
بسم الله الرحمن الرحيم

Phylum Mollusca
(연체동물문)

I. Coelomate Phyla

A. True coelom - body cavity lined by mesoderm

B. More efficient arrangement of internal organs

C. Gastrovascular system surrounded by muscle

II. Phylum Mollusca

A. L. *molluscus*, soft

B. Mol-lus' ka, Mollusca or Molluska

C. At least to Cambrian Period (600 MY)

D. 100,000 living species ;
   35,000 extinct species

E. Bilateral symmetry

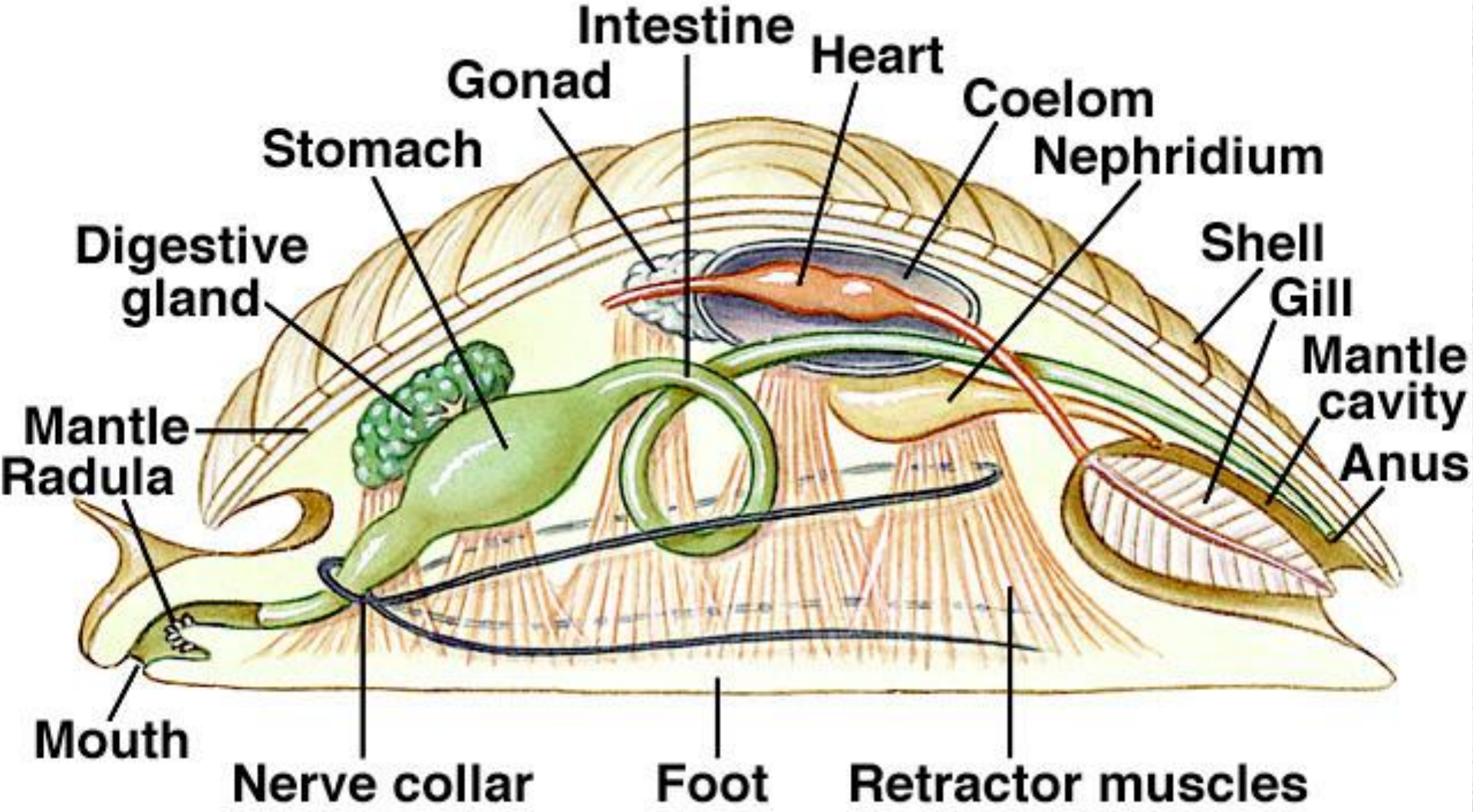
F. To 18m long, most small

- **Malacology; study of living molluscs;**
- **Conchology; study of shells only, shell collector**
- **Often have valves; none to 8**
- **Shell of $CaCo_3$**
- **Most have gills**
- **Usually open circulatory system**
- **Most have kidney (nephridia)**
- **Stomach with crystalline style** نمط بلوری A very long gelatinous **crystalline style** rotates against the gastric shield and releases digestive enzymes into the stomach lumen
- **Feeding; herbivores, carnivores, detrivores, filter feeders, deposit feeders**

