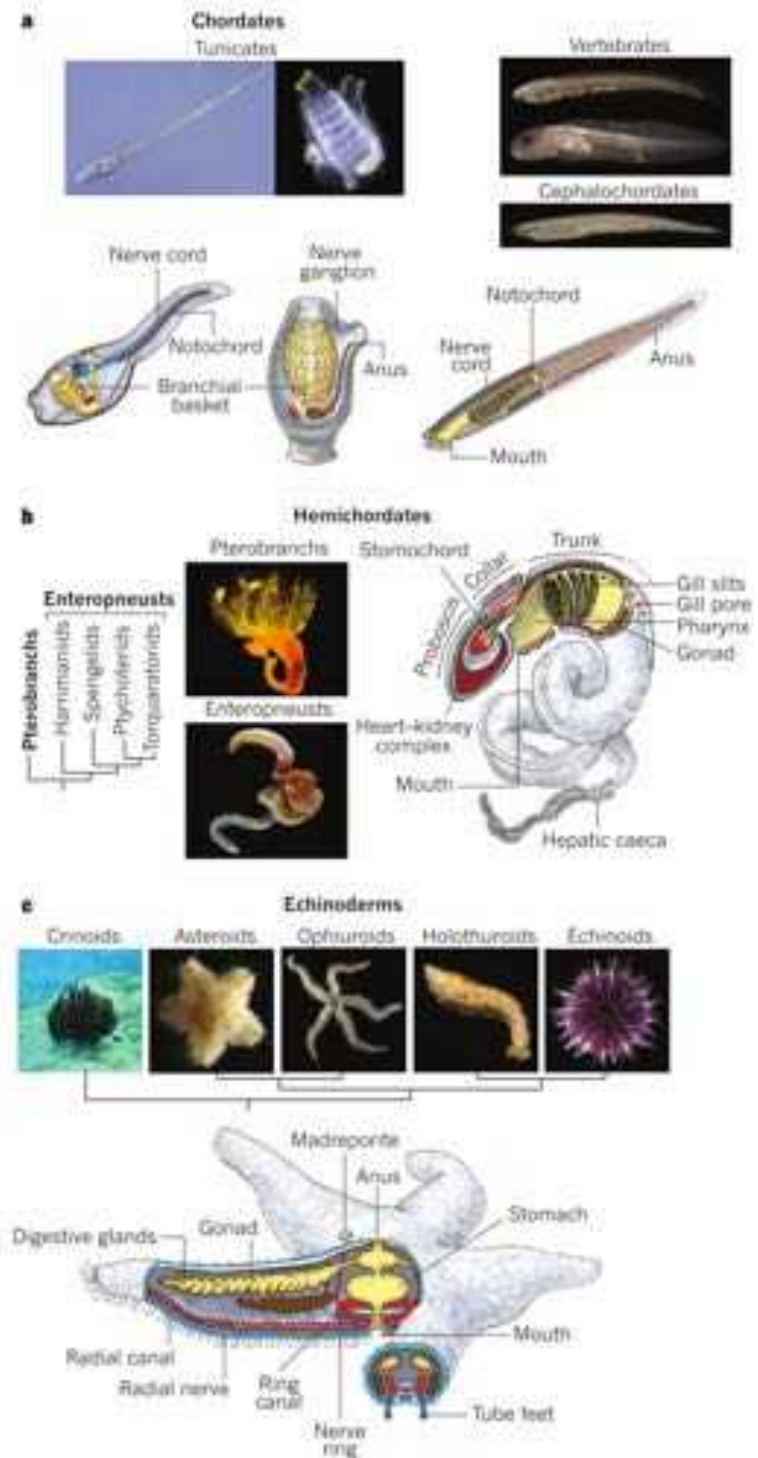


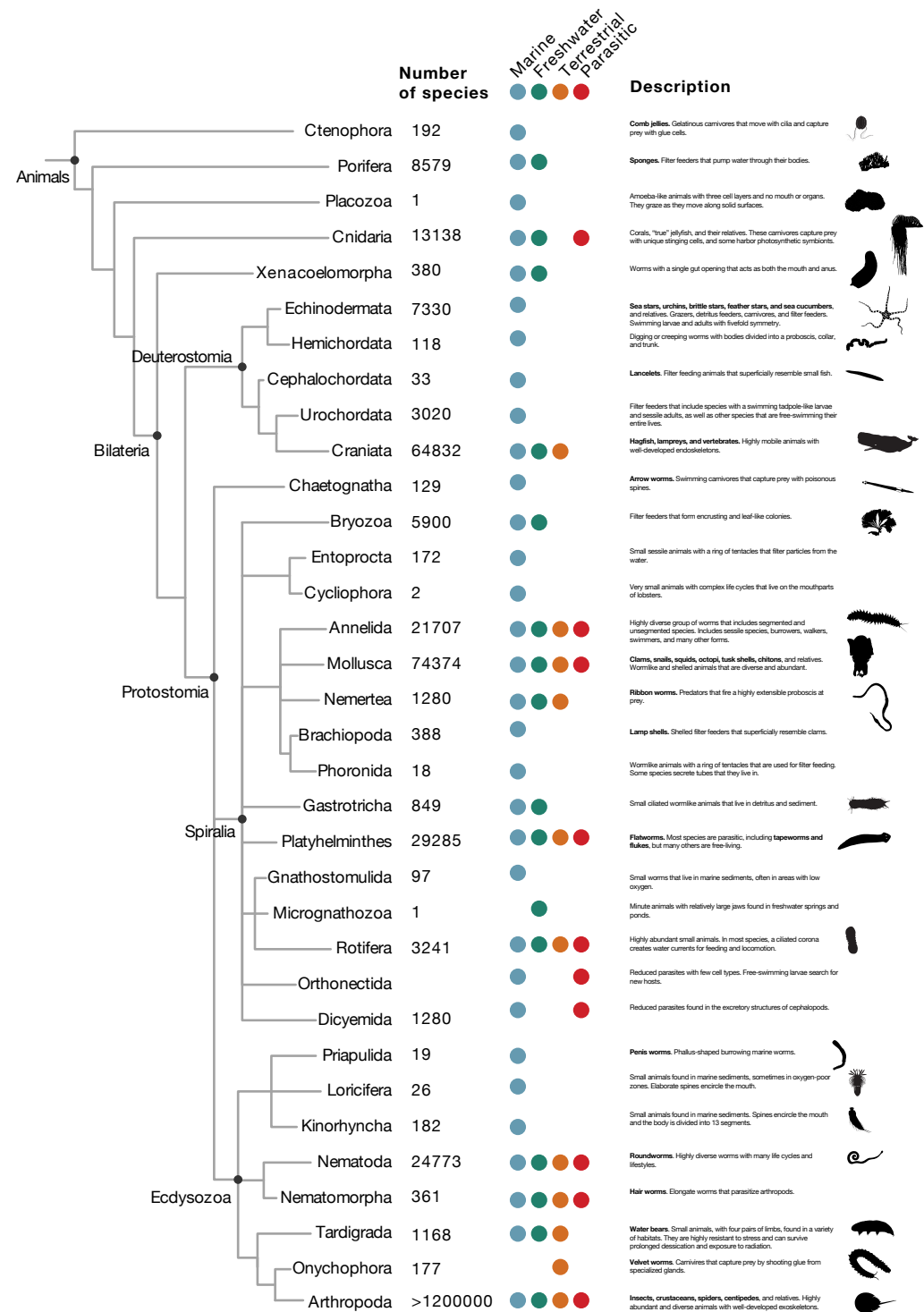
Origem dos cordados: os deuterostomos



Animal Phylogeny and Its Evolutionary Implications*

Casey W. Dunn,¹ Gonzalo Giribet,² Gregory D. Edgecombe,³ and Andreas Hejnol⁴

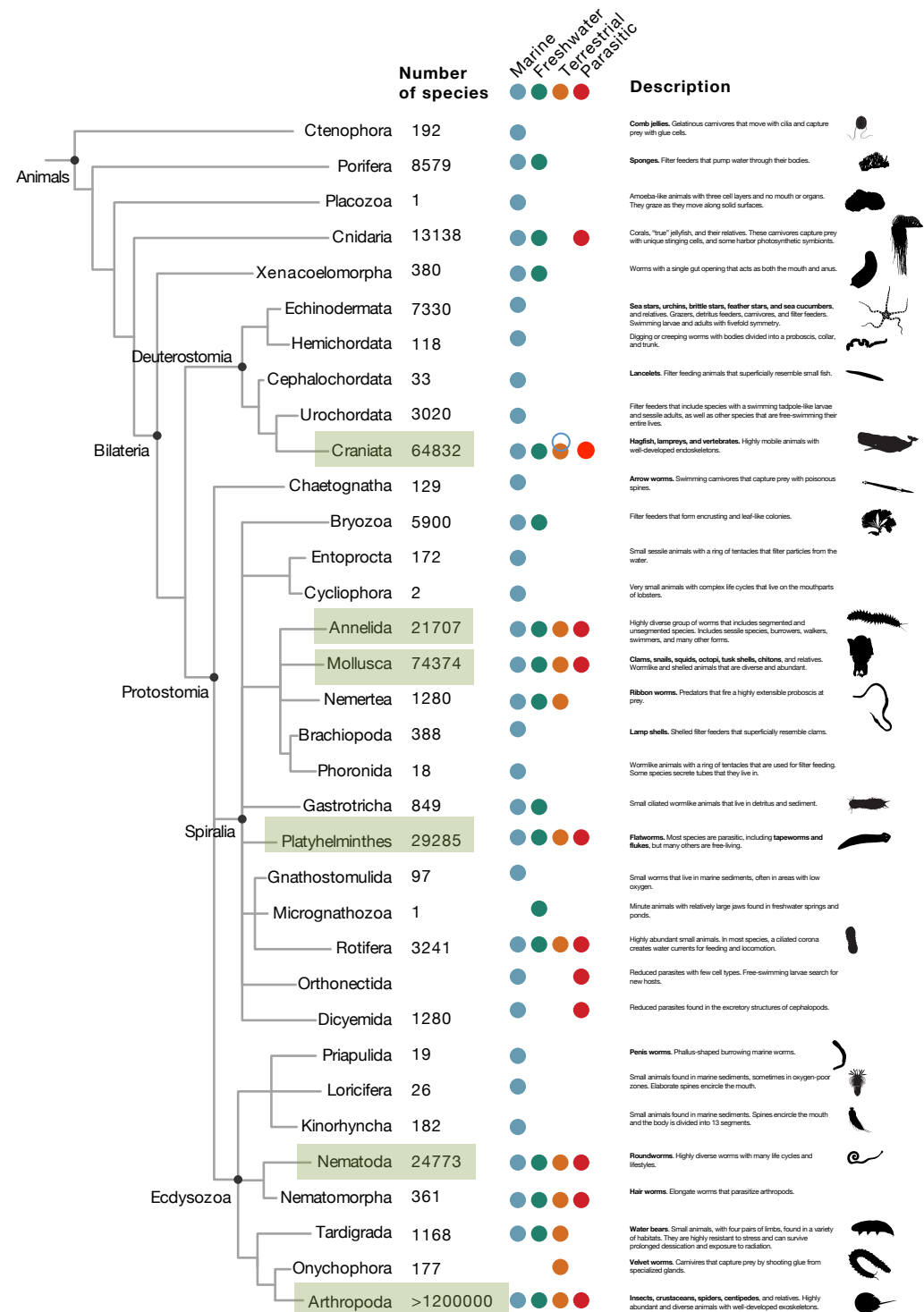
Annu. Rev. Ecol. Evol. Syst. 2014. 45:371–95



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Annu. Rev. Ecol. Evol. Syst. 2014. 45:371–95



Os Cordados

Aleksander Kowalewski: descreve a larva de ascidia

Wettere Studien über die Entwicklung der einfachen Ascidien.
Von
Prof. A. Kowalewsky.
Bonn, Vol. 8, 36, III und IIII.

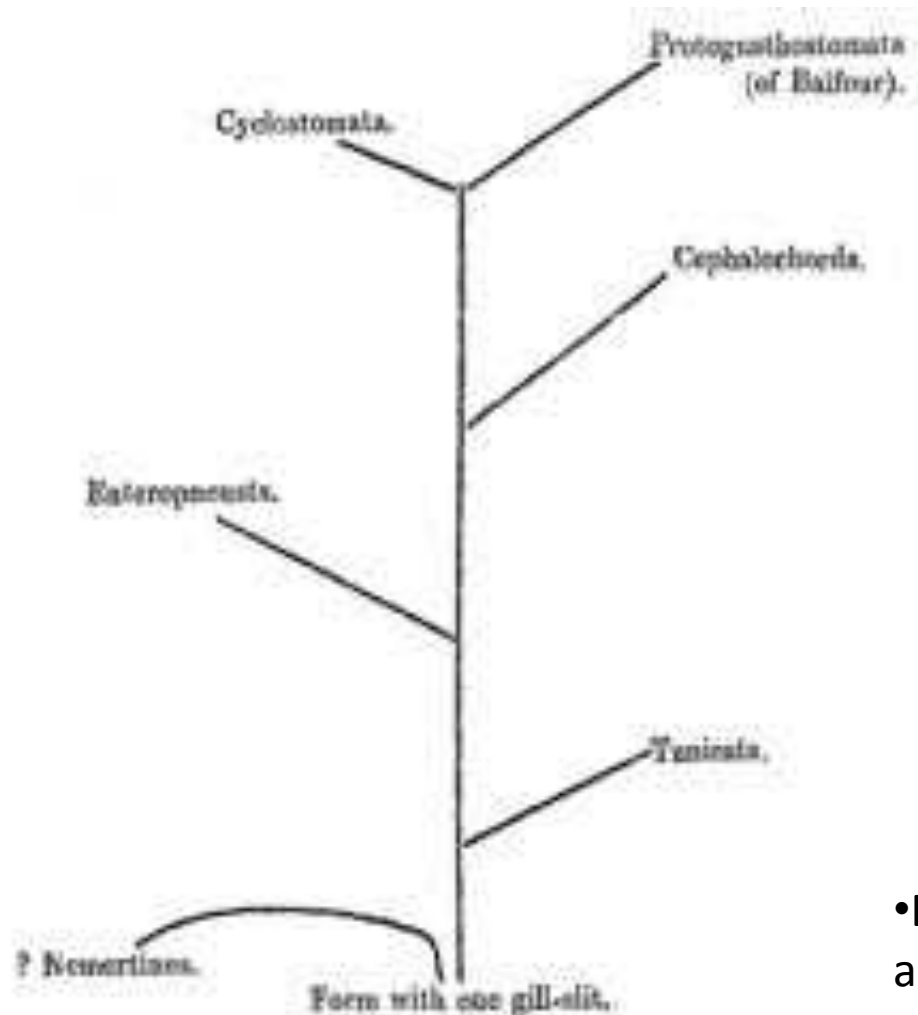
Nachdem ich im Jahre 1860 meine Abhandlung über die Entwicklung der einfachen Ascidien der Petersburger Academie vorgelegt habe, ward mir wieder Gelegenheit, im Jahre 1861 und 1869 das Material zu besorgen und meine früheren Untersuchungen über diese Gattung zu prüfen, in der Hinsicht besonders sich zu stellen als richtig, nur in gewissen Punkten unvollständig und selbst in Trüben, im Jahre 1867, habe ich die Haupttheile meiner Angaben in Beziehung auf das Fortwachsen und die Klammereibung schenkt. Ich habe schon zu jener Zeit die Gänge hinter der Blaseblase oder dem Otolithen nachgewiesen und deren Abgrenzung mit den Zellen der sich ansetzenden Endostome abbilden können.

Ich will meine neuere Ergebnisse über die Entwicklung der Ascidien in einem allgemeinen Aufsatz, welcher die Entwicklung der Thaliaceen überhaupt behandelte, mittheilen lassen; insbesondere aber lassen zwei Seiten über dieselben Gegenstand an die Leser, und da besonders die zweite, durch die Bestätigung der Wirbelkammer der Ascidienlarven als so bedeutsamen Interesse in

U. S. Kowalewsky Die Naturwissenschaften, 1866, 1869, 1867, 1868, 1869, 1870, 1871, 1872, 1873, 1874, 1875, 1876, 1877, 1878, 1879, 1880, 1881, 1882, 1883, 1884, 1885, 1886, 1887, 1888, 1889, 1890, 1891, 1892, 1893, 1894, 1895, 1896, 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1930, 1931, 1932, 1933, 1934, 1935, 1936, 1937, 1938, 1939, 1940, 1941, 1942, 1943, 1944, 1945, 1946, 1947, 1948, 1949, 1950, 1951, 1952, 1953, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 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3851, 3852, 3853, 38

Os Cordados

William Bateson: o geneticista que deu o nome aos Cordata

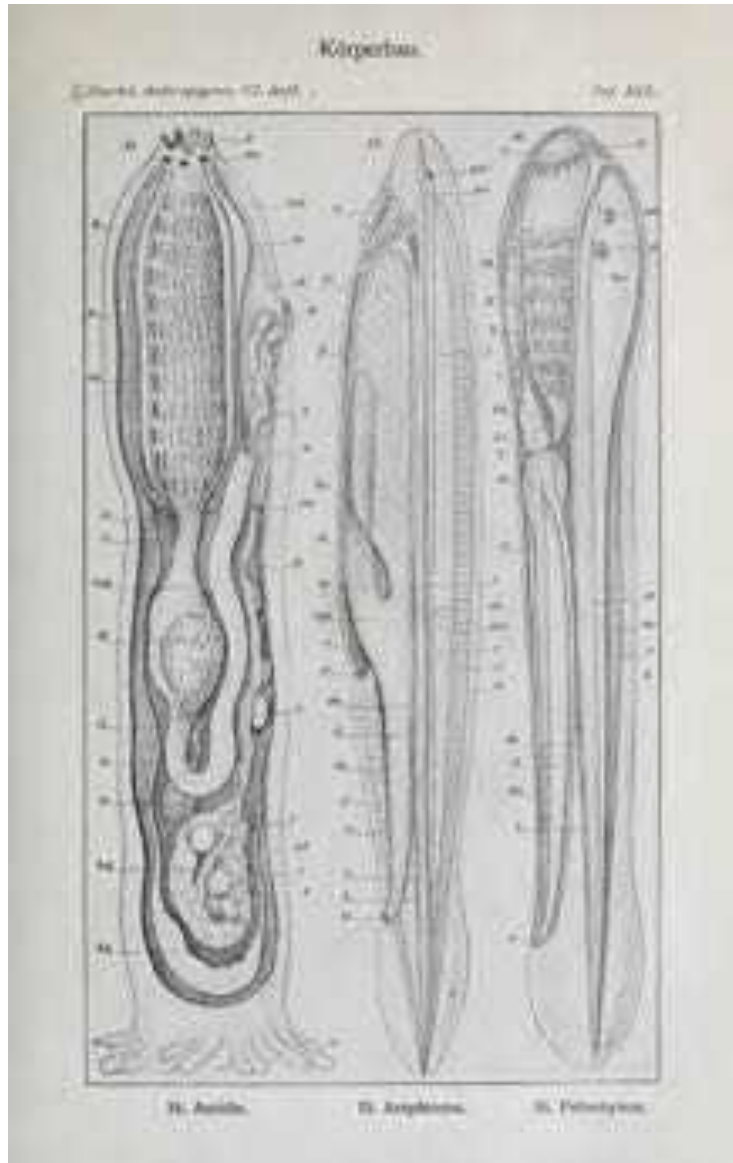


William Bateson

- Da o nome de Chordata (1885) e inclui aos hemicordados

Os Cordados

Ernst Haeckel: unifica o taxon “Chordonier”



- Haeckel primeiro coloca aos tunicados como moluscos (1866), e depois em 1886 aceita o taxon “*Chordonier*” (em alemão) composto por tunicados, cefalocordados e vertebrados.

O artista:



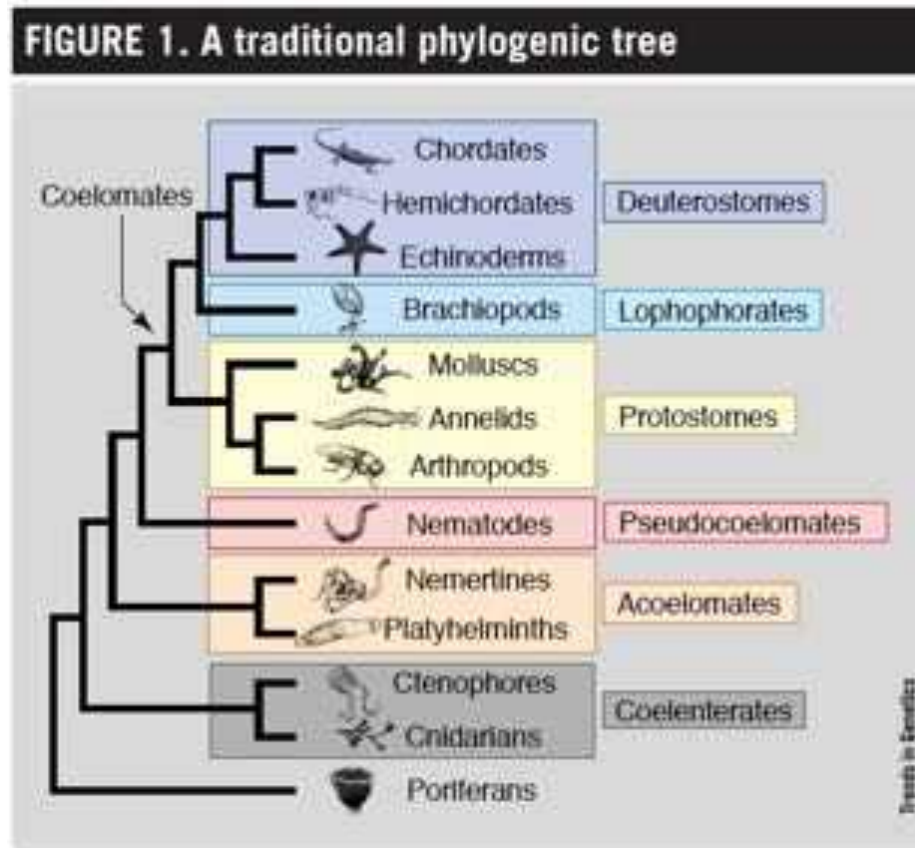
Propostas filogenéticas iniciais: Hyman

Hyman dá importância aos processos do desenvolvimento dos animais e gera propostas filogenéticas com base na morfologia (desenvolvimento do blastóporo, lofoforos e coelomas) dos grandes grupos animais.

"I believe my interest in nature is primarily aesthetic."



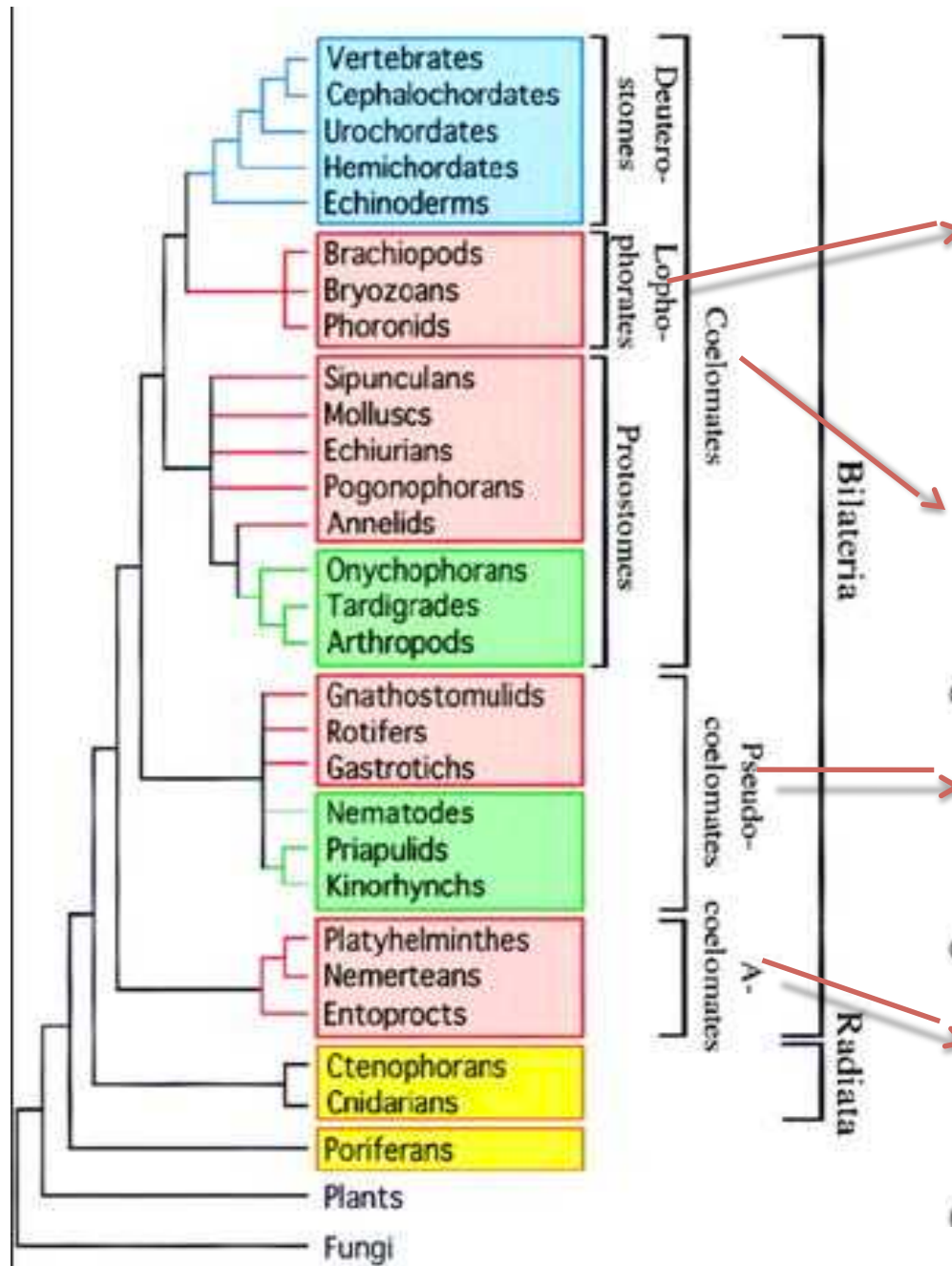
Libbie Henrietta
Hyman (1888-1969)



Grupos propostos que ainda são reconhecidos como monofiléticos:

- **Deuterostomados** como grupo monofilético

TRADITIONAL VIEWS

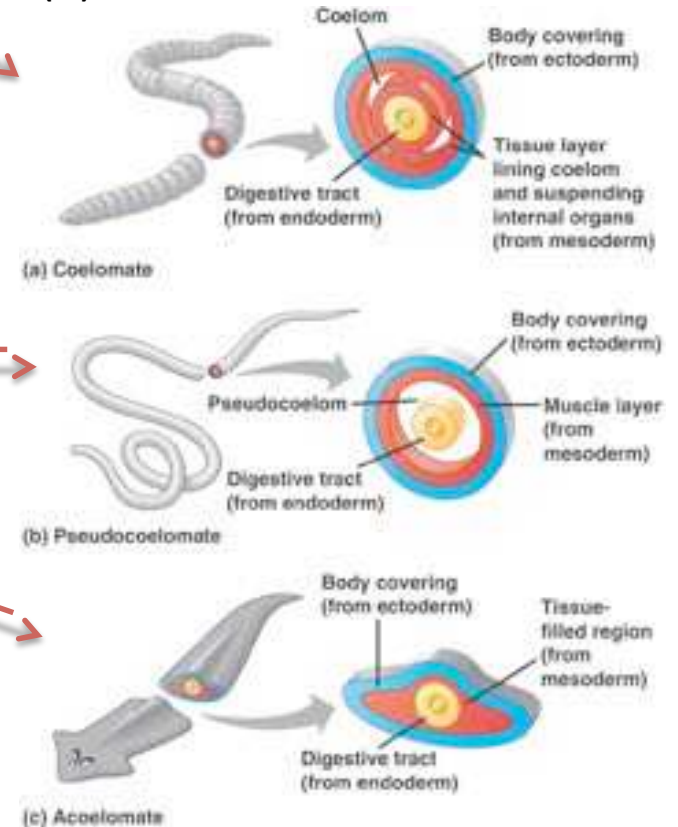


Importancia a:

