Mollusca II

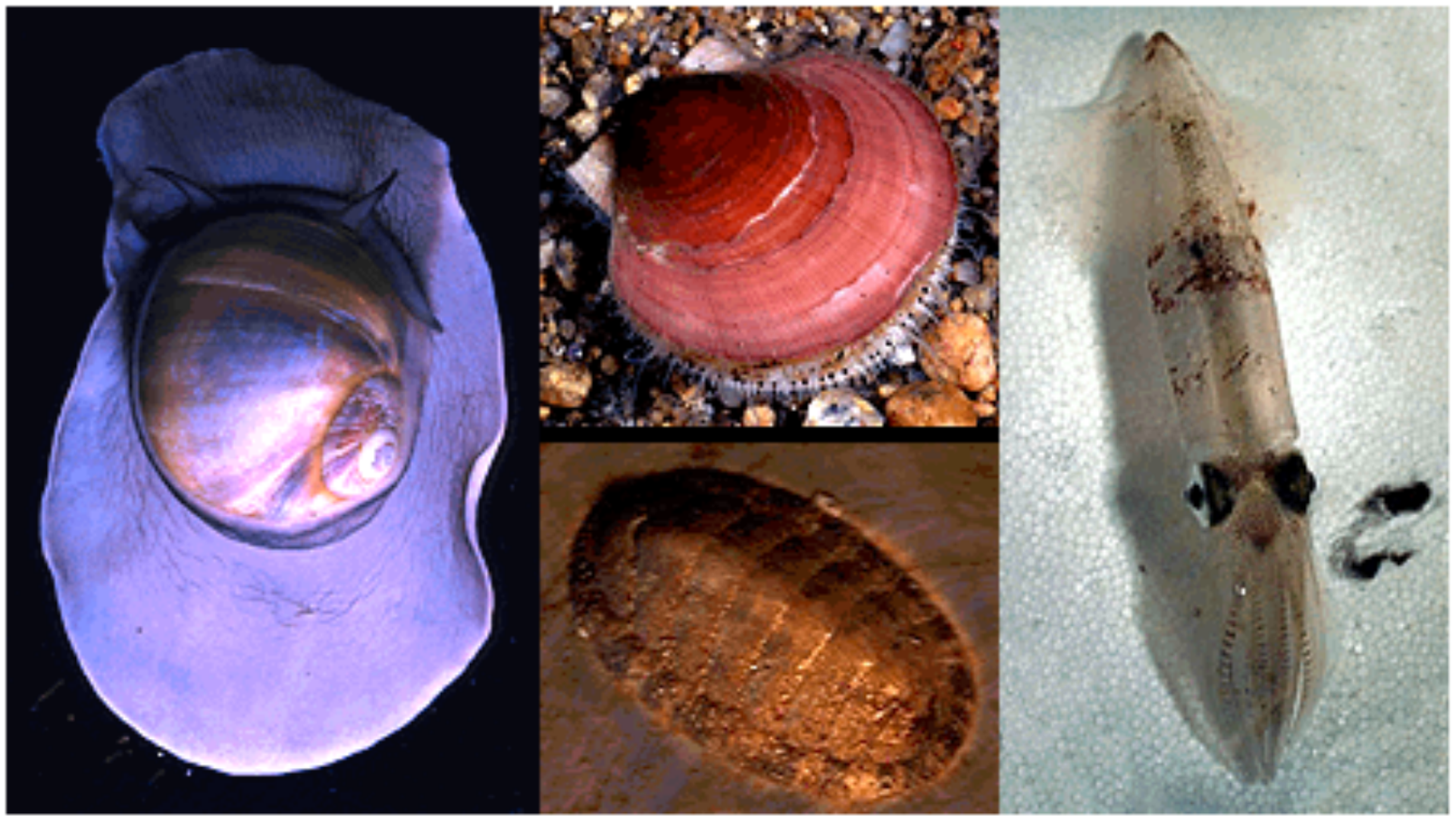
Lec 8

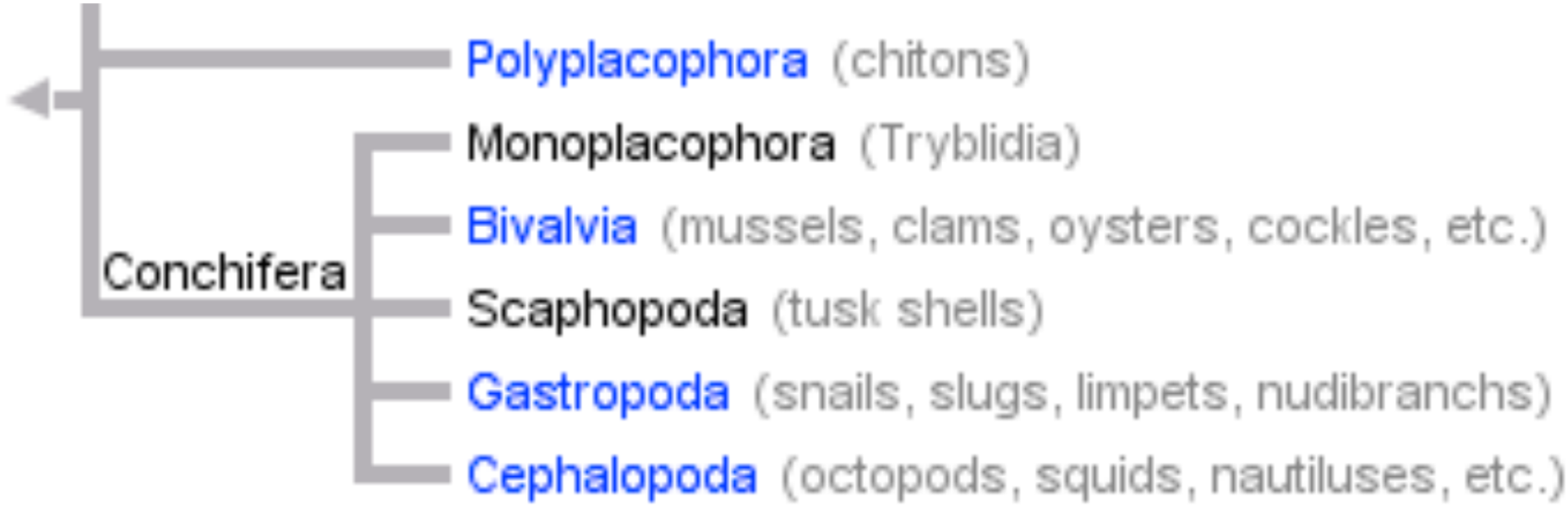
Classification

7 classes

Mollusca

Snails, clams, mussels, squids, octopi, chitons, and tusk shells





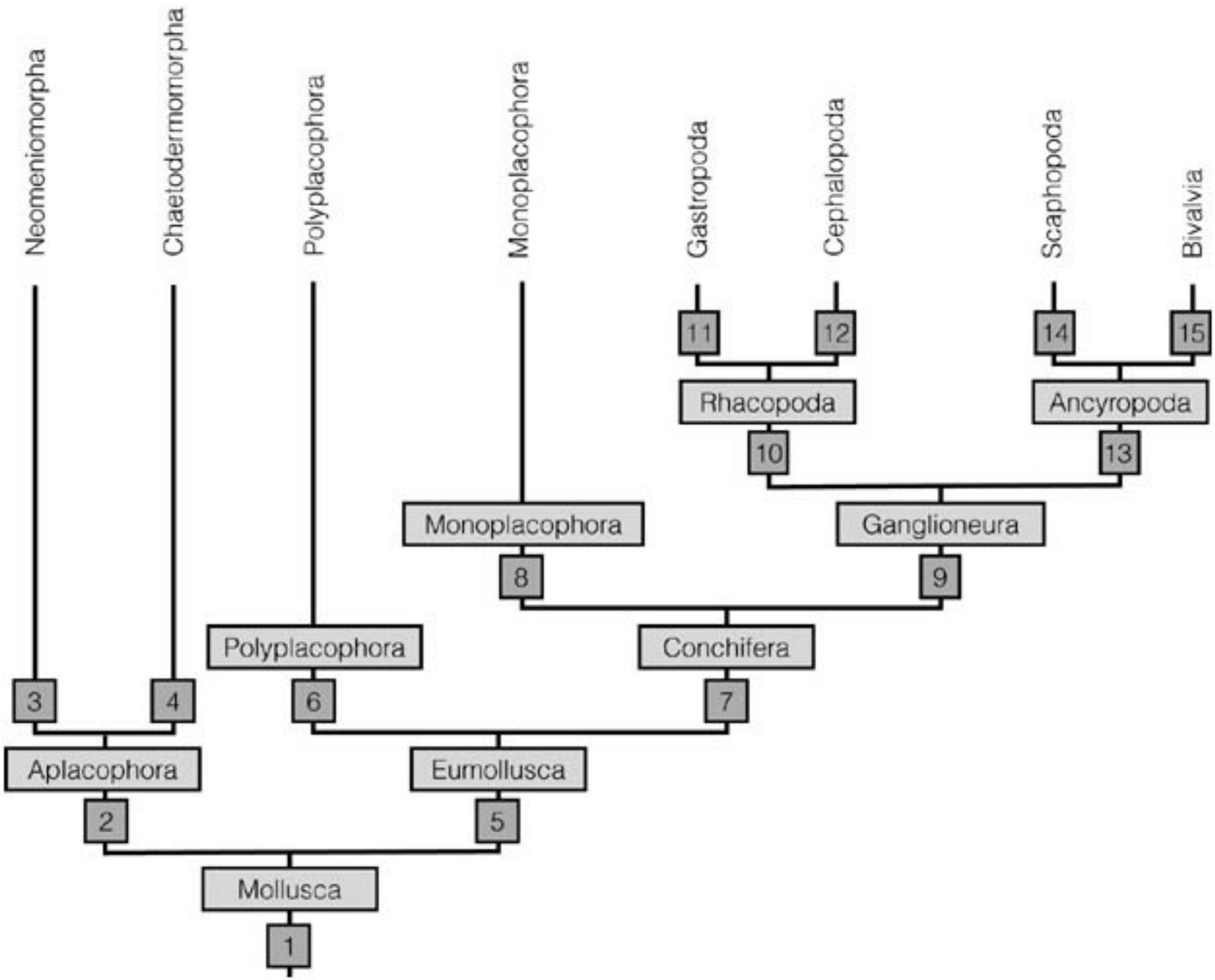
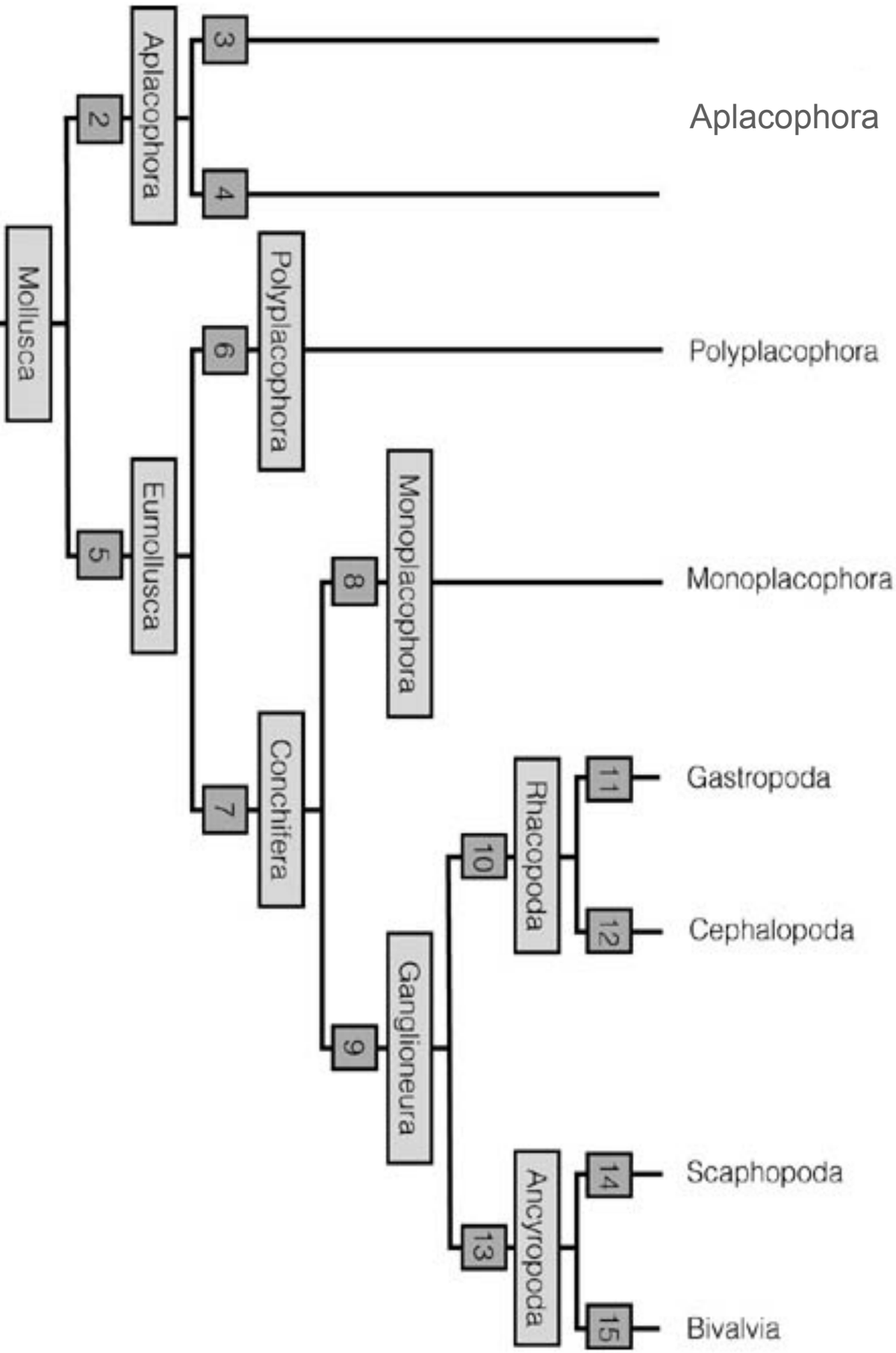


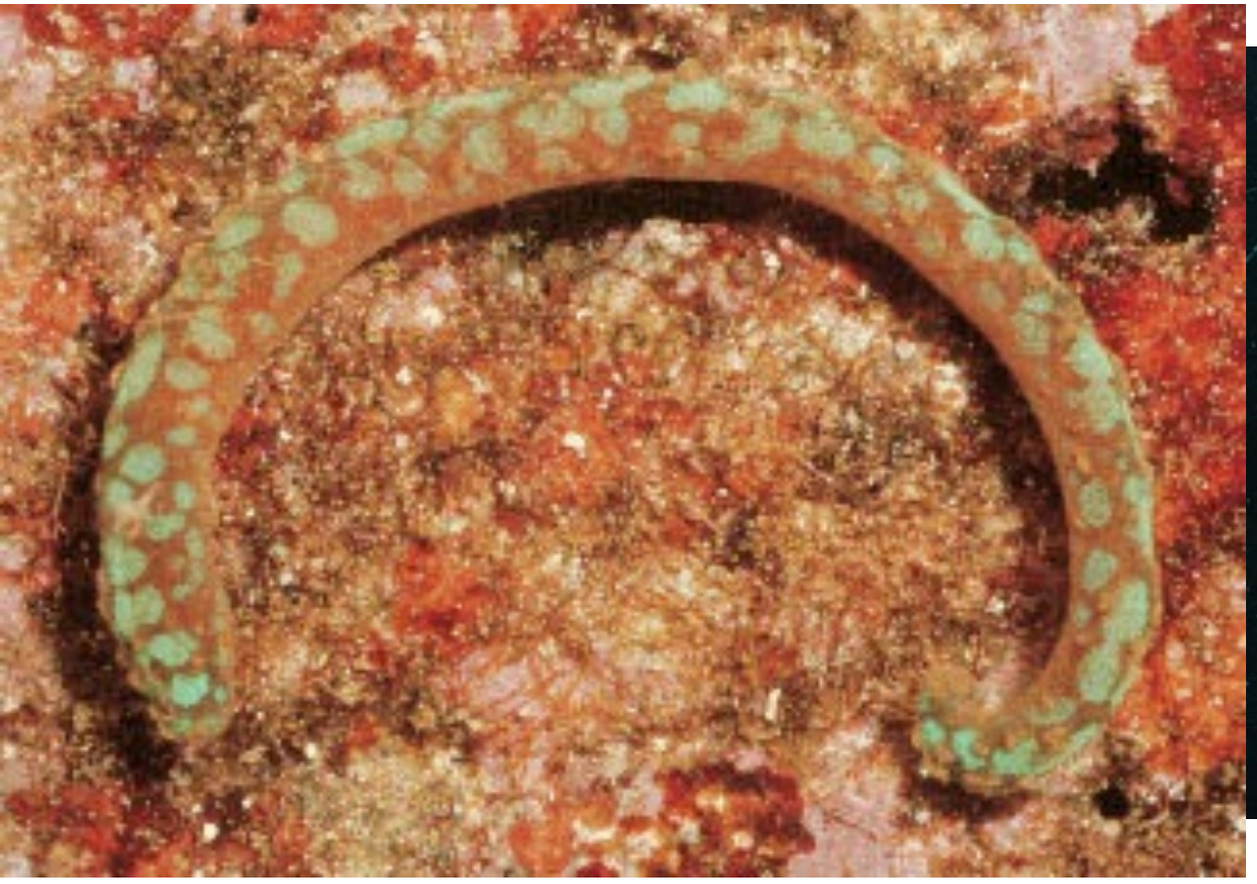
Figure 12-125: **A phylogeny of Mollusca.**



http://goo.gl/qDCWB

Aplacophora

- Defining Characteristics
  - Cylindrical, **vermiform** body with foot that is reduced or absent



Aplacophora

Mostly deep sea benthic animals

~320 extant species

Usually a few mm to 5 cm (up to 30 cm)

Lack a shell → spicules (only class w/o fossil record)

Reduced or absent foot

Gills as mantle folds or external

Aplacophora

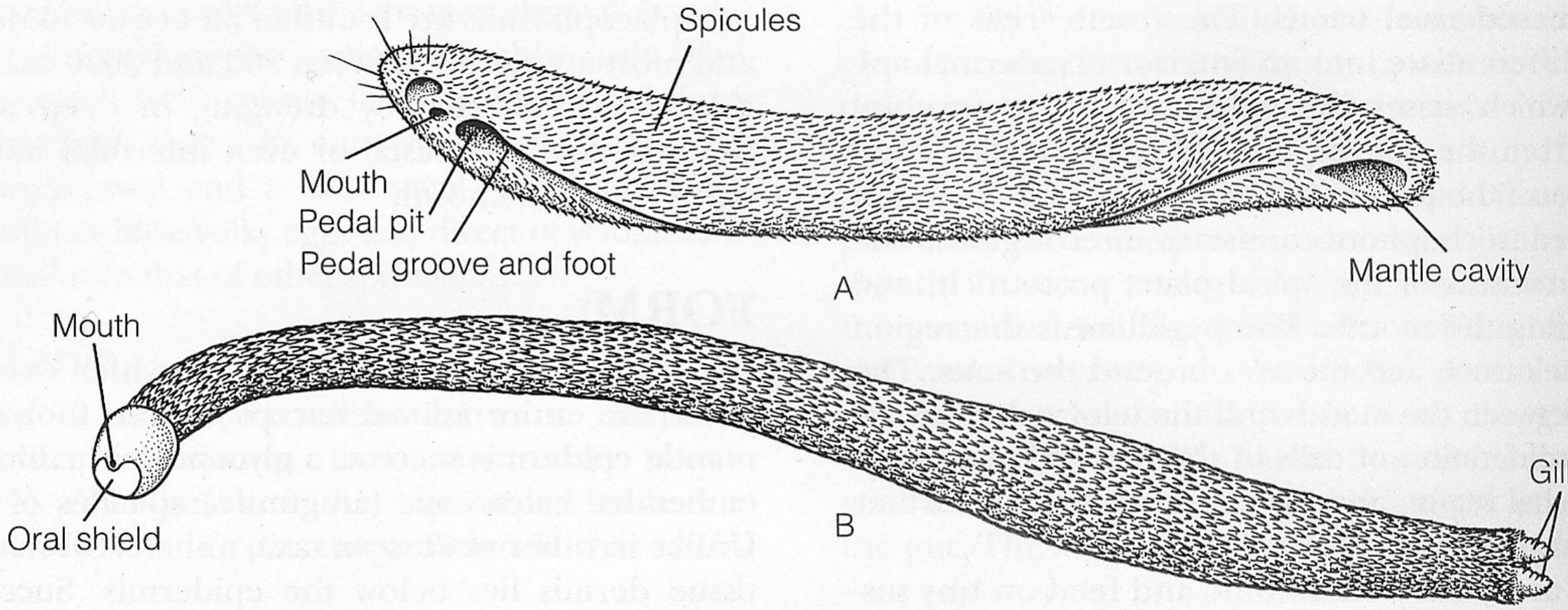
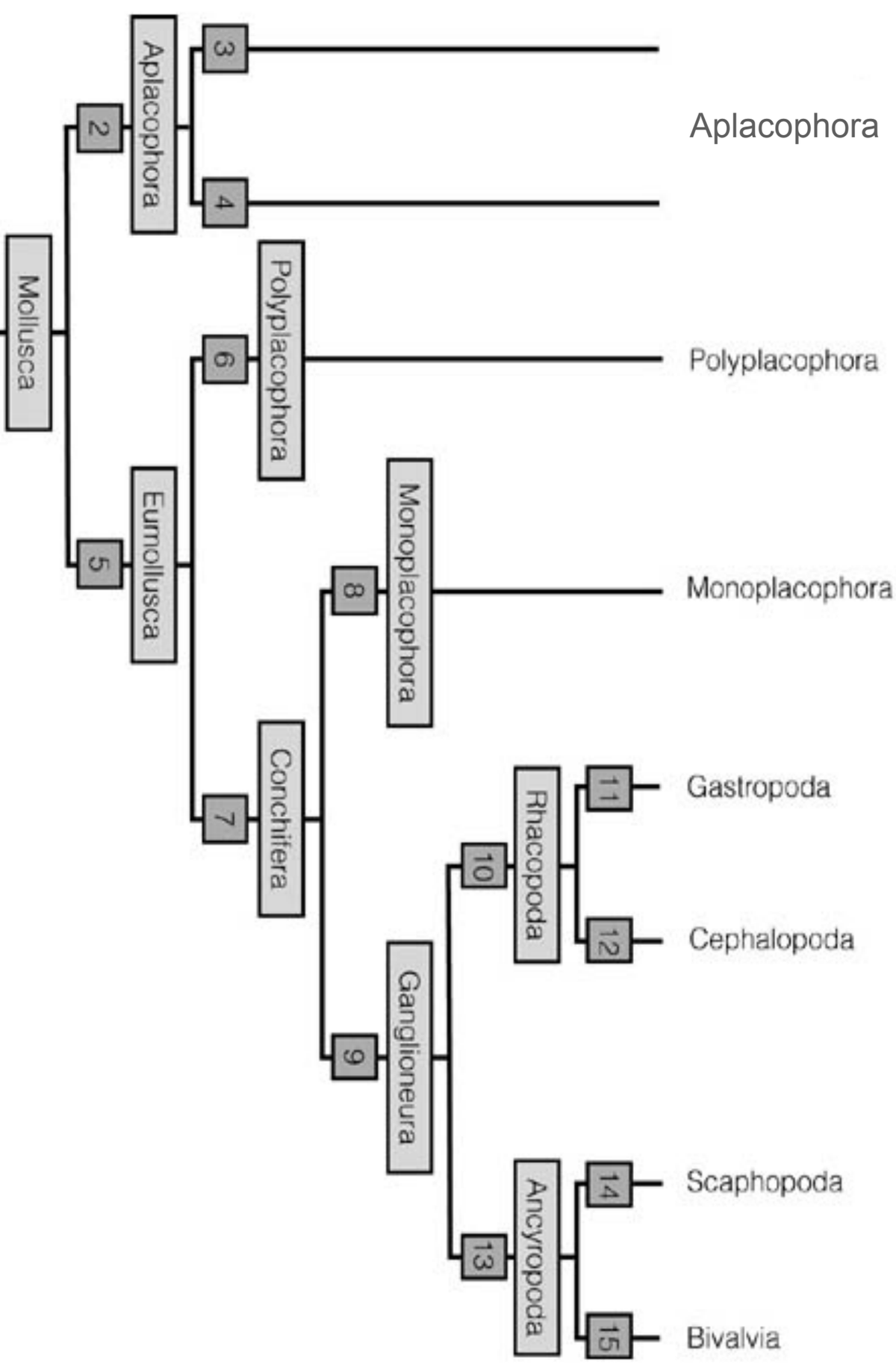


FIGURE 12-5 External anatomy of aplacophoran molluscs. **A,** A neomeniomorph. **B,** A chaetodermomorph. *(Redrawn and modified from Salvini-Plawen, L. V. 1972. Zur Morphologie und Phylogenie der Mollusken: Die Beziehungen der Caudofoveata und der Solenogastres als Aculivera, als Mollusca und als Spiralia. Z. wiss. Zool. 184:205–394)*

Ruppert, Fox, and Barnes 2004

Aplacophora Locomotion

- Foot, when present, is not muscular and locomotion is typically ciliarly
  - Use pedal cilia to glide over the sediment along a mucous trail they secrete
  - Some meander in or along mud
- Some live on cnidarians on which they feed and foot plays role in moving over cnidaria


Mollusca
Aplacophora
Polyplacophora
Eumollusca
Monoplacophora
Conchifera
Rhacopoda
Ganglioneura
Ancyropoda
1
2
3
4
5
6
7
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13
14
15
Aplacophora
Polyplacophora
Monoplacophora
Gastropoda
Cephalopoda
Scaphopoda
Bivalvia

Polyplacophora

Chitons

Defining Characteristic

- Shell forms series of 7-8 separate, overlapping plates

Katharina tunicata

Tonicella

Polyplacophora

Cryptochiton stelleri **in ventral view.**

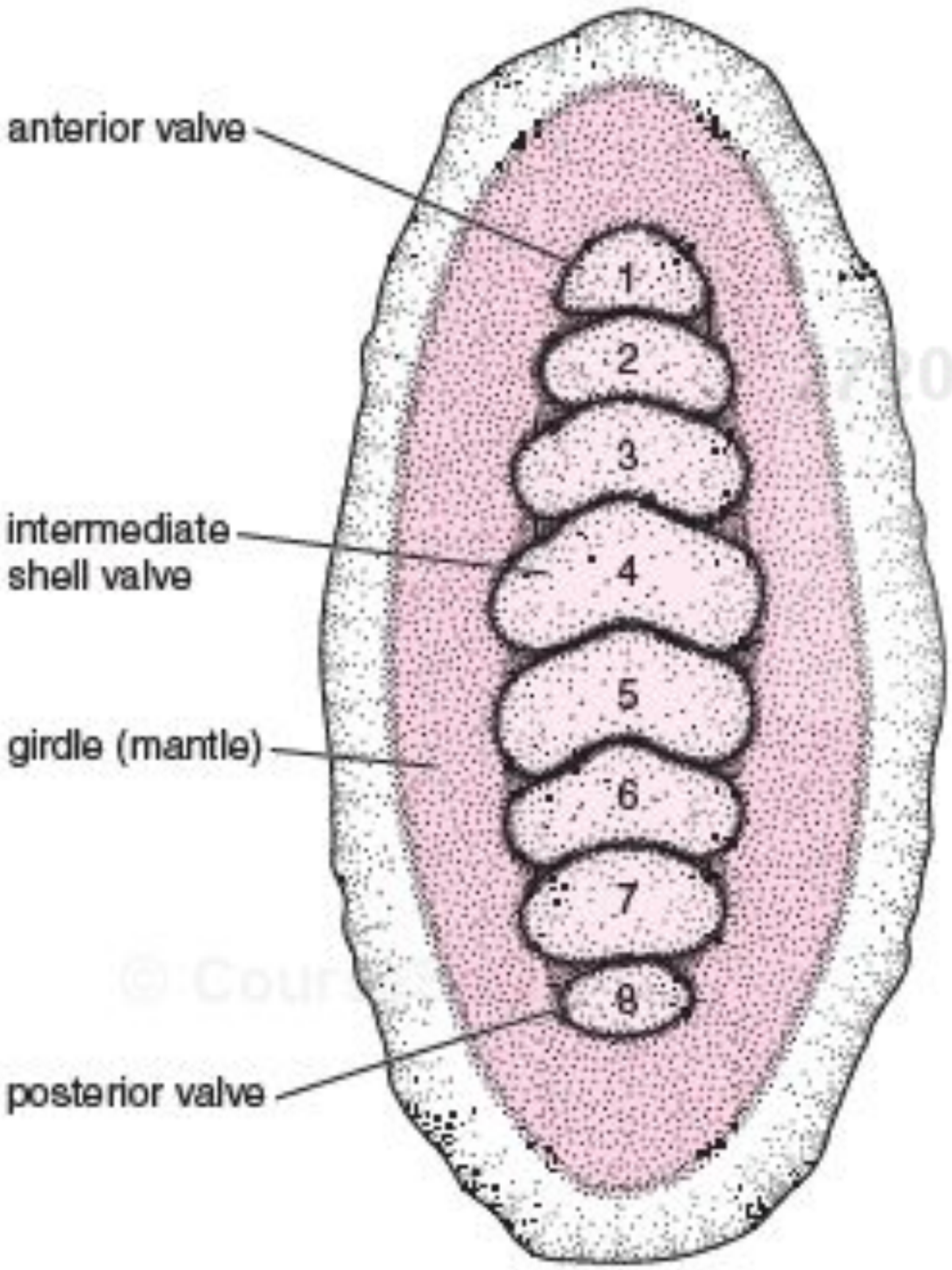
Friday Harbor, Washington.