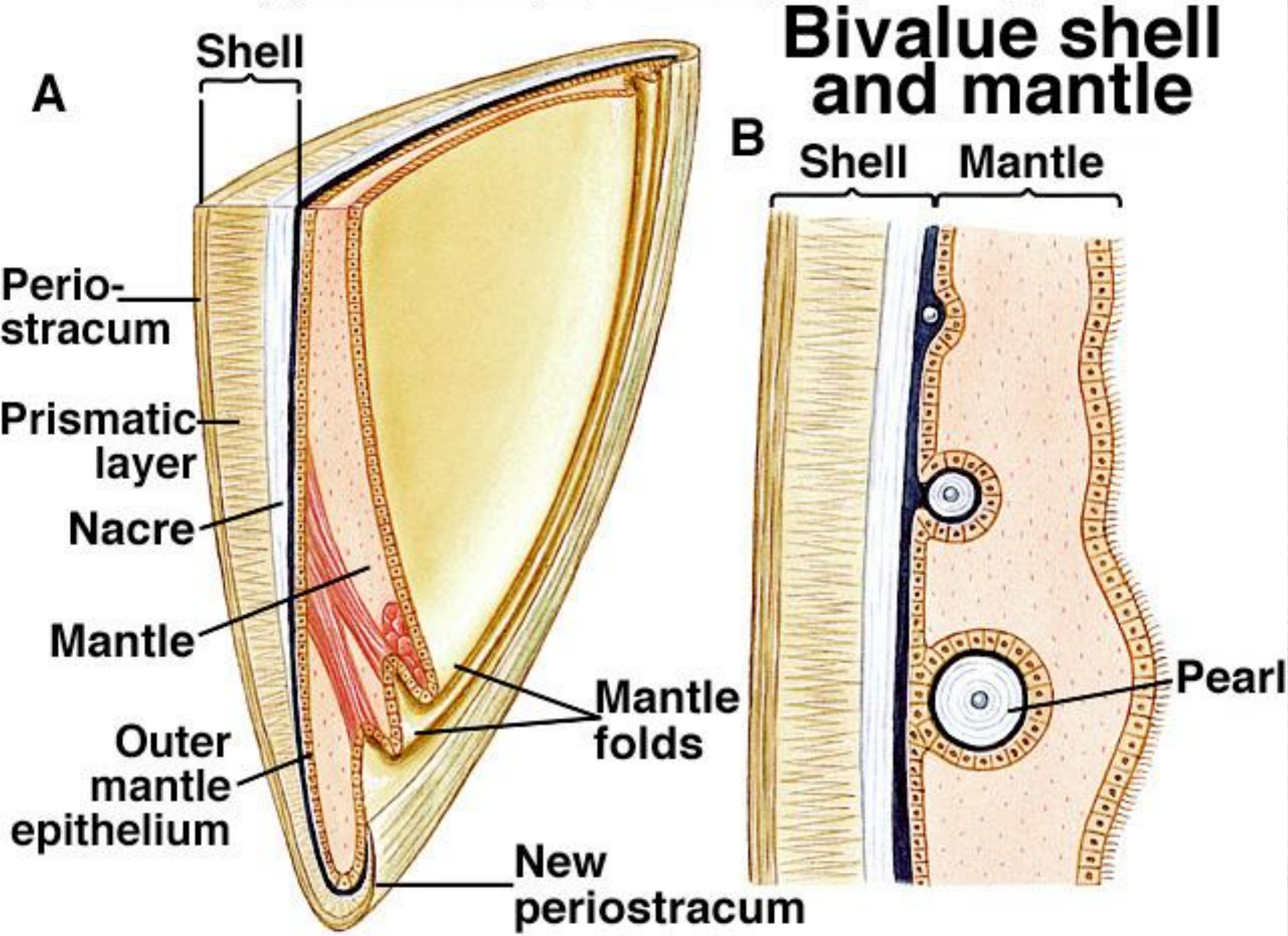
Phylum Mollusca – Body Structure

G. 3 embryonic germ layers:
   endoderm, mesoderm, ectoderm
H. Organ level of organization
I. Extracellular digestion in complete gastrovascular system
J. coelom
K. Excretory system with kidneys (metanephridia)
L. Often with special respiratory structures: gills, lungs, mantle surface

Generalized mollusca body



Bivalue shell and mantle



Phylum Mollusca – Systems

M. Open circulatory system with multi-chambered heart

N. Nervous system varies, based on ganglia at key points
   1. Least sophisticated اقل تطورا in some bivalves
   2. More sophisticated in cephalopods, with nerve ring surrounding pharynx

O. Various sense organs
   1. Eyes of cephalopods most advanced among invertebrates

Phylum Mollusca – Body Surface & Skeleton

P. Cilia on certain body surfaces
   1. Highly advanced on gill surfaces in bivalves

Q. Skeletal systems vary:
   1. Some have none
   2. Some have exoskeleton (shell)
   3. Some have endoskeleton (cuttlebone)

