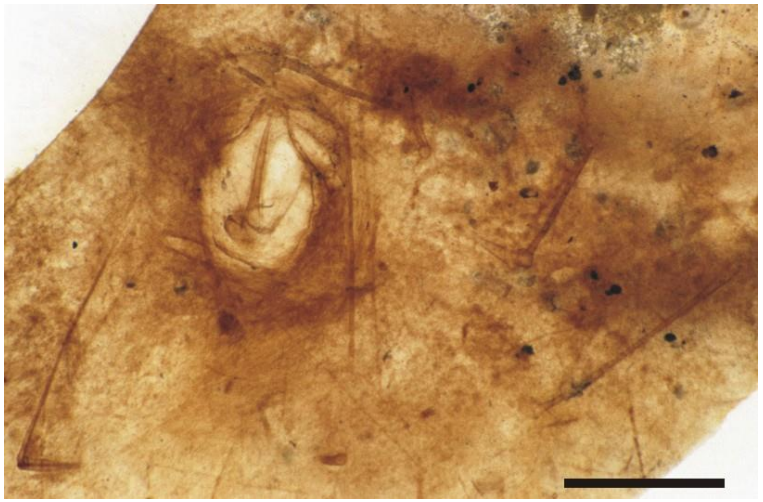
## Invertebrados terrestres – Chelicerata - Trigonotarbida



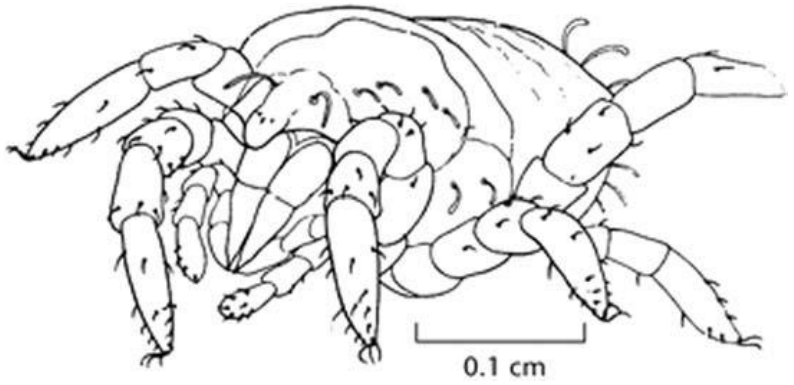



# A revolução devoniana

## Invertebrados terrestres de Rhynie – carnívoros e detritívoros



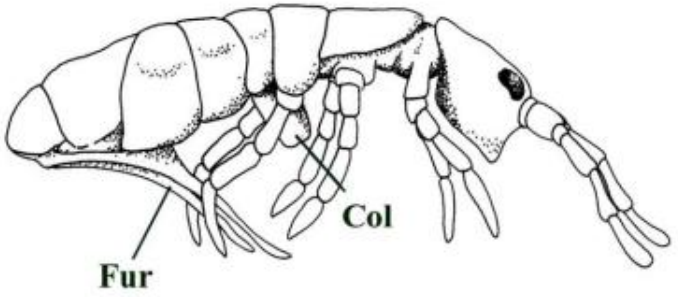
*Eophalangium* (Opiliones)



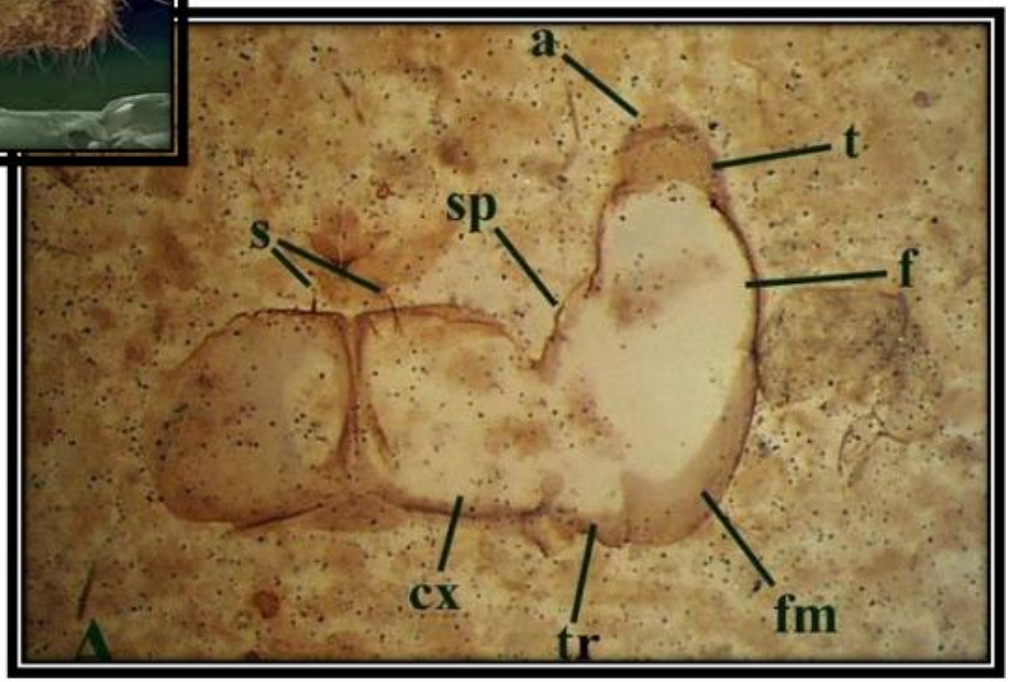

*Protacarus* (Acari)

# A revolução devoniana

## Invertebrados terrestres de Rhynie - Hexapoda



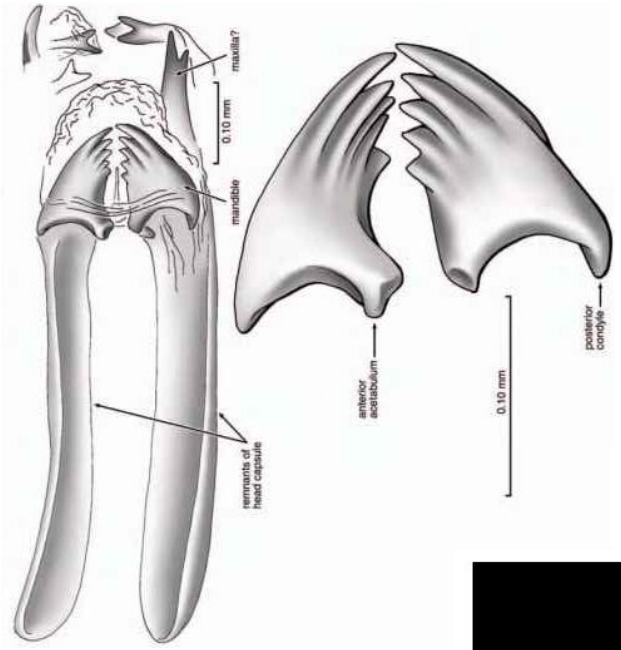

*Rhyniella* (Collembola)

