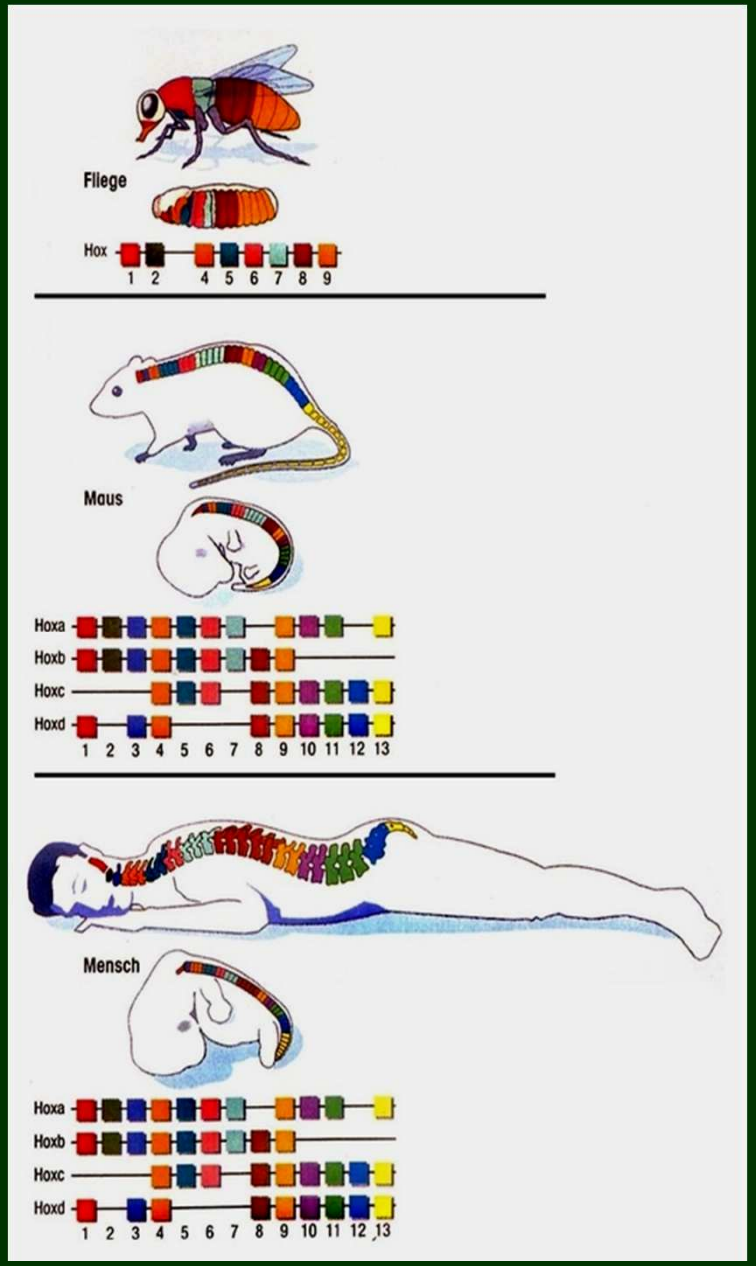
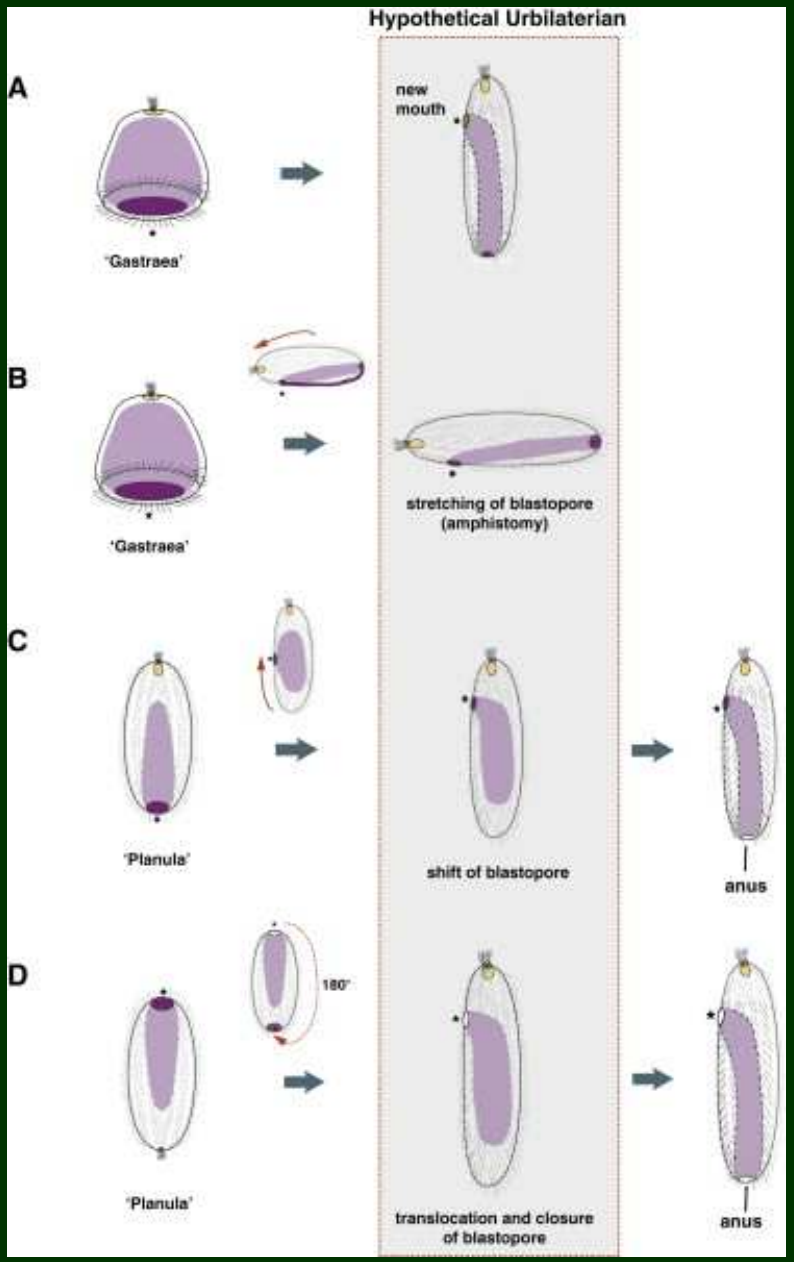
# Bilateria: Xenacoelomorpha a Chaetognatha

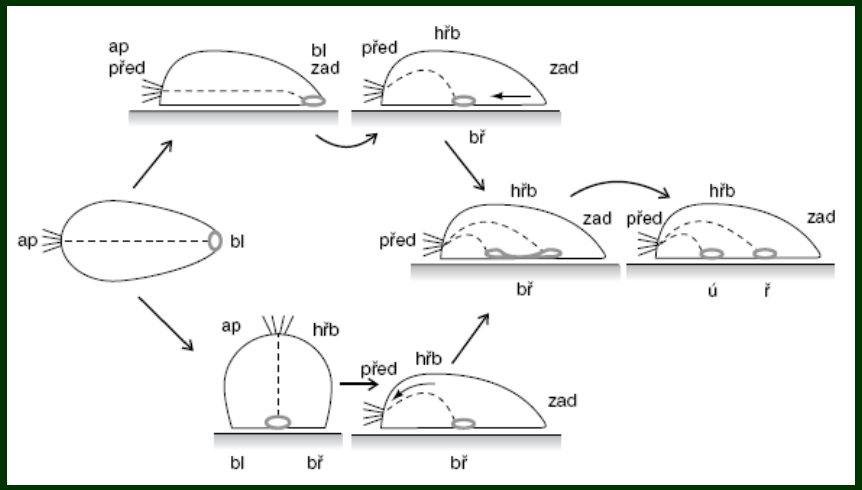
# Bilateria

- dvě tělní osy: antero-posteriorní a dorso-ventrální
- *Hox* komplex
- trubicovitá trávicí soustava
- obvykle mnohobičíkaté buňky epitelů
- célom, cévní soustava, protonefridie



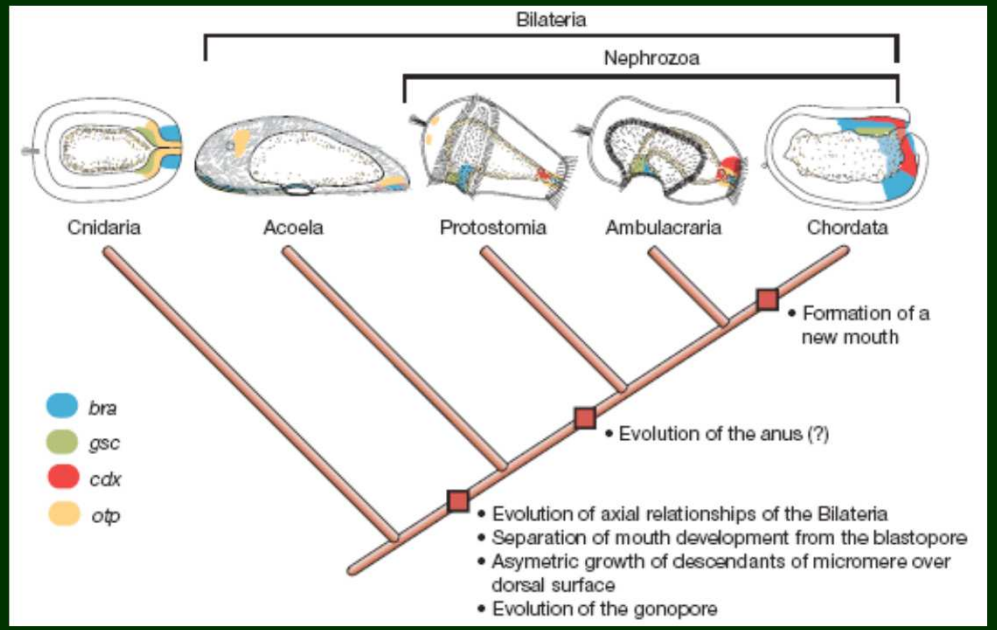
# Vznik bilaterality





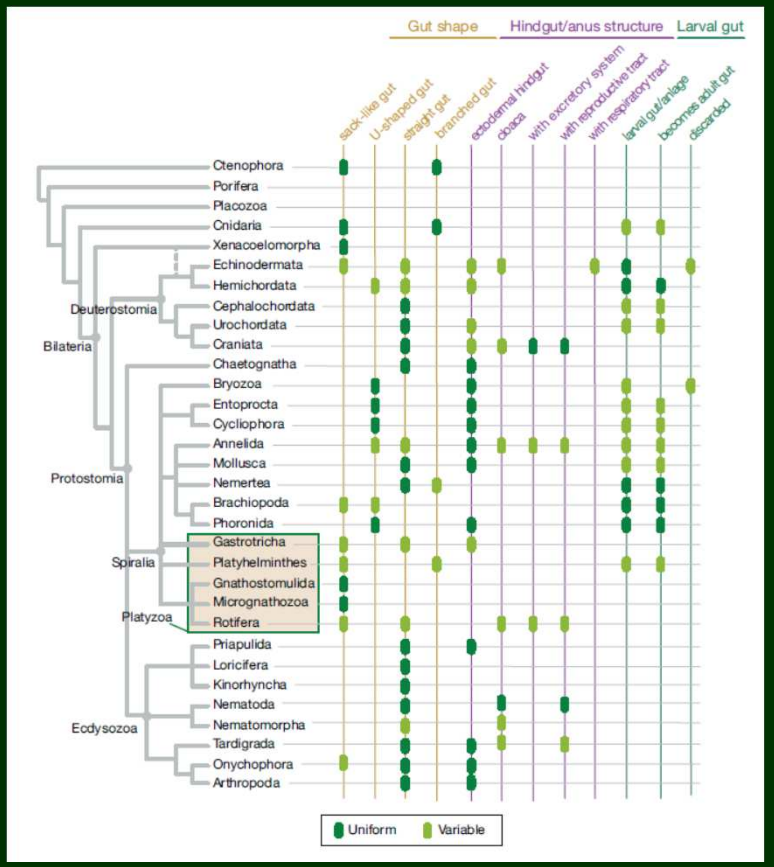

# Vznik bilaterality

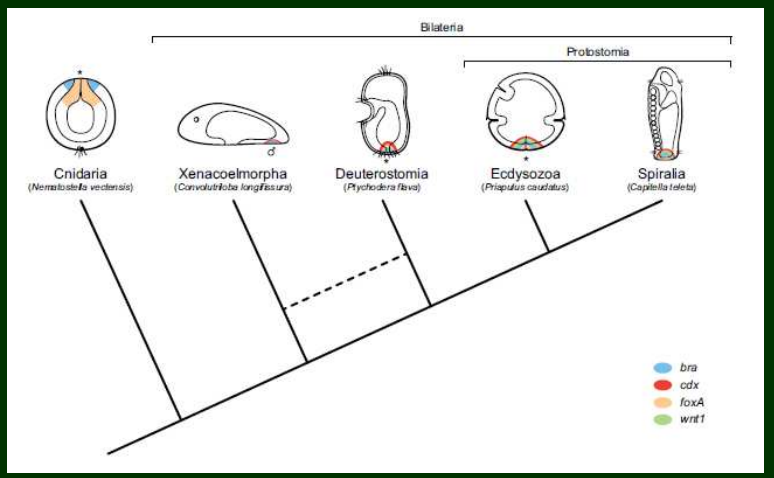
- Acoela: ústní otvor nevzniká z blastopóru (jako u mnoha protostomií a všech deuterostomií)
- gen *bra* není spojený s vývojem ústního otvoru (řitní otvor chybí), ale s gonopórem
- ústní otvor žahavců a acelomorf ~ ústní otvor bilaterií, řitní otvor vzniká nezávisle (endoderm + gonodukt)



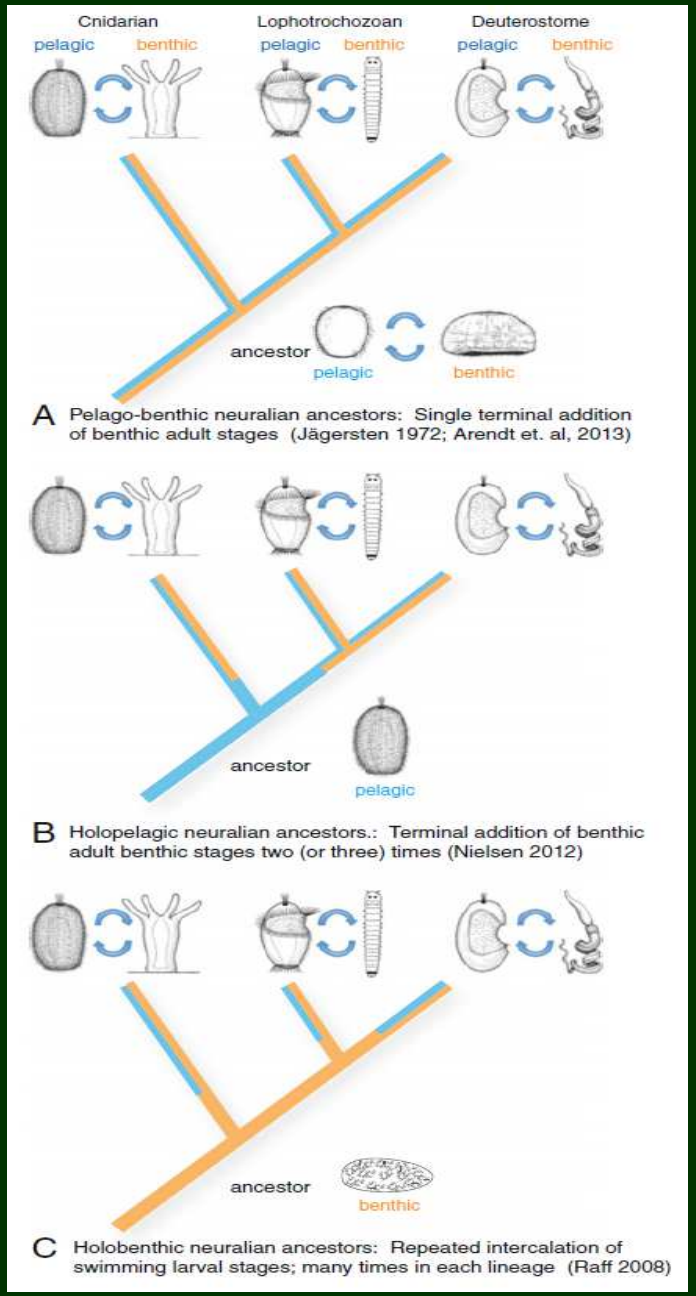
# Trávicí trubice (řitní otvor)

- ústní otvor acelomorf odpovídá ústnímu otvoru žahavců a nefrozoí (*brachyury* + *goosecoid*)
- řitní otvor ~ samčí gonopór (Acoela)