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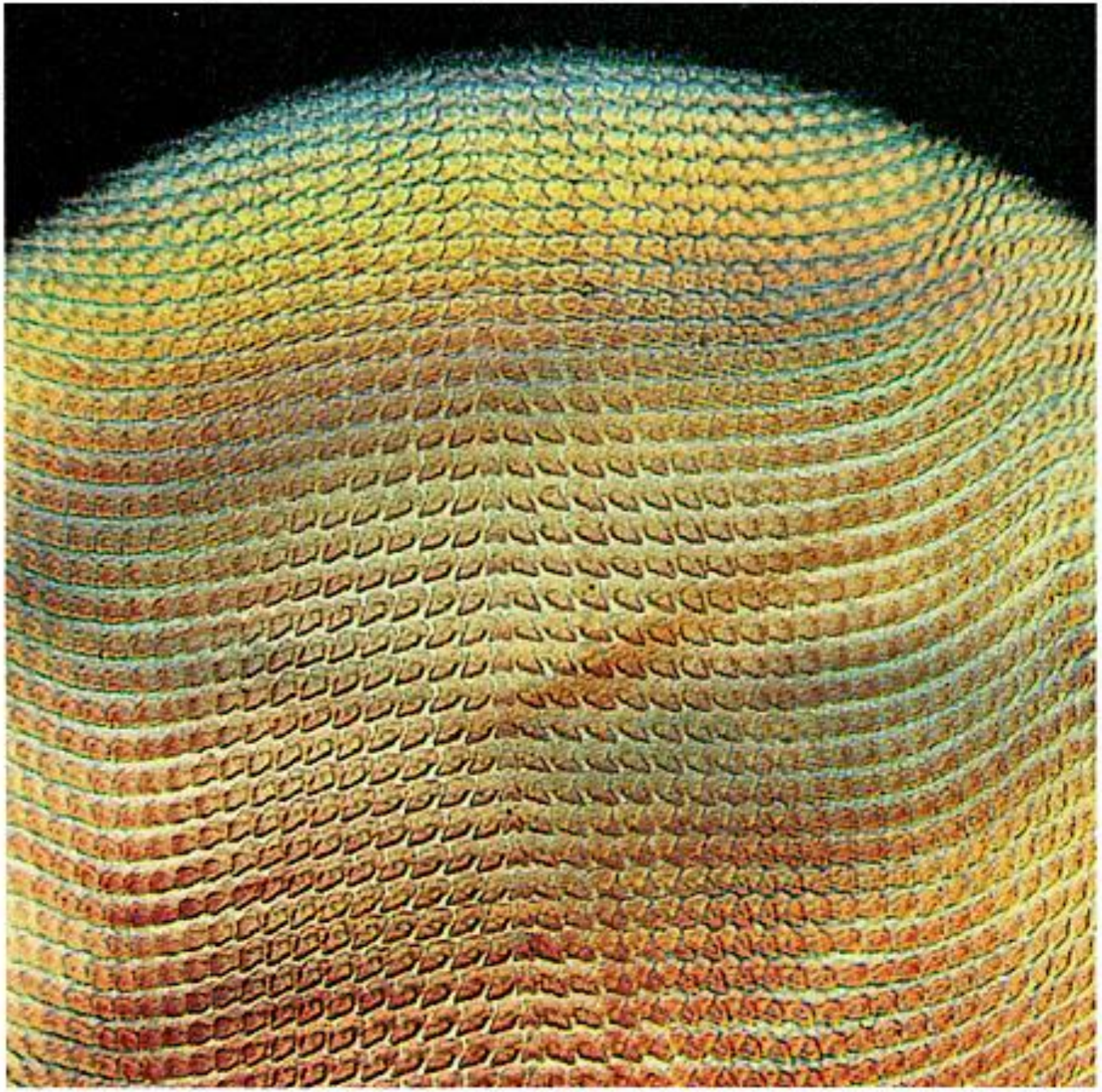
Phylum Mollusca – Unique Structures

R. Unique mollusc structures:

1. **Mantle: from dorsal body wall**
   a) Often forms gills or lungs
   b) Secretes shell
2. **Foot: from ventral body wall**
   a) Locomotion
3. **Radula**
   a) Scraping structure used for feeding