(1) lóforos:



(2) coelomas:

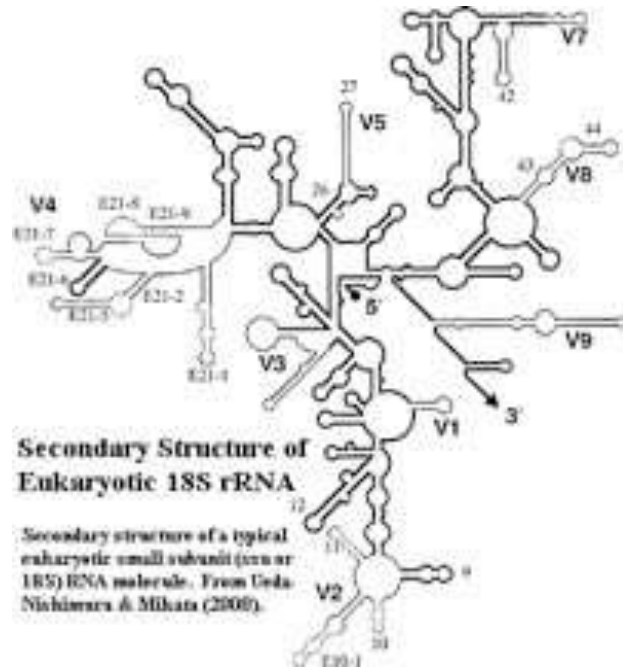


TAREFA! 1^a parte

Filogenias moleculares

Primeras filogenias moleculares:

- 18S SSU rRNA (*grandes grupos*)



- nuclear genes: 16S rRNA, 5S rRNA, 28S rRNA; mitochondrial genes: cytochrome oxidase, mitochondrial 12S, cytochrome b, control region; and few chloroplast encoded genes: *rbcl*, *matK*, *rpl16* (*grandes e pequenos grupos*)

Outros caracteres usados:

- NADH dehydrogenase subunit 5 ou NAD5 (*arthropodos + nematodos; chaetognatos como protostomados; lofoforados como protostomados; acoelos fora dos protostomados*)
- intrones (*Tunicados+Vertebrados*)
- genes 'diagnóstico' (*loci Ig em vertebrados o repetições ricas em leucina nos Cyclostomados ou peixes sem mandíbula*)
- miRNAs (*Tunicata+Craniata*)
- transcriptomas

Filogenias moleculares

FIGURE 1. A traditional phylogenetic tree

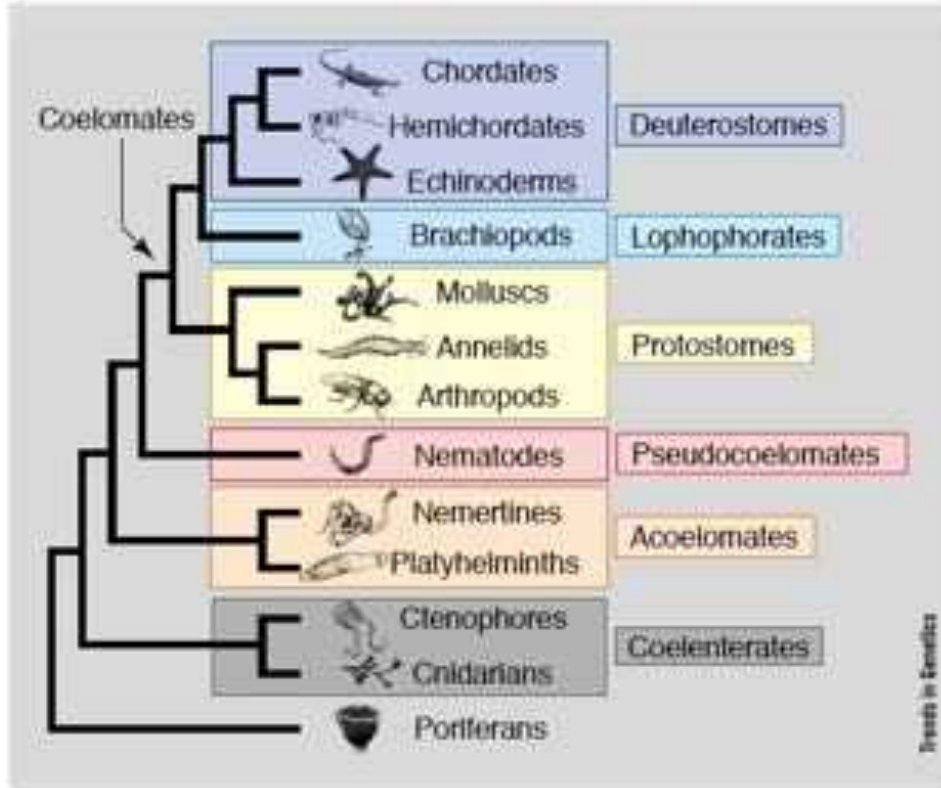
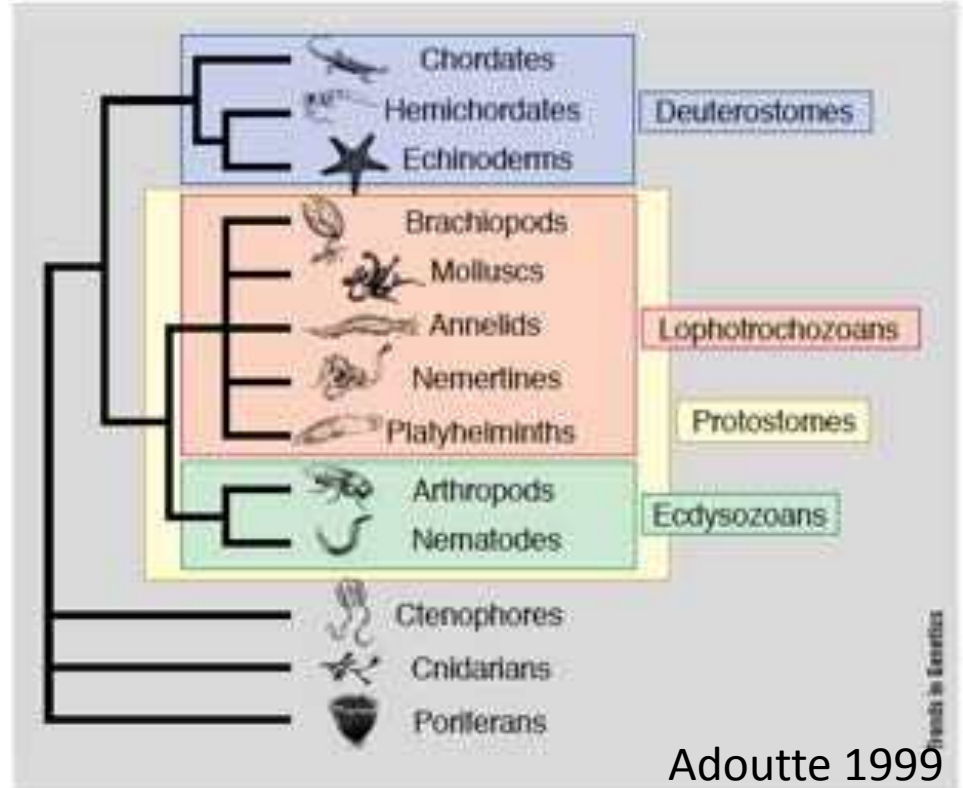


FIGURE 2. A phylogenetic tree based on 18S rRNA



Adoutte 1999

Grupos que tem mudado de lugar e pasado por revisão por filogenias moleculares:

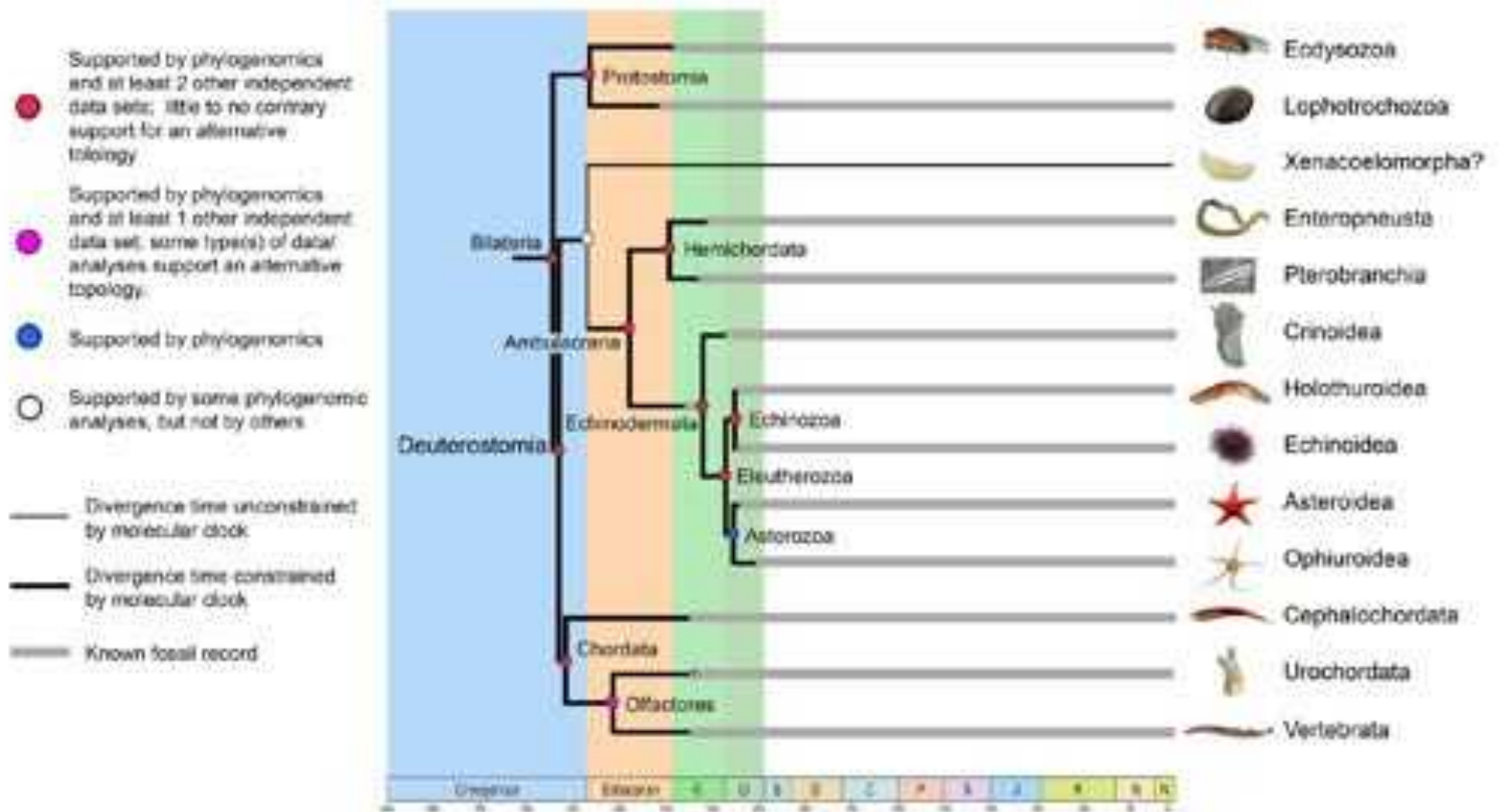
- lofoforados como grupos irmãos dos deuterostomados
- desapareção de coelomados, pseudocoelomados, e acoelomados

Grupos propostos das filogenias moleculares que ainda são reconhecidos como monofiléticos:

- **Ambulacraria** como grupo monofilético

Os deuterostomos

Filogenias usando transcriptomas



Xenacoelomorpha não é um Deuterostomo

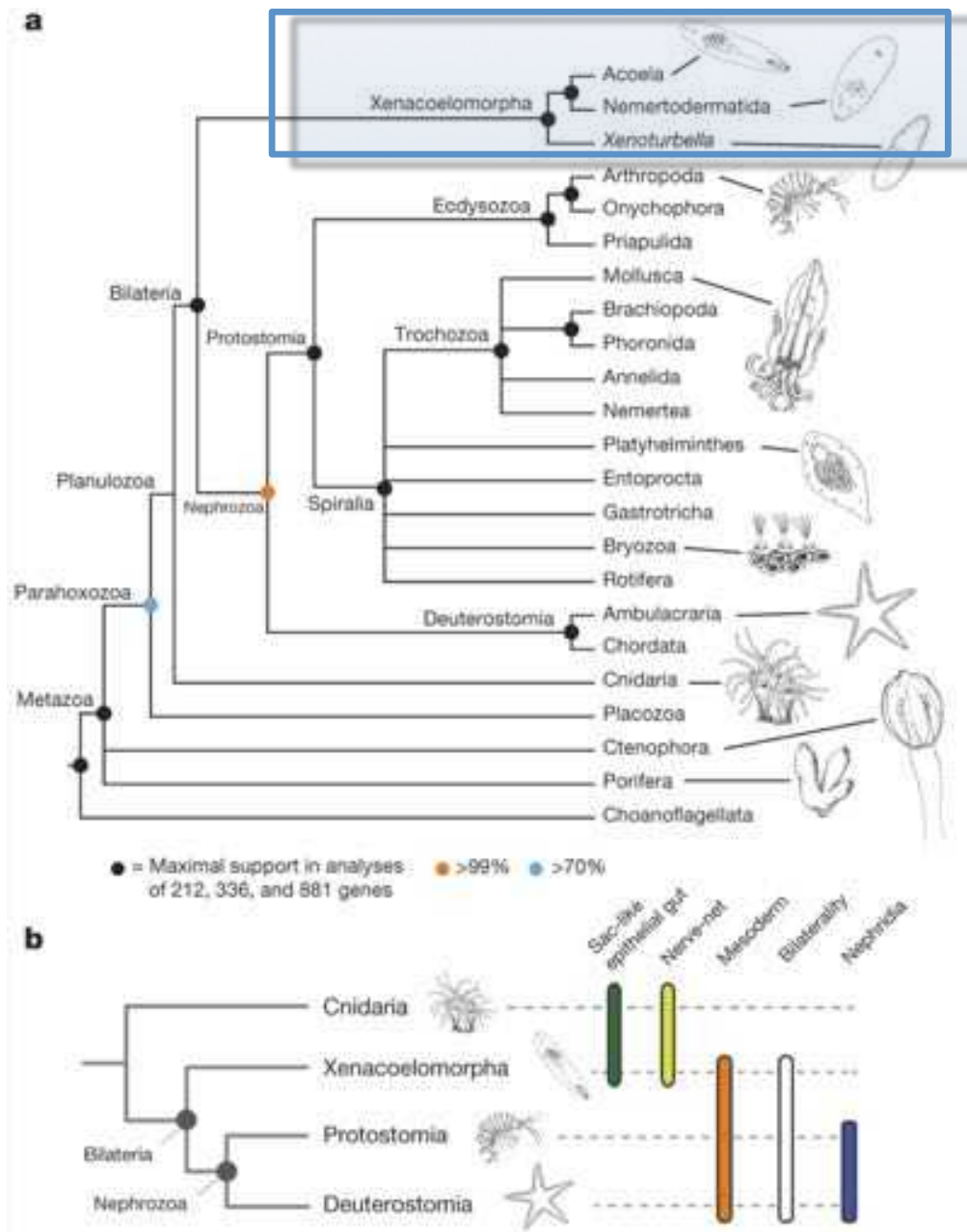
nature International weekly journal of science

Xenacoelomorpha is the sister group to Nephrozoa

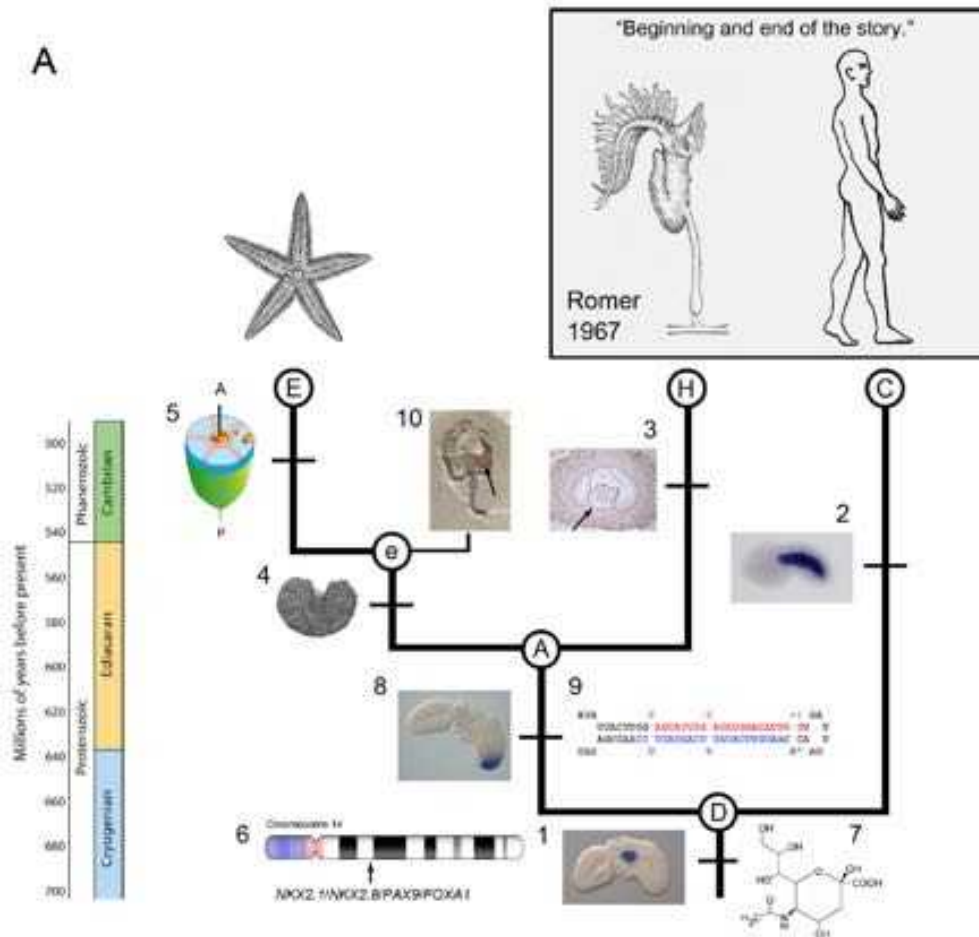
Johanna Taylor Cannon, Bruno Cossermelli Vellutini, Julian Smith, Fredrik Ronquist, Ulf Jondelius & Andreas Hejnol

[Affiliations](#) | [Contributions](#) | [Corresponding authors](#)

Nature 530, 89–93 (04 February 2016) | doi:10.1038/nature16520



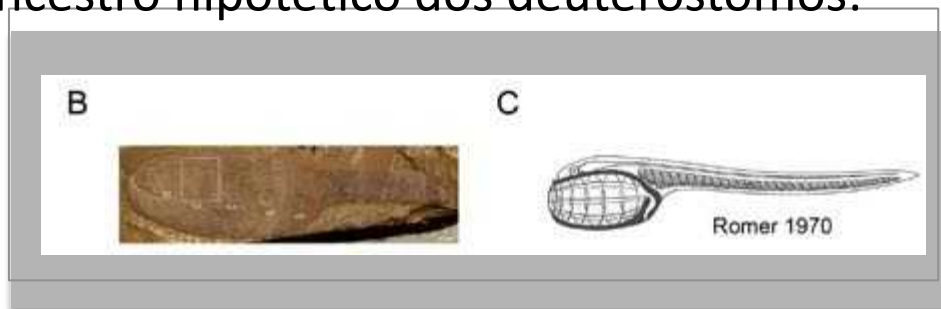
Os deuterostomos



Otras apomorfias propuestas para os deuterostomos:

- Fendas faringeads expresam Pax1/9
- Genes faringeads Pax1, Nkx2.1, Nkx2.8, e FoxA1 agrupados num cromosoma
- Genes de metabolismo de acidos sialicos

Ancestro hipotético dos deuterostomos:



Animal bipartito somato-visceral parecido ao fossil vetulicoliano

Os Cordados

Filogenias usando transcriptomas

Vol 439/23 February 2006/doi:10.1038/nature04336

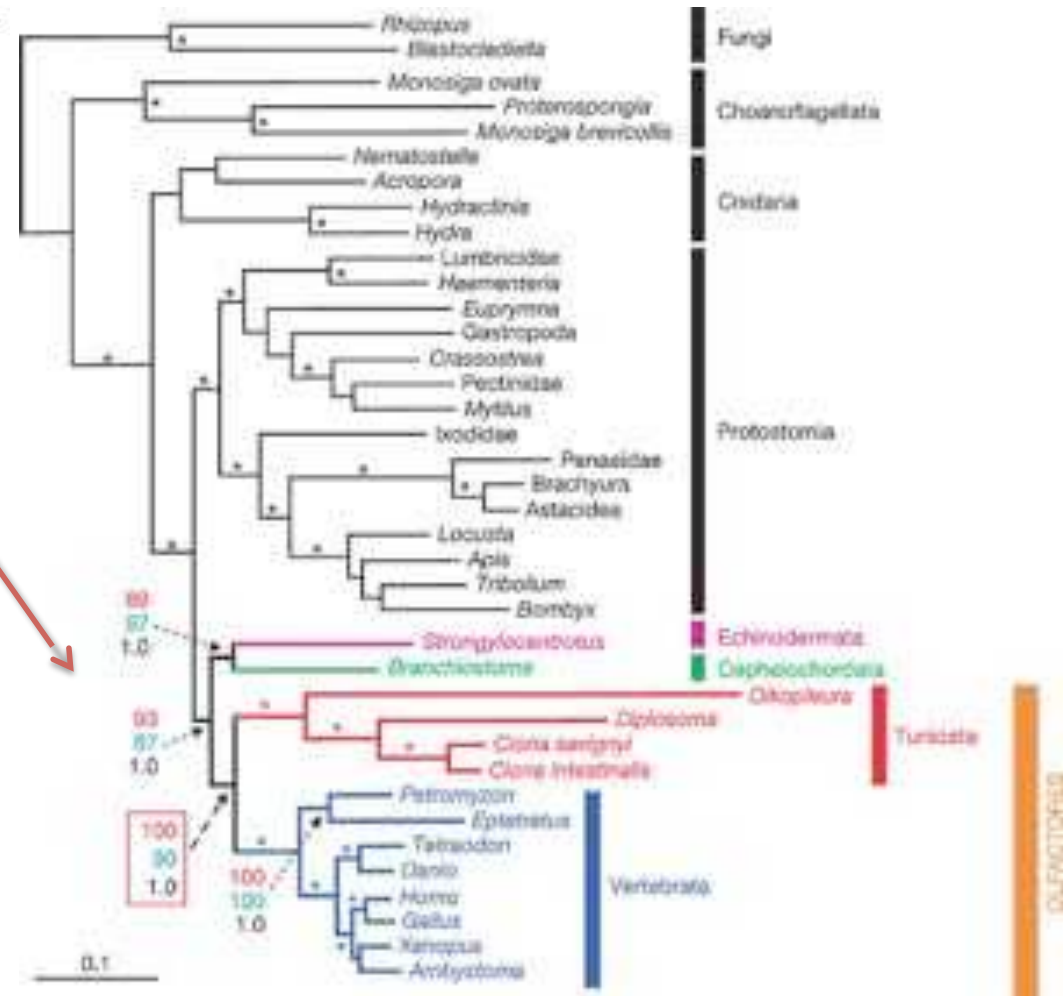
nature

LETTERS

Tunicates and not cephalochordates are the closest living relatives of vertebrates

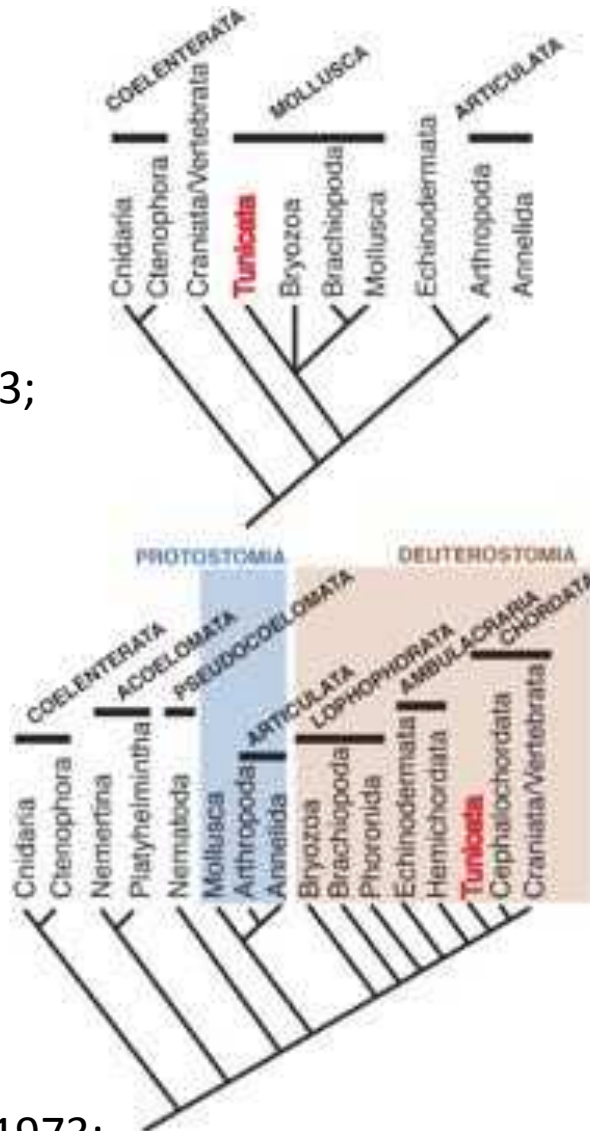
Frédéric Delsuc¹*, Henner Brinkmann¹, Daniel Chourrout² & Hervé Philippe¹

- Phylogenomic data set of 146 nuclear genes (33,800 unambiguously aligned amino acids)

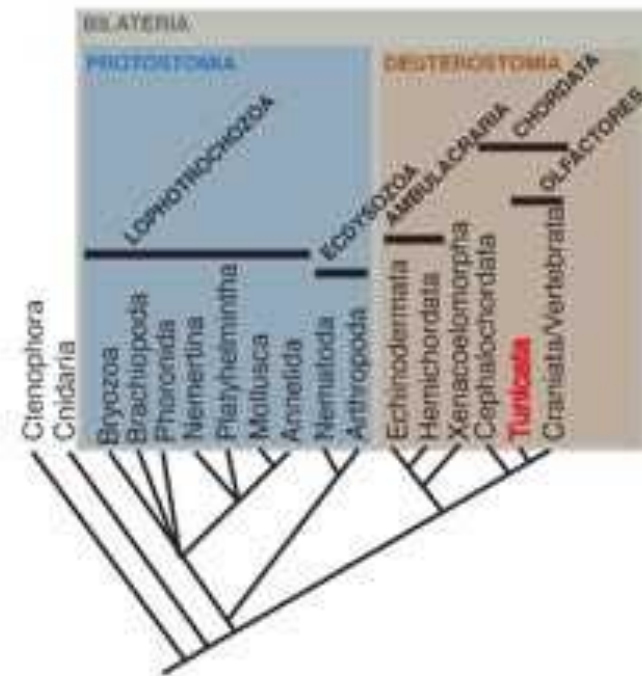


Posição dos Tunicados

(Milne-Edwards 1843;
Haeckel 1866)