# Evoluce životního cyklu



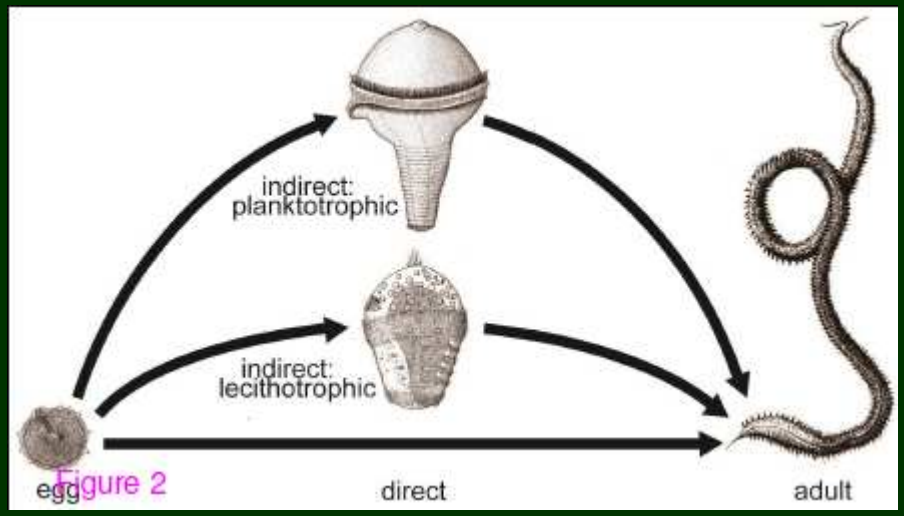



Figure 2

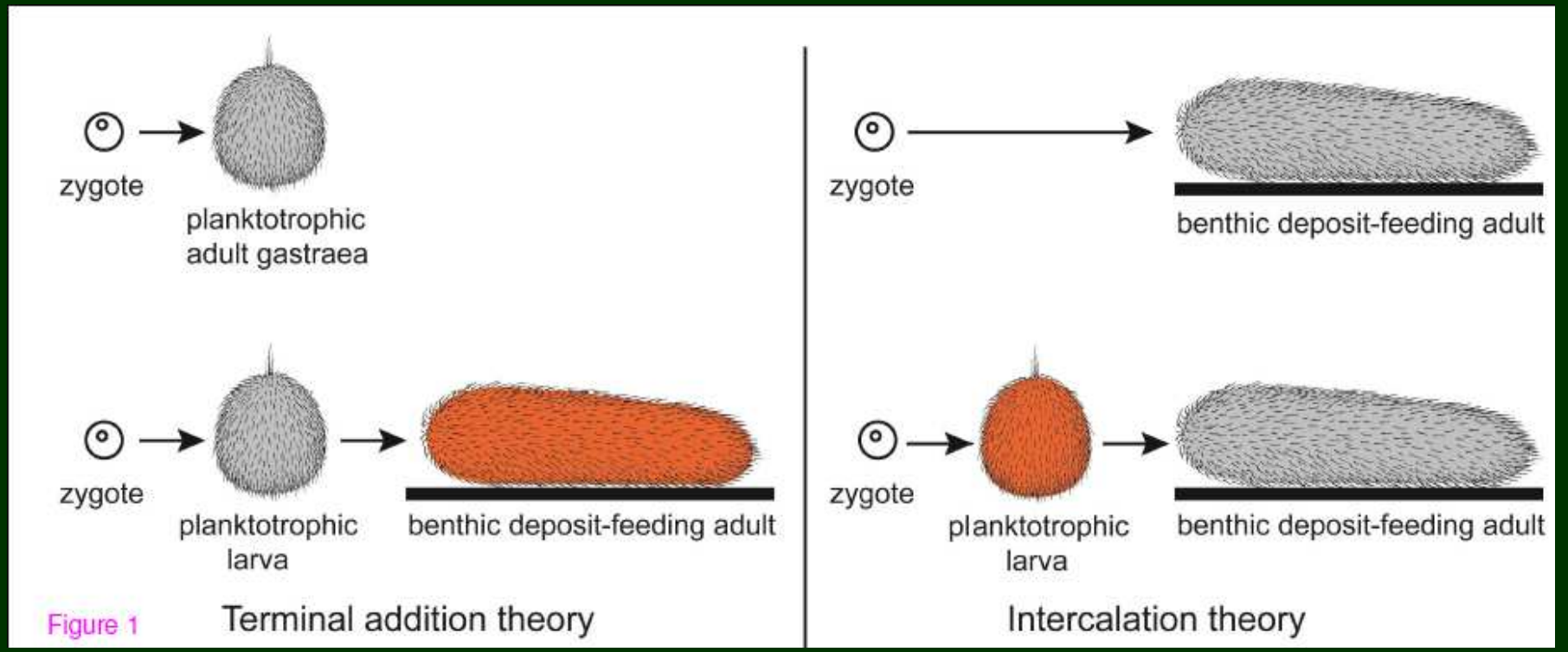
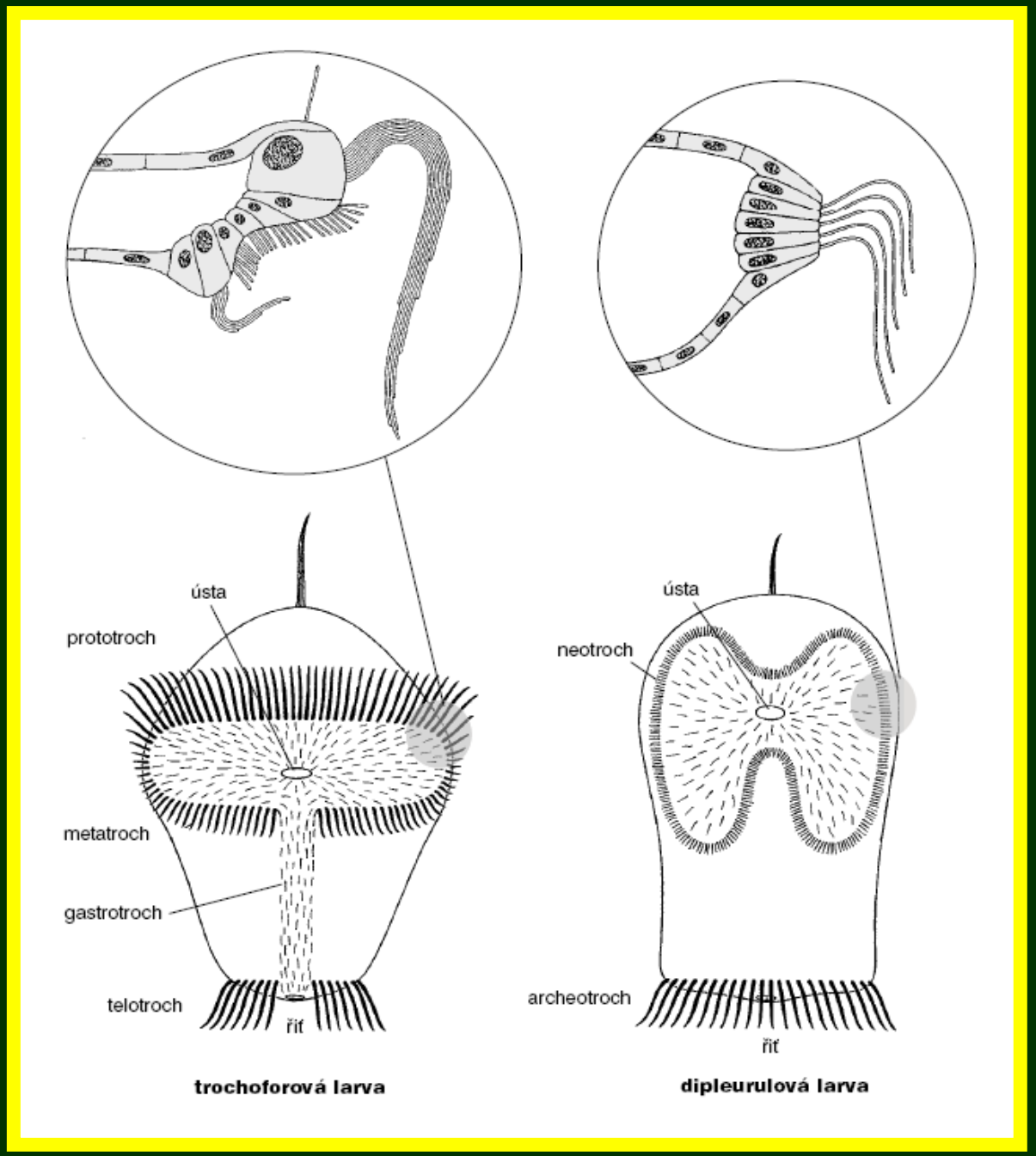
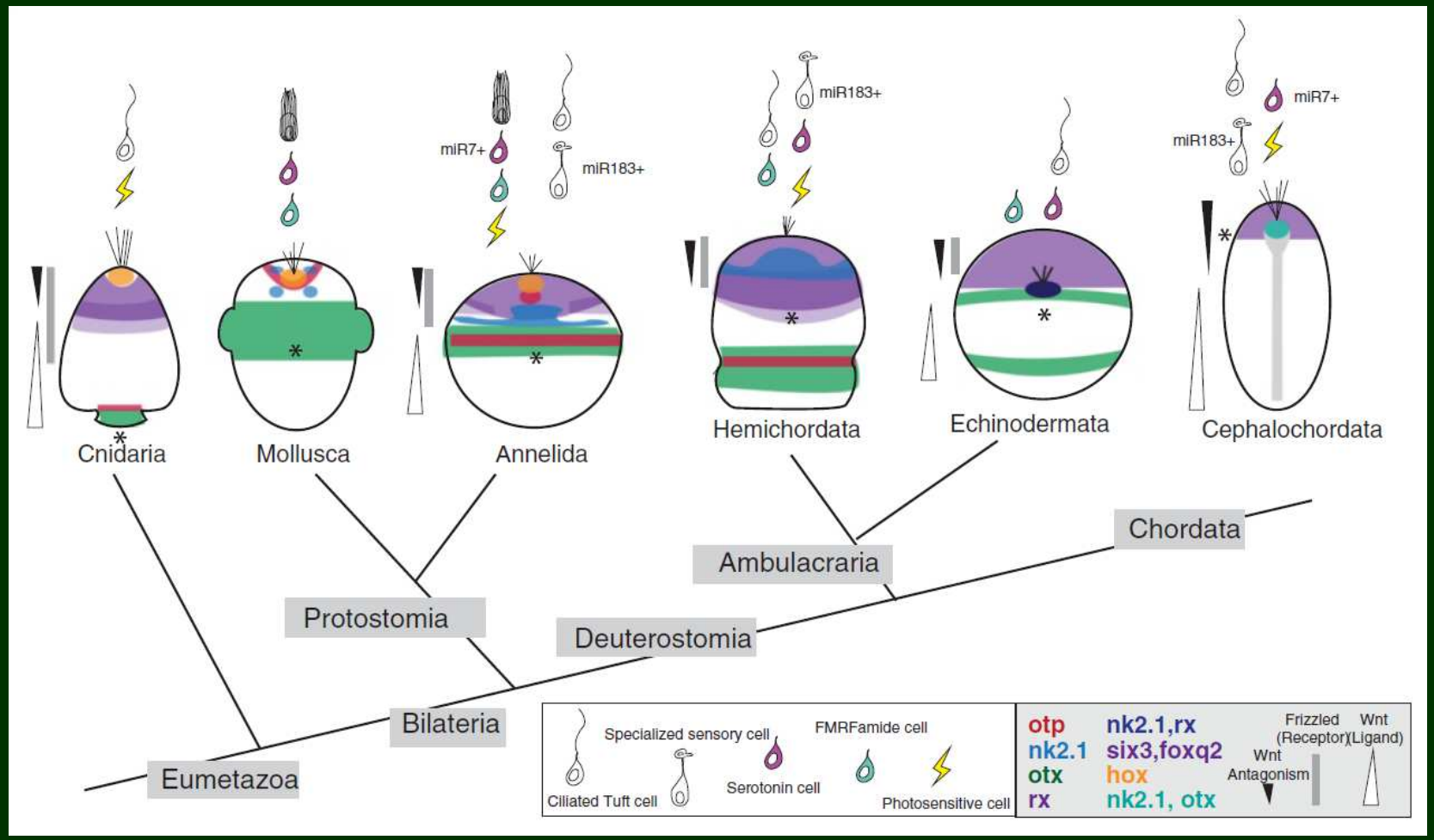


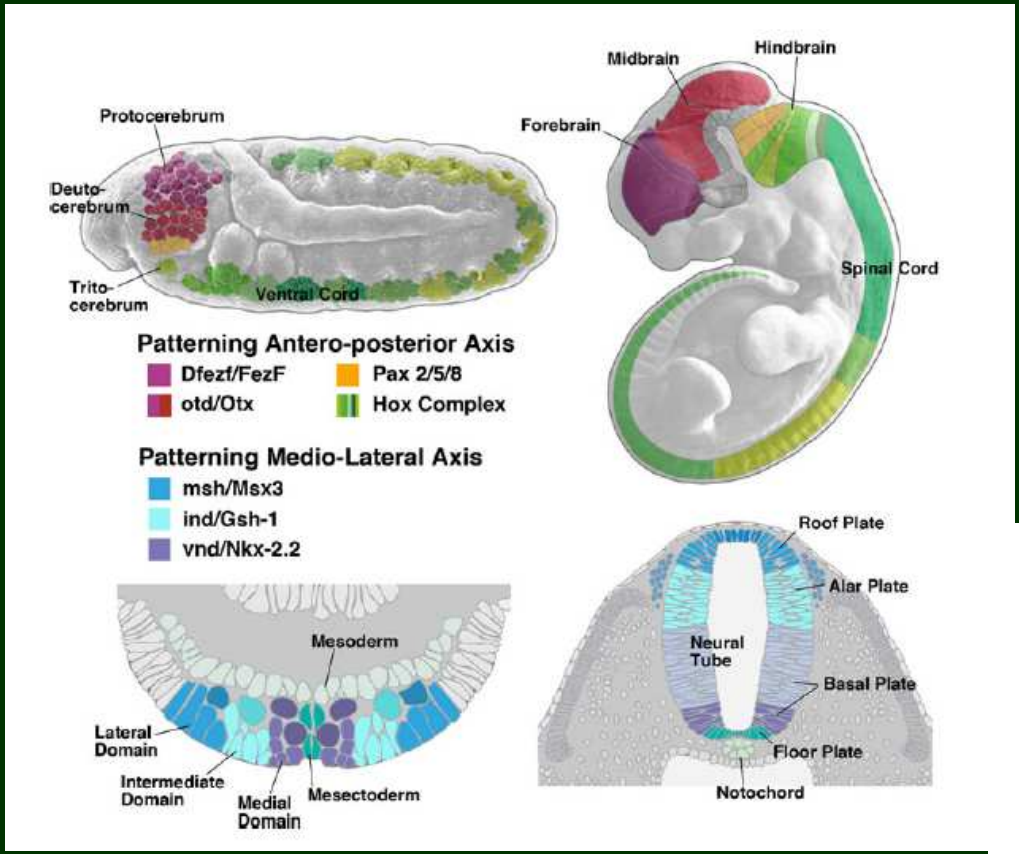

Figure 1

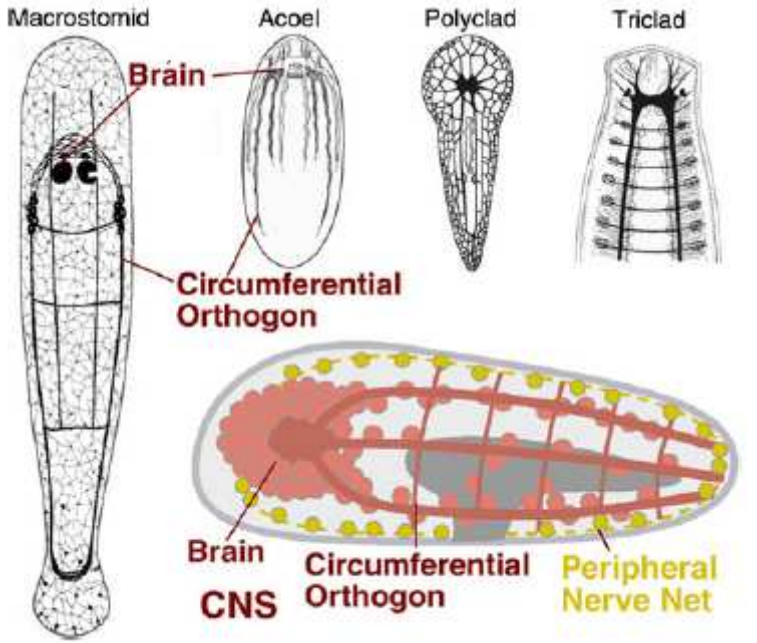

ústa
prototroch
metatroch
gastrotroch
telotroch
řitní
trochoforová larva
ústa
neotroch
archeotroch
řitní
dipleurulová larva

# Apikální orgán a NS: homologie primárních larev?



# Nervová soustava bilaterií



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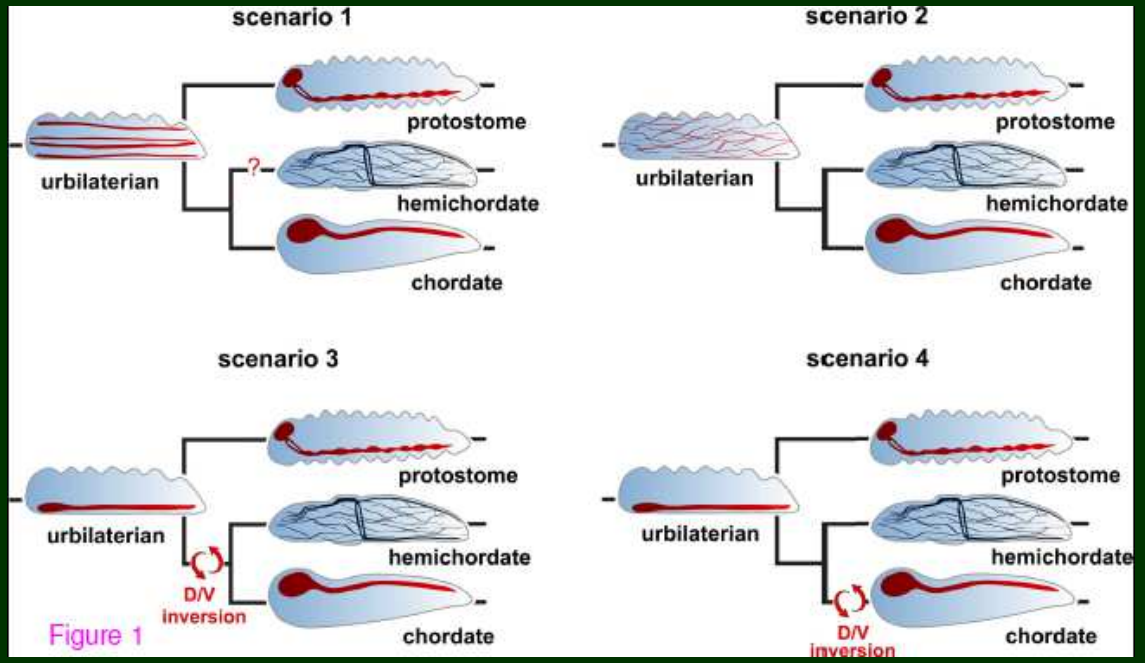


Figure 1

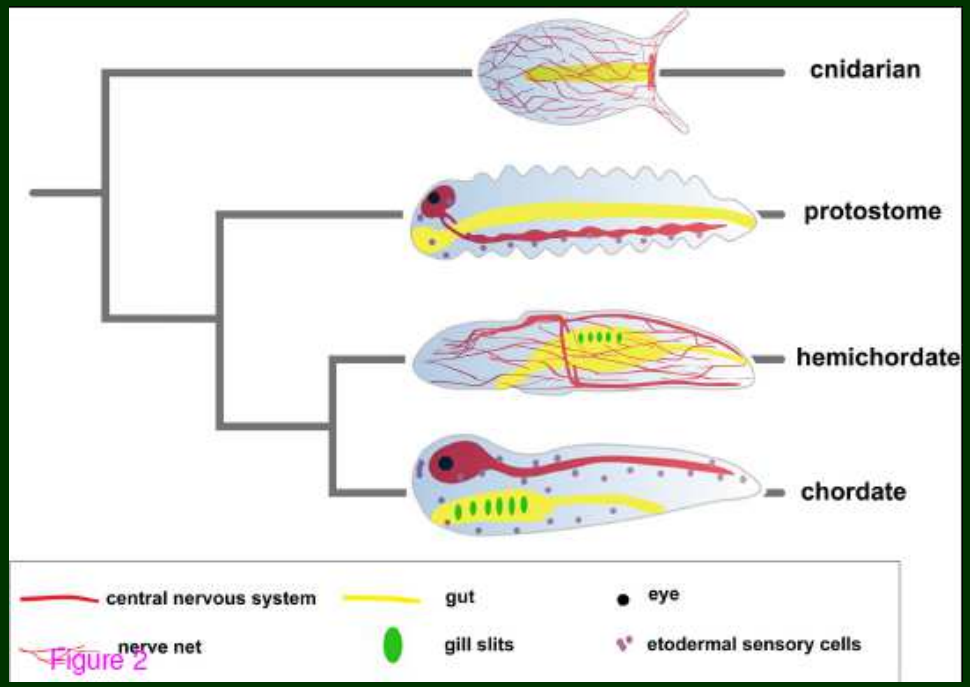
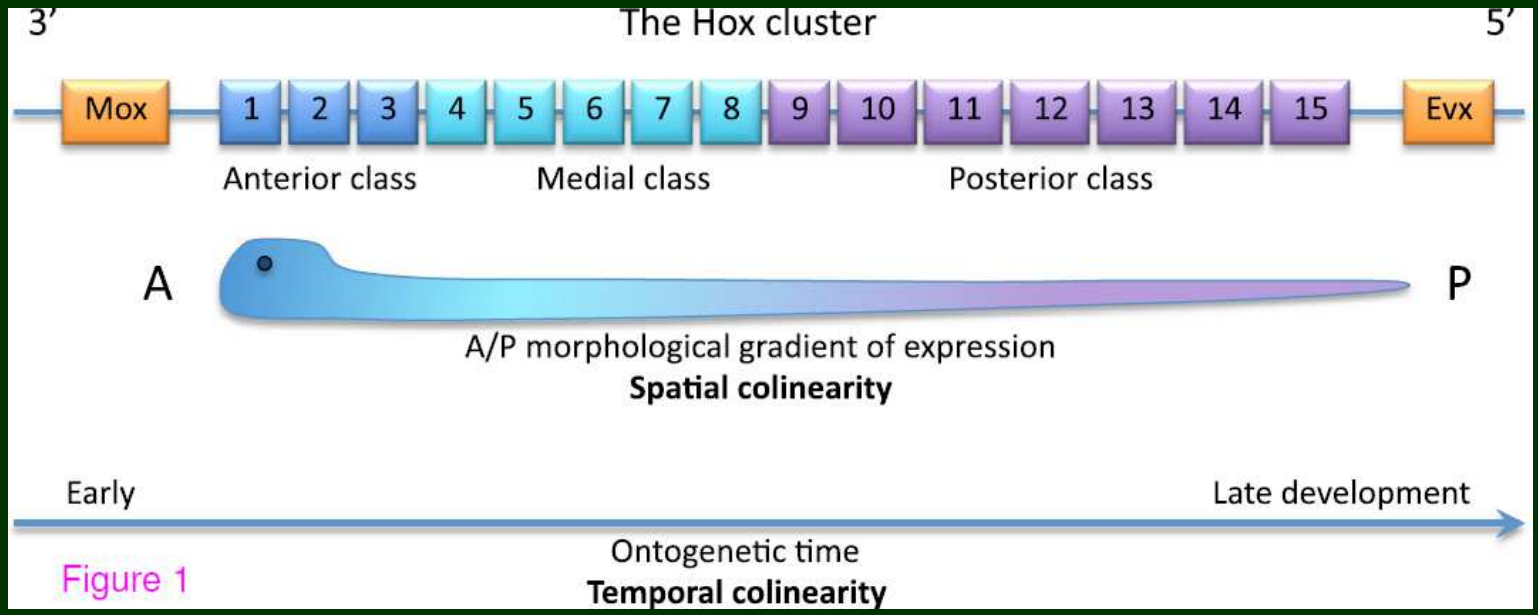