Radula of a gastropod



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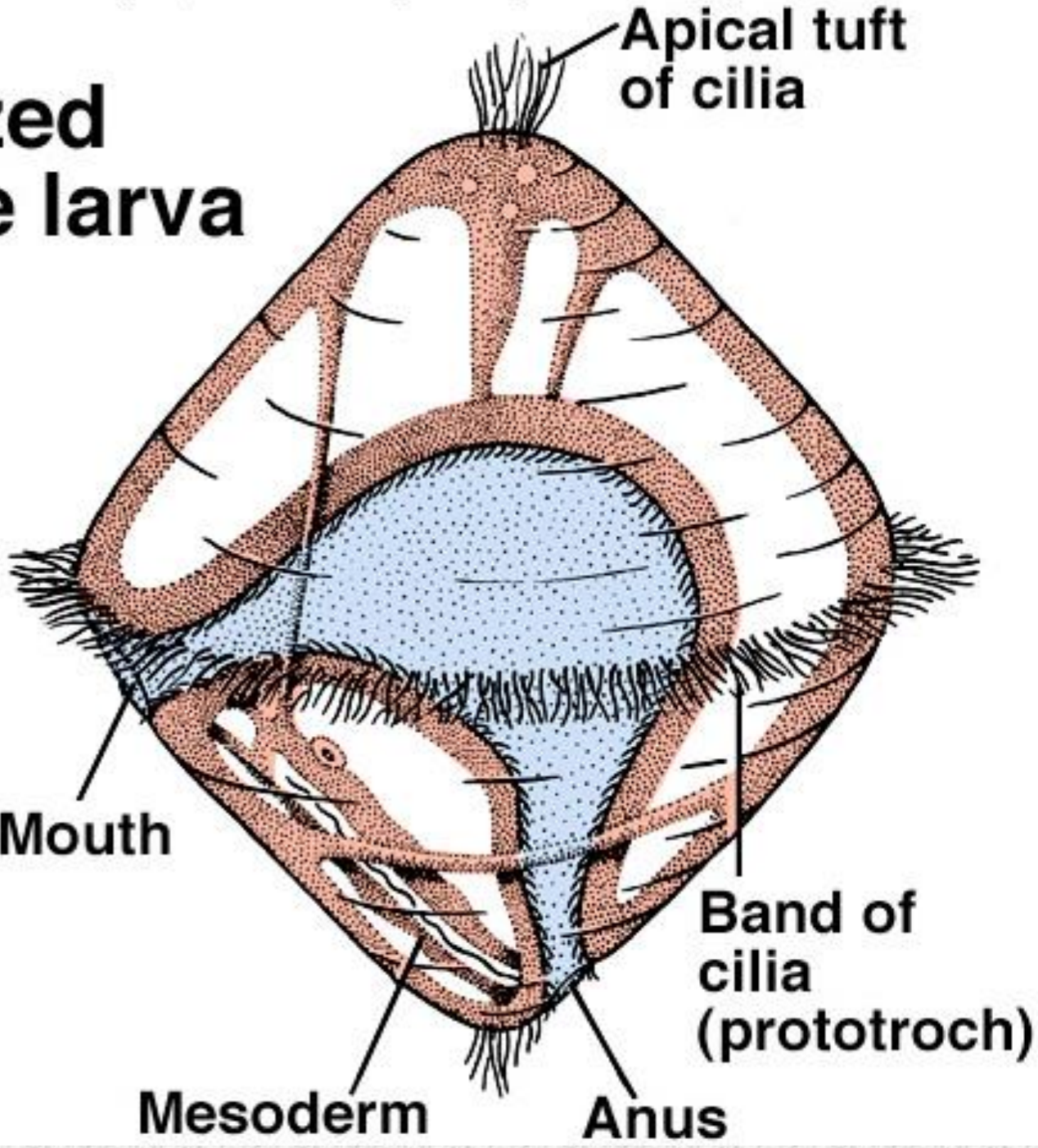
Phylum Mollusca – Reproduction

S. Reproduction usually sexual
   1. Sexual forms dioecious and monecious
   2. Protostome development
   3. Spiral cleavage
   4. Primitive larva - trochophore
   5. Advanced larva - veliger
   6. Some have direct development

T. Marine, freshwater, some terrestrial, some parasitic

Generalized trochophore larva



Phylum Mollusca – Taxonomy

Class Monoplacophora.

Class Polyplacophora .

Class Scaphopoda .

Class Gastropoda .

