Filogenia dos Metazoa

AULA 6

Origem e evolução de Bilateria

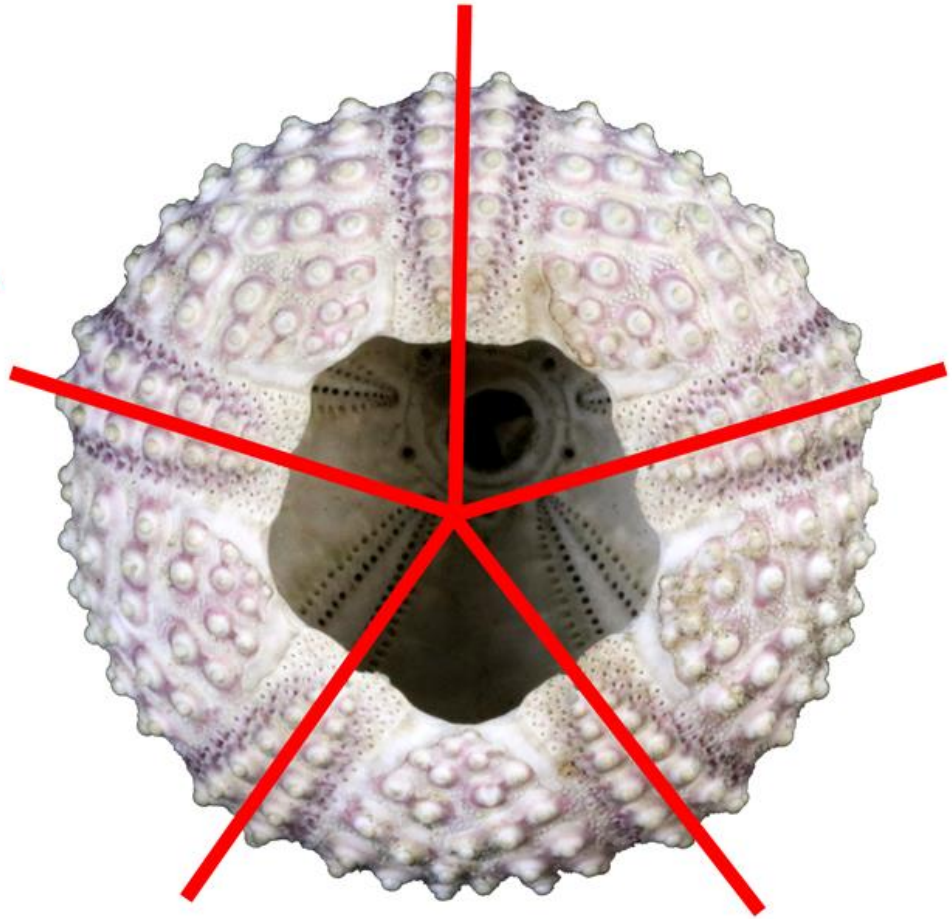
Professores: Dr. Felipe B. Ribeiro e Dr. Moysés E. Neto

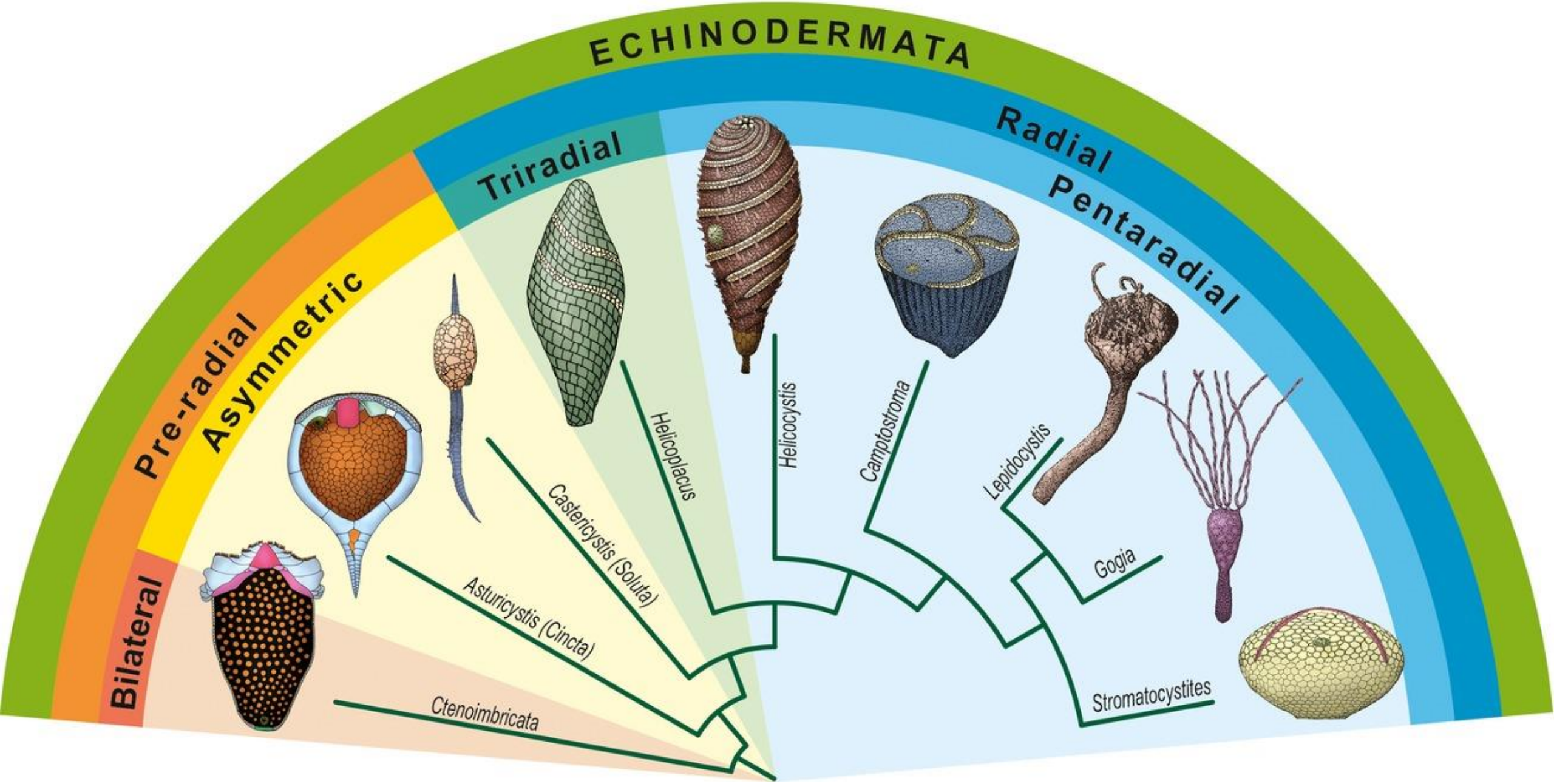
Bilateria (ou Tripoblastica)

- Tecidos adultos derivados de três folhetos embrionários;
- Eixo corporal principal: A–P → duas metades simétricas;
- Alguns bilatérios perderam secundariamente a simetria bilateral em sua forma adulta;
- Notável consequência na morfologia, concentração de nervos e estruturas sensoriais na região anterior do corpo (cefalização);

Asteroidea

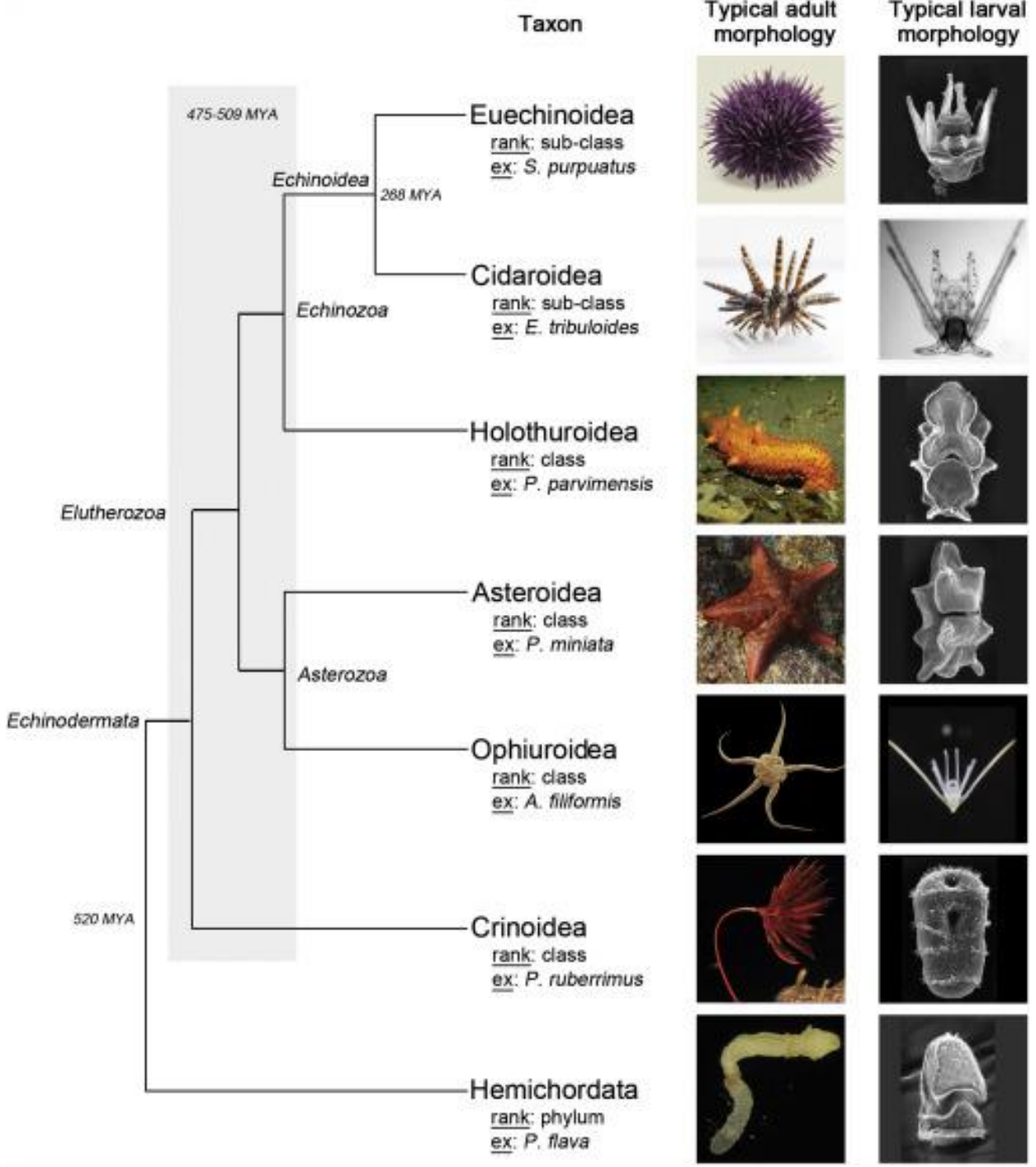
Echinoidea





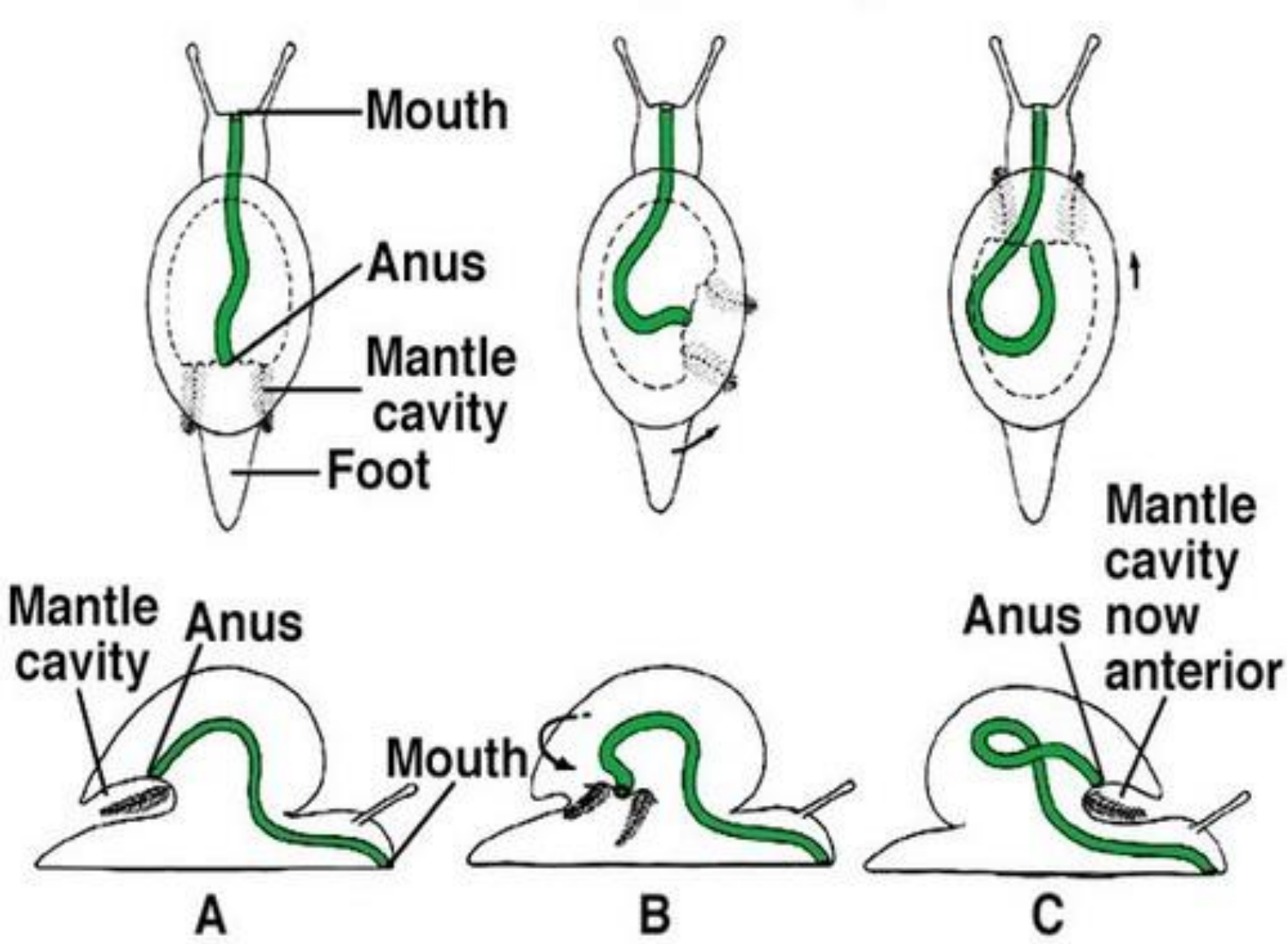
https://doi.org/10.1111/pala.12138

A larva apresenta simetria bilateral:

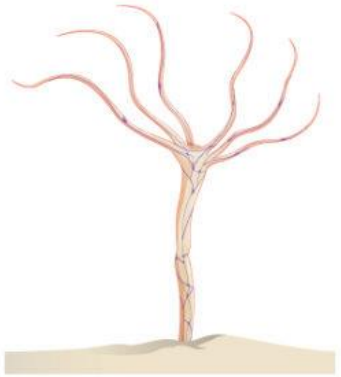


https://doi.org/10.1016/j.ydbio.2017.02.003

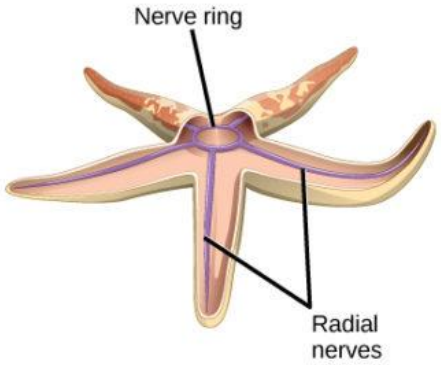
Torção corporal em Gastropoda



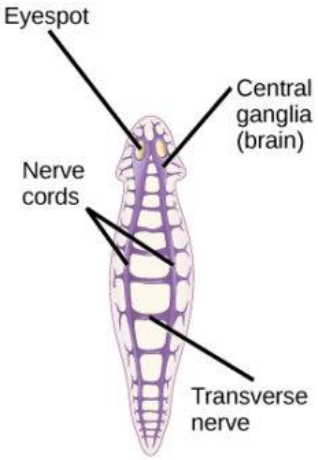
Cefalização



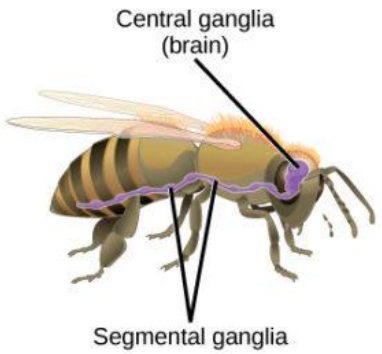
(a) Cnidarian
(hydra)



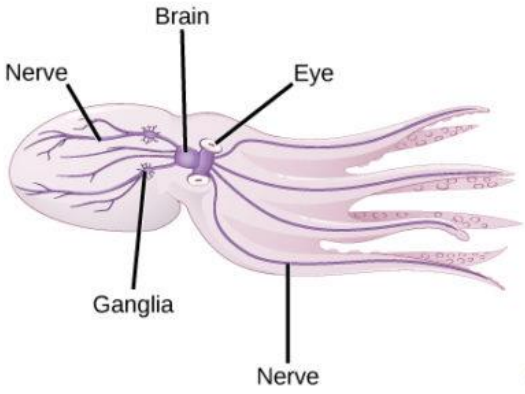
(b) Echinoderm
(sea star)



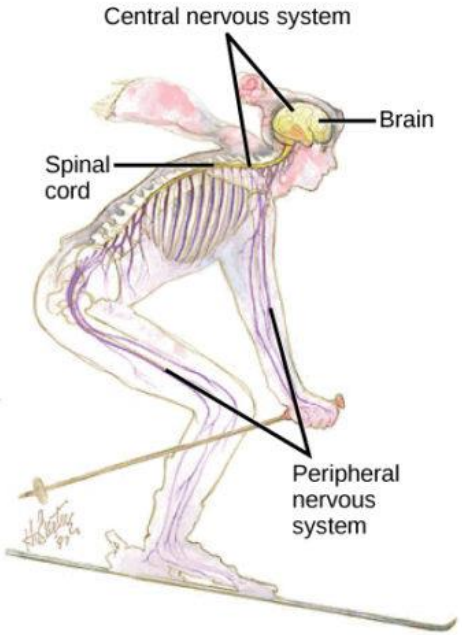
(c) Planarian
(flatworm)



(d) Arthropod
(bee)



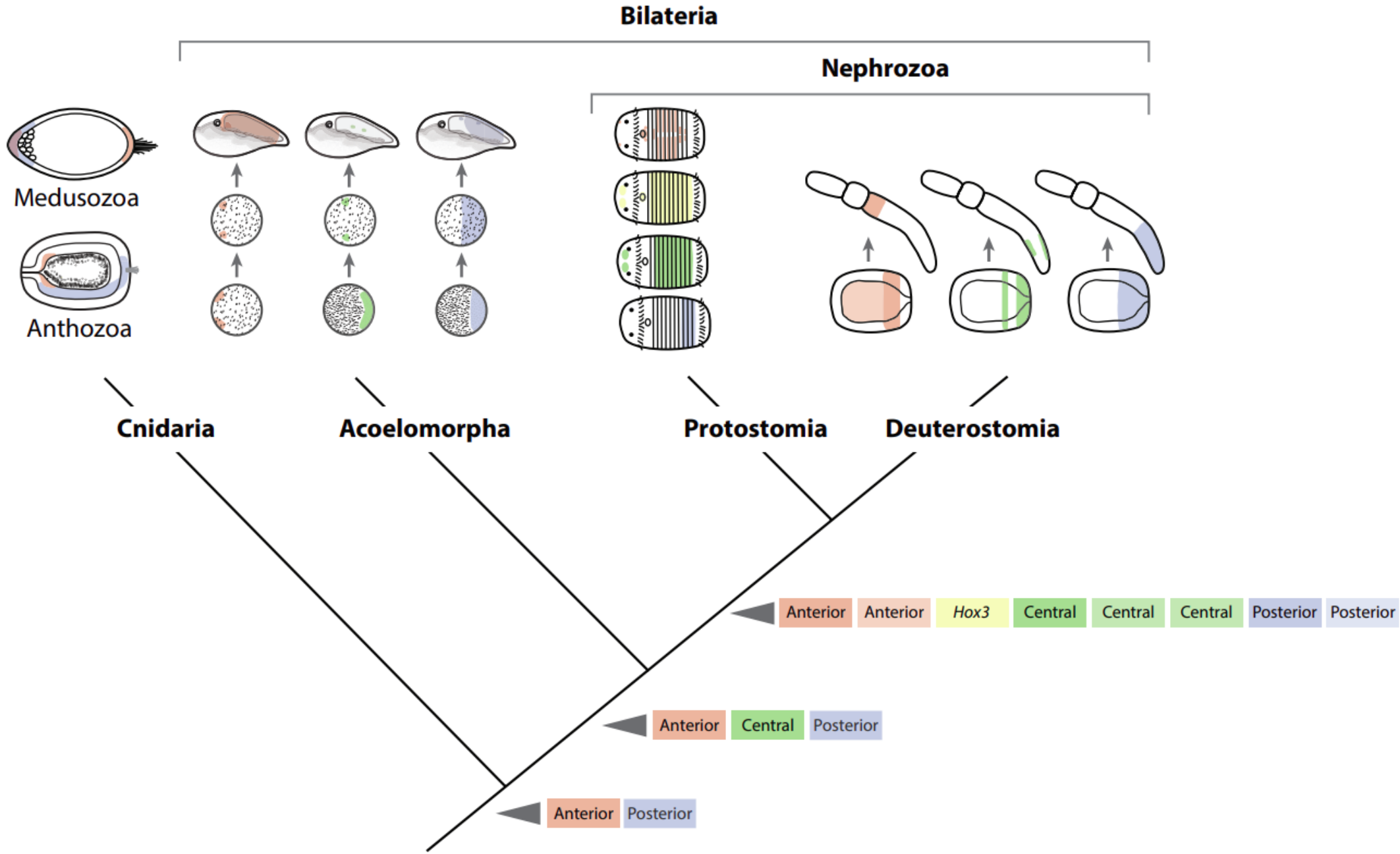
(e) Mollusk
(octopus)



(f) Vertebrate
(human)

Bilateria (ou Tripoblastica)

- Três classes de genes Hox: **anterior, central, posterior**;
- Principal sinapomorfia de Bilateria: **mesoderme**;
- A mesoderme é associada à formação do **celoma** (**esquizocelia e enterocelia**);
- Acelomados, pseudocelomados e celomados;


Bilateria
Nephrozoa
Medusozoa
Anthozoa
Cnidaria
Acoelomorpha
Protostomia
Deuterostomia
Anterior
Anterior
Hox3
Central
Central
Central
Posterior
Posterior
Anterior
Central
Posterior
Anterior
Posterior

Vantagens da simetria bilateral

- Obtenção de alimento;
- Cefalização e desenvolvimento de estruturas sensoriais concentradas na cabeça;
- Adaptação a novos tipos de ambiente;
- Surgimento de novas estruturas;
- Mudanças e avanços na excreção, circulação, respiração, sistema digestório, cavidades corporais e reprodução.

Primeiro bilatério?

The Late Precambrian fossil *Kimberella* is a mollusc-like bilaterian organism

Mikhail A. Fedonkin* & Benjamin M. Waggoner†

* *Paleontological Institute, Russian Academy of Sciences, ul. Profsoyuznaya 123, Moscow 117647, Russia*
† *Department of Integrative Biology, University of California, Berkeley, California 94720, USA*

Kimberella

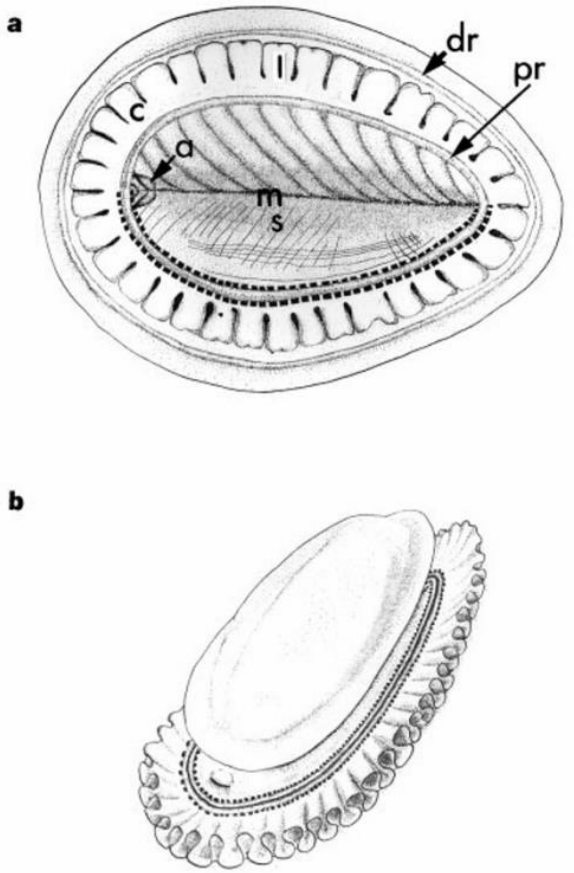
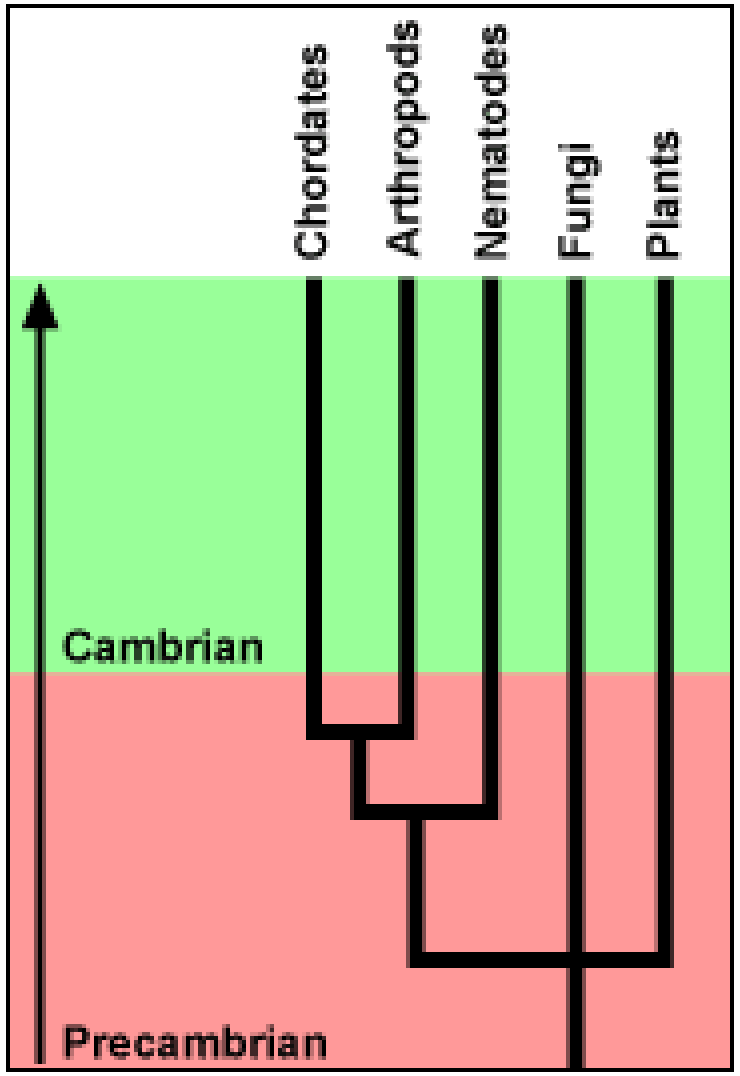


Figure 2 Reconstructions of *Kimberella*. **a**, Dorsal view. c, Crenellated zone; l, lobe; s, striae; dr, distal ridge; pr, proximal ridge; m, medial depression; a, anterior knoll. **b**, View of living organism, with folds of 'crenellated zone' extended beyond margin of shell; the folds would usually have been retracted under the shell at the time of burial.

Explosão Cambriana

- Evento evolutivo de grande magnitude que se manifestou em muitos aspectos, por exemplo, explosão de planos corporais de animais, aumento do tamanho do corpo, aquisição de esqueletos biomineralizados, modificação do substrato, aumento da complexidade do ecossistema, perturbações ambientais e assim por diante.



Wang et al. (1999)

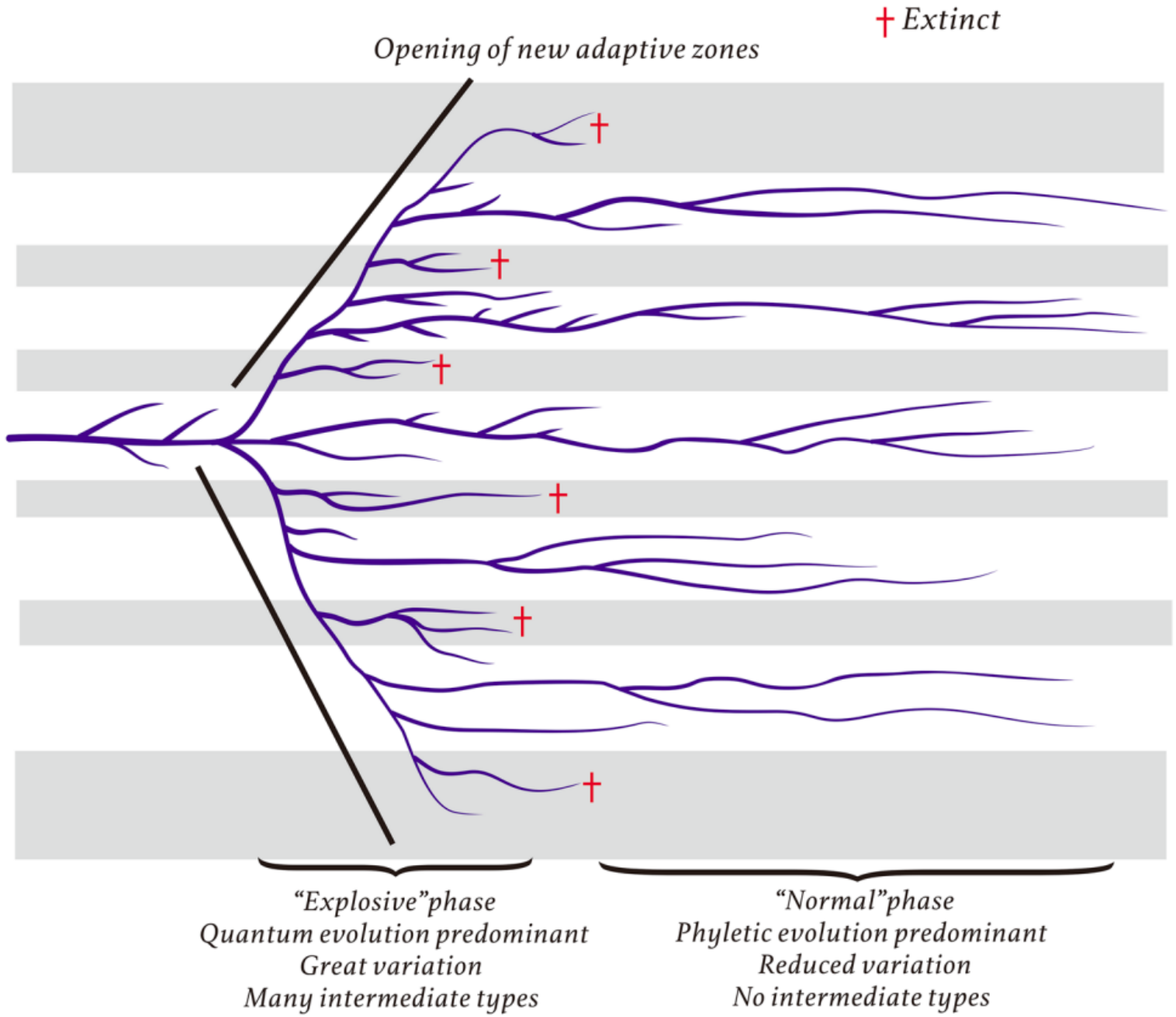


Diagram reminiscent of eruptive evolution of Cambrian faunas proposed in Cloud (1948). Redrawn after Simpson (1944: fig. 35)

https://doi.org/10.1007/s12542-021-00568-5

Explosão Cambriana

Filo x Bauplan

Salvador Vitanza, Ph.D.