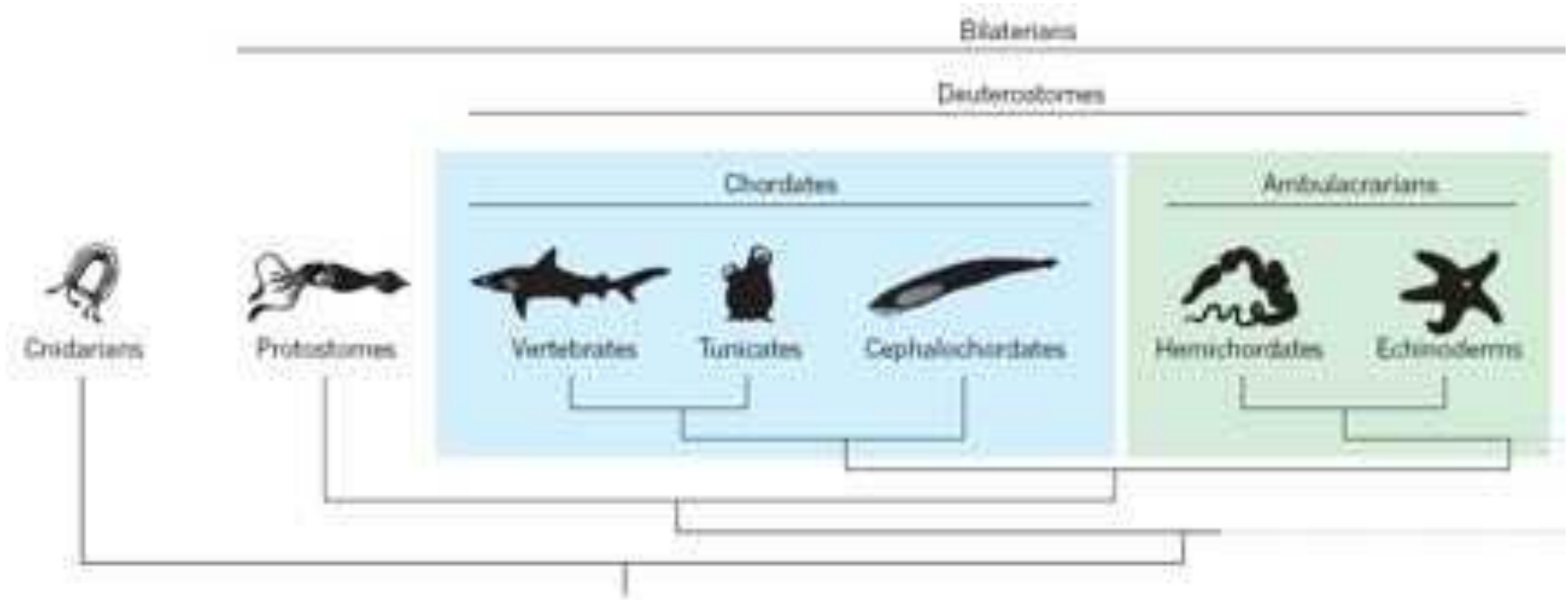


(Hyman 1959;
Zimmer and Larwood 1973;
Nielsen 2002)



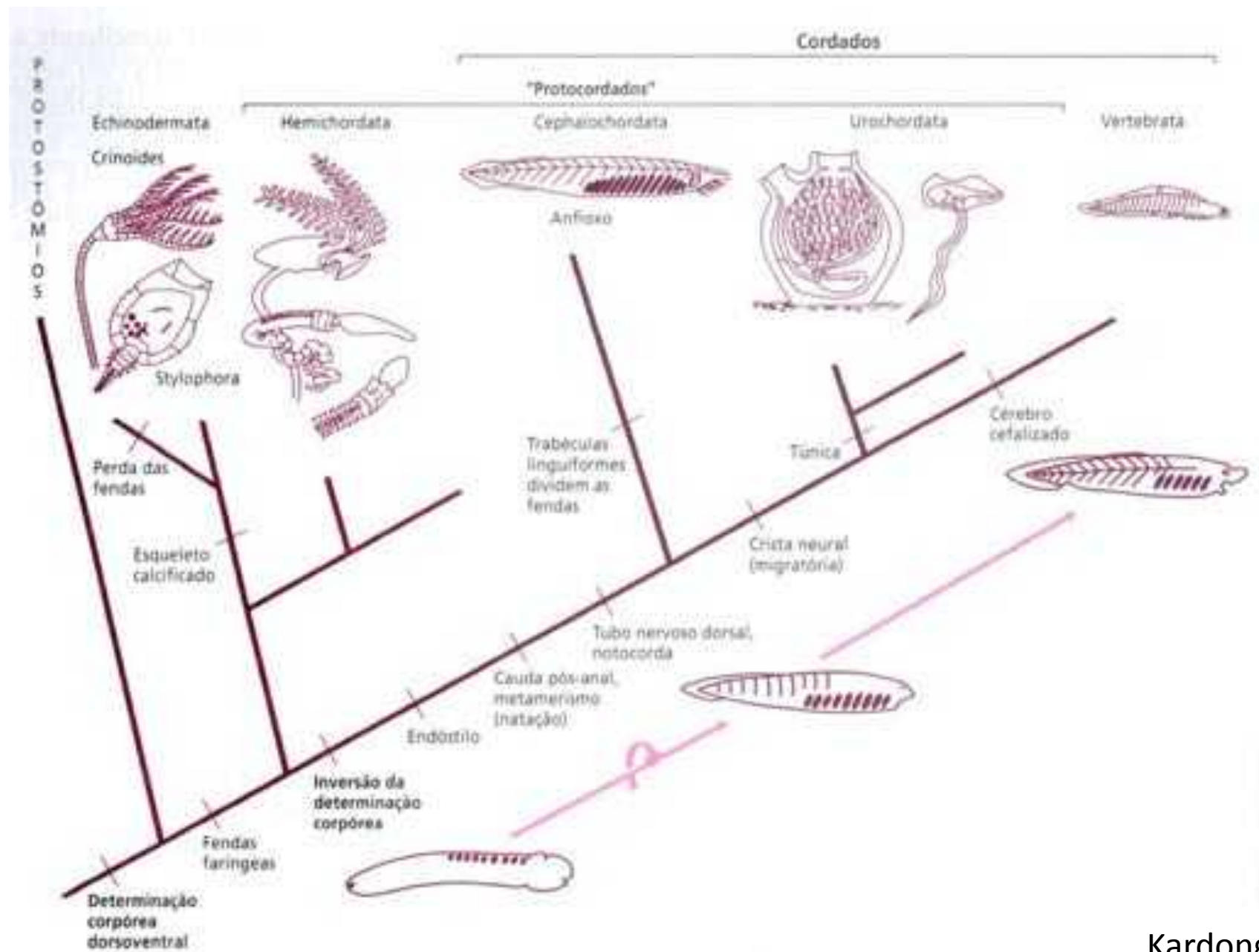
(Field et al. 1988; Cameron et al. 2000;
Swalla et al. 2000; Winchell et al. 2002)

Deuterostomos e cordados

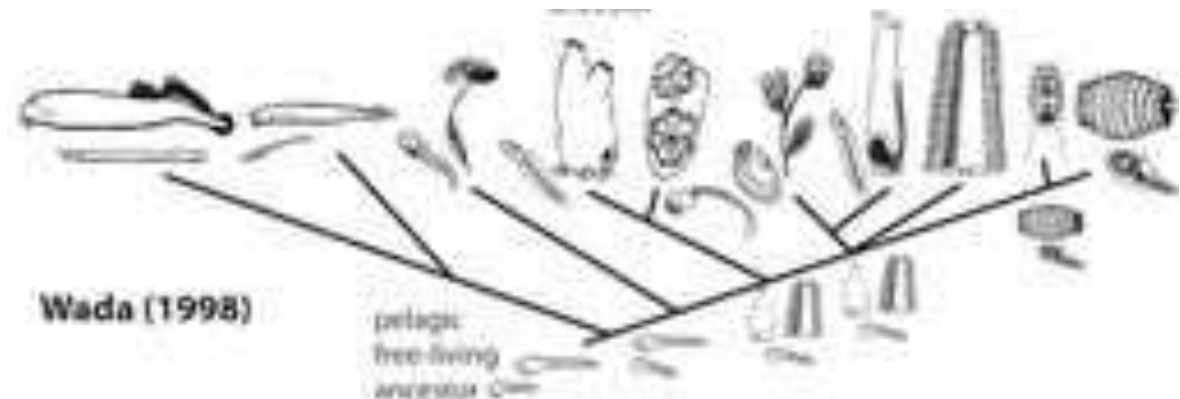
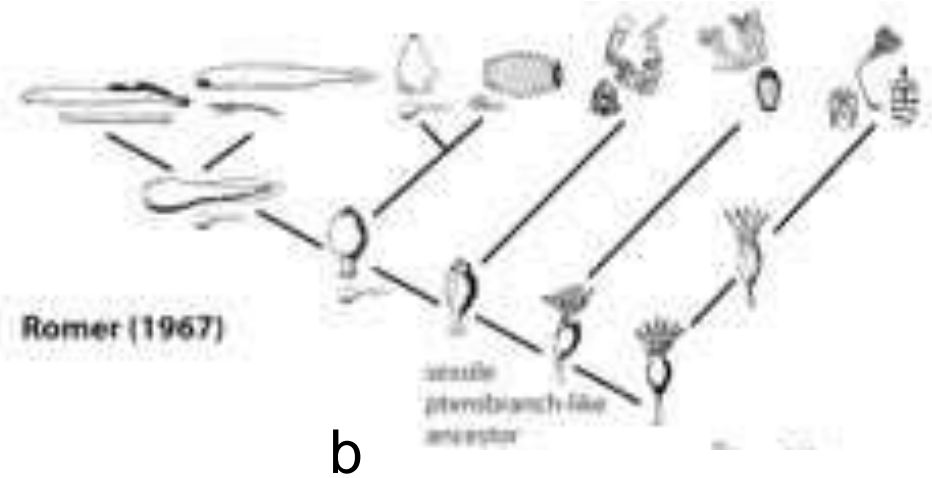
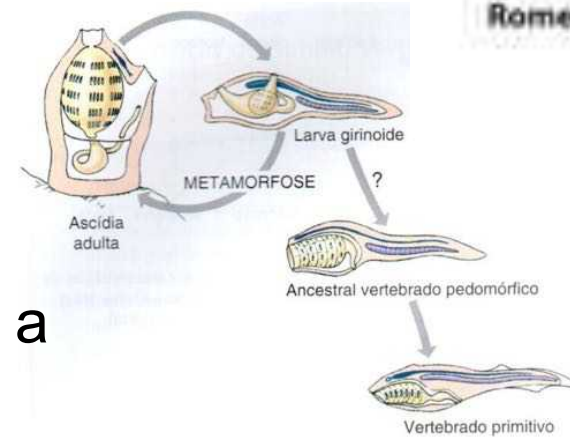
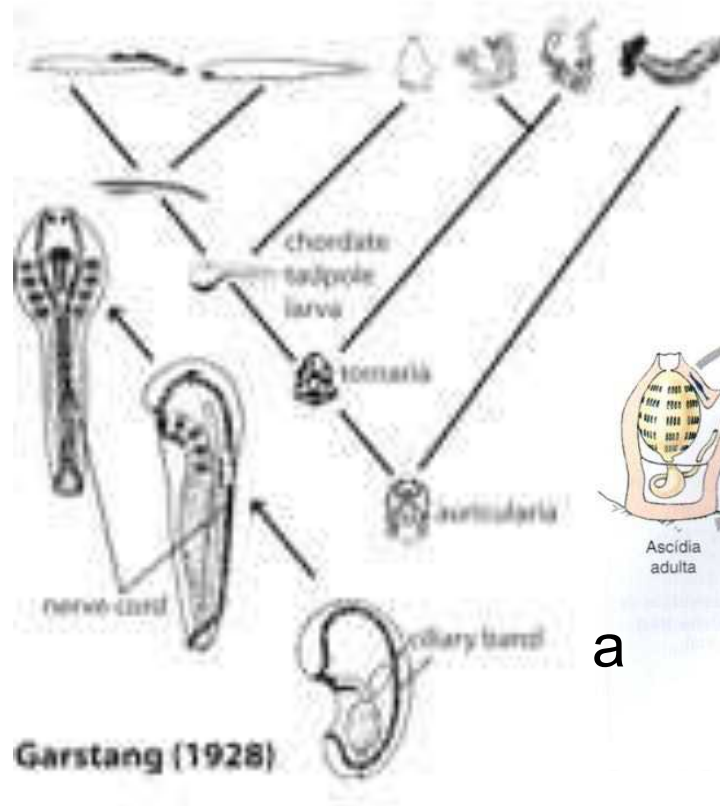


TAREFA! 2^a parte

Deuterostomos e cordados

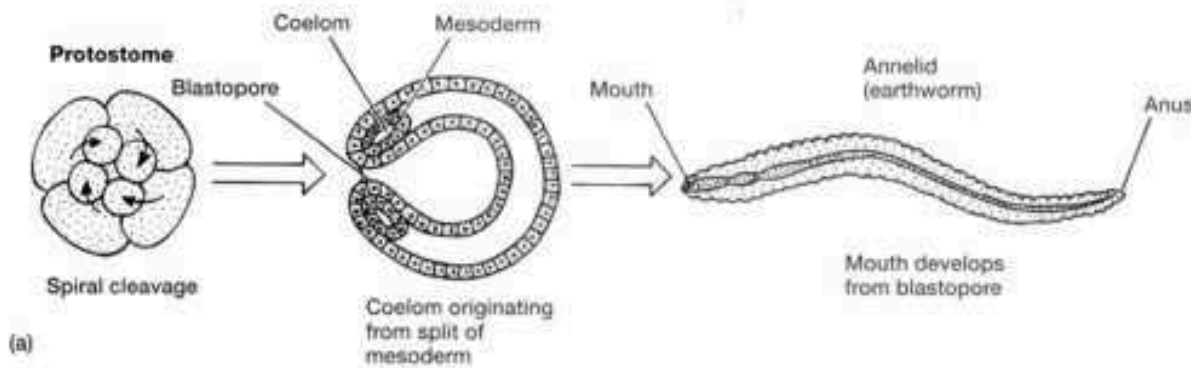


Origens dos cordados:

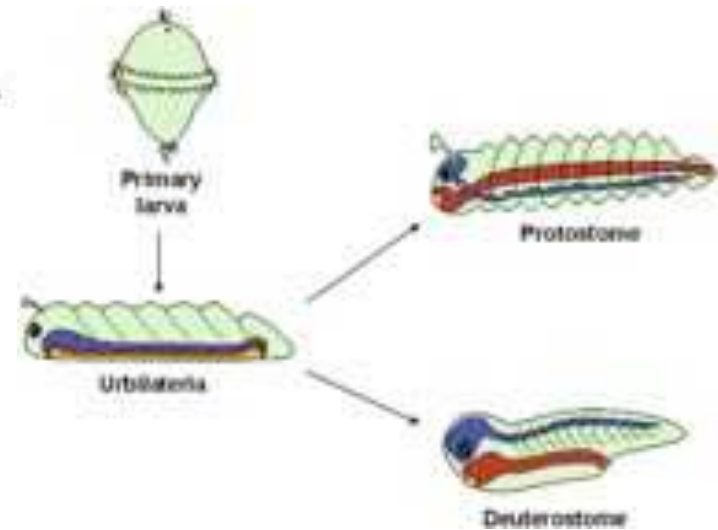


Construindo um cordado: Inversões Protostomo-Deuterostomo

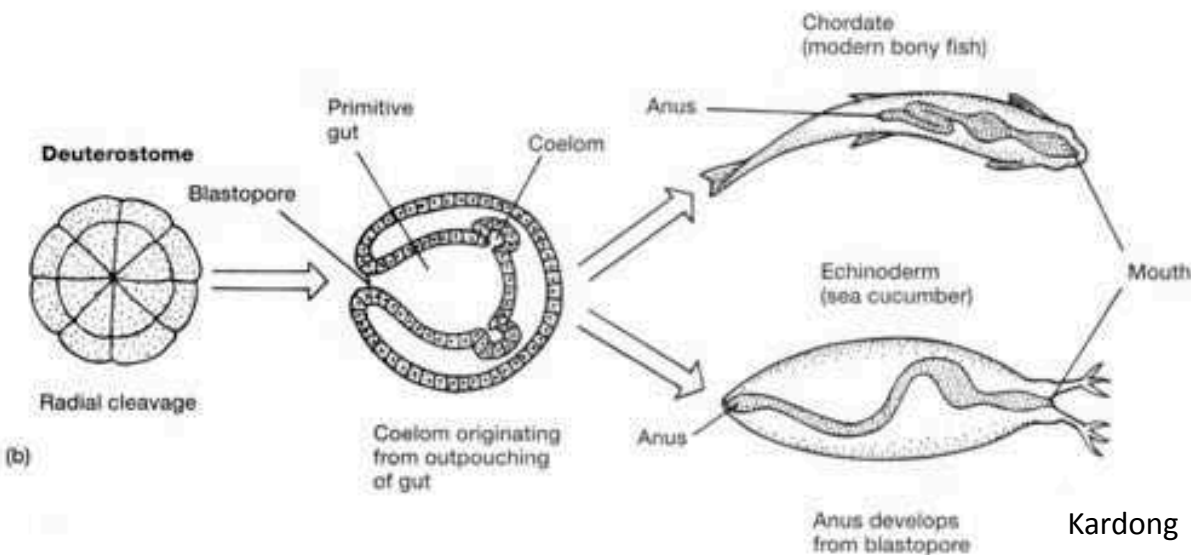
1. Mouth-forming to **Anus-forming blastopore**:



2. Ventral to **Dorsal nervous system**:



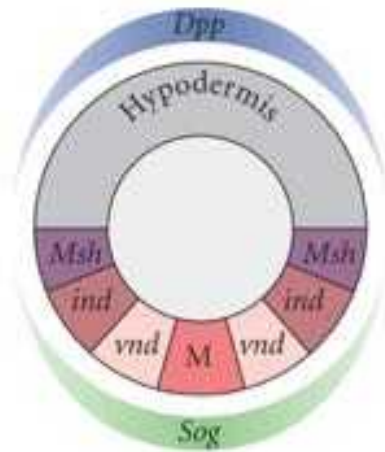
De Robertis 2008



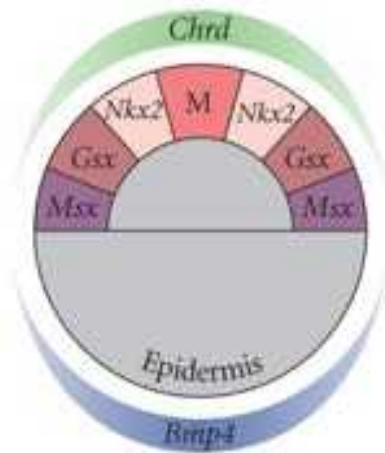
Kardong

Bilaterian D-V inversion with hypothetical “complex” Urbilaterian

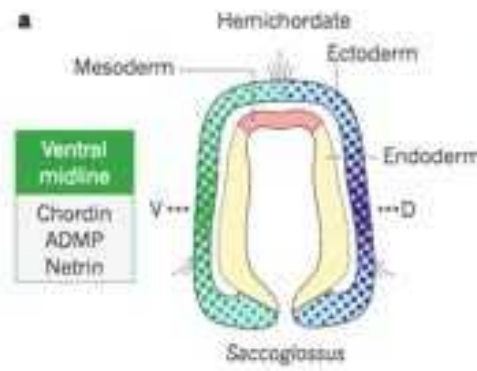
Construindo um cordado: inversão do sistema nervoso ocorre na linhagem que da origem aos cordados (Hemichordata → Chordata)



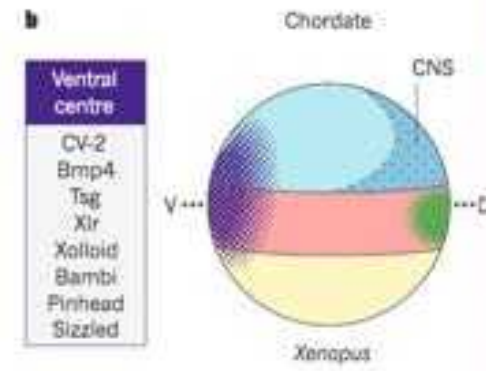
Drosophila



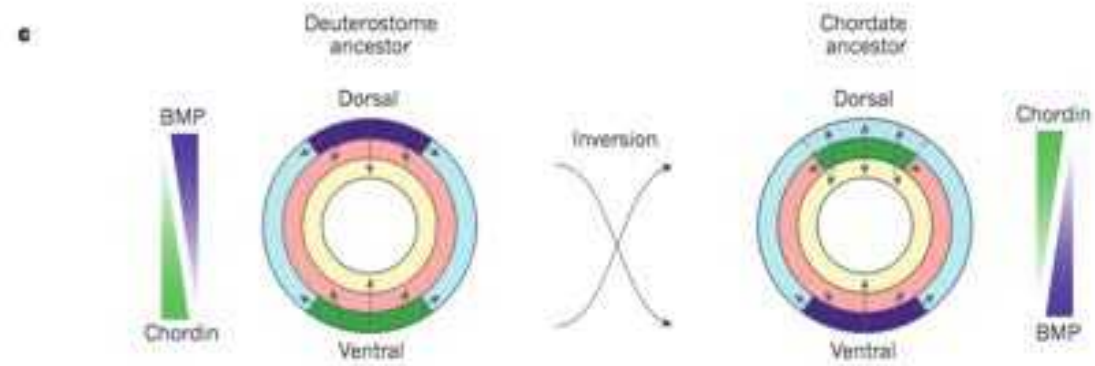
Mouse



- Dorsal midline**
- Bmp2/4
 - Bmp5-8
 - ADMP2
 - Neuralin
 - Grainin
 - CV-2
 - Tsg
 - Xolloid
 - Bambi
 - Pinhead

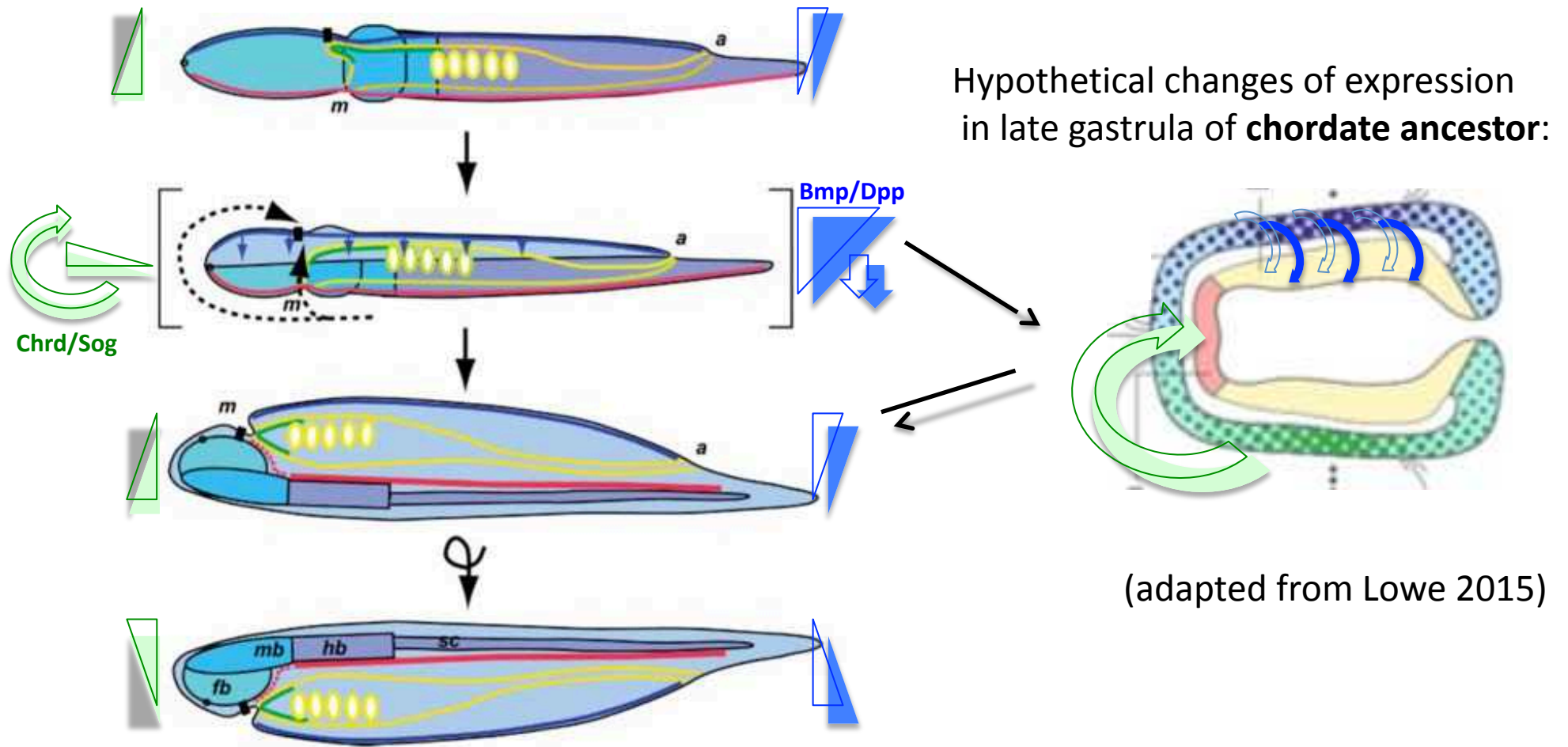


- Spemann's organizer**
- Chordin
 - Noggin
 - Follistatin
 - ADMP
 - Frzb-1
 - Crescent
 - sFRP2
 - Dkk-1
 - Cerberus
 - Antivin/Lefty
 - Xnrs
 - Shh
 - IGFBP5



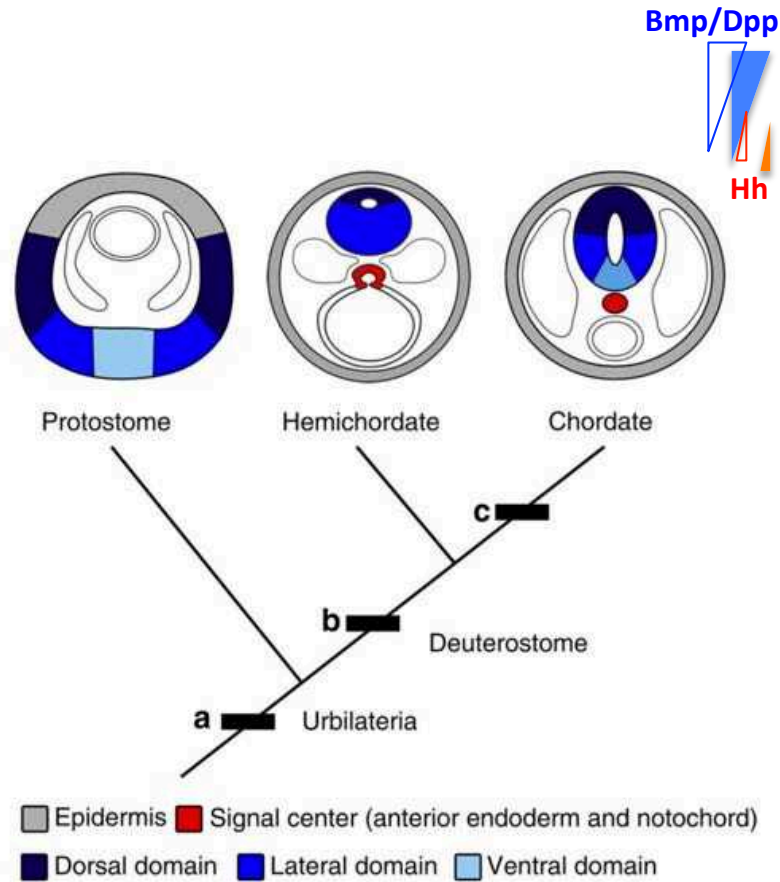
DEVELOPMENTAL BIOLOGY, Eighth Edition, Figure 23.7 © 2005 Sinauer Associates, Inc.