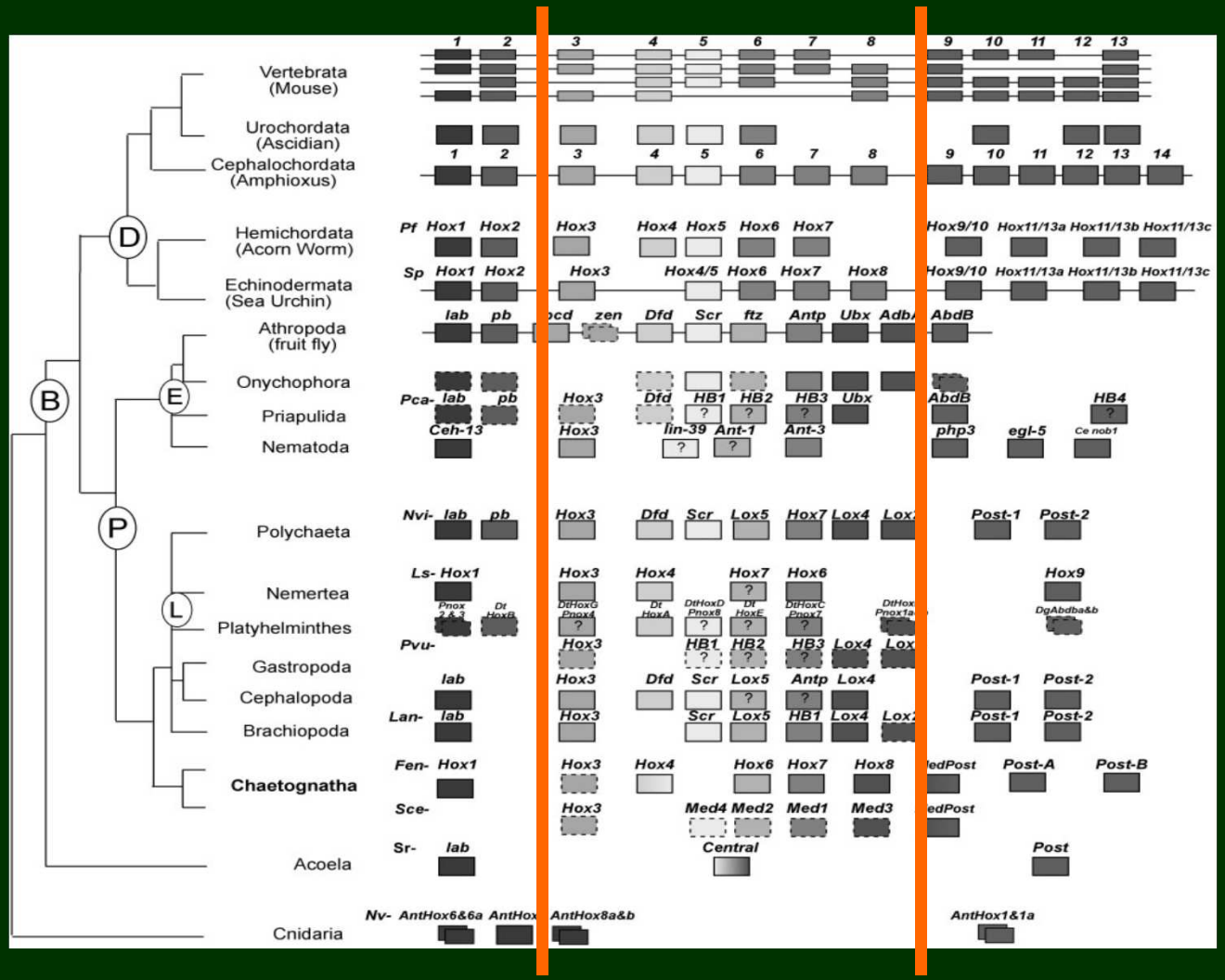
Figure 2

# Hox komplexy

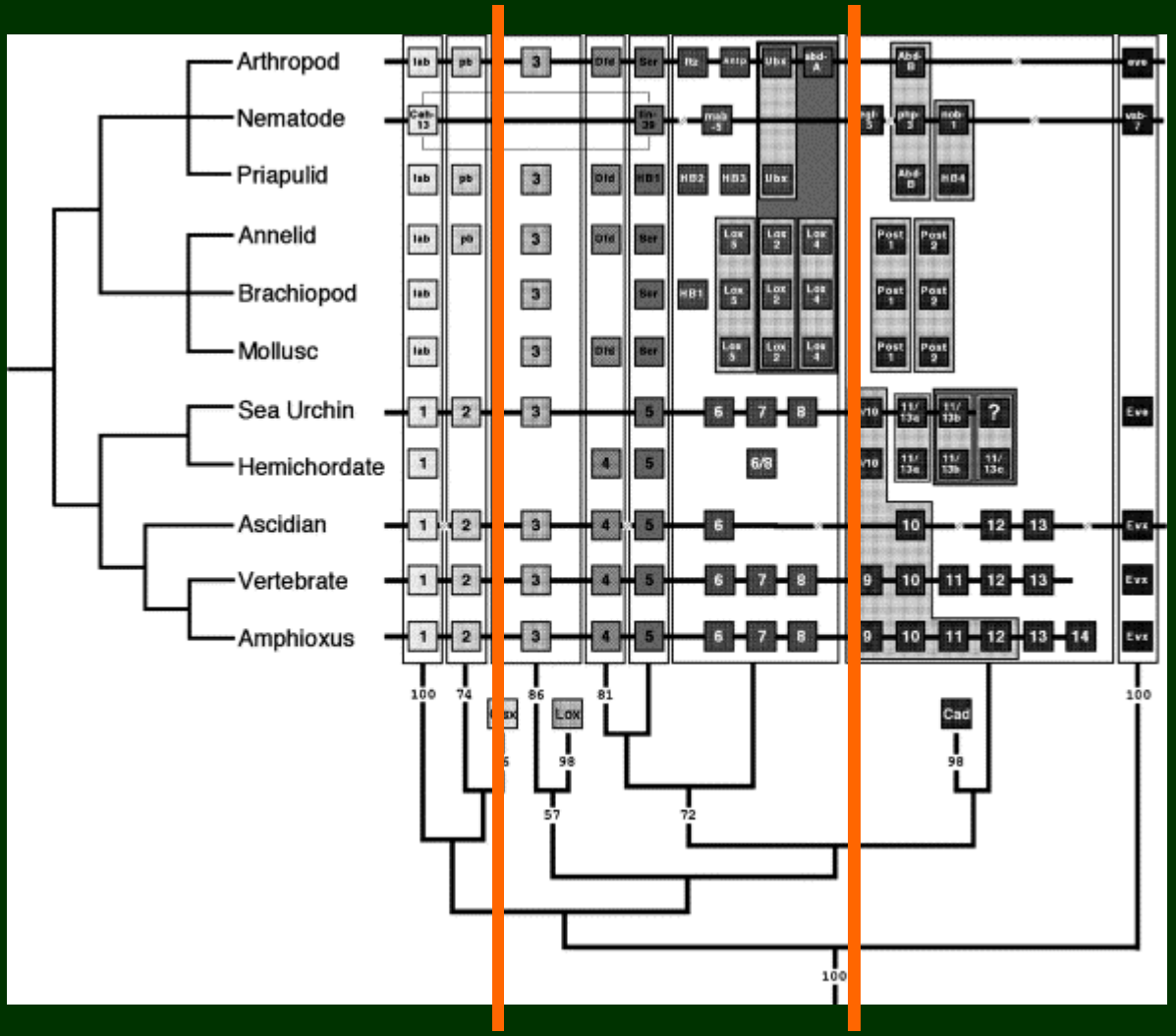
- Hox geny jsou homologické nejmíň u všech bilaterií
- tvoří lineární komplexy
- prostorová i časová kolinearita (3’ = anteriorní a časný)
- “zootyp”



# Evoluce Hox komplexů u metazoí



# Evoluce Hox genů ve dvou rozměrech (ortologie x paralogie)



# Hox a homologie NS

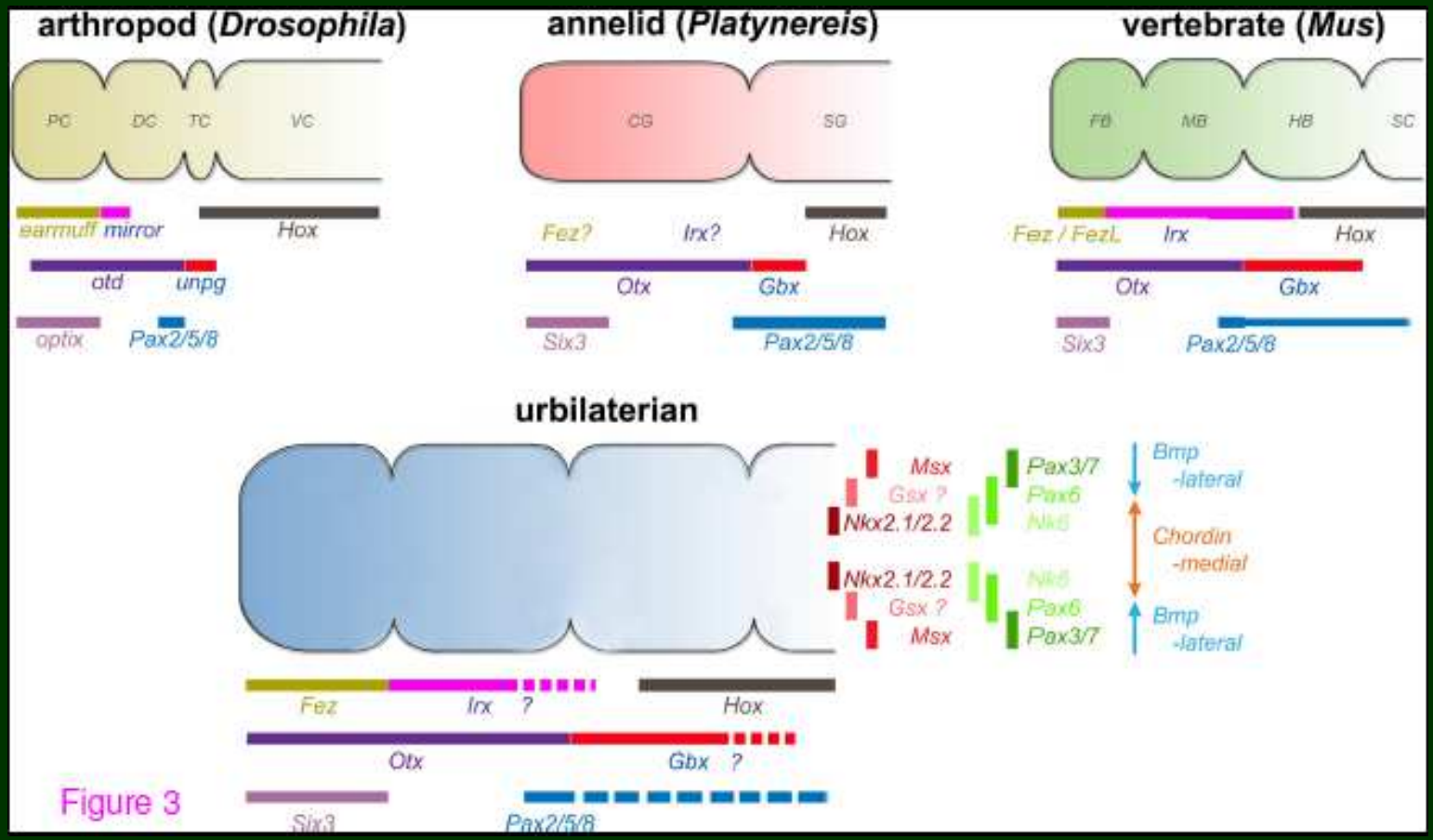
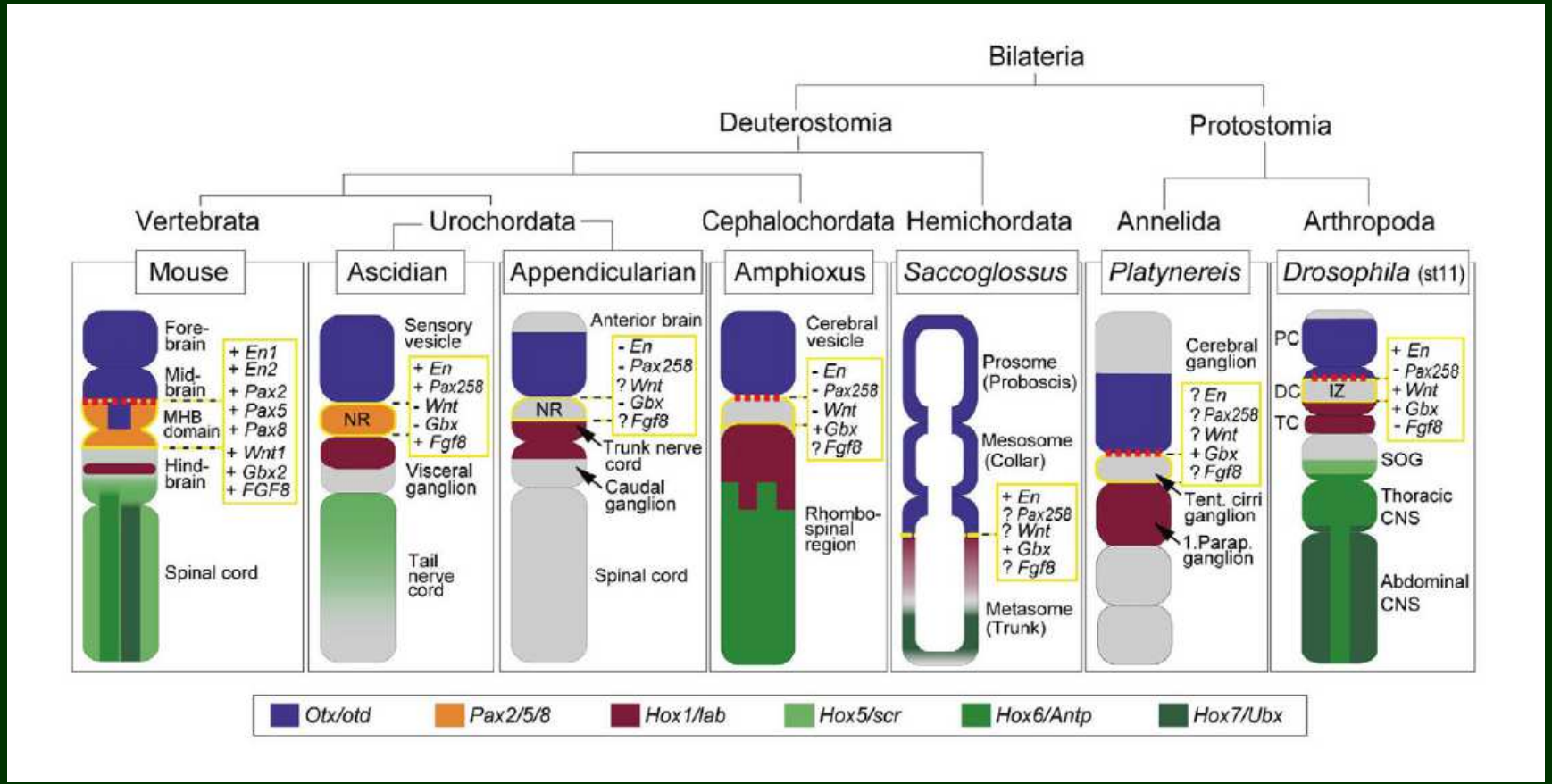
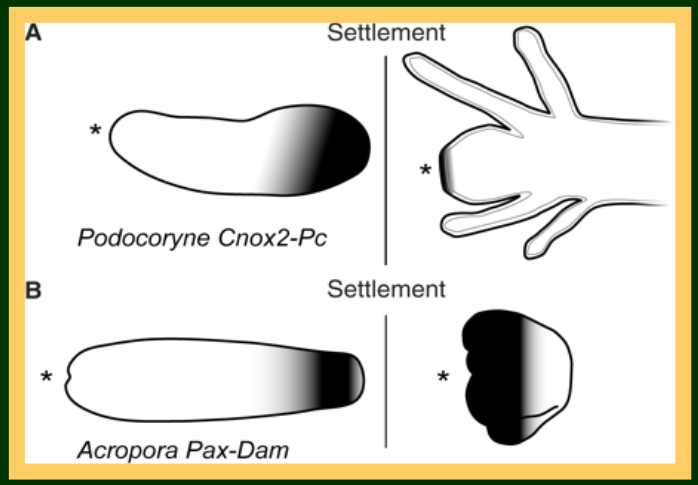