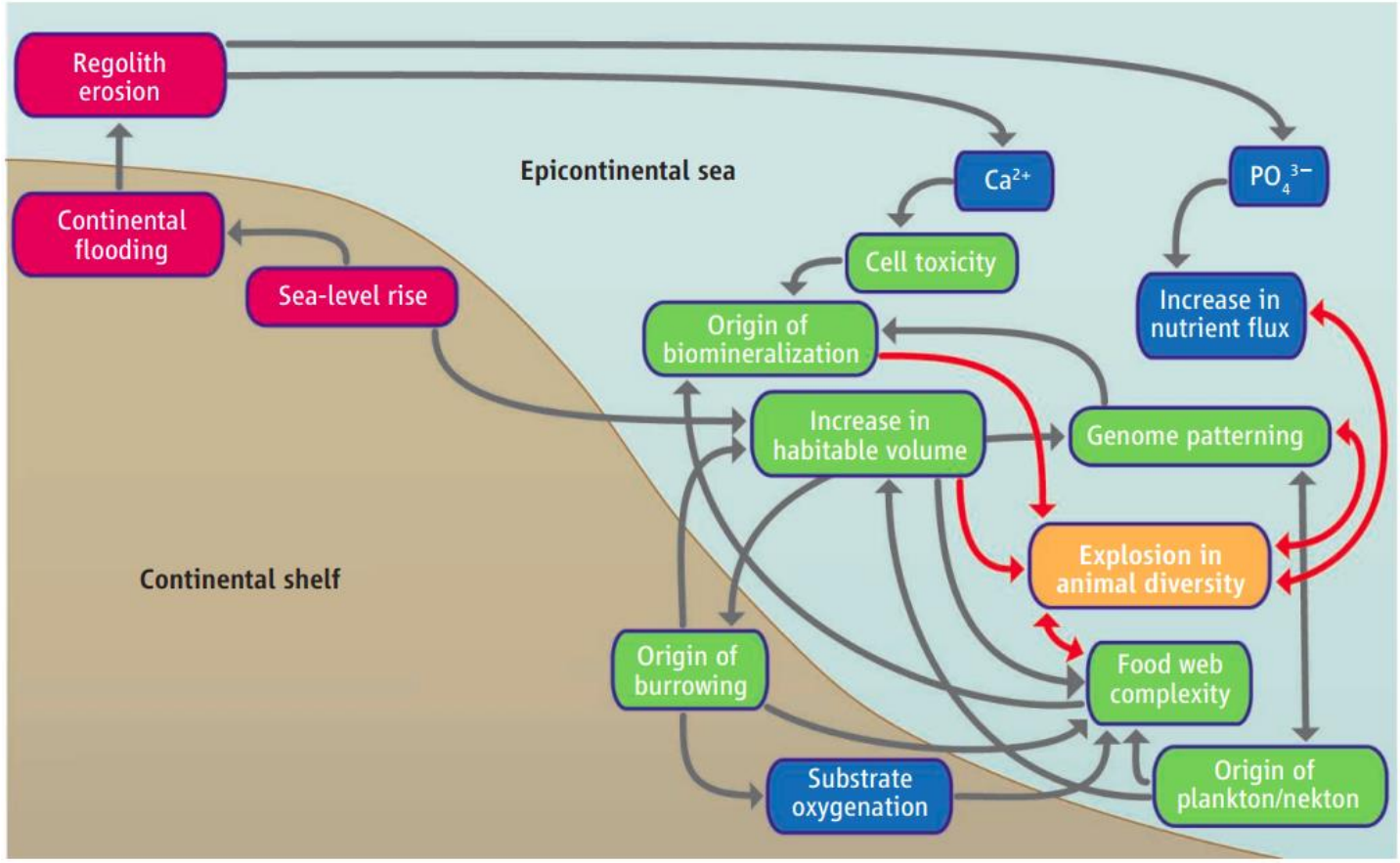
Explosão Cambriana

Filo x Bauplan

Explosão Cambriana

Causas

- Bilateralidade;
- Hábitos escavadores;
- Biomineralização;
- Extensas erosões: cálcio e fosfato para os oceanos;
- Fatores genéticos



https://www.science.org/doi/10.1126/science.1239450

Explosão Cambriana

- Desafios para a visão gradualista de Darwin:

- Falta de formas intermediárias e dificuldade de imaginar estados intermediários de caracteres;
- O tempo e modo de evolução durante a explosão Cambriana parece ter sido diferente do que foi inferido para períodos subsequentes;

- Soluções para explicar a explosão Cambriana:

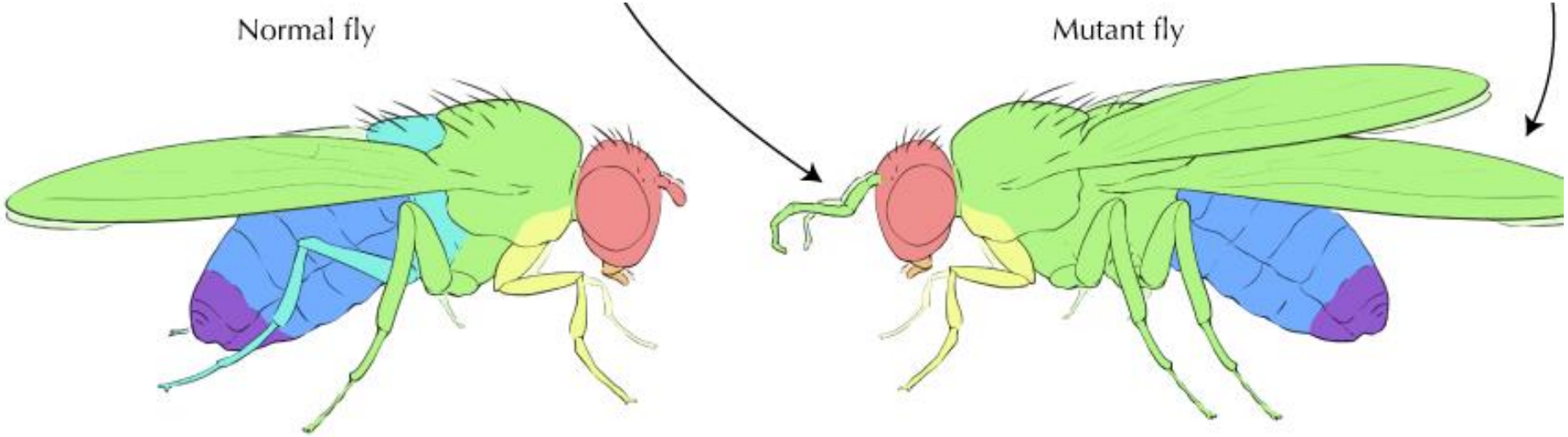
- Saltos aparentes na evolução animal podem ser devidos a um viés na reconstrução da evolução;
- Surgimento de planos corporais distintos foi ocasionado por eventos de **macromutações**.

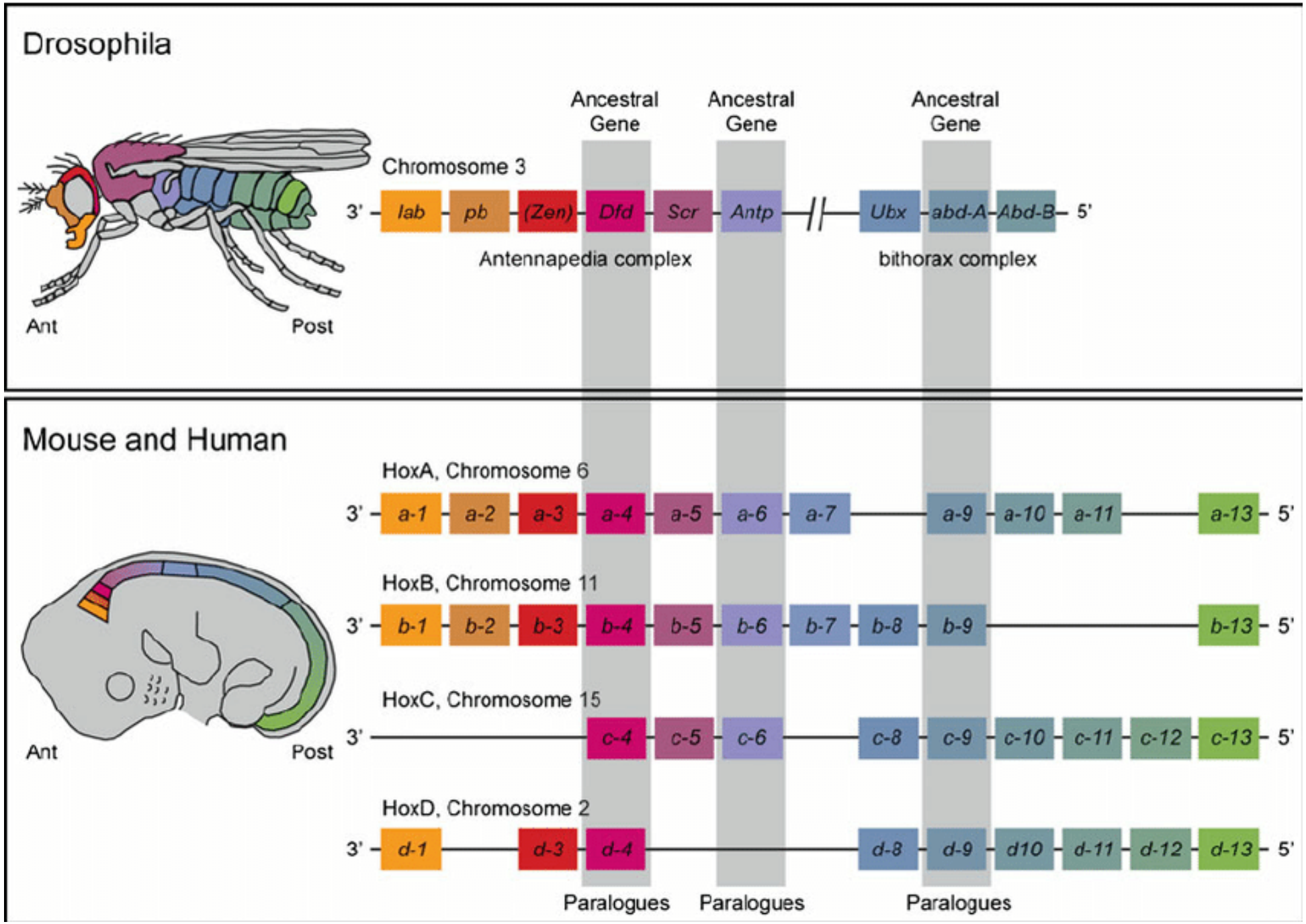
Explosão Cambriana

- Mutações direcionam as mudanças evolutivas:

- **Micromutações:** pequenas modificações sujeitas à seleção natural;
- **Macromutações:** provocam alterações profundas, geram seres vivos muito diferentes de seus genitores

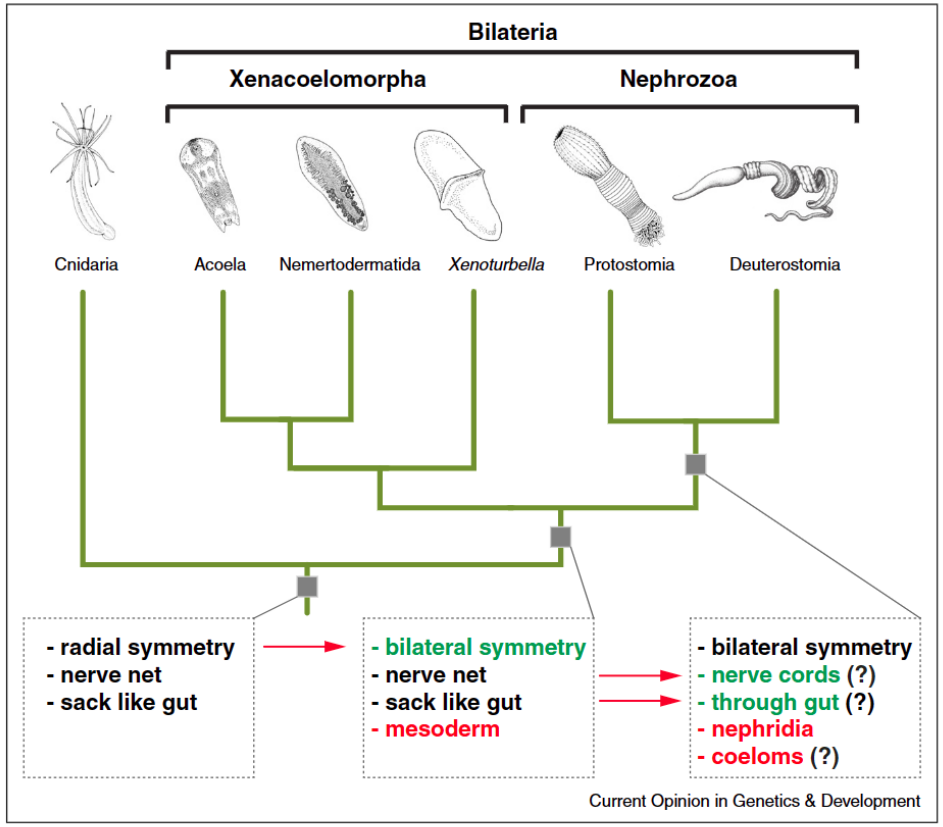
Mutação Homeótica:
Antennapedia e
Ultrabithorax