Cryptochiton stelleri**, giant pacific chitin (Polyplacophora: Acanthochitonina), in dorsal view. Friday Harbor, Washington**

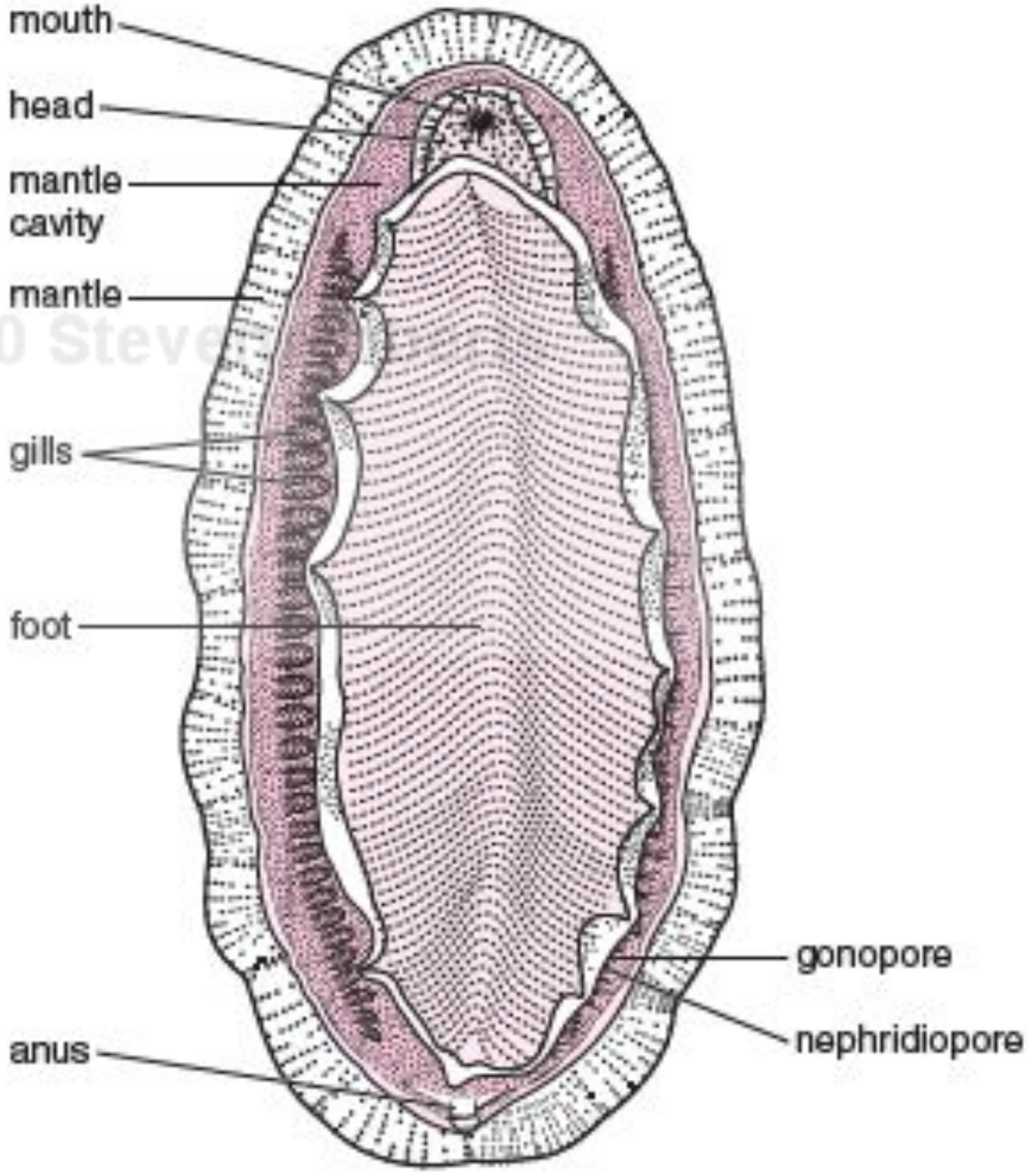
Polyplacophora

- ~800 extant species, ~350 fossil spp.
- Usually 3-10 cm in length, 40 cm max size
- All marine; most near shore – some deep

Polyplacophora

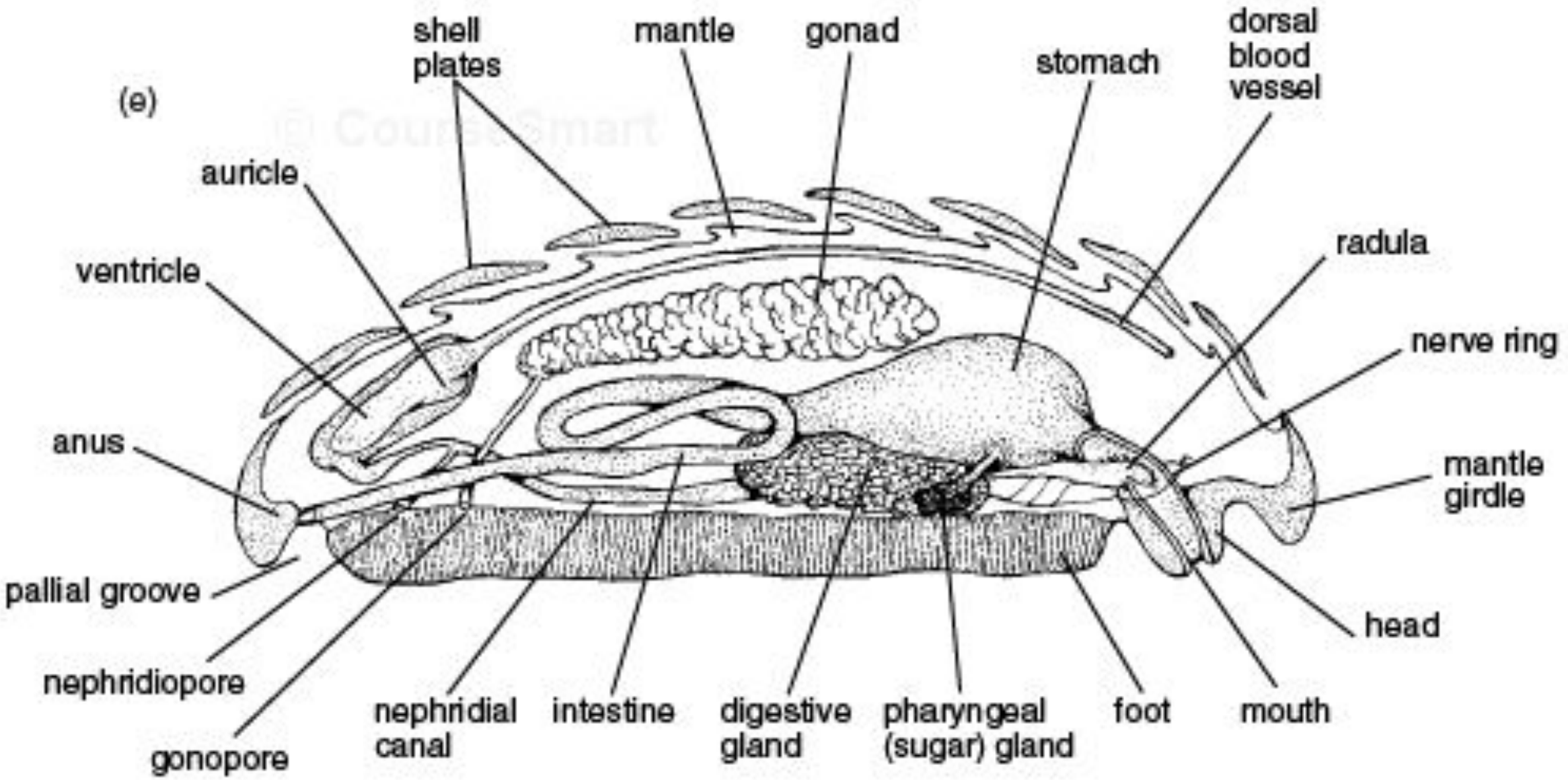


(a)



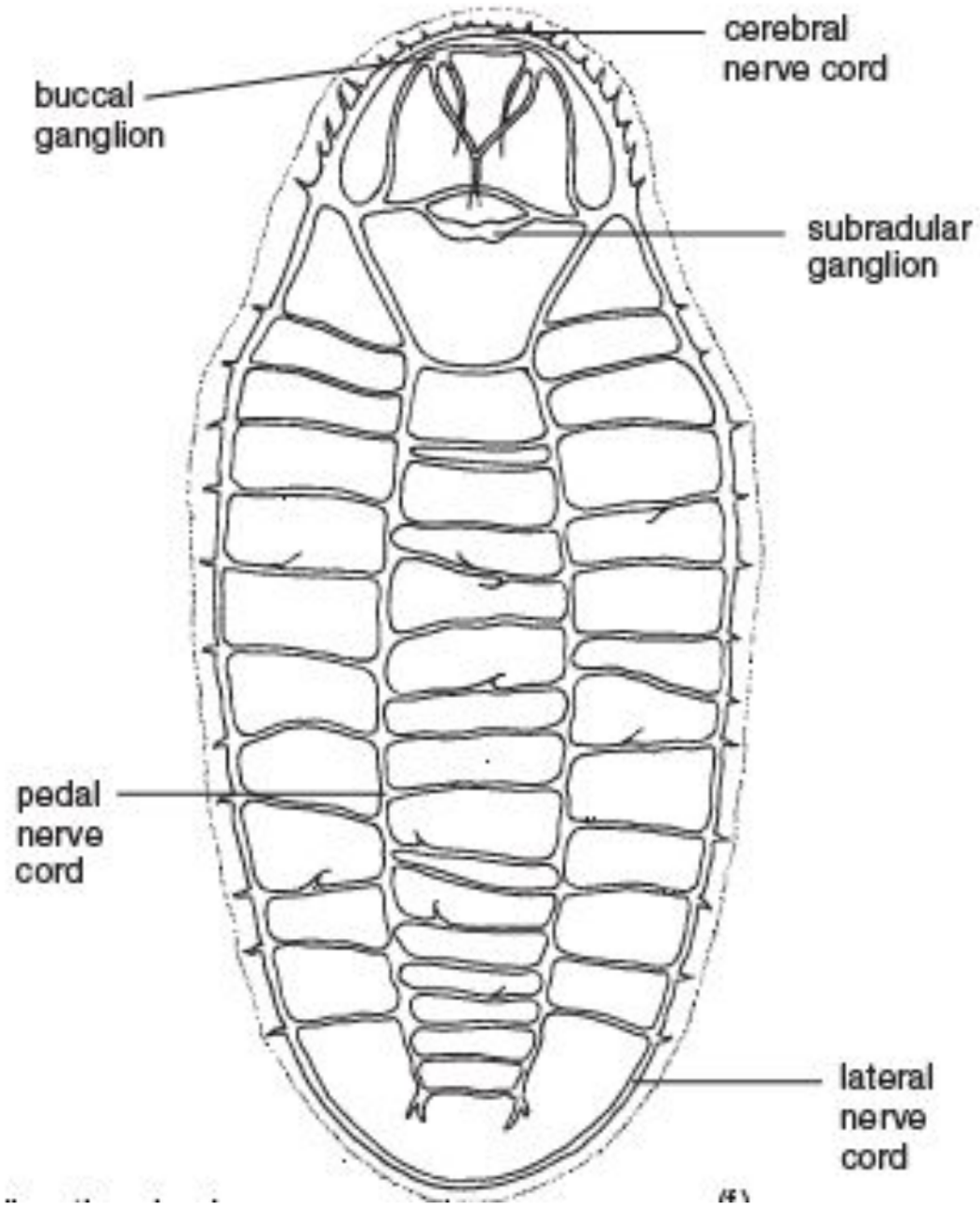
(b)

Polyplacophora



Polyplacophora - nervous system

Ladder-like



Sense organs limited:

subradular organ (tongue-like chemosensory organ for feeding),

mantle receptors

Aesthetes

some with **osphardium** (tests water)

lack statocysts, tentacles, and eyes on head

STUDIES ON HOMING IN THE CHITON *ACANTHOZOSTERA GEMMATA*

By M. J. THORNE*

Feeding excursions are made only at night while uncovered by the tide. One or two excursions may be made per night, depending on the tide times. When the time between onset of darkness and cover by the tide was 40 min, chitons did not move from their homesites, but when there was an interval of 90 min between dusk and cover by the tide, 12 out of 20 chitons in a marked group moved out to feed. The distances travelled were small (20 cm or less) and all but two individuals returned to their homesites before tidal cover. These two chitons were still active after one hour's cover by the tide.

TABLE 1

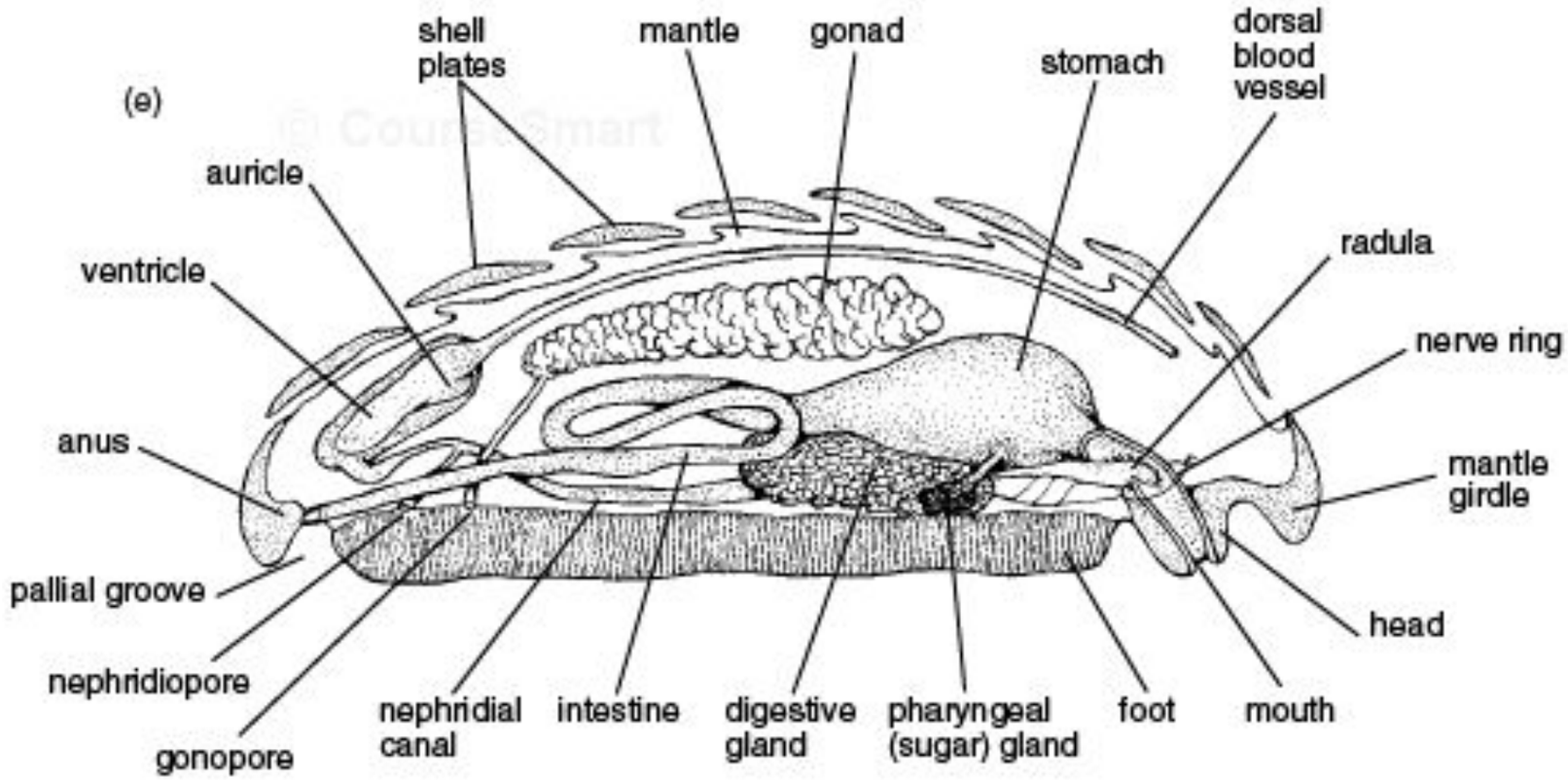
DISTANCE TRAVELLED (cm) FROM HOMESITE AND HOMING ABILITY OF A. GEMMATA

No. of Chiton	Distance Travelled	Return to Homesite	No. of Chiton	Distance Travelled	Return to Homesite
A1	84	yes	A19	79	yes
A2	133	yes	A20*		
A3	39	yes	A21	28	yes
A4*			A22	49	yes
A5*			A23	34	yes
A6	24	yes	A24	21	yes
A7	44	yes	A25	0	—
A8	41	yes	A26	0	—
A9*			A27	82	yes
A10	66	yes	A28	29	yes
A11	79	yes	A29	30	yes
A12	24	yes	A30	18	yes
A13	34	yes	A31	41	yes
A14	60	yes	A32	26	yes
A15	0	—	A33	24	yes
A16	49	yes	A34	46	yes
A17	51	yes	A35	42	yes
A18	41	yes			

* Chiton and homesite marked in the afternoon but chiton could not be found that night or subsequently.

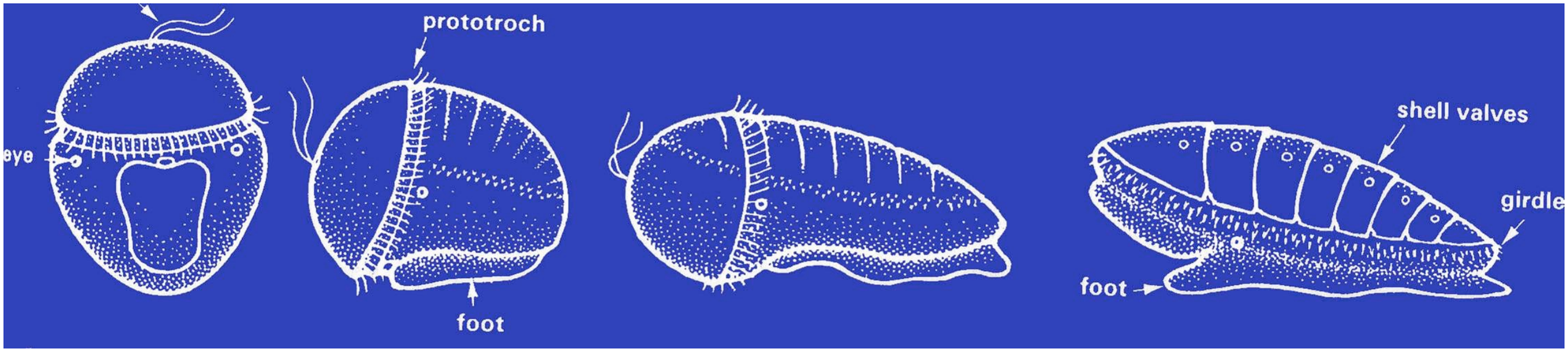
- Chitons moved at an average speed of 0.24 cm/min
- *Fasted recorded speed 3 cm/min*

Polyplacophora - feeding



- 'Linear' digestive tract – mouth and anus at opposite ends
- Most use radula (often tipped with iron-oxide) for feeding
- Salivary glands
- Paired esohageal glands (sugar glands) secrete amylase into posterior esophagus → stomach

Polyplacophora - development

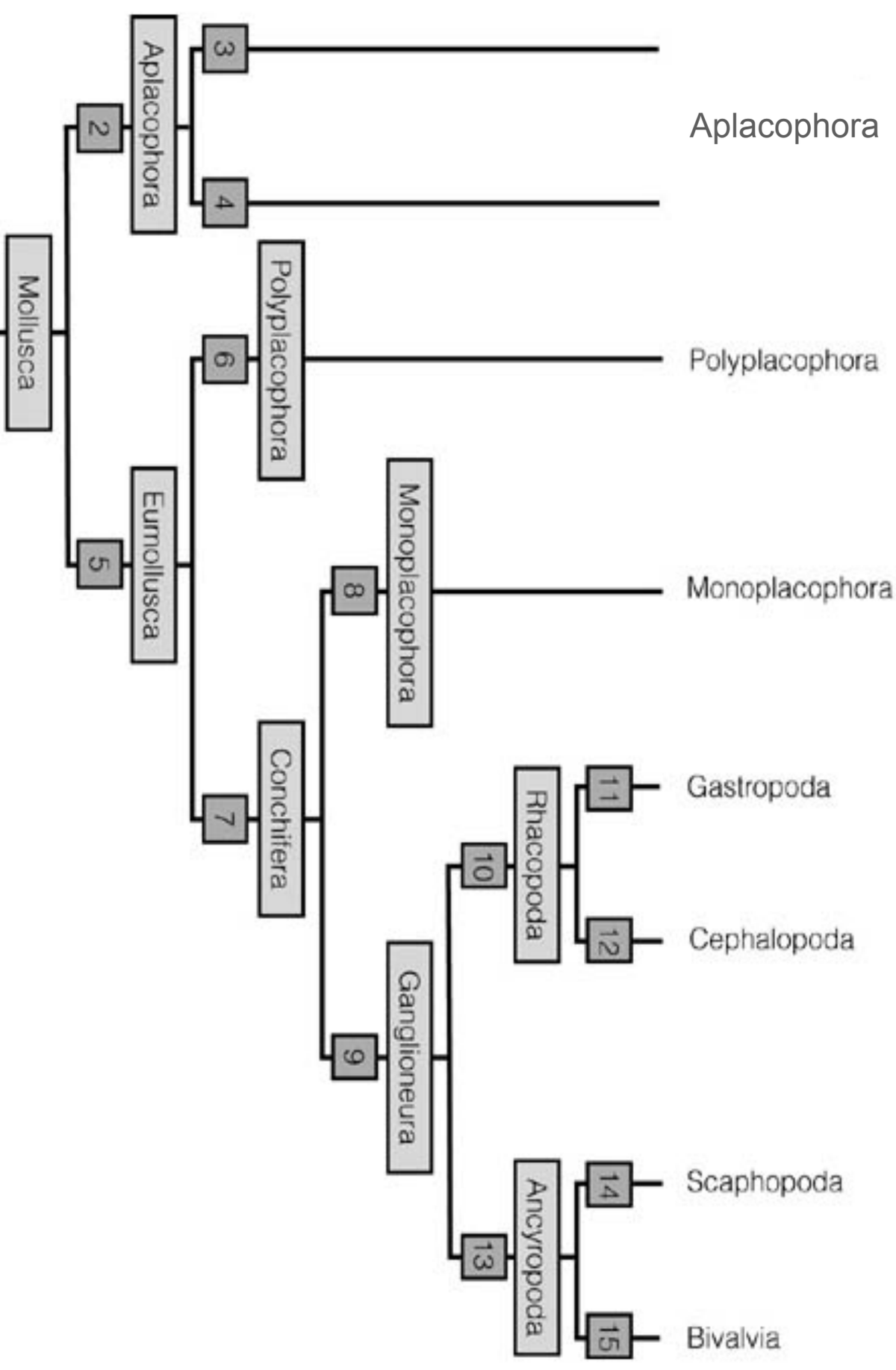


trochophore **juvenile**

-External fertilization in the sea or female's mantle cavity

-Lecithotrophic trochophore larvae (**no veliger**)

~30 spp. eggs brooded in female mantle cavity; development is direct


Mollusca
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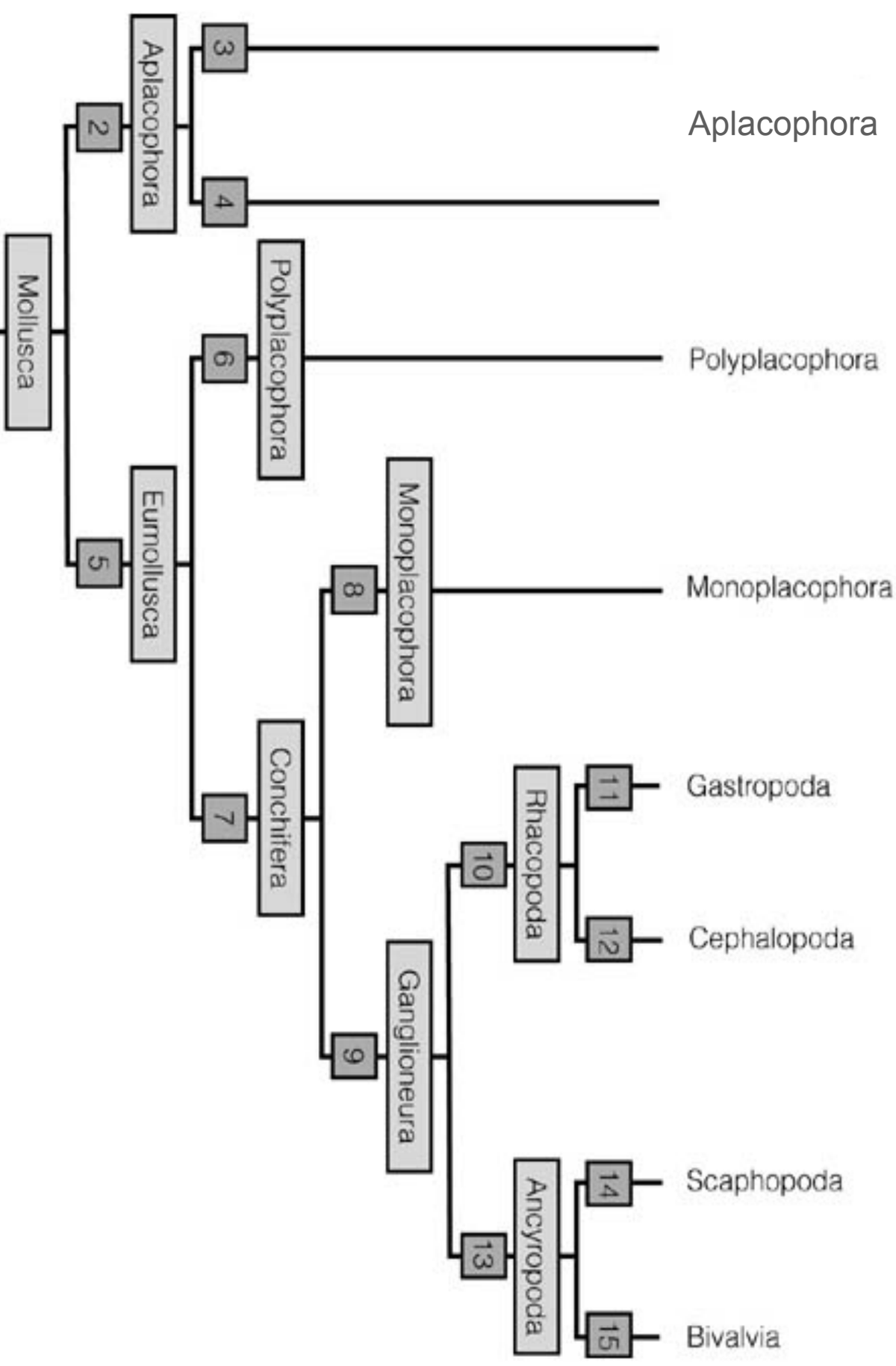
Monoplacophora
Gastropoda
Cephalopoda
Scaphopoda
Bivalvia



Hypothesize that this group arose from common ancestor similar to Monoplacophora

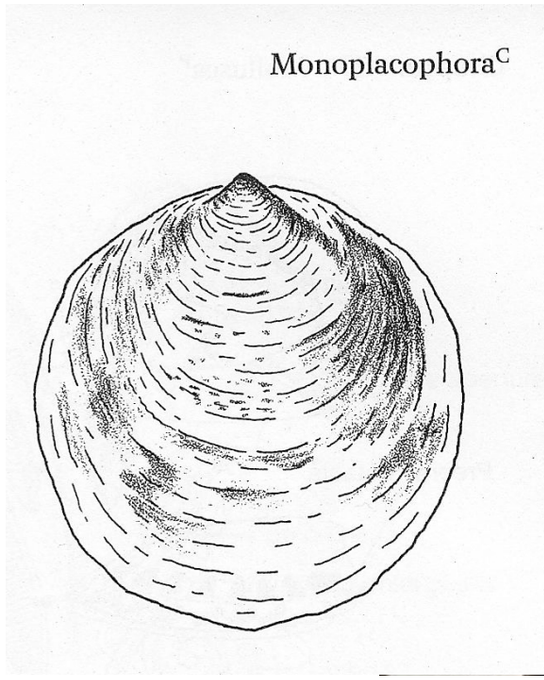
Includes:

Monoplacophora, Gastropoda, Cephalopoda, Bivalvia, and **Scaphopoda**

Monoplacophora

- Defining Characteristics
  - –3-6 pairs of ctenidia
  - –6-7 pairs of nephridia
  - –Multiple (usually 8) pairs of pedal retractor muscles

Monoplacophora



Deep sea (1.8-7K m)

1 in CA found at 200m

Fossils only until 1952

~20 species; 3 genera

3-30 mm in maximum size

"Ventral view of the monoplacophoran mollusc, *Neopilina.*"
http://www-biol.paisley.ac.uk/courses/Tatner/biomedia/pictures/neopi93.htm

Monoplacophora

Deep sea (1.8-7K m)

1 in CA found at 200m

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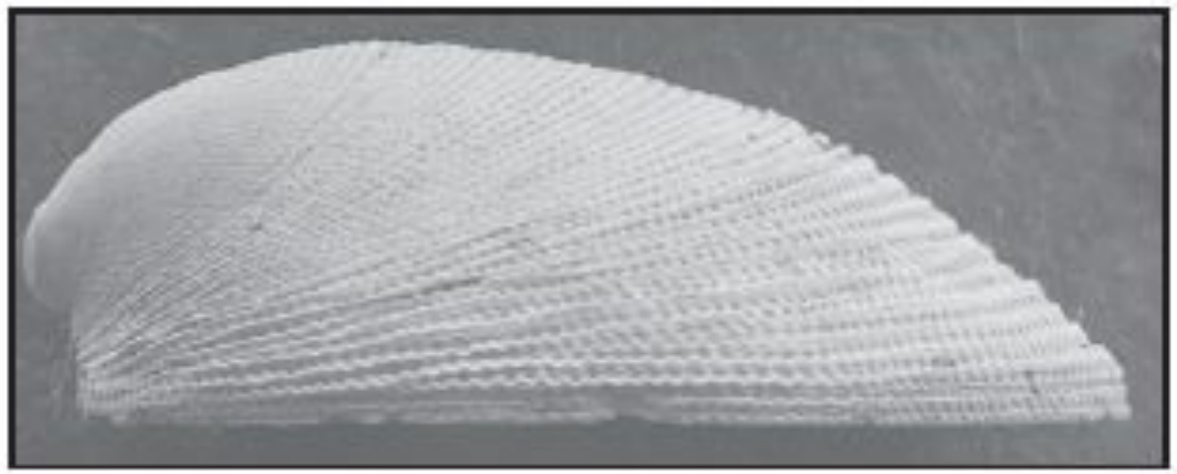
(a)



(b)

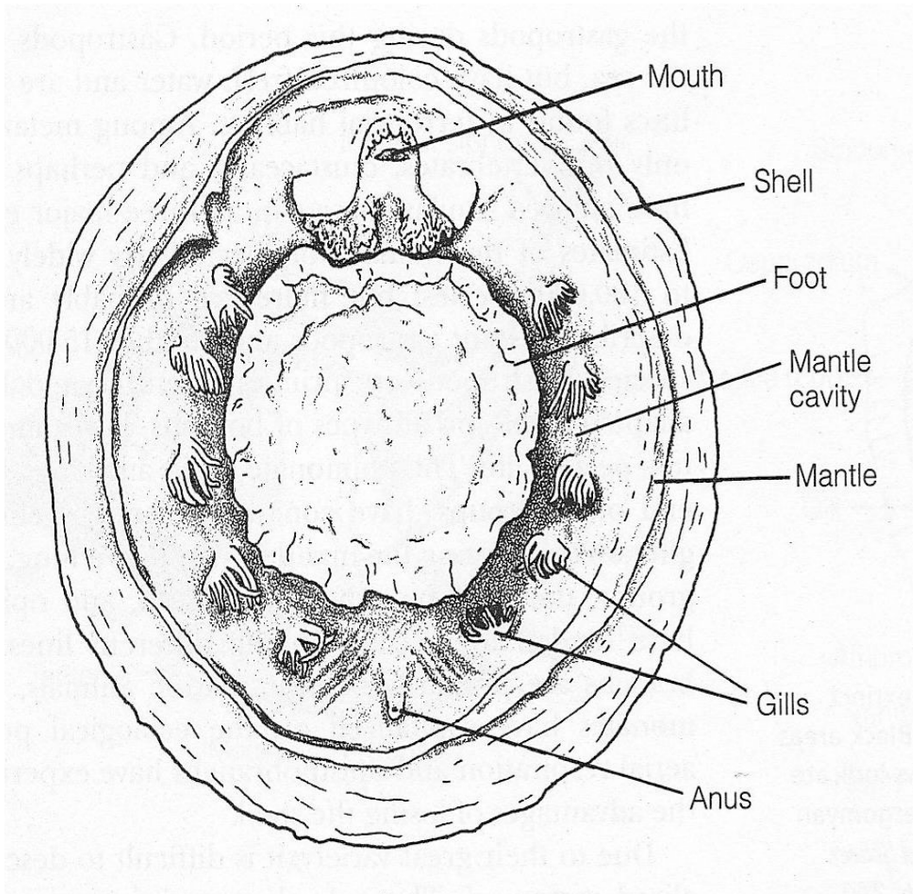
Figure 12.8

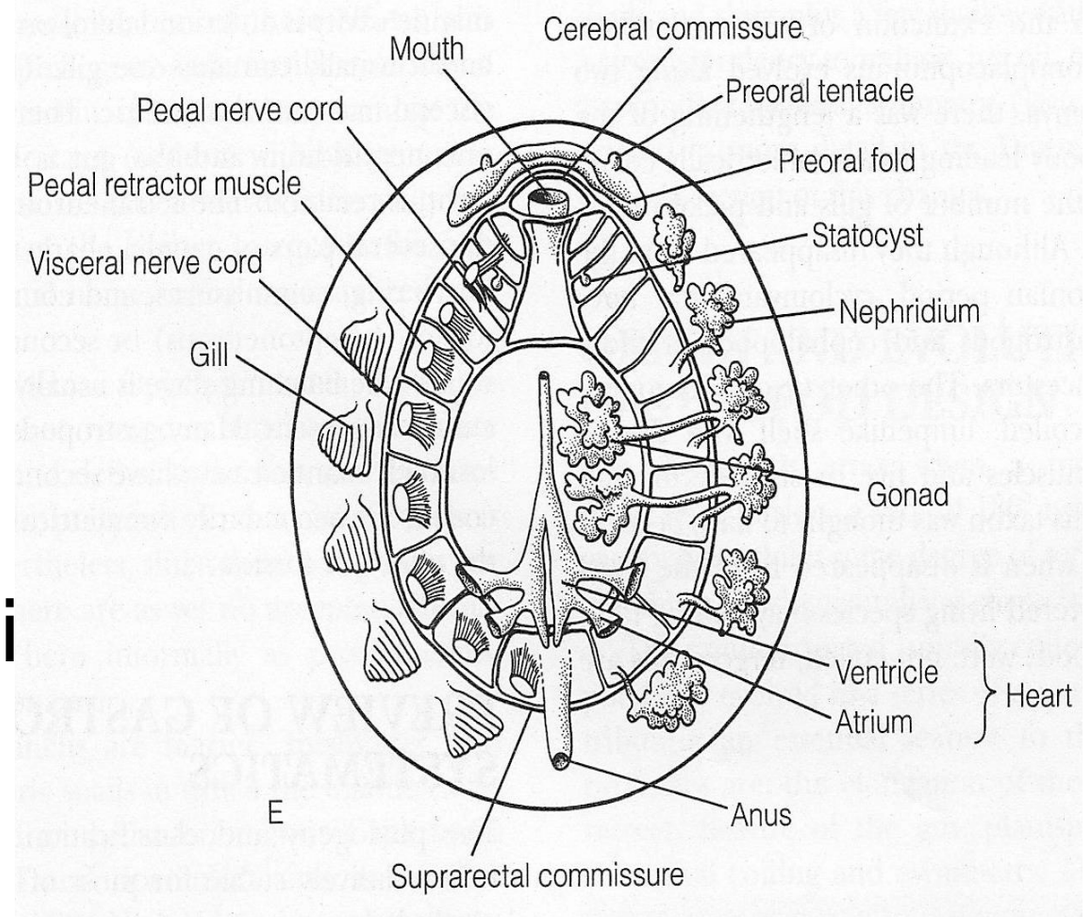
The shell of the monoplacophoran *Veleropilina reticulata* in (a) dorsal and (b) lateral views. The largest species found to date are only 1.6 mm long.

Courtesy of A. Warén. From A. Warén and S. Gofars, 1996. *Zoologica Scripta* 25:215–32 (figs. 3B, 4E).

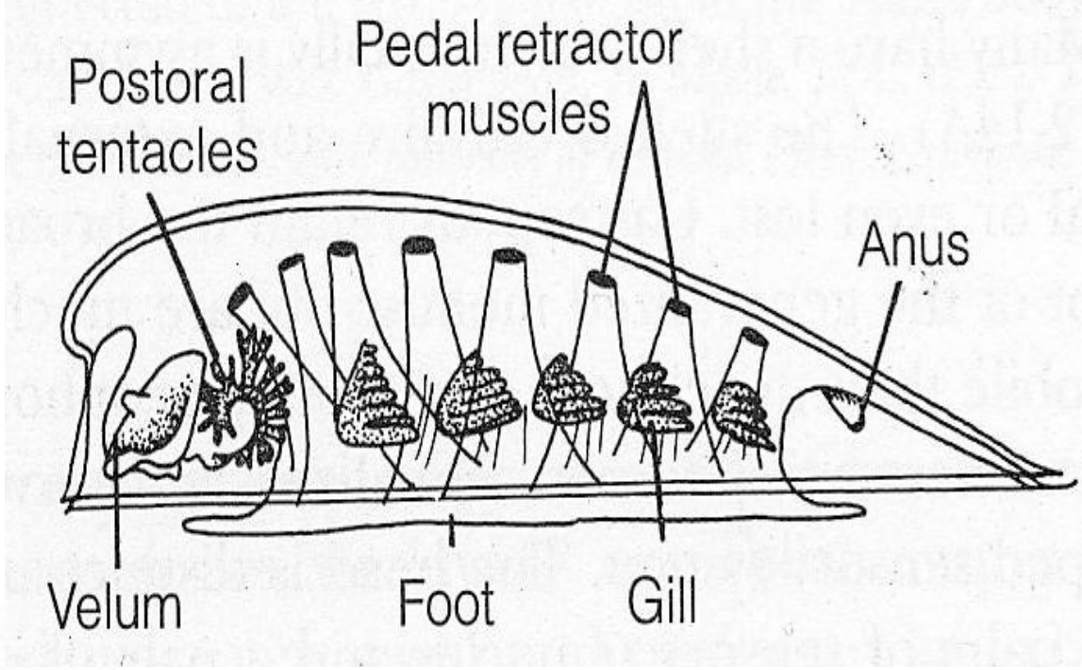
Monoplacophora

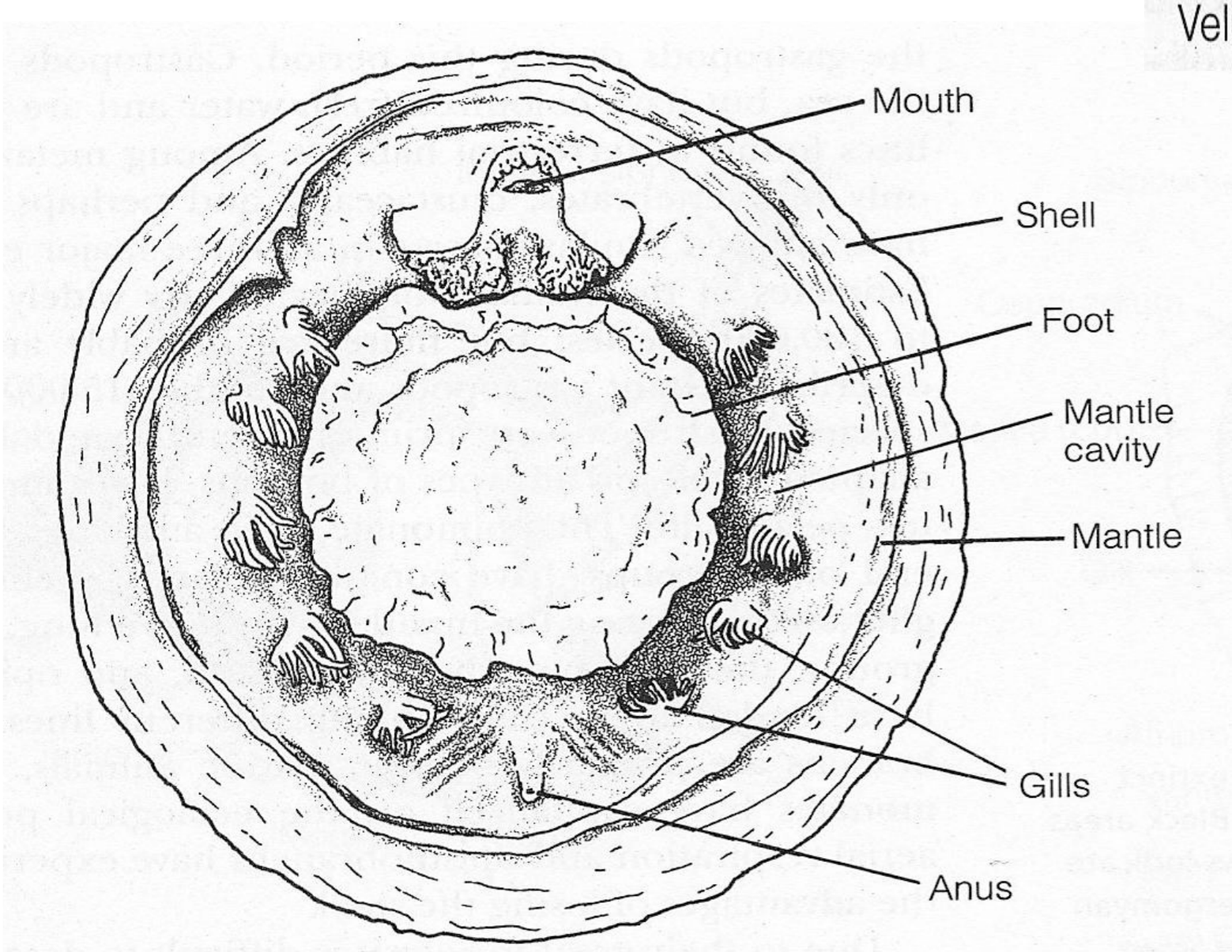
- **Serial repetition** of paired organs
  - 3, 5 or 6 pairs of **monopectinate gills**
  - 6 pairs of **nephridia (kidneys)**
  - multiple **atria, gonopores**
  - 8 pr pedal retractor muscles
- Nephridia-pericardial connection lost
- **Bilateral symmetry**
- Dioecious (gonochoric)
- Tetraneurous nervous system weakly developed cerebral gangli



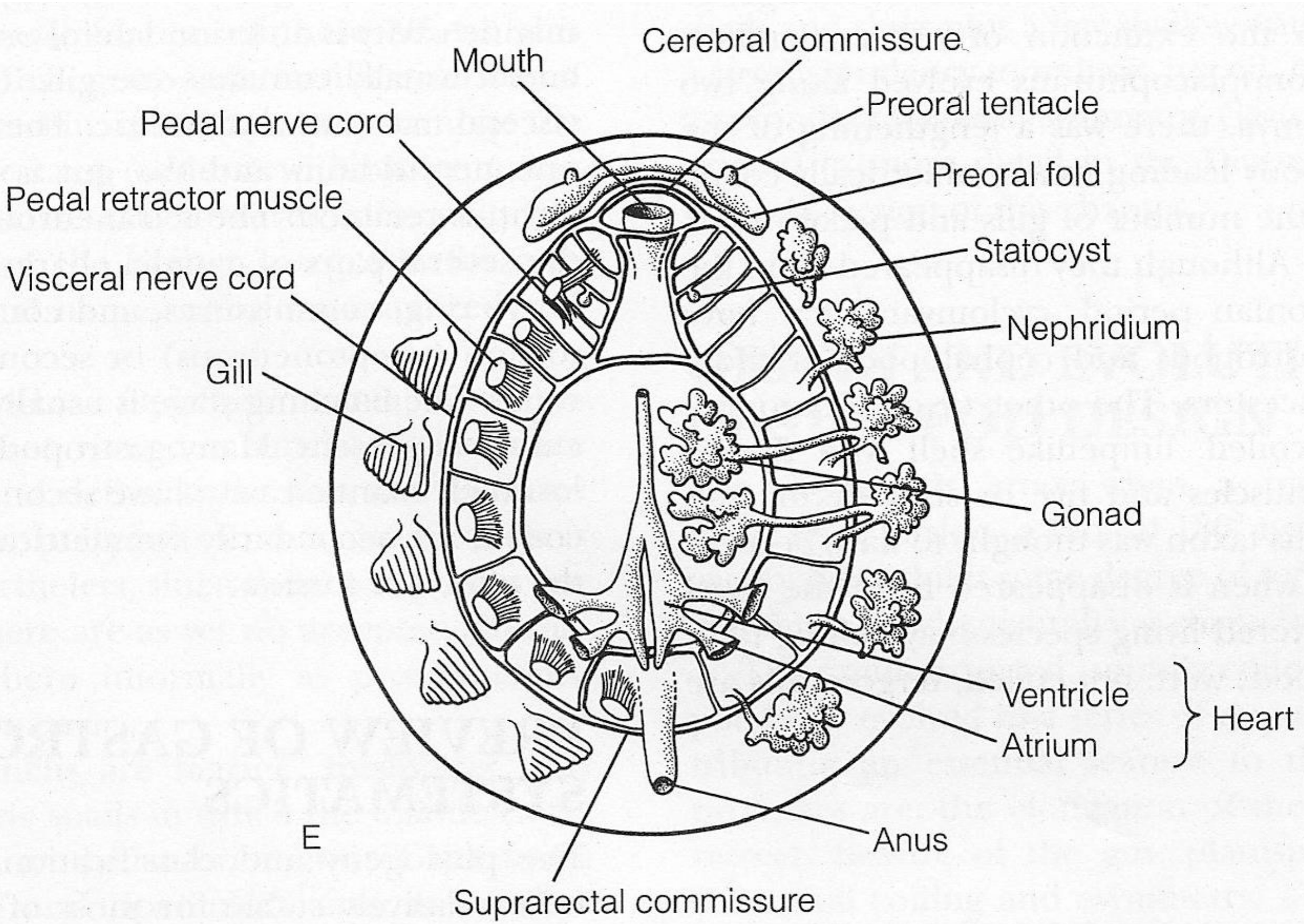


Monoplacophora





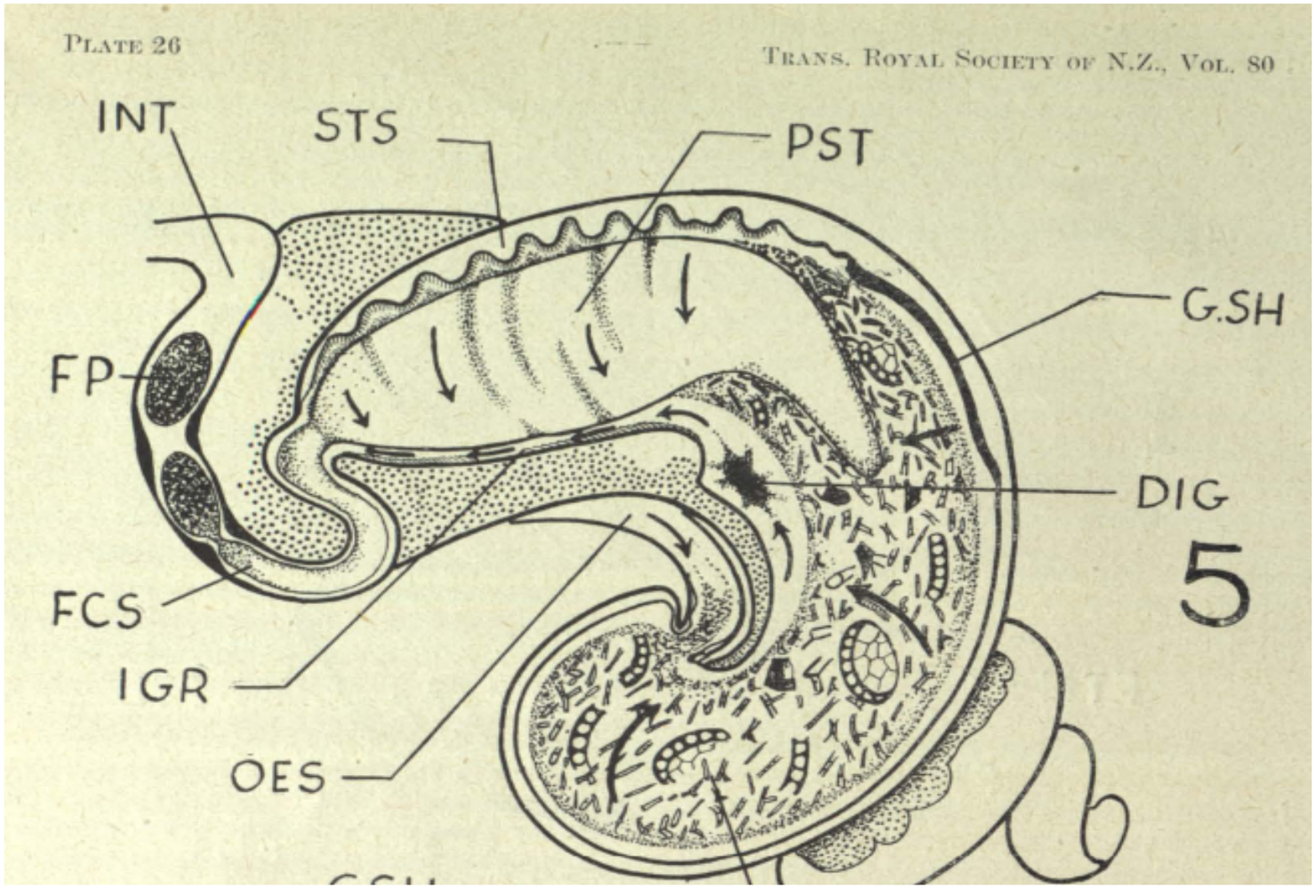
Monoplacophora



Monoplacophora - Feeding

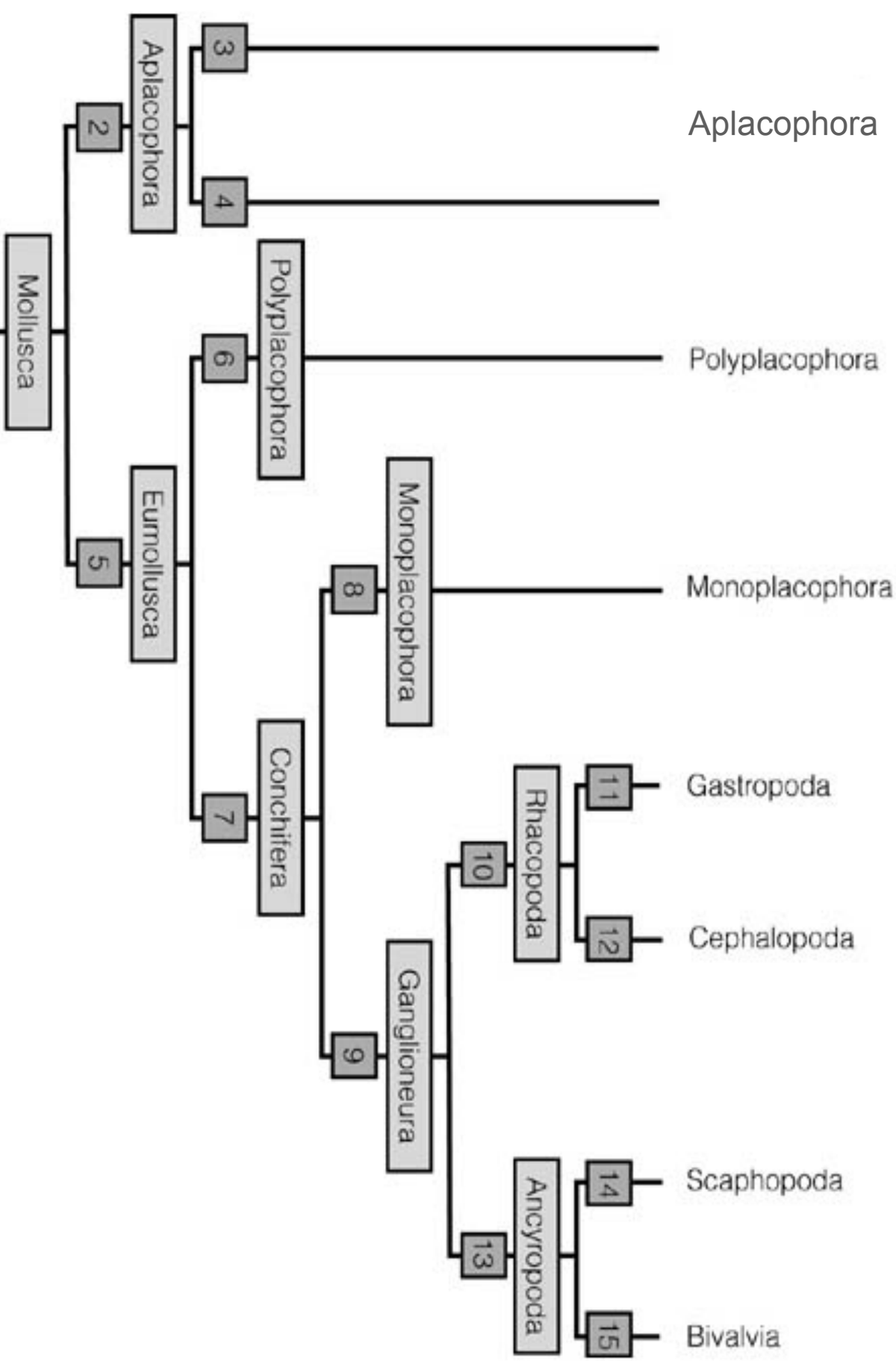
Micro-organisms, detritus
on hard substrates

May contain protostyle



CT, cuticle; DIG, digestive diverticulum; FCS, faecal string; FDS, food string within the stomach; FP, faecal pellet; GSH, gastric shield; IGR, intestinal groove; INT, intestine: PST, protostyle; STS, "style" sac.