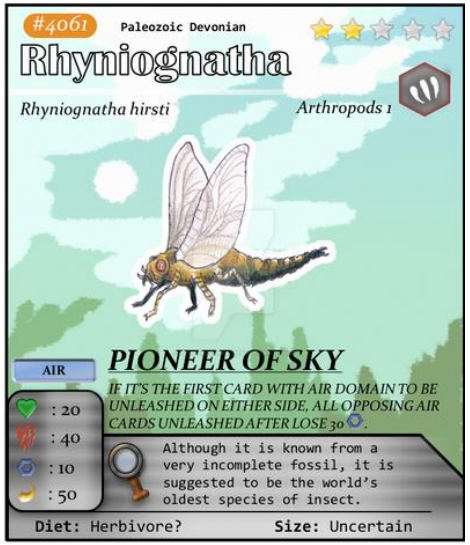


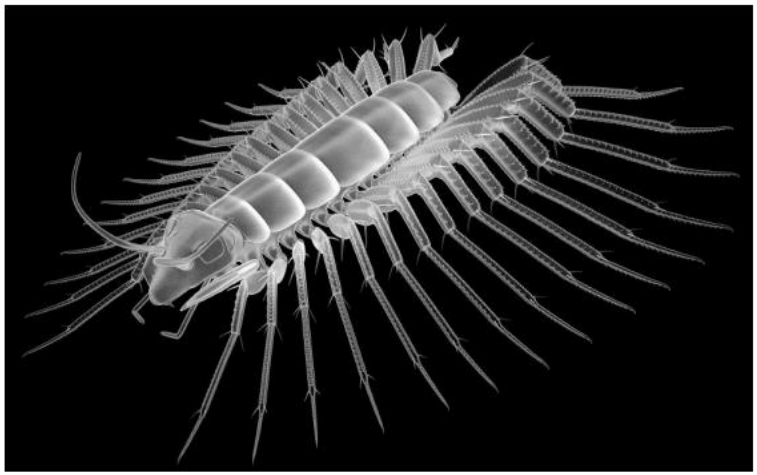
# A revolução devoniana

## Invertebrados terrestres de Rhynie – Hexapoda (?Miriapoda)

*Rhyniognatha*

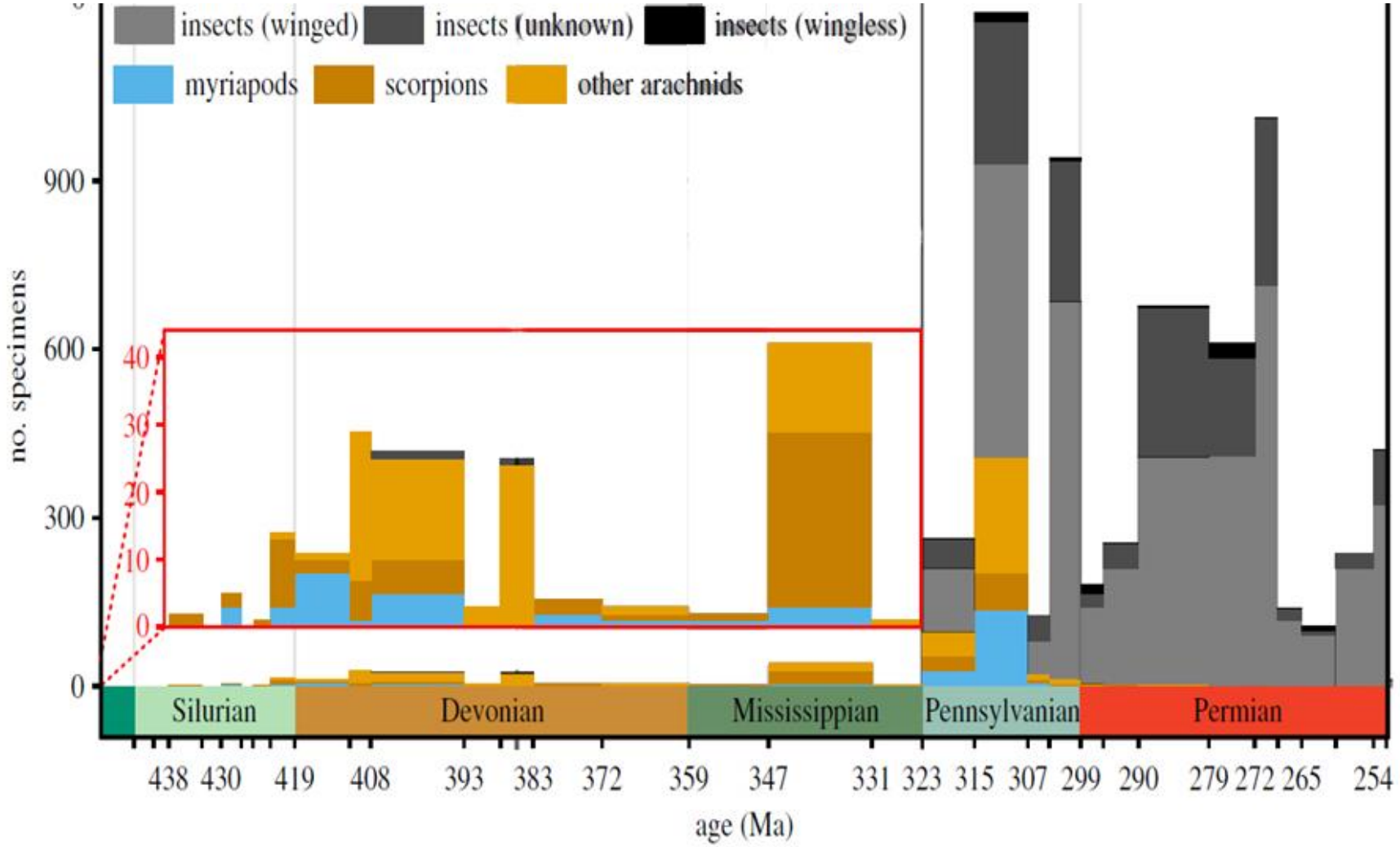


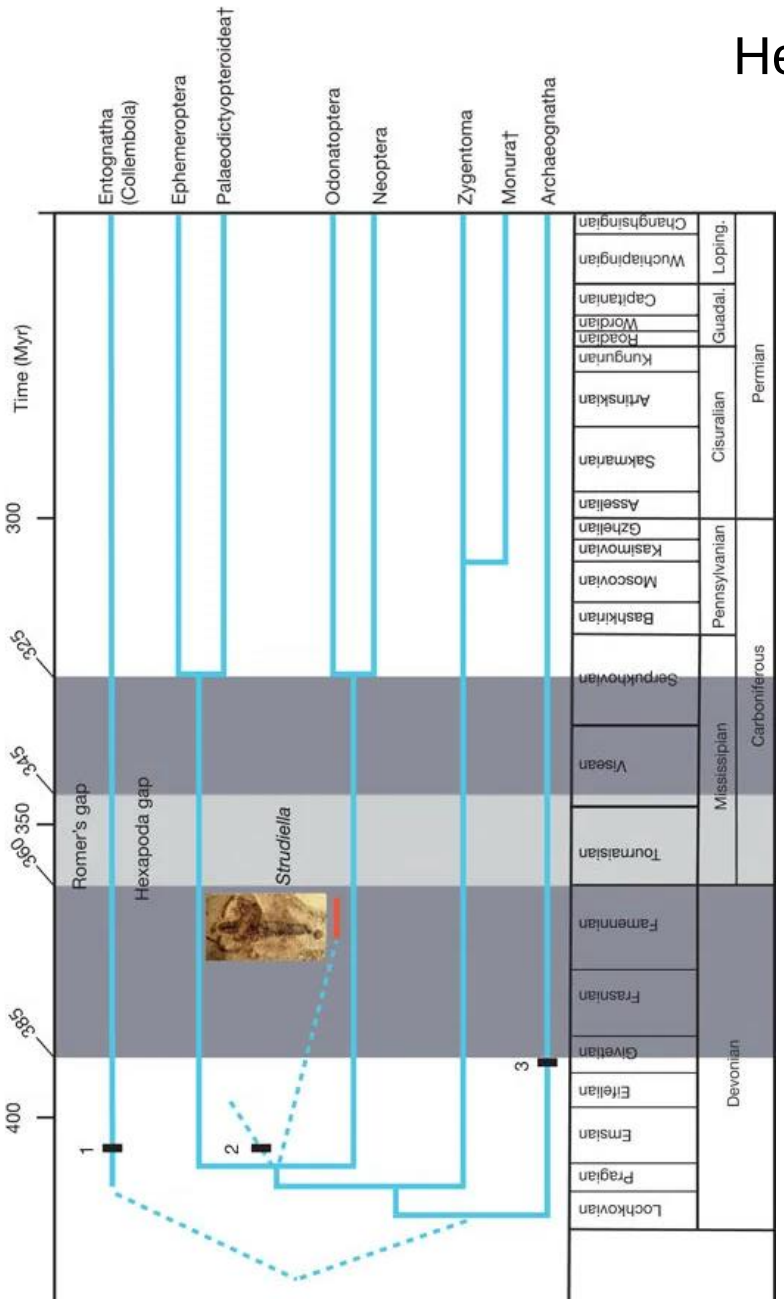
# A revolução devoniana

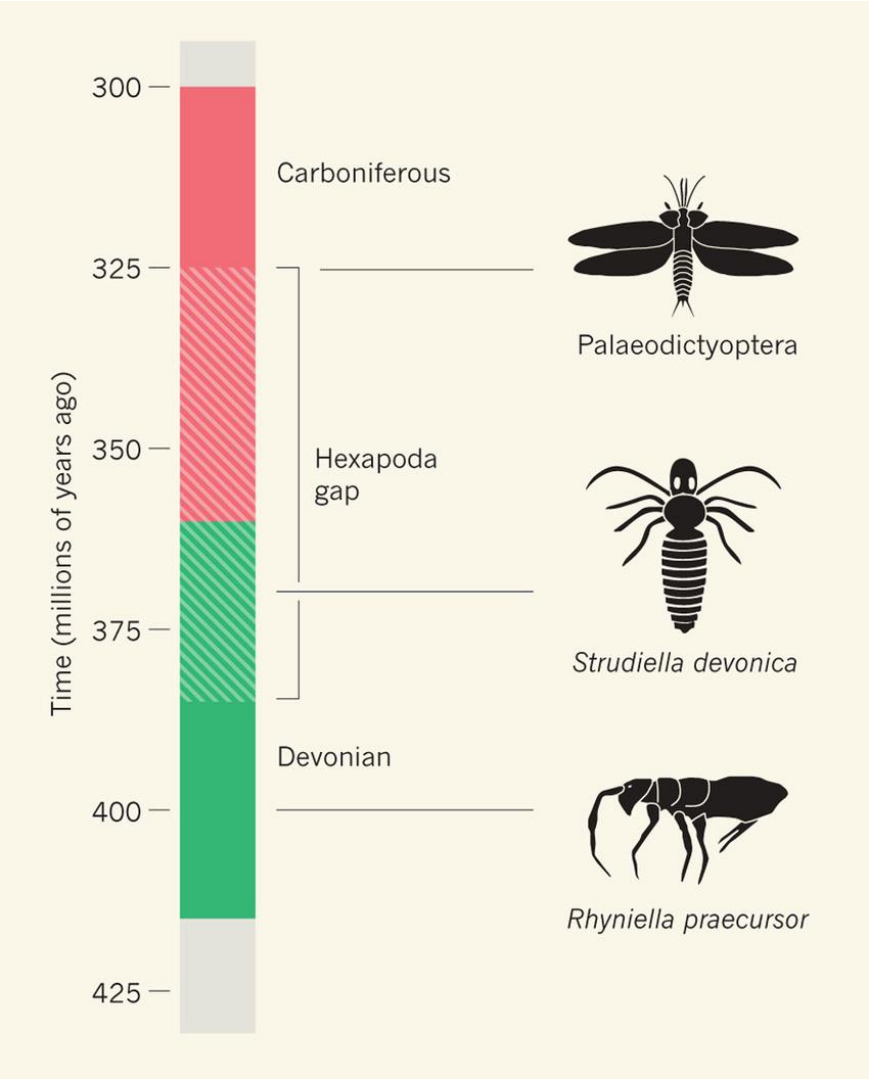
## Hexapoda gap



# A revolução devoniana

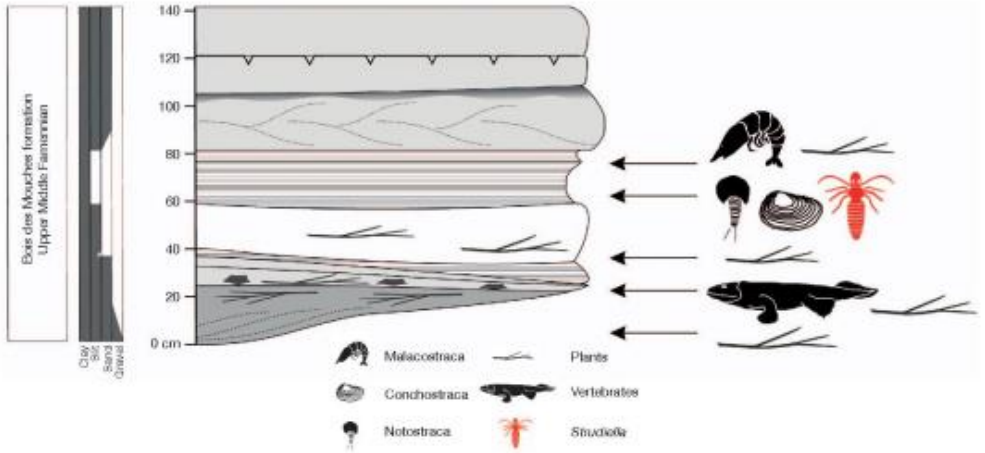
## Hexapoda gap



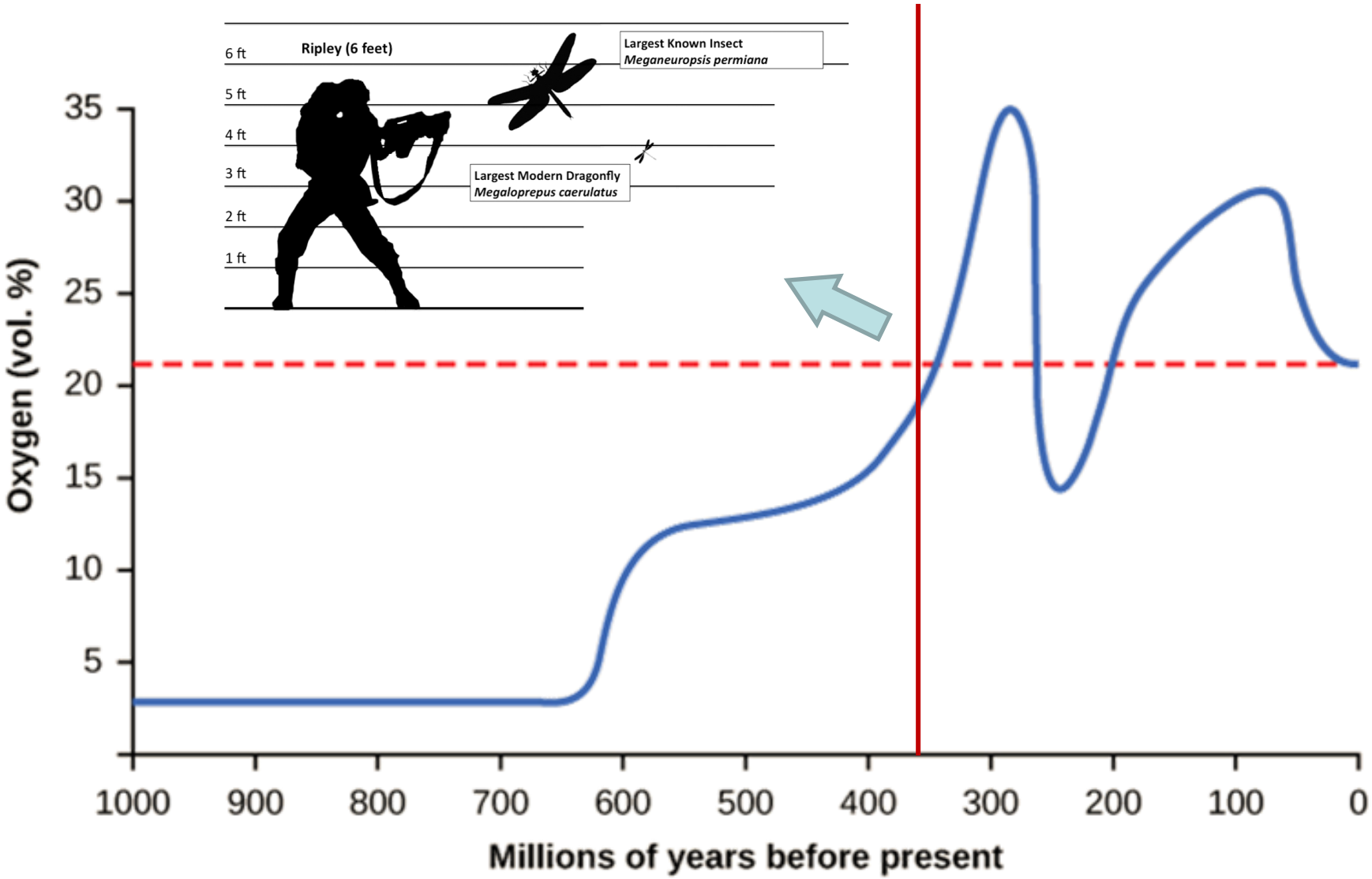
# A revolução devoniana

## Hexapoda gap – *Strudiella* (Devoniano da Bélgica)

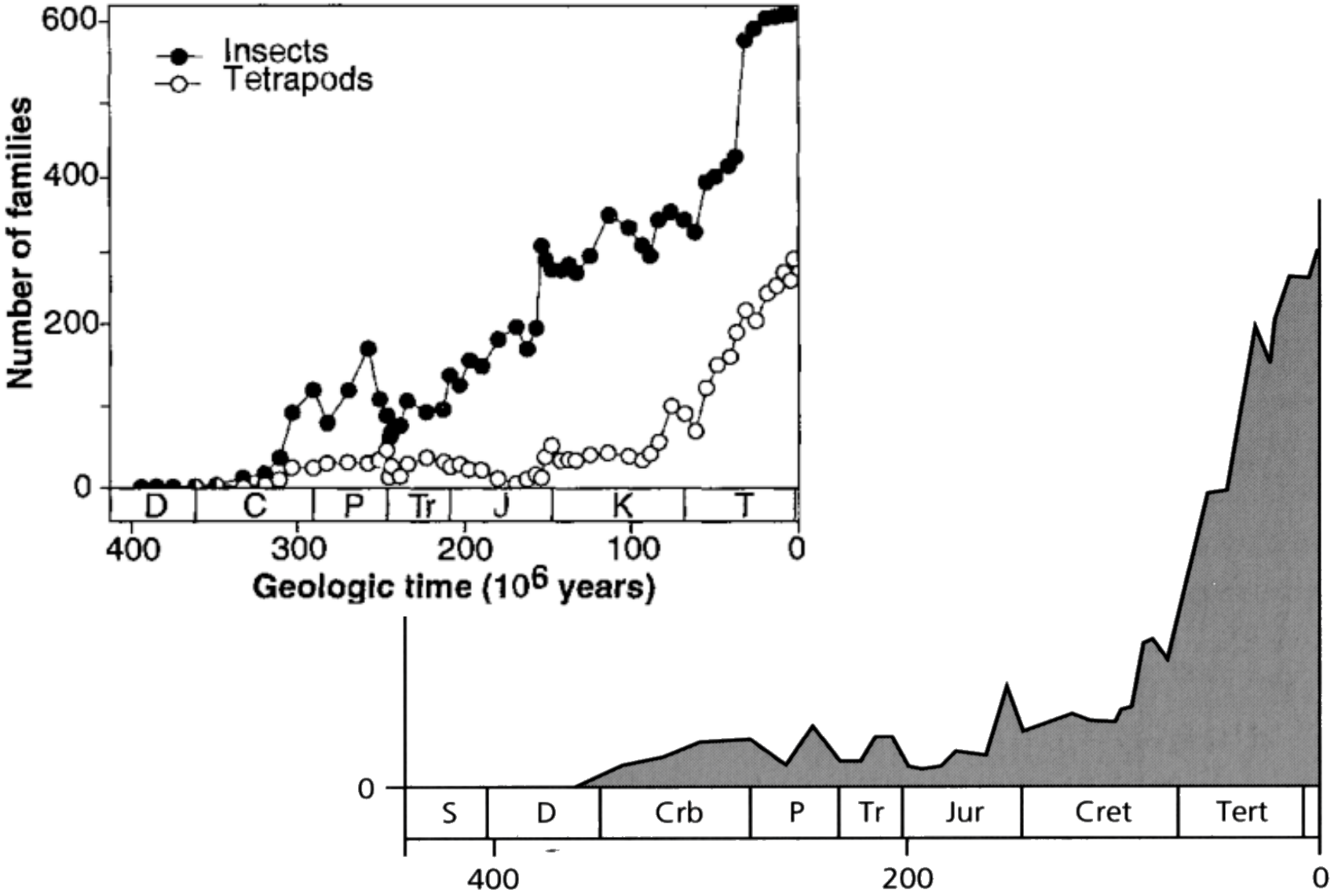

*Strudiella*

# A revolução devoniana



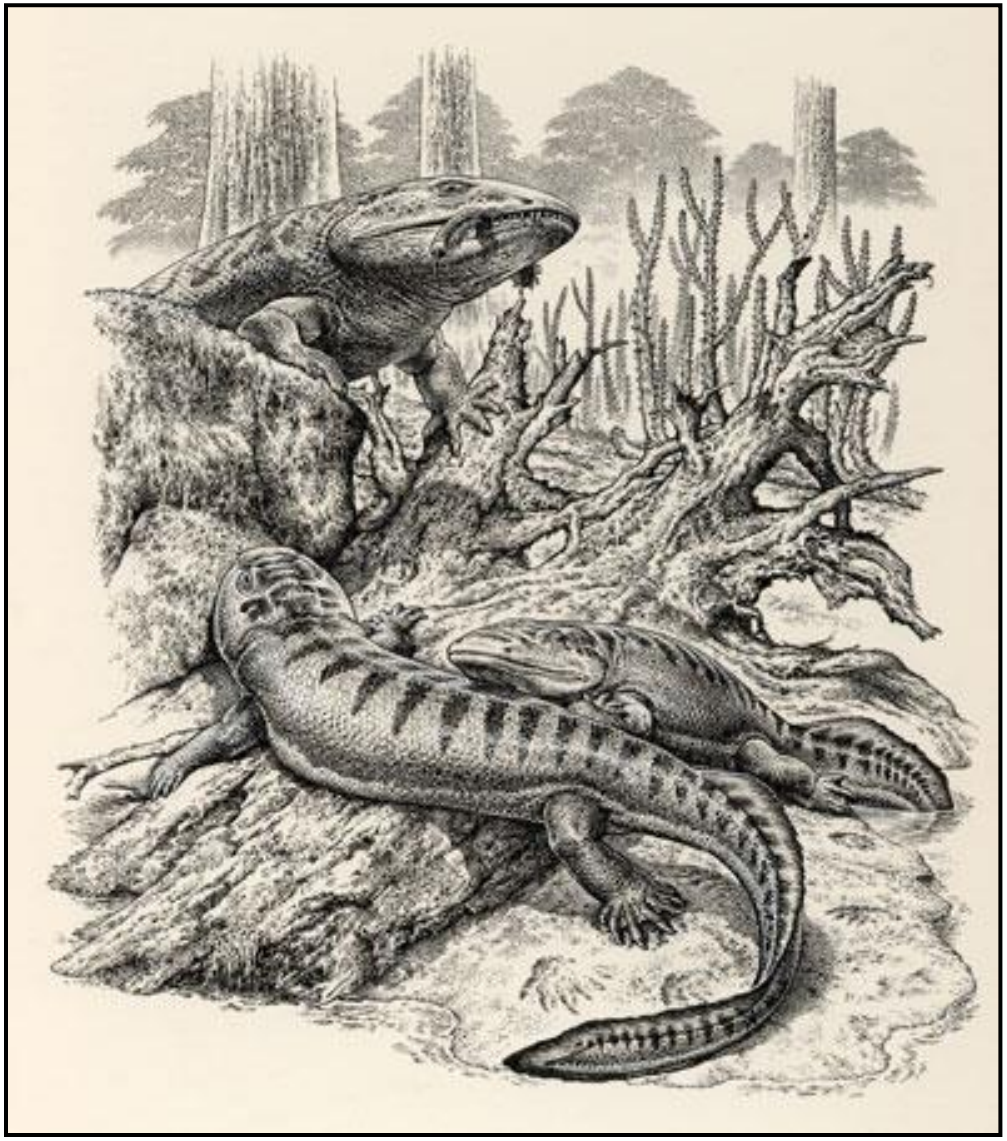