Inversão do sistema nervoso



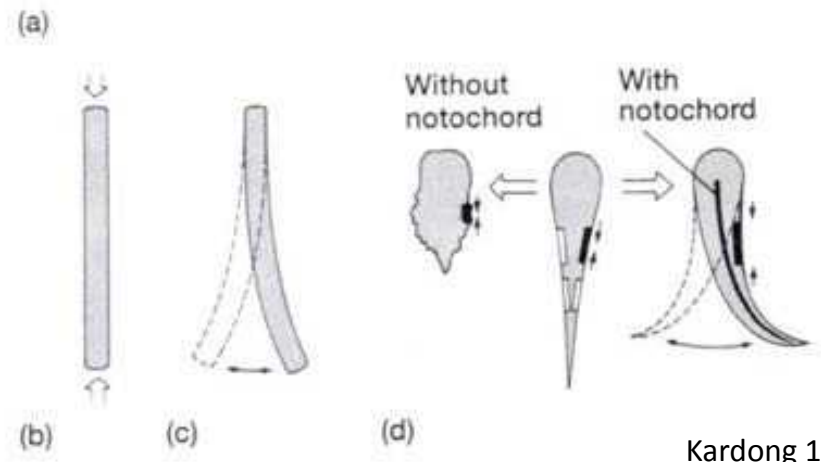
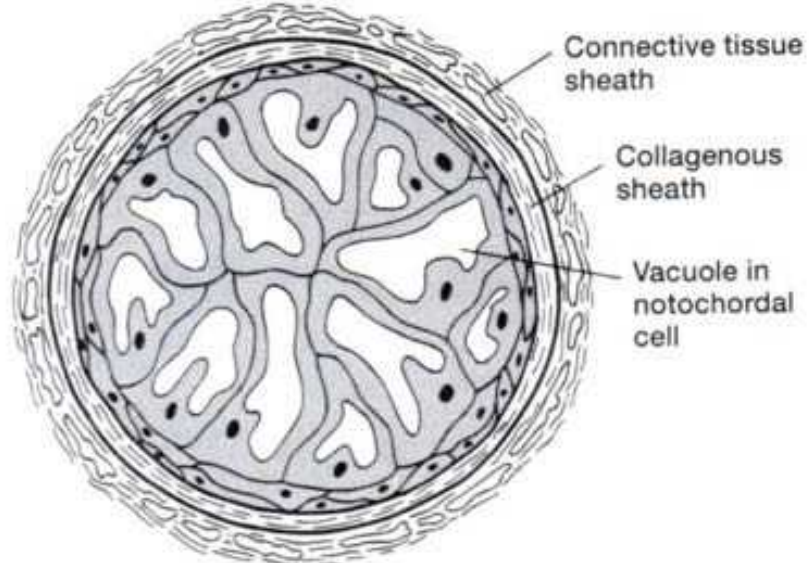
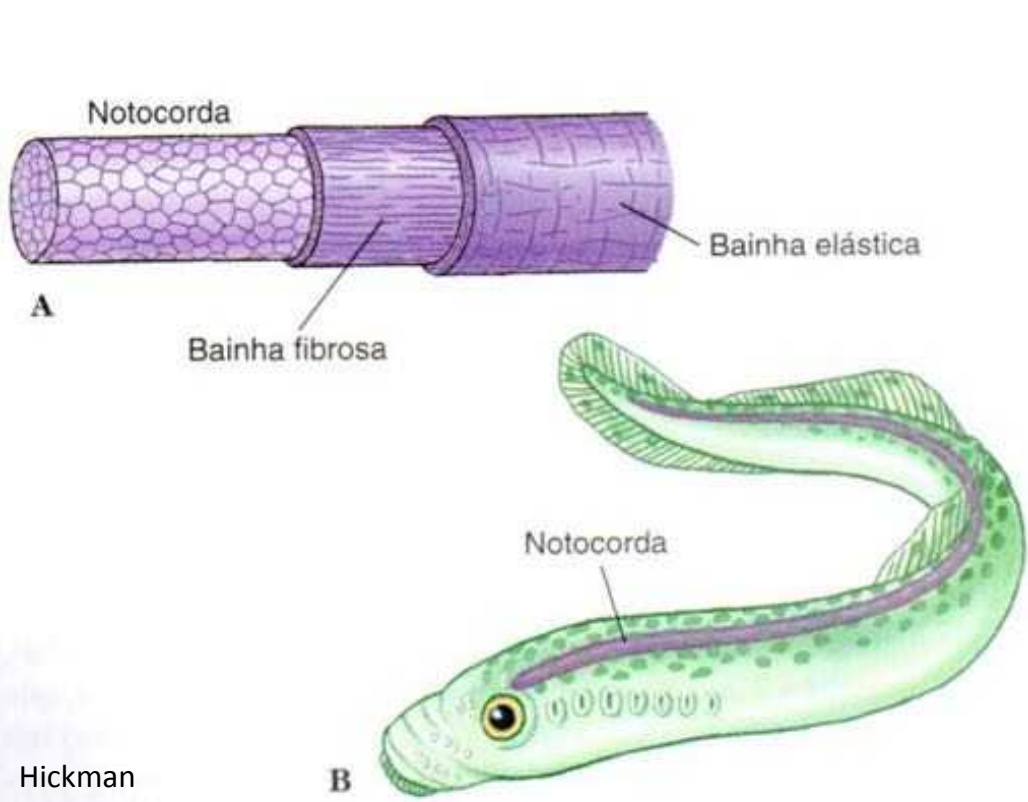
Evolução da neurulação

Hemichordate neurulation and the origin of the neural tube



Miyamoto & Wada, 2013

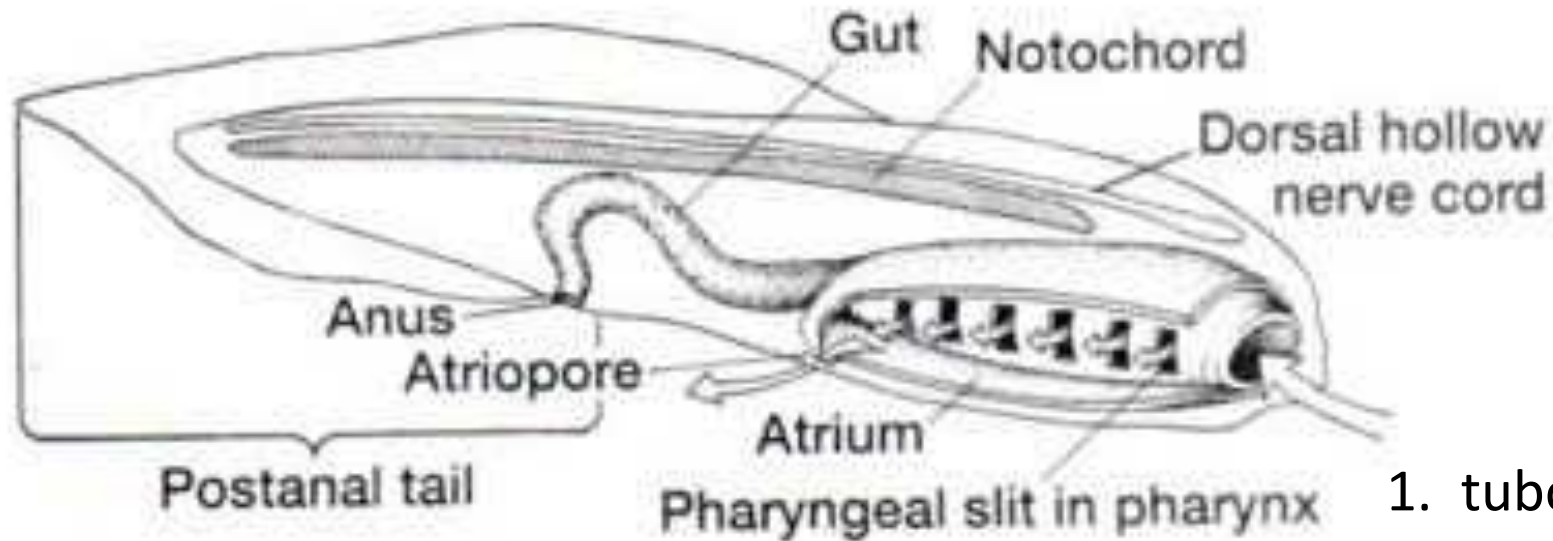
Construindo um cordado: a notocorda



Kardong 1995

Hickman

Contruindo um cordado: sinapomorfias

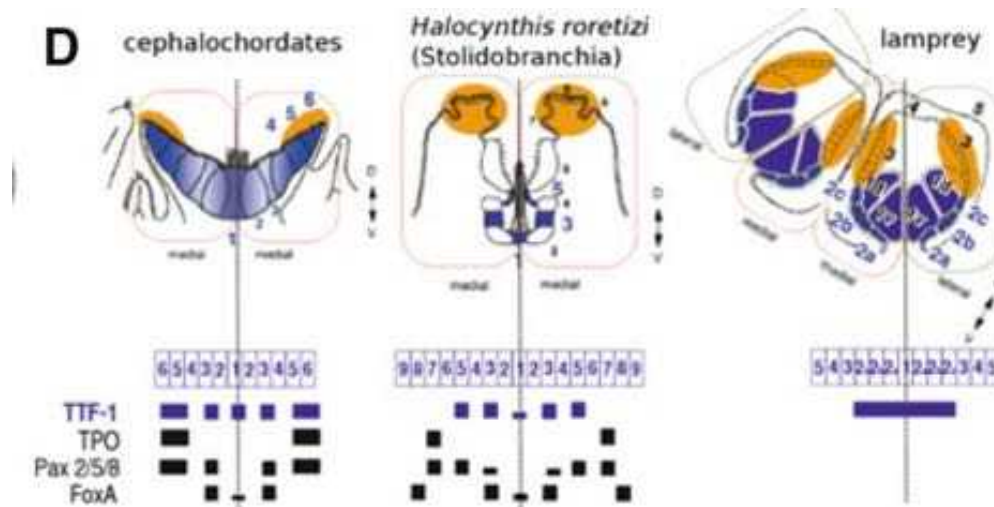


1. tubo neural dorsal

2. notocorda

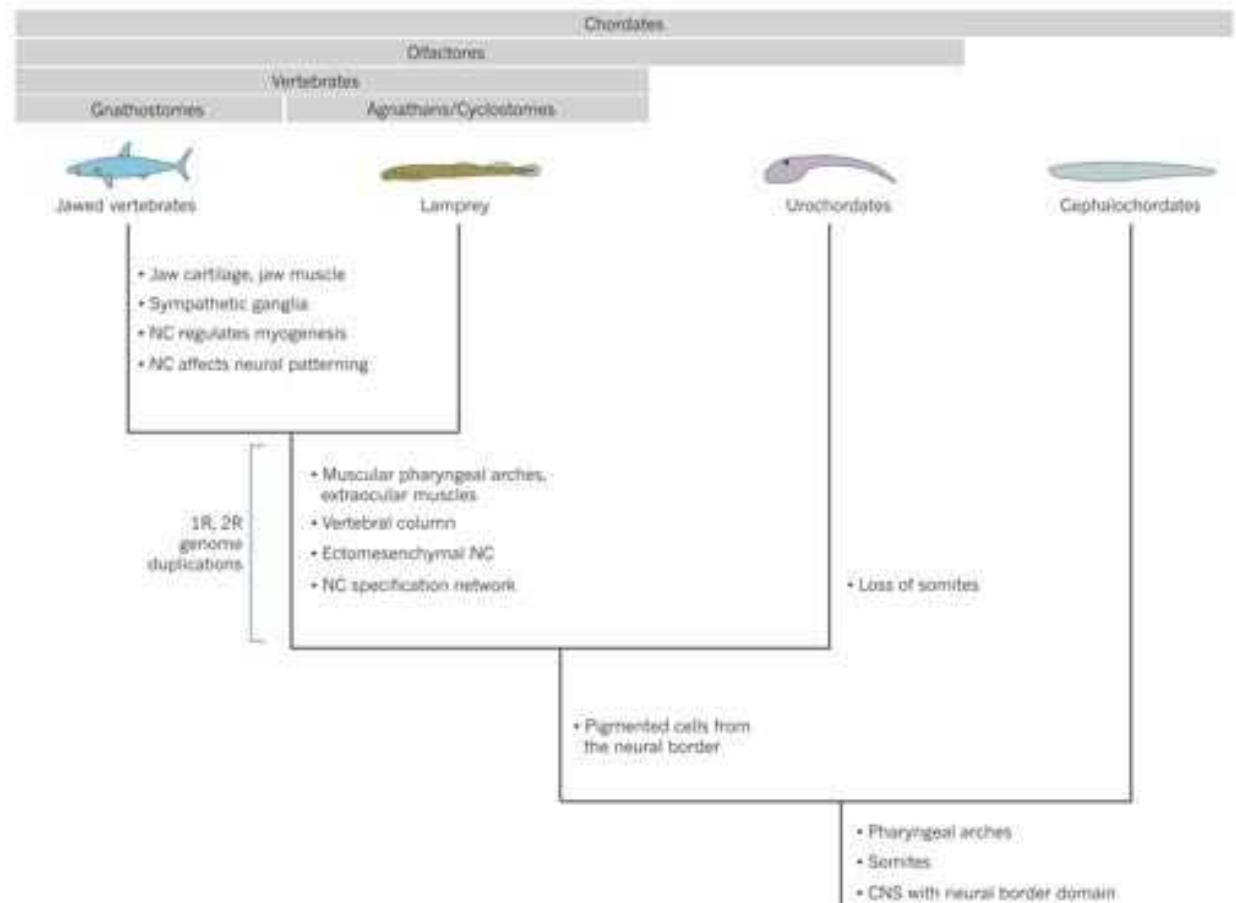
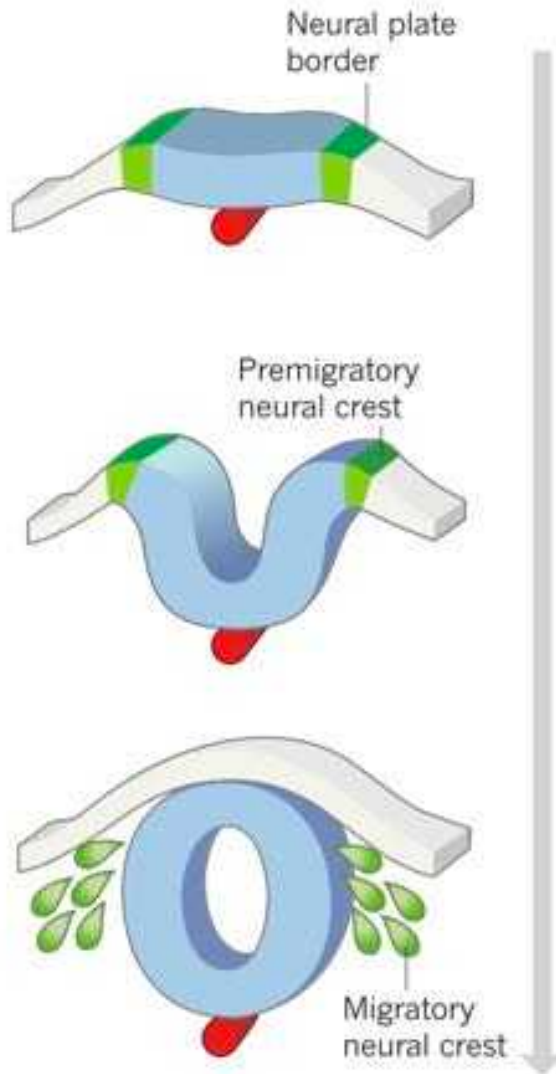
3. cauda postanal

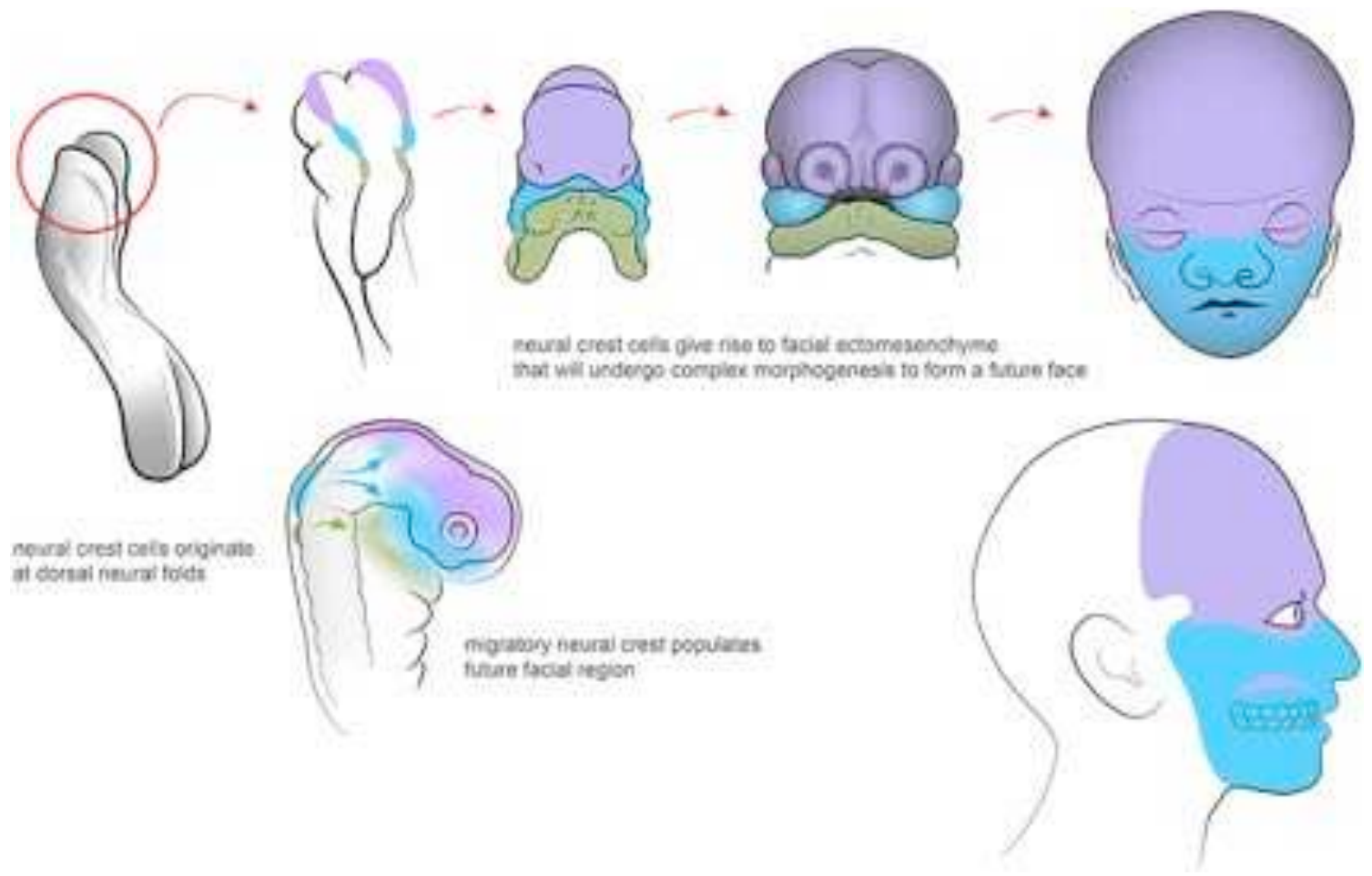
4. (endostilo/glândula tireoide)



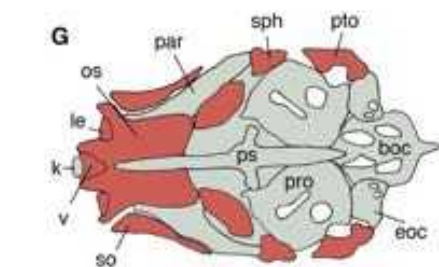
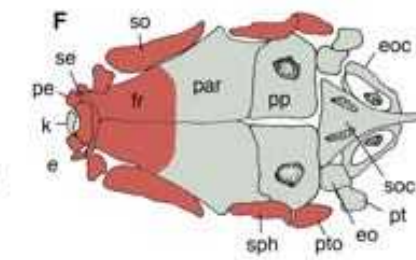
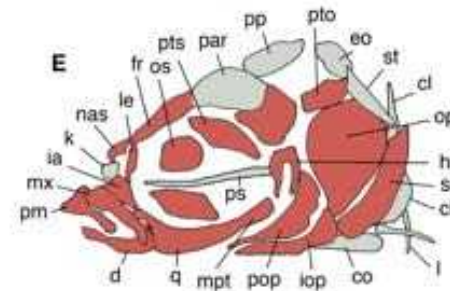
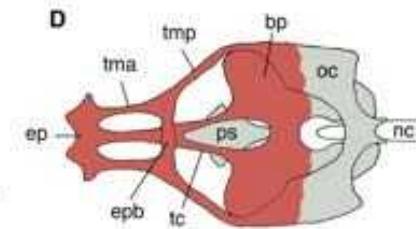
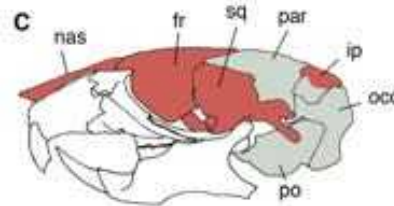
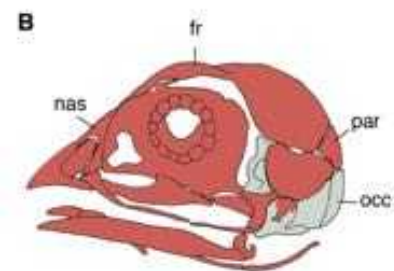
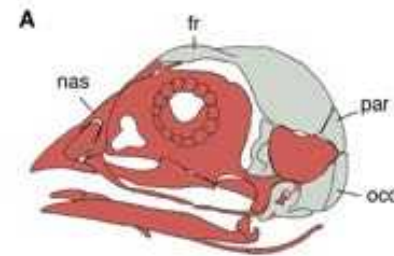
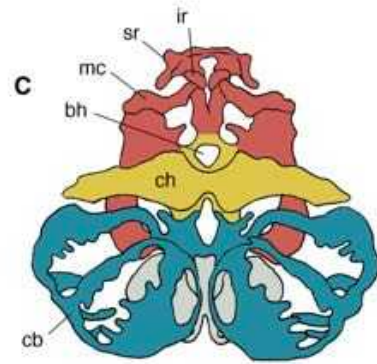
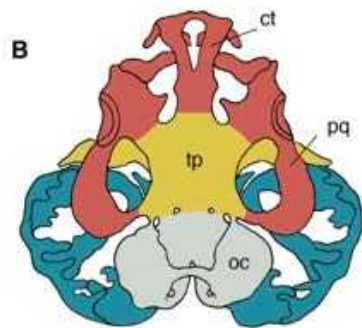
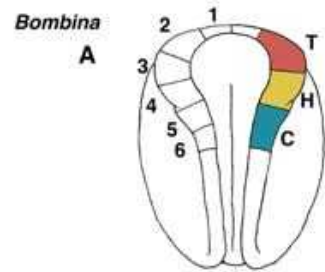
Contruindo um cordado: a cresta neural

a Vertebrate neural crest development



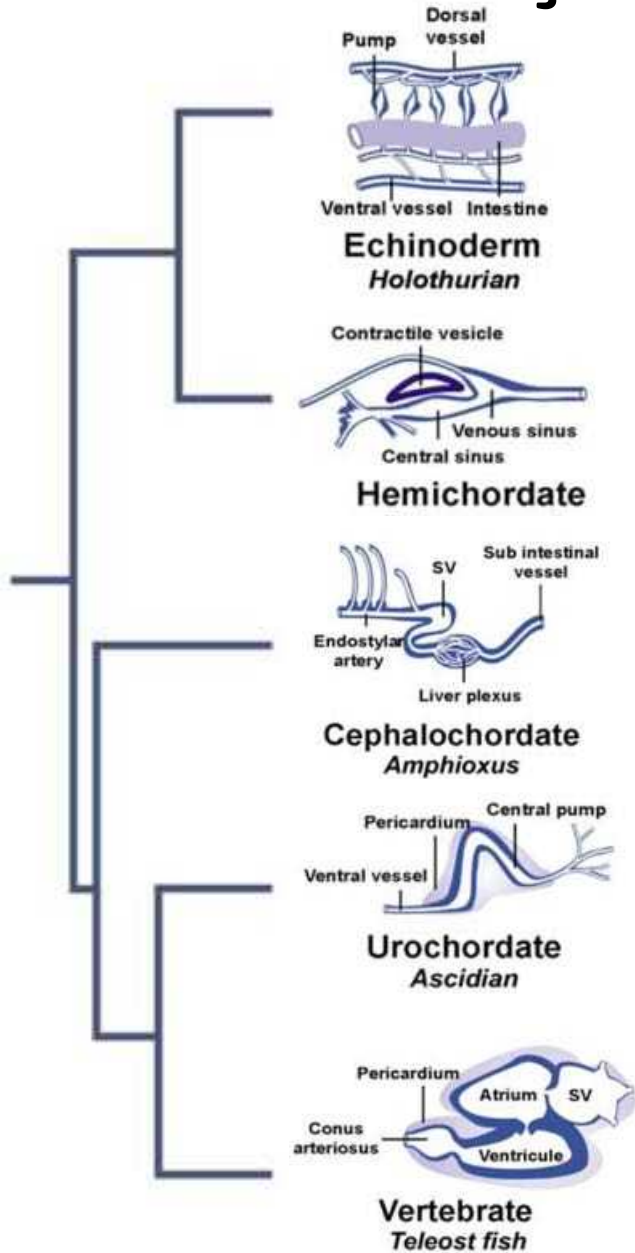


Neural crest and evolution of vertebrate head

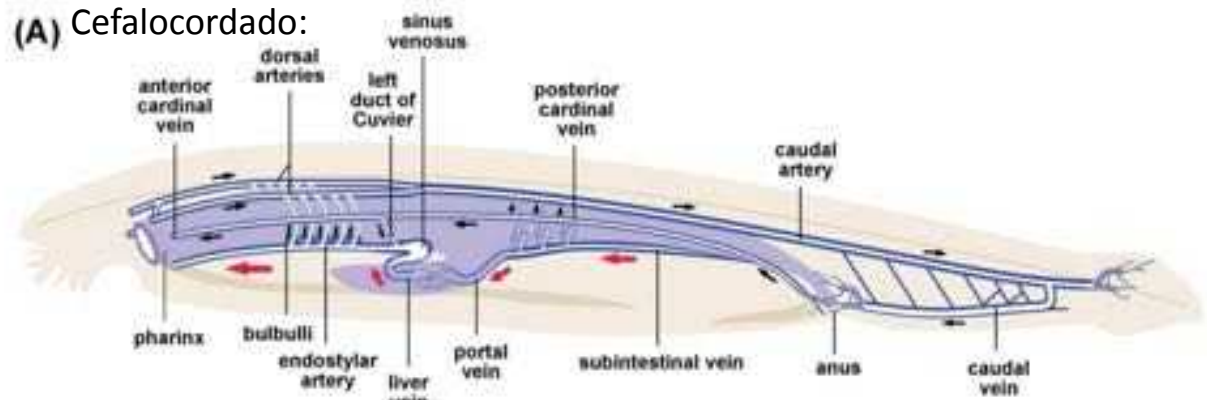


■ neural crest-derived
■ non crest-derived
■ unassigned

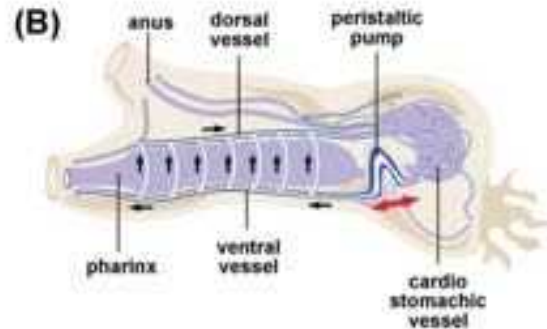
Contruindo um cordado: coração e sistema circulatório