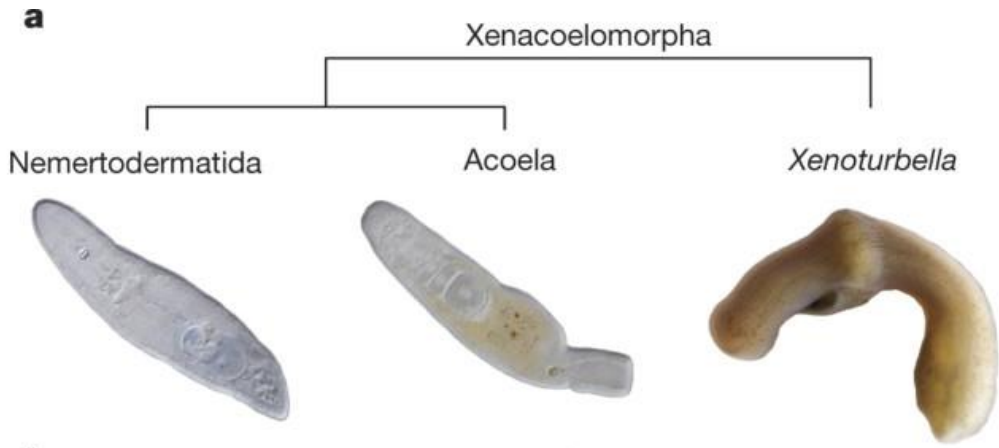



Drosophila
Ancestral Gene
Ancestral Gene
Ancestral Gene
Chromosome 3
3'
lab
pb
(Zen)
Dfd
Scr
Antp
Ubx
abd-A
Abd-B
5'
Antennapedia complex
bithorax complex
Ant
Post
Mouse and Human
HoxA, Chromosome 6
3'
a-1
a-2
a-3
a-4
a-5
a-6
a-7
a-9
a-10
a-11
a-13
5'
HoxB, Chromosome 11
3'
b-1
b-2
b-3
b-4
b-5
b-6
b-7
b-8
b-9
b-13
5'
HoxC, Chromosome 15
3'
c-4
c-5
c-6
c-8
c-9
c-10
c-11
c-12
c-13
5'
HoxD, Chromosome 2
3'
d-1
d-3
d-4
d-8
d-9
d10
d-11
d-12
d-13
5'
Ant
Post
Paralogues
Paralogues
Paralogues

O posicionamento de Xenacoelomorpha

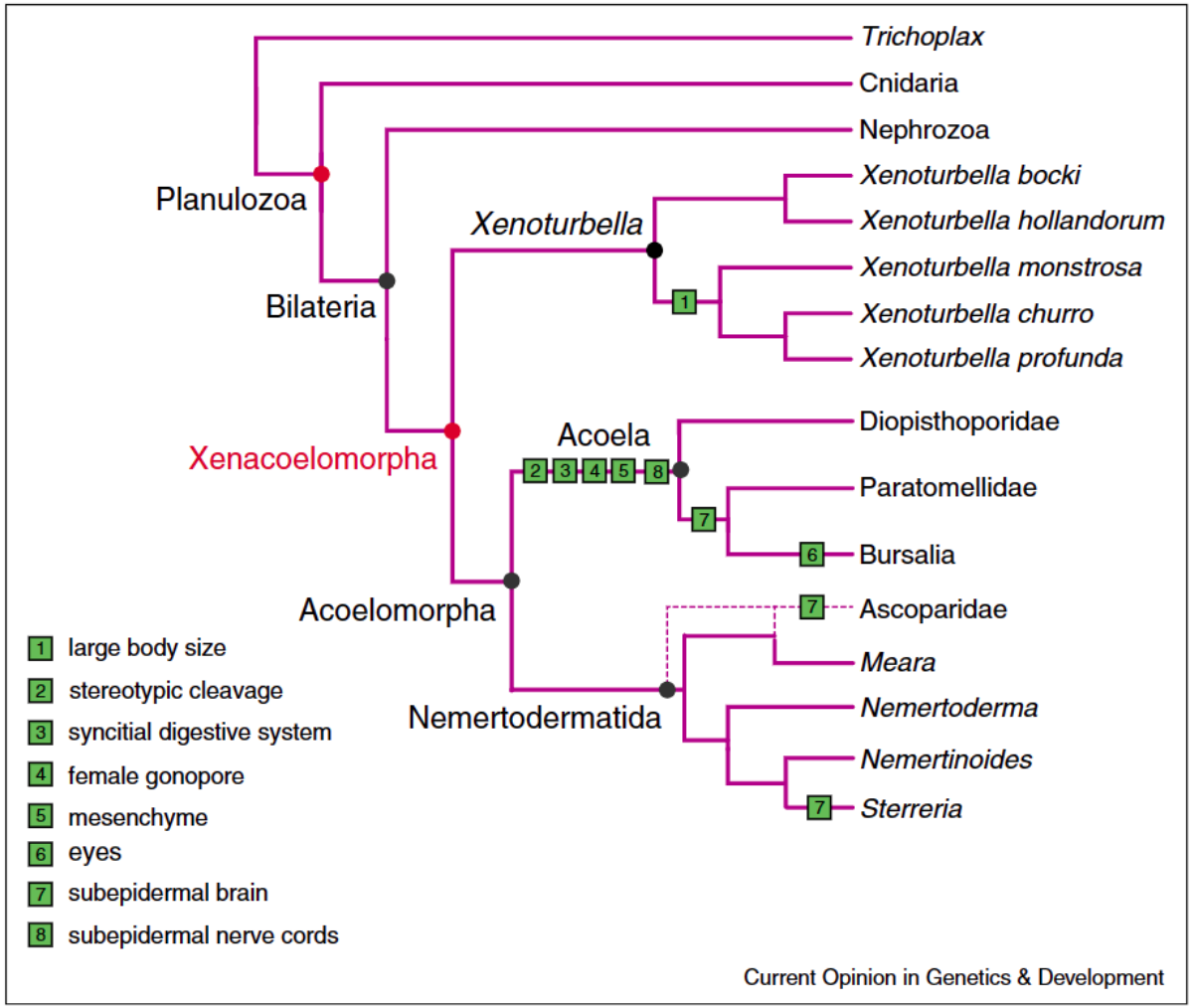
- Organismos acelomados, bilatérios, com sistema nervoso centralizado e sem sistema excretor;





Phylogenetic relationships and the sequence of the evolution of bilaterian characters. Significant organ systems and their major transitions (red arrows) and novelties (red) mapped on the phylogeny.

O posicionamento de Xenacoelomorpha



Character evolution within Xenacoelomorpha. Phylogenetic relationships based on recent molecular phylogenetic studies [4,17••,22,46]. Examples of character evolution inside the clade Xenacoelomorpha (outgroups not labeled).

Nephrozoa

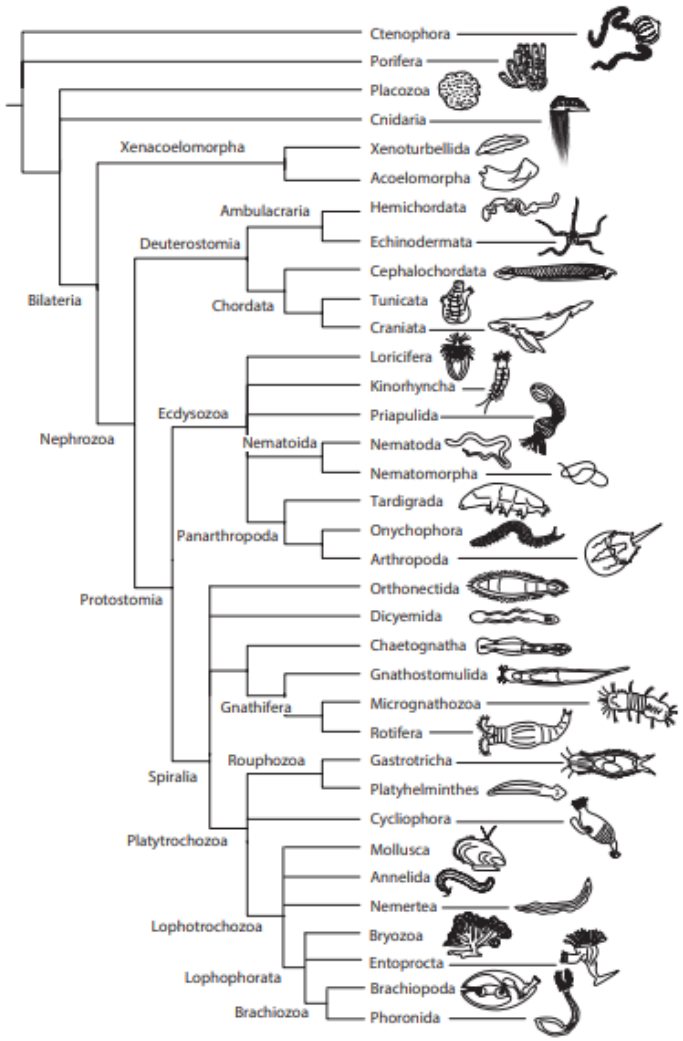
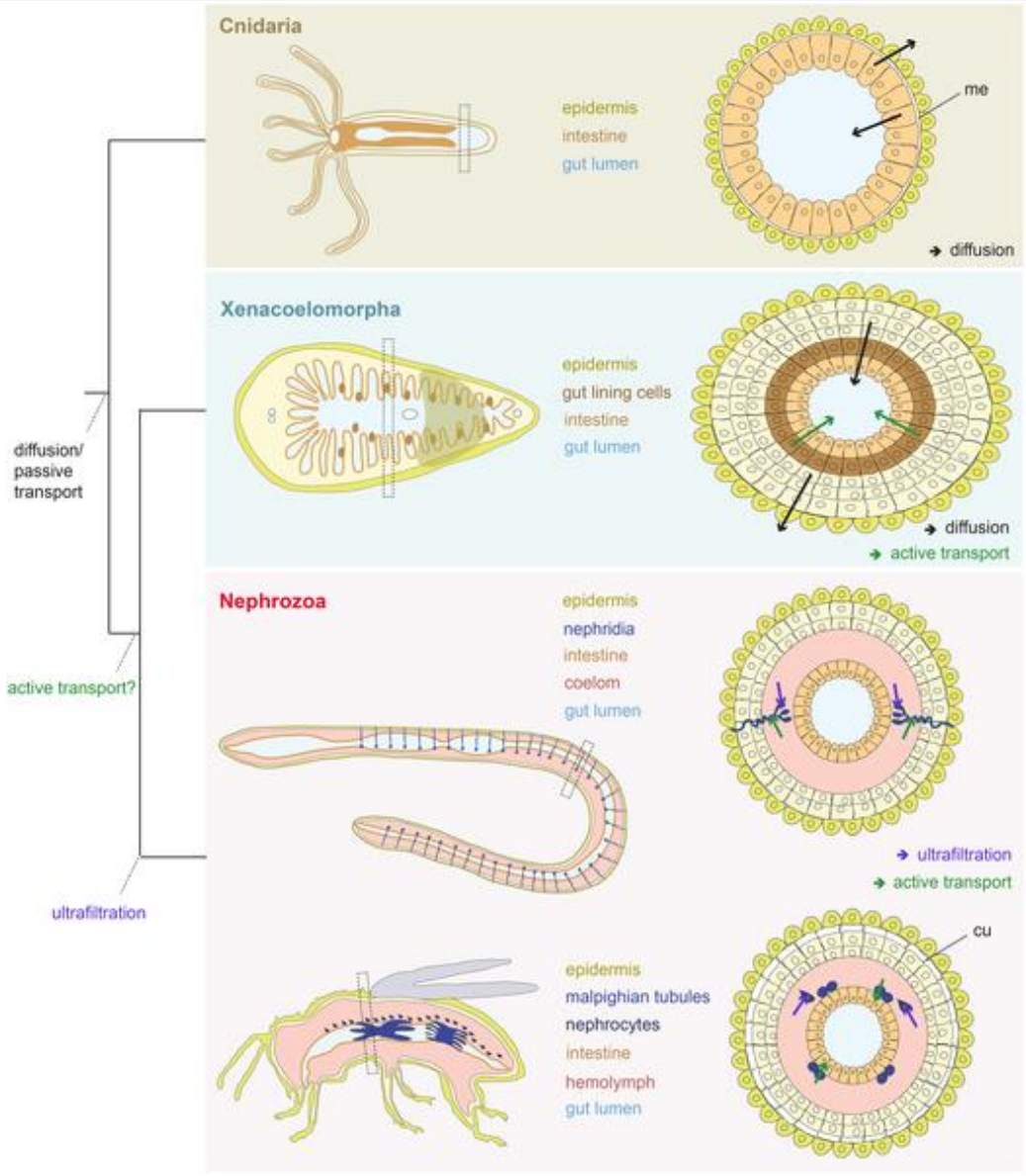


FIGURE 2.2. Preferred animal phylogeny followed in this book with phyla at the tips and major clades indicated at nodes. This tree is derived from a synthesis of works, most of which are discussed in these pages.