# Floresta carbonífera

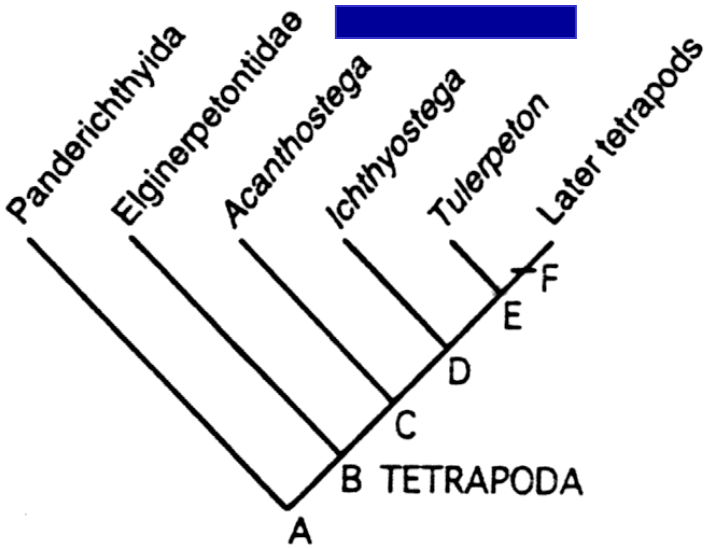
# Vertebrados: tetrápodos



# "Ichthyostegalia" (Devoniano superior)

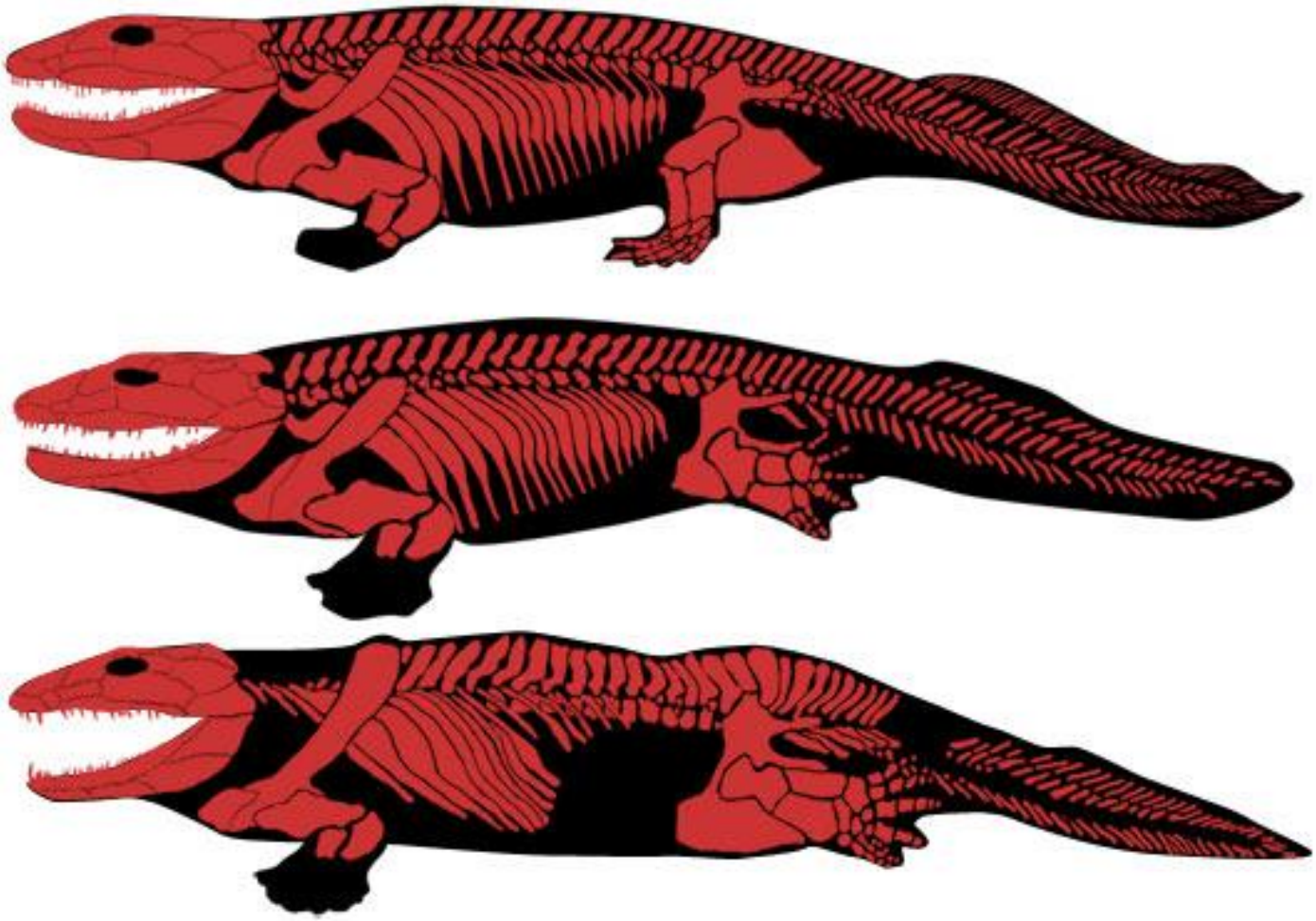
## Grupo parafilético: inclui *Ichthyostega* e *Acanthostega* (Groenlândia)





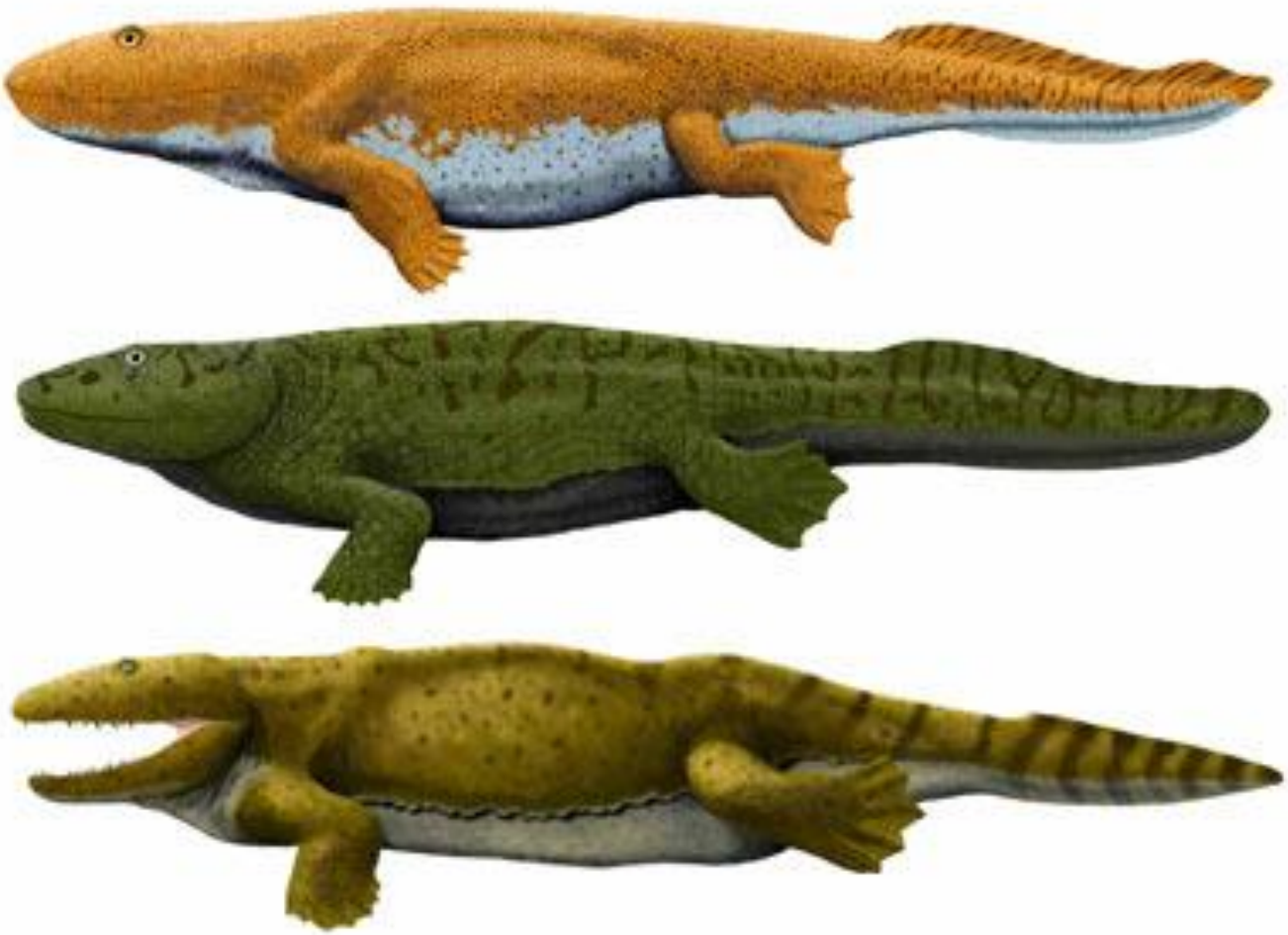

Formas de águas continentais
*Ichthyostega* e *Acanthostega*

# "Ichthyostegalia" (Devoniano superior)



*Ichthyostega*

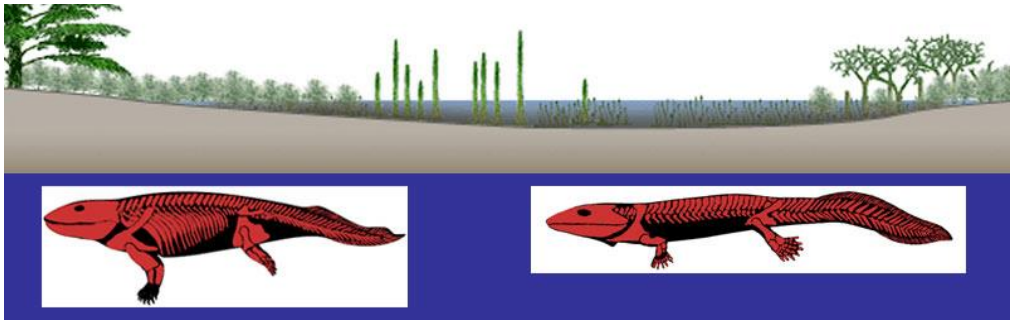
# "Ichthyostegalia" (Devoniano superior)



*Ichthyostega*

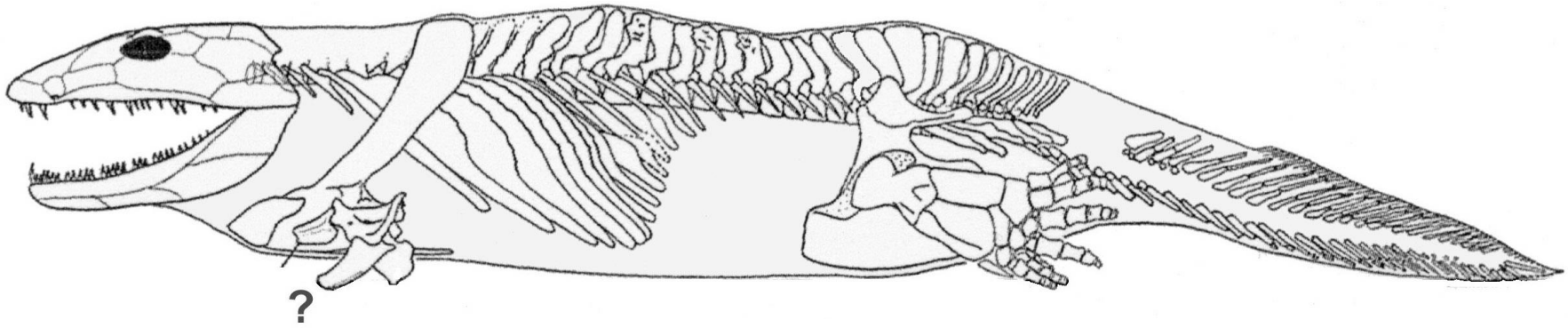
# "Ichthyostegalia" (Devoniano superior)

## *Acanthostega* seria algo mais aquático



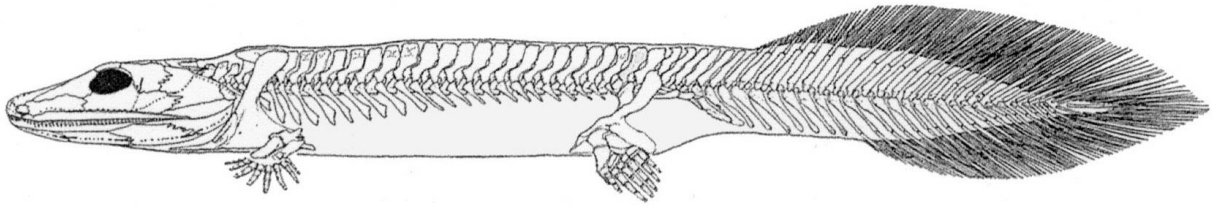
# "Ichthyostegalia" (Devoniano superior)