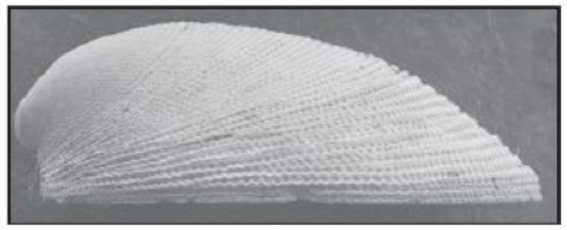
Morton 1952



Aplacophora

Polyplacophora

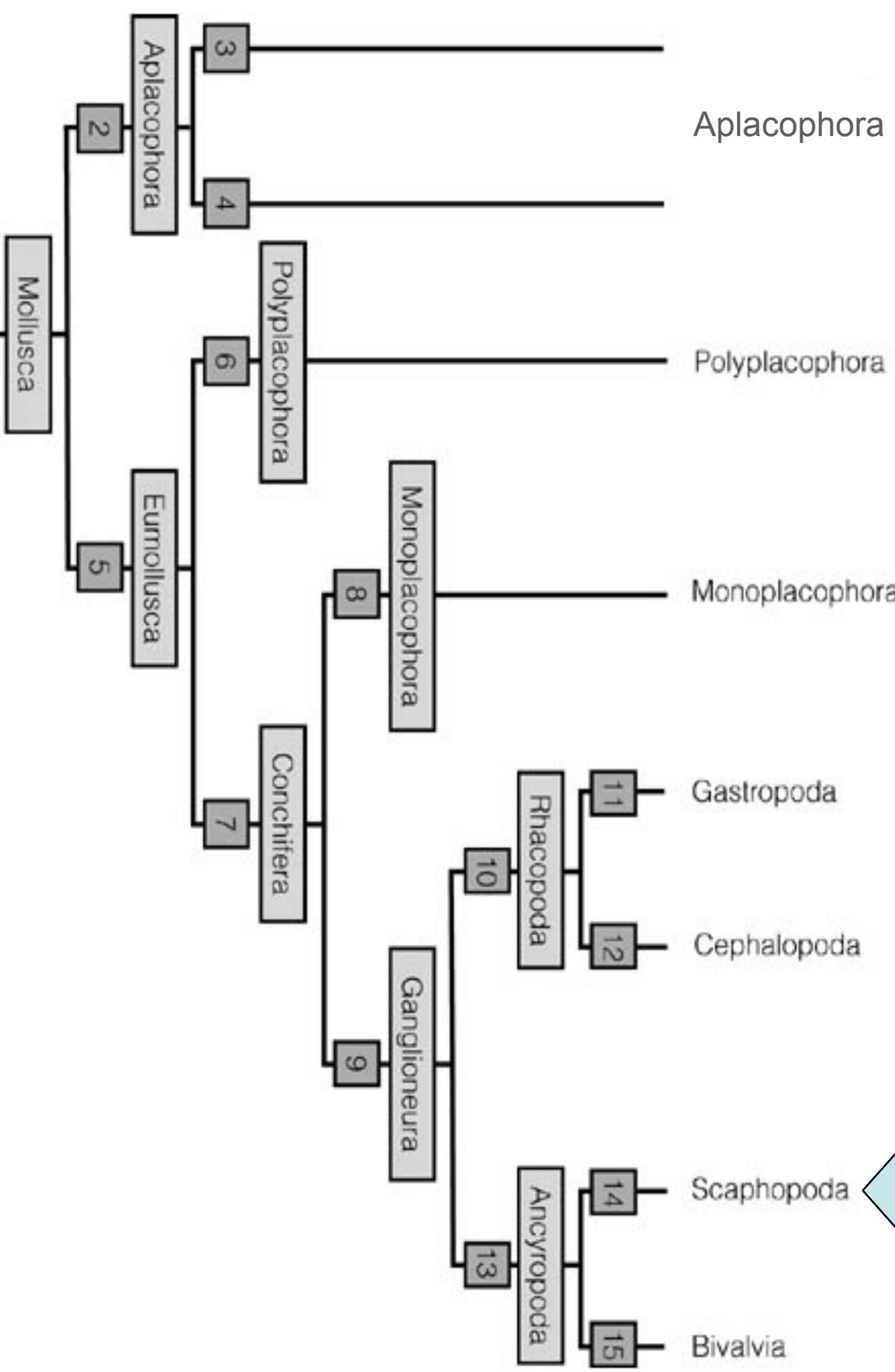
Monoplacophora

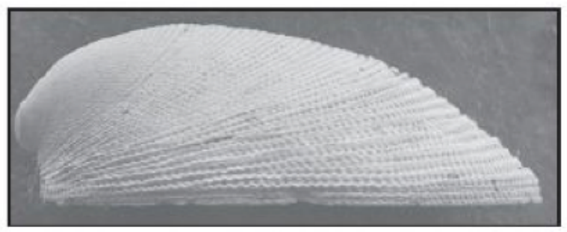


Hypothesize that this group arose from common ancestor similar to Monoplacophora

Includes:

Monoplacophora, Gastropoda, Cephalopoda, Bivalvia, and **Scaphopoda**





Hypothesize that this group arose from common ancestor similar to Monoplacophora

Includes:

Monoplacophora, Gastropoda, Cephalopoda, Bivalvia, and **Scaphopoda**

Scaphopoda

Defining Characteristics: 1) Tusk-shaped, conical shell, open at both ends; 2) development of anterior, threadlike, adhesive feeding tentacles

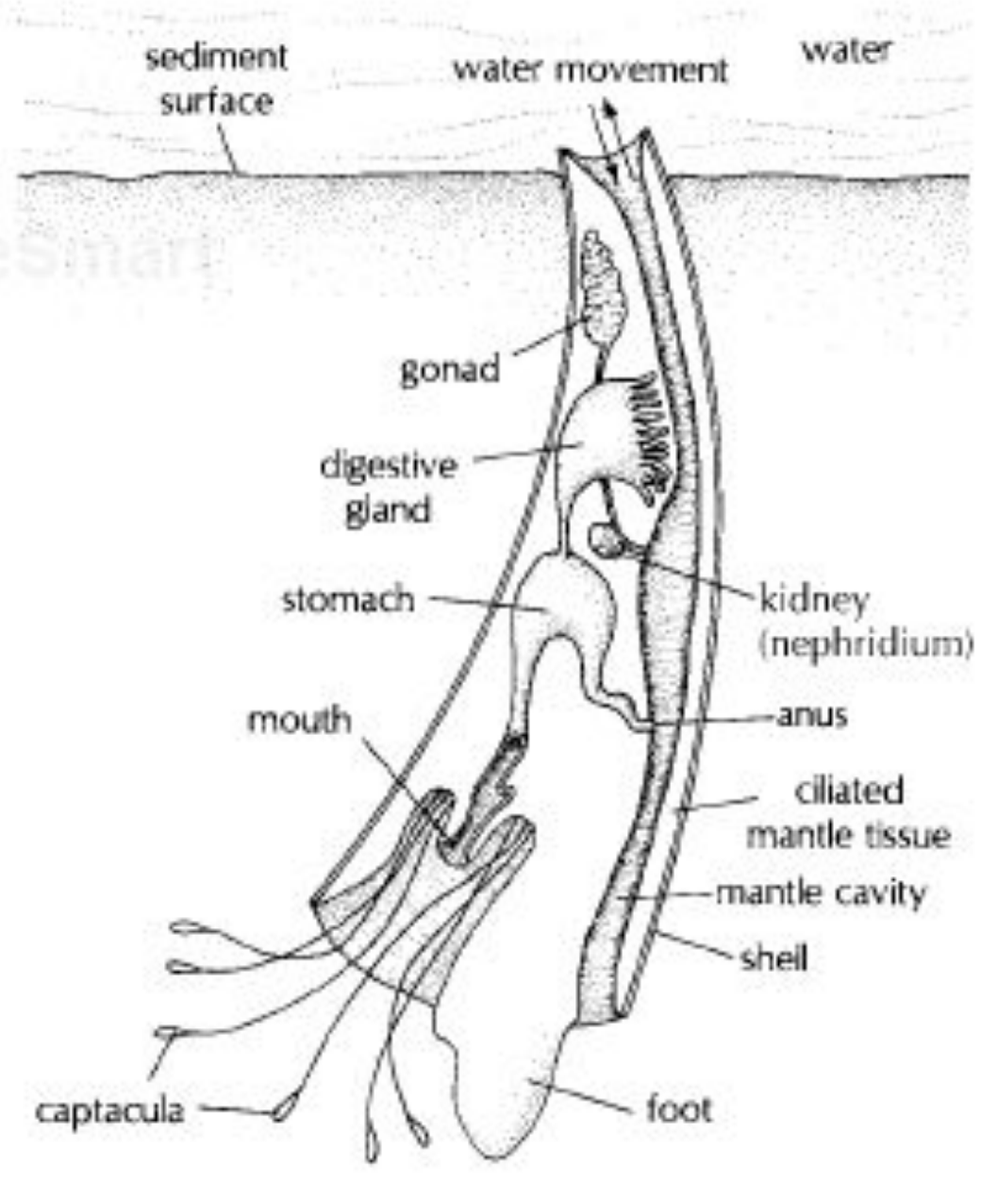
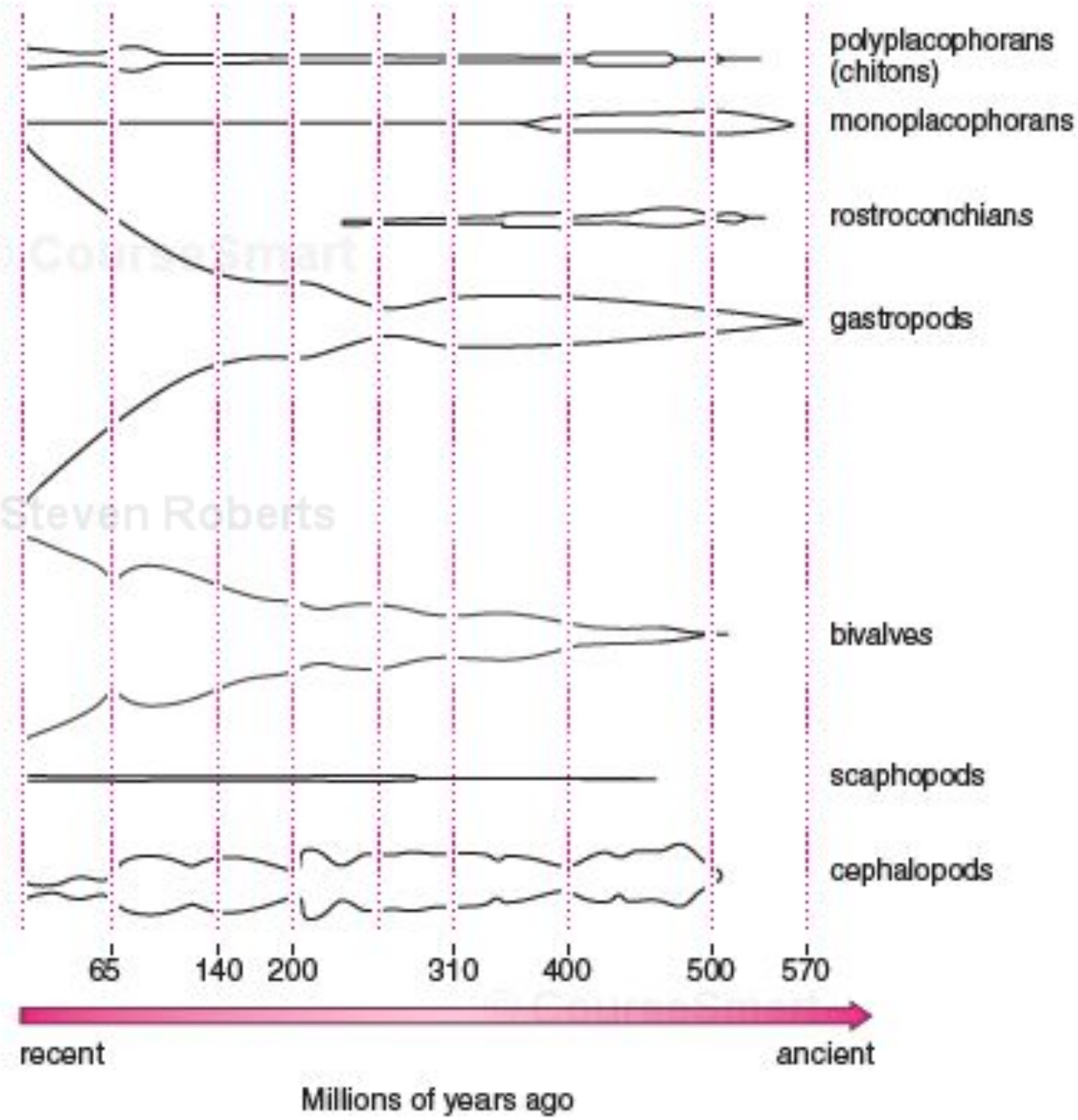


Figure 12.36

Dentalium sp., a scaphopod, in its normal feeding orientation. Food particles are captured by the captacula.

After Borradaile, after Naef.

Scaphopoda



Young

Figure 12.5

Molluscan species diversity as represented in the fossil record. The width of each bar is proportional to the number of species in each class. Members of the Rostroconchia superficially resembled the clams and related bivalves, except that they had hingeless, gaping shells. Bivalved molluscs and scaphopods may be descendants of rostroconchian ancestors.

Based on R. S. Boardman *et al*, eds., *Fossil Invertebrates*, 1987.

Scaphopoda

300-400 Species
Deep
Features: foot, mantle tissue, mantle cavity
radula, shell
Shell- Grows linear

no gills! no heart! no circulatory system!

Scaphopoda

300-400 Species
Deep
Features: foot, mantle tissue, mantle cavity
radula, shell
Shell- Grows linear

no gills! no heart! no circulatory system!

no osphradium!

Scaphopoda

300-400 Species
Deep
Features: foot, mantle tissue, mantle cavity
radula, shell
Shell- Grows linear

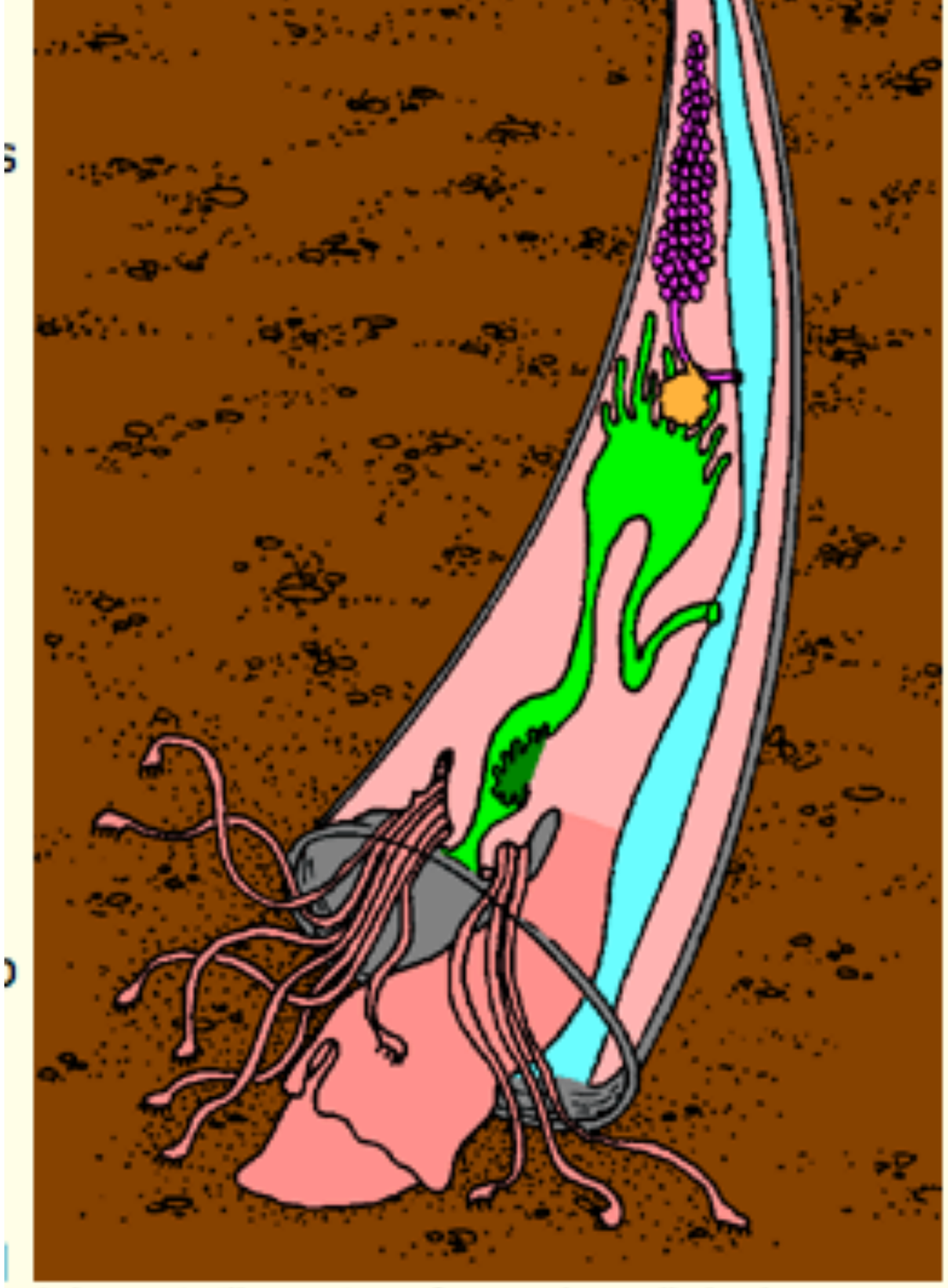
no gills! no heart! no circulatory system!

no osphradium!

Sensory

Scaphopoda

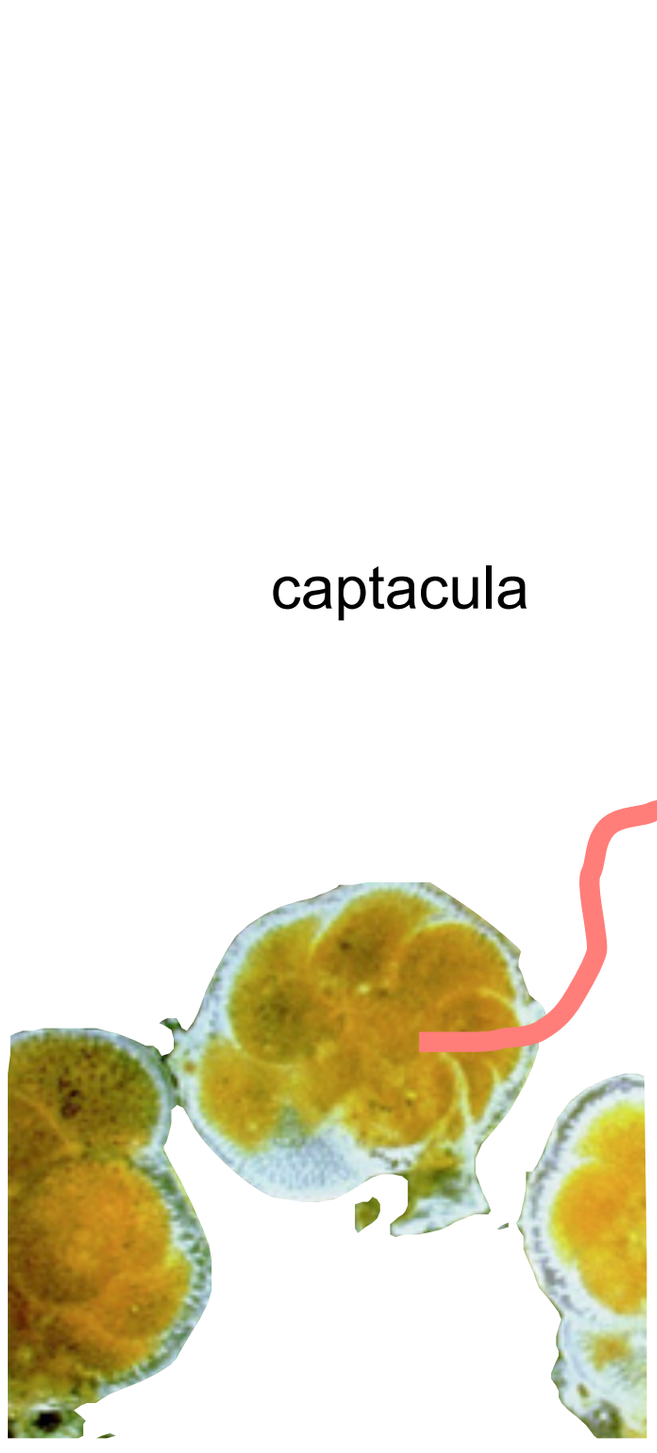
captacula

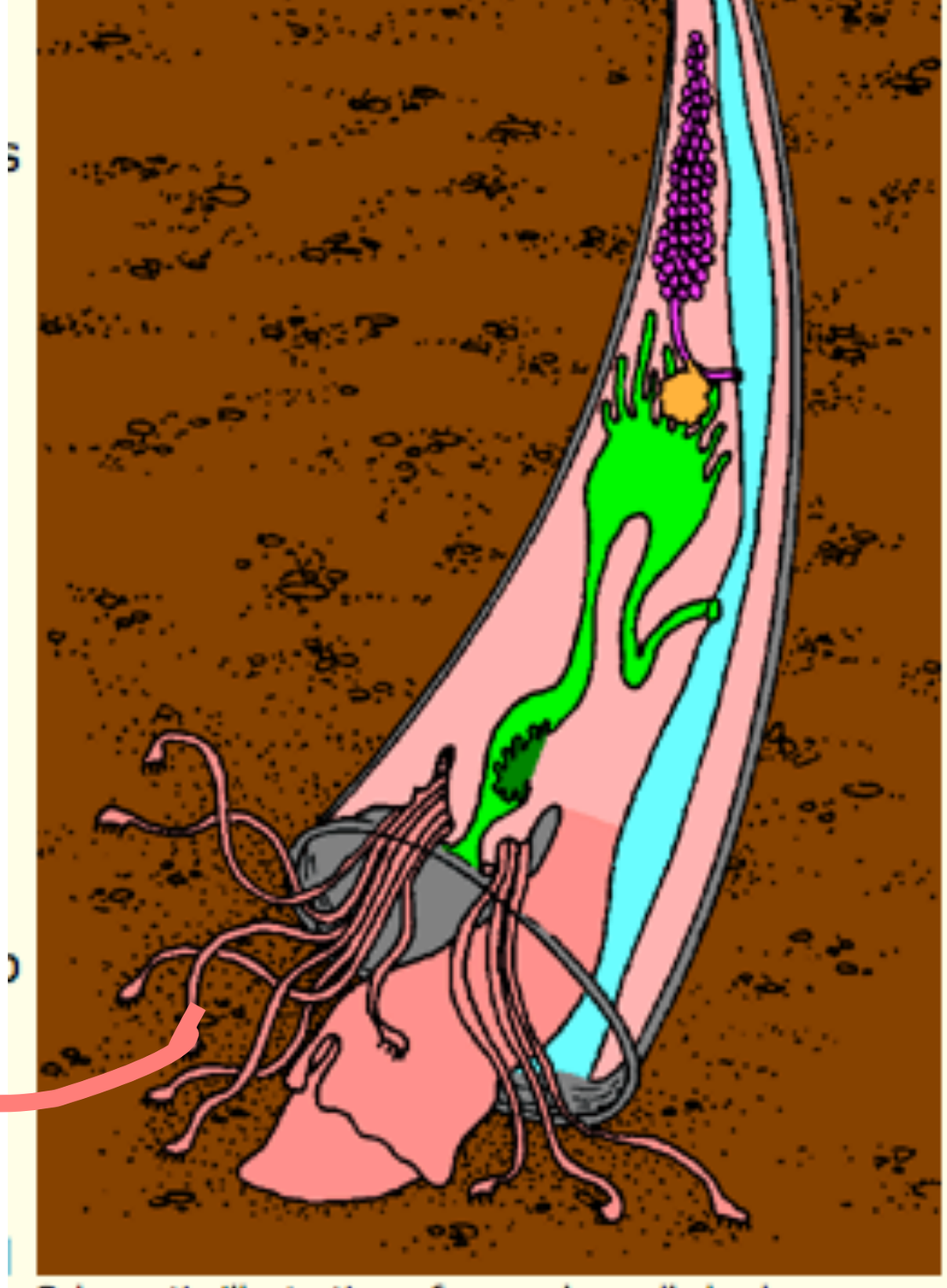


Schematic illustration of a scaphopod's body.
Source: Biodidac, further editing: R. Nordsieck.

Scaphopoda

captacula

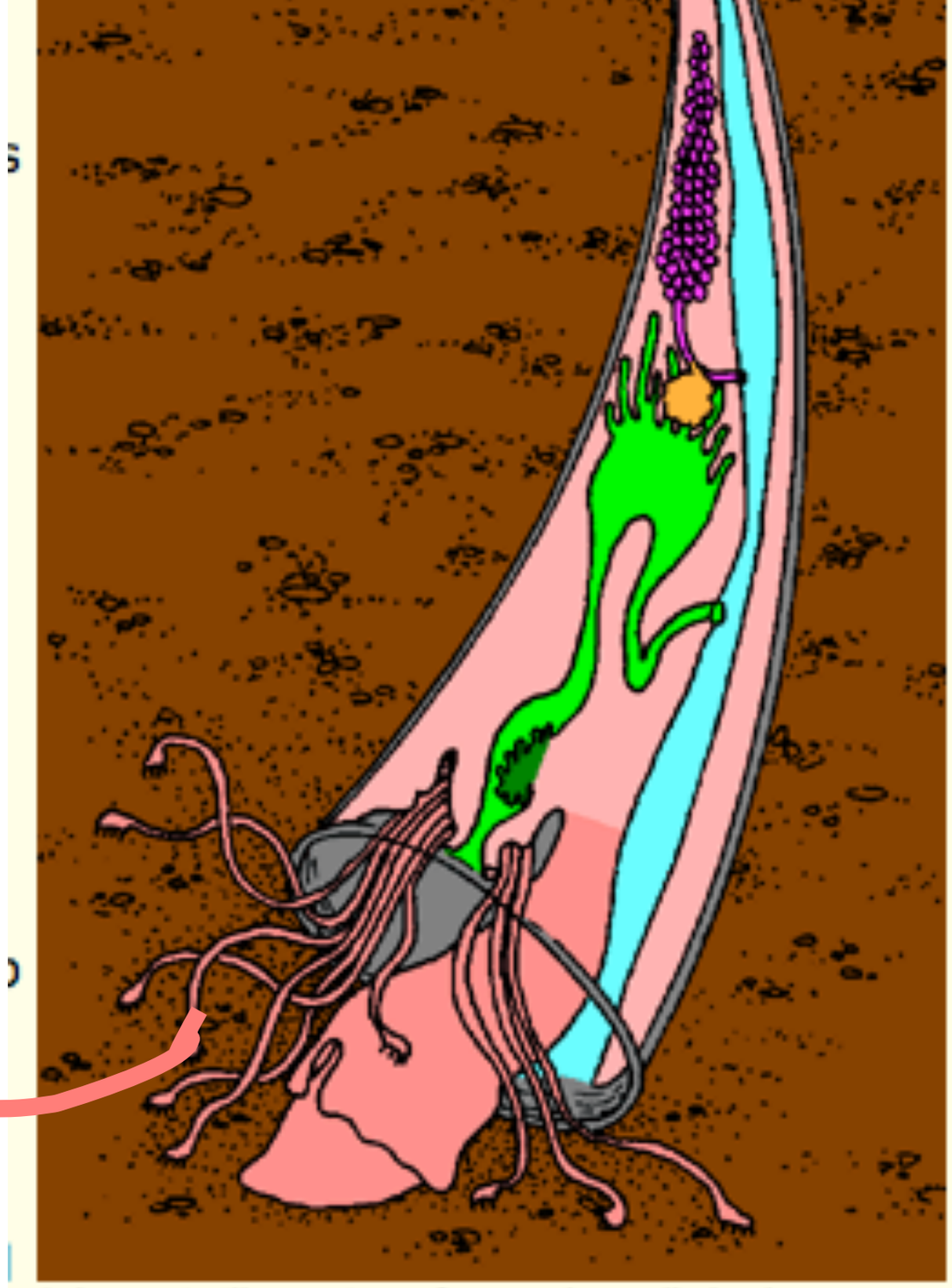




Schematic illustration of a scaphopod's body.
Source: Biodidac, further editing: R. Nordsieck.