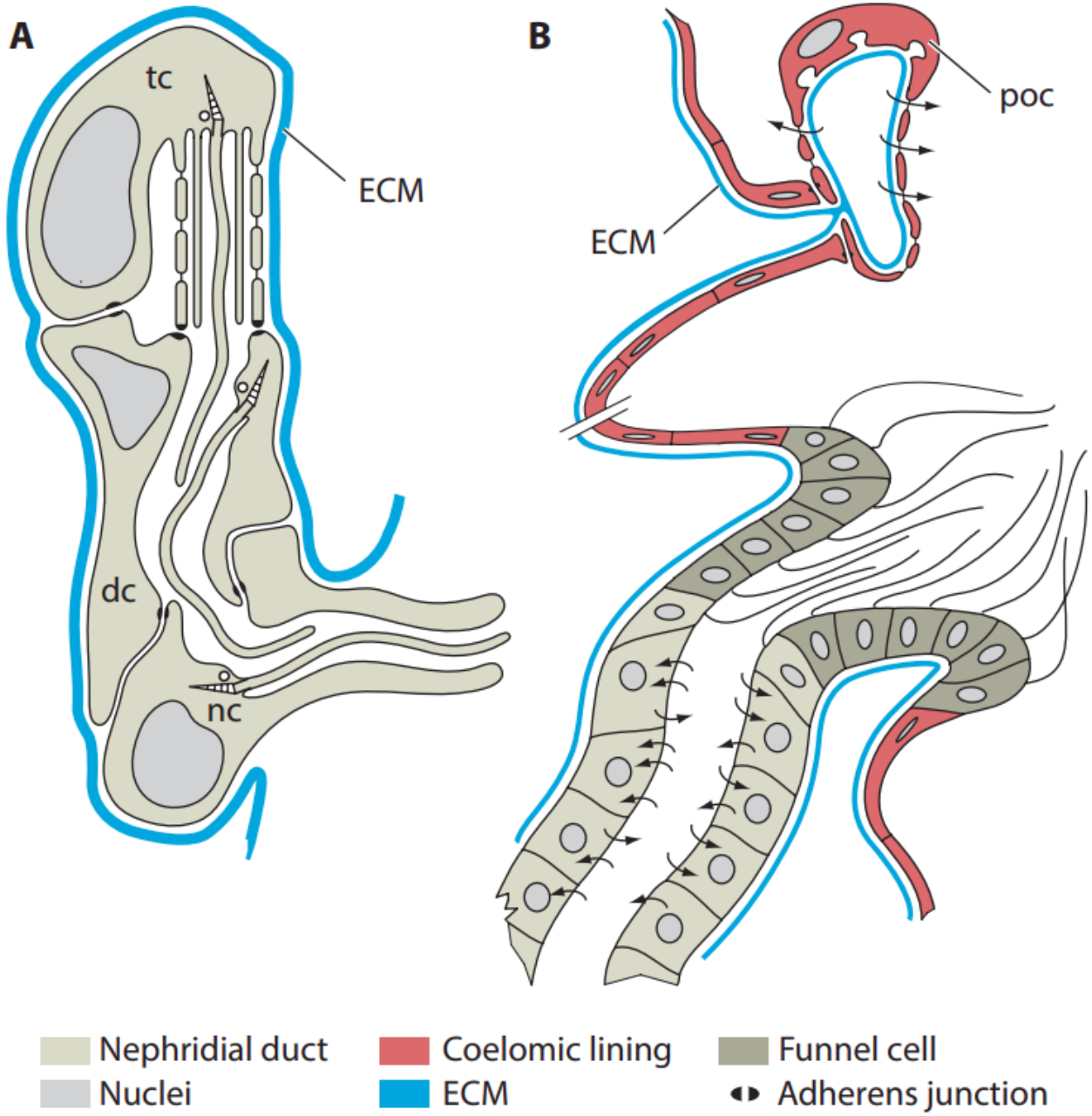
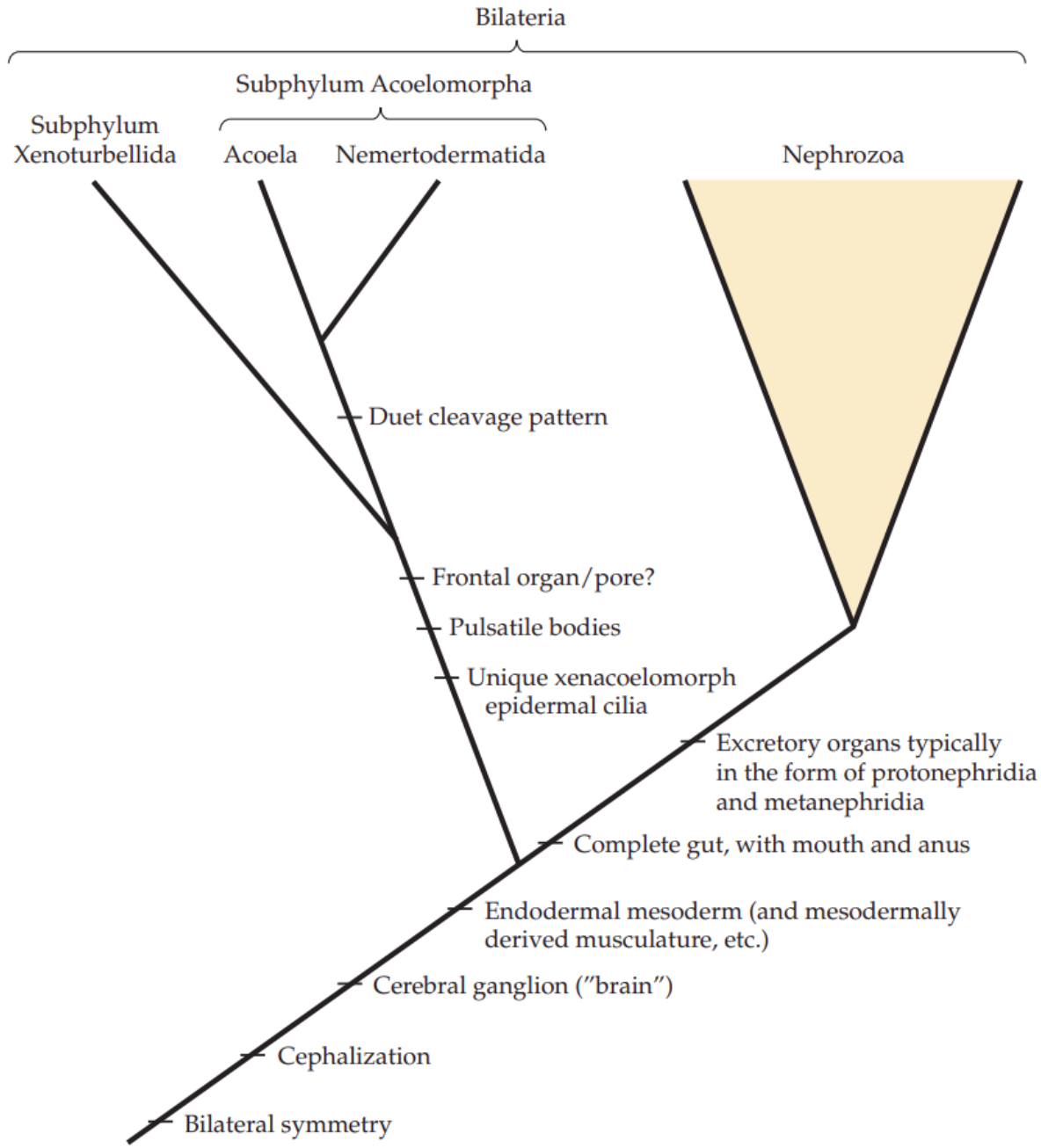


FIGURE 13.1. Schematics of filtration structures: A, protonephridium showing the terminal cell (tc), duct cell (dc) and nephropore cell (nc). The structural integrity of the protonephridium is maintained by adherens junctions connecting adjacent cells; B, metanephridium showing the direction of the ultrafiltrate and the podocytes (poc) resting on the coelomic face of a blood vessel and acting as a supporting structure. ECM = extracellular matrix. Based on Koch et al. (2014).

FIGURE 9.26 The distribution of some important animal features at the base of the bilaterian clade.



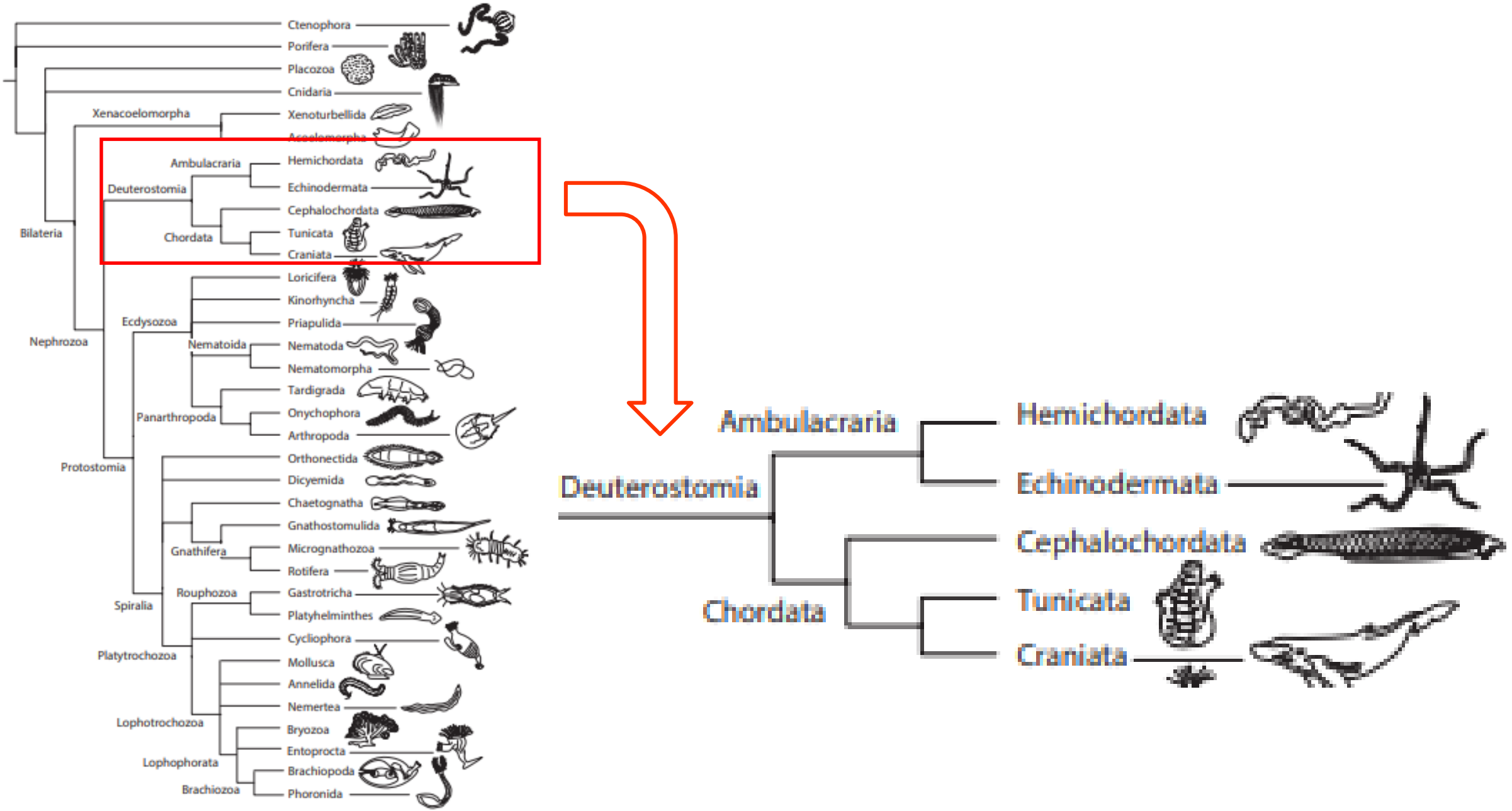
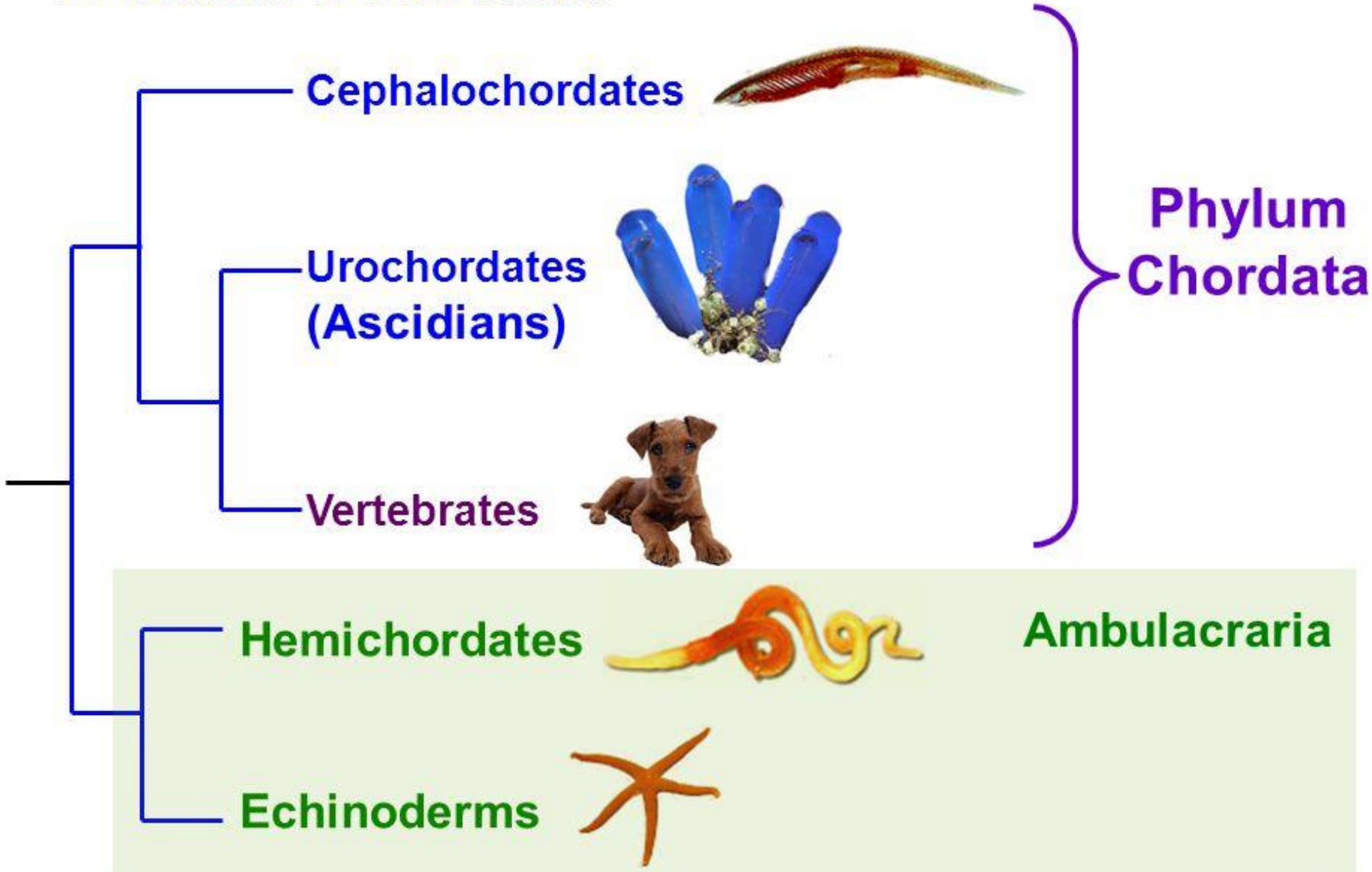
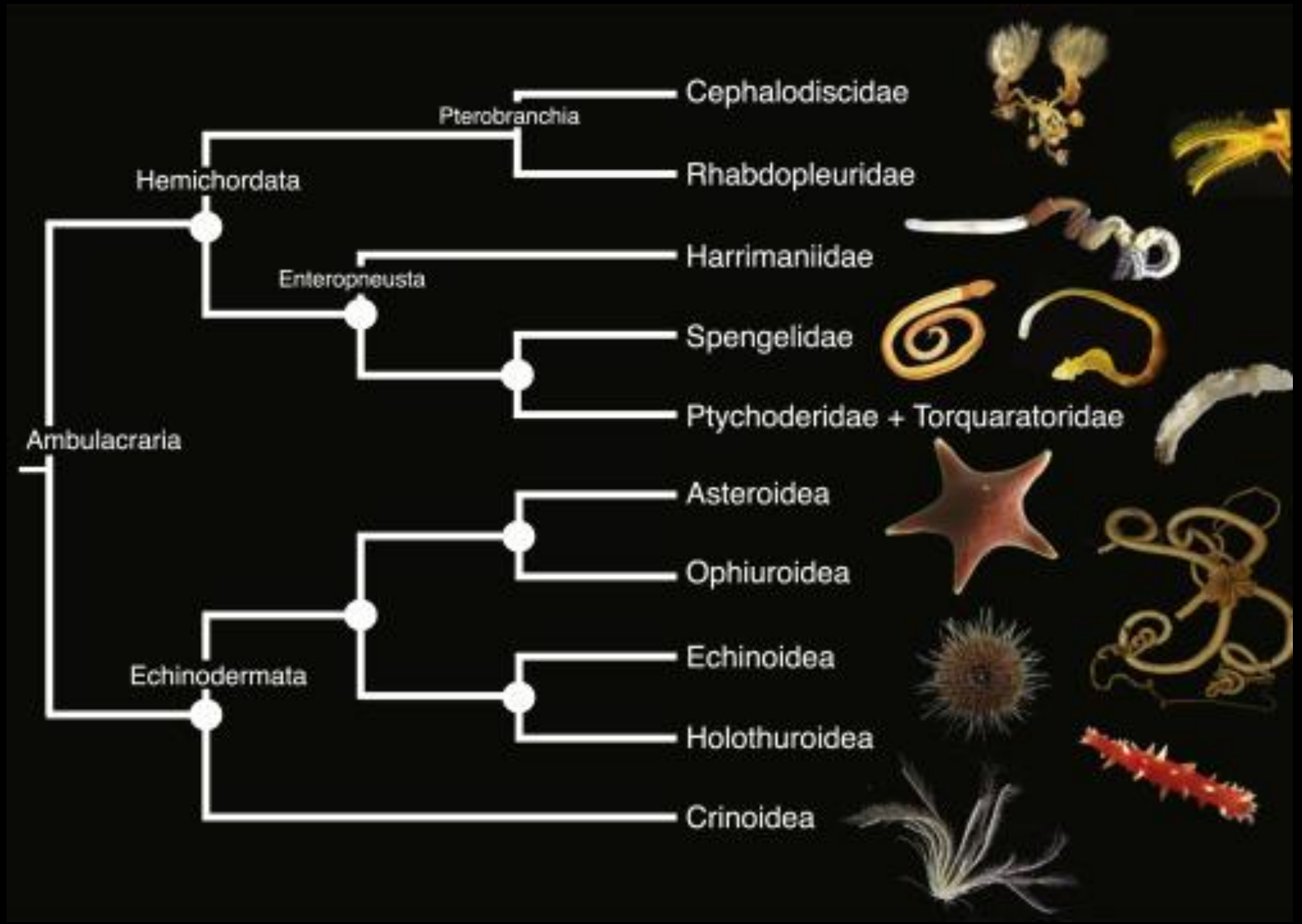
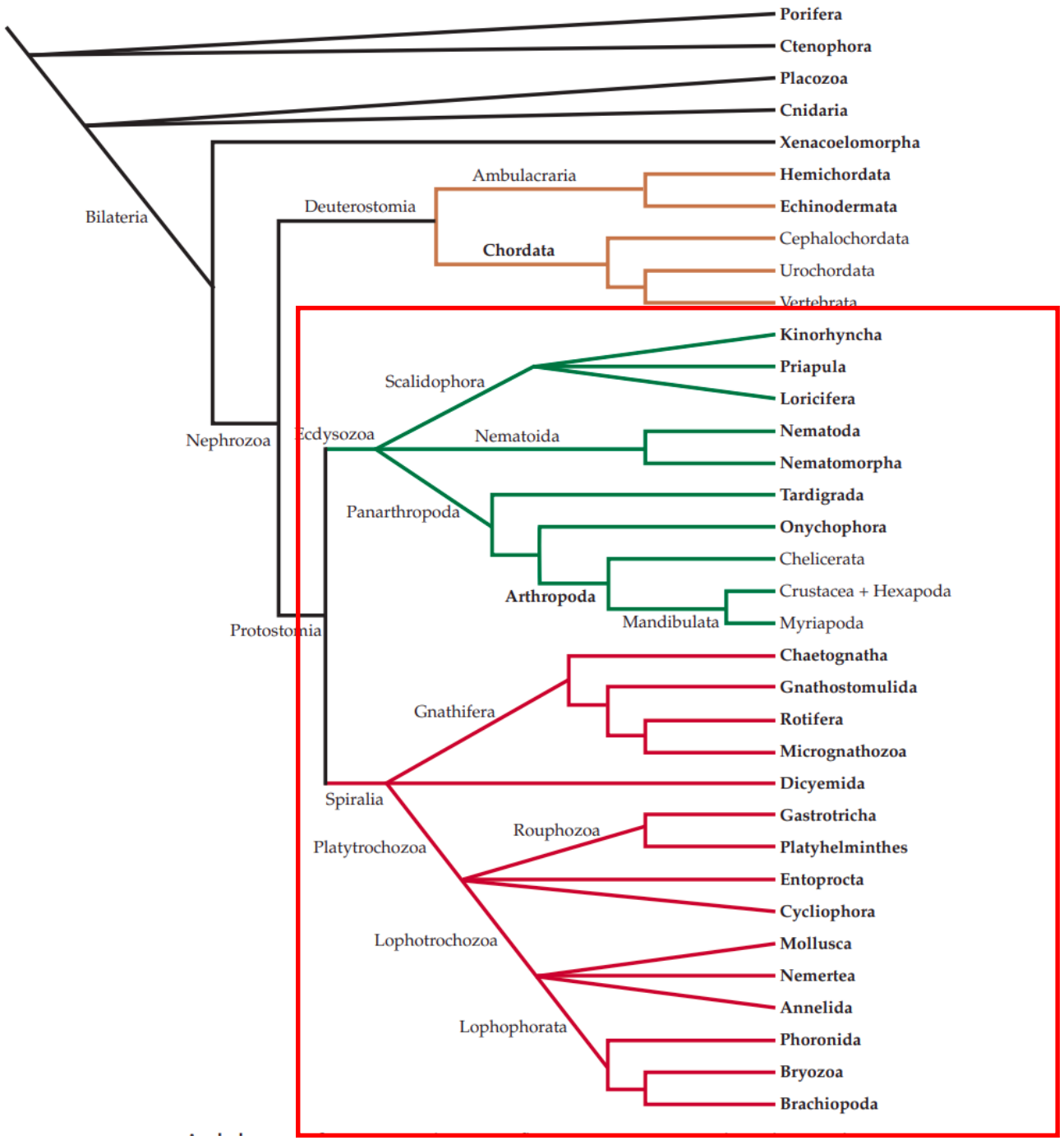