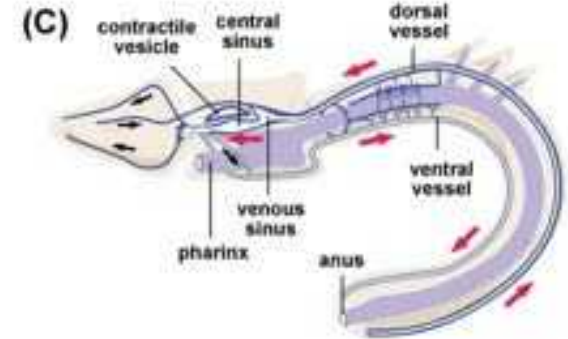
(A) Cefalocordado:



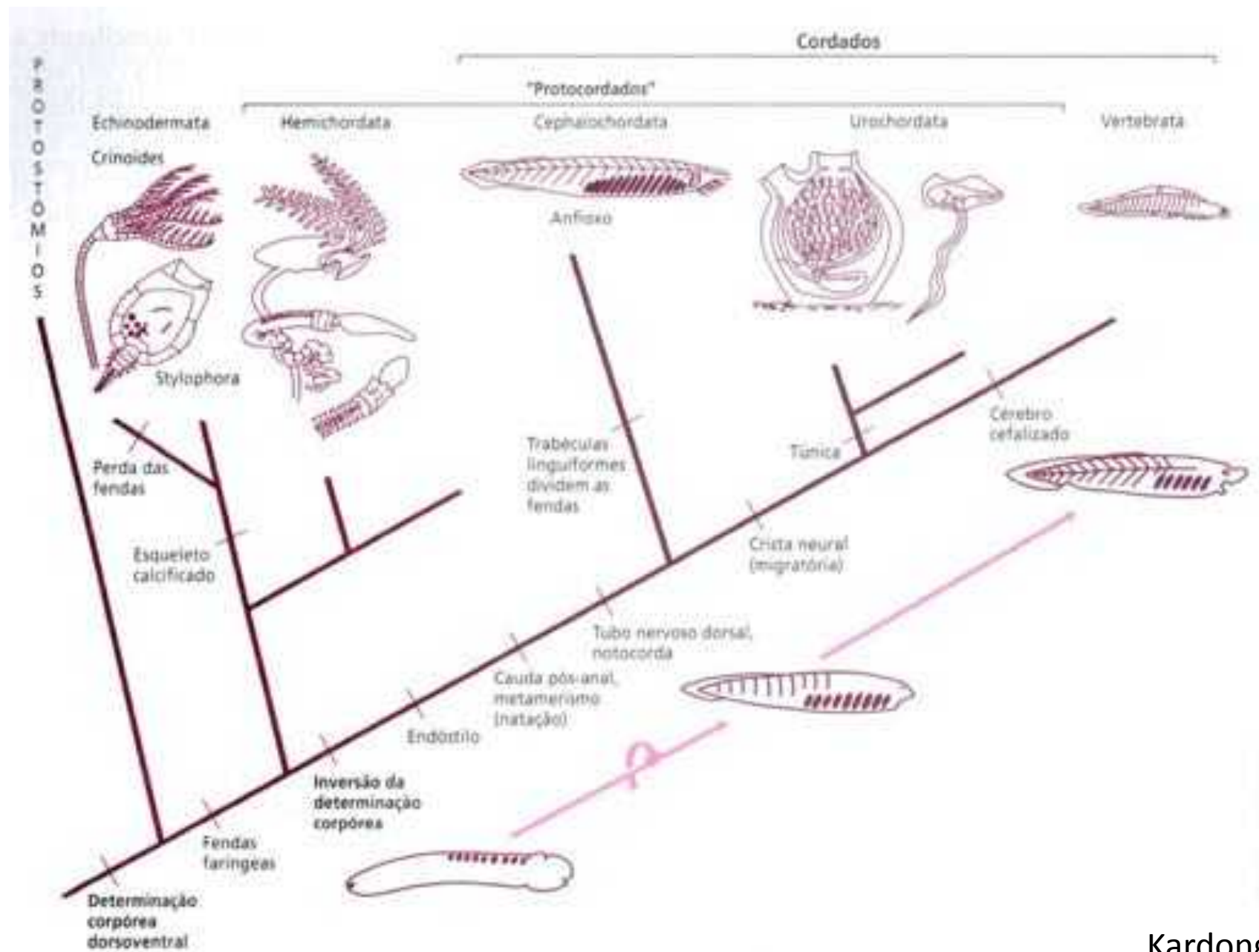
Tunicado:



Hemicordado:

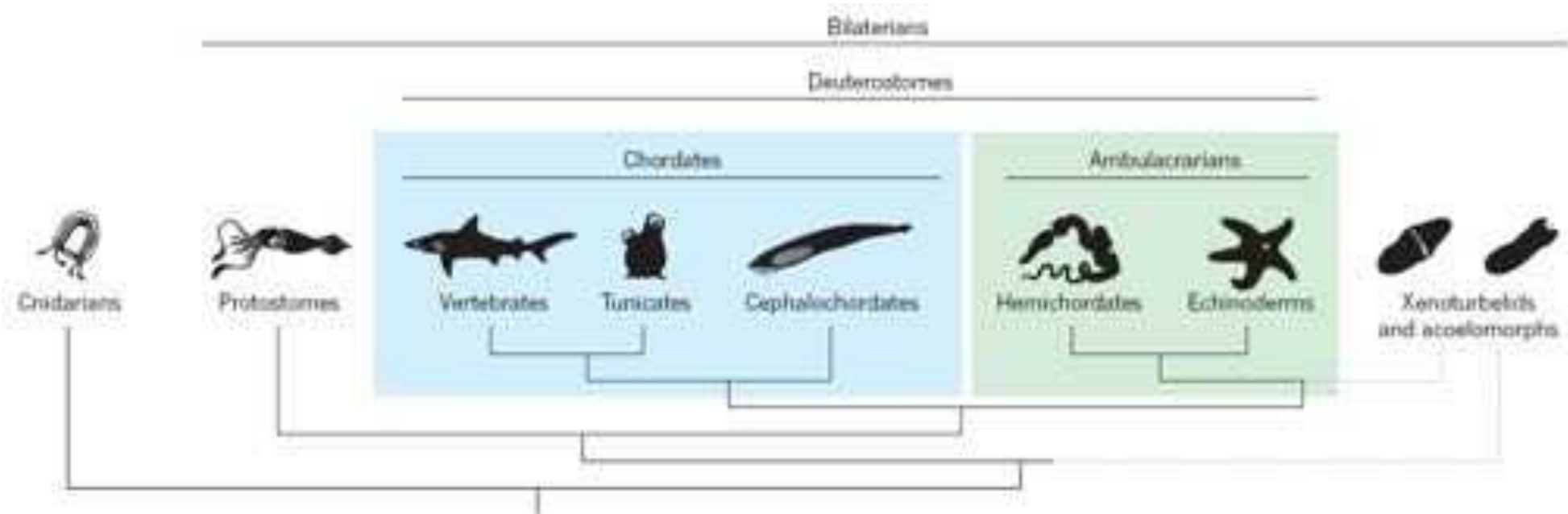


Contruindo um cordado: resumo



The deuterostome context of chordate origins

Christopher J. Lowe¹, D. Nathaniel Clarke¹, Daniel M. Medeiros², Daniel S. Rokhsar^{3,4,5} & John Gerhart³



Hemichordata

Enteropneusta

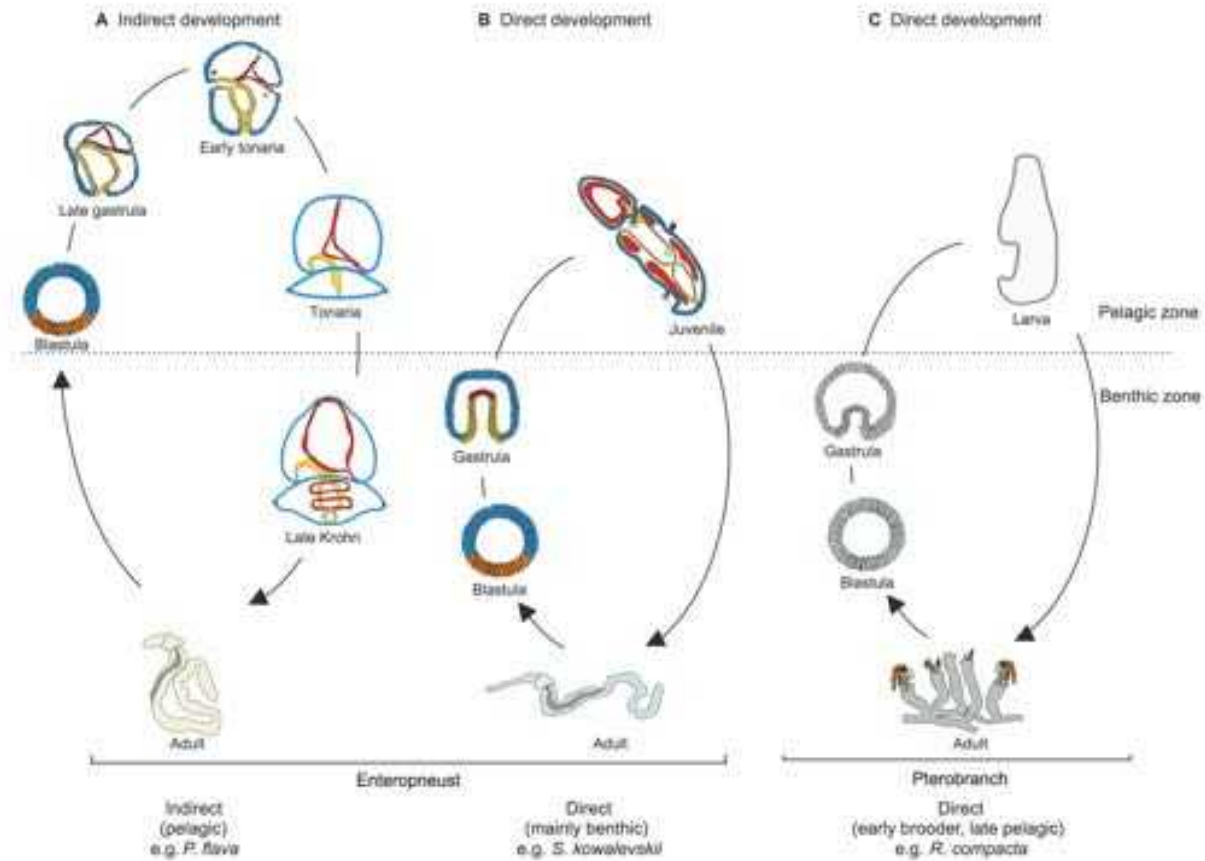


Saxipendium coronatum

Pterobranchia



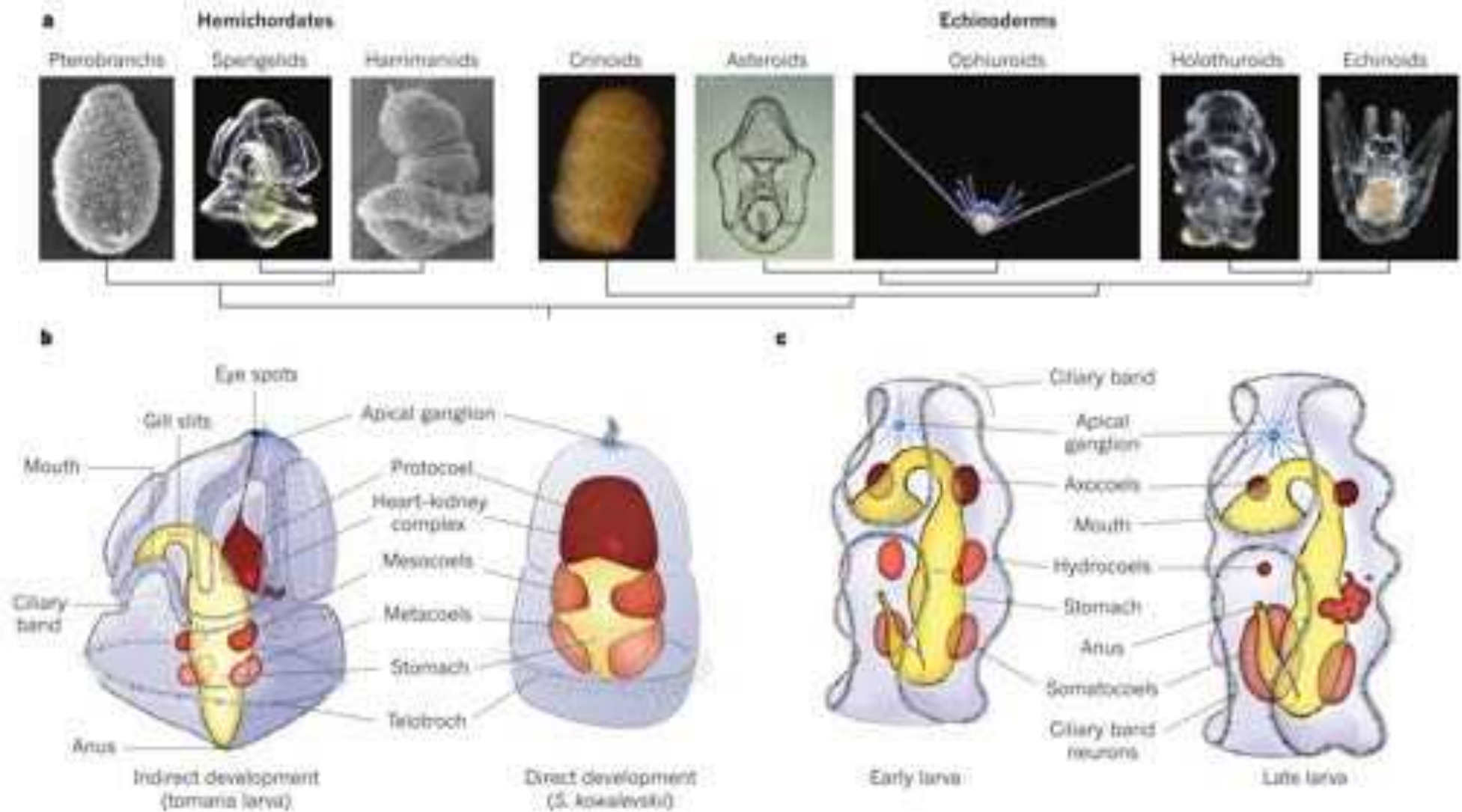
Cephalodiscus sp.



Características gerais

- Marinhos, quase todos bentônicos
- Bilateria, celomados, deuterostômios
- Corpo vermiforme, trimérico
- Fendas faríngeas
- Possuem um curto cordão nervoso dorsal, por vezes oco
- Dióicos, com reprodução assexuada

Hemichordata



Hemichordata

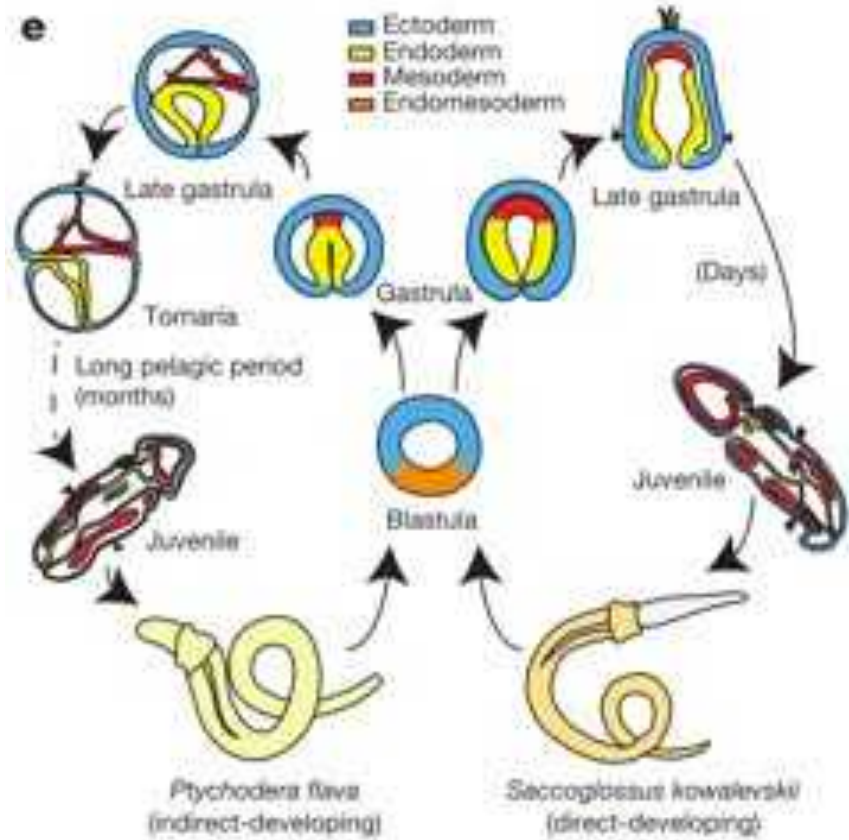
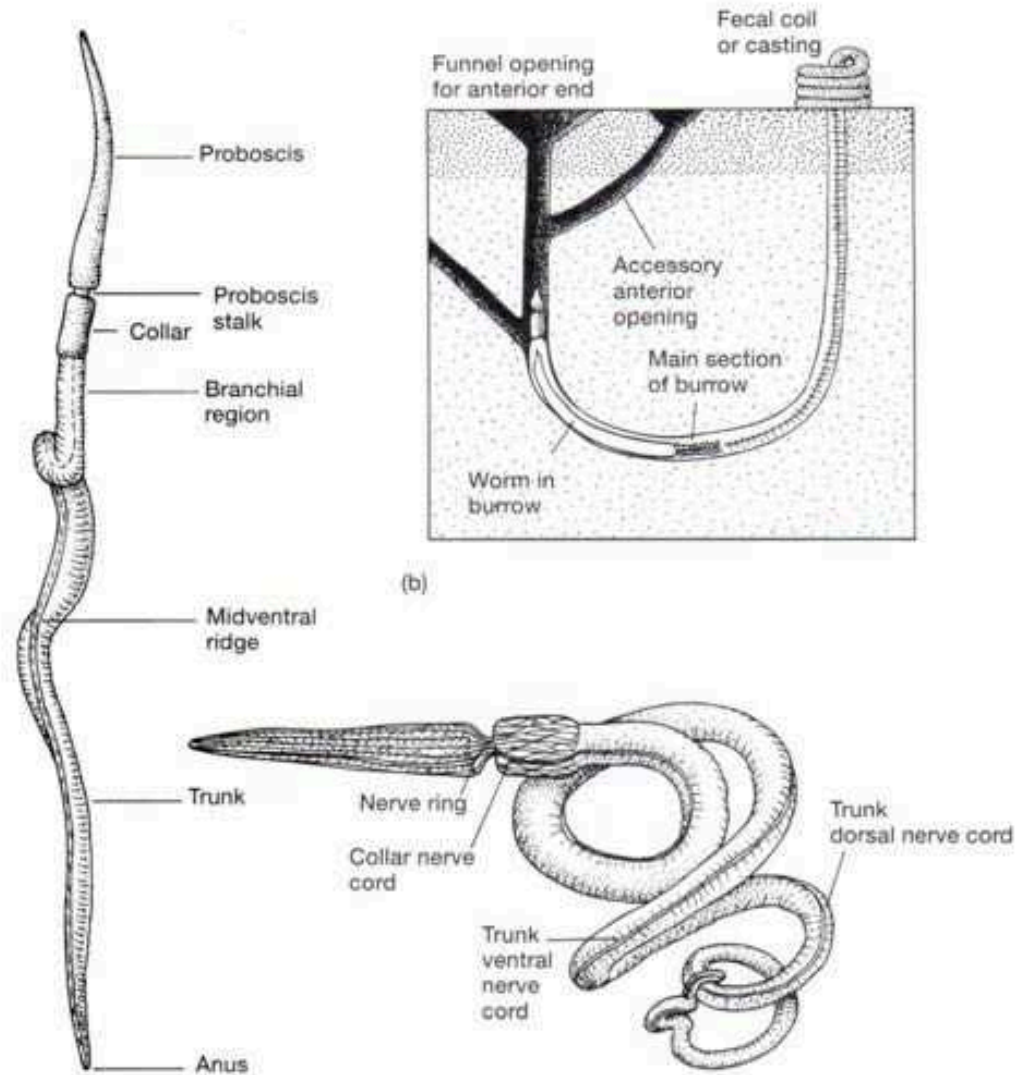
Auricularia (Holothuroidea)

Enteropneusta

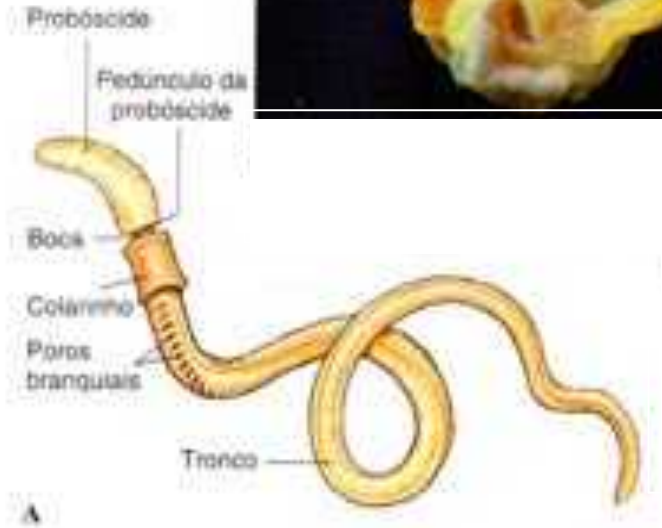
- Cerca de 75 espécies
- Grupo mais bem conhecido
- Formato vermiforme, comuns em praias arenosas
- Algumas espécies muito grandes (>2m)