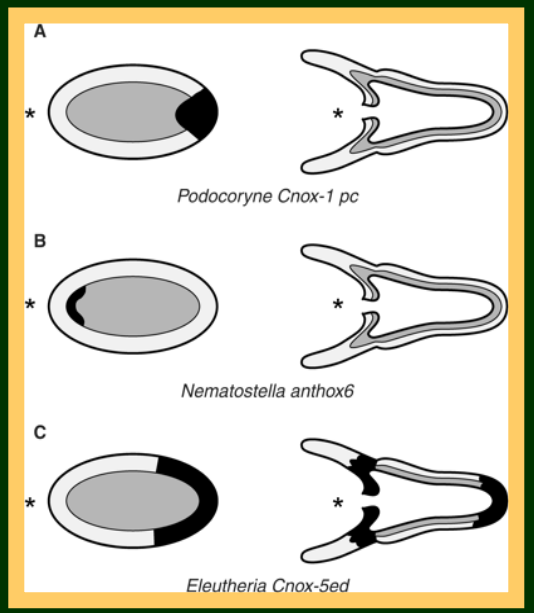

Figure 3


Bilateria
Deuterostomia
Protostomia
Vertebrata
Urochordata
Cephalochordata
Hemichordata
Annelida
Arthropoda
Mouse
Ascidian
Appendicularian
Amphioxus
Saccoglossus
Platynereis
Drosophila (st11)
Fore-brain
Mid-brain
MHB domain
Hind-brain
Spinal cord
+ En1
+ En2
+ Pax2
+ Pax5
+ Pax8
+ Wnt1
+ Gbx2
+ FGF8
Sensory vesicle
NR
Visceral ganglion
Tail nerve cord
+ En
+ Pax258
- Wnt
- Gbx
+ Fgf8
Anterior brain
NR
Trunk nerve cord
Caudal ganglion
Spinal cord
- En
- Pax258
? Wnt
- Gbx
? Fgf8
Cerebral vesicle
Rhombo-spinal region
- En
- Pax258
- Wnt
+ Gbx
? Fgf8
Prosome (Proboscis)
Mesosome (Collar)
Metasome (Trunk)
+ En
? Pax258
? Wnt
+ Gbx
? Fgf8
Cerebral ganglion
Tent. cirri ganglion
1.Parap. ganglion
? En
? Pax258
? Wnt
+ Gbx
? Fgf8
PC
DC
TC
IZ
SOG
Thoracic CNS
Abdominal CNS
+ En
- Pax258
+ Wnt
+ Gbx
- Fgf8
Otx/otd
Pax2/5/8
Hox1/lab
Hox5/scr
Hox6/Antp
Hox7/Ubx

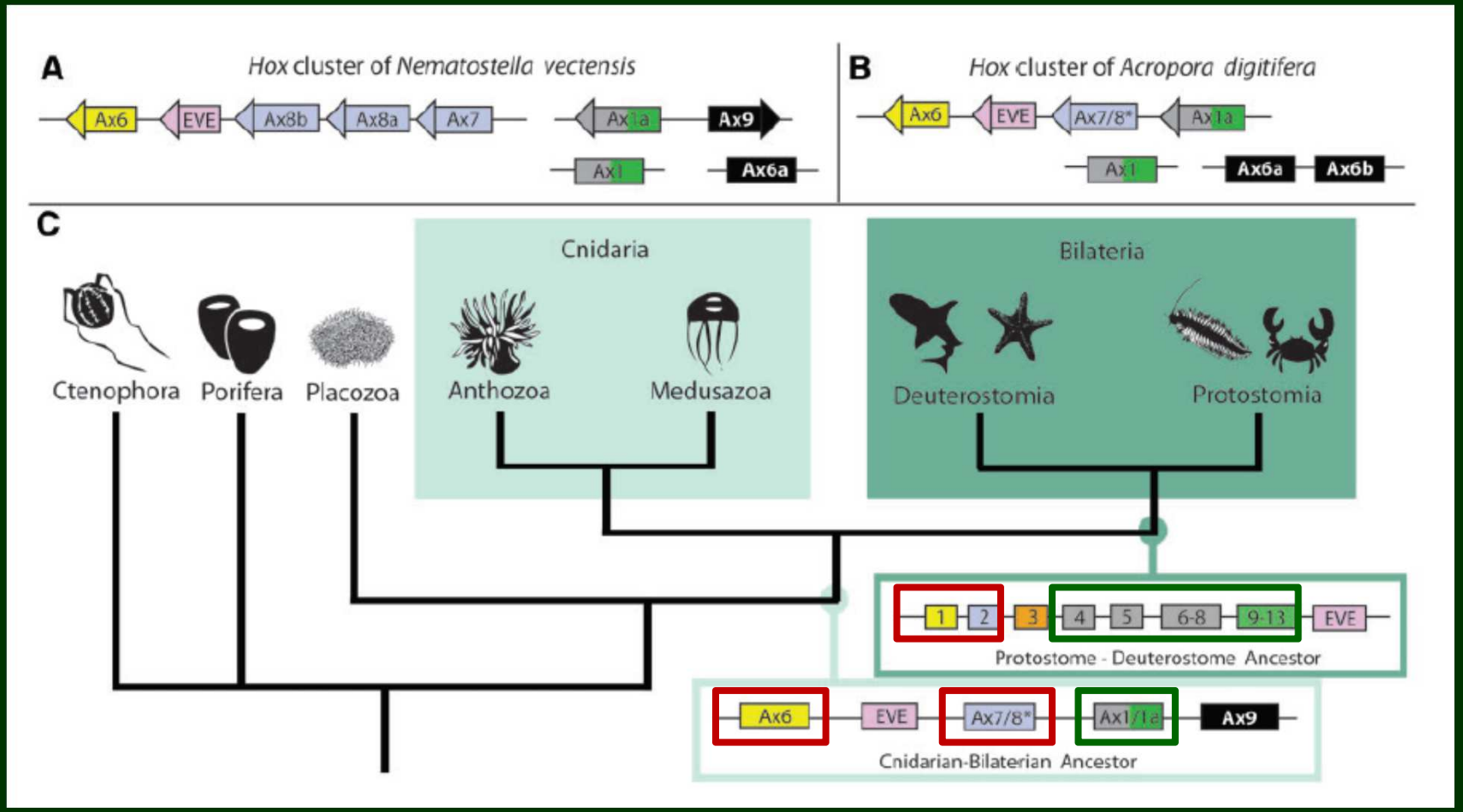
# Hox geny u žahavců

- netvoří komplexy (pouze jako výsledky pozdější duplikace)
- některé skupiny Hox genů chybí úplně
- jejich expresní zóny neodpovídají situaci u bilaterií
- jejich expresní zóny vykazují podstatně větší diverzitu než u bilaterií



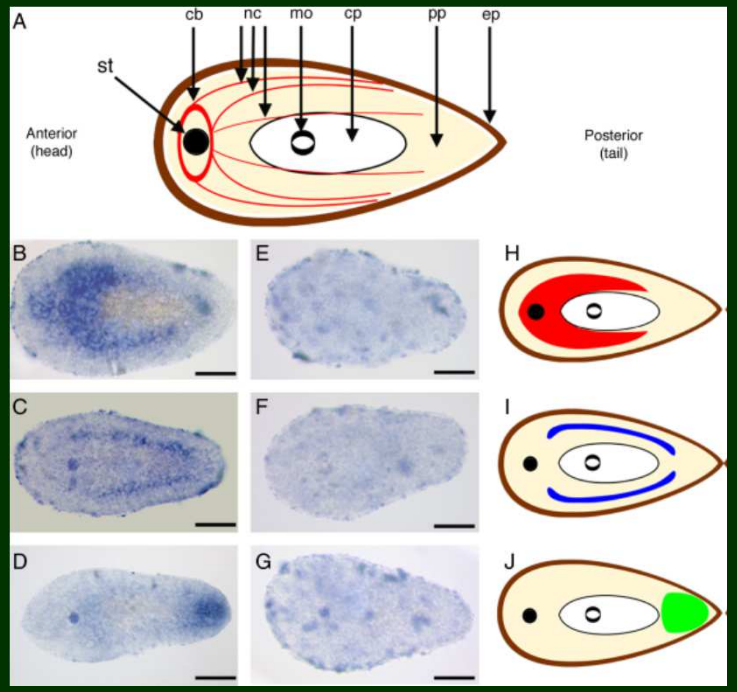



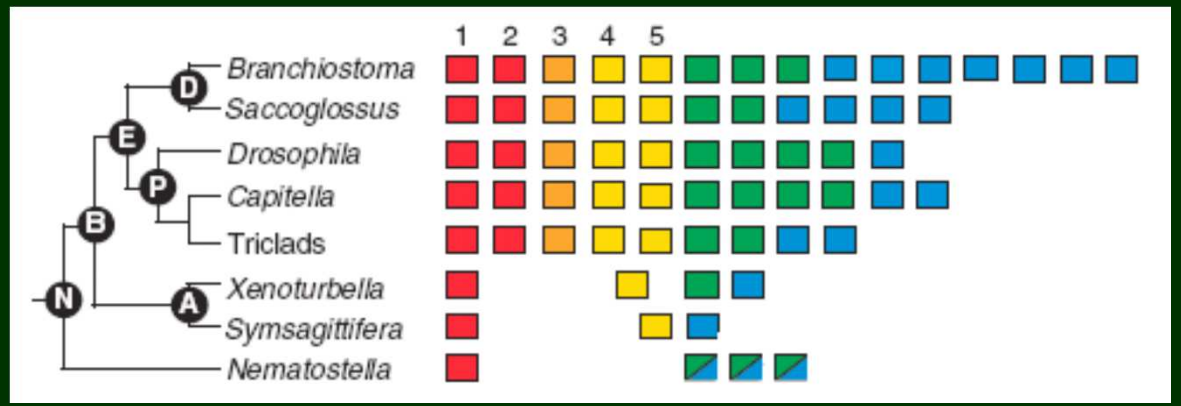
# Hox komplex žahavců

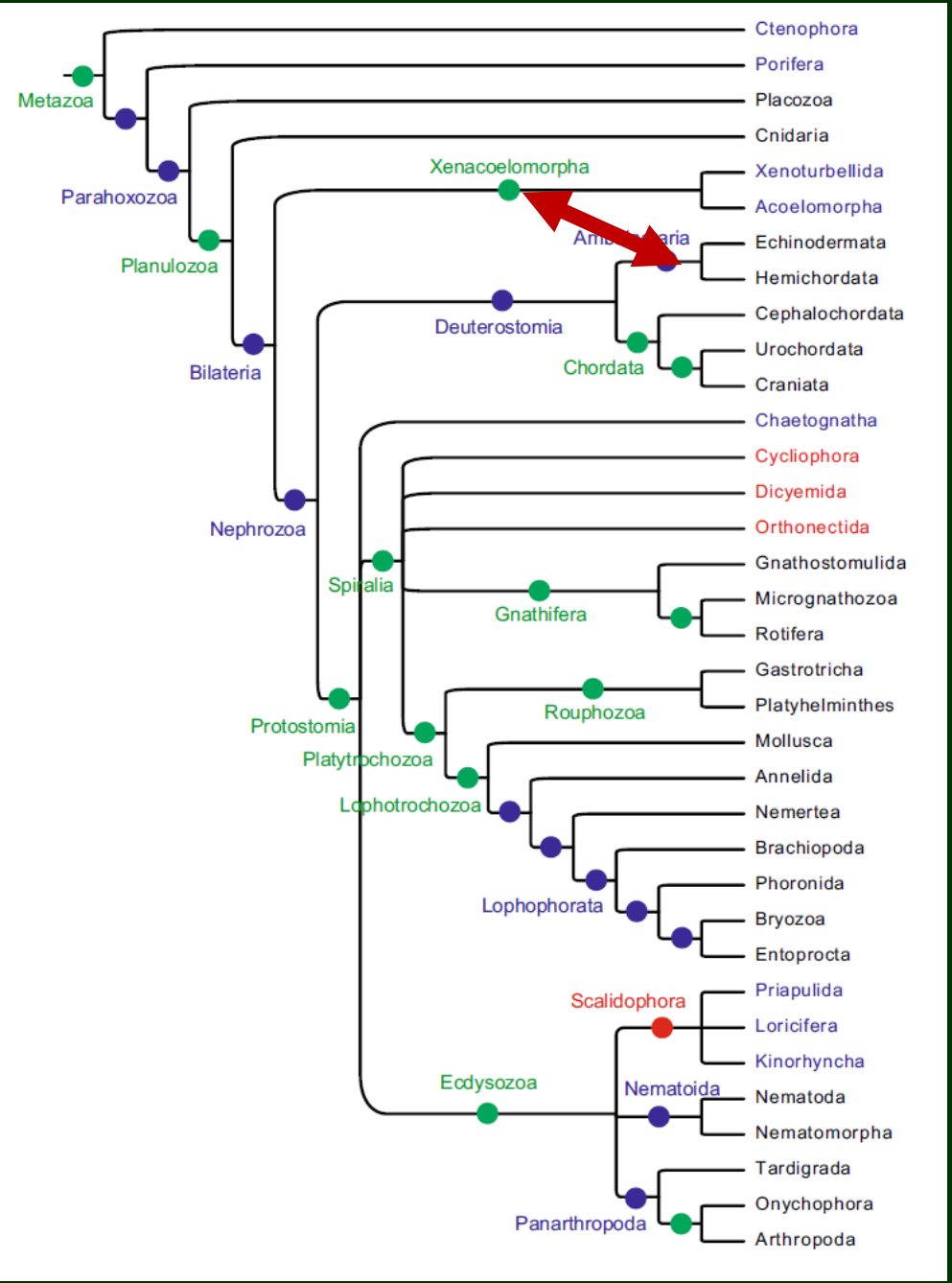


# Evoluce Hox systému

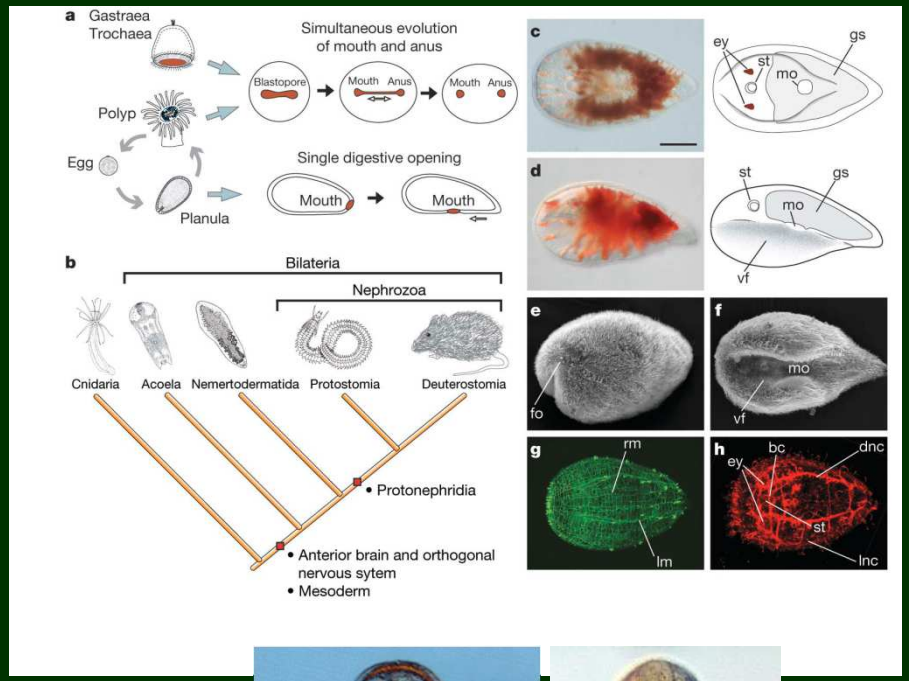
- 1. Cnidaria ~2-4 geny: A+?C/P (nejasná kolinearita)
- 2. Acoela 3 geny: A+C+P
- 3. Nemertodermatida: ?+2C+P
- 3. Xenoturbellida 4-5 genů: A+2(3)C+P
- (Porifera a Ctenophora 0, Placozoa ~1)



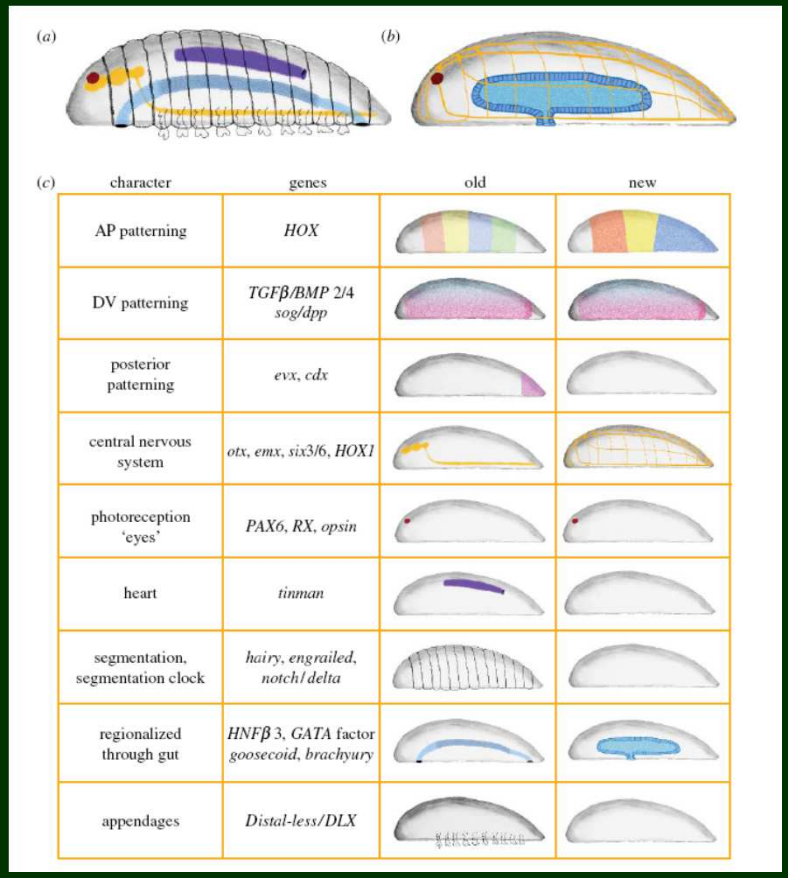




Ctenophora
Porifera
Placozoa
Cnidaria
Xenacoelomorpha
Xenoturbellida
Acoelomorpha
Echinodermata
Hemichordata
Cephalochordata
Urochordata
Craniata
Chaetognatha
Cycliophora
Dicyemida
Orthonectida
Gnathostomulida
Micrognathozoa
Rotifera
Gastrotricha
Platyhelminthes
Mollusca
Annelida
Nemertea
Brachiopoda
Phoronida
Bryozoa
Entoprocta
Priapulida
Loricifera
Kinorhyncha
Nematoda
Nematomorpha
Tardigrada
Onychophora
Arthropoda
Metazoa
Parahoxozoa
Planulozoa
Bilateria
Deuterostomia
Chordata
Nephrozoa
Spiralia
Gnathifera
Protostomia
Rouphozoa
Platytrochozoa
Lophotrochozoa
Lophophorata
Scalidophora
Ecdysozoa
Nematoida
Panarthropoda