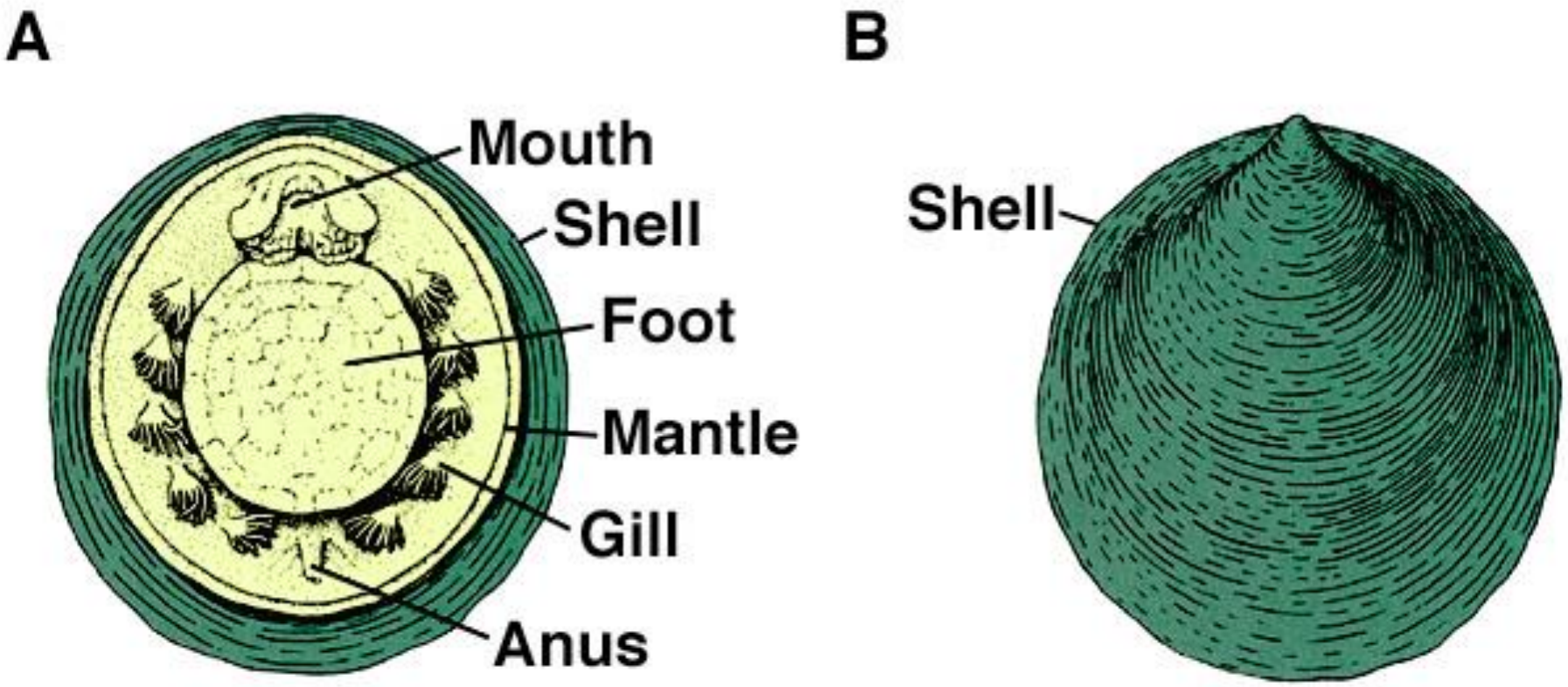
Class Bivalvia .

Class Cephalopoda .