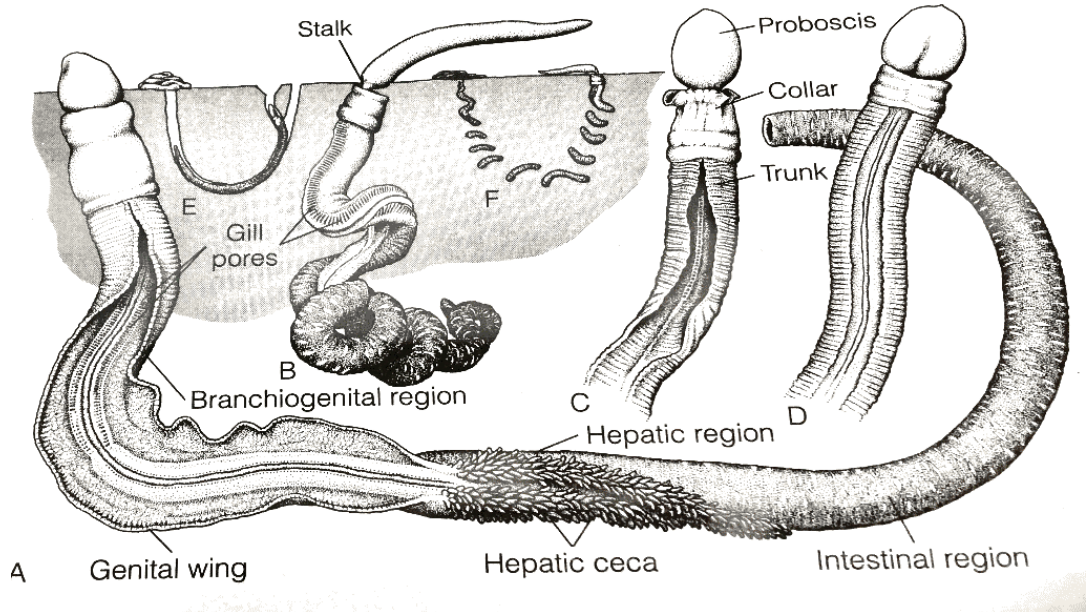
Modo de vida



Anatomia

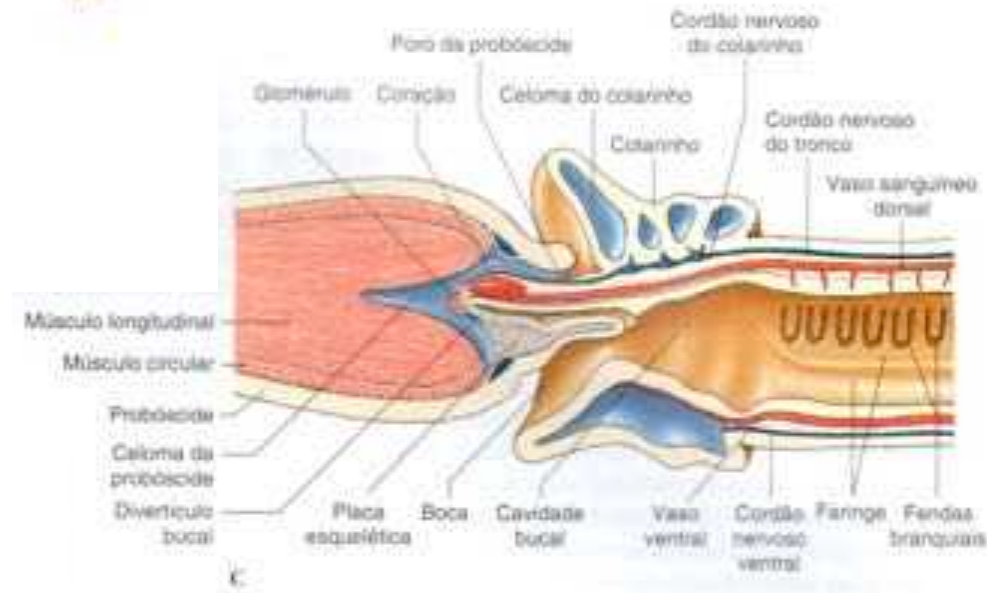


Saccoglossus kowalevskii



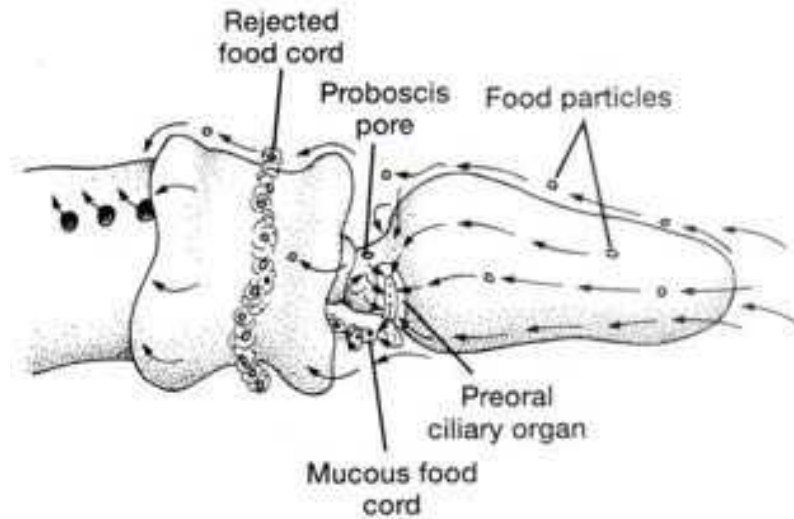
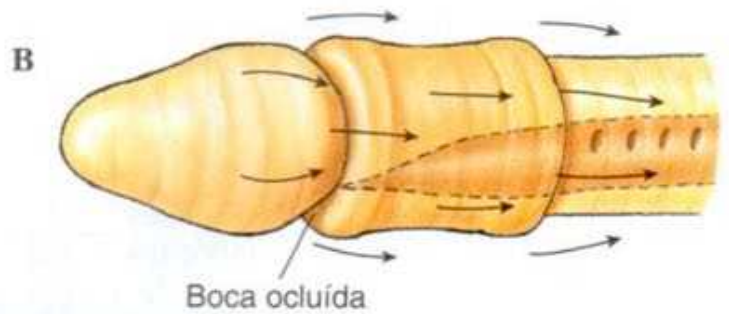
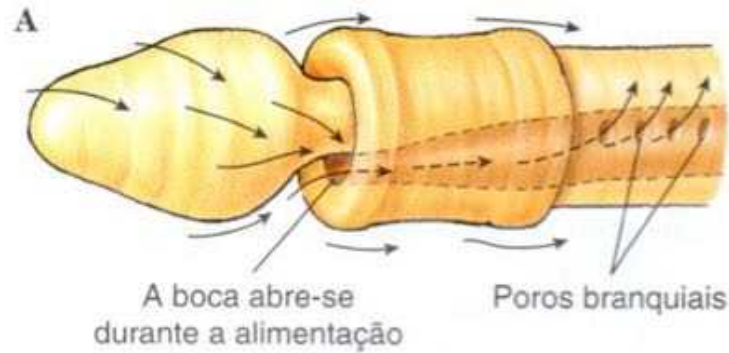
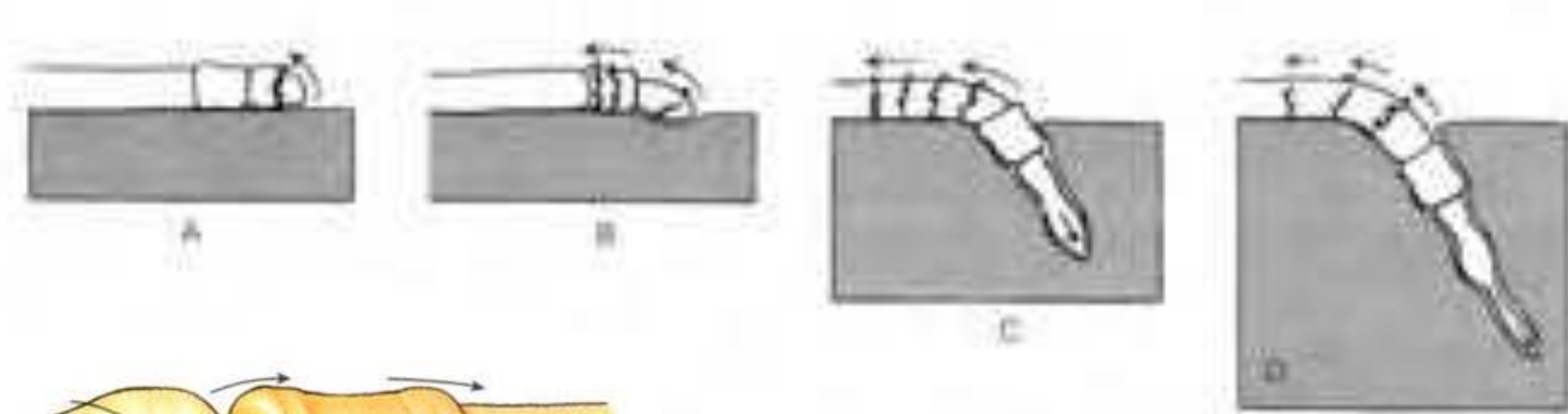
Balanoglossus aurantiacus

Ruppert, 2004



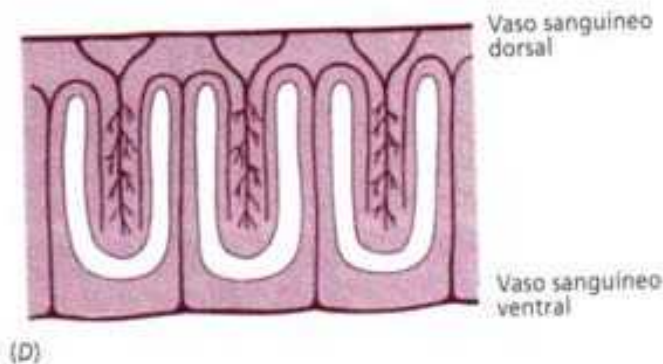
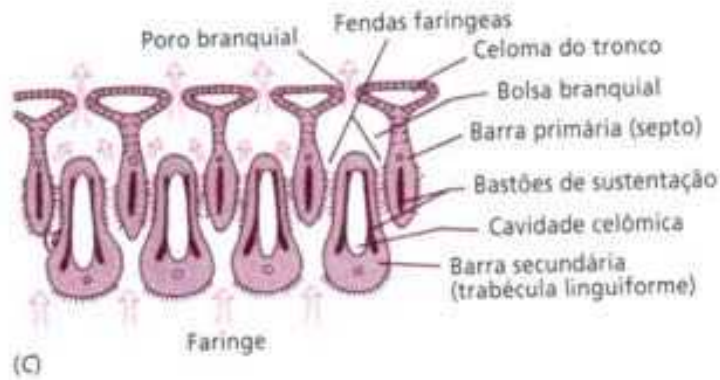
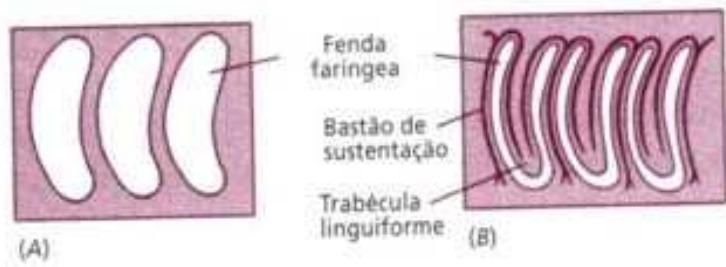
Hickman

Alimentação



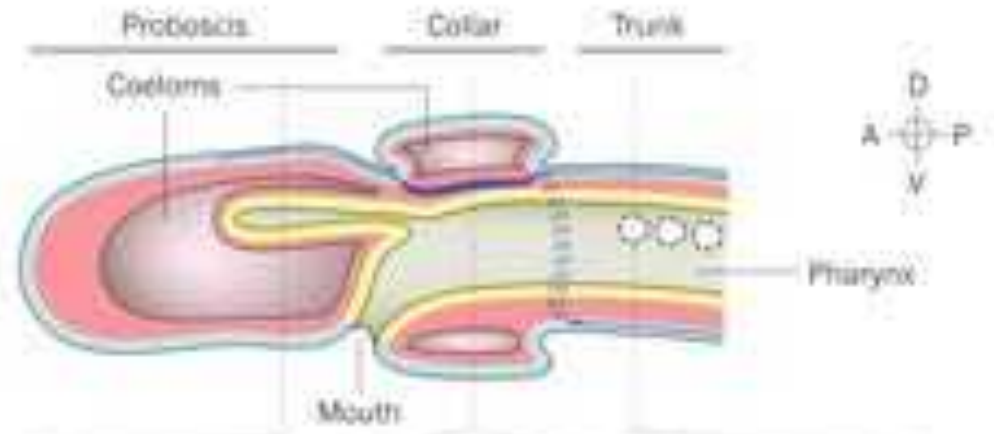
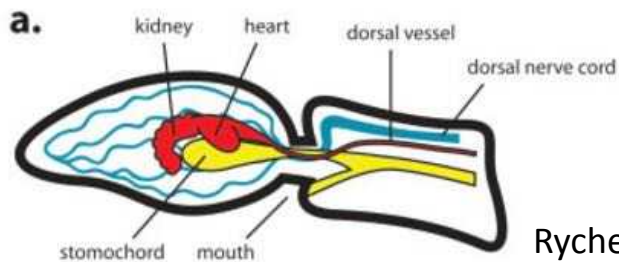
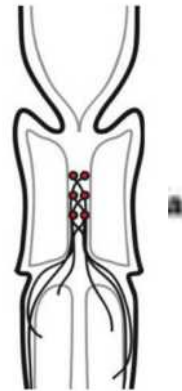
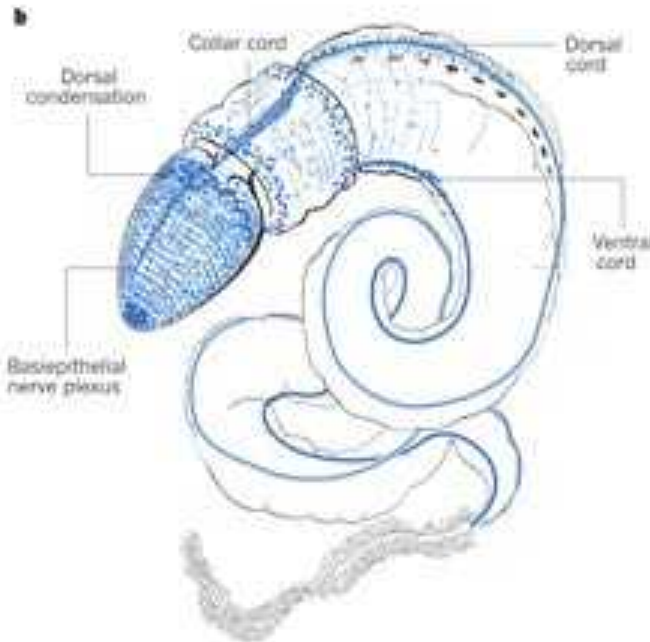
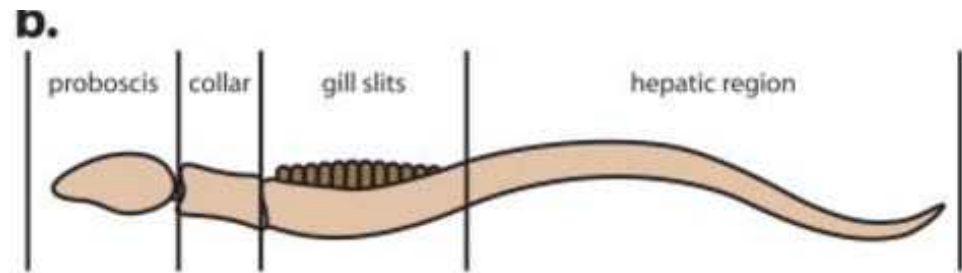
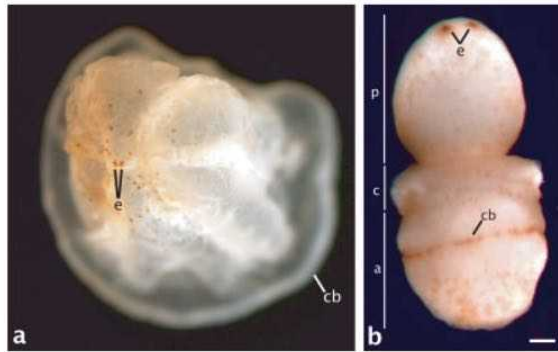
Hickman

Sistema faríngeo

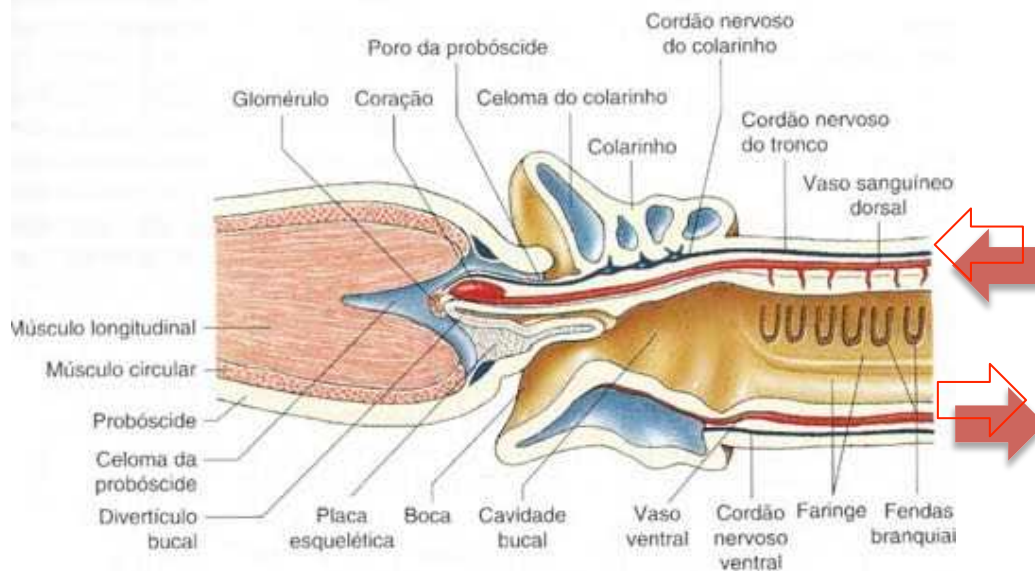
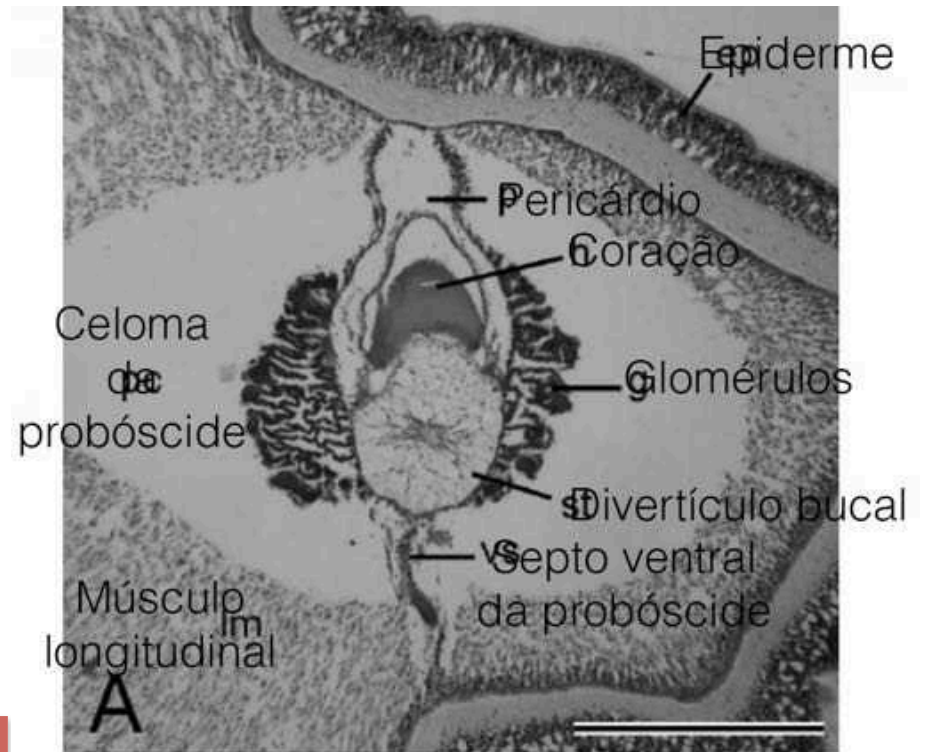
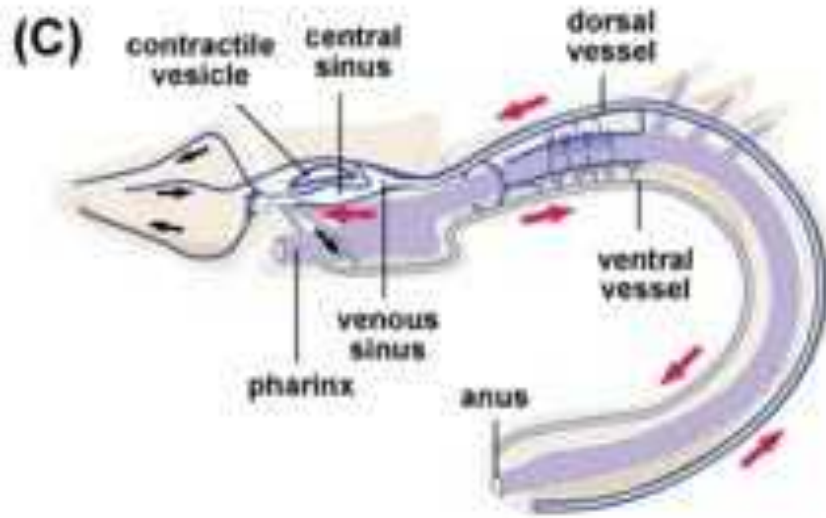


Não há brânquias nas fendas faríngeas, mas alguma troca de gases respiratórios ocorre no epitélio vascular faríngeo e, também, na superfície do corpo.

Sistema nervoso



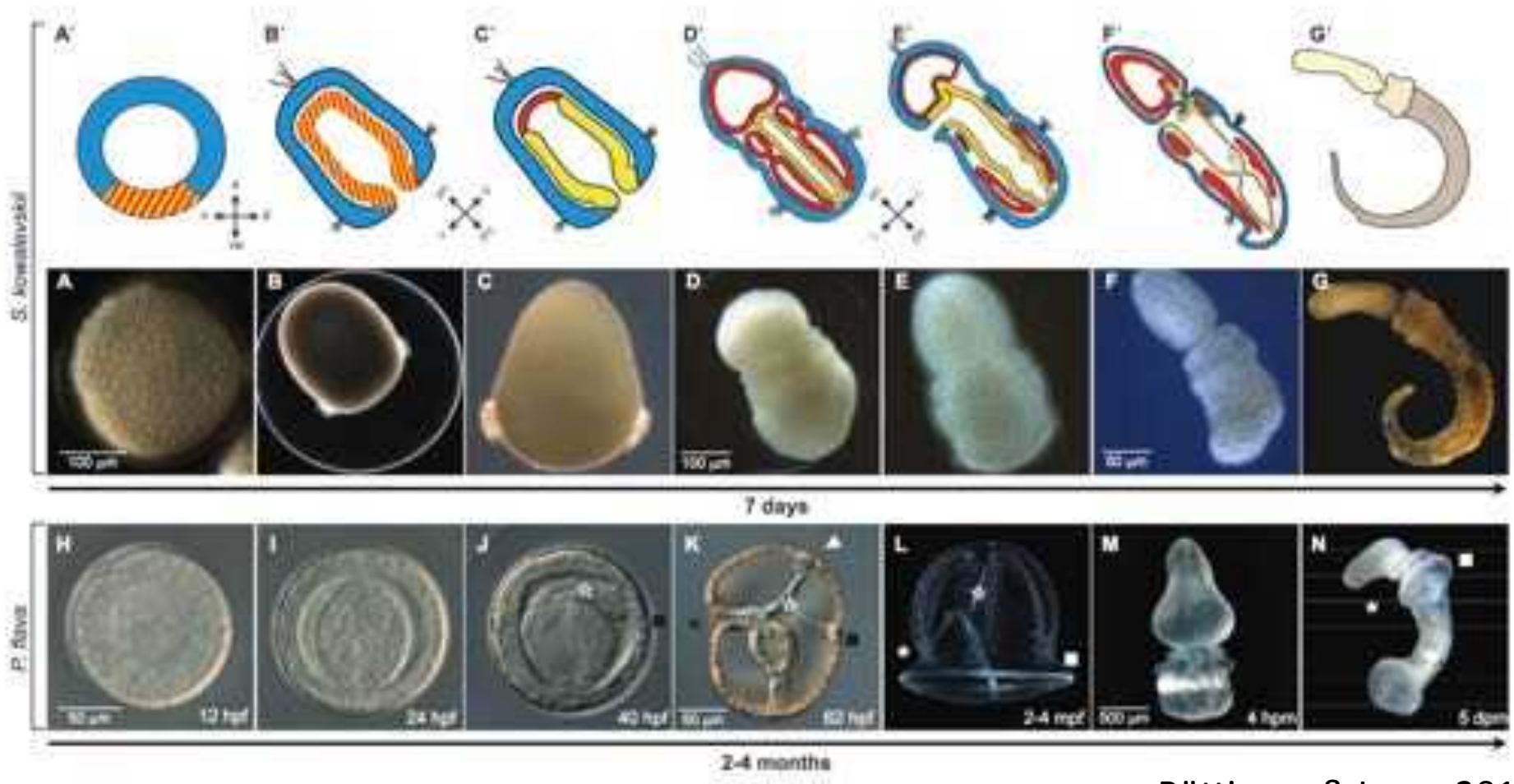
Circulação e excreção



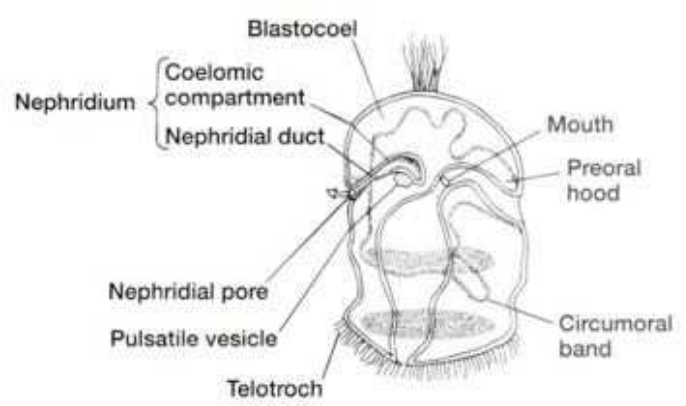
Cortesia T. Lotufo

Reprodução

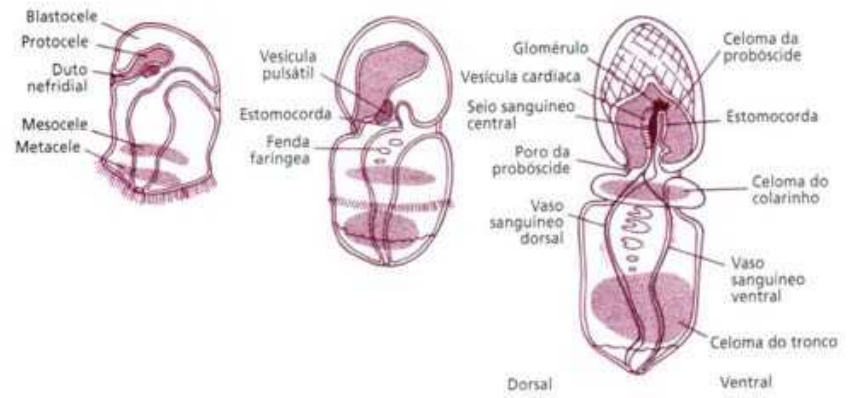
- Dióicos, com estágio larval (tornária)
- Alto poder de regeneração, mas geralmente se reproduzem apenas de forma sexuada
- Juvenis possuem uma cauda pós-anal longa para fixação no substrato



Röttinger & Lowe 2010



Kardong



Pterobranchia

- 26 espécies, em 2 gêneros (*Cephalodiscus* e *Rhabdopleura*)
- Hemicordados coloniais
- Vivem em tubos aderidos a substratos duros
- Geralmente pequenos (1-5 mm)
- Anatomicamente possuem muitas semelhanças com os Enteropneusta