Scaphopoda

foraminiferans



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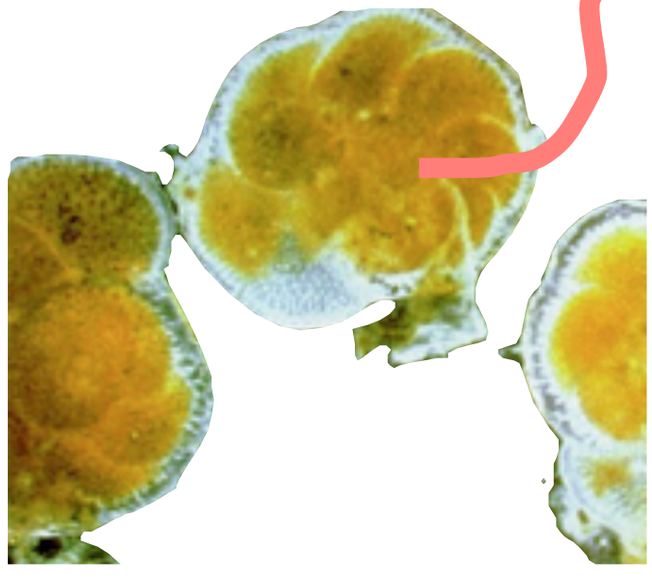
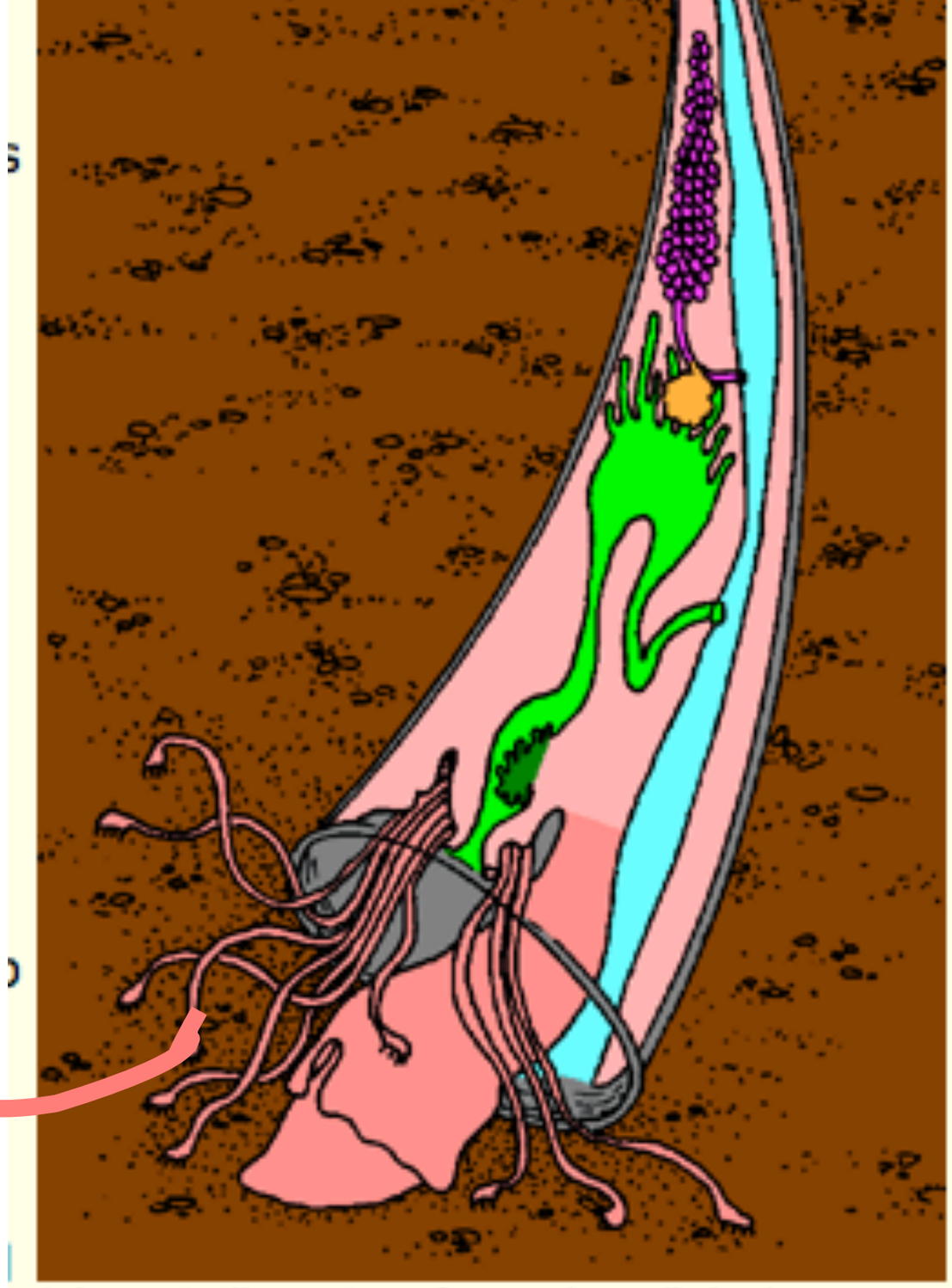
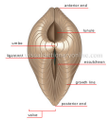


Scaphopoda

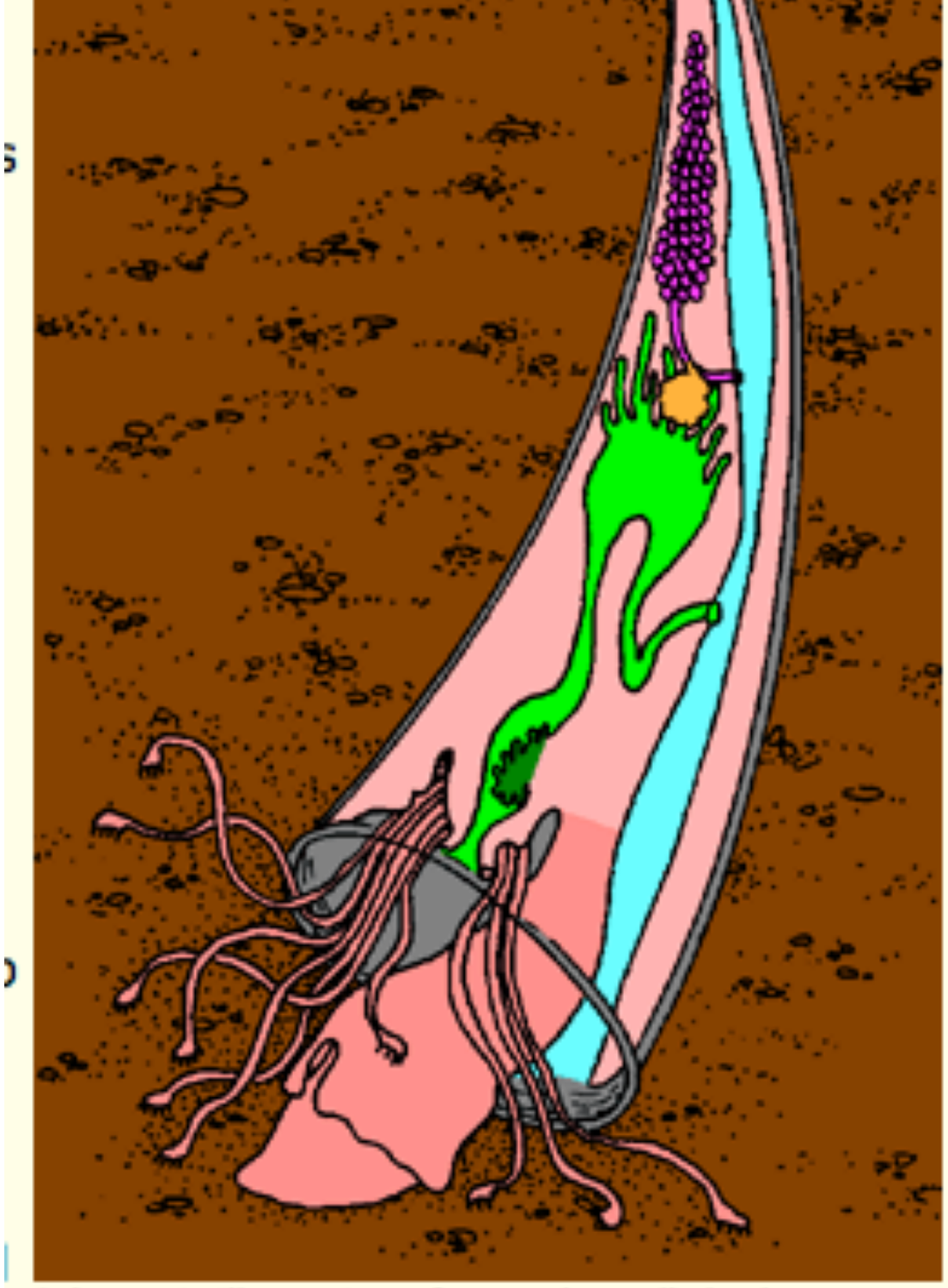




Schematic illustration of a scaphopod's body.
Source: Biodidac, further editing: R. Nordsieck.

Scaphopoda

Economic / Cultural Significance ?



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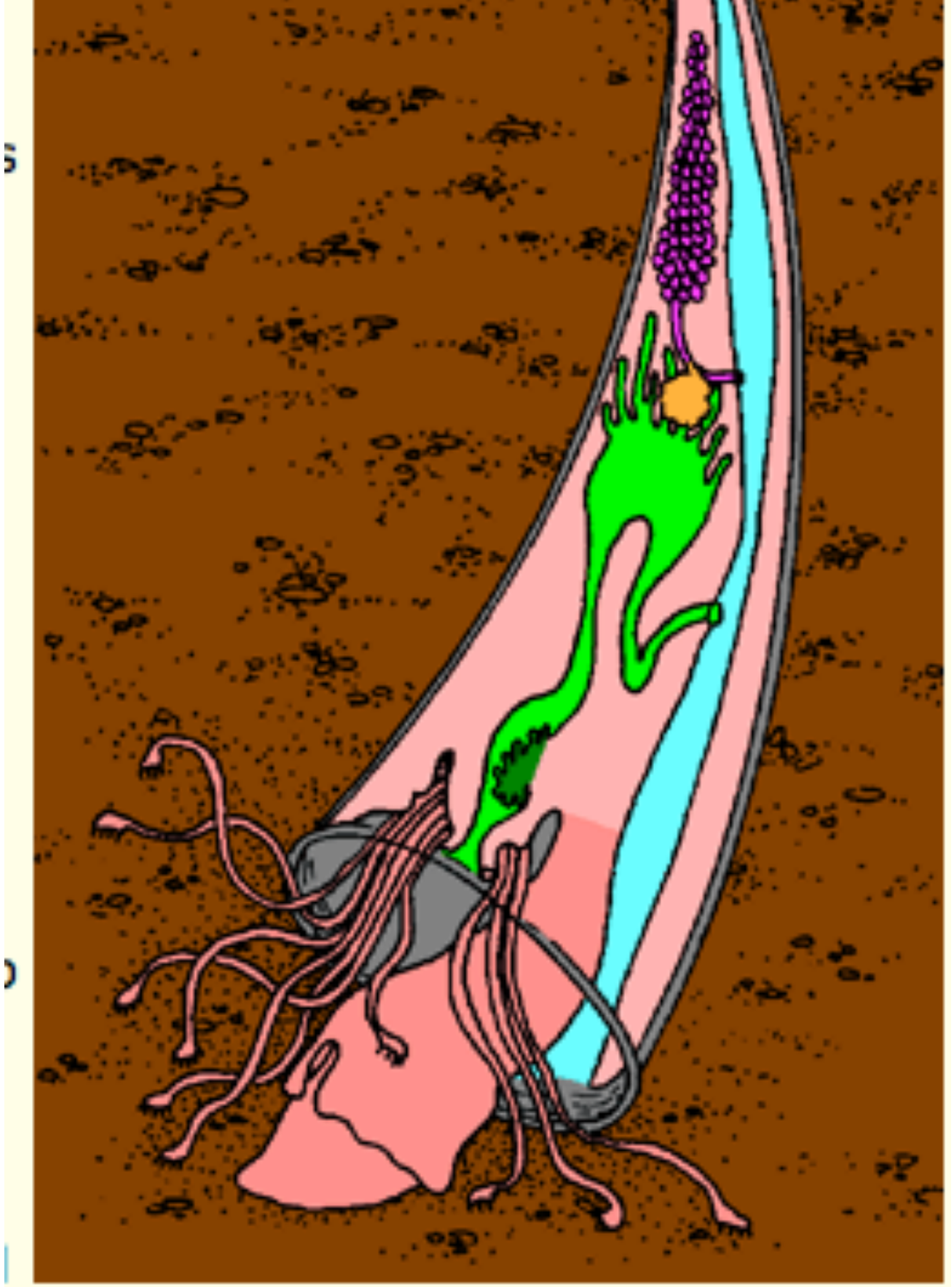
Source: Biodidac, further editing: R. Nordsieck.

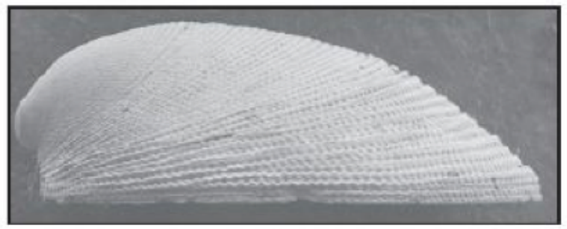
Scaphopoda

Economic / Cultural Significance ?

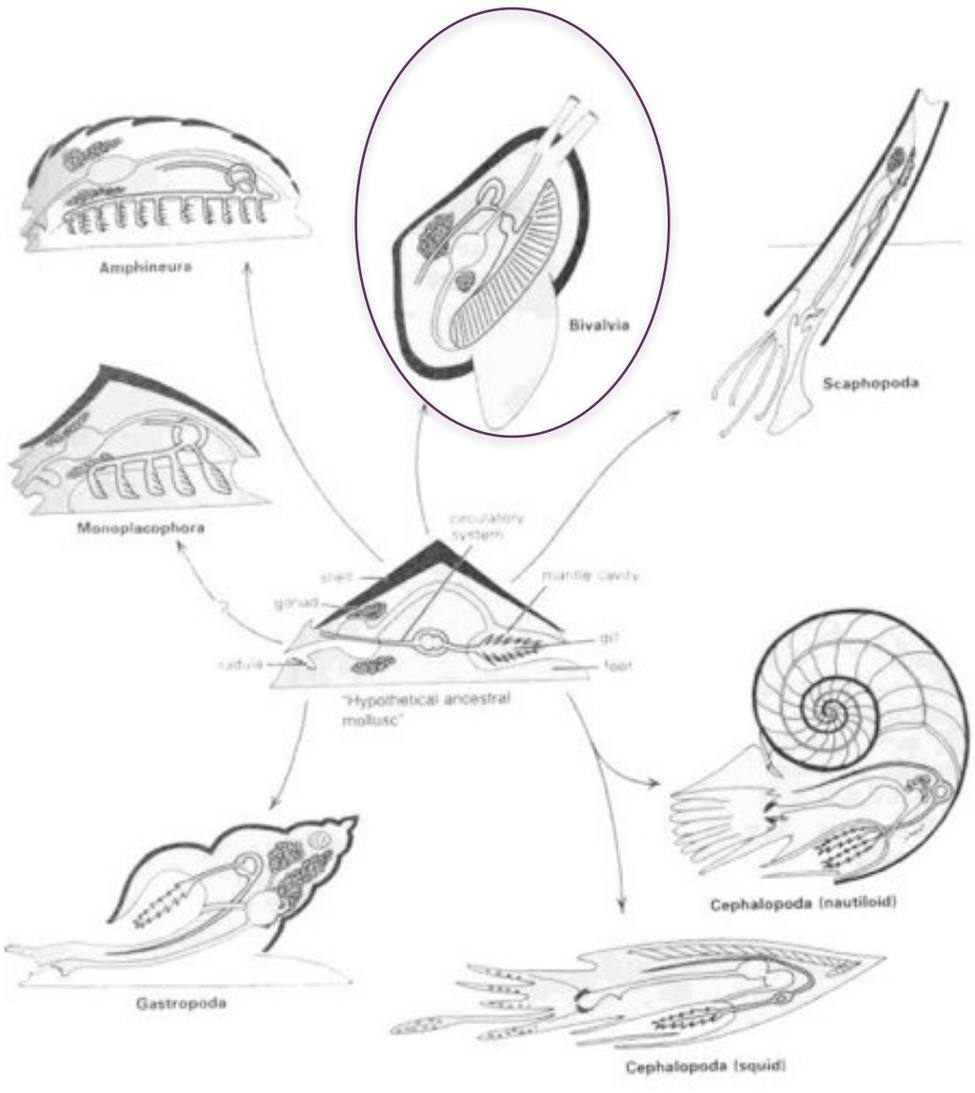


Schematic illustration of a scaphopod's body.
Source: Biodidac, further editing: R. Nordsieck.

Mollusca
Aplacophora
3
4
2
Polyplacophora
6
Eumollusca
5
Monoplacophora
8
Conchifera
7
Ganglioneura
9
Rhacopoda
11
12
10
Ancyropoda
14
15
13
Aplacophora
Polyplacophora
Monoplacophora
Gastropoda
Cephalopoda
Scaphopoda
Bivalvia

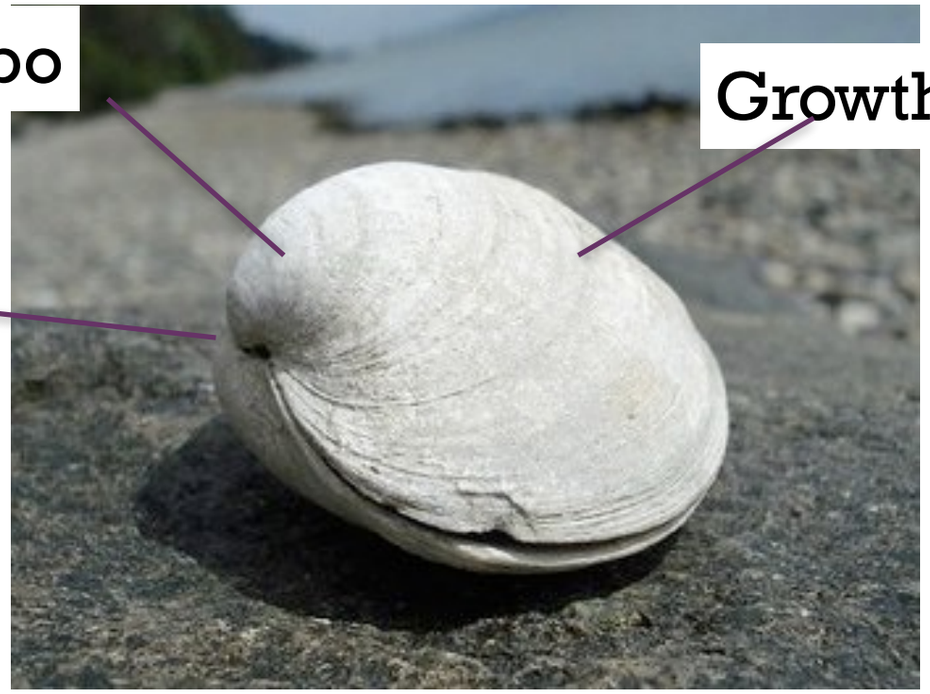


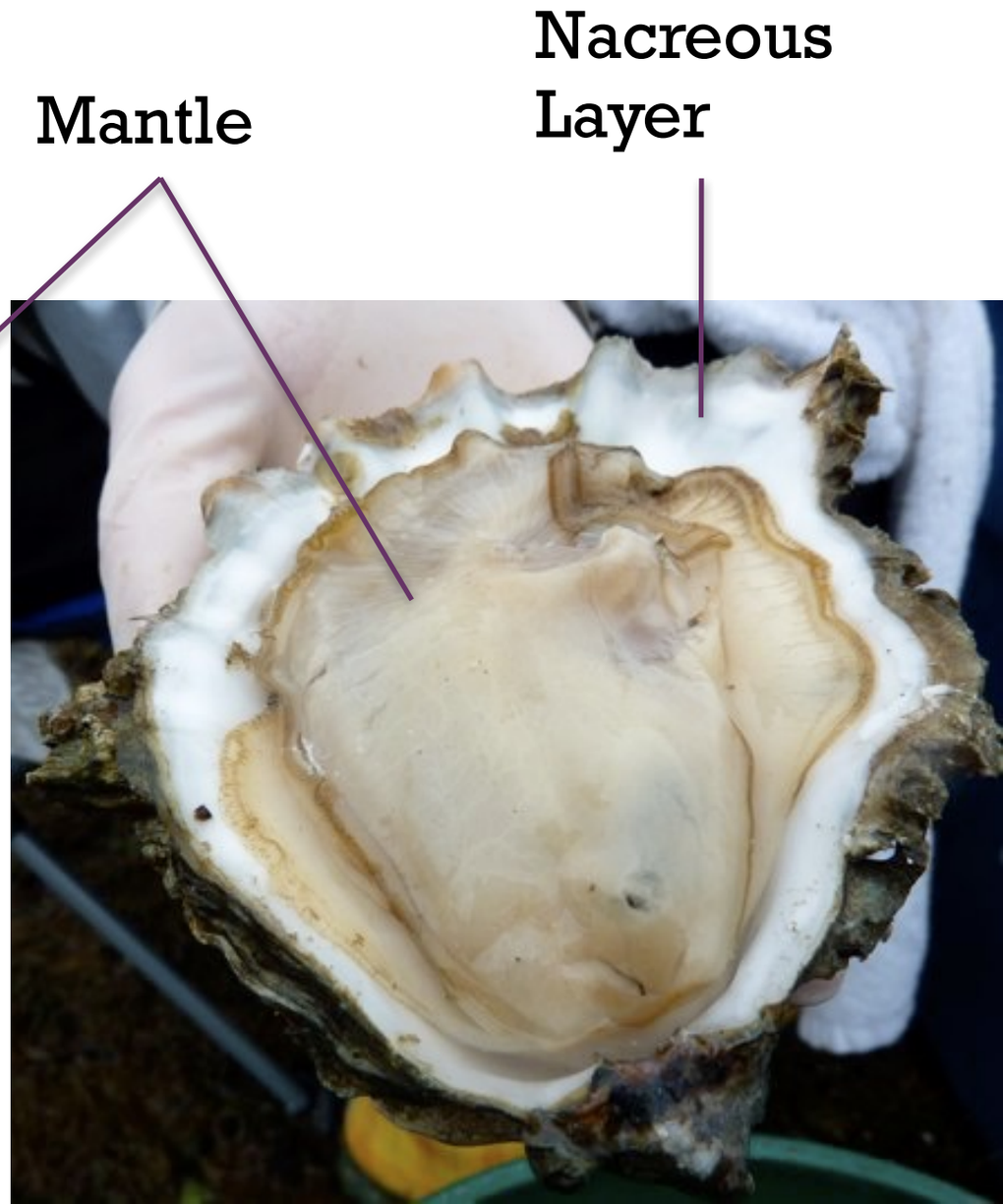
Bivalve Phylogeny



- Characteristics of Class
  - Mostly marine
  - 2-valved shell
  - Laterally flattened body
  - Lack of cephalization
  - Extensive mantle
  - Sedentary
  - No radula/odontophore
  - Microphagous suspension feeders
  - Umbo
- ~7,650 species & 90 families

Bivalve Morphology





Taxonomy

- Protobranchia
- Anomalodesmata
- Pteriomorphia
- Paleoheterodonta
- Heterodonta

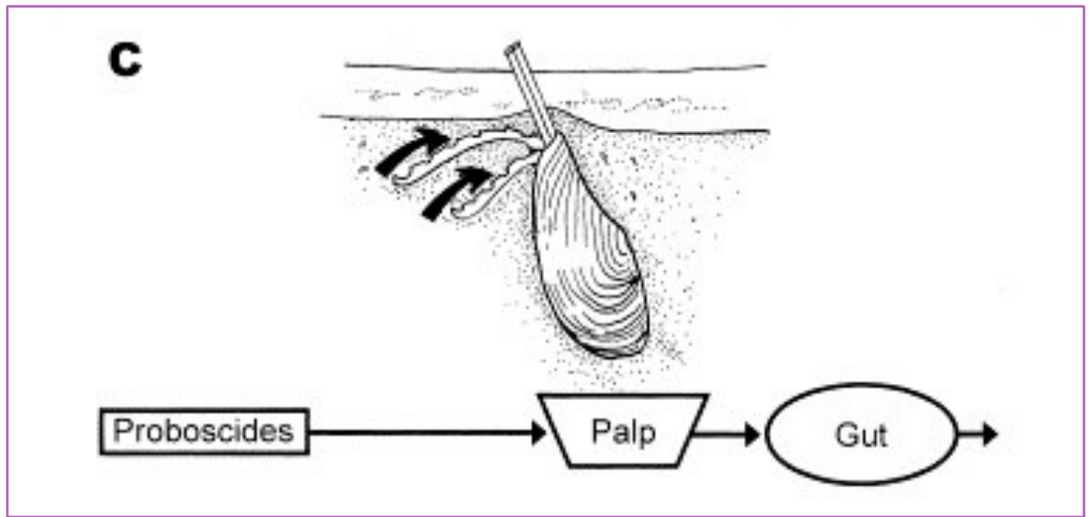
Lamellibranchia

Subclass Protobranchia

- Defining Characteristics
  - Small gills function just for gas exchange
  - Collect food with palp proboscides
- Primitive physiology - ancestral
- 100% marine
- Found in soft substrates
- Found in deep waters (>1000m)
- Example genus: *Yoldia*

Protobranchia Feeding

- Selective deposit feeders (primitive)
- Traps particles in mucus on palp proboscide
- Particles travel along ventral proboscide cilia to labial palp
- Ciliated ridges of labial palp sort particles
  - Nutritious are ingested
  - Non-nutritious and toxic are expelled = pseudofeces



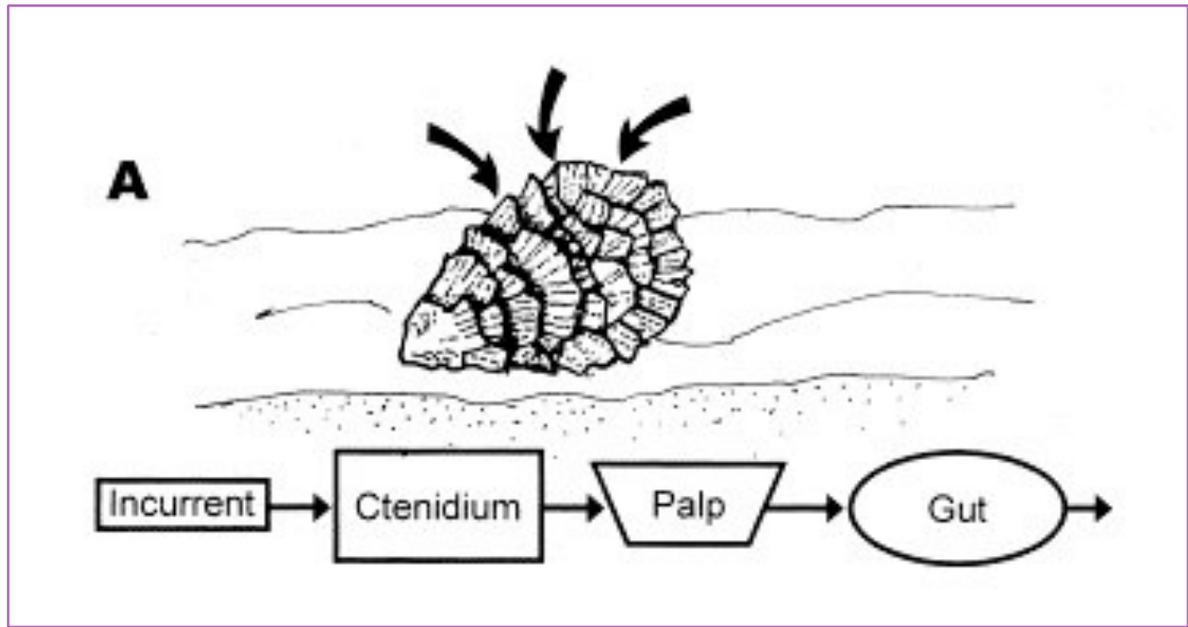
Ward & Shumway 2004

Lamellibranchia

- Defining Characteristics
  - Gills function in gas exchange and food acquisition
  - Byssal thread production
- Mostly marine; includes all freshwater bivalves
- Dominate animal biomass in habitat
- Applications: food, jewelry, biomonitoring
- Invasive species
- Incurrent & excurrent siphons

Lamellibranchia Gills

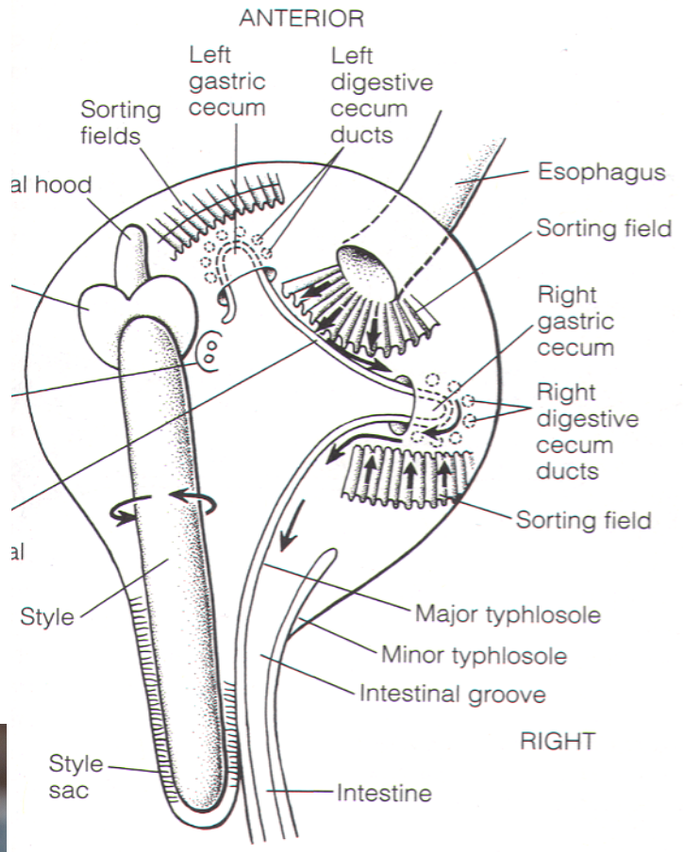
- In- and excurrent siphons
  - Tubular extensions of the mantle
- High rate of water processing + high density = ecological impact
- Gills modified for food acquisition
  - Large ctenidium
  - Ciliated central groove of ctenidium
  - Increased # filaments
  - Lengthen & folded gill



Ward & Shumway 2004

Lamellibranch Digestion

- Particles concentrated at labial palps & delivered to stomach
- Stomach digestion = crystalline style
  - Protein & digestive enzymes
  - Style sac cilia
  - Gastric shield degrades style
- Particle sorting in stomach
- Delivery to digestive glands
- Chemosynthetic symbionts