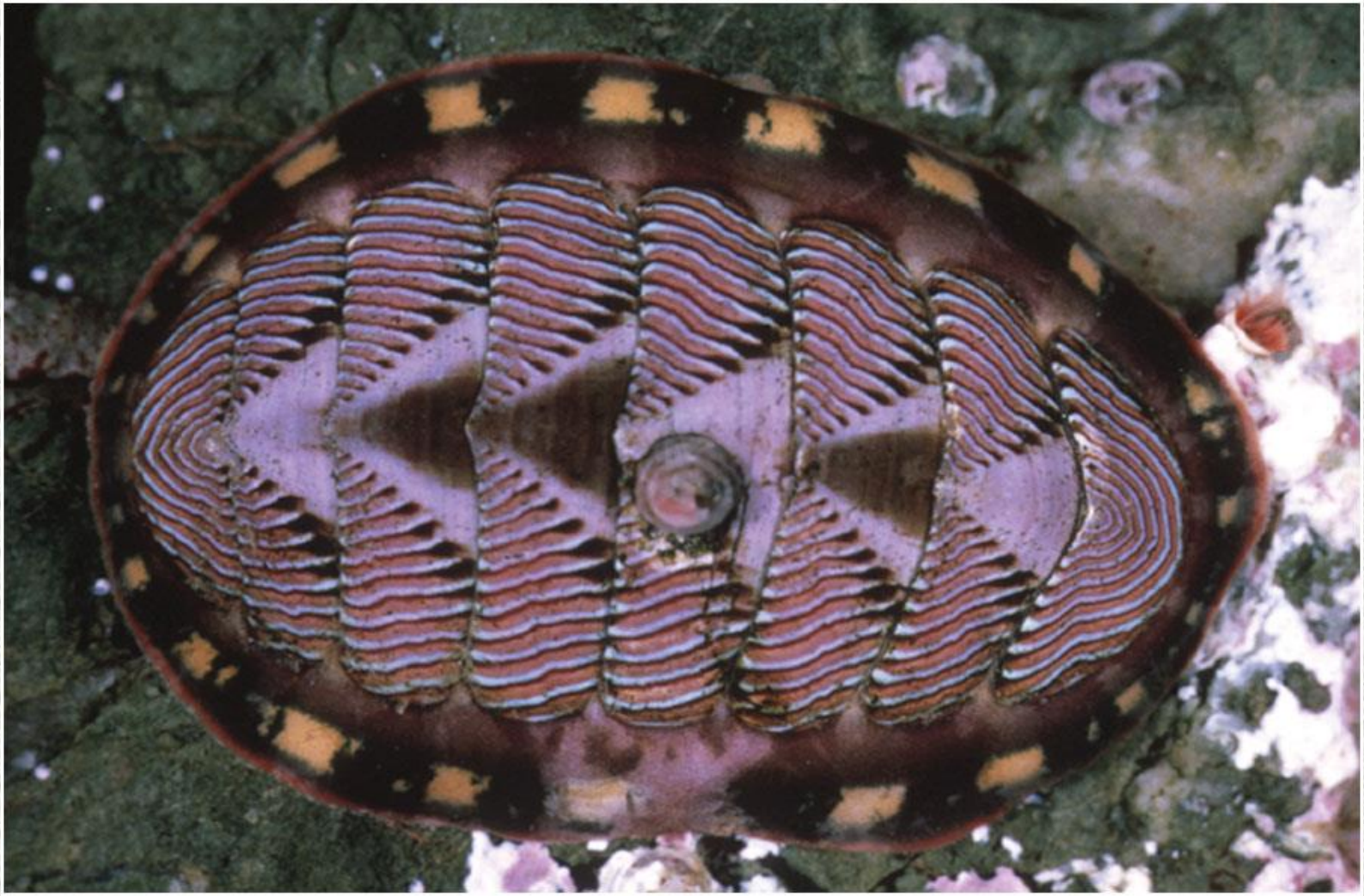
Class Monoplacophora

A. Gr. *monos* - one + *plax*, - plate + *phora*, bearing
B. Mon’ o-pla-kof’ o-ra
C. 12 species
D. serially repeated organs
E. Marine habitat; 2000 to 7000 m depth
F. Unipectinate gill
G. 3 mm to 3 cm size
H. Radula and subradula
I. Separate sexes, external fertilization

The monoplacophoran Neopilina



Class Polyplacophora
Chitons



A

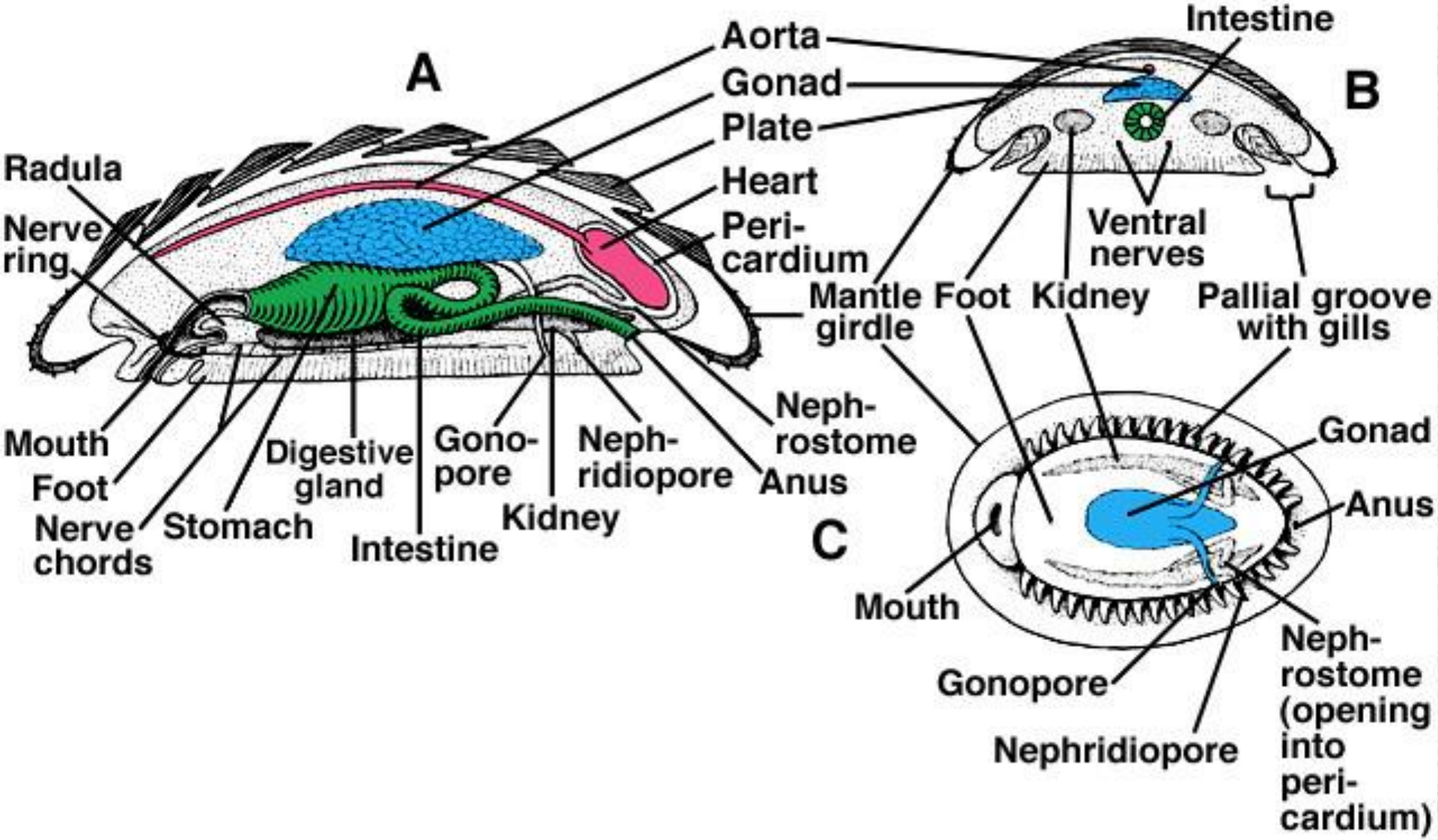
Class Polyplacophora – chitons

A. Gr. *poly* - many + *plax*, - plate + *phora*, bearing
B. Pol´ y-pla-kof´o-ra
C. =Amphineura (old name)
D. 600 species
E. 8 overlapping dorsal plates
F. scrapers using radula; herbivores
G. Marine, benthic
H. No cephalic tentacles or eyes