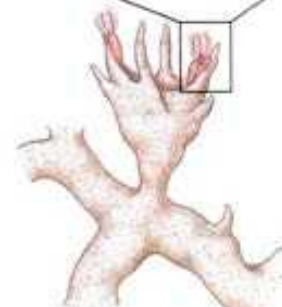
Pterobranchia



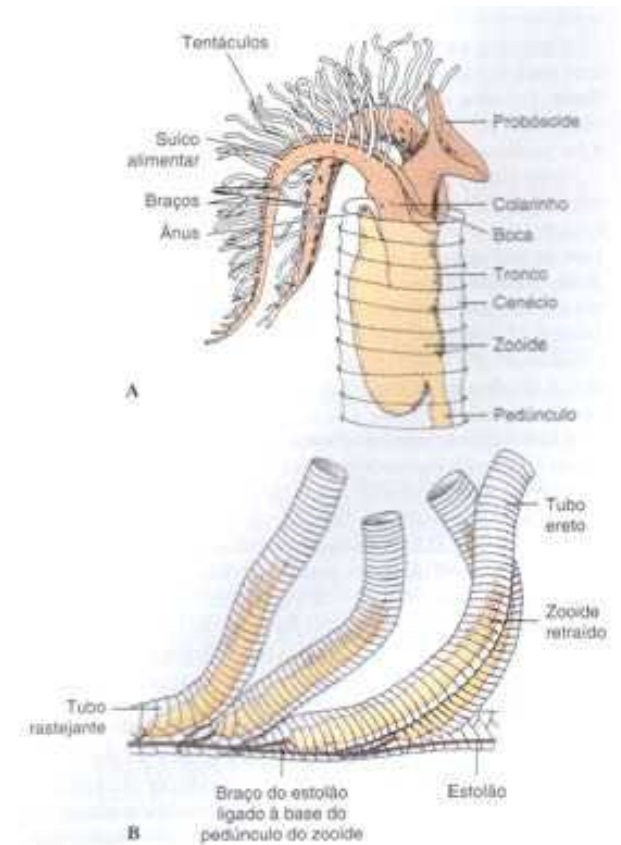
Rhabdopleura normani



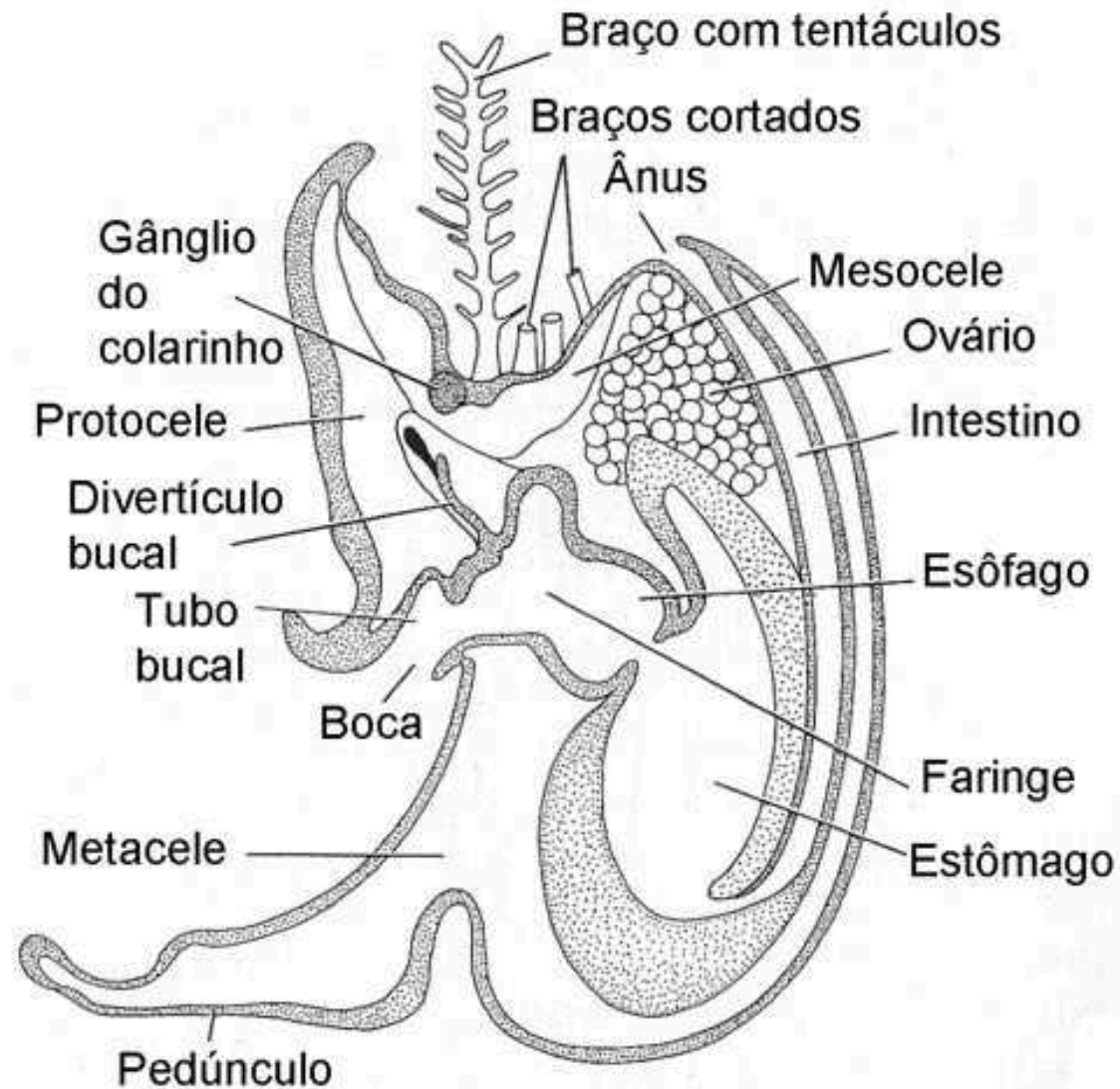
Cephalodiscus gracilis



Colônia de *Cephalodiscus*



Anatomia *Cephalodiscus*



Reprodução

- Assexuada por brotamento a partir de um estolão basal ou disco adesivo
- Colônias hermafroditas, mas zoóides são machos ou fêmeas, com dimorfismo.
- Machos liberam o esperma na água
- Fêmeas retêm os ovócitos no cenécio
- Estágio larval curto

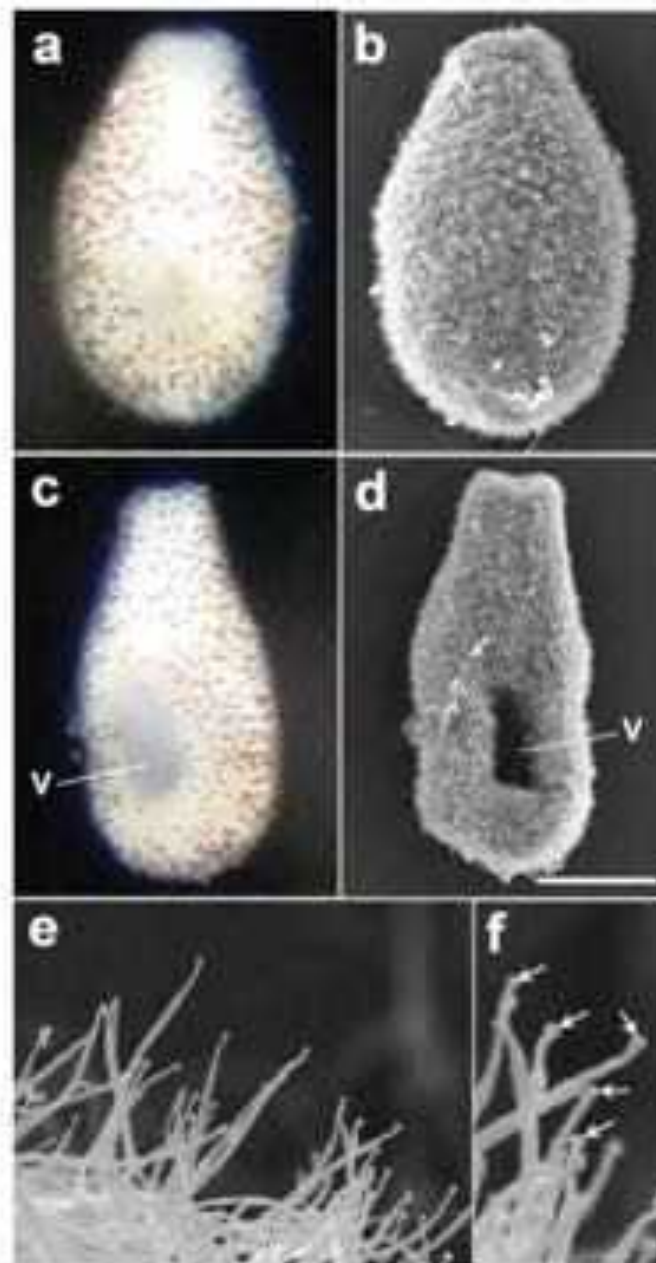
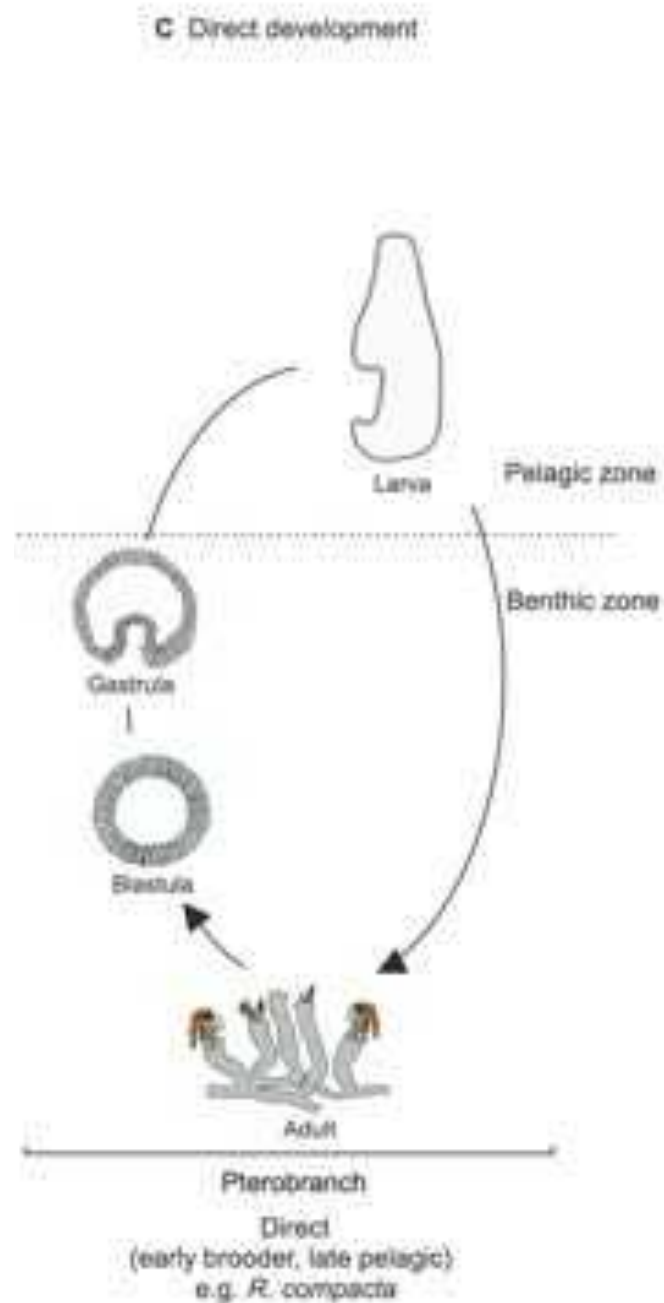
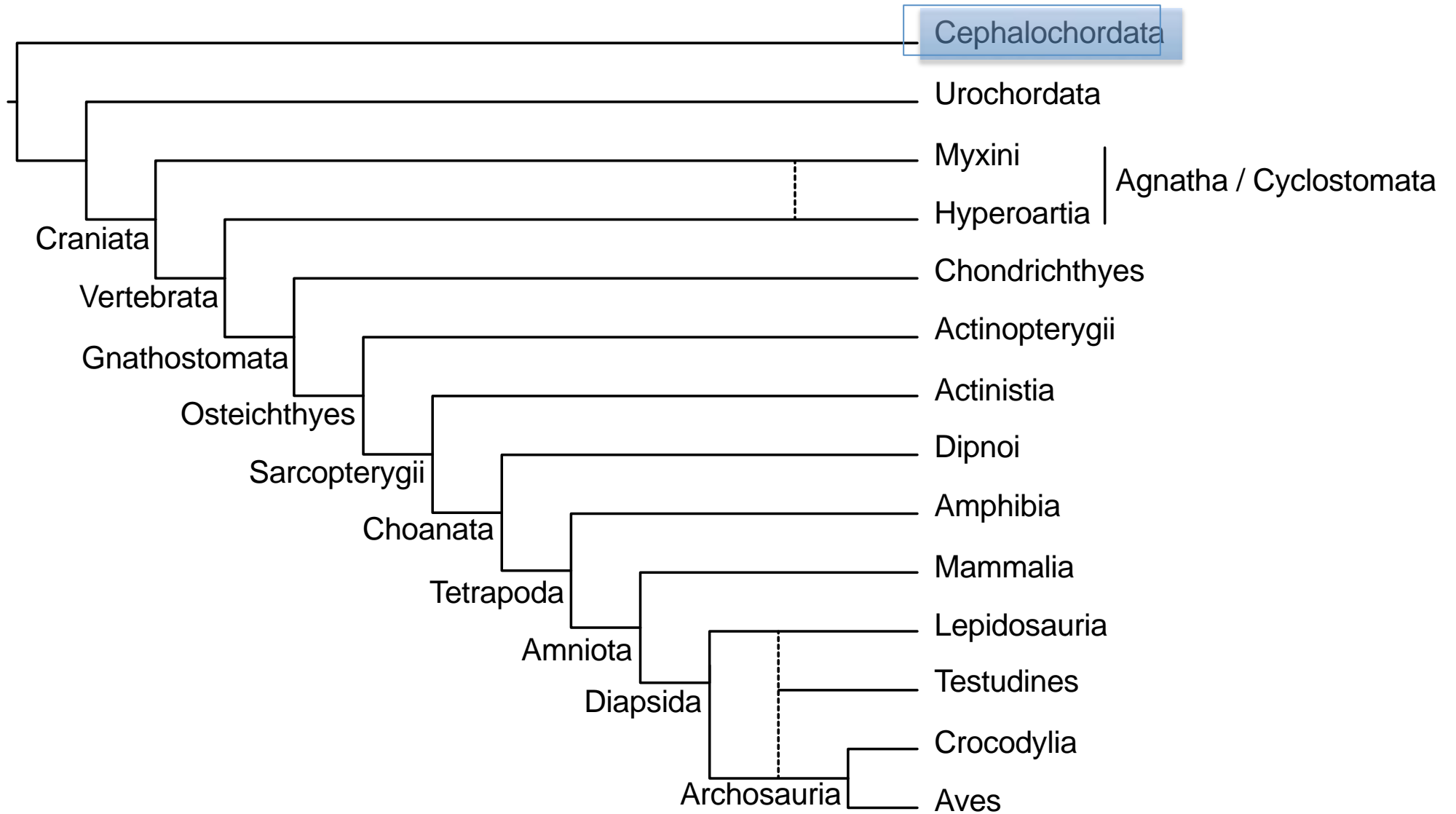
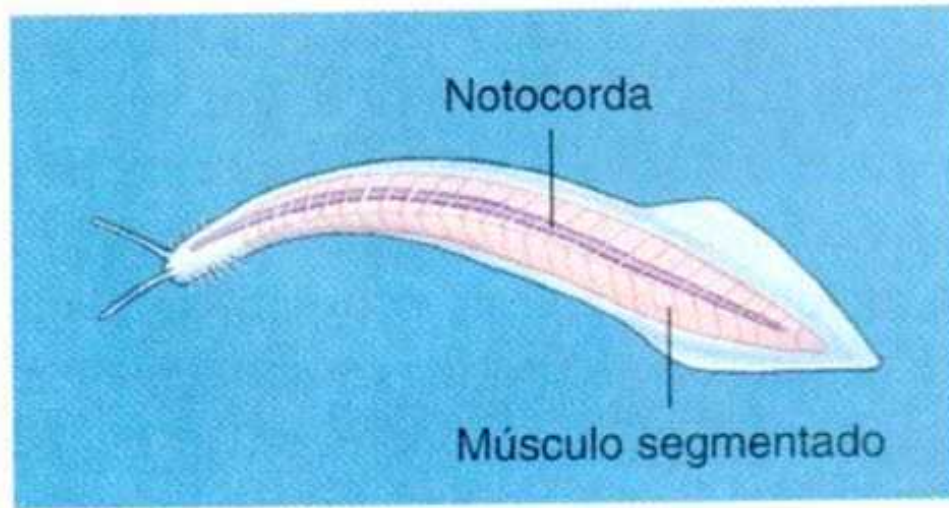


FIG. 2. Larval form of *R. compacta*. (a) Dorsal view of a larva showing pigmentation, light microscopy; (b) Dorsal view of larva showing cilia, SEM; (c) Ventral view of a larva showing pigmentation and ventral depression, light microscopy; (d) Ventral view of larva, SEM. Larva in a and b is different from the larva shown in c and d; v, ventral depression. (e) Cilia of larva showing peculiar shape at the tip, magnified in (f) (arrows). Scale bar: 20 μm .

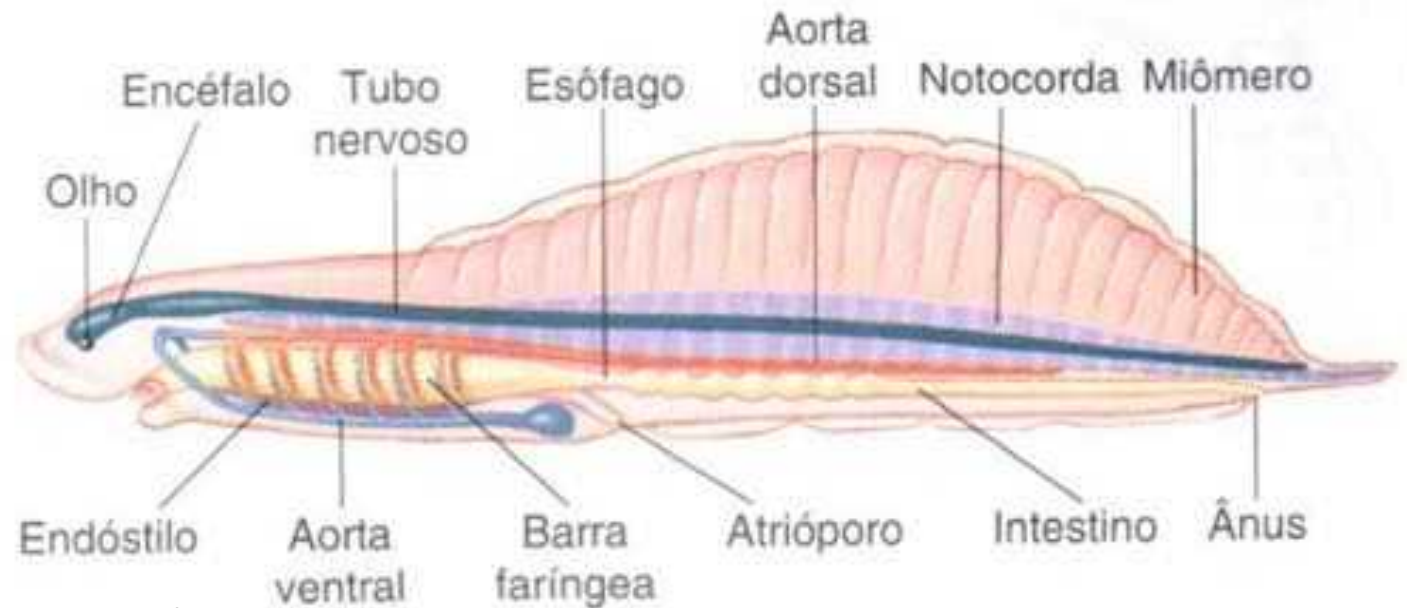
Filogenia de Chordata



Cordados fosseis



Pikaia (cefalocordado)



Haikohuella
(taxón-irmão dos vertebrados?)

Cephalocordata

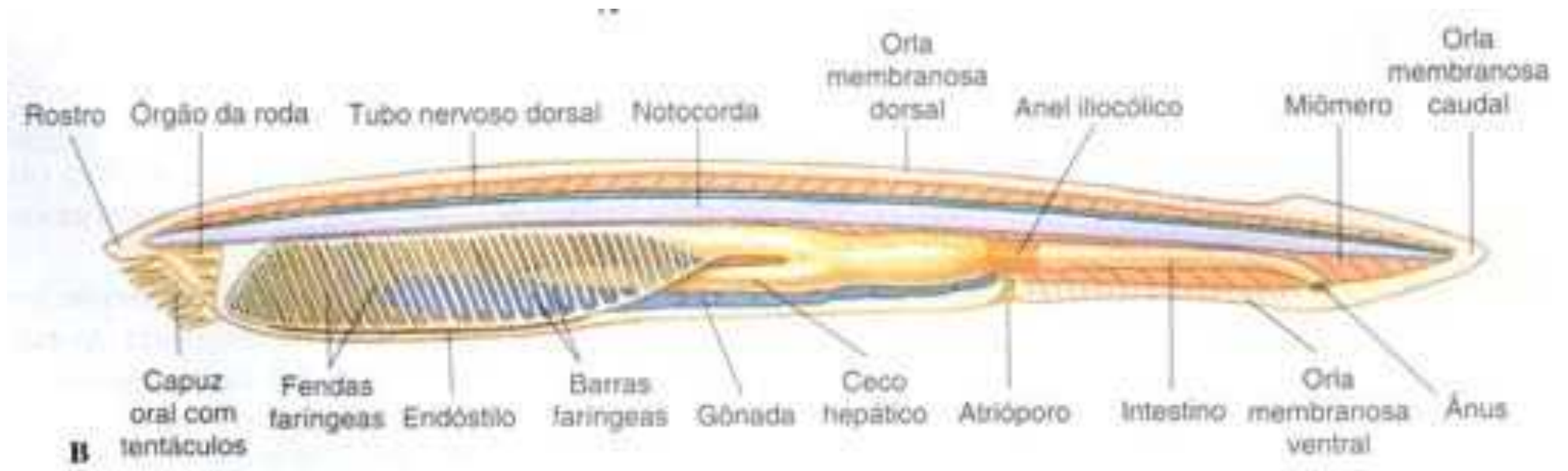
- Ficaram conhecidos como "anfioxos"
- 30 espécies descritas em 3 gêneros
- Marinheiros e estuarinos



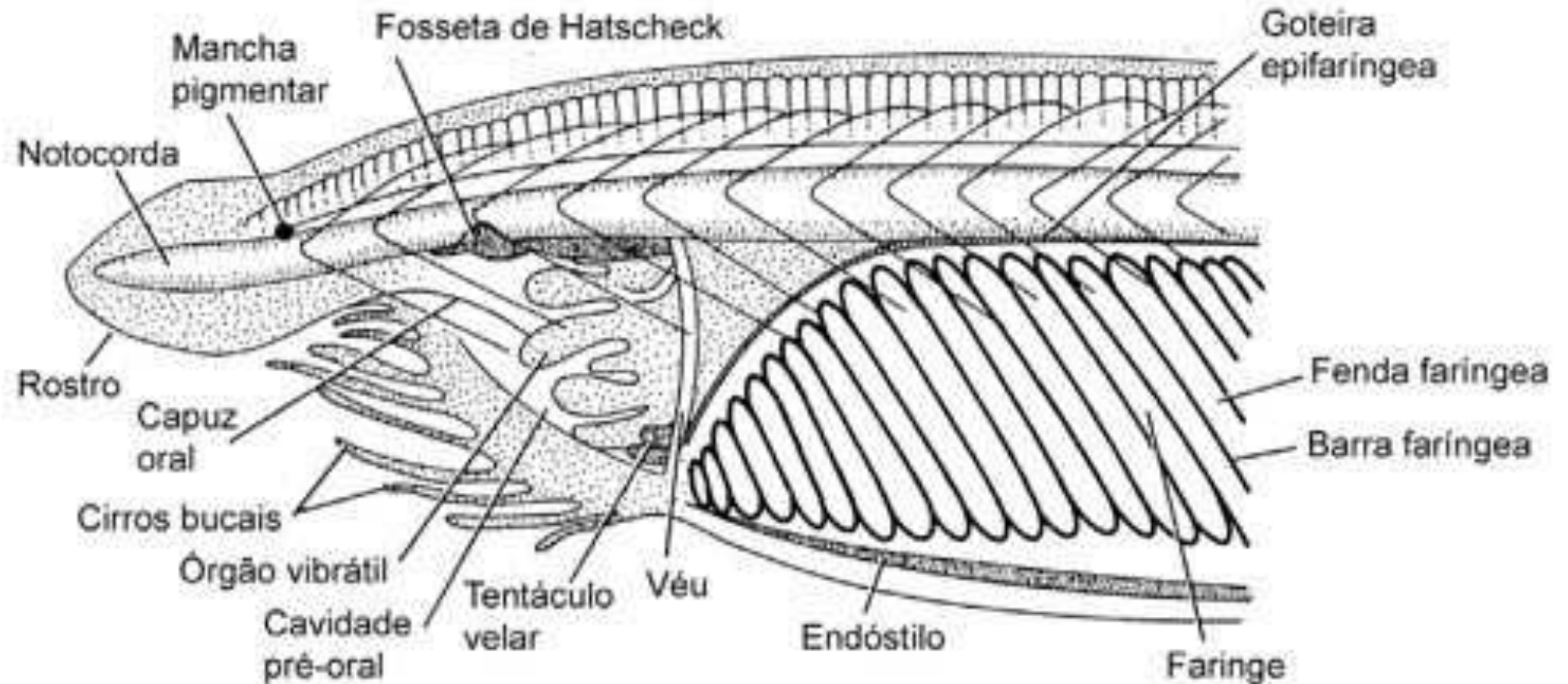
Importância Econômica

- Na China, a pesca de cefalocordados chegou a 35 toneladas (1 bilhão de indivíduos), próximo a Xiamen, em uma área de apenas 11 Km .
- São consumidos em grande quantidade no sudeste asiático
- No Brasil, alguns pequenos produtores levam suas galinhas na maré baixa para se alimentarem deste animais