Lamellibranch Byssus

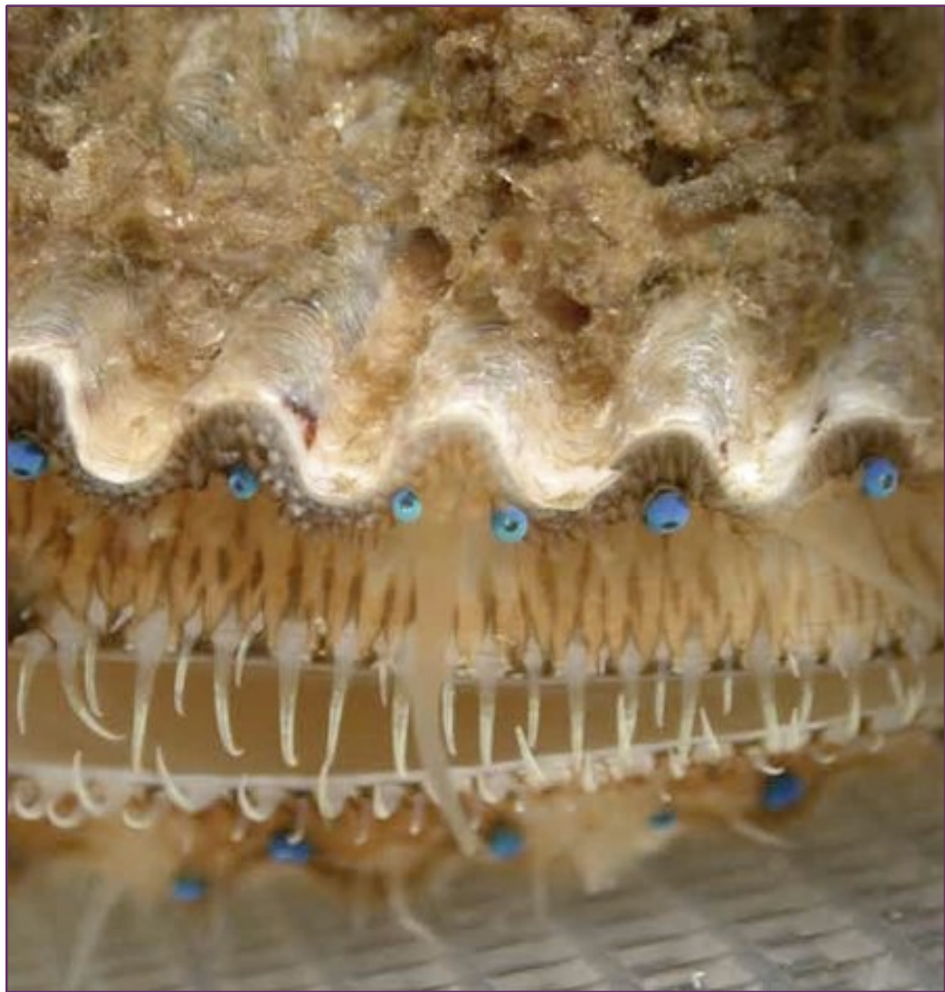
- Byssal threads
  - Proteinaceous liquid
  - Transported to substrate via foot groove
  - Hardens in salt water (thin & sturdy threads)
- Oysters permanently cement one shell valve
- Life stage-dependent in some

Byssus: Life Stage-Dependent

- Use byssal threads as juveniles
- Lose threads when heavy enough to resist currents

Lamellibranch Diversity

- Swimming scallops
  - http://www.youtube.com/watch?v=tFmMS_a7Q9I
- Boring
- Symbiosis: bacteria
  - Shipworms, family Teredinidae
    - *Solemya reidi*
- Geoducks (genus *Panopea*)

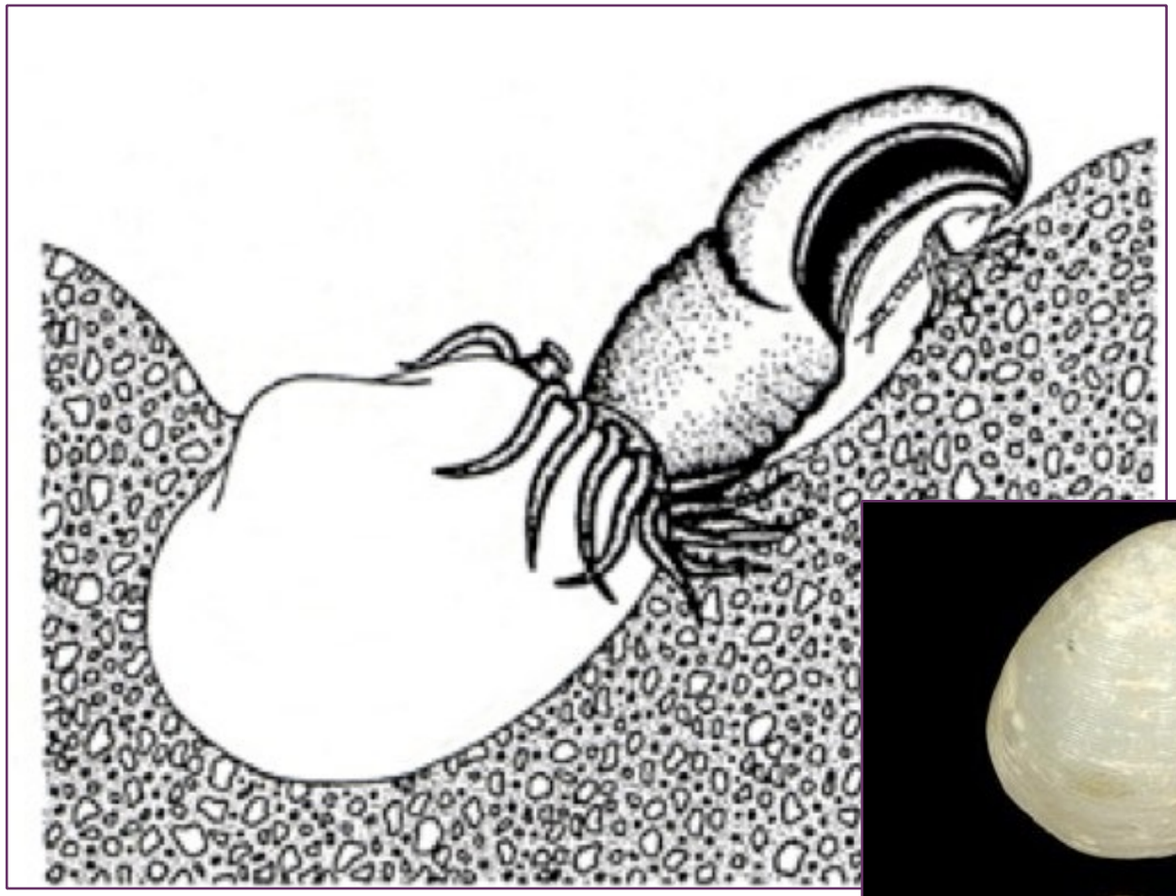


Anomalodesmata

- Defining Characteristic
  - Lacks true teeth or hinge
- Widely distributed
- Some hermaphroditic
- Up to 15 tentacles around siphon
- Aragonitic shell, 2-3 layers
- The only Order is Pholadomyoida

Anomalodesmata Carnivory

- Capture prey using suction from mantle cavity
  - Large, eversible inhalant siphon – retracts quickly to bring prey to mouth
  - Tentacles have ciliary sense organs – motion detectors?
- Modified intestine to digest large food fragments
- Evidence of hemoglobin in red amoebocytes
- Very novel bivalve adaptation and evolution!



Bivalve Reproduction

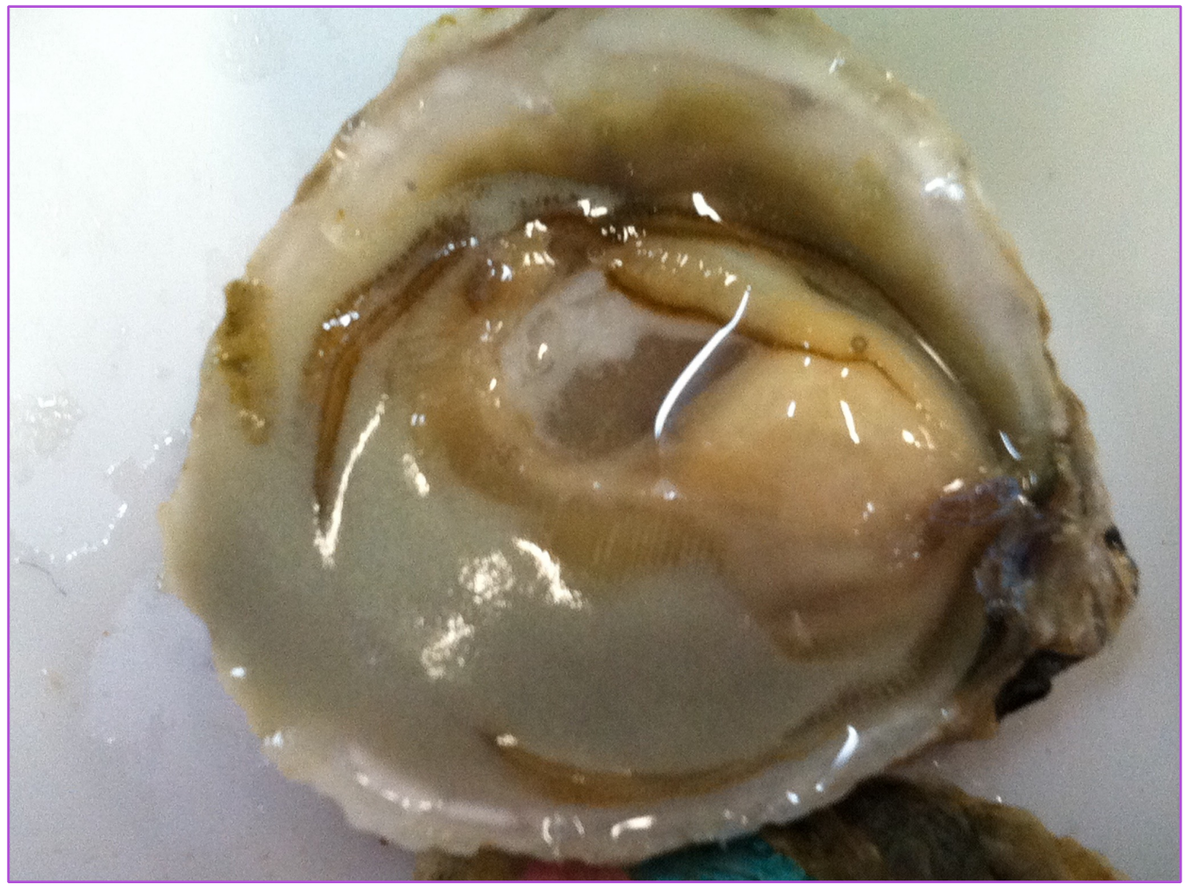
- Most free-spawning
- Reproductive germinal follicles between mantle and digestive glands
- Sequential or alternating hermaphrodism, usually protandrous
  - Clams: *Tapes, Mercenaria, Mya, Spisula*
  - Oysters*: Crassostrea, Ostrea*
    Mussels: *Mytilus, Perna*
- Monoecious – European King scallop, *Pecten maximus* and others

Bivalve Reproduction

- Oysters
  - Sperm and ova move through paired gonoducts, then out via respiratory current
- Male *Crassostrea*: spermatozoa
- Male *Ostrea*: spermatozeugmata

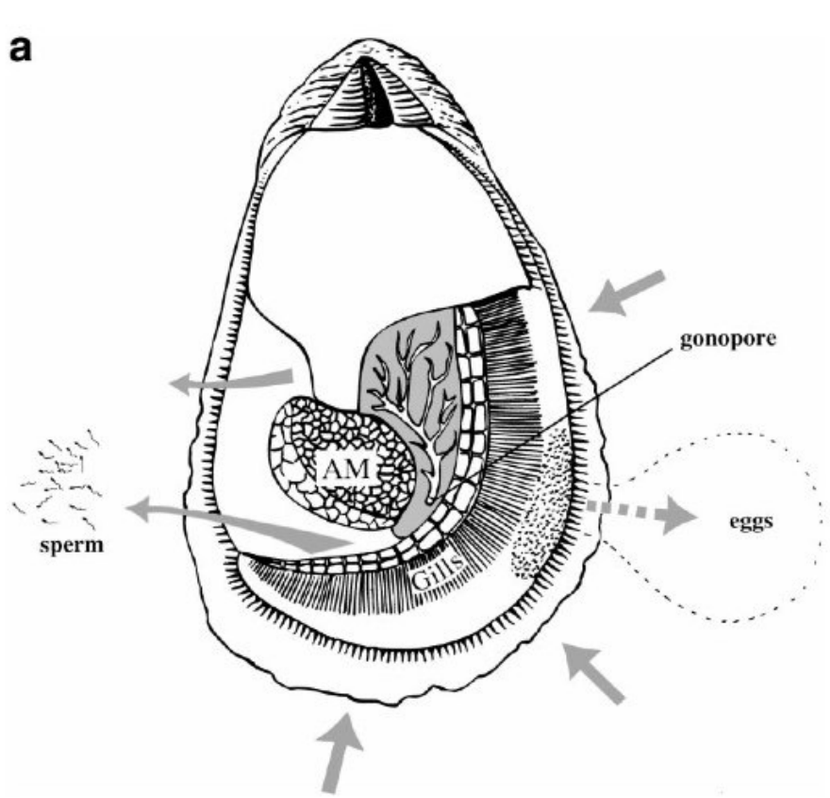
Bivalve Reproduction

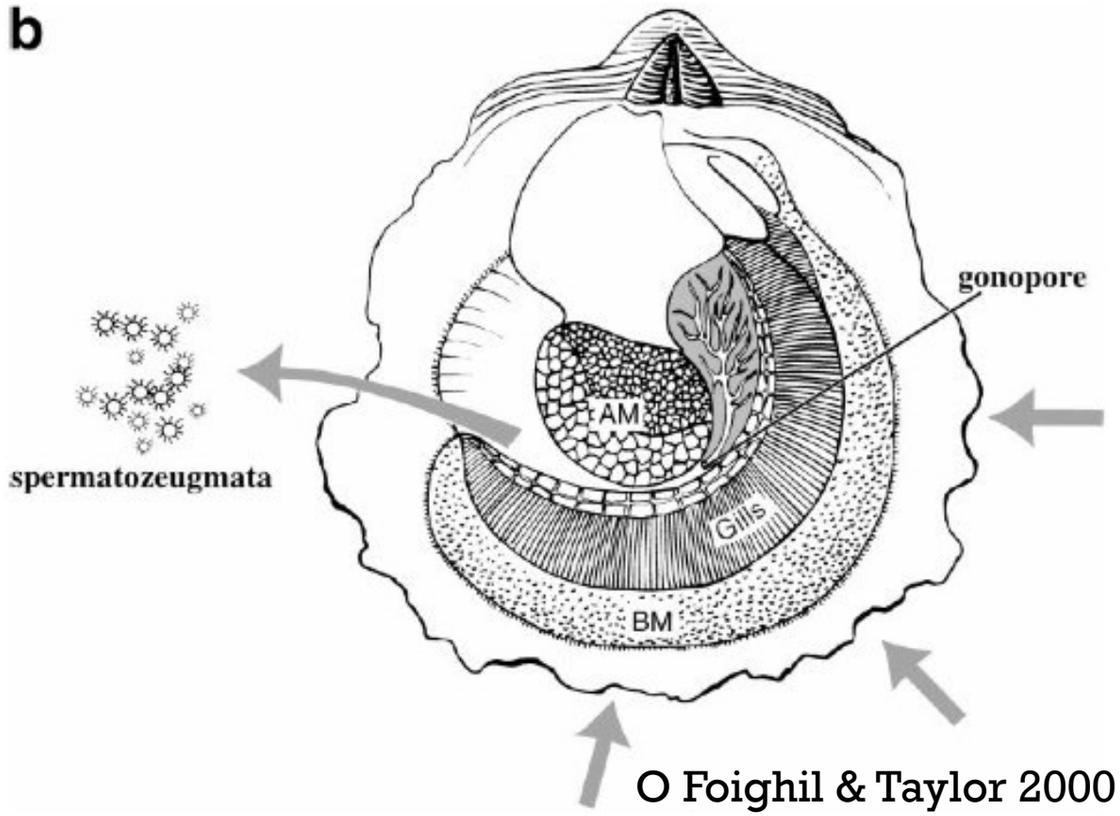
- Olympia oyster, *Ostrea lurida*
- Brooding
  - Males release packets of sperm that are filtered by females
  - Development inside mantle cavity of female for several weeks
  - Release veliger larva



Bivalve Reproduction

- *Crassostrea*
  - 10-50 million eggs per female
  - Eggs = 50 um diameter
  - Larvae develop in plankton for a few weeks
- *Ostrea*
  - 1 million eggs per female
  - Eggs = 150 um diameter
  - Brooding for 10-12 days, in plankton 11-16 days

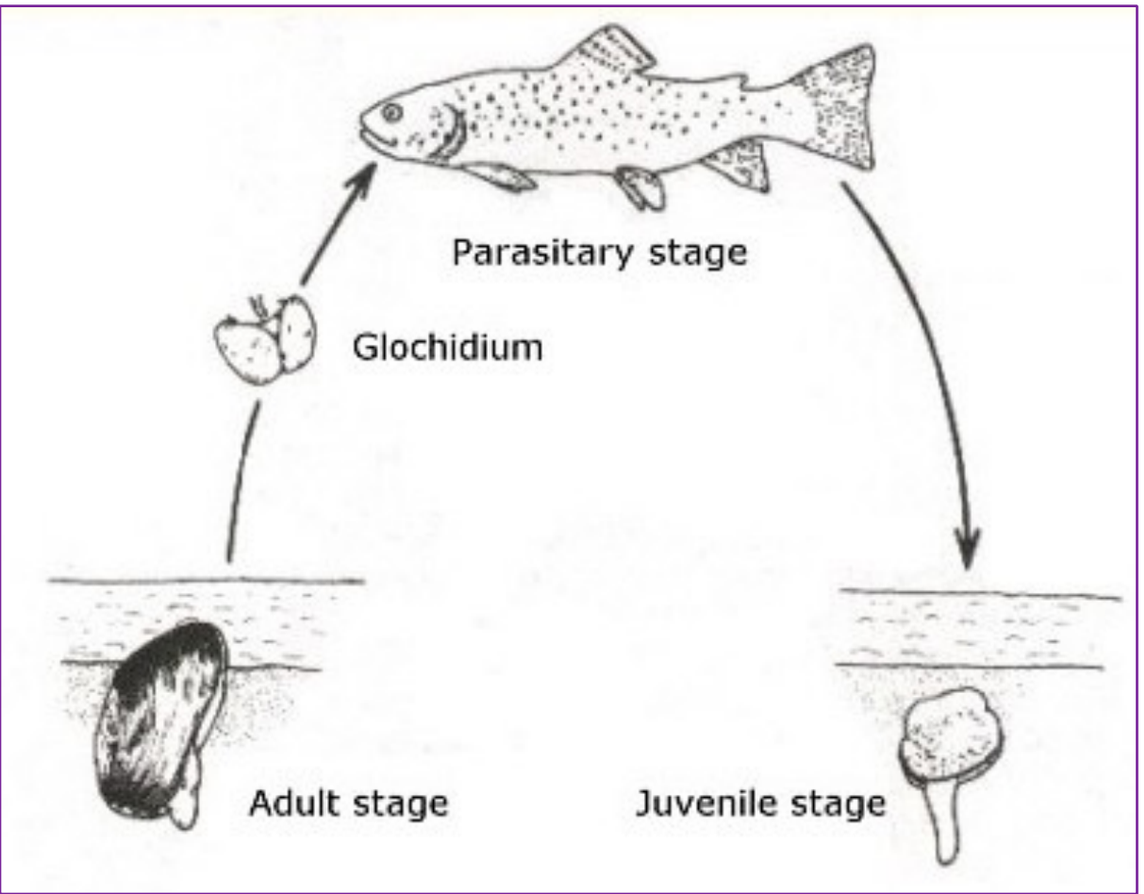




O Foighil & Taylor 2000

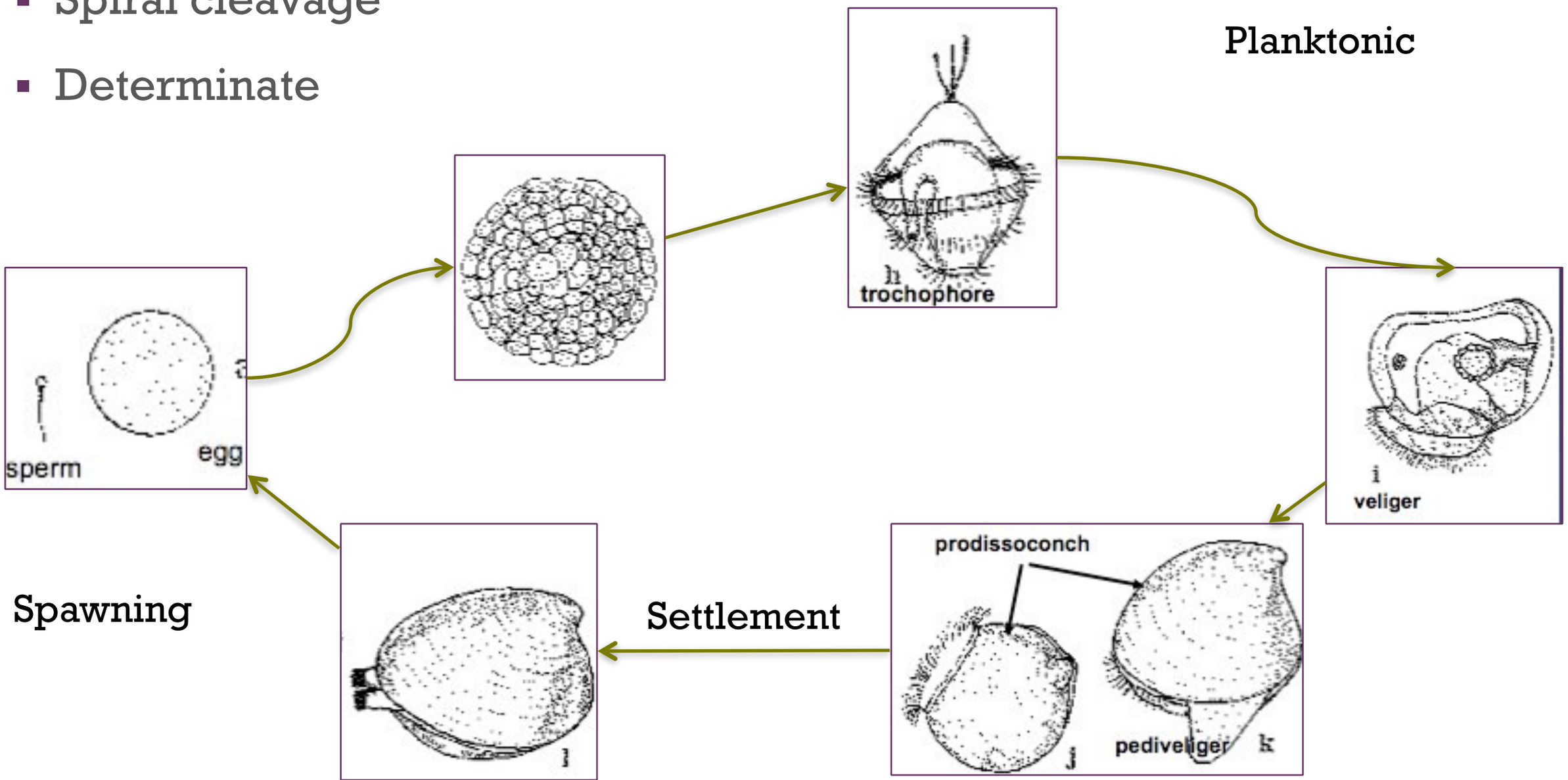
Bivalve Reproduction

- Glochidia: parastitic larvae of freshwater mussel
  - Attach to passing fish gill filaments
  - Covered by epithelium to make cyst – feeds on fish body fluids



Molluscan Development

- Protostomes
- Spiral cleavage
- Determinate

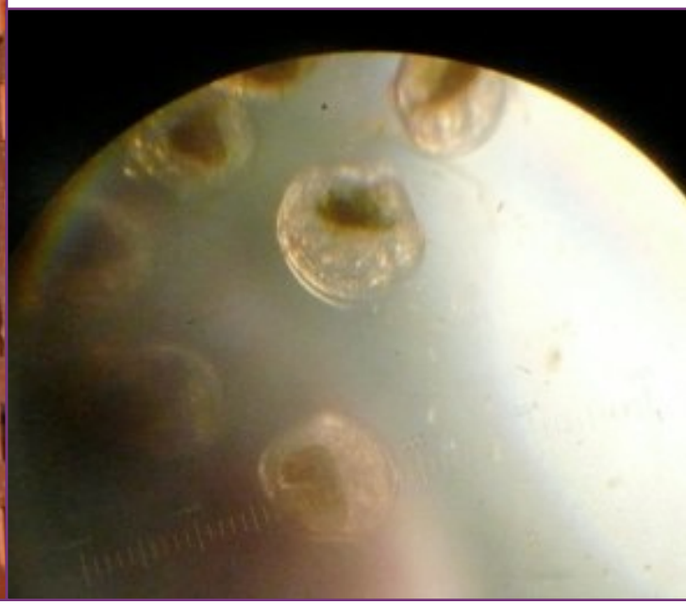


Ecological Importance

- Diverse & broadly distributed
- Filter water
  - *Crassostrea virginica*: 37 L/hr
  - Mussels: 1L/hr per gram wet weight
- Shells provide habitat
  - Oyster shell recycling

Economic Importance

- Large industries focused on bivalves
  - Local PNW aquaculture in a variety of species

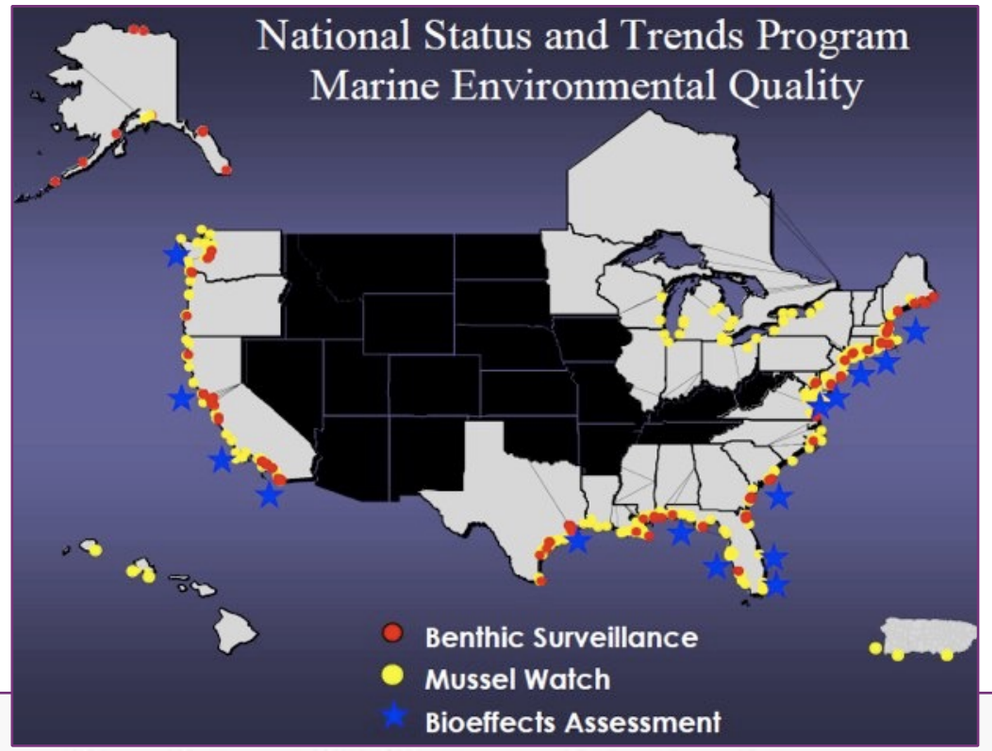


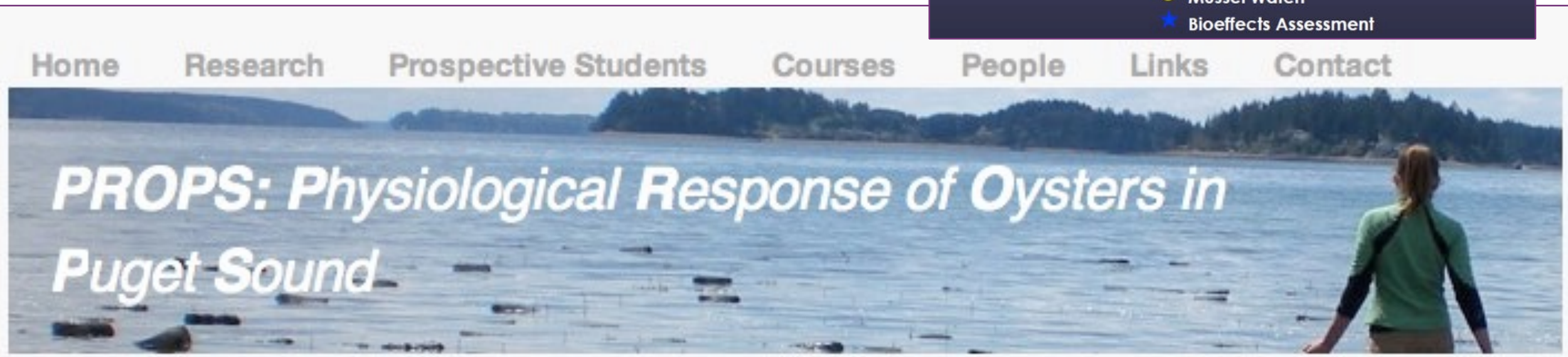
Ecological + Economic = Social

- Ecosystem services
- Habitat and species restoration

Bioindicators

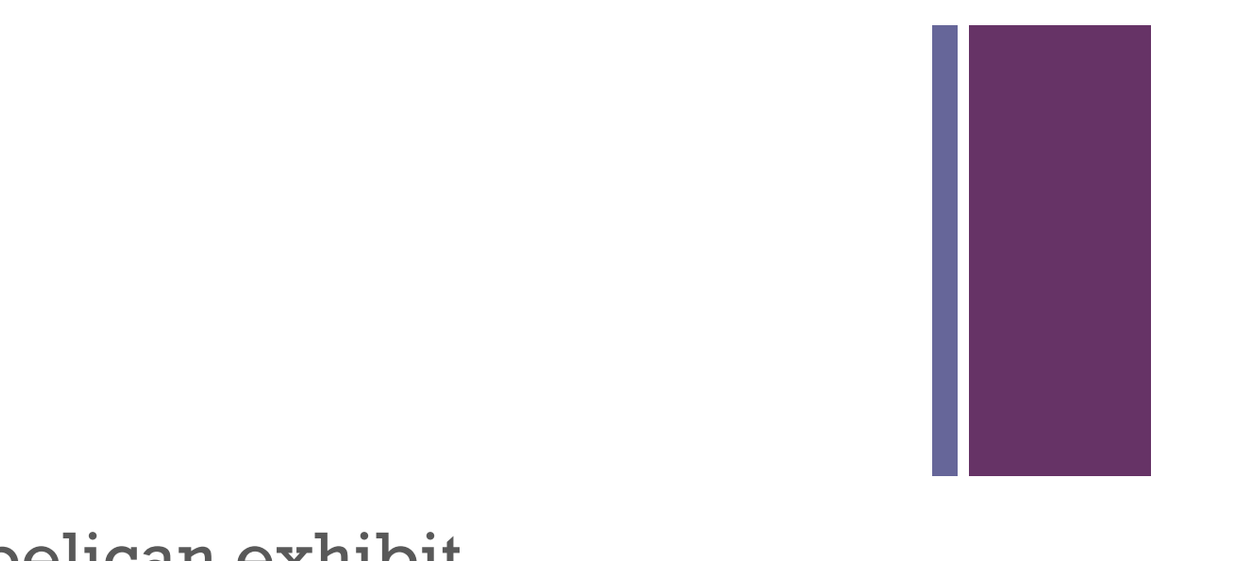
- Portray local environmental parameters
  - Sedentary
  - Filter feeders
  - Bioaccumulation
- Mussel Watch
  - Environment
  - Seafood safety