## *Acanthostega* seria algo mais aquático




*Ichthyostega*

10 cm



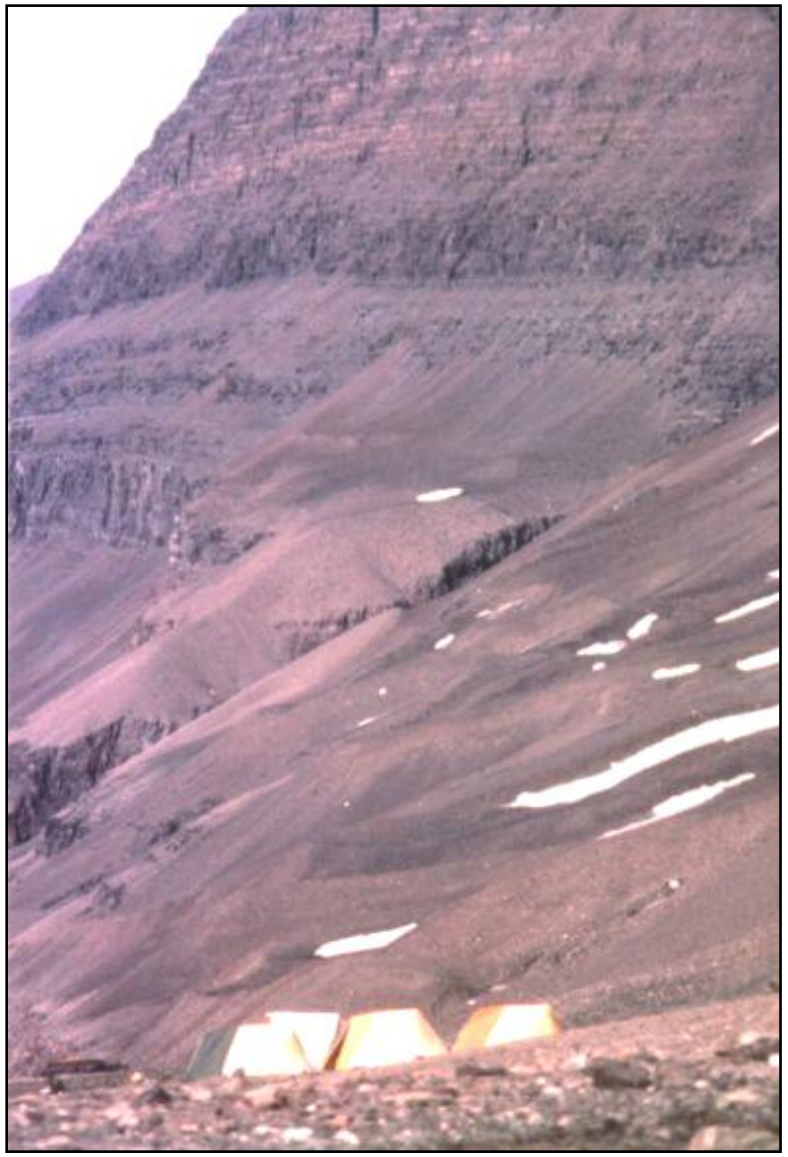
*Acanthostega*

# "Ichthyostegalia" (Devoniano superior)

## Groenlândia: passado e presente

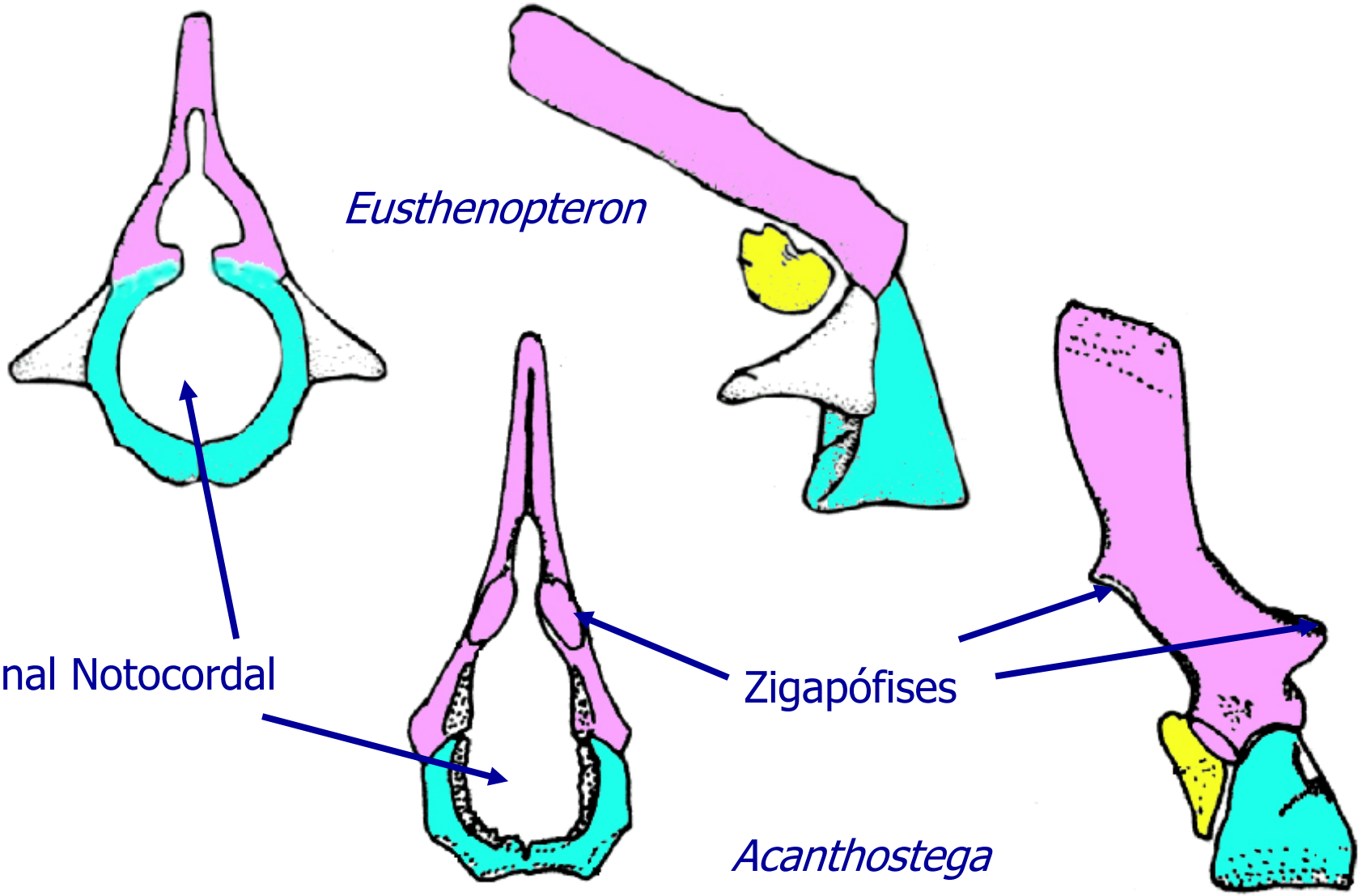
Passado

Presente



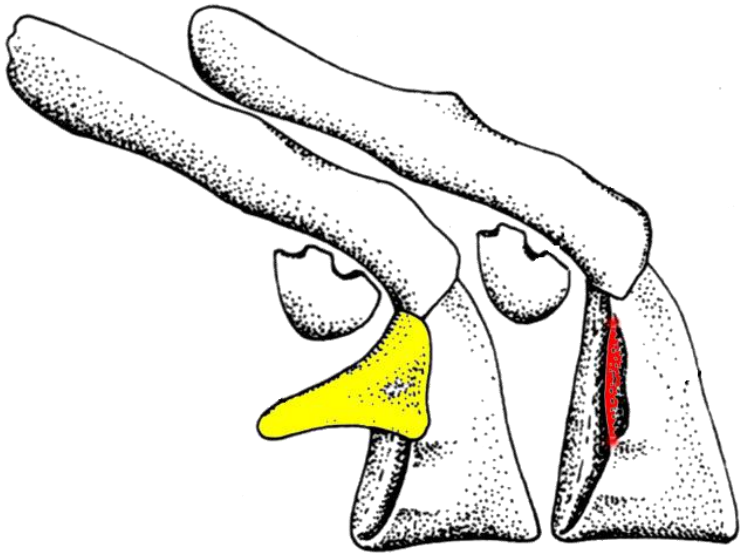
# Tetrapoda (Devoniano – Recente)

## Caracteres derivados: vértebras com pré- e pószigapófises



# Tetrapoda (Devoniano – Recente)

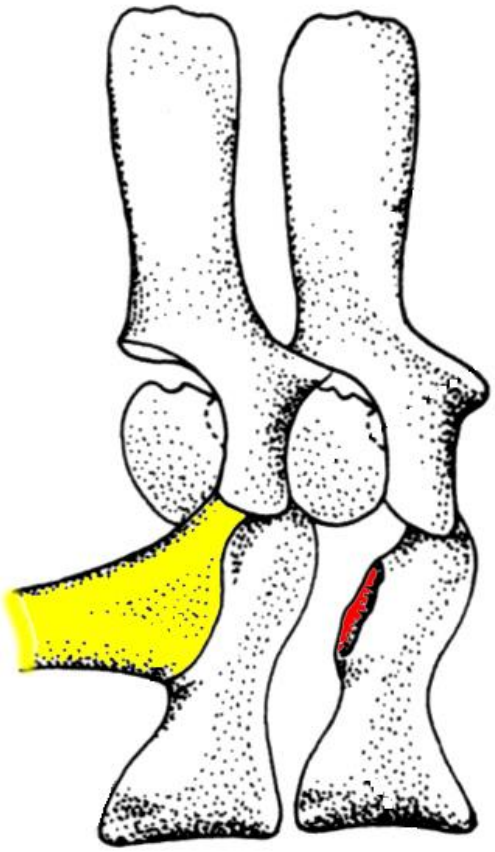
## Caracteres derivados: costelas bem desenvolvidas e dicocéfalas