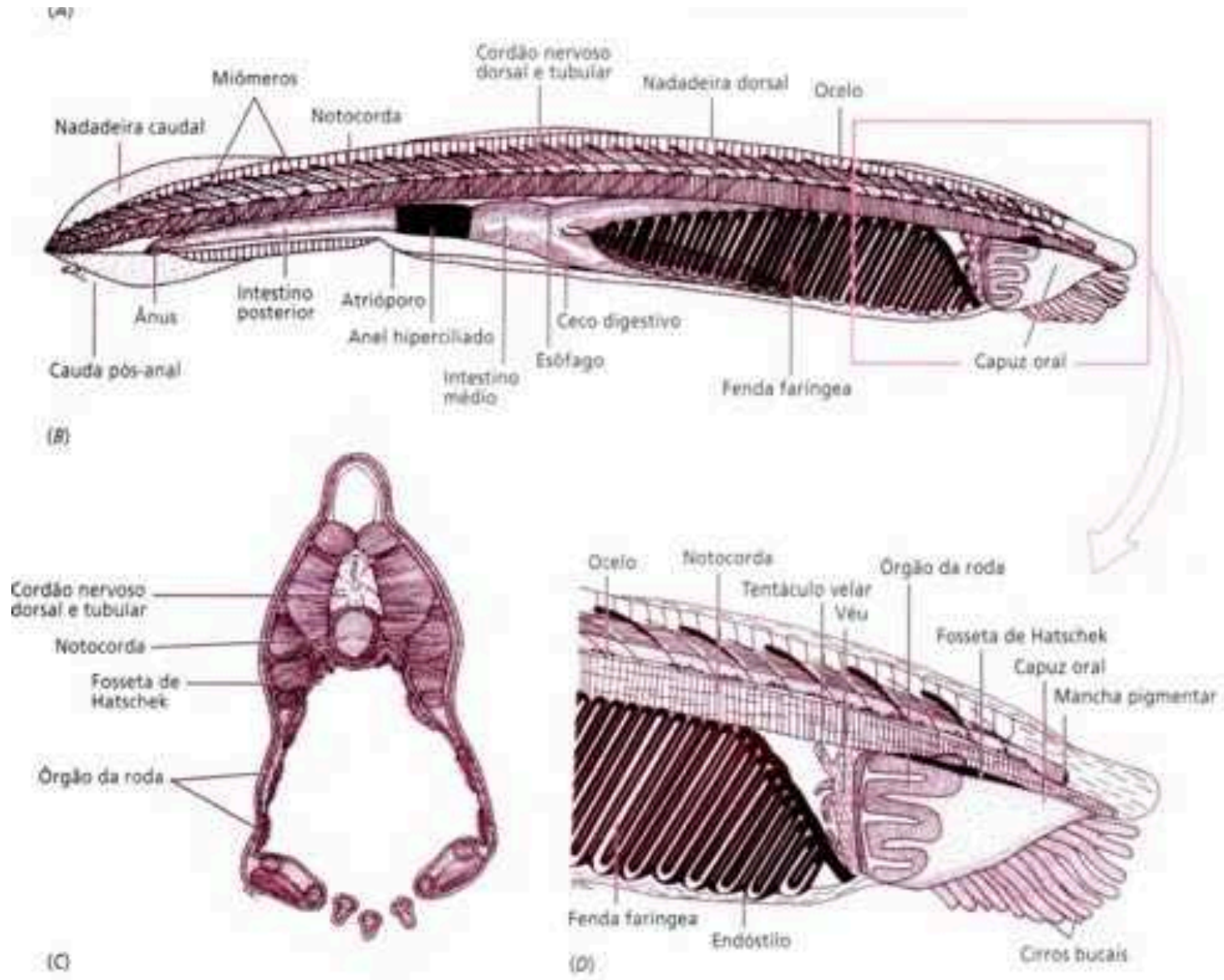
Anatomia



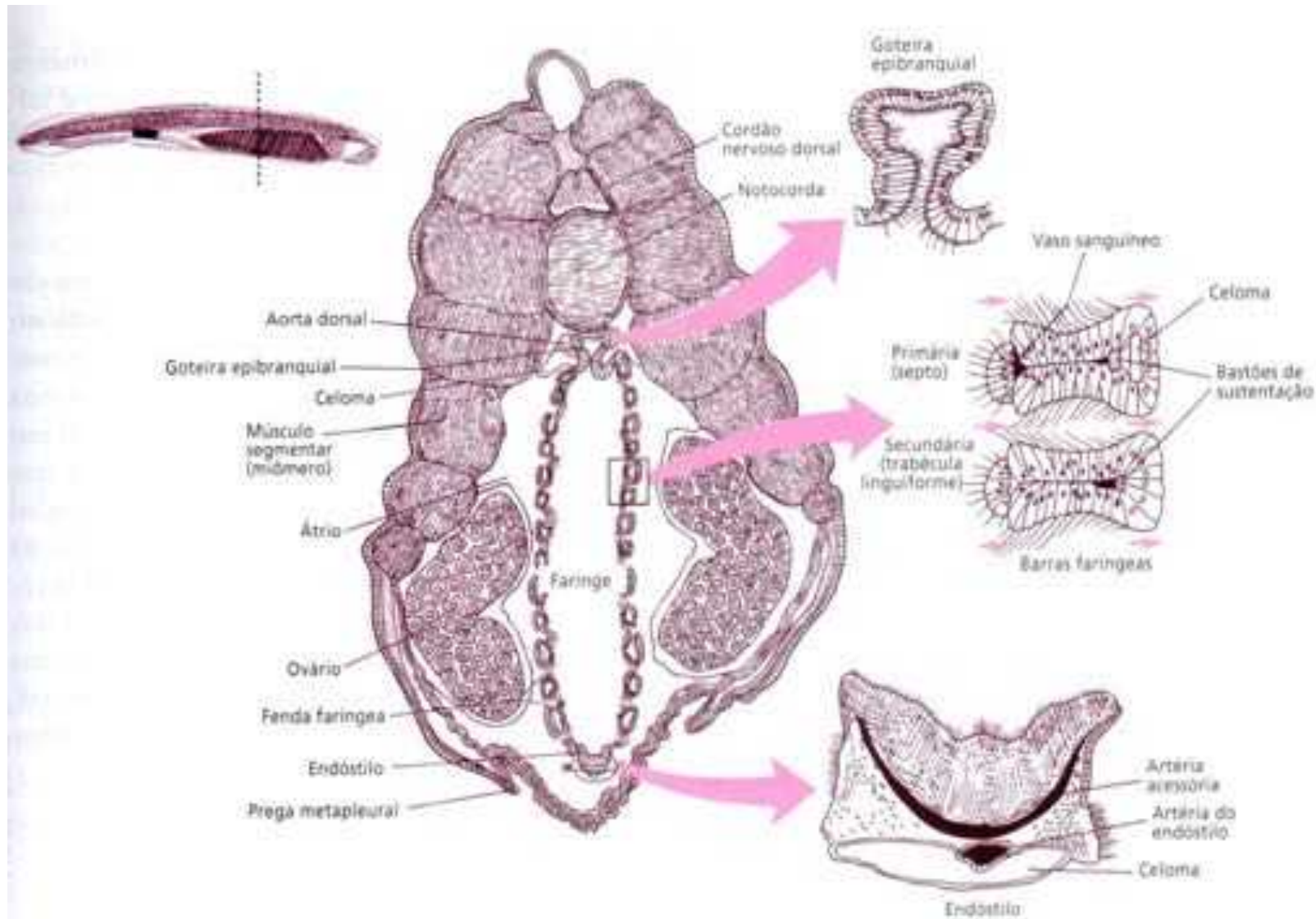
Anatomia: região anterior



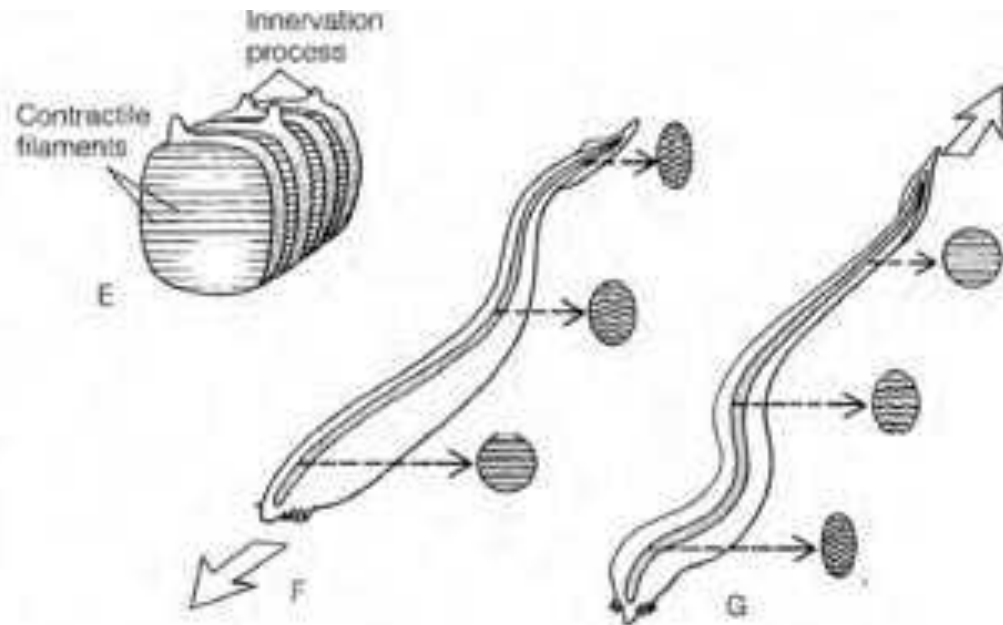
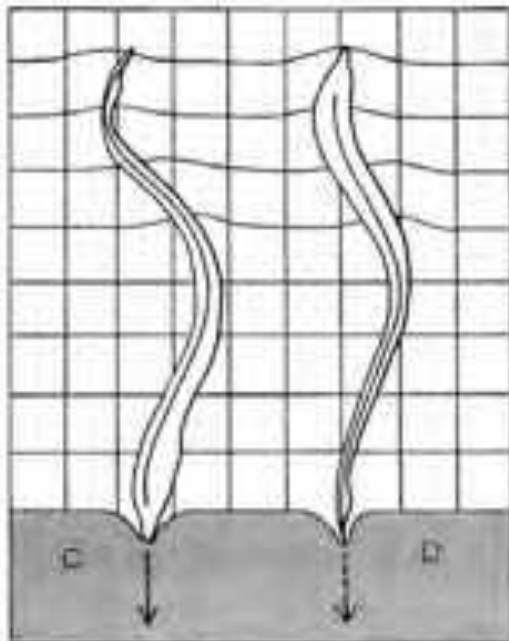
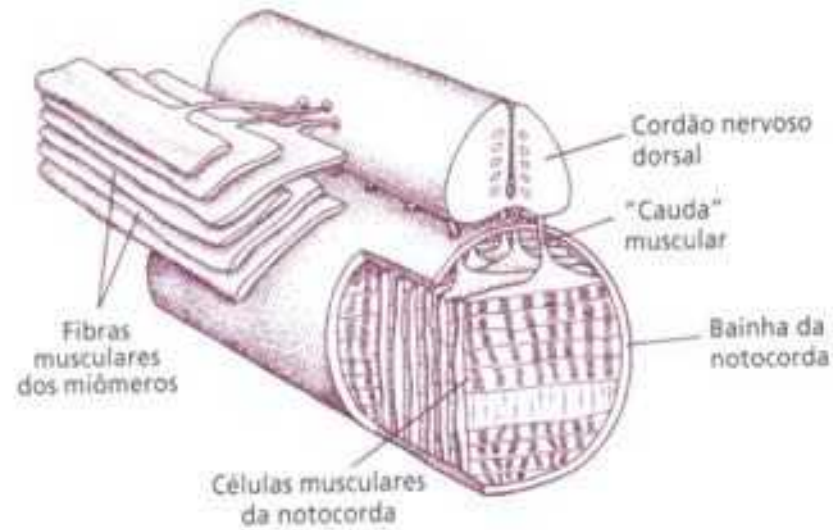
Anatomia: região anterior



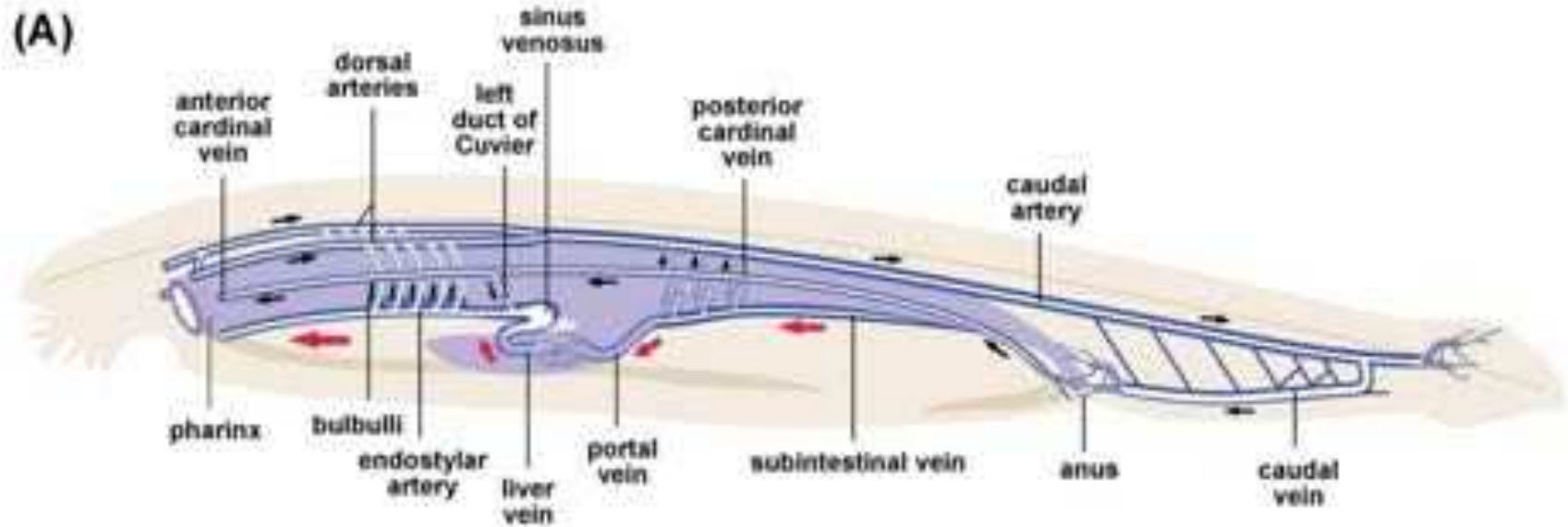
Anatomia: região da faringe



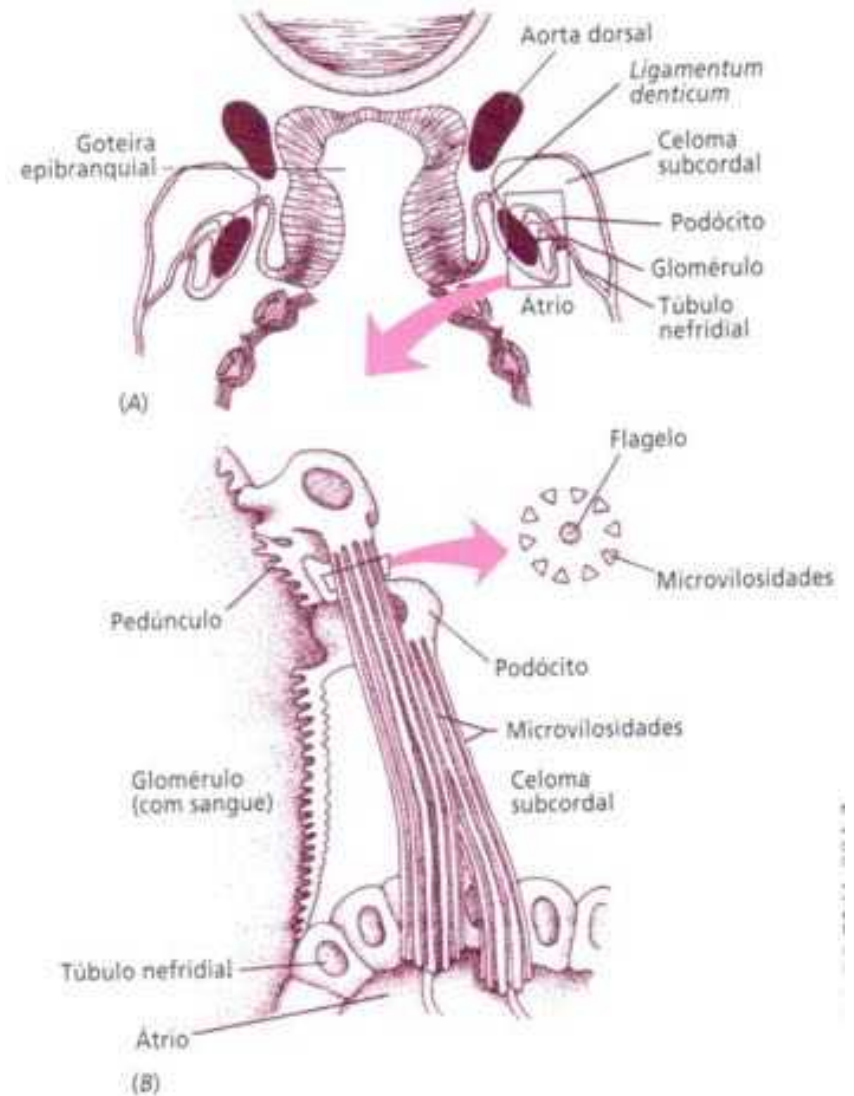
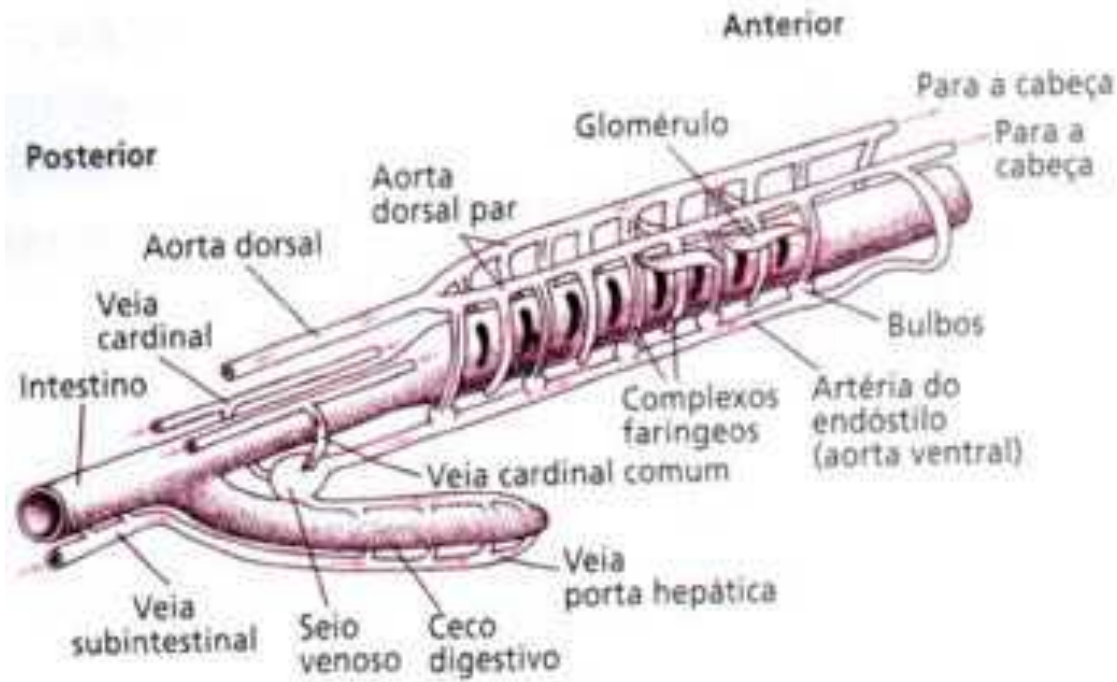
Notocorda e locomoção



Circulação



Circulação e excreção



Kardong

Reprodução



Gônada feminina



Gônada masculina

Desenvolvimento larval

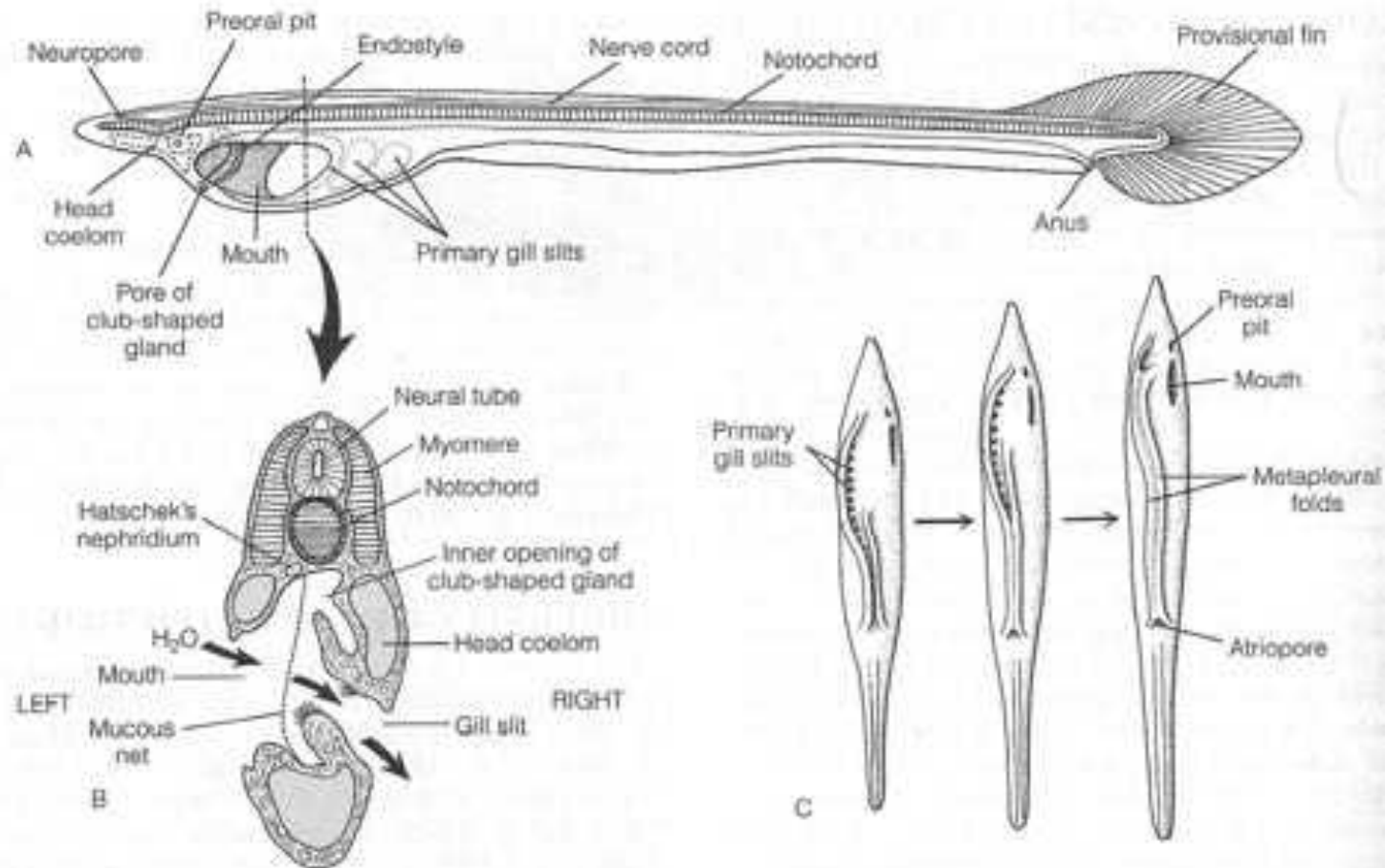
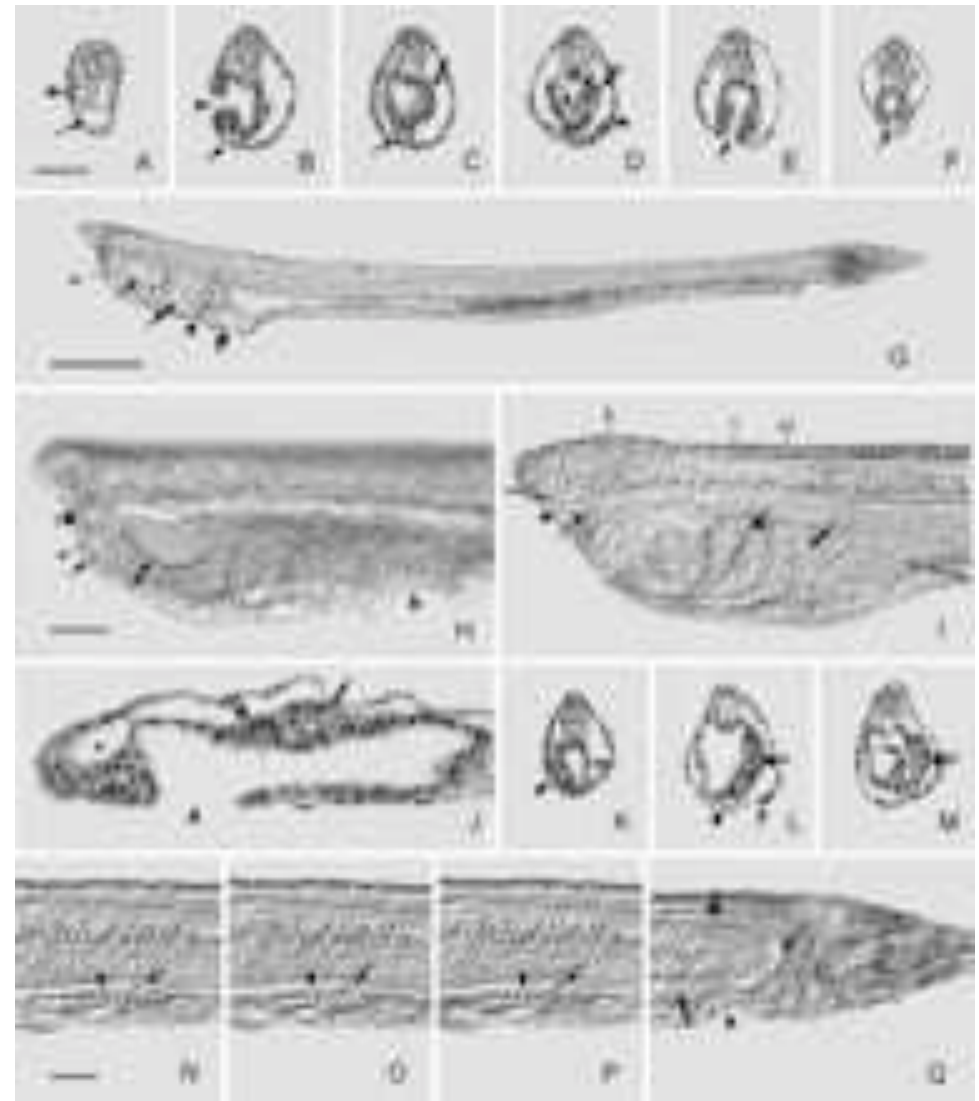
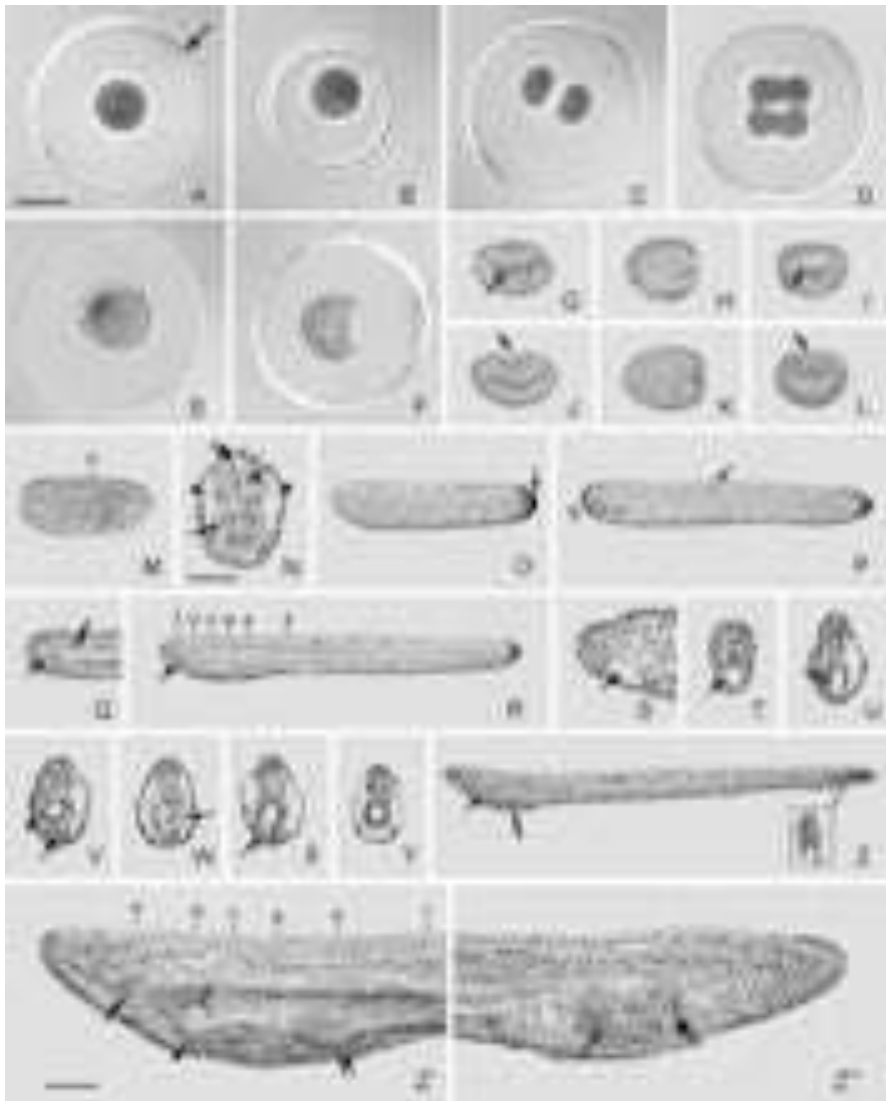


FIGURE 29-11 Cephalochordata: larval anatomy and metamorphosis. **A**, Left lateral view of the larva. **B**, Cross section through the mouth of the larva in **A**, showing asymmetry, the path of water flow, and the filter-feeding mucous net. **C**, Ventral views of stages in metamorphosis showing the enclosing of the larval gill slits by the metapleural folds to form the atrium. Later, the mouth and preoral pit migrate ventrally from their positions on the left side of the head and become enclosed in the buccal cavity, which has not yet formed. The larval mouth becomes the adult velum, and the preoral pit differentiates into Hatschek's pit and the wheel organ. (C, Modified and redrawn from Willey, A. 1894. *Amphioxus and the Ancestry of the Vertebrates*. MacMillan and Co., New York. 316 pp.)

Amphioxus development (Cephalochordata)

Asymmetron lucayanum- Bahama lancelet



(Holland&Holland, 2008)

O próximo filo (ou subfilo dos Cordados): os Tunicados!