Biotechnology

- Zebra mussels purify water in zoo pelican exhibit
- Antimicrobial peptides in mussel gill tissues
- Bioadhesives from byssal threads
- Genetics & gene expression



SIGEN@E

Système d'Information des GENomes des Animaux d'Elevage

Mollusca
2
Aplacophora
3
4
5
Eumollusca
6
Polyplacophora
7
Conchifera
8
Monoplacophora
9
Ganglioneura
10
Rhacopoda
11
12
13
Ancyropoda
14
15

Aplacophora

Polyplacophora

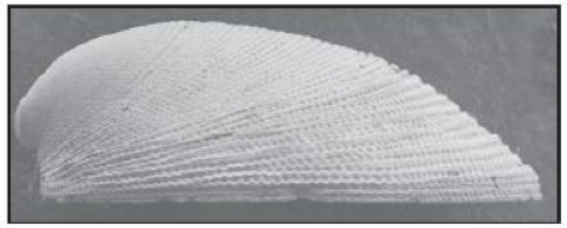
Monoplacophora

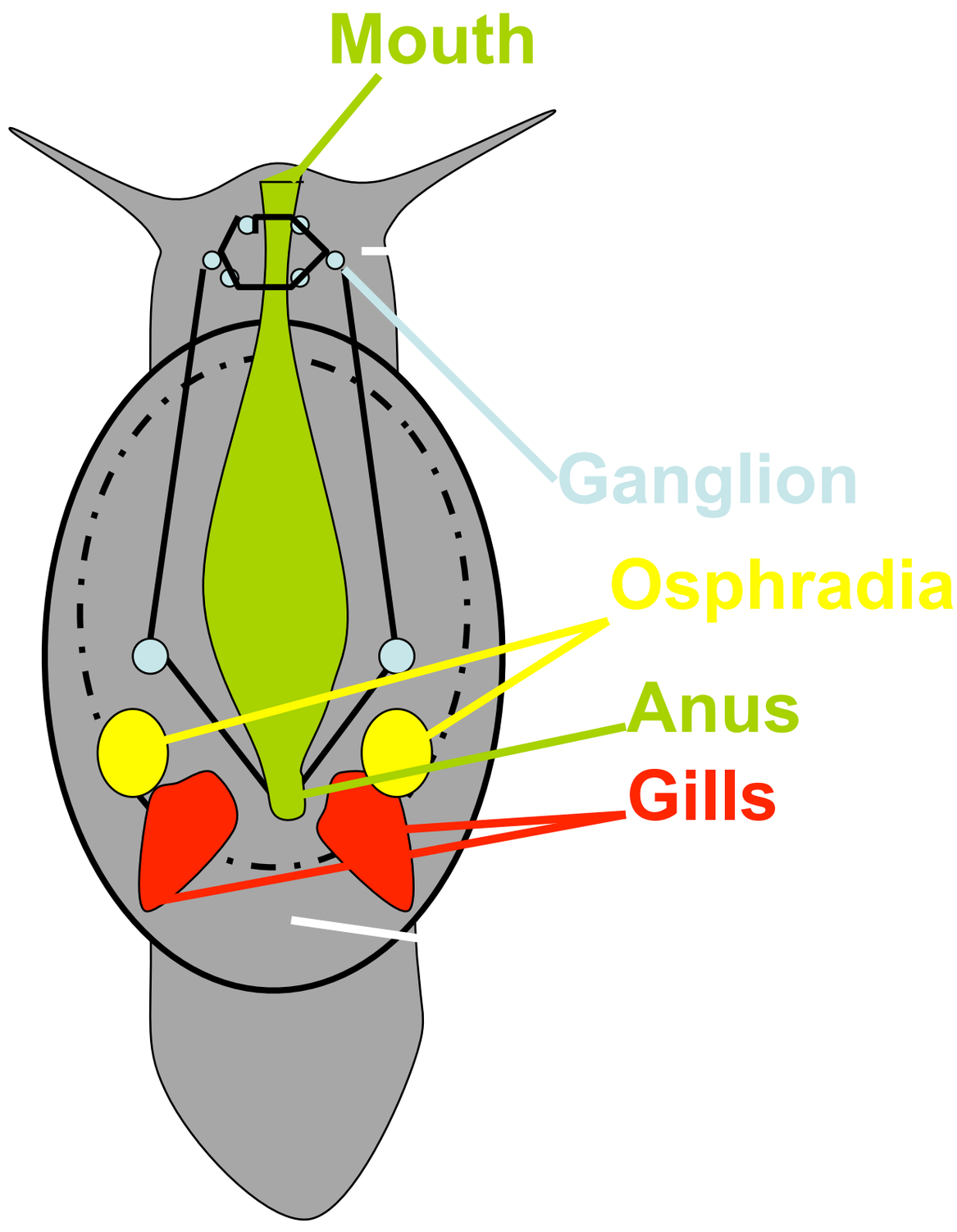
Gastropoda

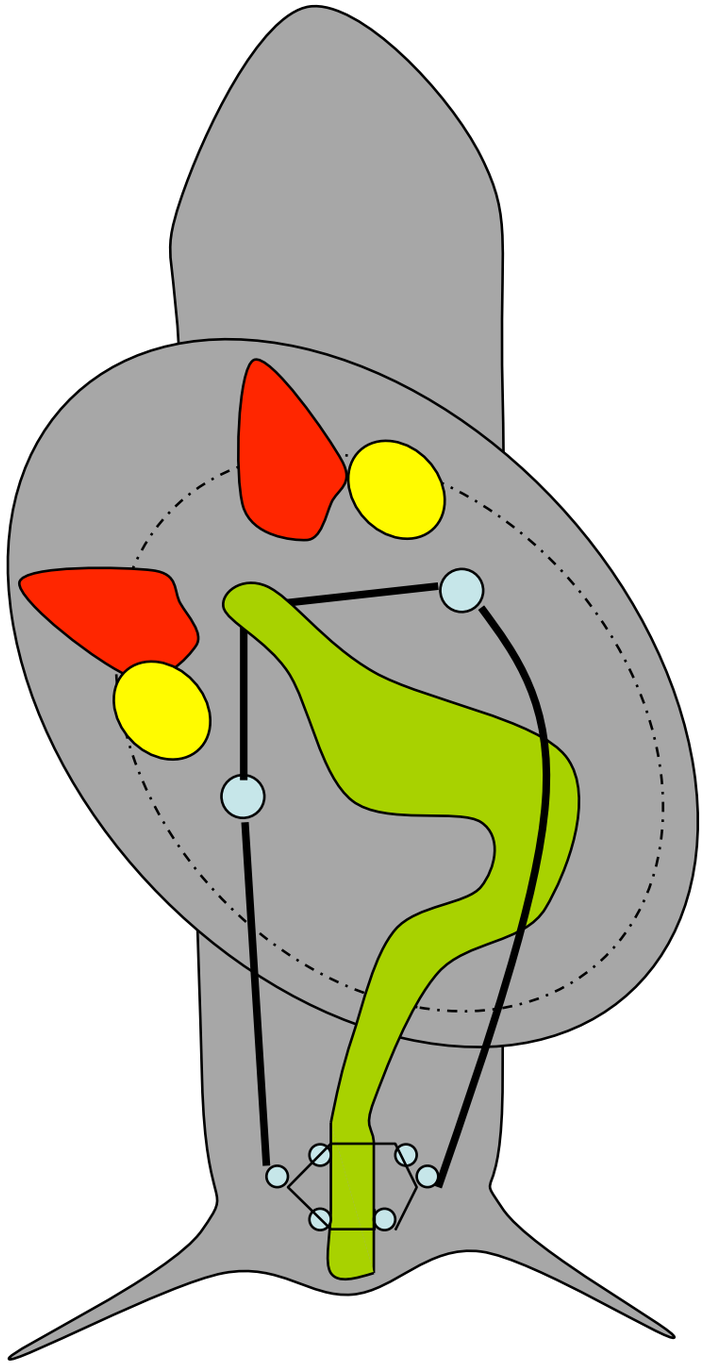
Cephalopoda

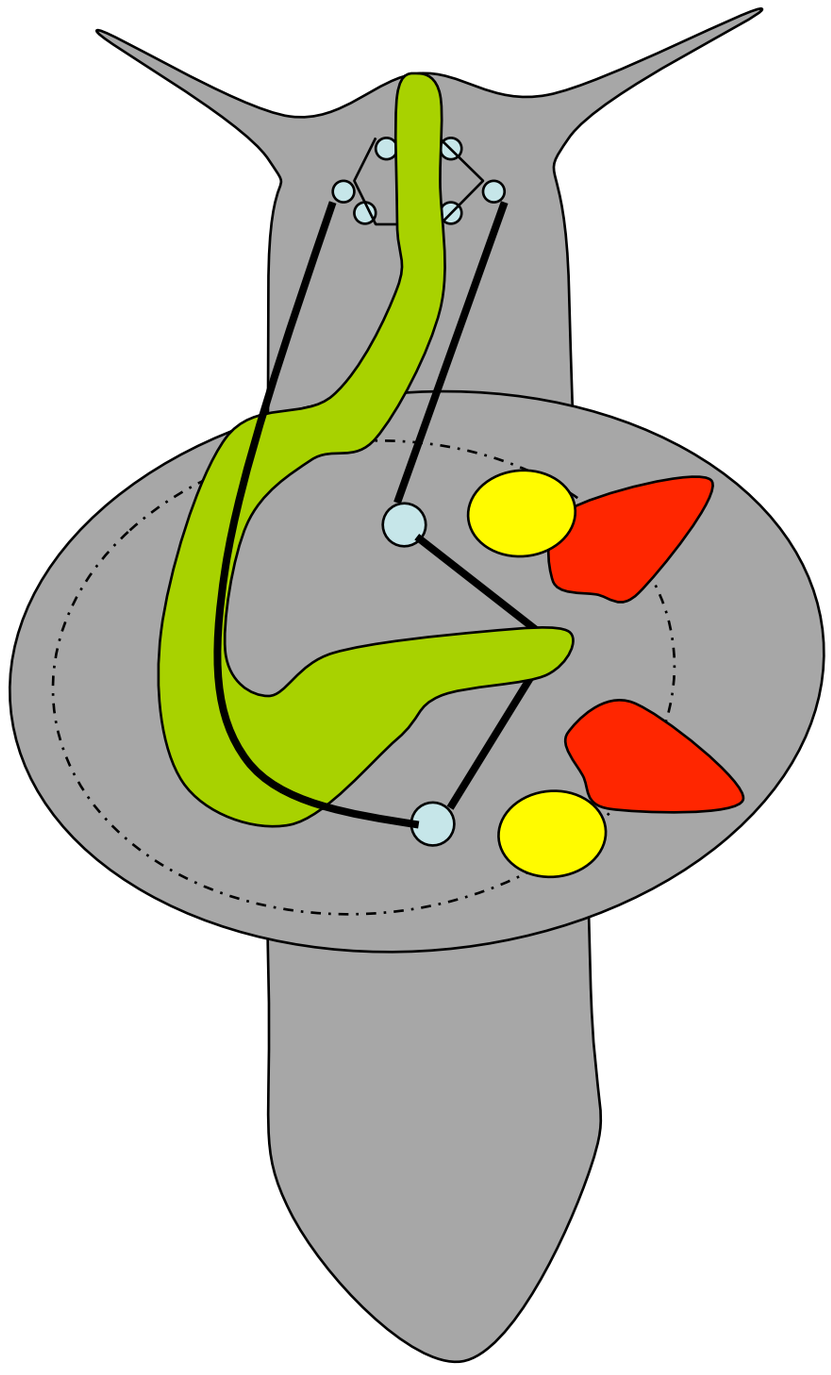
Scaphopoda

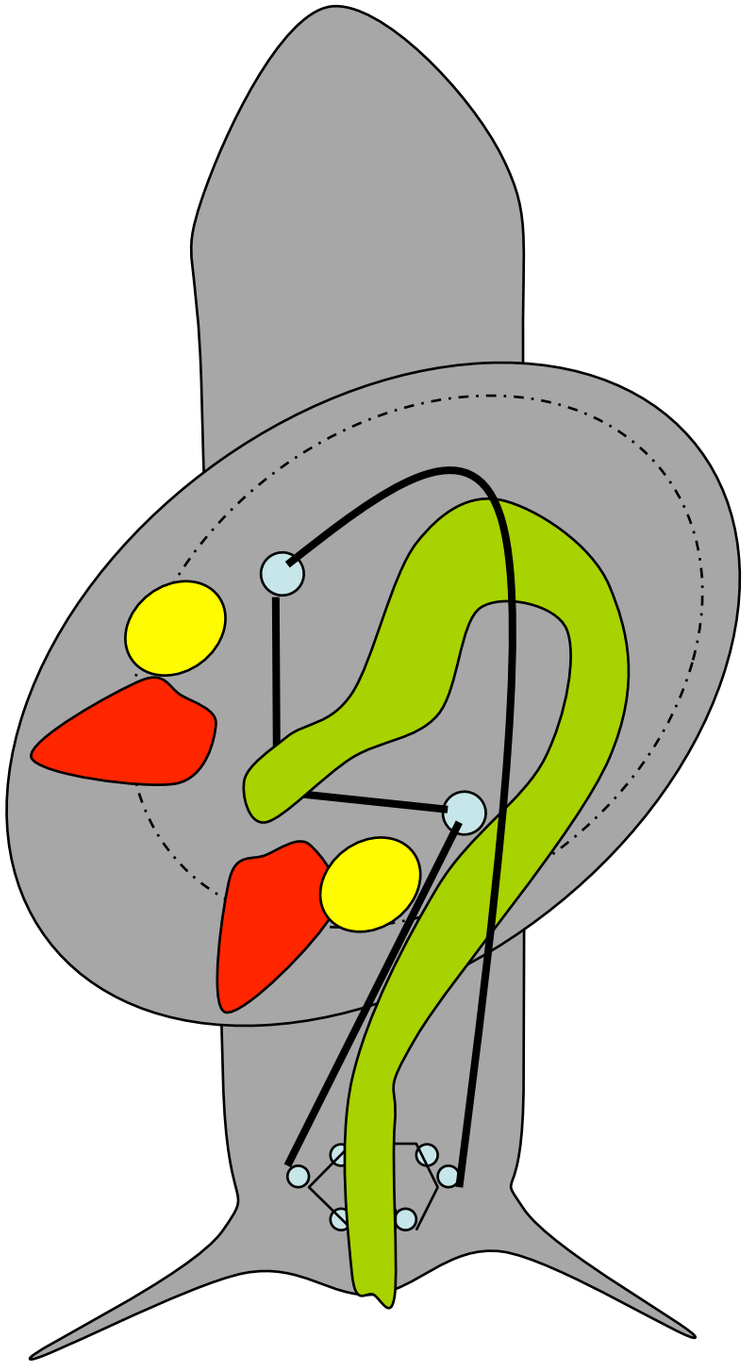
Bivalvia

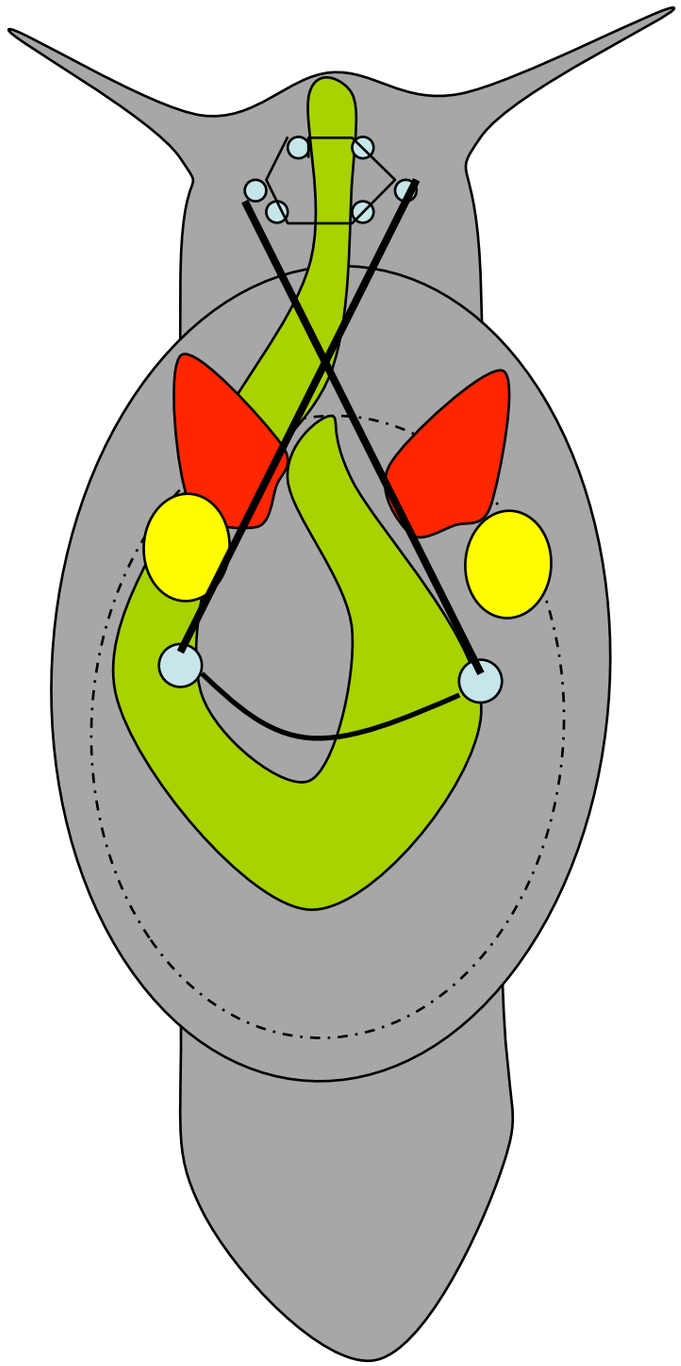



Mouth
Ganglion
Osphradia
Anus
Gills









Mouth

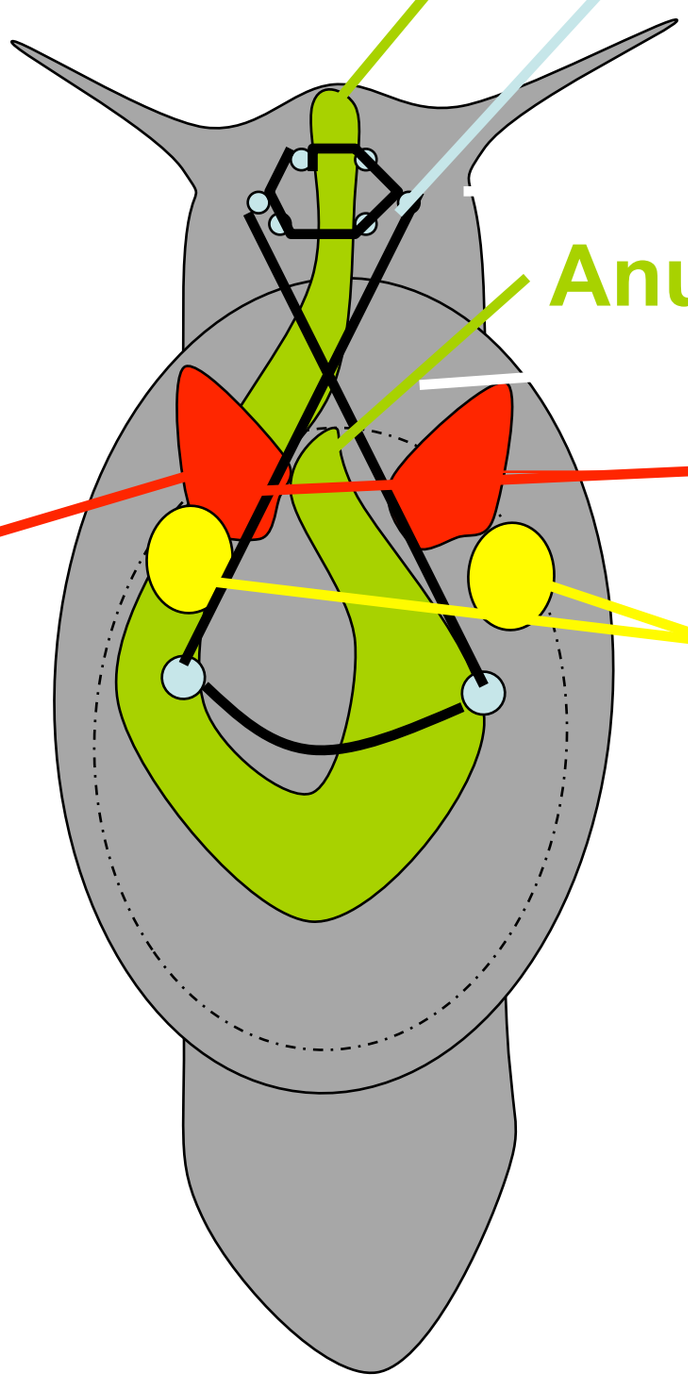
Ganglion

Anus

Gills

Originally the right gill

Osphradia



Gastropoda

- Three main groups (used to be subclasses but classification in flux)
- Prosobranchia – anterior gill
- Opisthobranchia – posterior gill
- Pulmonata - lung

Gastropoda - Prosobranchia

- In all environments, primarily marine
- Most primitive
- Mostly dioecious
- Monopectinate (except primitive= bipectinate)
- Anterior mantle cavity due to torsion (=**defining characteristic**)
- Operculum
- Coiled
- Asymmetrical
  - Patellogastropoda – most primitive
  - Vetigastropoda (= Archeogastropoda) – also primitive
  - Mesogastropoda - intermediate
  - Neogastropoda- most derived

Gastropod Prosobranchs

- **Patellogastropoda**
- **Vetigastropoda**
- Neritomorpha
- **Caenogastropoda (>50% of species)**
  - **Mesogastropoda**
  - **Neogastropoda**
- Heterostropha

- Patellogastropoda
- Vetigastropoda
- Neritomorpha

  Caenogasgtropoda (>50% of species)
  - Mesogastropoda
  - Neogastropoda
- Heterostropha

Order Patellogastropoda

Families Patellidae, Nacellidae, Acmaeidae, Lepetidae, Lottiidae

True limpets

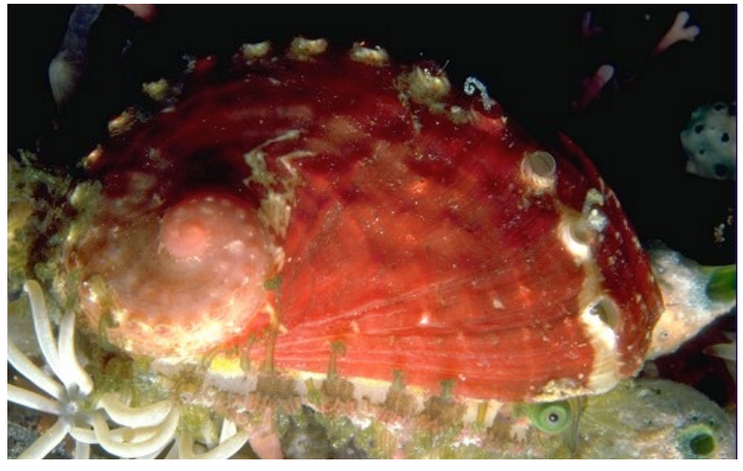
- Patellogastropoda
- Vetigastropoda
- Neritomorpha

  Caenogasgtropoda (>50% of species)
  - Mesogastropoda
  - Neogastropoda
- Heterostropha

Vetigastropods (=Archeogastropods)- old style

- Patellogastropoda
- Vetigastropoda
- Neritomorpha

  Caenogasgtropoda (>50% of species)
  - Mesogastropoda
  - Neogastropoda
- Heterostropha



Mesogastropods- middle

Neogastropods- new and improved!