*Eusthenopteron*

Costelas

Articulações



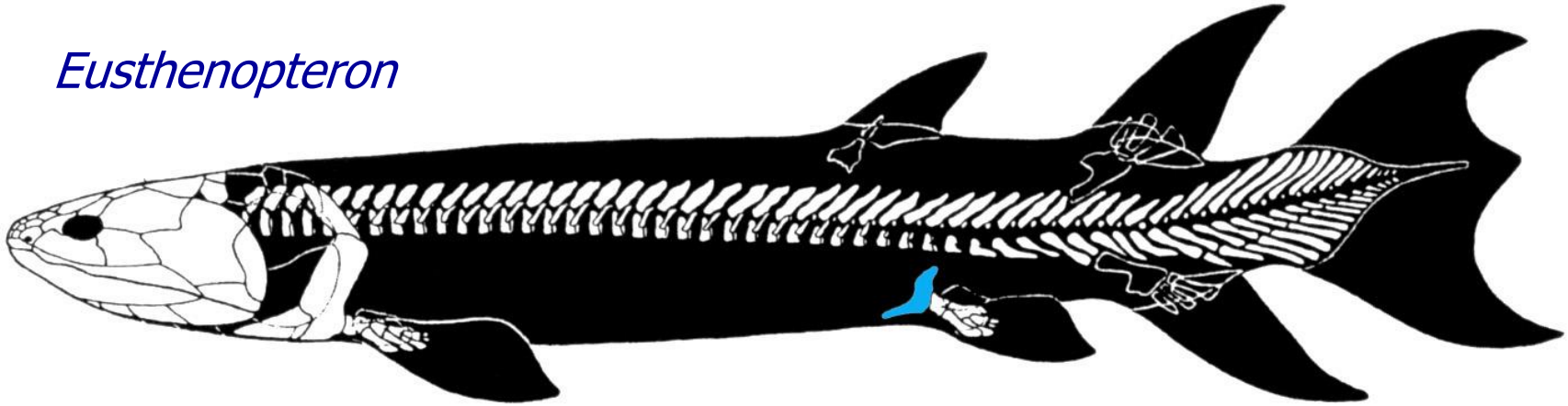
*Ichthyostega*

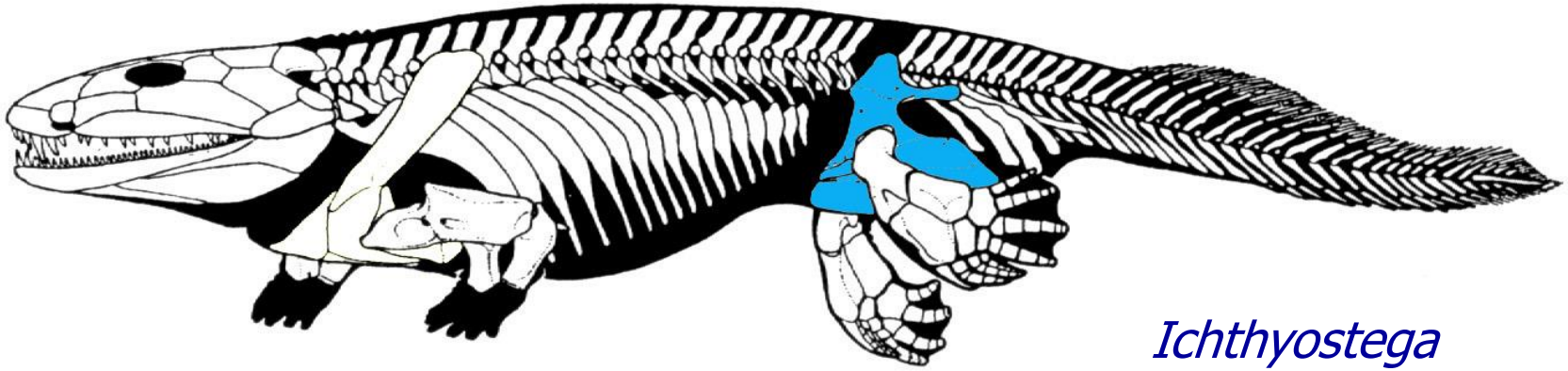
*Acanthostega*

# Tetrapoda (Devoniano – Recente)

## Caracteres derivados: ílio ligado à coluna vertebral

*Eusthenopteron*



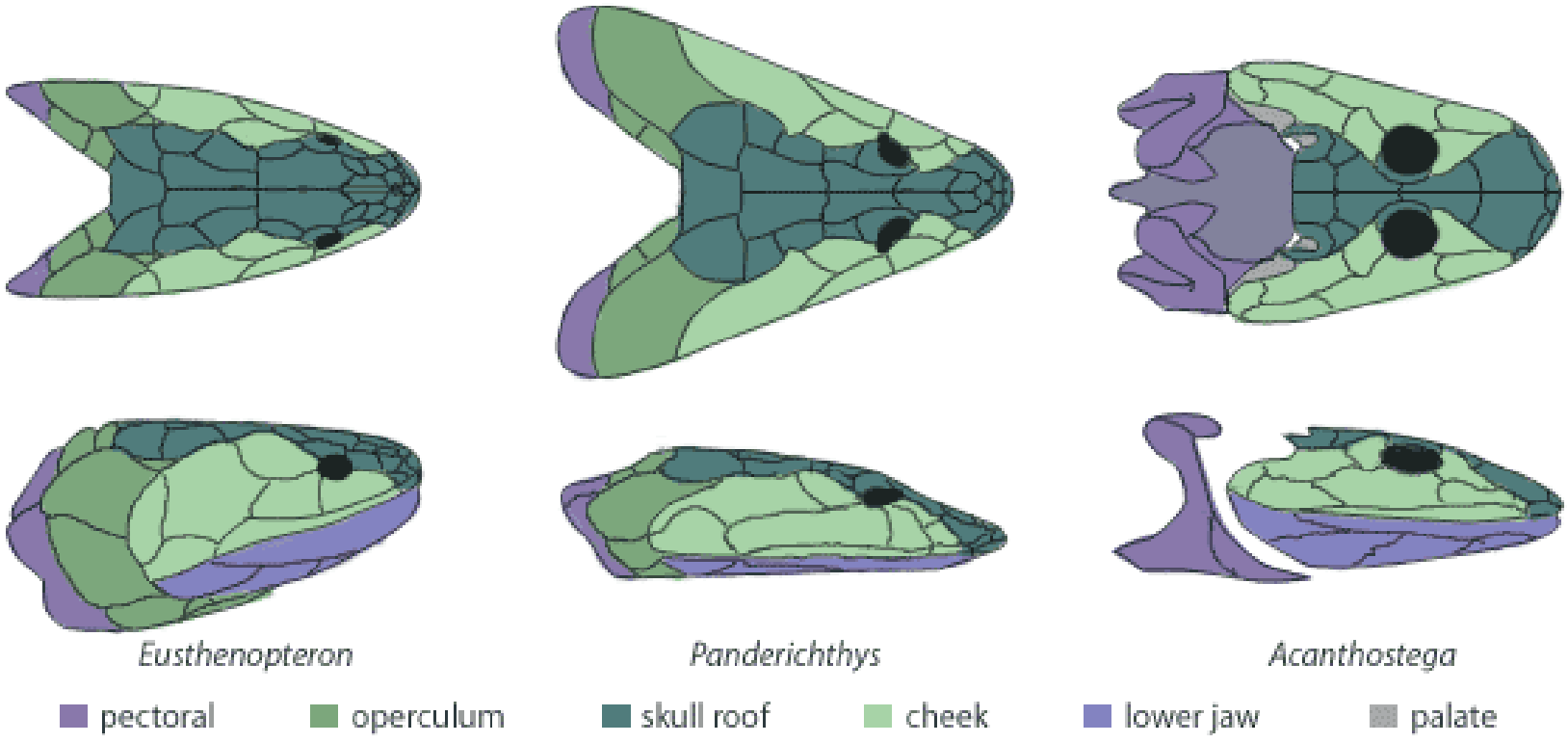


*Ichthyostega*

# Tetrapoda (Devoniano – Recente)

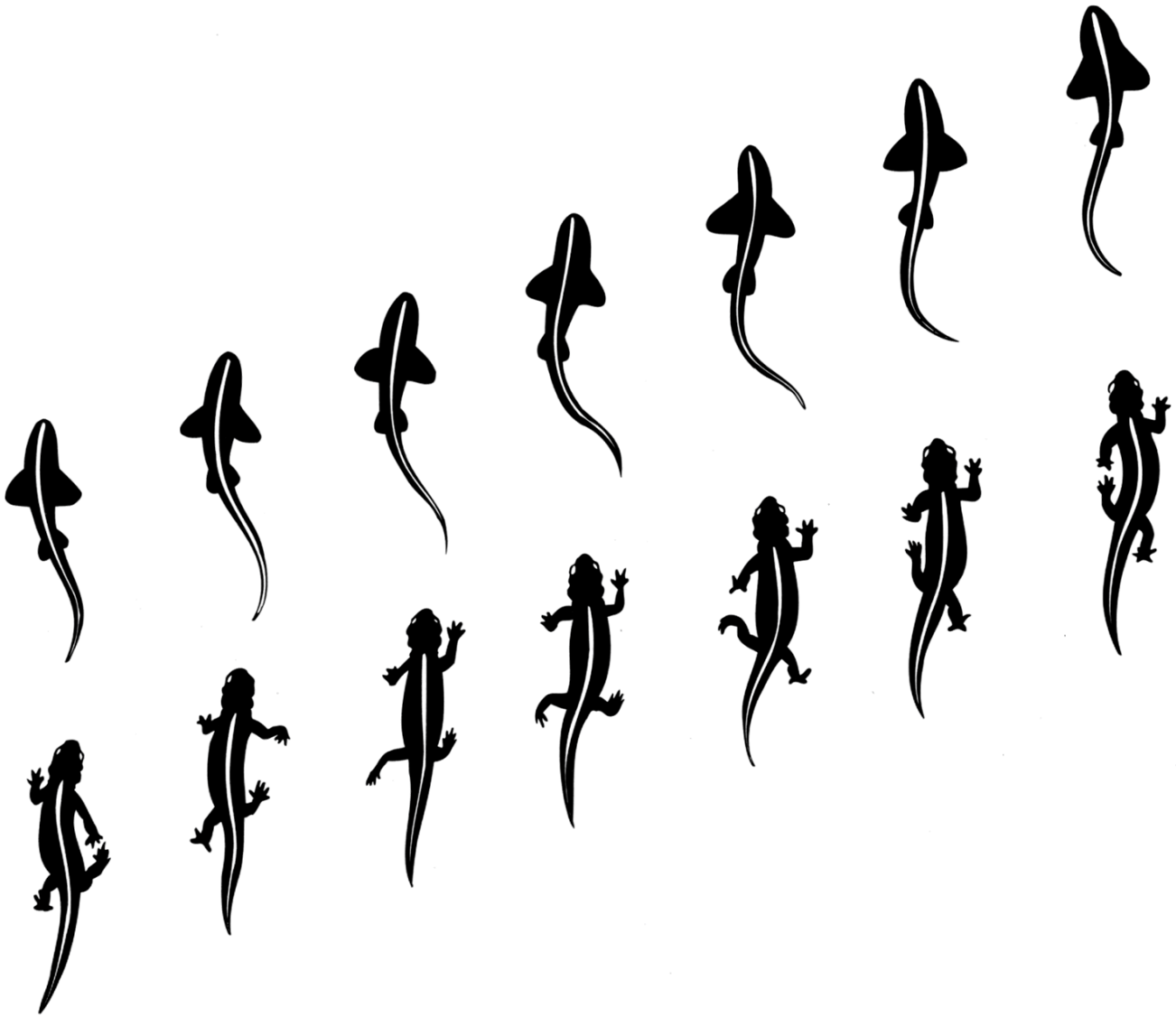
## Caracteres derivados: cintura escapular se separa do crânio

## redução dos elementos dérmicos da cintura escapular



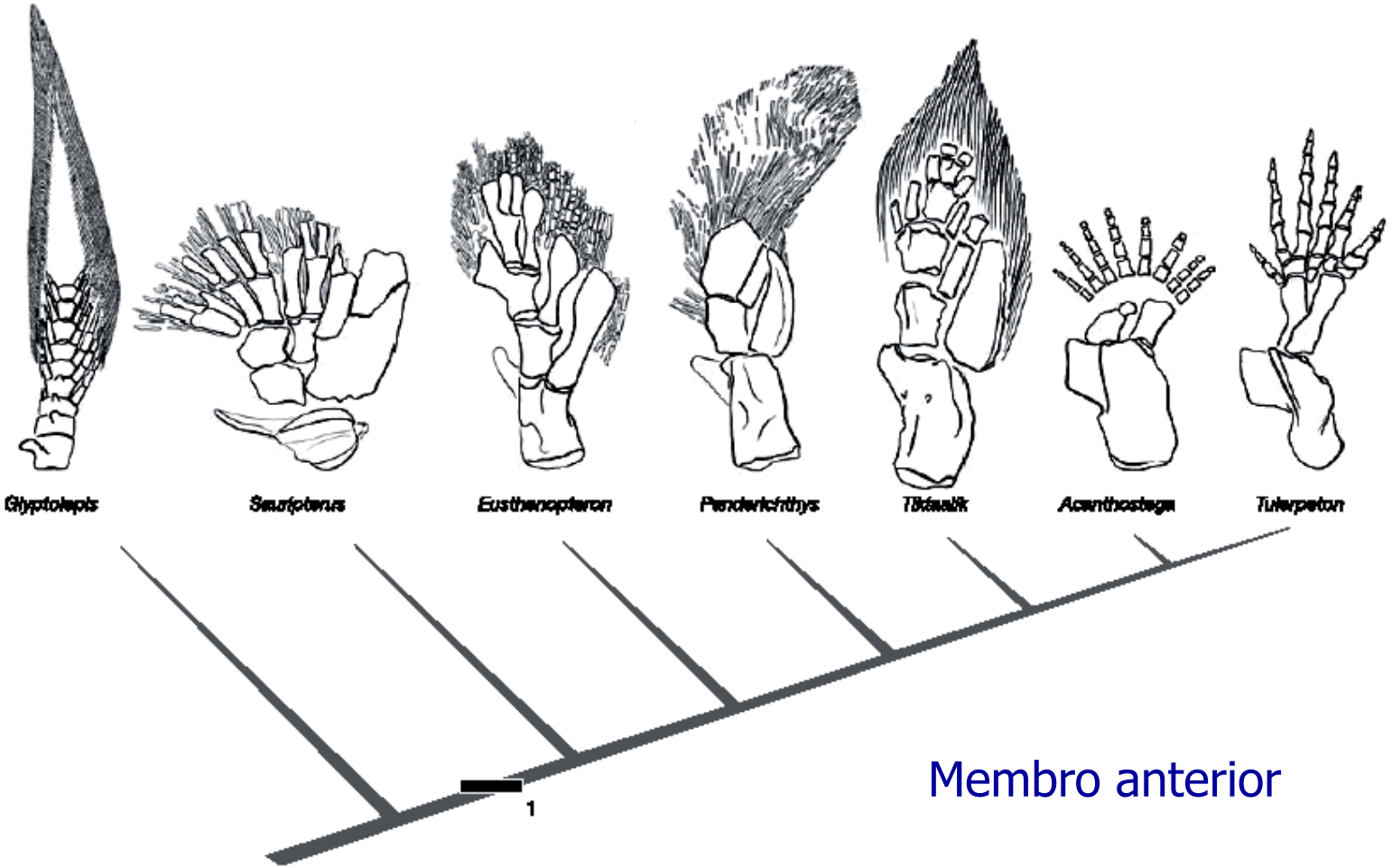
# Problemas da vida na terra

Locomoção: tetrápodos basais caminham por ondulações laterais do corpo, suportadas pelas patas



# Tetrapoda (Devoniano – Recente)

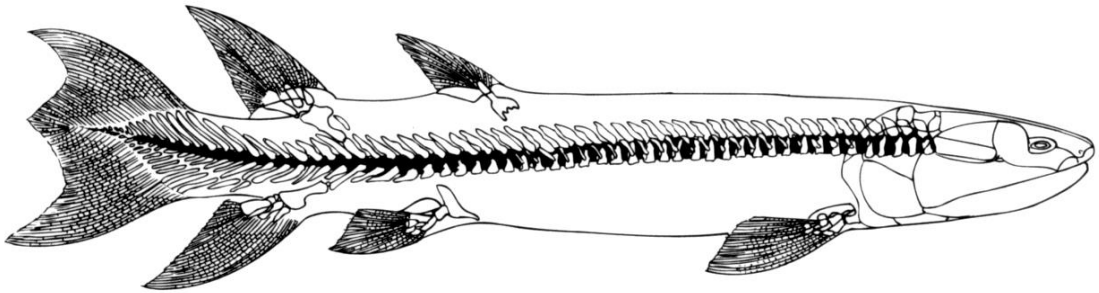
## Caracteres derivados: perda de raios nas "nadadeiras" pares e dígitos desenvolvidos