FIGURE 2.2. Preferred animal phylogeny followed in this book with phyla at the tips and major clades indicated at nodes. This tree is derived from a synthesis of works, most of which are discussed in these pages.

Deuterostomia




Cephalodiscidae
Pterobranchia
Rhabdopleuridae
Hemichordata
Harrimaniidae
Enteropneusta
Spengelidae
Ptychoderidae + Torquaratoridae
Ambulacraria
Asteroidea
Ophiuroidea
Echinoidea
Echinodermata
Holothuroidea
Crinoidea


Porifera
Ctenophora
Placozoa
Cnidaria
Xenacoelomorpha
Ambulacraria
Hemichordata
Echinodermata
Deuterostomia
Bilateria
Cephalochordata
Chordata
Urochordata
Vertebrata
Kinorhyncha
Priapula
Scalidophora
Loricifera
Nephrozoa
Ecdysozoa
Nematoida
Nematoda
Nematomorpha
Tardigrada
Panarthropoda
Onychophora
Chelicerata
Arthropoda
Crustacea + Hexapoda
Mandibulata
Myriapoda
Protostomia
Chaetognatha
Gnathostomulida
Gnathifera
Rotifera
Micrognathozoa
Dicyemida
Spiralia
Gastrotricha
Rouphozoa
Platytrochozoa
Platyhelminthes
Entoprocta
Cycliophora
Lophotrochozoa
Mollusca
Nemertea
Annelida
Lophophorata
Phoronida
Bryozoa
Brachiopoda

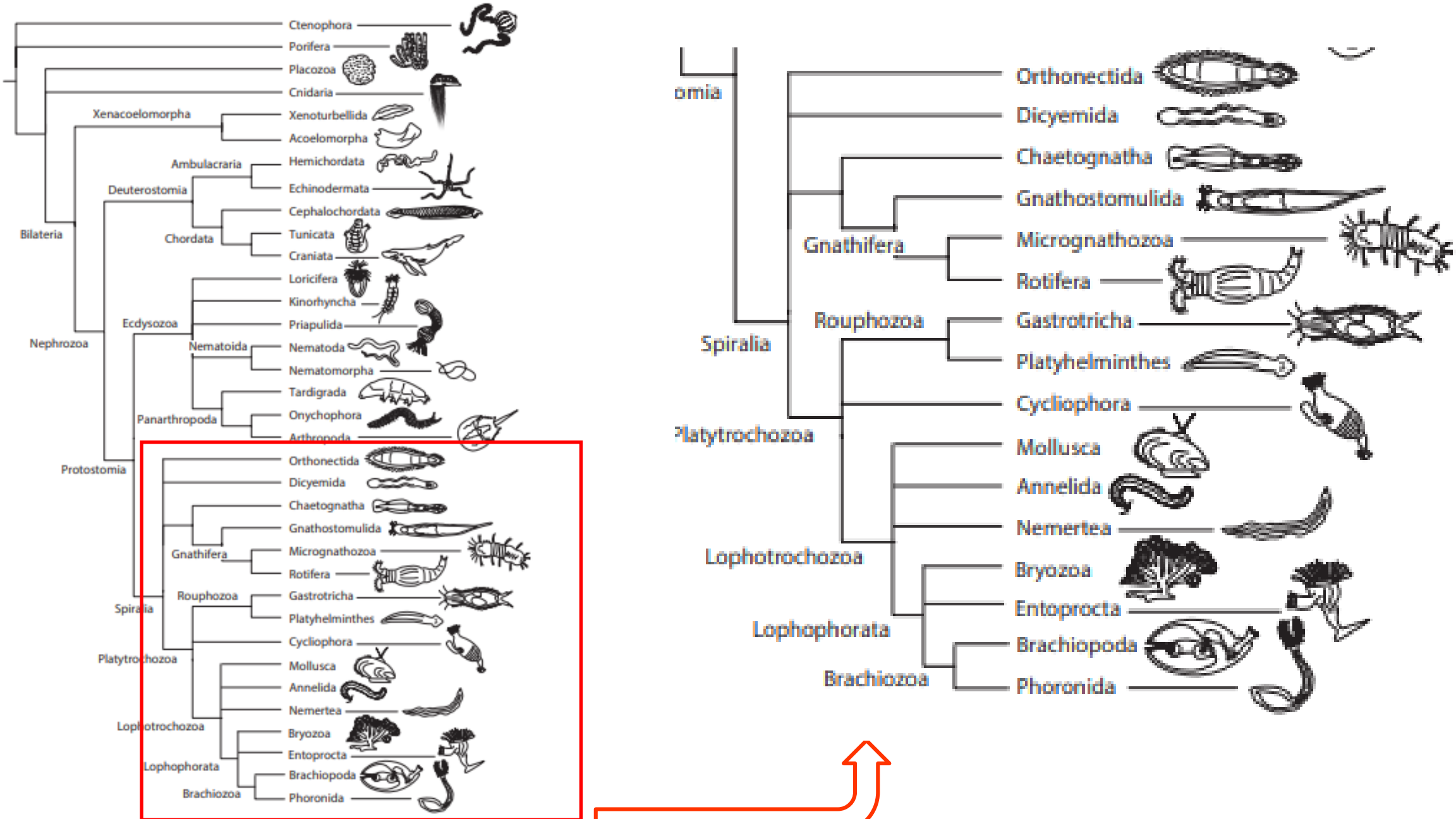


FIGURE 2.2. Preferred animal phylogeny followed in this book with phyla at the tips and major clades indicated at nodes. This tree is derived from a synthesis of works, most of which are discussed in these pages.