# Acoelomorpha



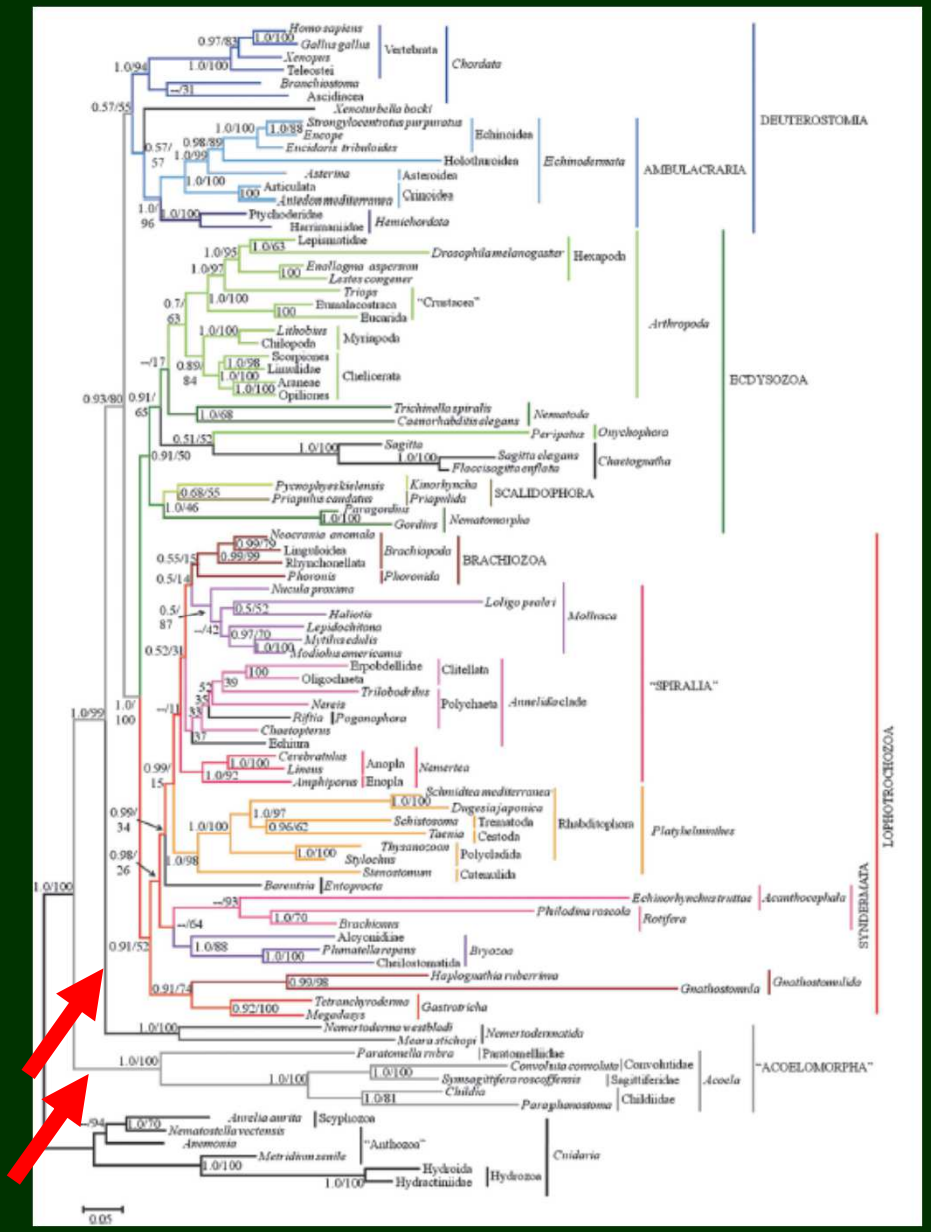


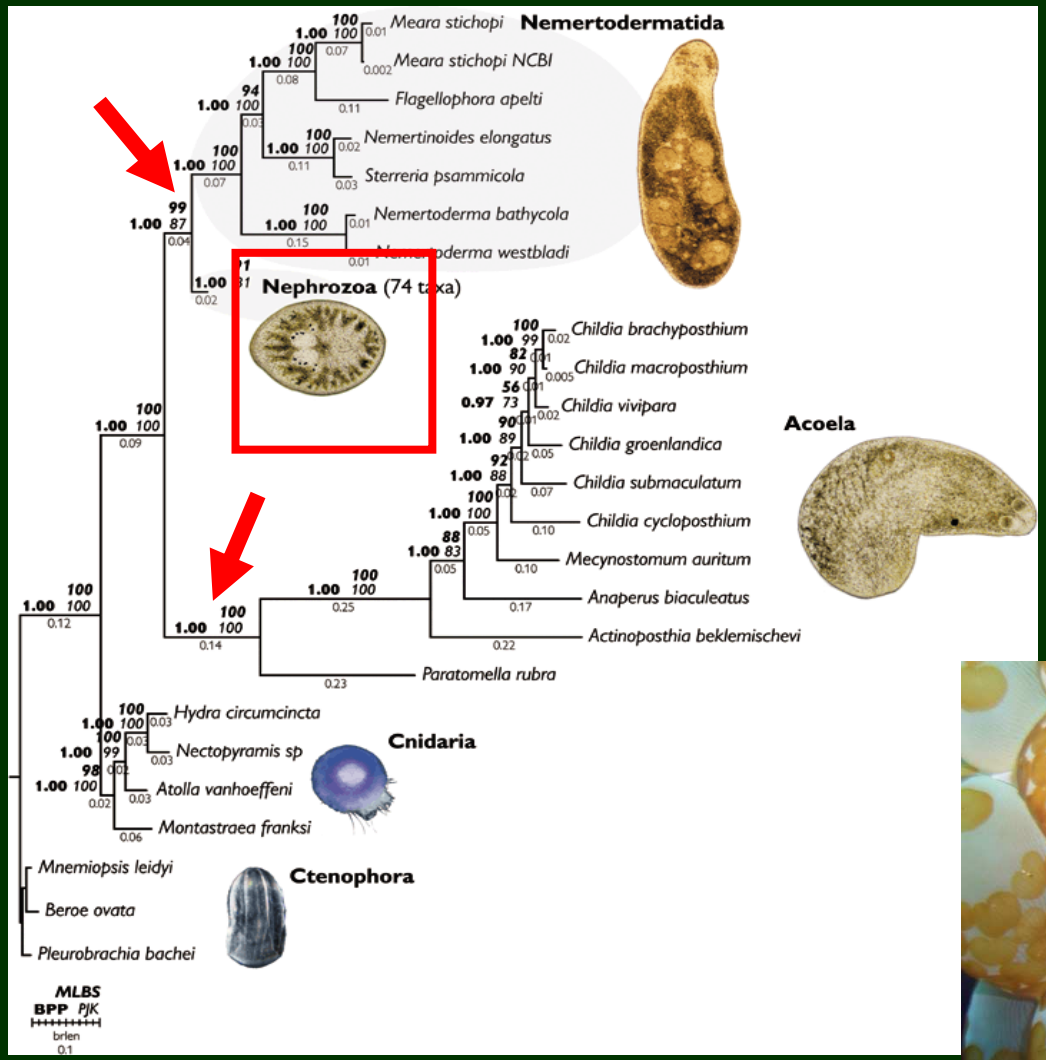

- Acoela + Nemertodermatida

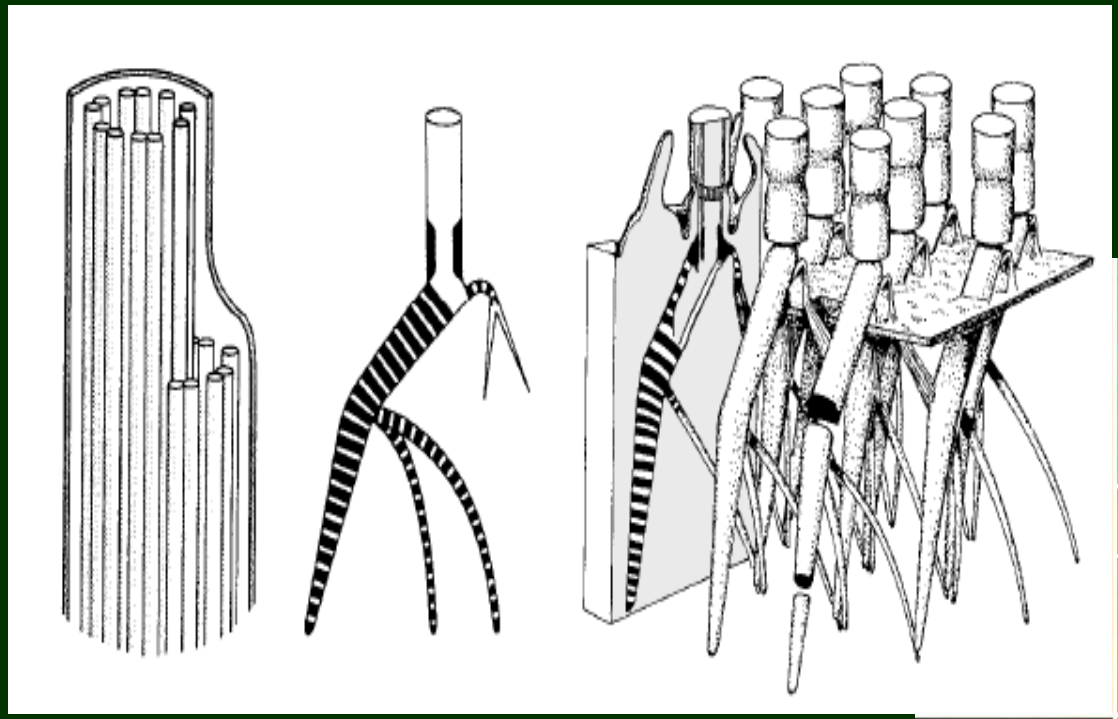
# Acoelomorpha: bazální a parafyletická???

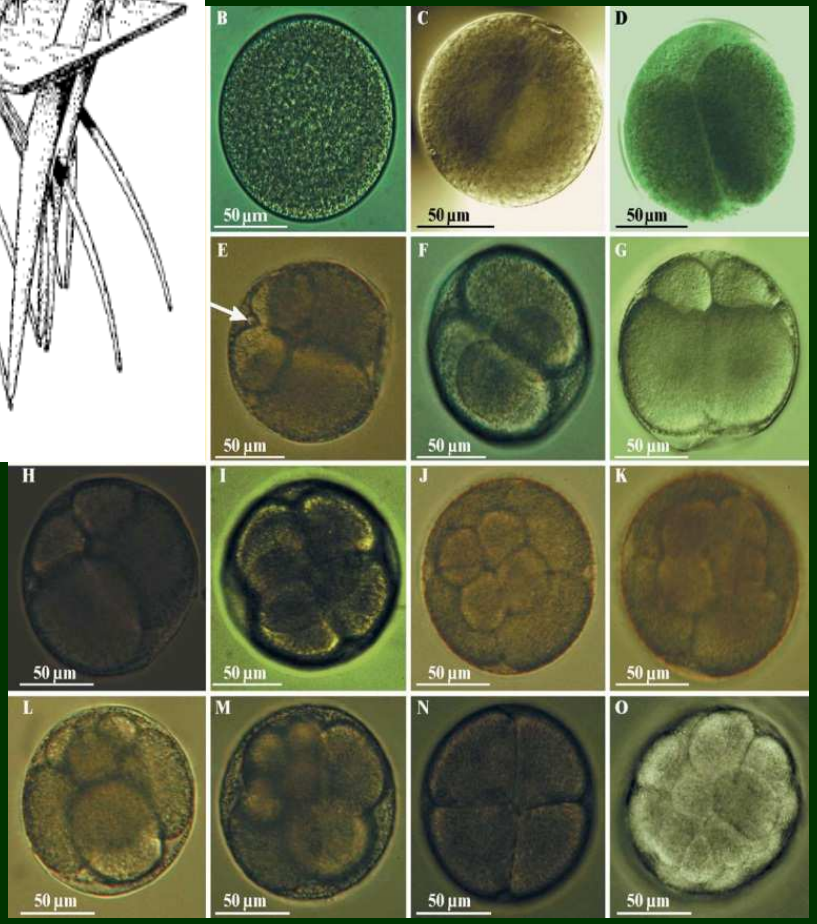
13 jaderných genů



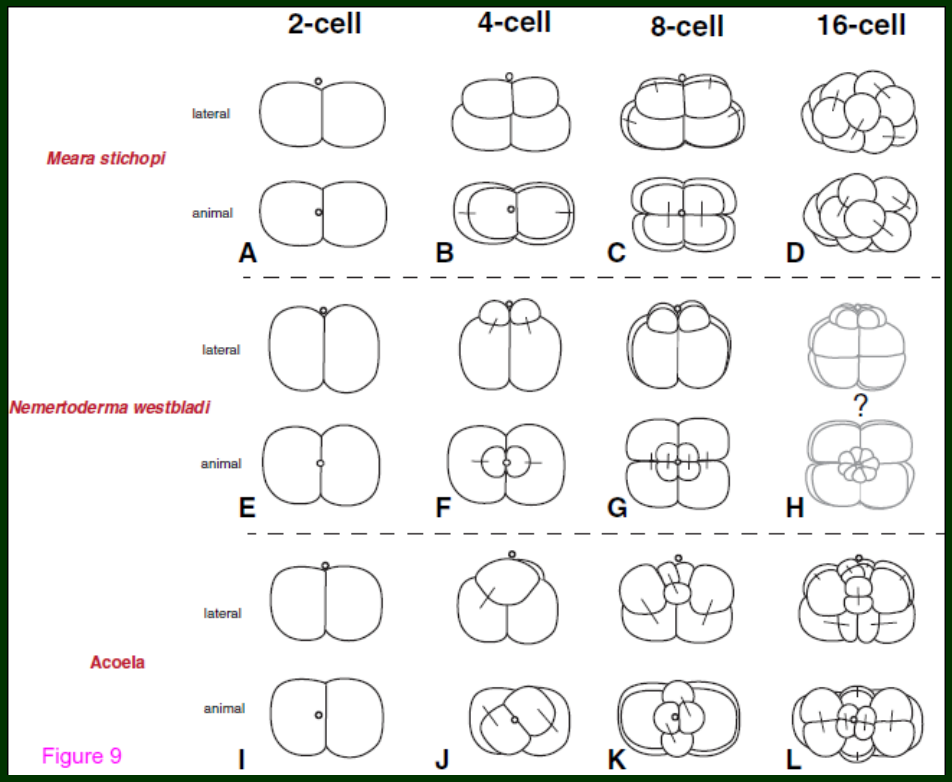
# Acoelomorpha: bazální a parafyletická???

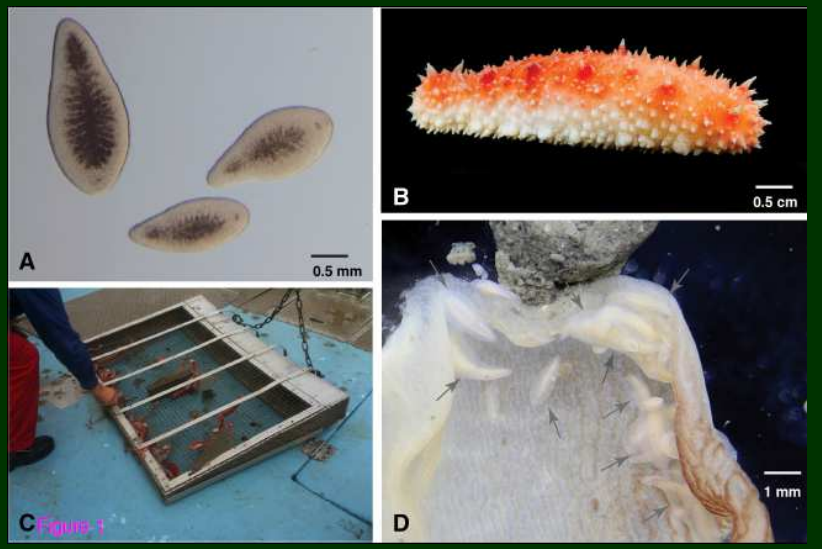



B
C
D
E
F
G
H
I
J
K
L
M
N
O
50 µm

# Xenacoelomorpha: Nemertodermatida

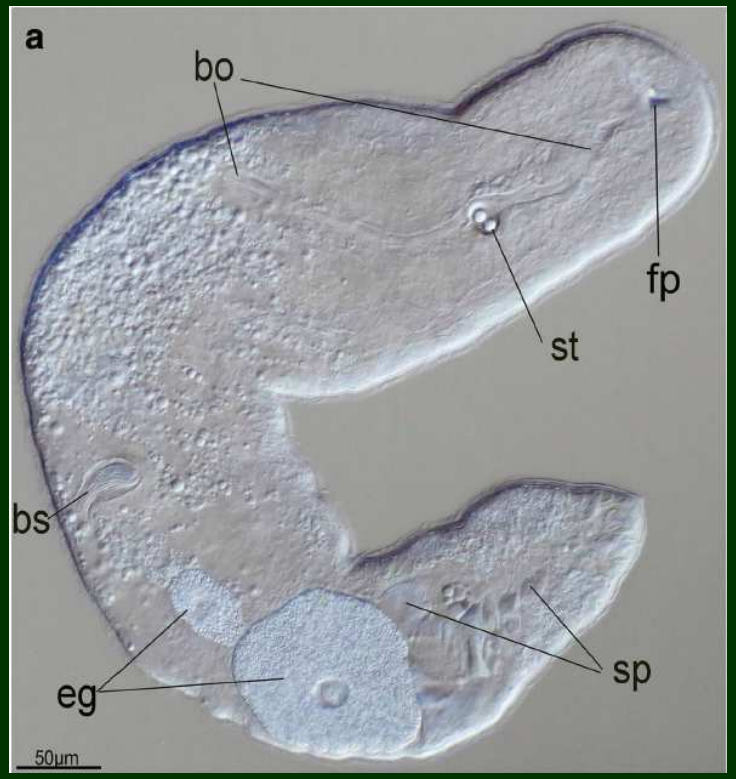



*Meara* – komenzál v přední části TS sumýše *Parastichopus*

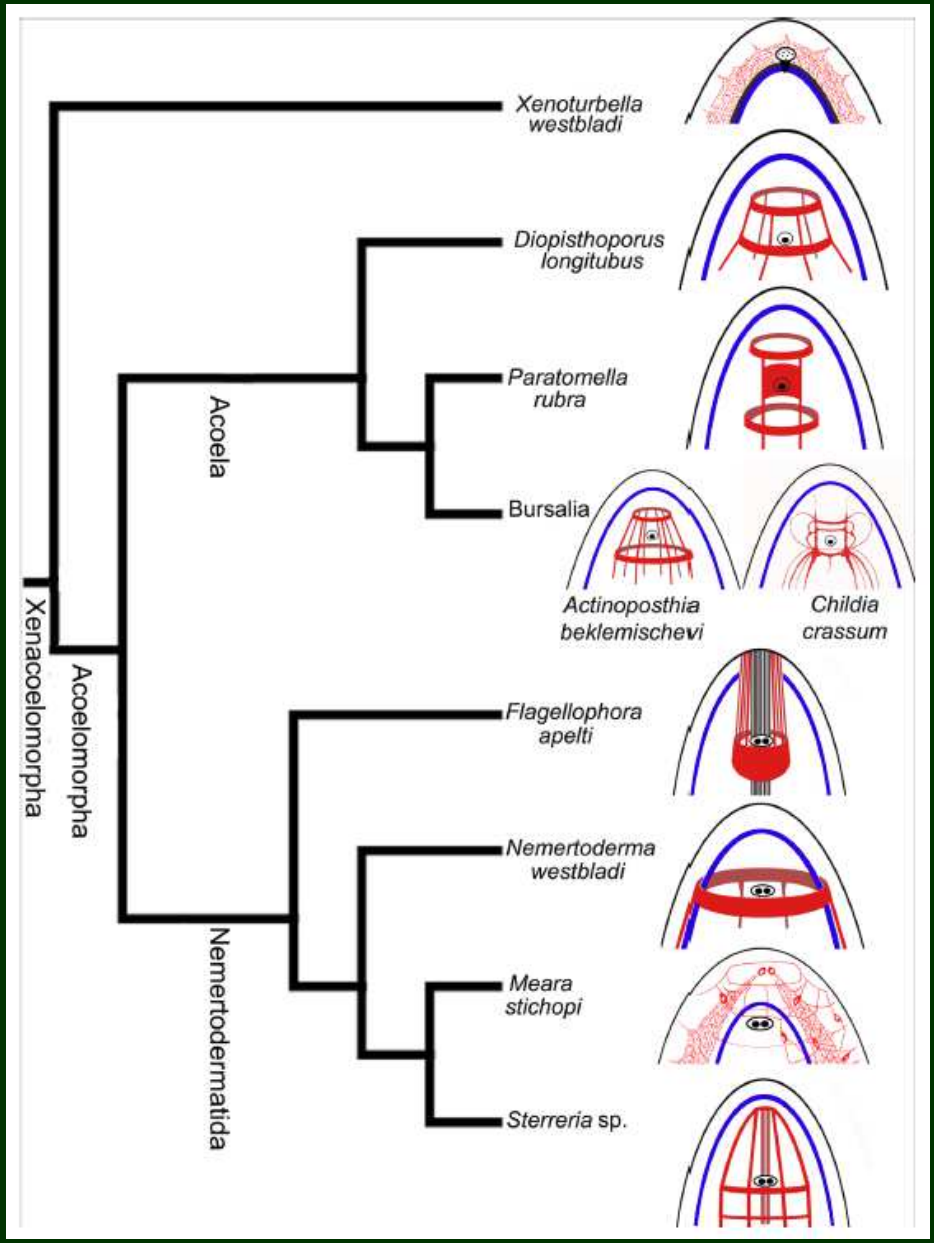
# Xenacoelomorpha

- statocysty s pohyblivými buňkami (statokoniemi), statolity ve statokoniích
- statokonie monoflagelátní u X, aflagelátní u Acm (1 u Ac, 2 u Nd)