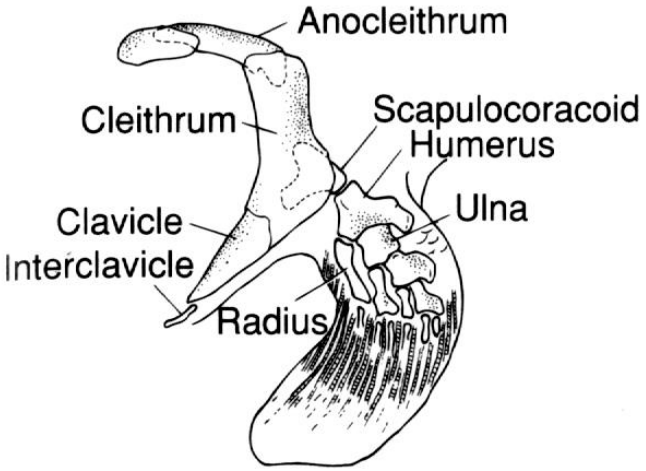


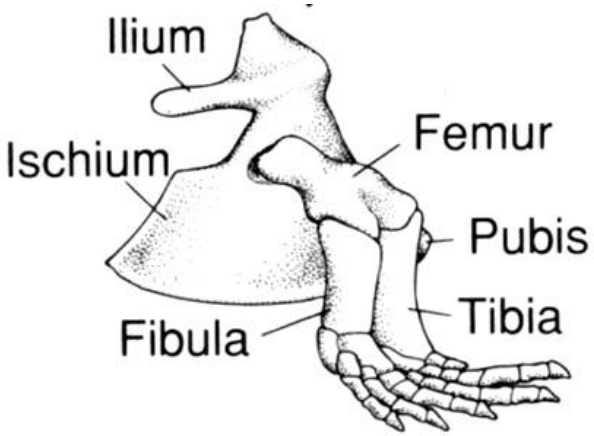

Membro anterior

# Problemas da vida na terra

## Locomoção: terápodos com plataforma de apoio mais robusta formada por *manus* / *pes* com dígitos

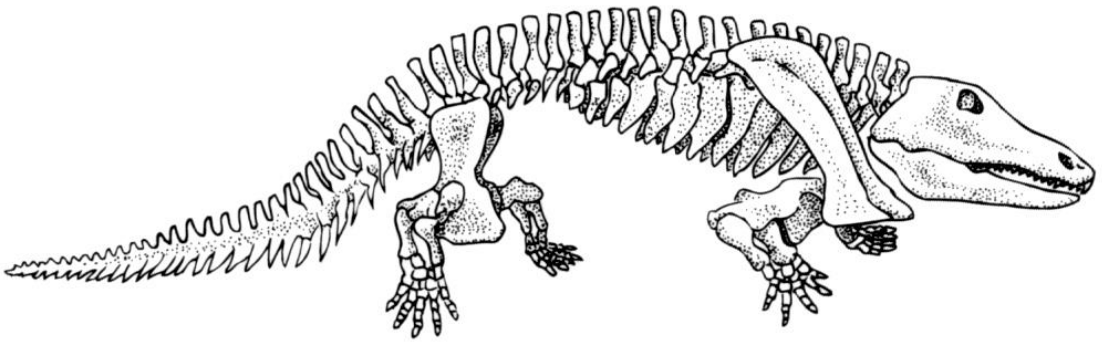




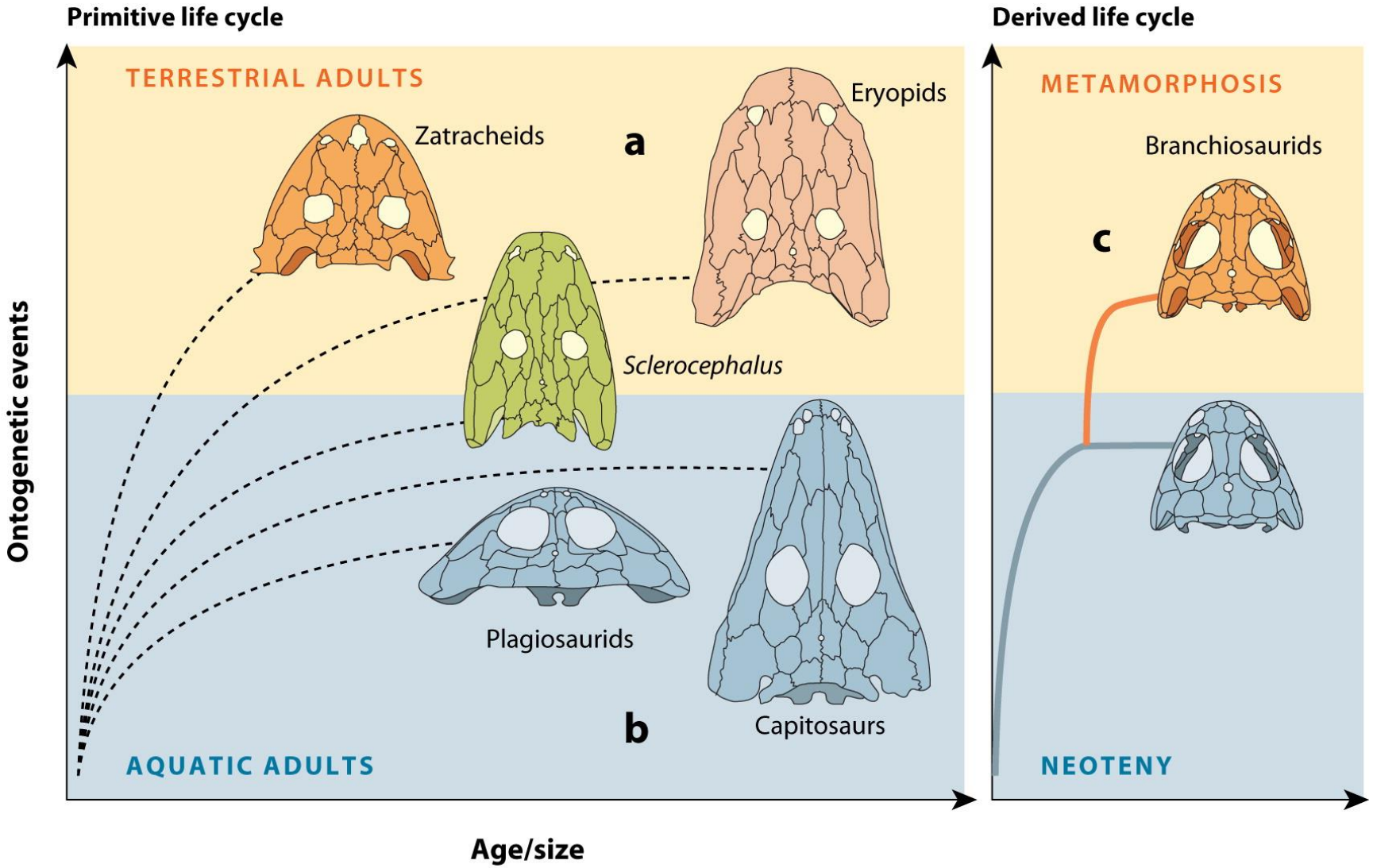

Cinturas e membros

Coluna vertebral



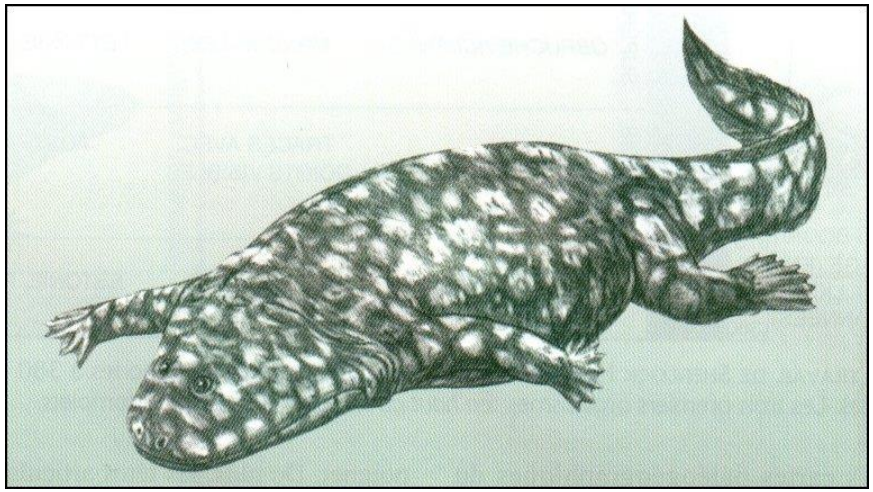
# Problemas da vida na terra

## Reprodução: presença de estágio larval aquático

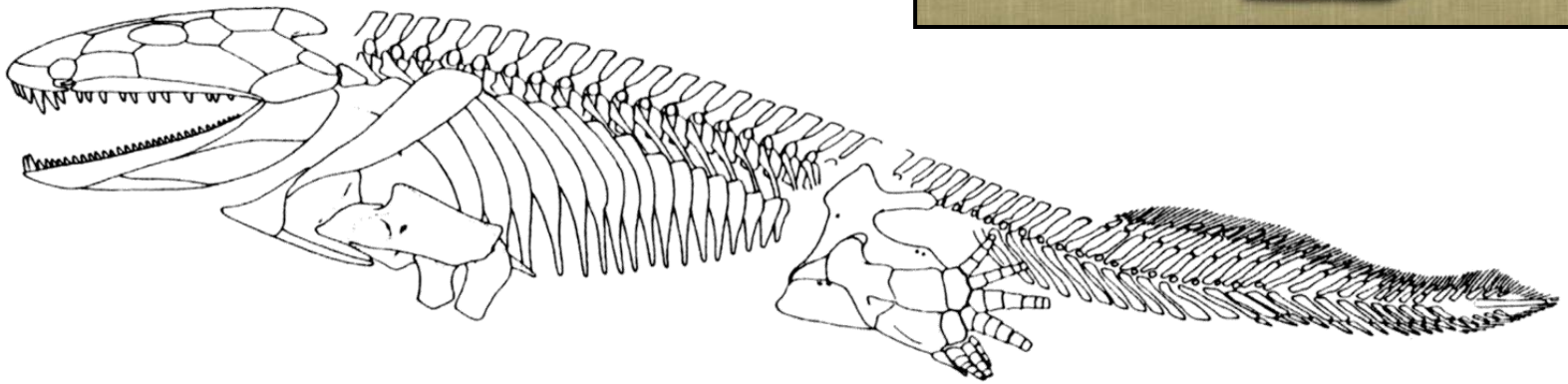


# "Ichthyostegalia" (*Acathostega* e *Ichthyostega*)

## Adaptações para vida aquática: corpo pisciforme, patas em forma de nadadeiras

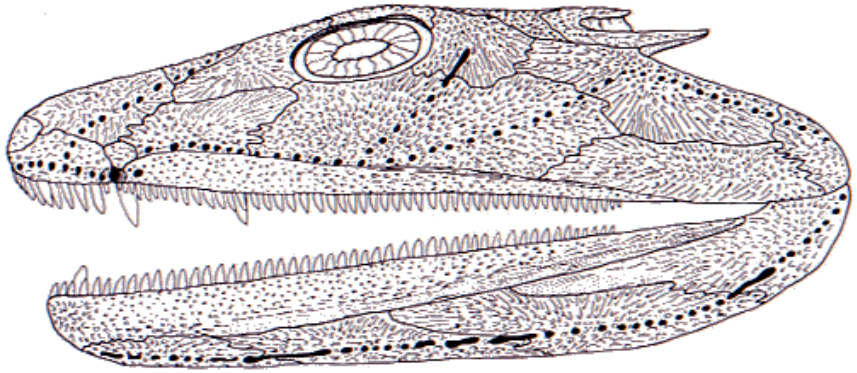


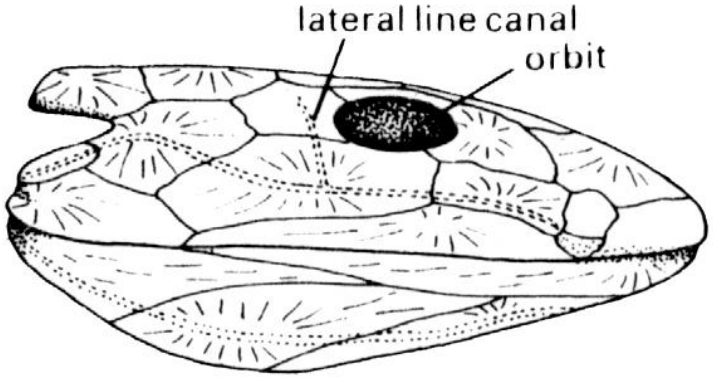
*Ichthyostega*



# "Ichthyostegalia" (*Acathostega* e *Ichthyostega*)

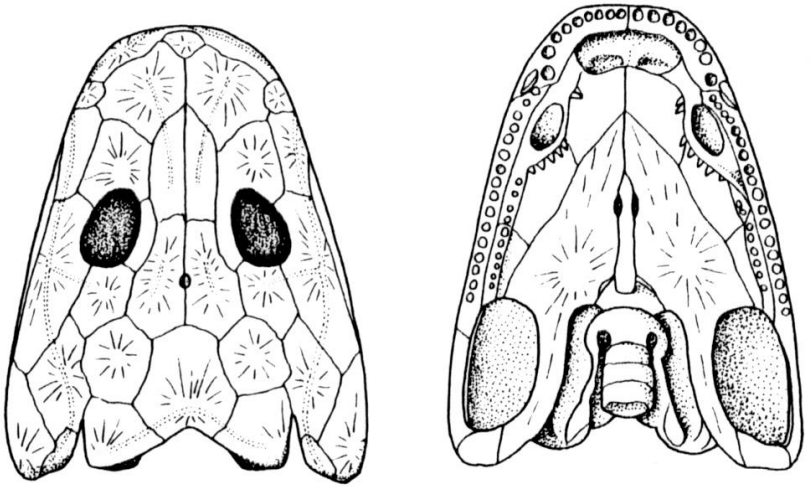
## Adaptações para vida aquática: linha lateral no crânio






*Acanthostega*

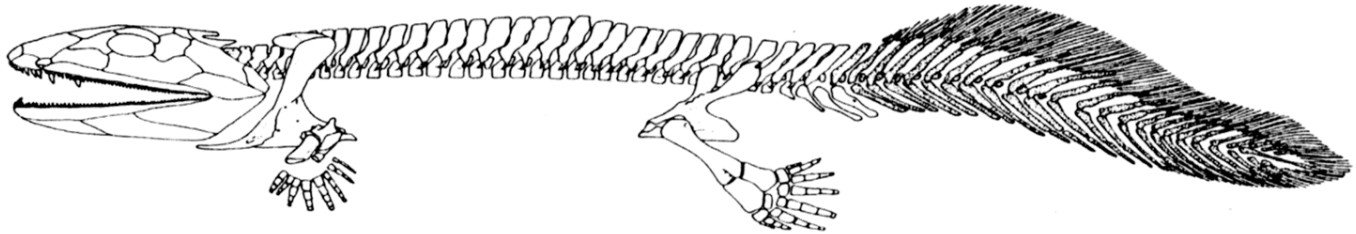
*Ichthyostega*



# "Ichthyostegalia" (*Acathostega* e *Ichthyostega*)

Adaptações para vida aquática: grande nadadeira caudal

Nadava por ondulações do corpo, mas poderia caminhar na terra



*Acanthostega*

# "Ichthyostegalia" (*Acathostega* e *Ichthyostega*)

Adaptações para vida aquática: grande nadadeira caudal

Nadava por ondulações do corpo, mas poderia caminhar na terra

*Panderichtyes*

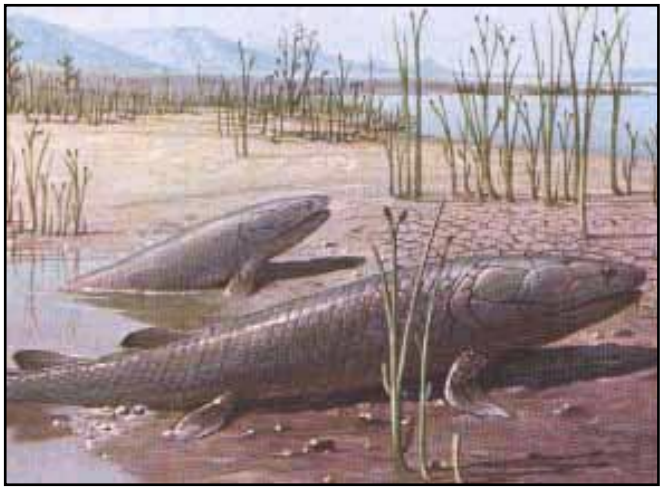
*Tiktaalik*

*Acanthostega*

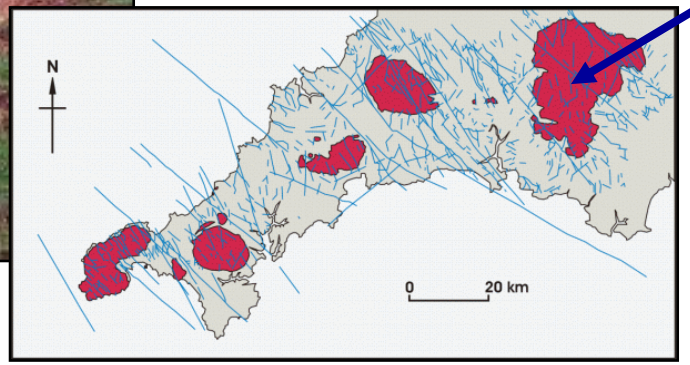
# Conquista do ambiente terrestre

Teoria clássica (A. S. Romer): momentos de aridez no Devoniano isolava corpos d'água em resecamento, favorecendo formas com capacidade de locomoção em terra firme e com respiração aérea

"Old Red Sandstone"

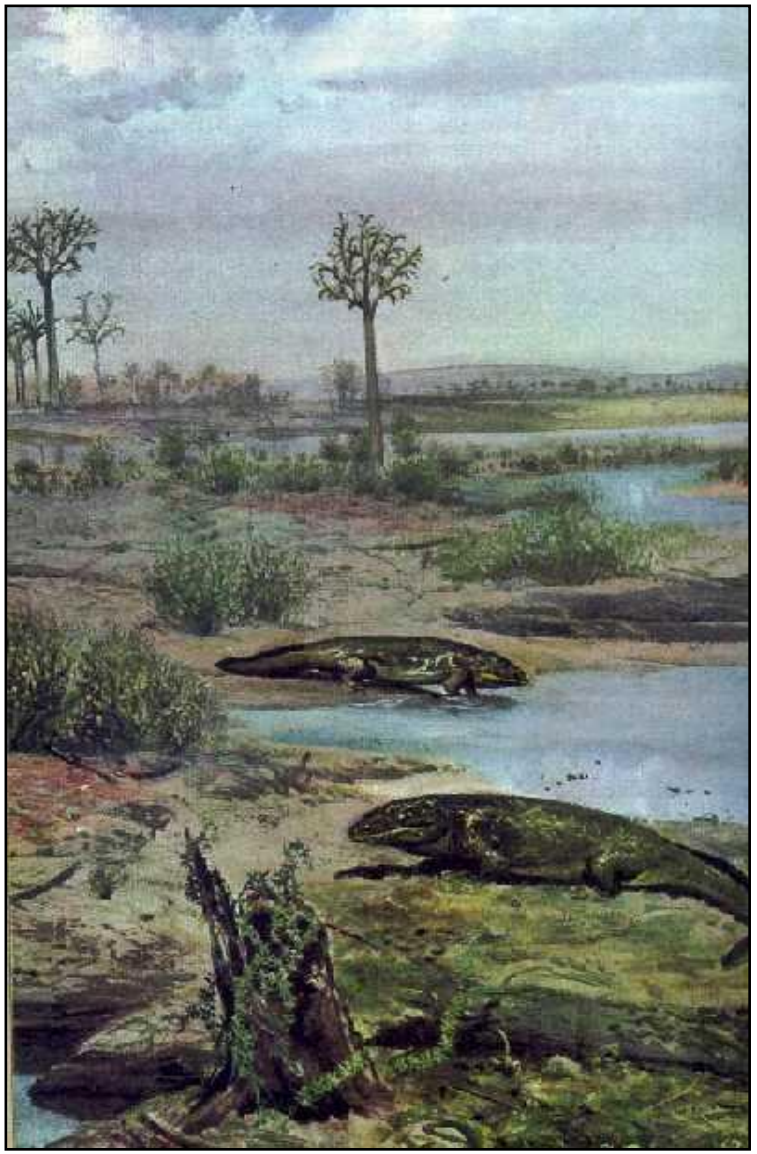


Devon

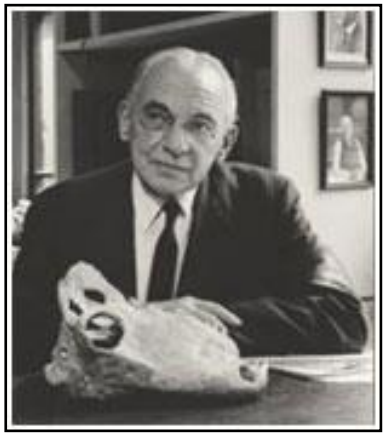


# Conquista do ambiente terrestre

## "Patas surgiram para os organismos permanecerem na água"



Romer considerava os primeiros tetrápodos tipicamente aquáticos

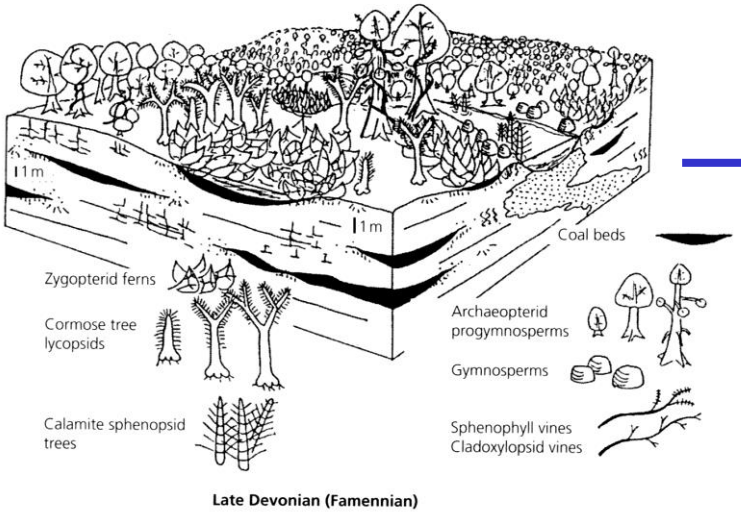


# Conquista do ambiente terrestre

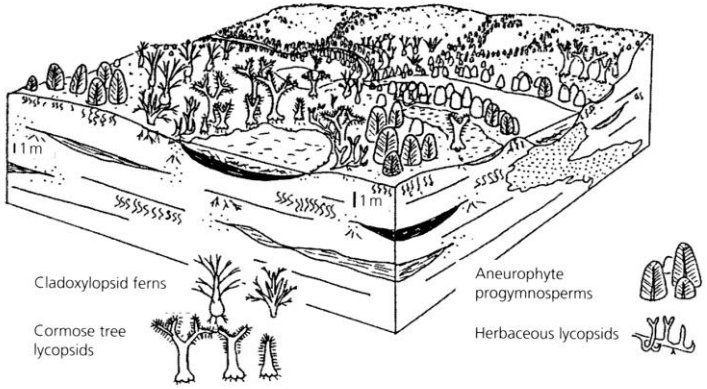
*Problemas* : evidencias de secas no Devoniano são controversas