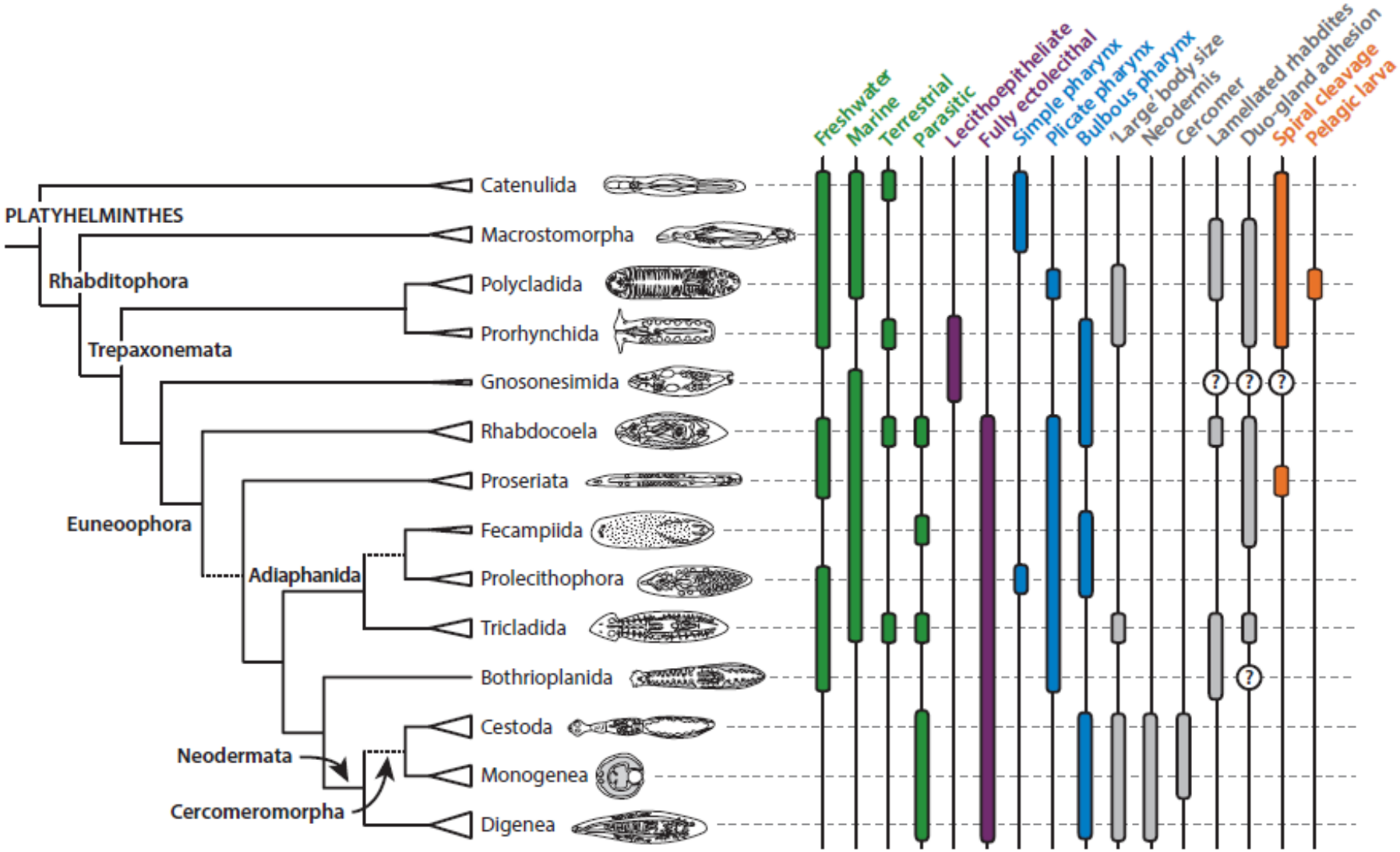
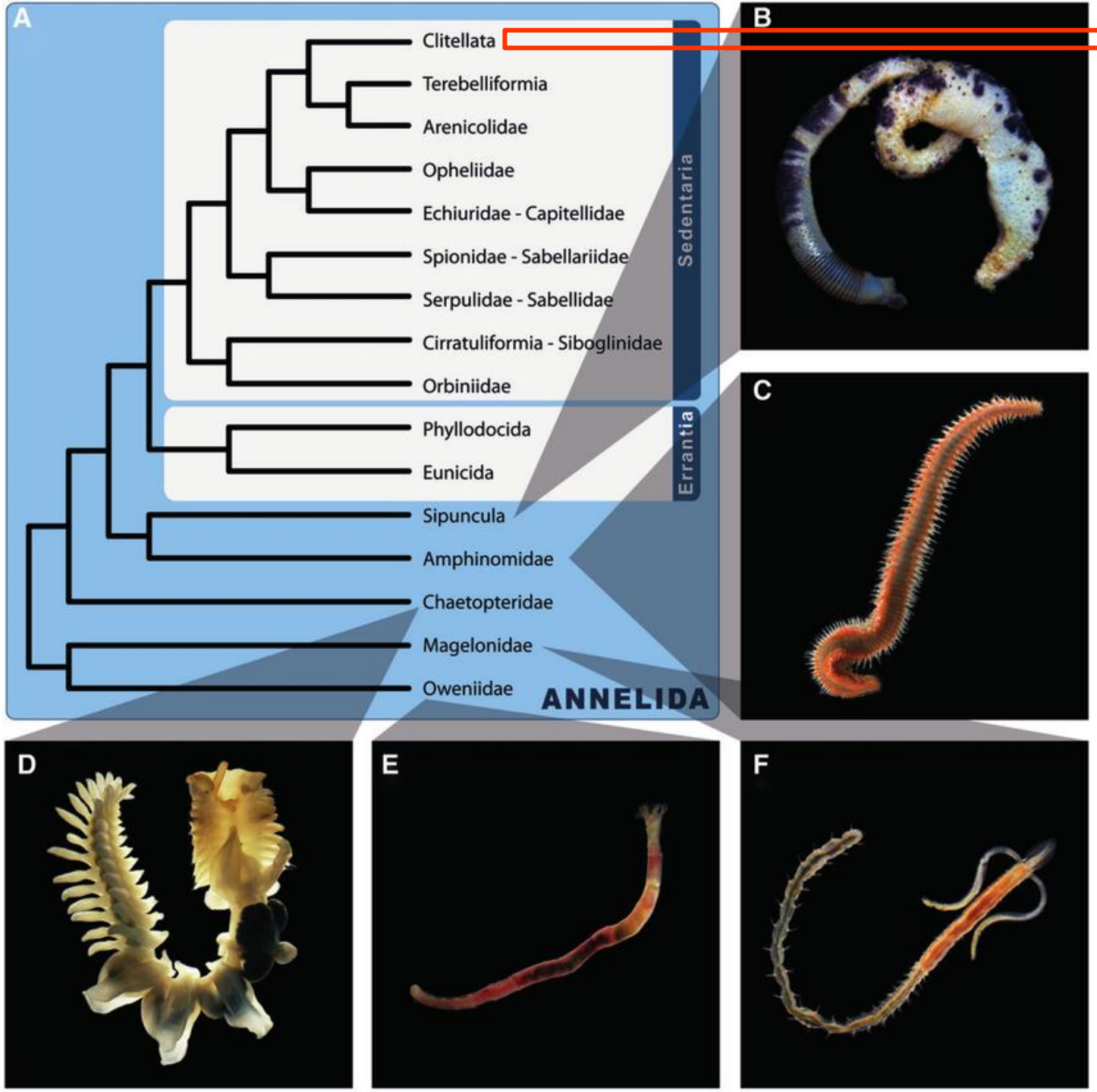
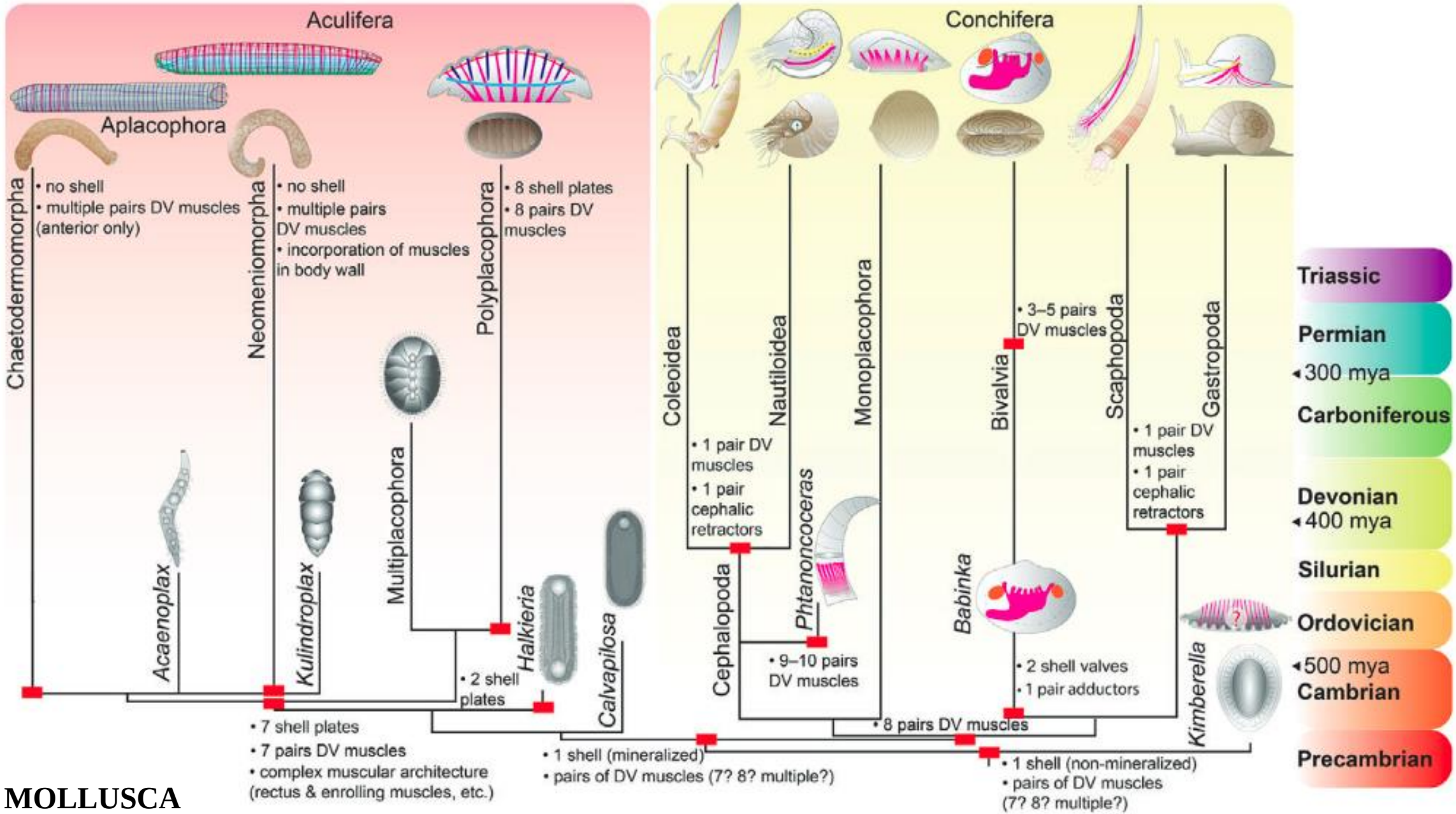
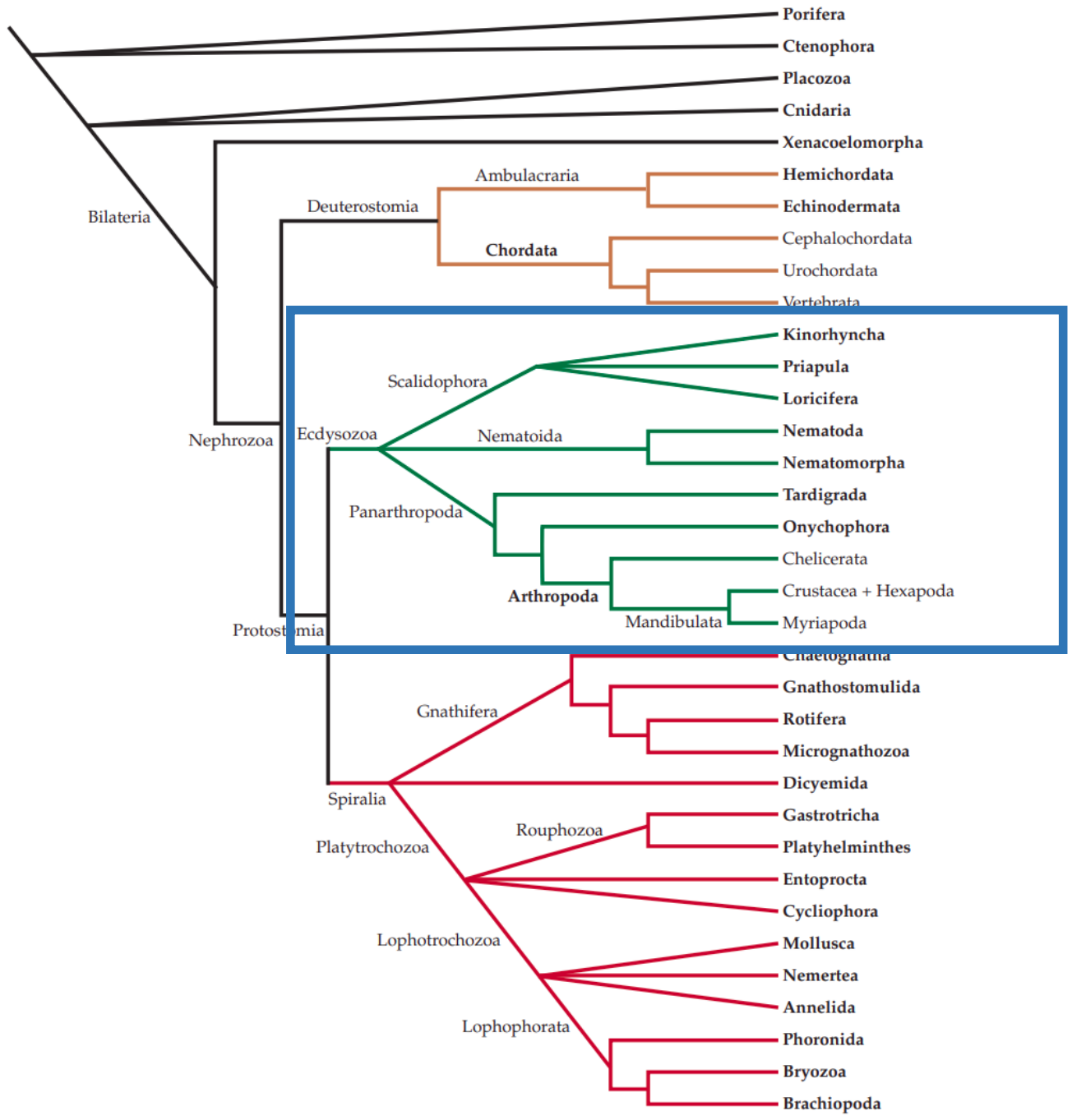


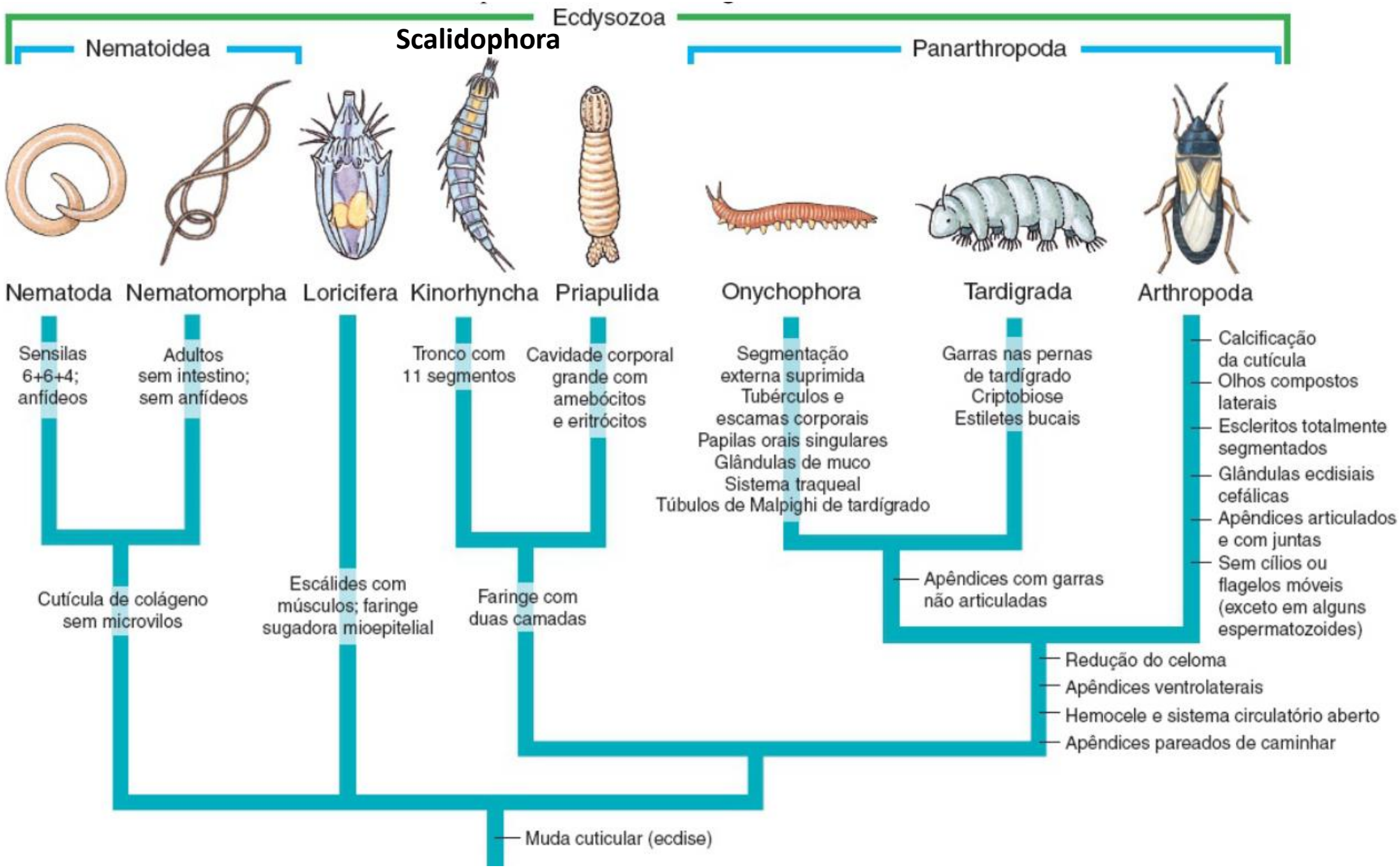
Figure 43.2 . Phylogeny of the major platyhelminth taxa with ecological, anatomical and developmental characteristics mapped on the tree. Based on Laumer et al. (2015b), https://doi.org/10.7554/eLife.05503.010.

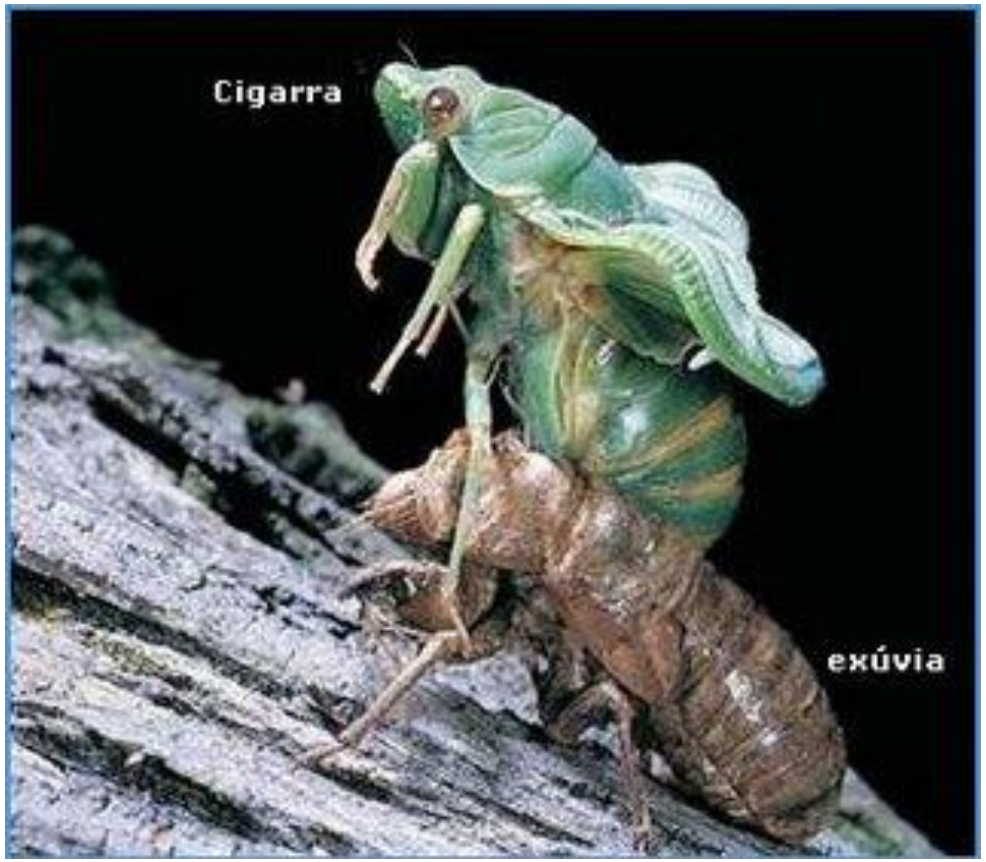

A
Clitellata
Terebelliformia
Arenicolidae
Opheliidae
Echiuridae - Capitellidae
Spionidae - Sabellariidae
Serpulidae - Sabellidae
Cirratuliformia - Siboglinidae
Orbiniidae
Sedentaria
Phyllodocida
Eunicida
Errantia
Sipuncula
Amphinomidae
Chaetopteridae
Magelonidae
Oweniidae
ANNELIDA
B
C
D
E
F