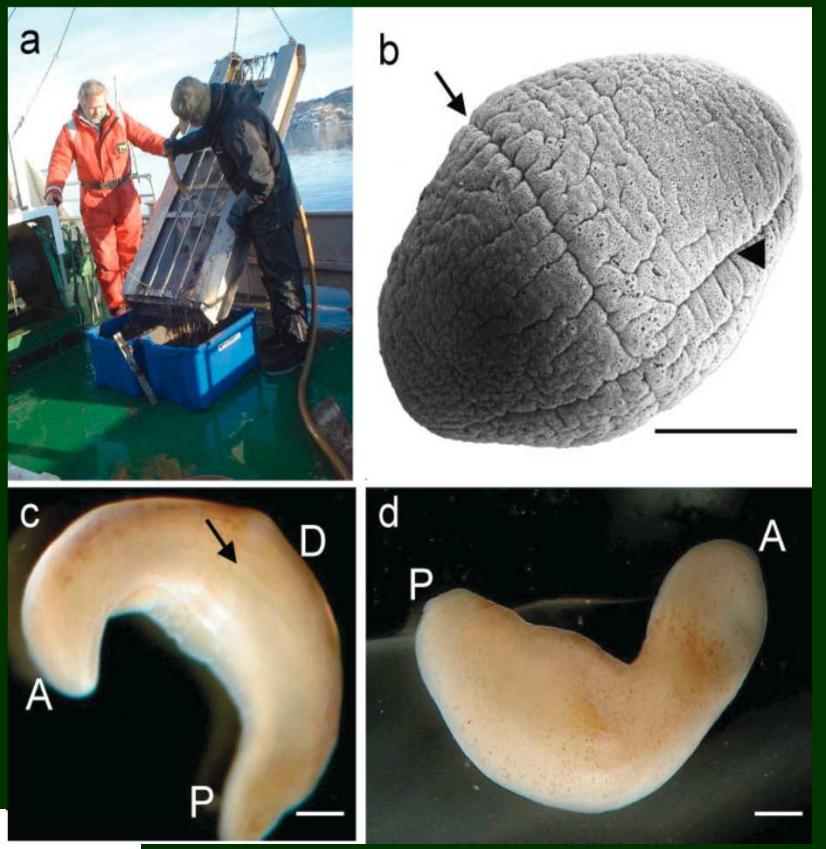
# Acoelomorpha NS

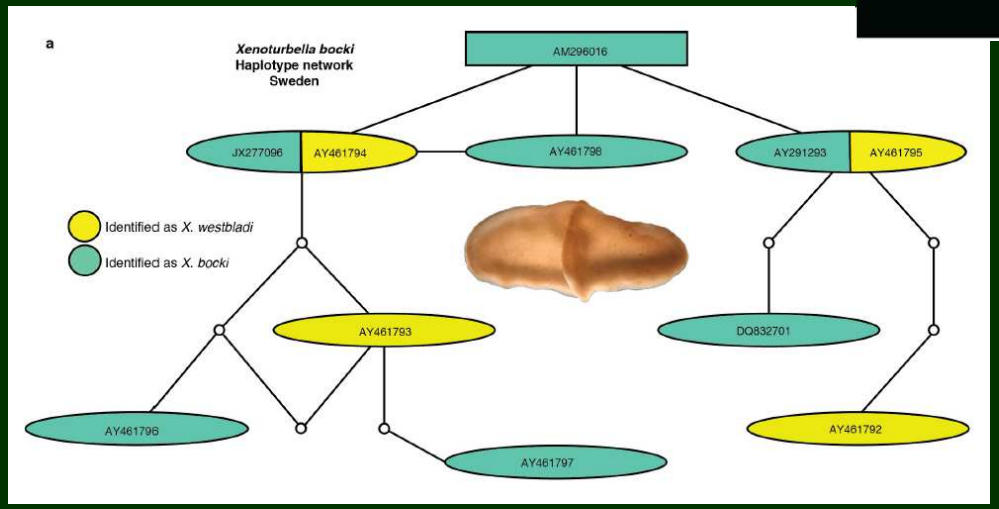
- odpovídá předkům s jednoduchým mozkem
- obrovská diverzita



# Xenoturbellida

- *Xenoturbella bocki*: Gullmarsfjord, 50-150 m
- ryje tunely (v laboratoři hluboké až 15 cm)
- živí se patrně ranými stadii mlžů nebo jejich slizem/výkaly

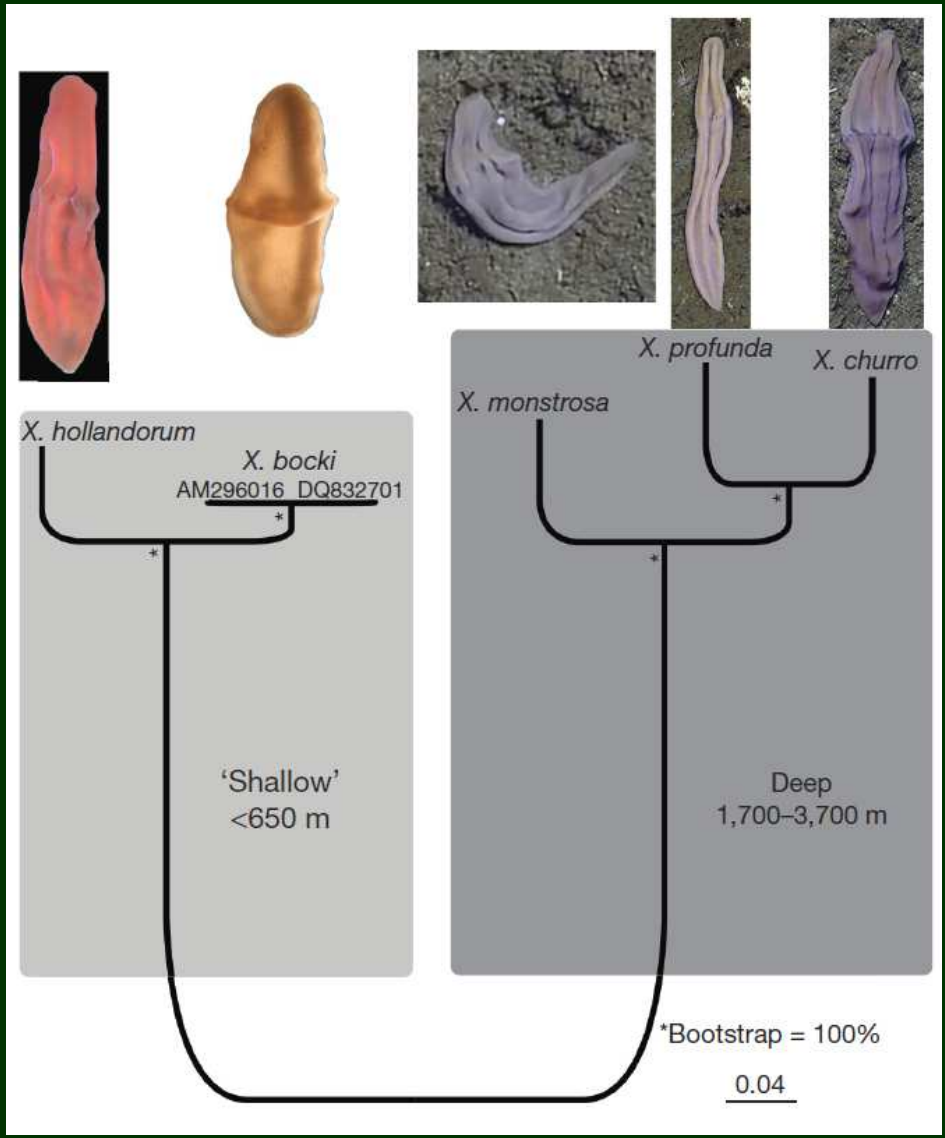


# Xenoturbellida

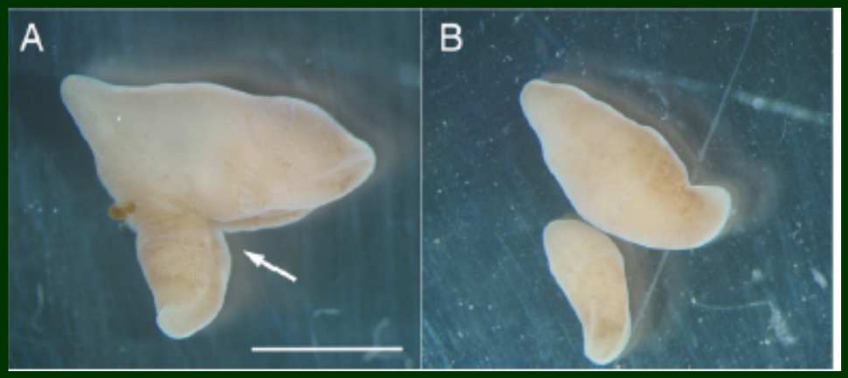
# Xenoturbellida

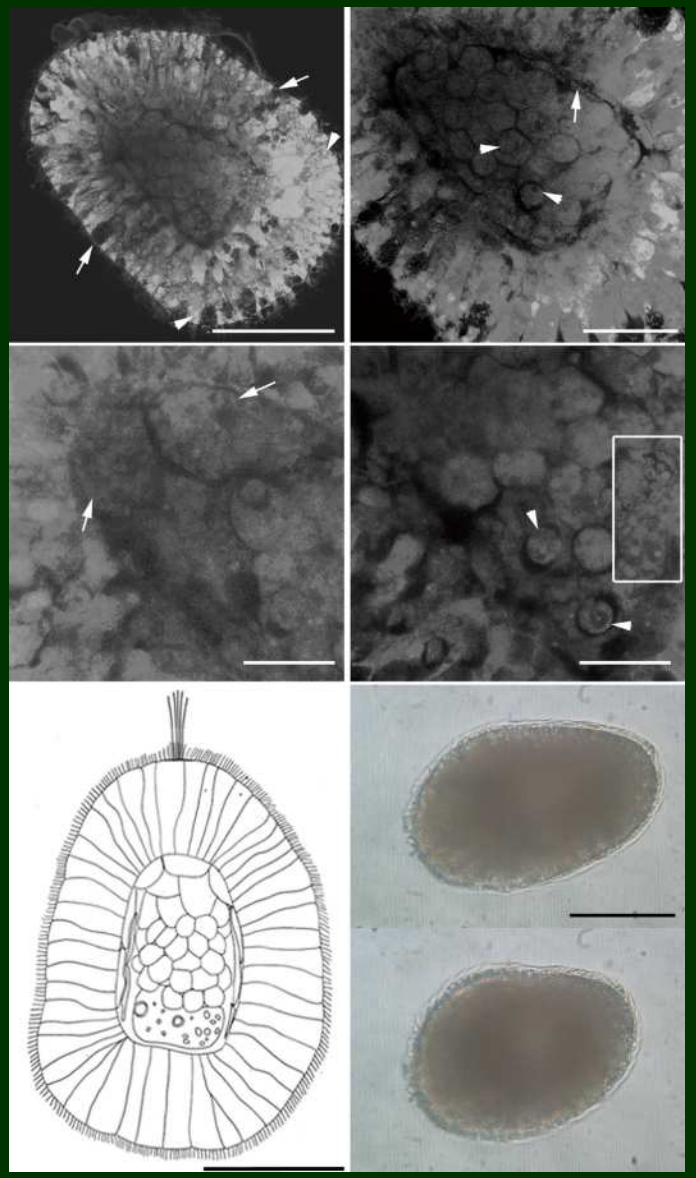
- hlubokomořské formy až 20 cm

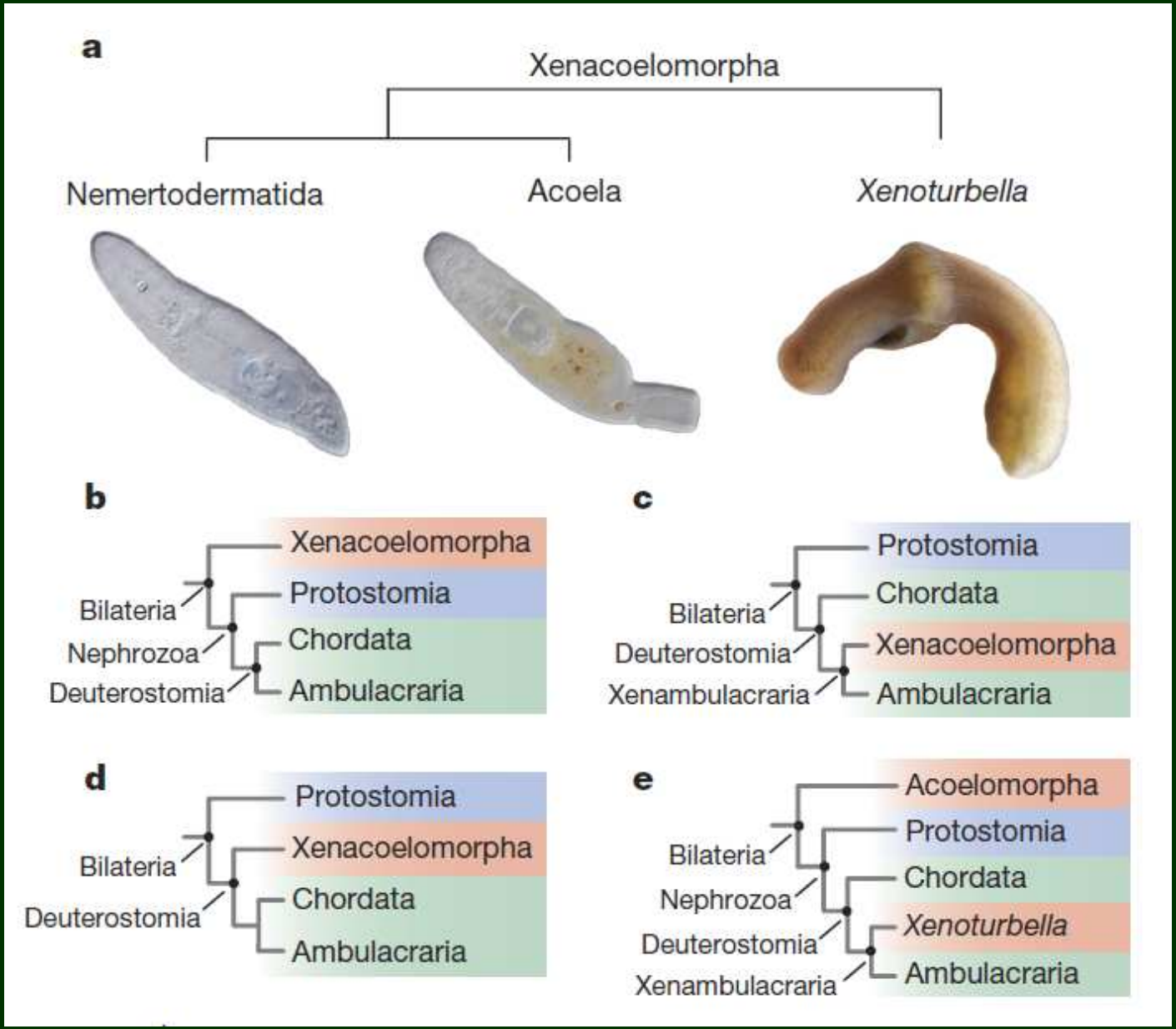


# Xenoturbellida

- přímý vývoj – obrvená plovoucí stadia s apikálním orgánem ~ planula (nežerou)
- x druhotně zjednodušené larvy bilaterií obvykle mají zbytky trávicí soustavy (ústa, řiť) či obrvených pásů
- asexuální dělení??? (regenerace – nový jedinec musí obsahovat „statocystu“)




a
Xenacoelomorpha
Nemertodermatida
Acoela
Xenoturbella
b
Xenacoelomorpha
Protostomia
Chordata
Ambulacraria
Bilateria
Nephrozoa
Deuterostomia
c
Protostomia
Chordata
Xenacoelomorpha
Ambulacraria
Bilateria
Deuterostomia
Xenambulacraria
d
Protostomia
Xenacoelomorpha
Chordata
Ambulacraria
Bilateria
Deuterostomia
e
Acoelomorpha
Protostomia
Chordata
Xenoturbella
Ambulacraria
Bilateria
Nephrozoa
Deuterostomia
Xenambulacraria

# microRNA

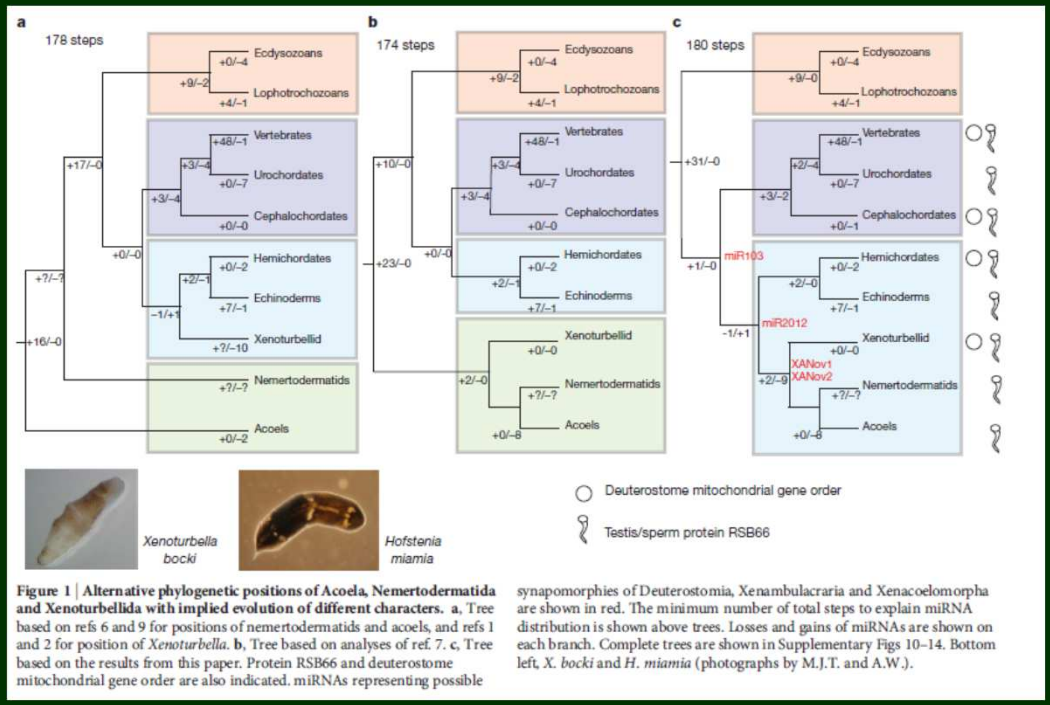



**Figure 1 | Alternative phylogenetic positions of Acoela, Nemertodermatida and Xenoturbellida with implied evolution of different characters.** **a**, Tree based on refs 6 and 9 for positions of nemertodermatids and acoels, and refs 1 and 2 for position of *Xenoturbella*. **b**, Tree based on analyses of ref. 7. **c**, Tree based on the results from this paper. Protein RSB66 and deuterostome mitochondrial gene order are also indicated. miRNAs representing possible synapomorphies of Deuterostomia, Xenambulacraria and Xenacoelomorpha are shown in red. The minimum number of total steps to explain miRNA distribution is shown above trees. Losses and gains of miRNAs are shown on each branch. Complete trees are shown in Supplementary Figs 10–14. Bottom left, *X. bocki* and *H. miamia* (photographs by M.J.T. and A.W.).