*Red-beds* pode formar-se em qualquer ambiente oxidante

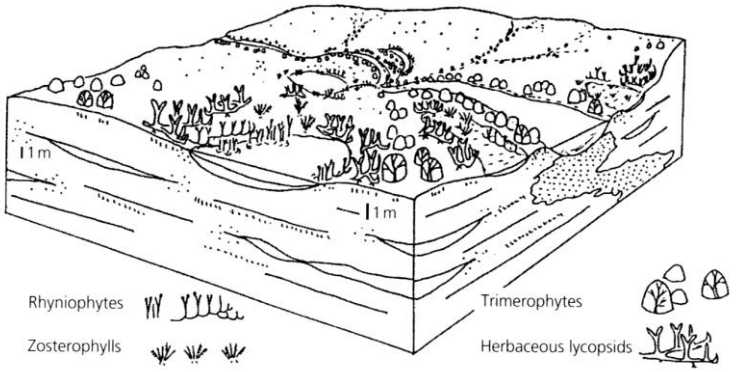
como as florestas que ocorriam em baixas latitudes no Paleozóico superior




Late Devonian (Famennian)




Middle Devonian (Eifelian–Givetian)




Early Devonian (Pragian–Emsian)

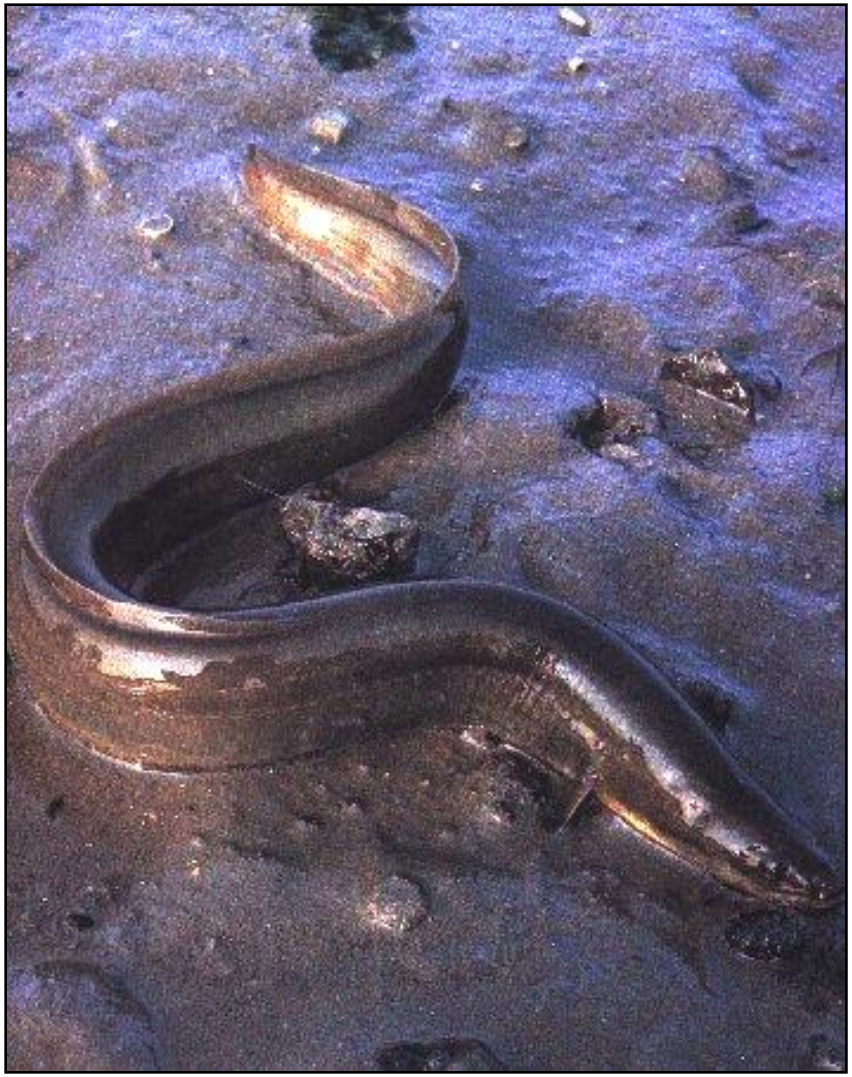
# Conquista do ambiente terrestre

## Problemas: em geral, os "anfíbios" de áreas desérticas não abandonam lagos secos

*Cyclorana alboguttata*

# Conquista do ambiente terrestre

## Problemas : modificações anatômicas muito profundas para hábito relacionado à comportamento eventual



A maioria dos “peixes” atuais que se aventuram em ambiente subaéreo (e.g.: enguias, pirambóia) carecem de estruturas “tipo patas”

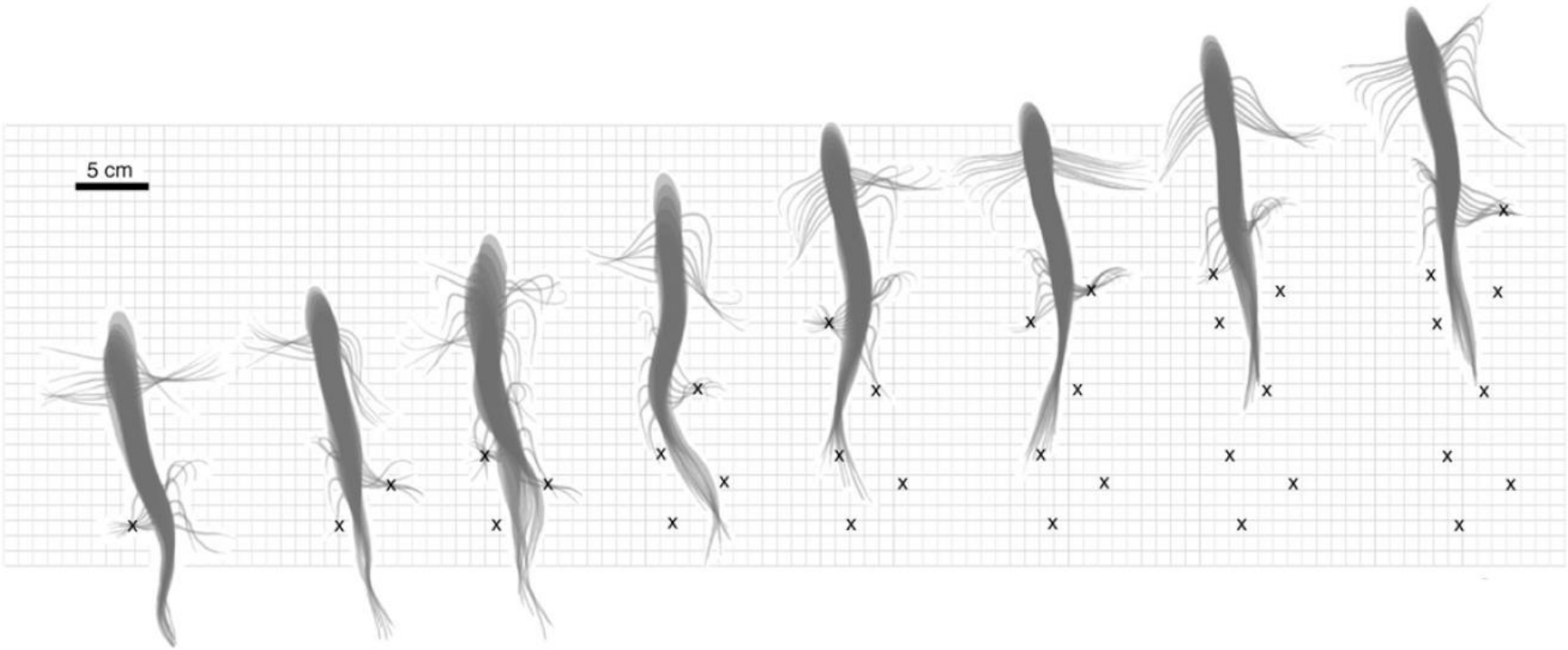
# Conquista do ambiente terrestre

## Problemas: formas tipicamente aquáticas podem "caminhar"

*Antennarius multiocellatus*

# Conquista do ambiente terrestre

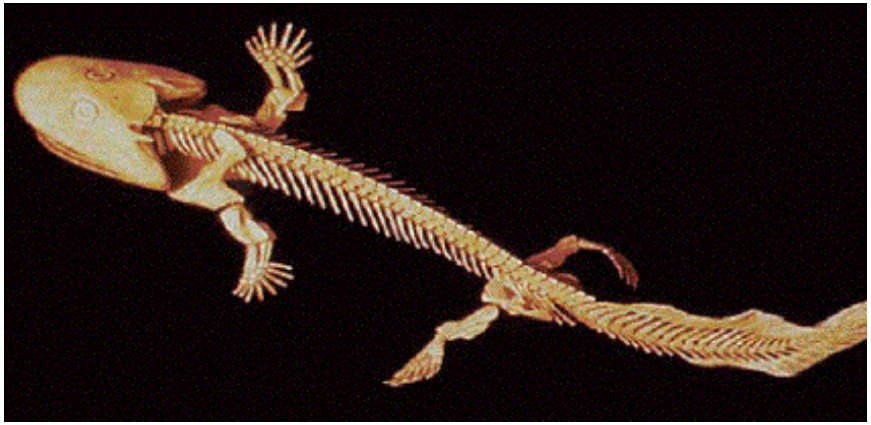
## Problemas: formas aquáticas podem "caminhar"

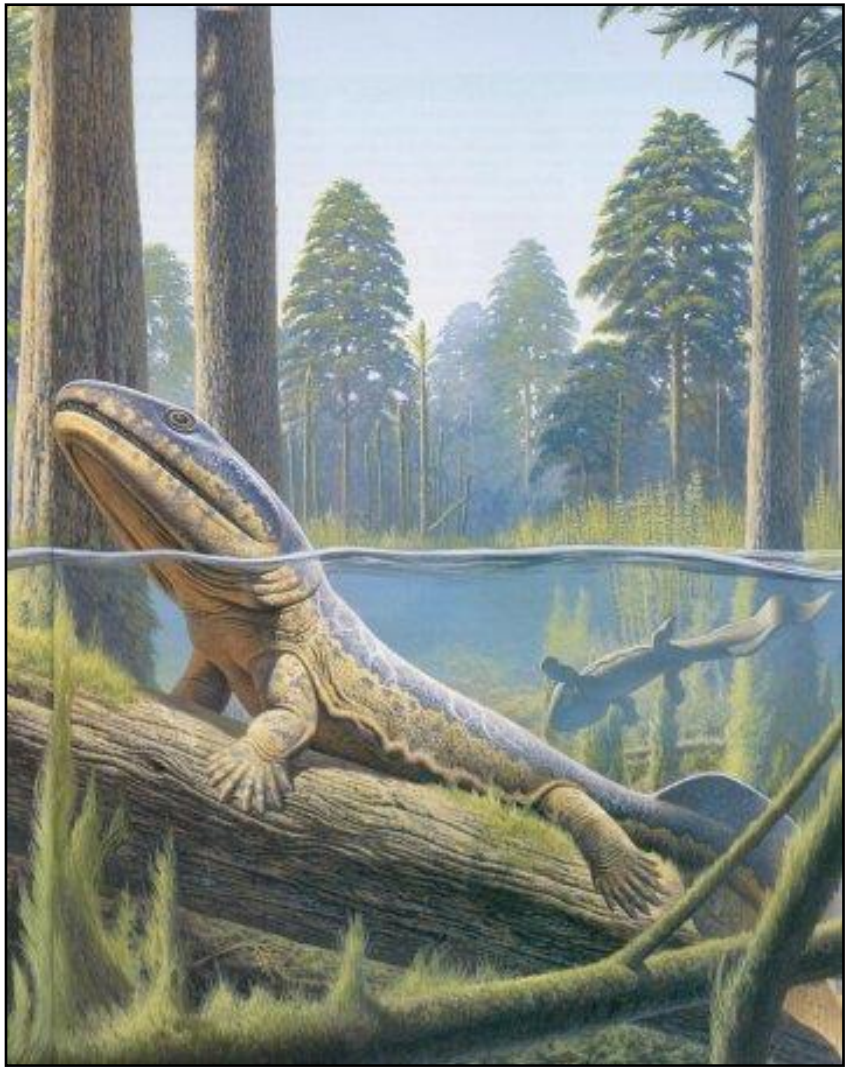



*Protopterus*

# Conquista do ambiente terrestre

## Importante dissociar o surgimento de estruturas tipo pata, da locomoção tipo "caminhar" e da terrestrialidade

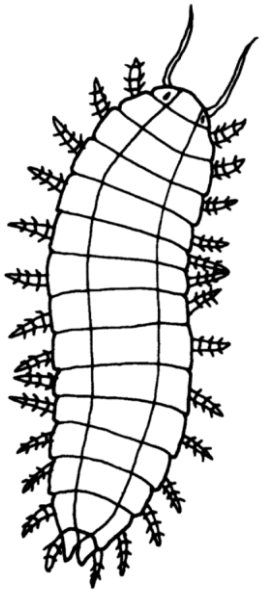




Caracteres de tetrápodos surgiram antes da terrestrilaização, como adaptações à ambientes subaquáticos rasos, sendo que representavam "pré-adaptações" à ambientes terrestres

# Conquista do ambiente terrestre

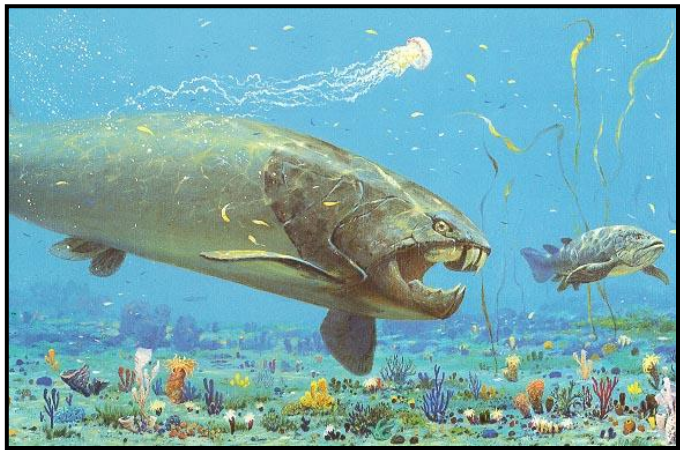
Terrestrialização deve ter sido condicionada à procura de novos recursos (pouco explorados nos ambientes continentais), bem como para escapar da maior pressão de predação dos ambientes aquáticos