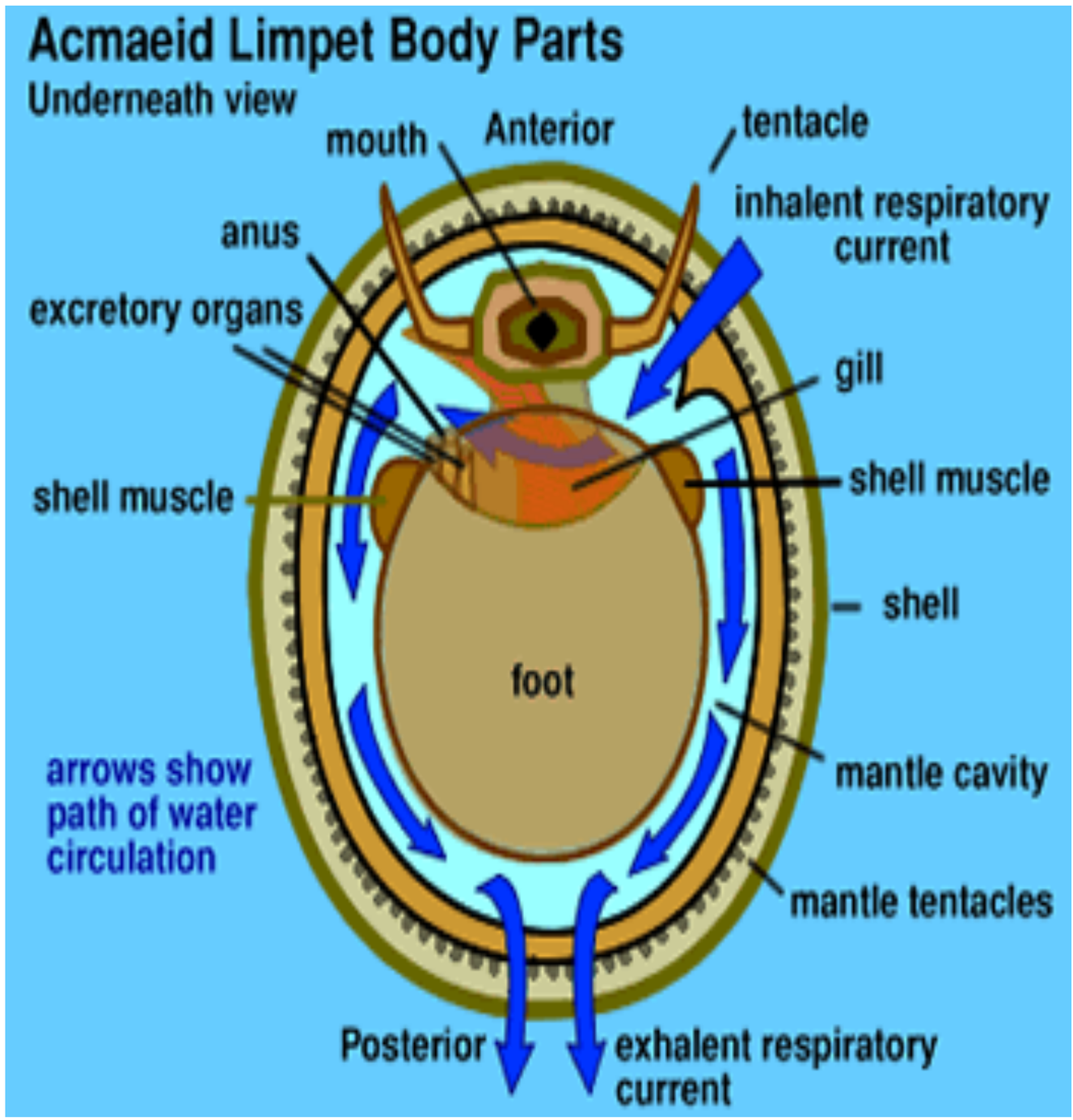
Evolution within Prosobranchs

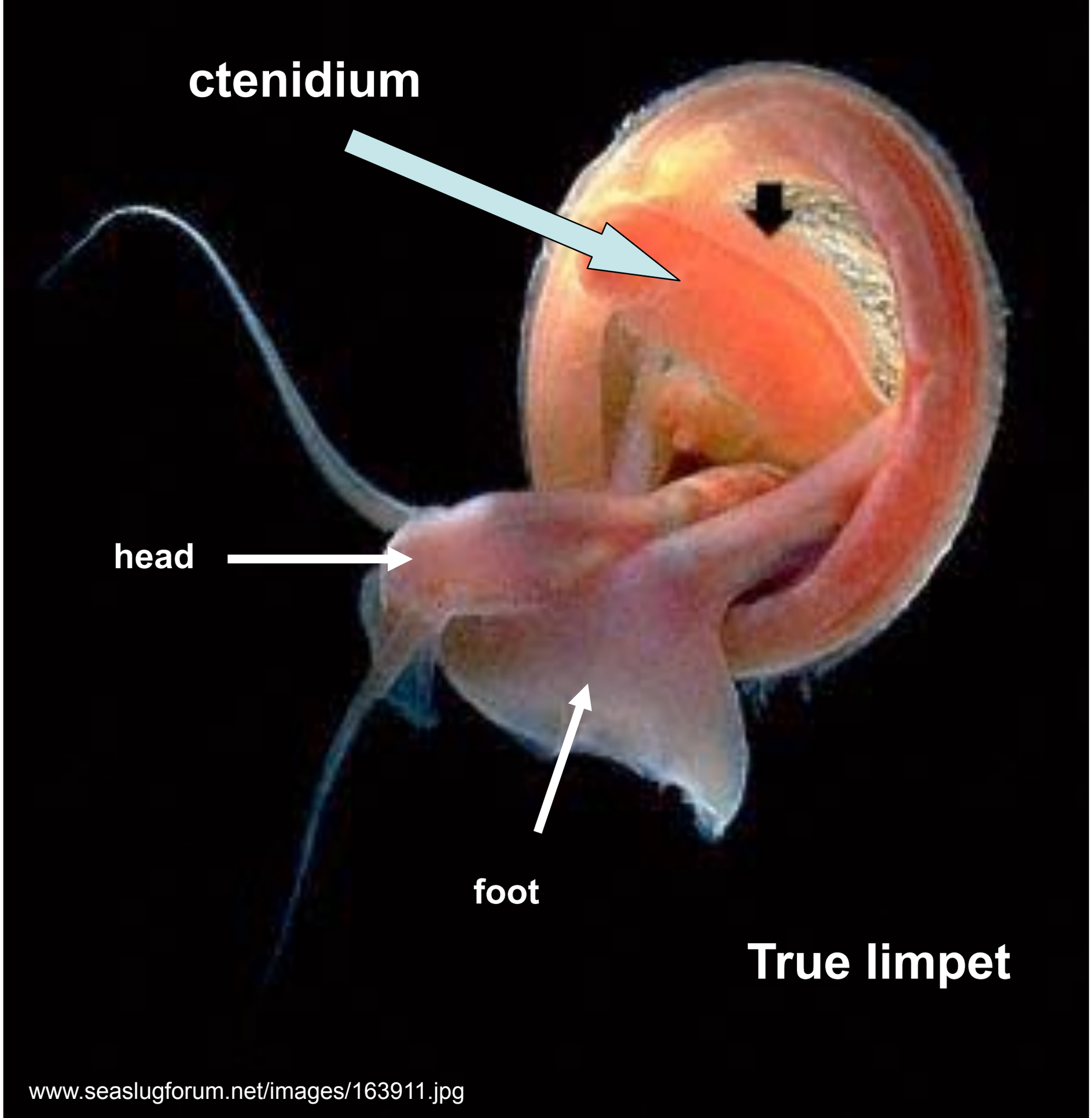
- Trend towards reduction and specialization as become more derived
  - Atria from two to one
  - Gills from two bipectinate to one monopectinate
  - Nephridia from two to one
  - Radula with many teeth to those with few and modified function
  - Development of siphon and poison glands
  - Reproduction from free-spawning to copulation

Patellogastropoda

- True limpets that evolved independently of keyhole limpets
  - Primitive - Shallow to deep sea
  - Non-coiled, symmetrical cone
  - One atrium and one bipectinate gill

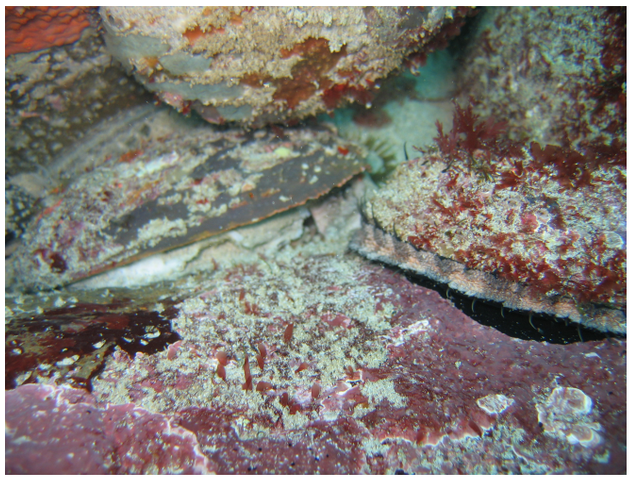
    Lottia, Acmea




ctenidium
head
foot
True limpet
www.seaslugforum.net/images/163911.jpg

Vetigastropoda

- Primitive with
  - Two atria, nephridia and bipectinate gills
    - Right may = reduced or lost
    - Dorsal + ventral membranes suspending gill = easily fouled by sediment from respiratory curren
  - *Haliotis,* keyhole limpets, turban and slit snails



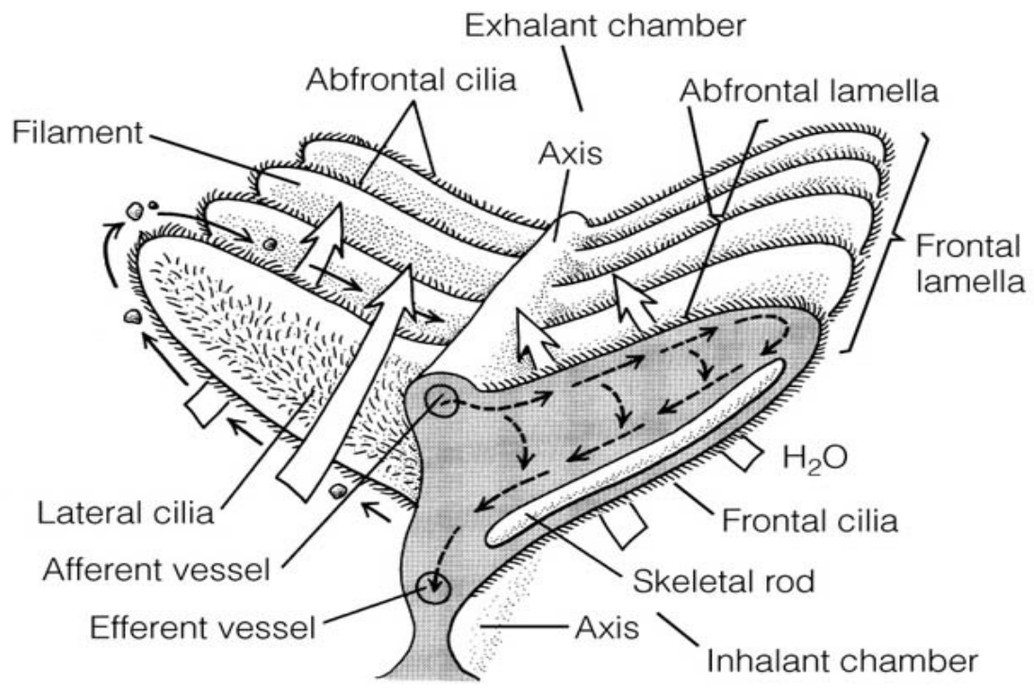
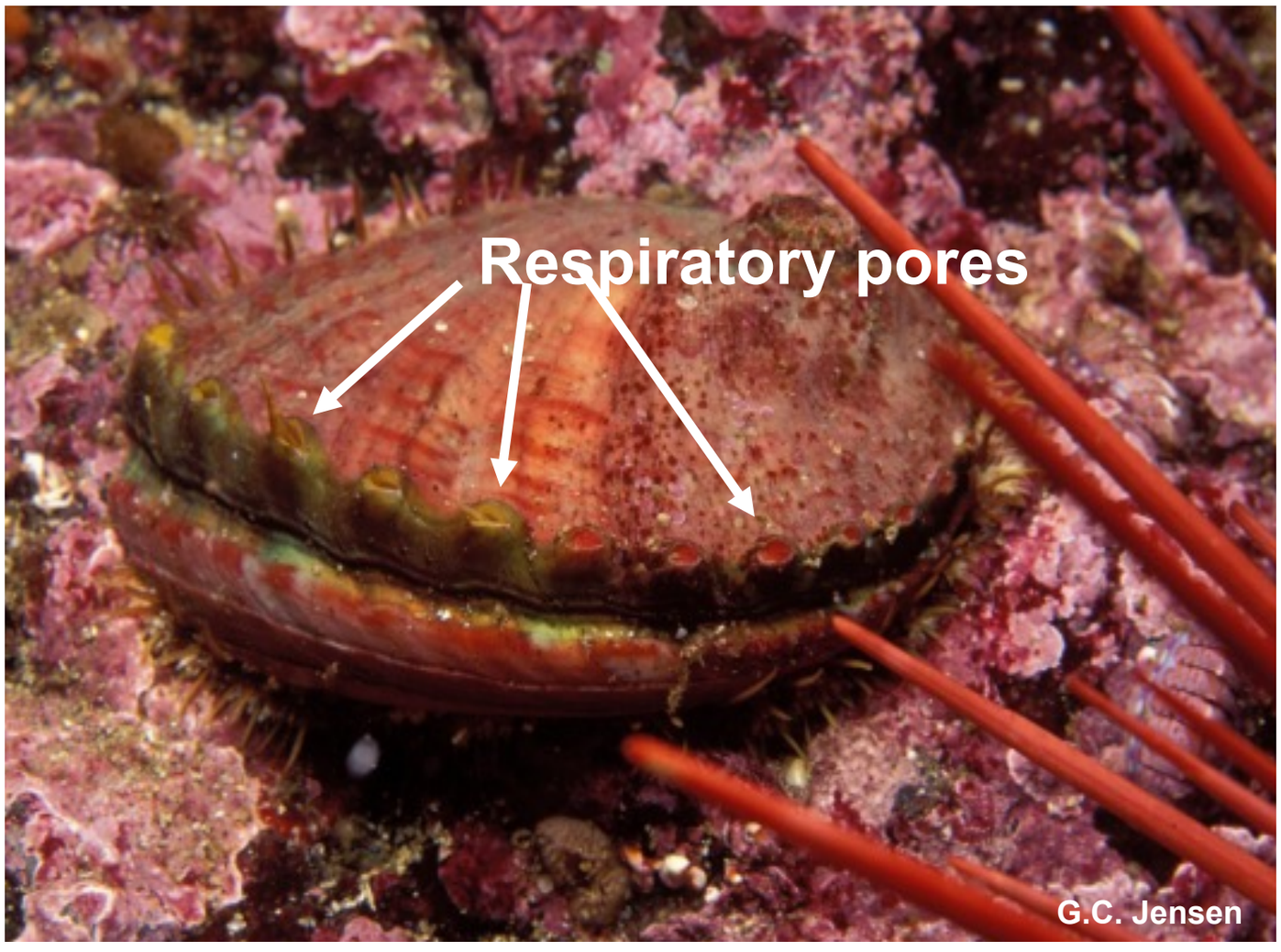


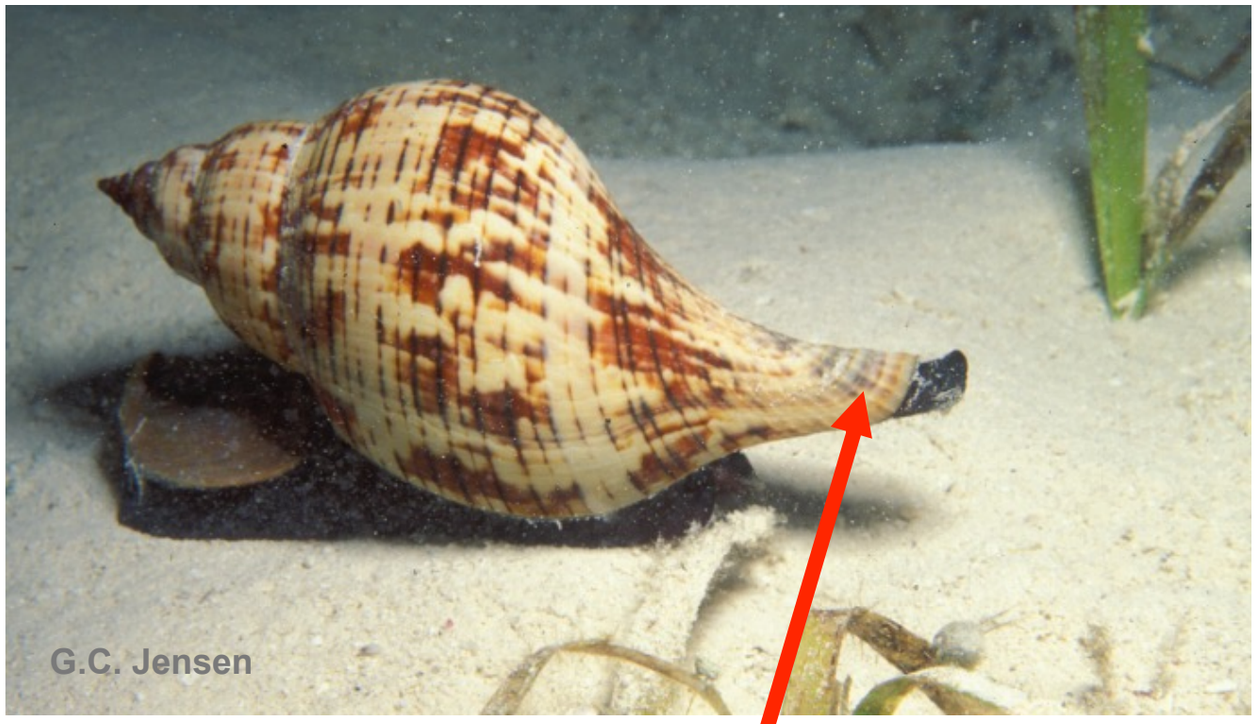
Figure 12-1D: **The generalized mollusc. D, Transverse section through the gill of the primitive gastropod *Haliotis*.**

Vetigastropods

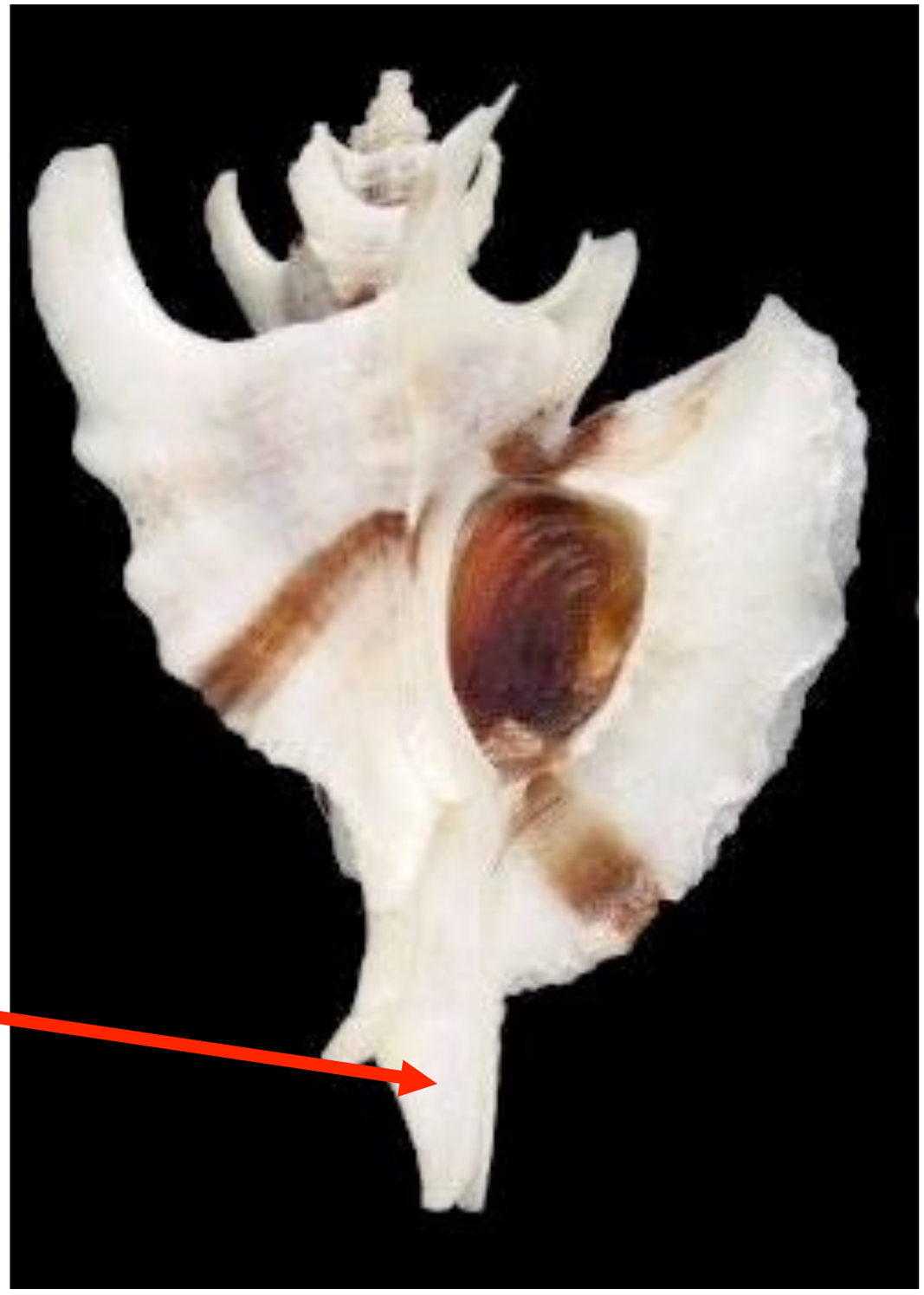


Caenogastropoda

- Meso- & Neogastropods
  - Great radiation due to single **monopectinate** gill
    - May have facilitated expansion from clean water, rocky coasts into soft-bottom, silty habitats
  - Flexible, extensible **inhalent siphon** in many



Siphonal canal



Caenogastropods


Crepidula fornicata

Mesogastropod snails

– Single monopectinate gill, atria, and nephridium
– Complex reproduction with penis
– Mostly marine, but some FW and terrestrial taxa

Littorina, *Polinices* (moon snails)

Caenogastropods

Neogastropod

- Only marine share many meso- characters
- Highly specialized carnivores
- Radula with ≤ 3 teeth per row (predators – often with eversible proboscis)
- Many with poison glands
- **Most derived of all prosobranchs**

Gastropoda

- Three main groups (used to be subclasses but classification in flux)
- Prosobranchia – anterior gill
- Opisthobranchia – posterior gill
- Pulmonata - lung

Gastropoda

<u>Opisthobranchs</u> – seaslugs, sea hares, sea butterflies, bubble snails, etc.

- Defining char: mantle cavity lateral or posterior due to partial or complete detorsion, or lost

Opisthobranchs: e.g. Nudibranchs- “naked gills”

Dorid nudibranch

Nudibranchs

http://www.naturalsciences.org/education/deepsea/images/nudibranch.jpg

http://www.reefdvd.com/VIP/Images/Nudibranch.jpg

Phyllidia tula

Flabellinopsis iodinea

Gastropoda

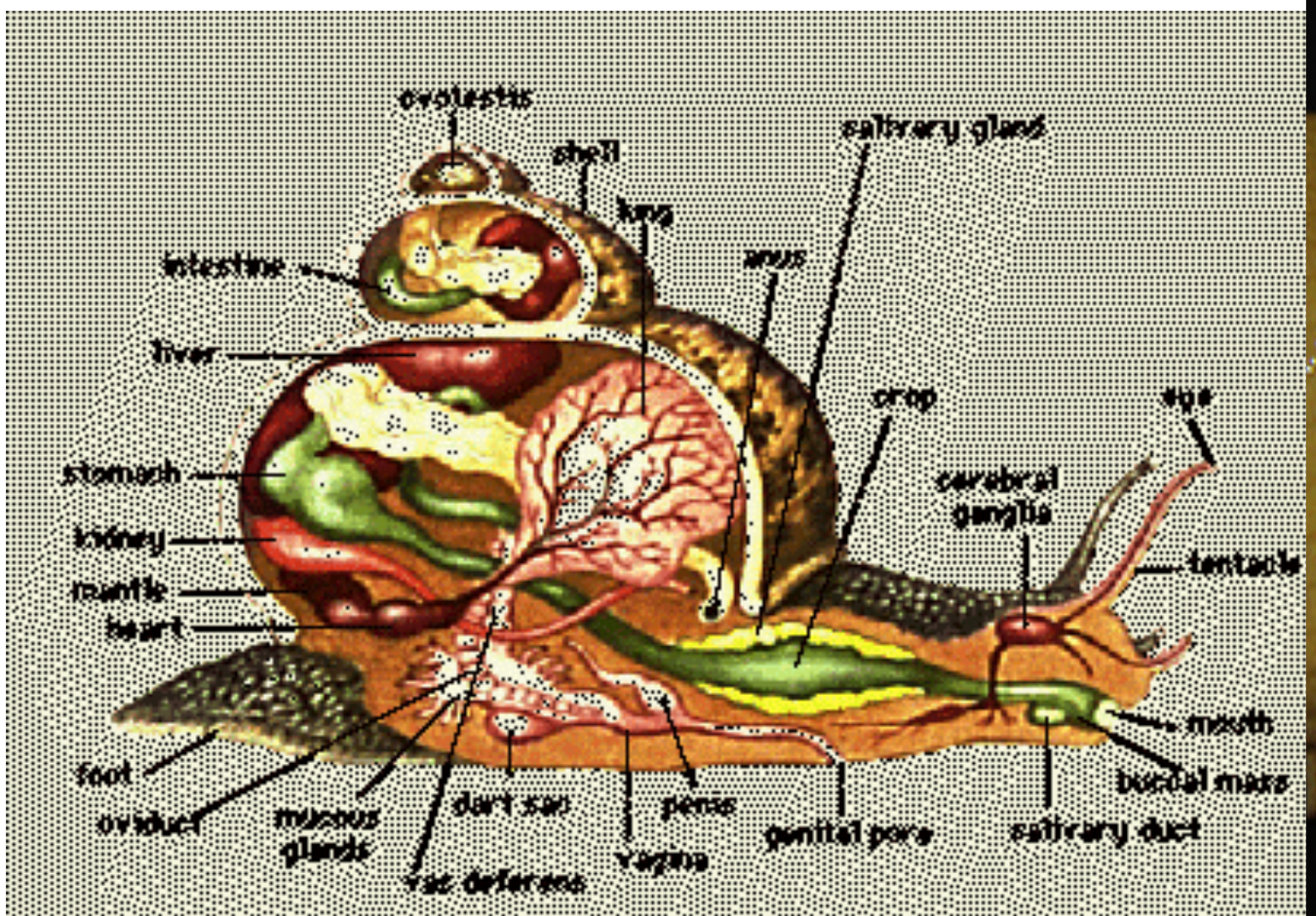
- Three main groups (used to be subclasses but classification in flux)
- Prosobranchia – anterior gill
- Opisthobranchia – posterior gill
- Pulmonata - lung

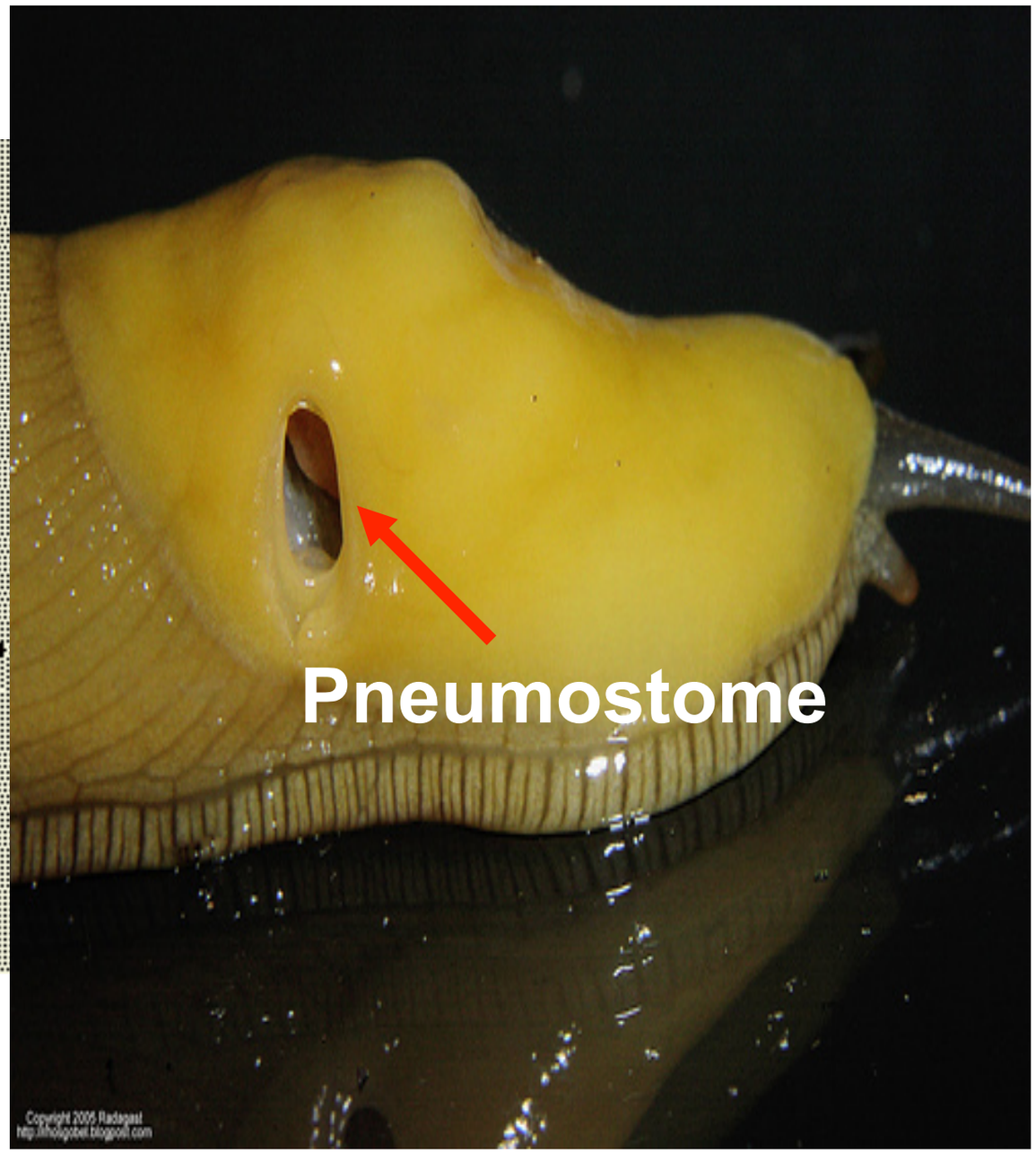
Gastropoda

<u>Pulmonates</u> – terrestrial and FW snails, slugs and a few shallow marine species

– Defining char: mantle cavity highly vascularized → lung

Terrestrial snails and slugs - pulmonates





Terrestrial snails- pulmonates