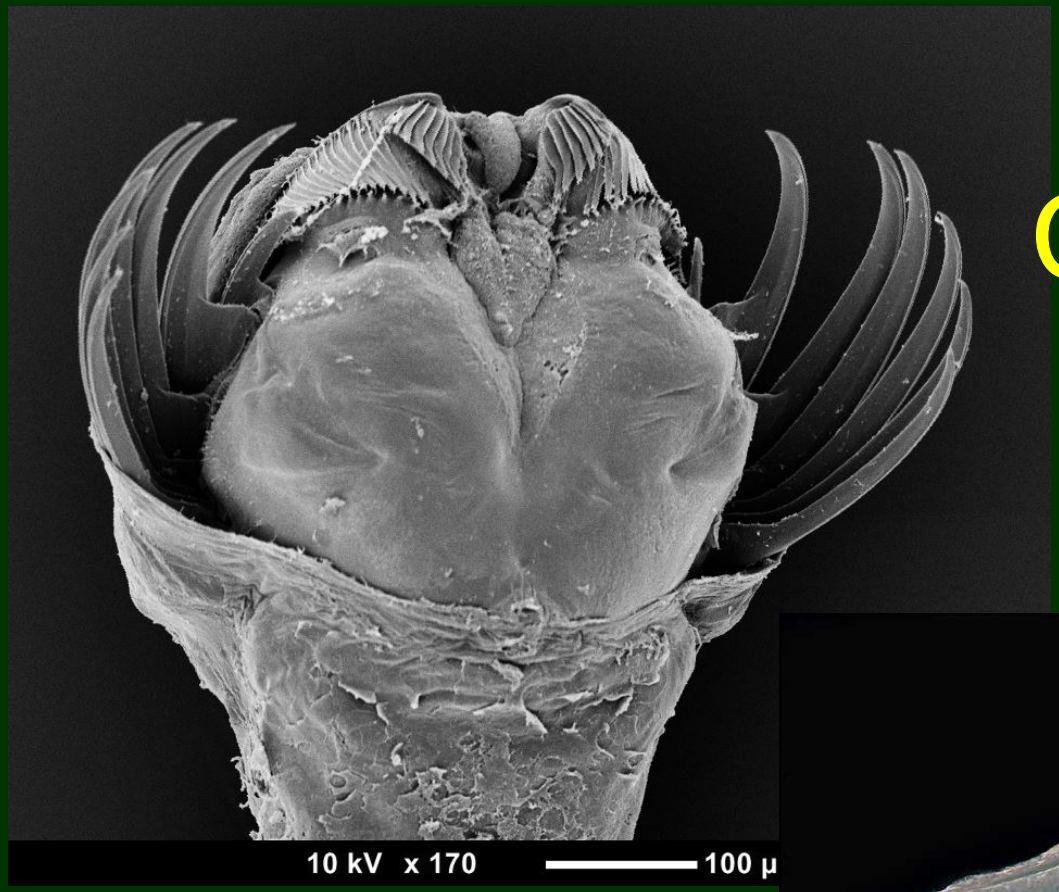
- zásadní rozdíly v prezenci/absenci miRNA i u různých druhů Acoela (*Hofstenia* x *Symsagittifera*) → velké redukce miRNA
- x specifické deuterostomní miRNA má *Xenoturbella* a někdy i Acoela

# Nephrozoa = Eubilateria

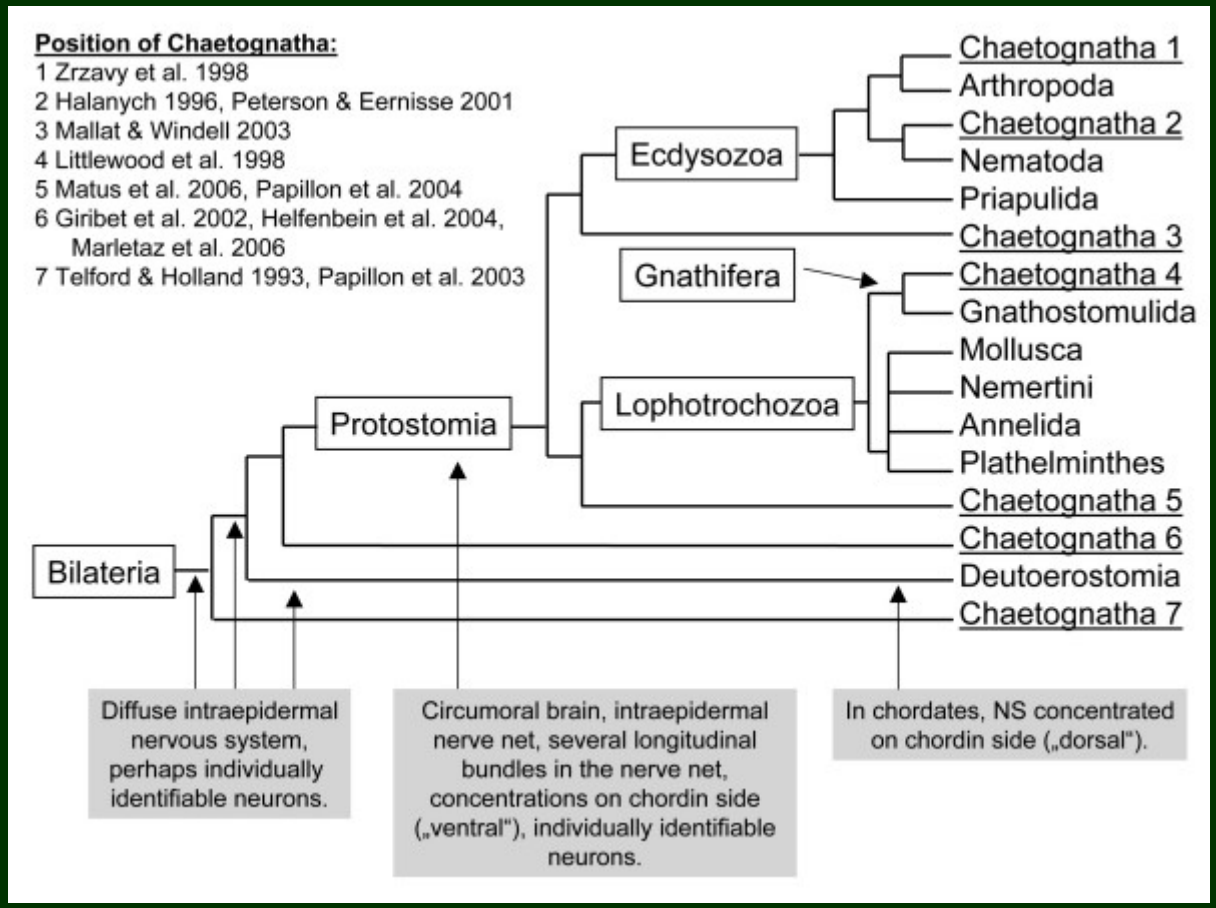
- 1. Hyponeuria
  - 1.1. Protostomia
    - 1.1. Spiralia
    - 1.2. Ecdysozoa
  - 1.2. Chaetognatha
- 2. Deuterostomia
  - 2.1. Ambulacraria
  - 2.2. Chordata

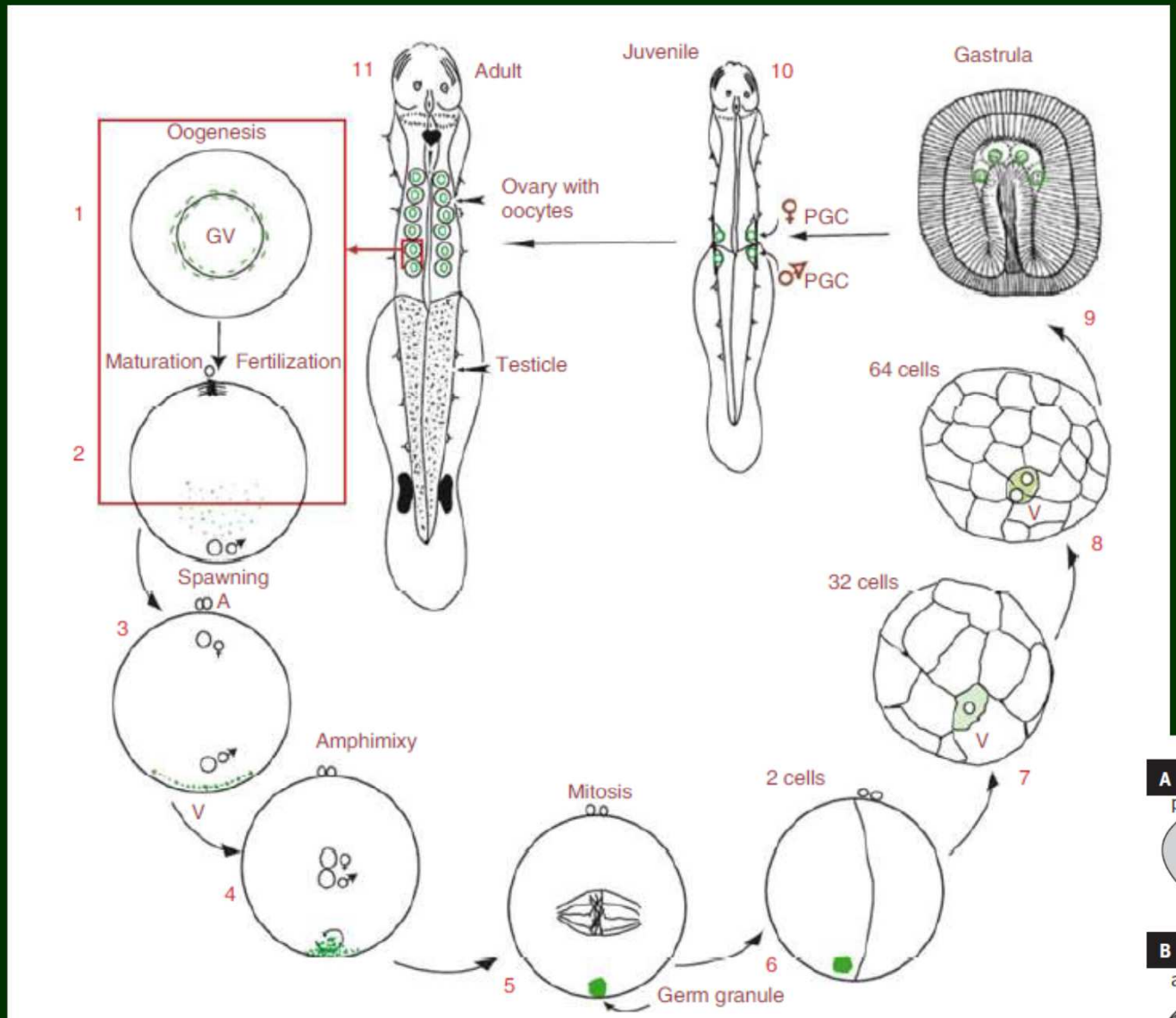
- trávicí trubice s řitním otvorem, nefridia, mozek, planktonní larvy ???

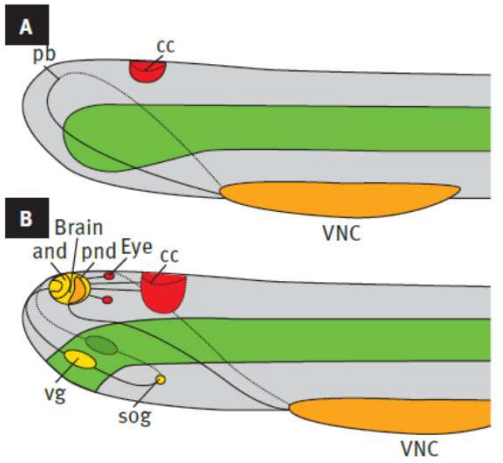
# Chaetognatha




# Chaetognatha

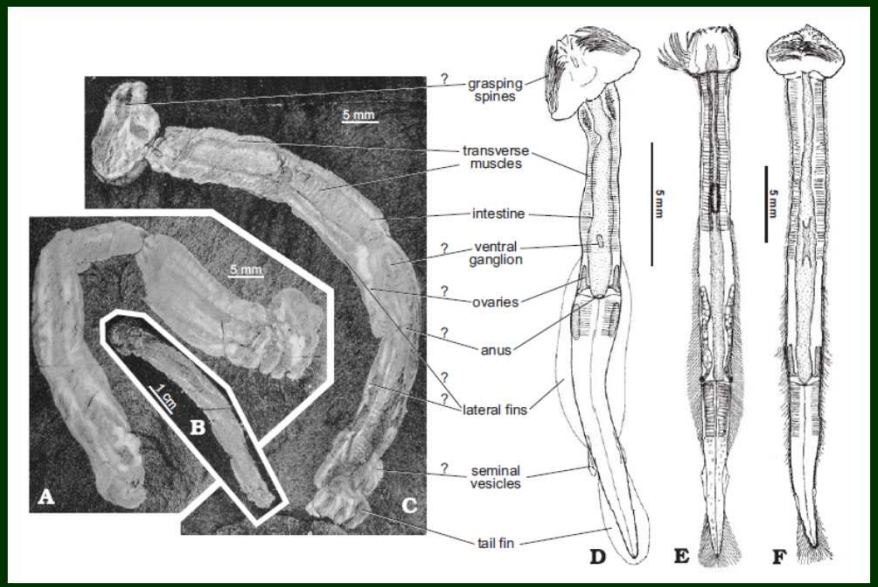


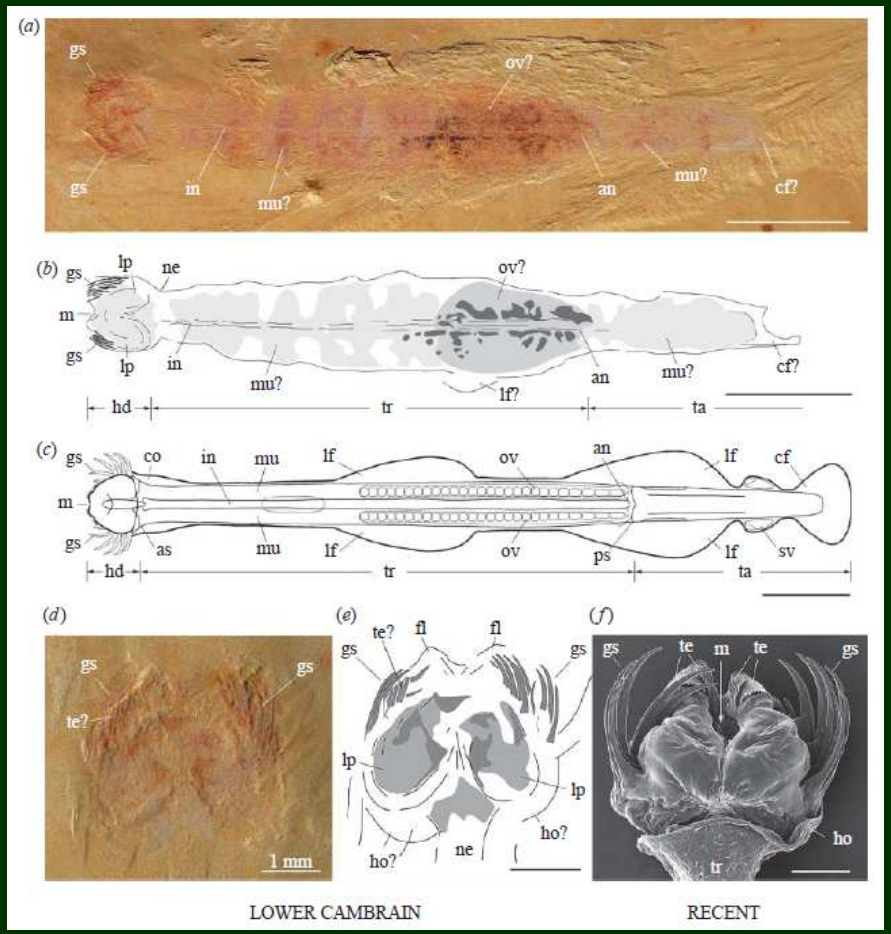

Oogenesis
1
GV
Maturation
Fertilization
2
Spawning
A
3
V
4
Amphimixy
5
Mitosis
Germ granule
6
2 cells
7
32 cells
V
8
64 cells
V
9
Gastrula
10
Juvenile
♀ PGC
♂ PGC
11
Adult
Ovary with
oocytes
Testicle


A
pb
cc
VNC
B
Brain
and
pnd
Eye
cc
vg
sog
VNC

# Chaetognatha

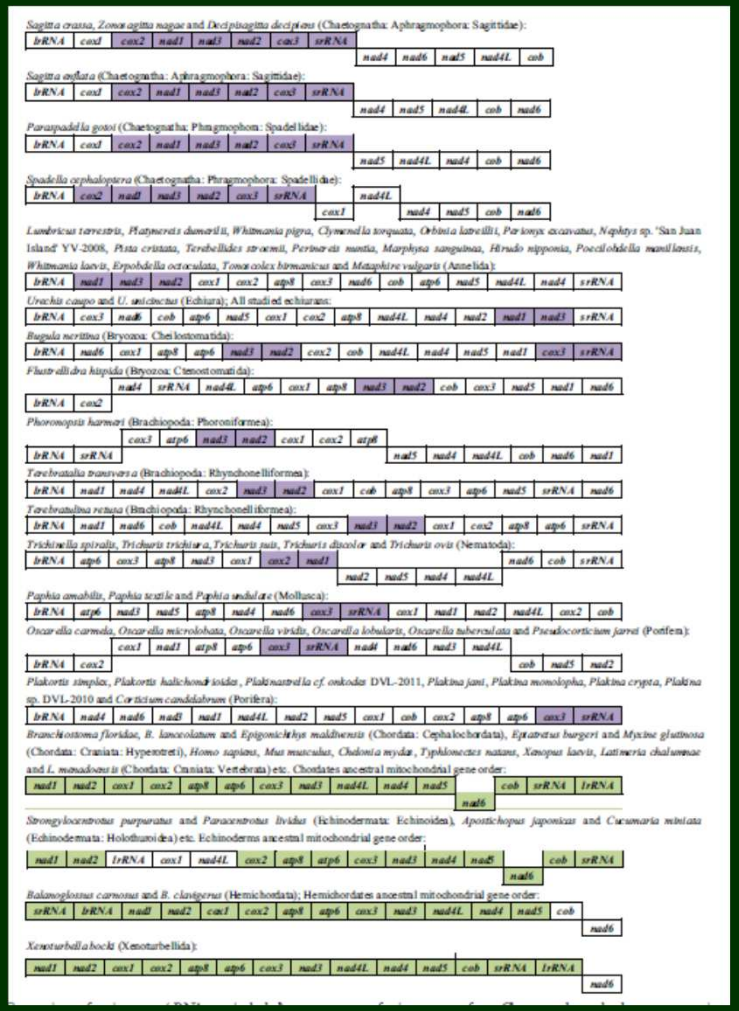
- fosilní záznam patrně už z kambria (*Protosagitta*, *Oesia*?)
- *Paucijaculum* (karbon)
- (protokonodonty?)
- (*Amiskwia*???)