Miriápode

Euriptérido

Trigonotarbídeo

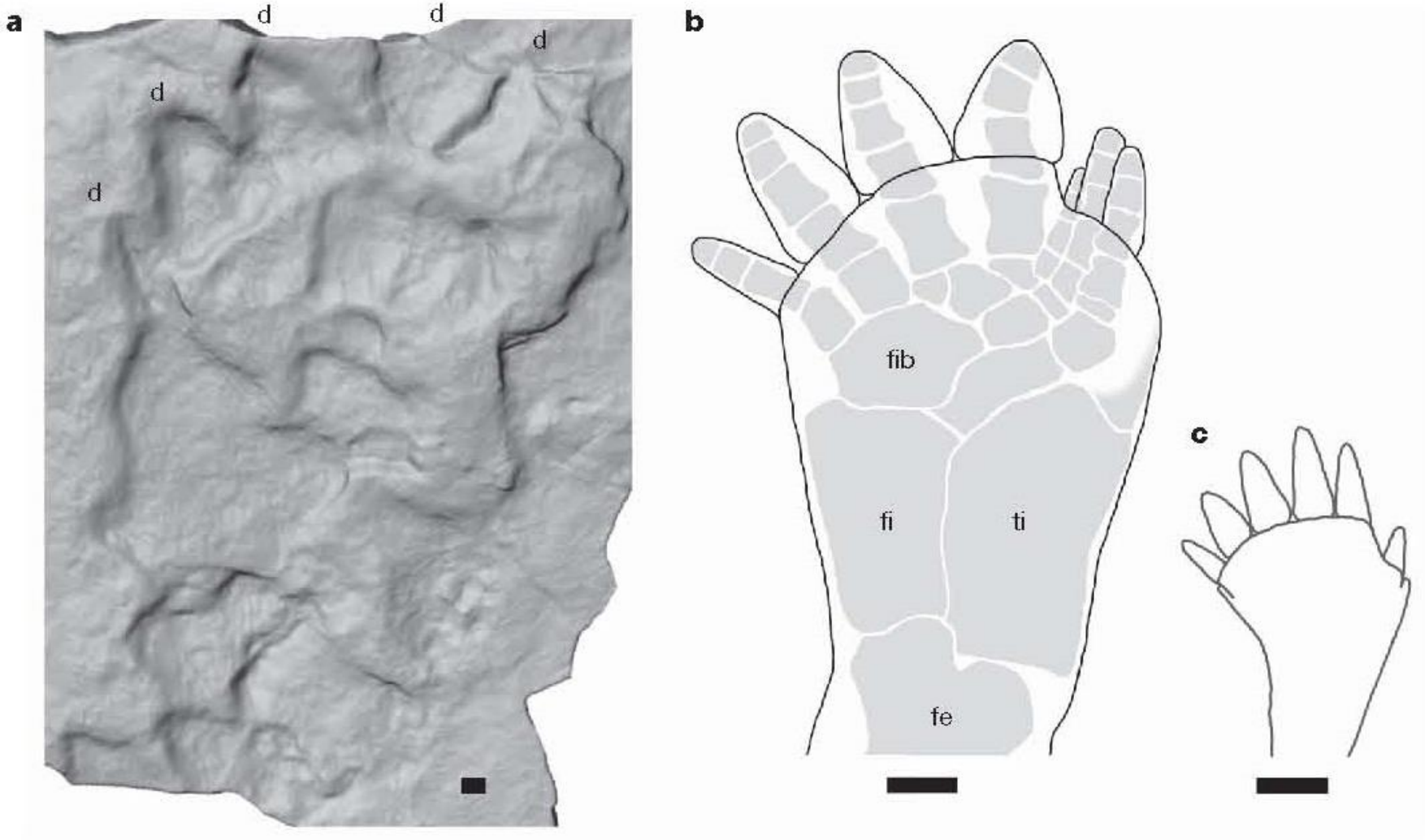


"Peixes"

# Pegadas de Zachełmie (Eifeliano da Polônia)

## Origem mais antiga do padrão locomotor de Tetrapoda

## Gosth Lineage? Convergências?



# Pegadas de Zachełmie (Eifeliano da Polônia)

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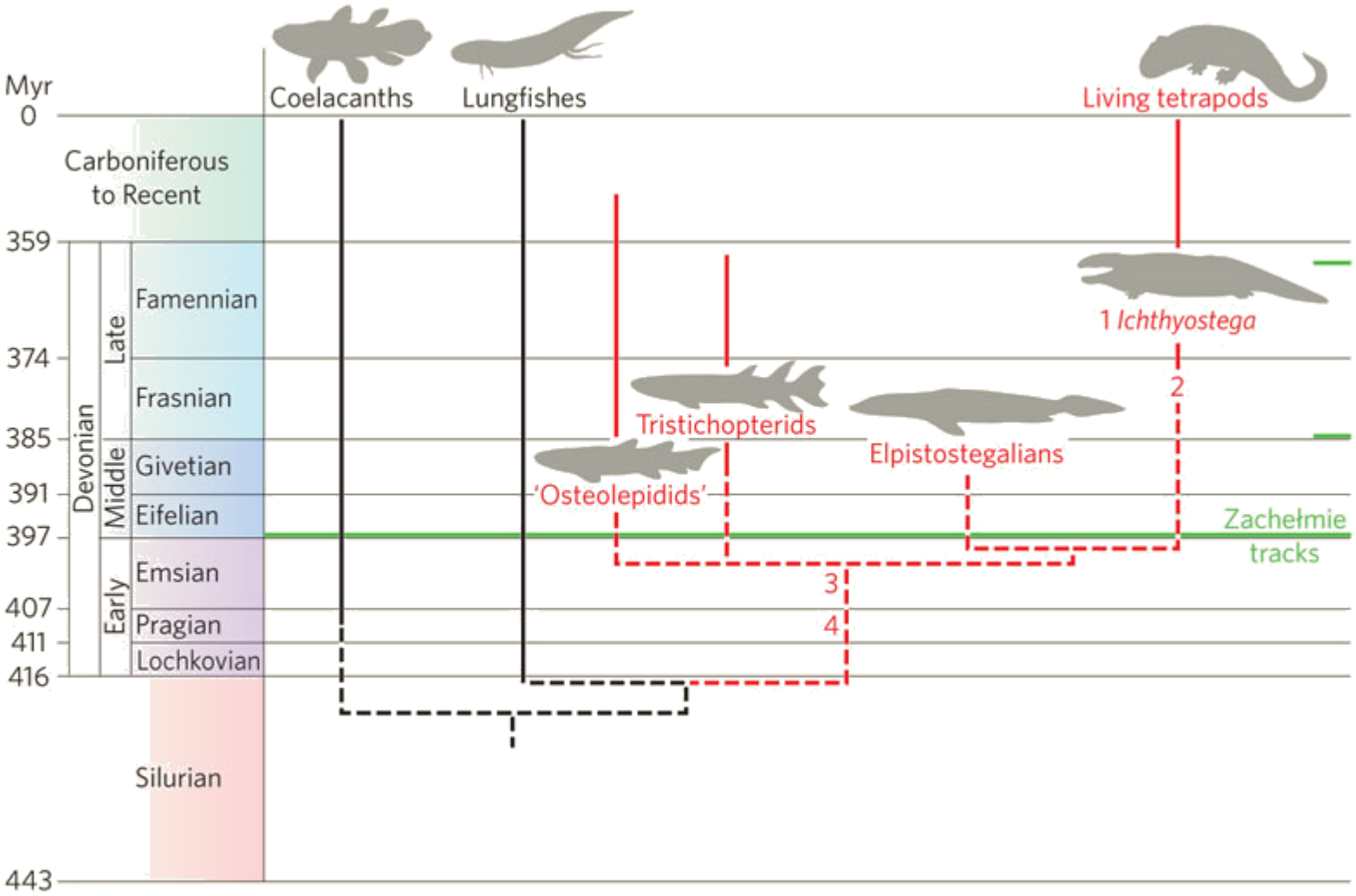
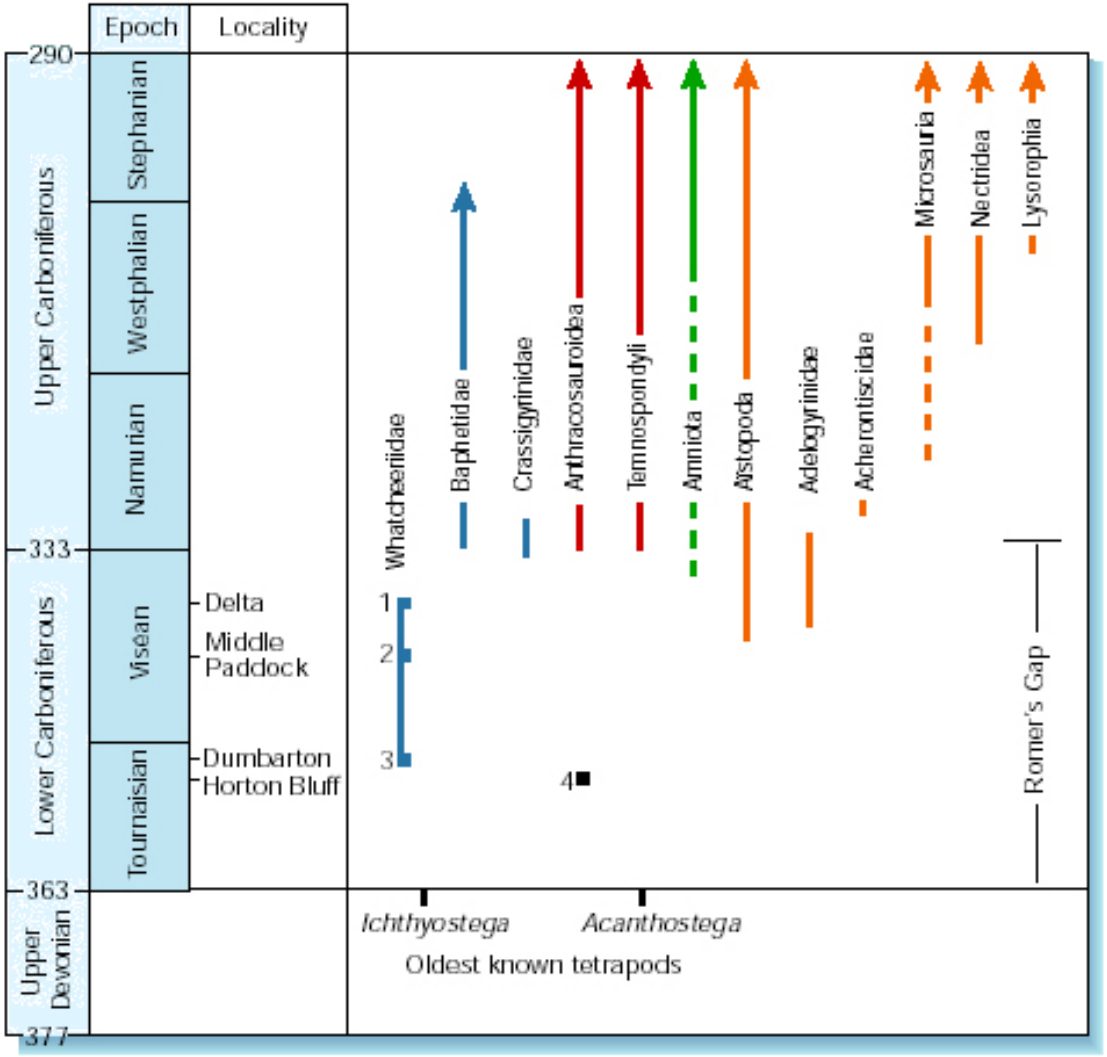
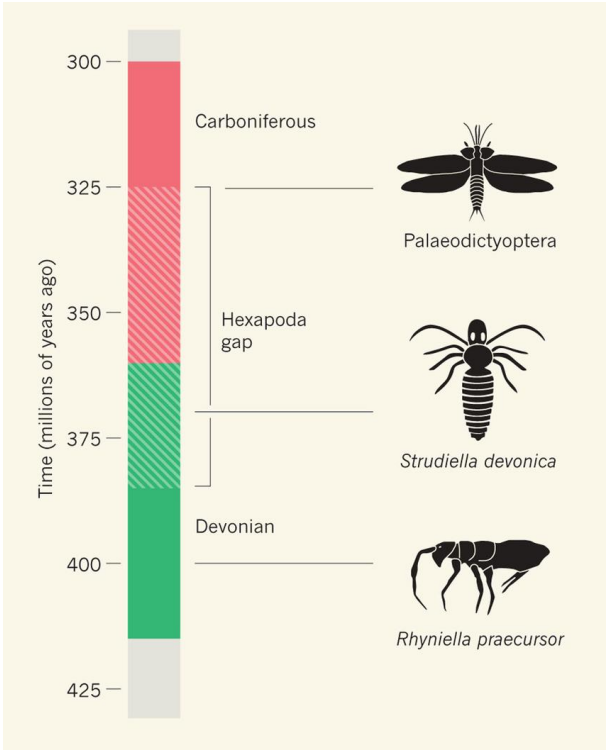
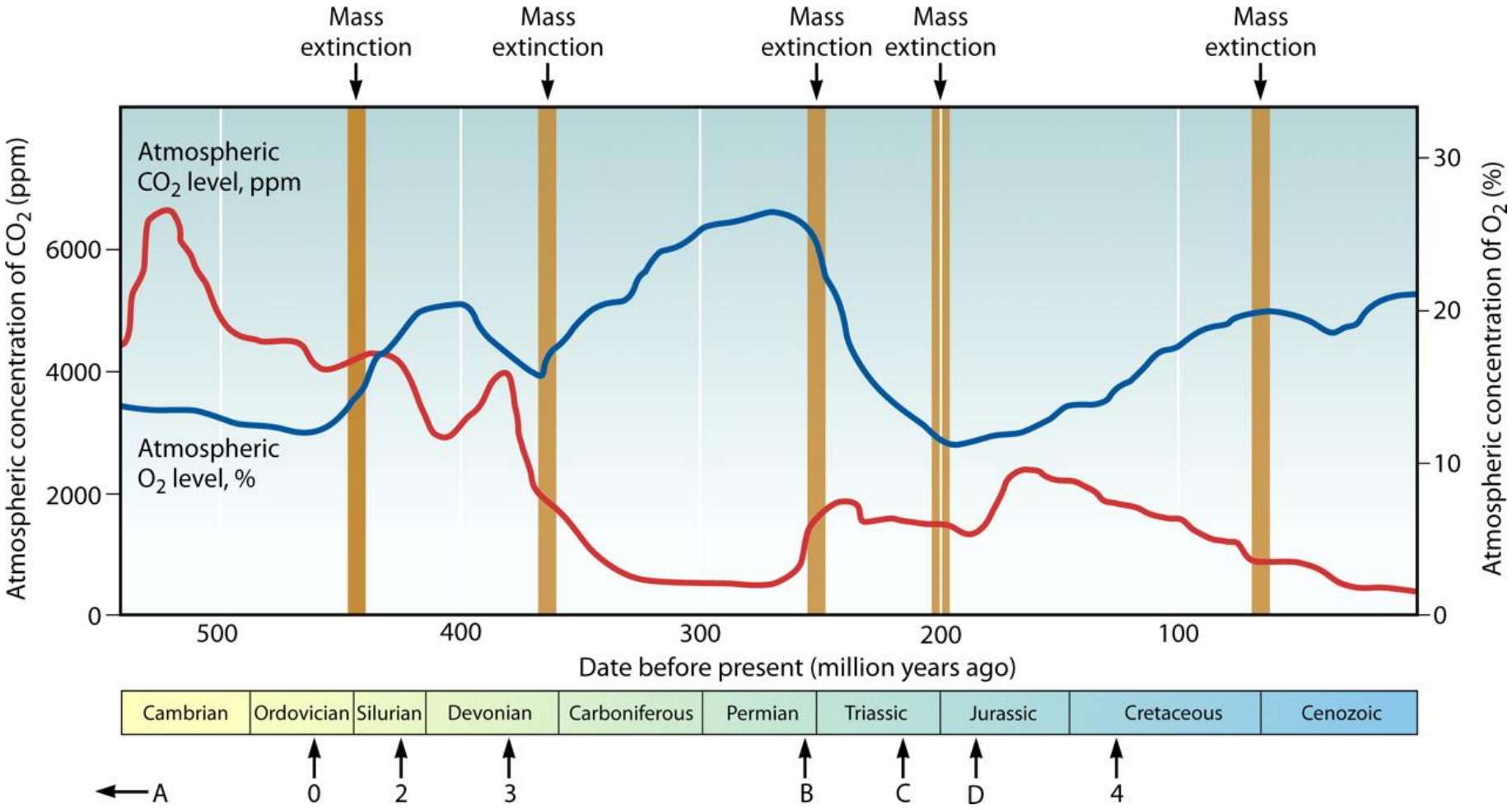


# Romer's gap


Epoch
Locality
290
333
363
377
Upper Carboniferous
Lower Carboniferous
Upper Devonian
Stephanian
Westphalian
Namurian
Visean
Tournaisian
Delta
Middle Paddock
Dumbarton
Horton Bluff
Whatcheeriidae
Baphetidae
Crassigyrinidae
Anthracosauroidea
Temnospondyli
Amniota
Aistopoda
Adelogyrinidae
Acherontiscidae
Microsauria
Nectridea
Lysorophia
1
2
3
4
Romer's Gap
Ichthyostega
Acanthostega
Oldest known tetrapods


Time (millions of years ago)
300
325
350
375
400
425
Carboniferous
Hexapoda gap
Devonian
Palaeodictyoptera
Strudiella devonica
Rhyniella praecursor

# Variações nos níveis de Oxigênio




WALKING
WITH MONSTERS
LIFE BEFORE DINOSAURS
bbc.co.uk/science