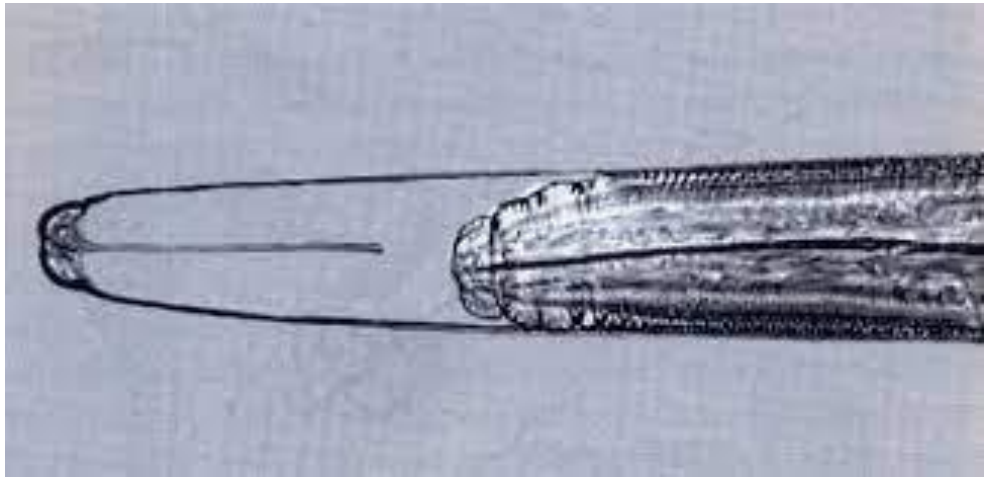

Aculifera
Aplacophora
Chaetodermomorpha
• no shell
• multiple pairs DV muscles (anterior only)
Neomeniomorpha
• no shell
• multiple pairs DV muscles
• incorporation of muscles in body wall
Polyplacophora
• 8 shell plates
• 8 pairs DV muscles
Acaenoplax
Kulindroplax
Multiplacophora
Halkieria
Calvapilosa
• 2 shell plates
• 7 shell plates
• 7 pairs DV muscles
• complex muscular architecture (rectus & enrolling muscles, etc.)
Conchifera
Coleoidea
Nautiloidea
• 1 pair DV muscles
• 1 pair cephalic retractors
Cephalopoda
Phtanoconceras
• 9–10 pairs DV muscles
Monoplacophora
• 8 pairs DV muscles
Bivalvia
• 3–5 pairs DV muscles
Babinka
• 2 shell valves
• 1 pair adductors
Scaphopoda
Gastropoda
• 1 pair DV muscles
• 1 pair cephalic retractors
Kimberella
• 1 shell (mineralized)
• pairs of DV muscles (7? 8? multiple?)
• 1 shell (non-mineralized)
• pairs of DV muscles (7? 8? multiple?)
Triassic
Permian
300 mya
Carboniferous
Devonian
400 mya
Silurian
Ordovician
500 mya
Cambrian
Precambrian

MOLLUSCA


Porifera
Ctenophora
Placozoa
Cnidaria
Xenacoelomorpha
Ambulacraria
Hemichordata
Echinodermata
Deuterostomia
Bilateria
Chordata
Cephalochordata
Urochordata
Vertebrata
Kinorhyncha
Priapula
Loricifera
Scalidophora
Nephrozoa
Ecdysozoa
Nematoida
Nematoda
Nematomorpha
Panarthropoda
Tardigrada
Onychophora
Chelicerata
Arthropoda
Crustacea + Hexapoda
Mandibulata
Myriapoda
Protostomia
Chaetognatha
Gnathostomulida
Gnathifera
Rotifera
Micrognathozoa
Dicyemida
Spiralia
Gastrotricha
Rouphozoa
Platytrochozoa
Platyhelminthes
Entoprocta
Cycliophora
Lophotrochozoa
Mollusca
Nemertea
Annelida
Lophophorata
Phoronida
Bryozoa
Brachiopoda

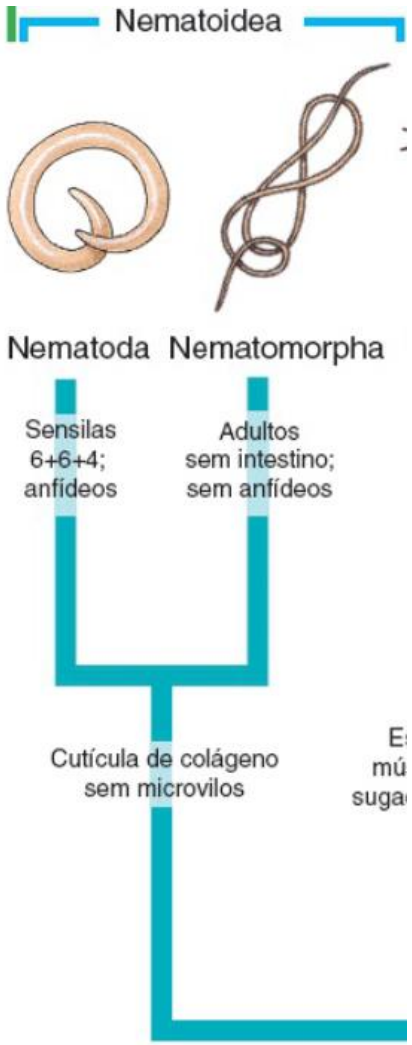

Ecdysozoa
Scalidophora
Nematoidea
Panarthropoda
Nematoda
Nematomorpha
Loricifera
Kinorhyncha
Priapulida
Onychophora
Tardigrada
Arthropoda
Sensilas 6+6+4; anfídeos
Adultos sem intestino; sem anfídeos
Tronco com 11 segmentos
Cavidade corporal grande com amebócitos e eritrócitos
Segmentação externa suprimida
Tubérculos e escamas corporais
Papilas orais singulares
Glândulas de muco
Sistema traqueal
Túbulos de Malpighi de tardígrado
Garras nas pernas de tardígrado
Criptobiose
Estiletes bucais
Calcificação da cutícula
Olhos compostos laterais
Escleritos totalmente segmentados
Glândulas ecdisiais cefálicas
Apêndices articulados e com juntas
Sem cílios ou flagelos móveis (exceto em alguns espermatozoides)
Cutícula de colágeno sem microvilos
Escálides com músculos; faringe sugadora mioepitelial
Faringe com duas camadas
Apêndices com garras não articuladas
Redução do celoma
Apêndices ventrolaterais
Hemocele e sistema circulatório aberto
Apêndices pareados de caminhar
Muda cuticular (ecdise)

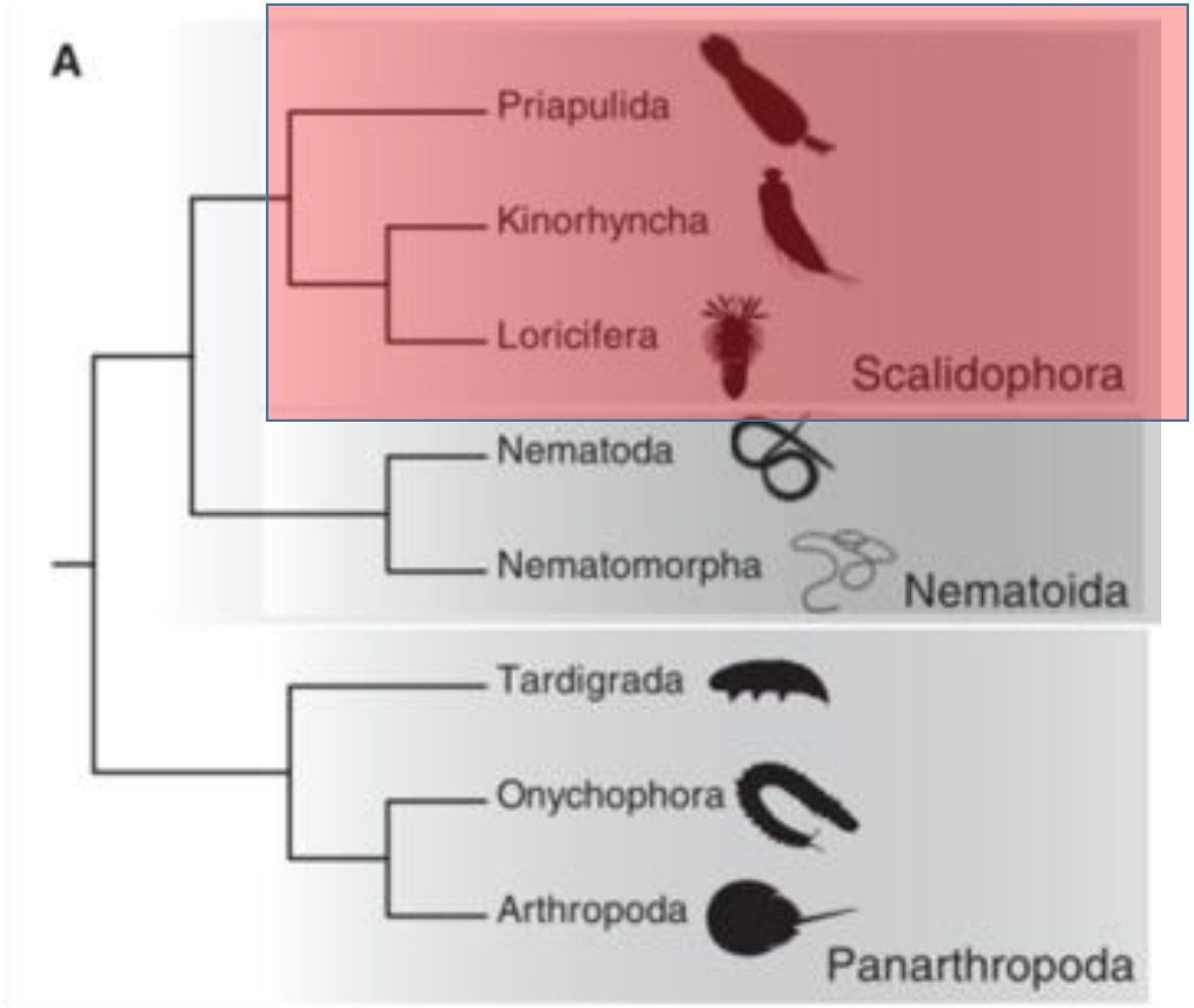

Cigarra
exúvia



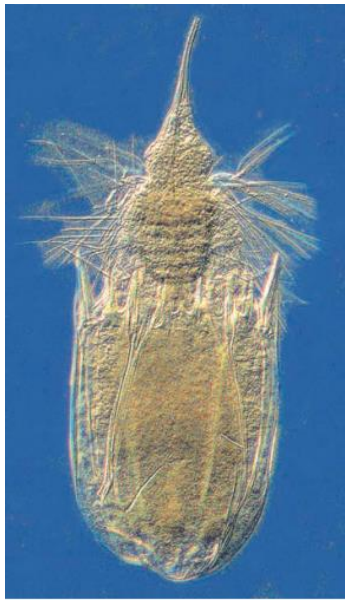

4GIFs.com

Clado Nematoida ou Nematoidea





Giribet & Edgecombe (2017)



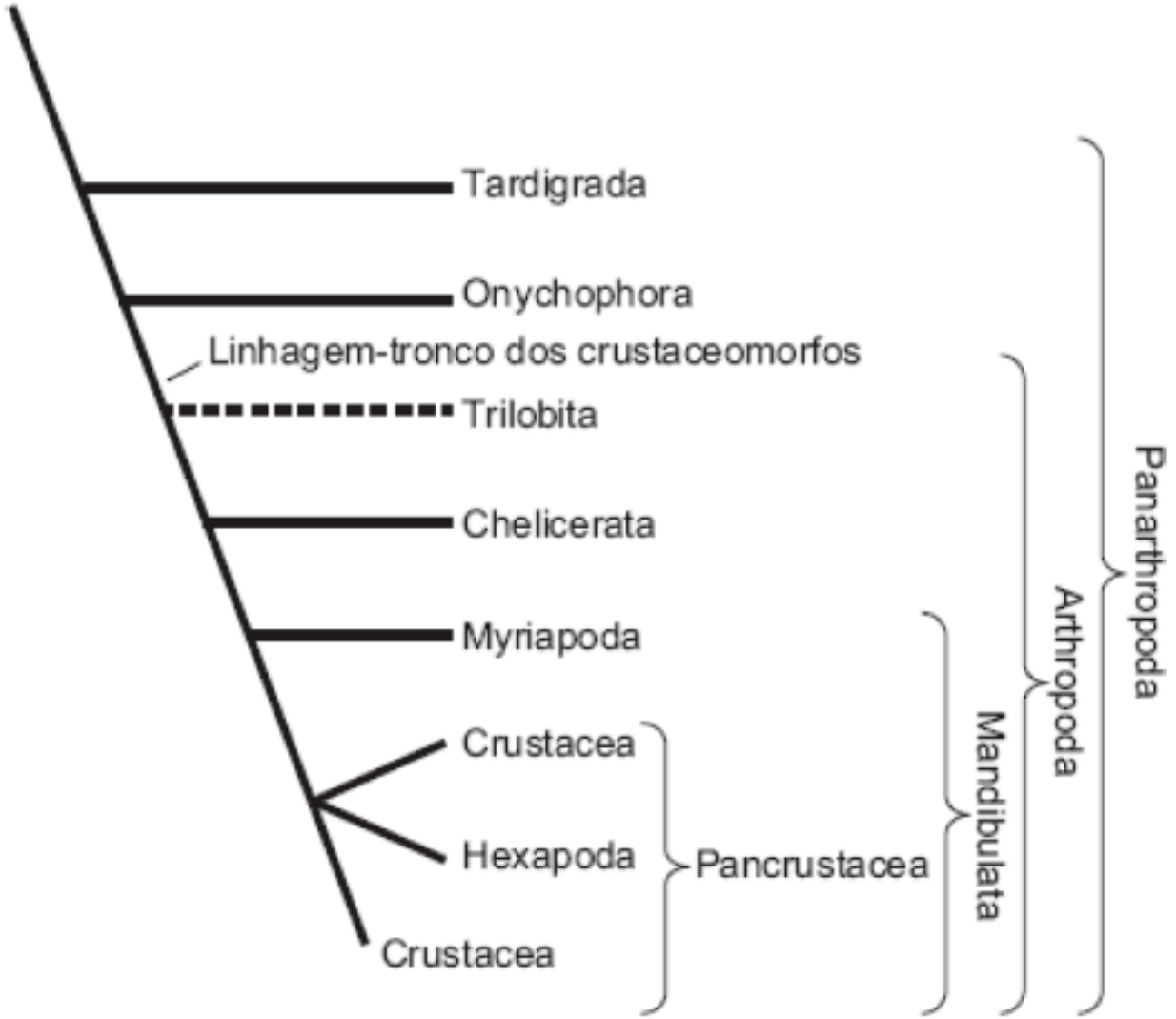


Figura 20.38 Filogenia dos Panarthropoda. Com base em uma síntese dos estudos paleontológicos e filogenéticos, os artrópodes parecem ter suas raízes em uma linhagem ancestral semelhante aos crustáceos, a partir da qual surgiram os subfilos que existem hoje em dia. O subfilo Crustacea é parafilético (a menos que os hexápodes estejam incluídos). A posição dos trilobitas é incerta. Ver detalhes no texto.