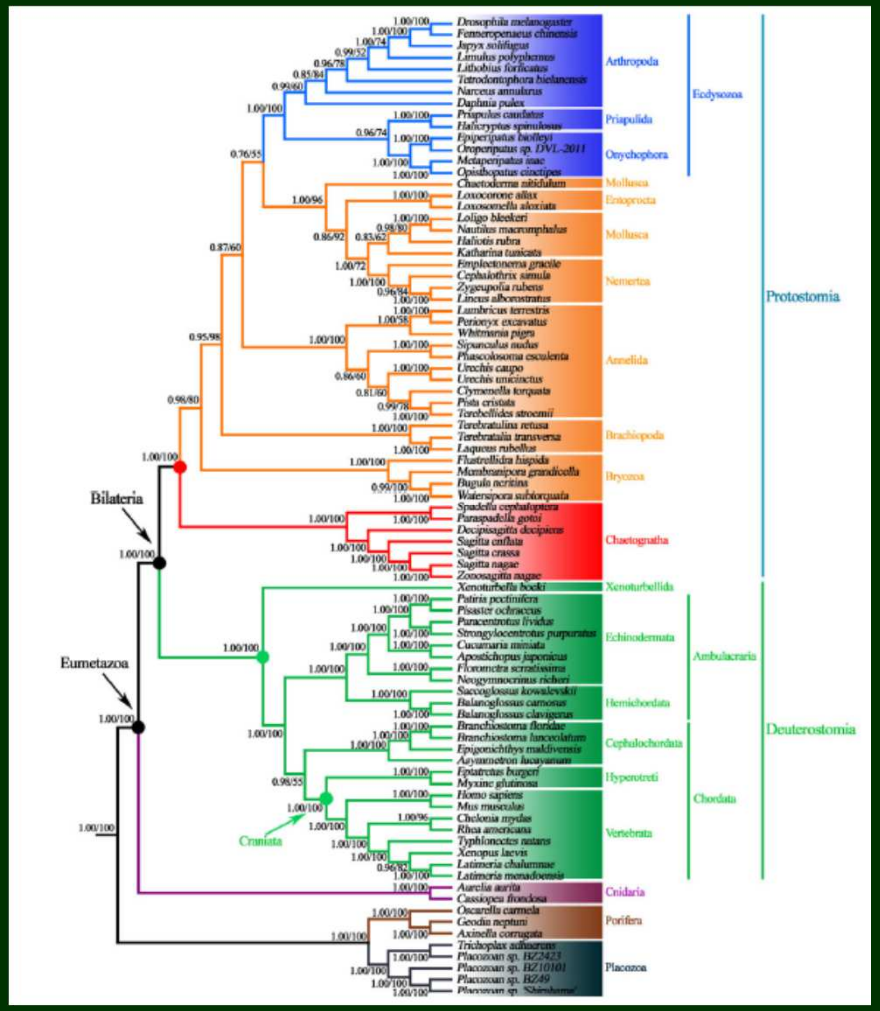


# Chaetognatha

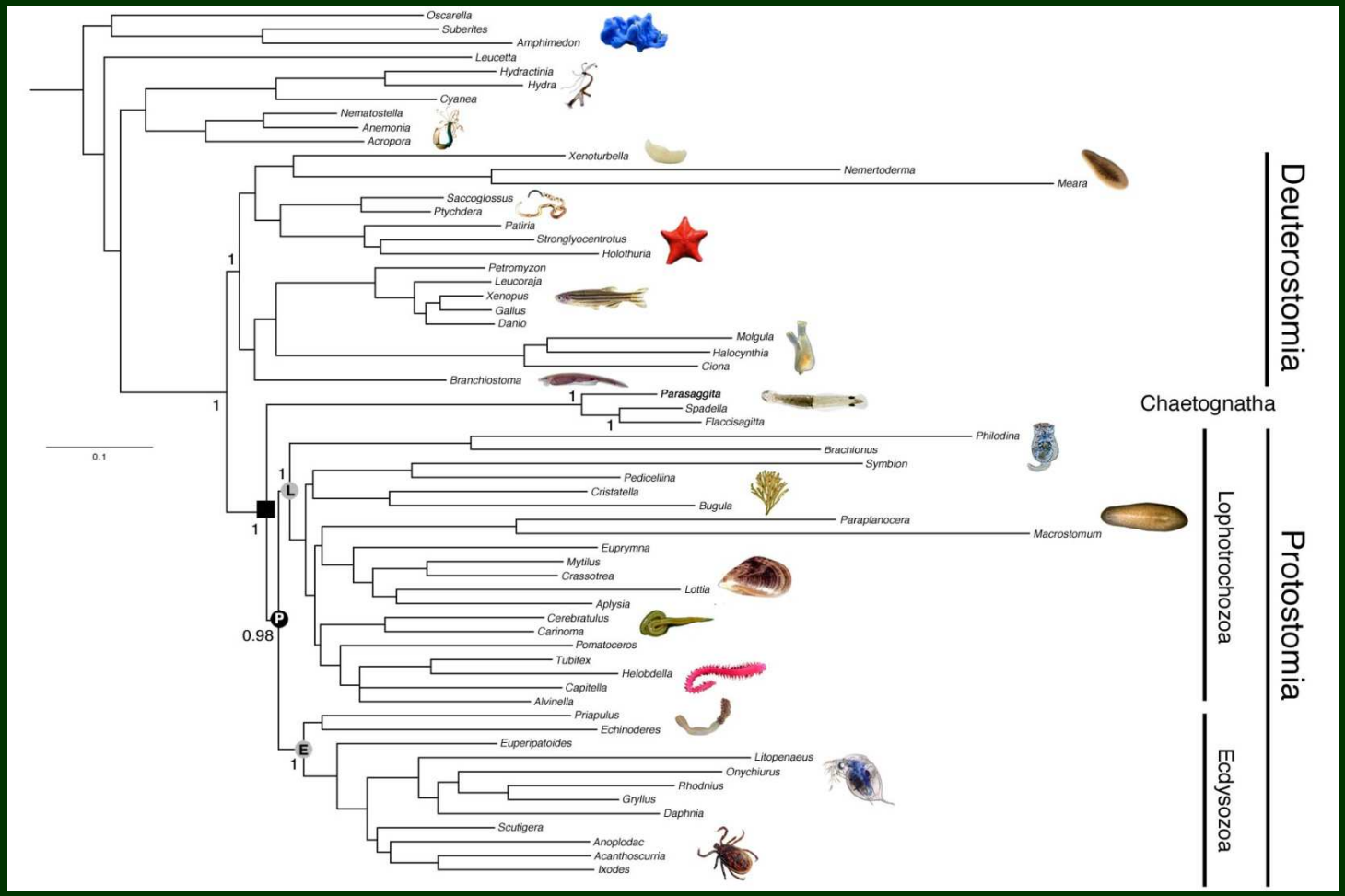
mtDNA



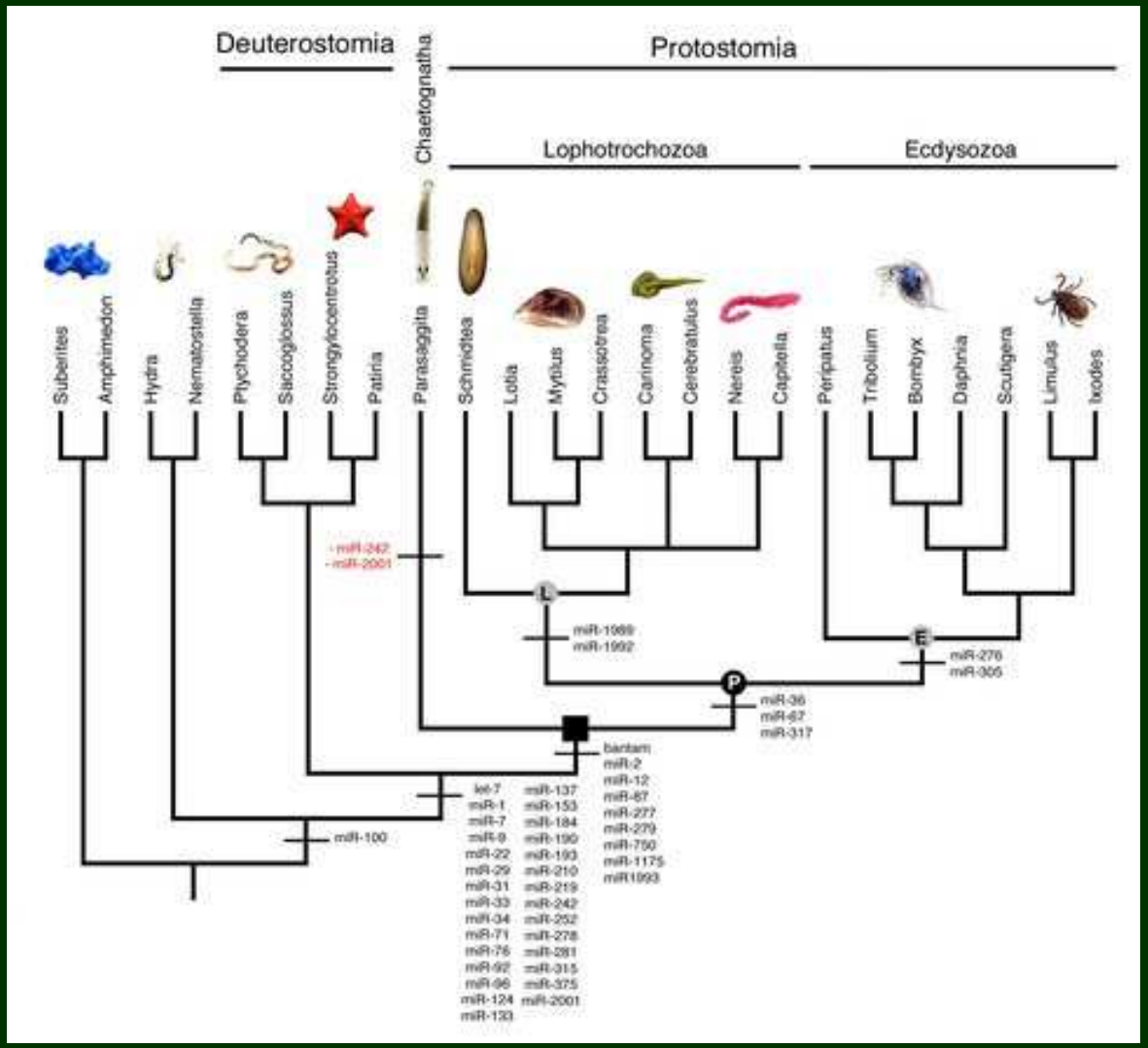
# Fylogeneze ploutvenek

186 genů



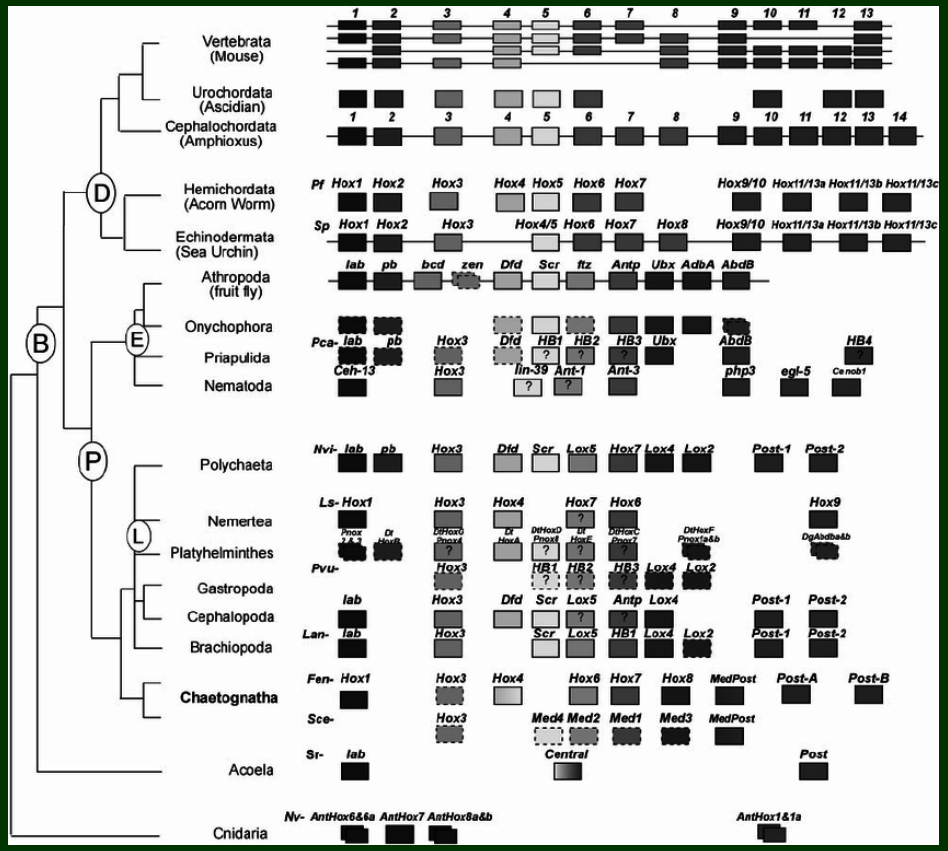
# Fylogeneze ploutvenek

miRNA



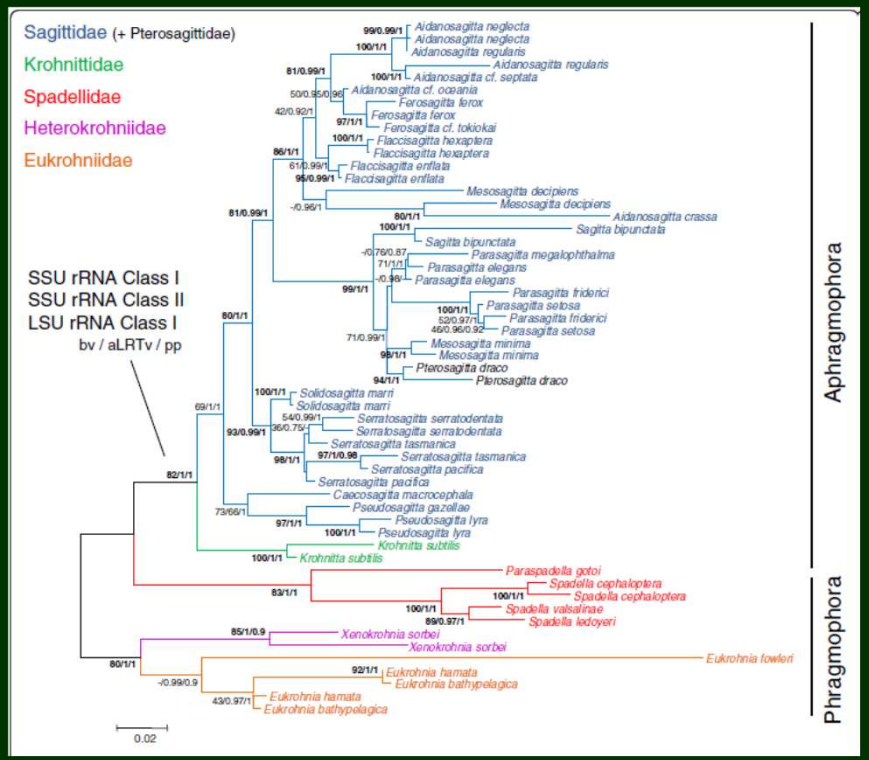
# Chaetognatha Hox

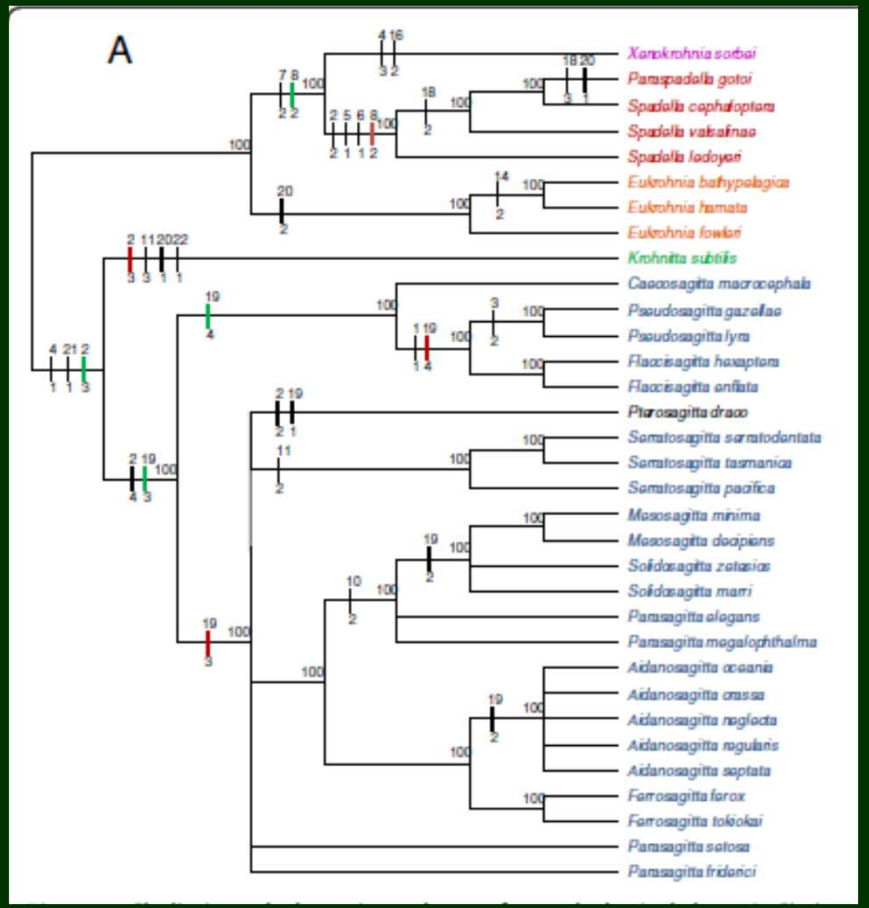
- zvláštní (primitivní???) Hox geny – *MedPost* spojuje vlastnosti mediánních a posteriorních (ty nejsou příbuzné genům u spirálií a ekdysozoí)



# Fylogeneze ploutvenek

18S + 28S + morfologie



# Fylogeneze ploutvenek

- Phragmophora parafyletická (1. Eukrohniidae + Heterokrohniidae; 2. Spadellidae)
- Aphragmophora monophyletická
- převládající zjednodušování tělního plánu