Polyplacophora continued

I. Buccal cavity has radula sac&subradual organ
J. Simple nervous system; no ganglia
K. Separate Sexes; gonoduct and gonopore presents in pallial grooveميزاب البرنس
L. Trochophore larvae, no veliger larvae
M. Have larval eyes but lose them after settlement الثبات,larval stage last 5 to13 days
N. Long lives, at least to 20 years
O. Hard bottom dwellers

Anatomy of a chiton



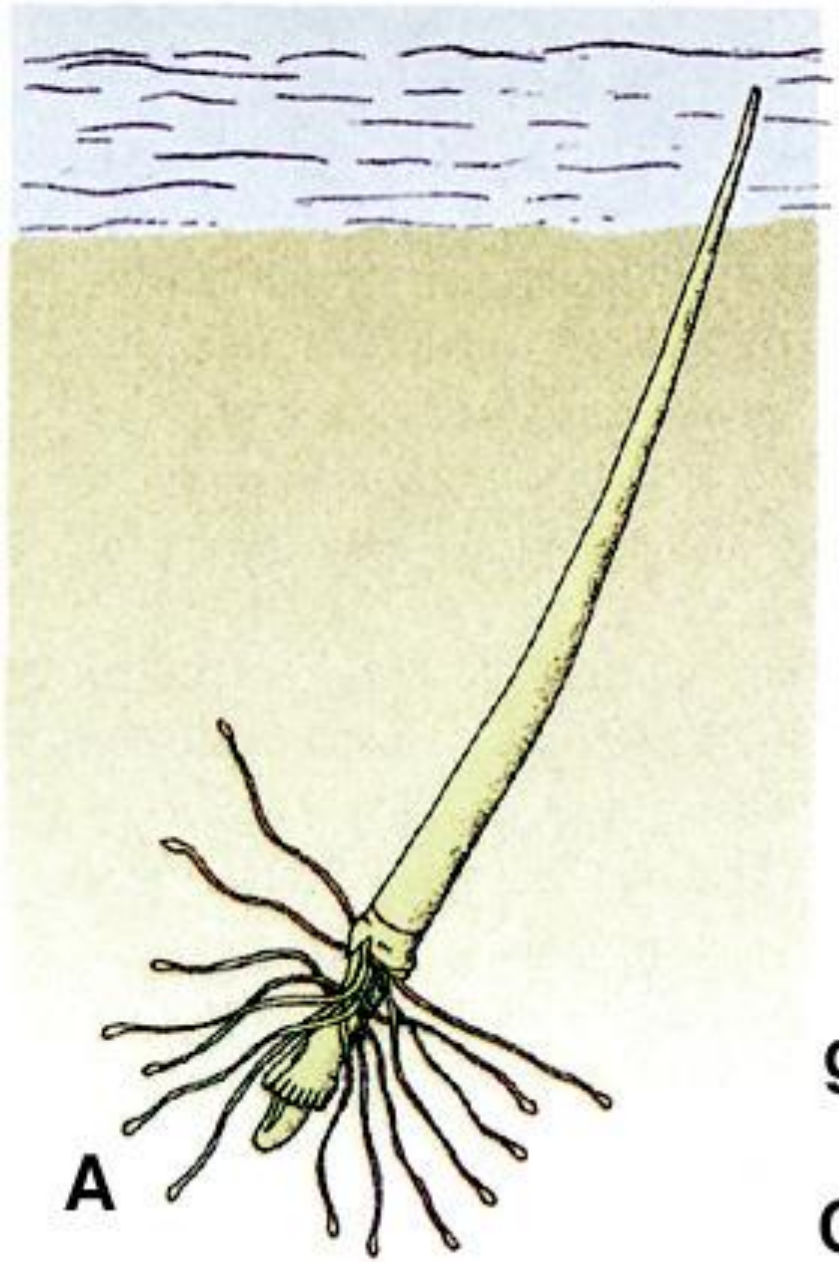
Class Scaphopoda - tooth shells

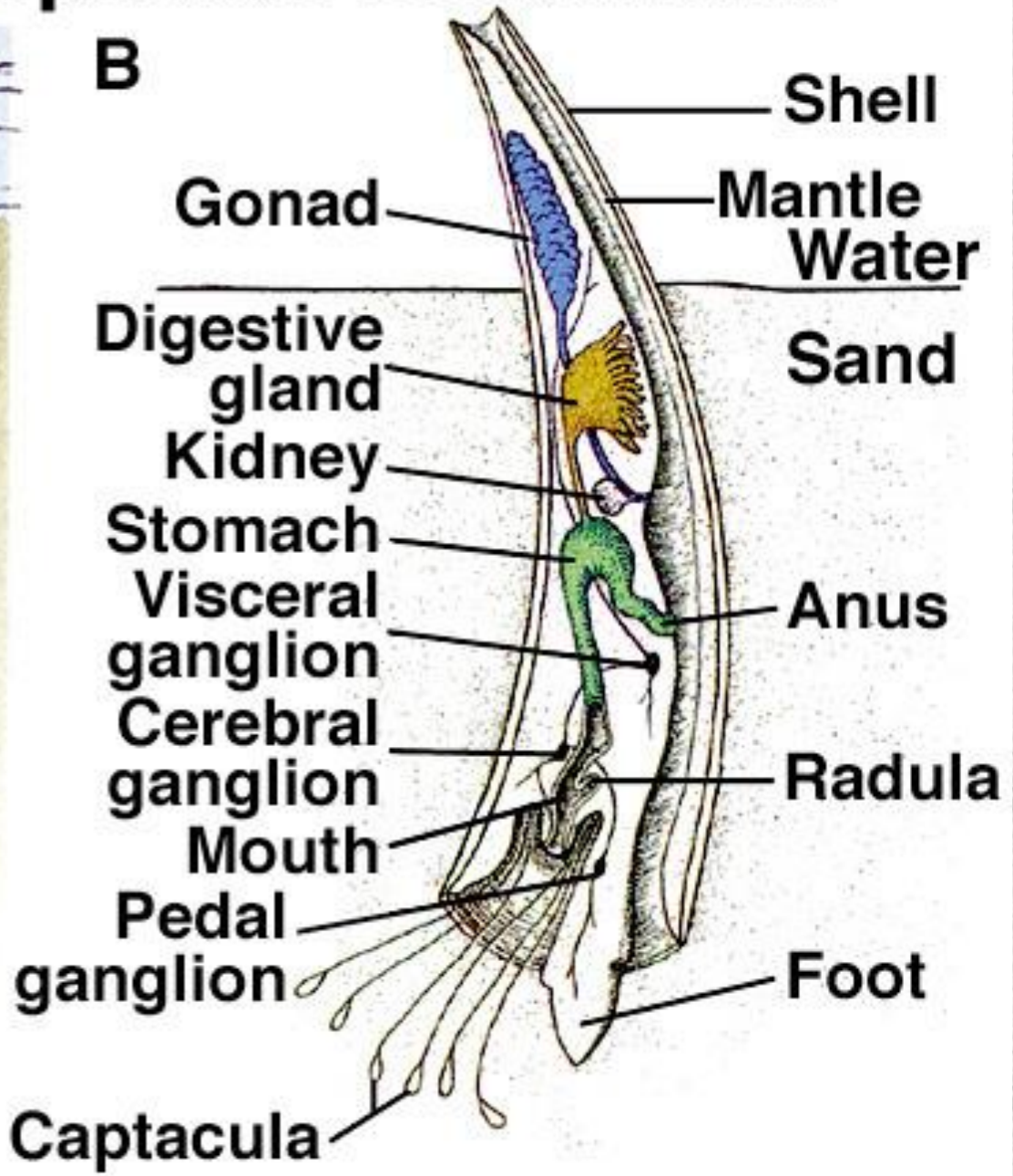
A. Gr. *scaphe* – trough, boat + *podos*, - foot
B. Ska-fop´o-da, shell both ends
C. 350 species
D. burrows in mud, tentacles, cilia capture food, mostly detritus تفتت
E. 4 to 15cm, Marine, benthic
F. No gills, exchange gas through mantle
G. Feed on foramenifera
H. Radula present, for breaking up food particles
I. Separate sexes, external fertilization

Class Scaphopoda – tooth shells

- External fertilization; trochopore and veliger larvae bilobed mantle and shell, like bivalves
- Scaphopods have classic “spiral cleavage”
- Two families; Family Dentalidae-most common ex) Dentalium sp. Family Siphodentaliidae-spiny foot, offshore, ex) Cadulus – cigar shape

The scaphopodan *Dentalium*





Class Gastropoda (복족류)

- One shell (if present)
- Torsion of body

Gastropod Morphology and Movement

- The typical snail consists of a visceral mass, which sits atopاعلى a muscular foot
  - The visceral mass is protected by a univalve shell that is coiled

Characteristics

- The largest and most diverse mollusc class
- >70,000 living species and >15,000 fossil species
- So diverse that there is no single general term in our language that applies to them all as a whole
- Include: snails, limpets, slugs, whelks, conchs, periwinkles, sea slugs, sea hares, and sea butterflies

More Characteristics

- Range from primitive marine organisms to highly evolved terrestrial, air-breathing snails and slugs
- Basically bilaterally symmetrical, except torsion causes visceral mass to be asymmetrical
- Shell (if present) is always one piece (univalve) and may be coiled or uncoiled

*The apex is the oldest and smallest whorl of the shell and successive whorls larger and larger as them spiral around the central axis (columella)
*Shells can be right handed (dextral) or left handed (sinistral) depending on the direction of coiling.
This is genetically controlled. (Dextral) is much more common

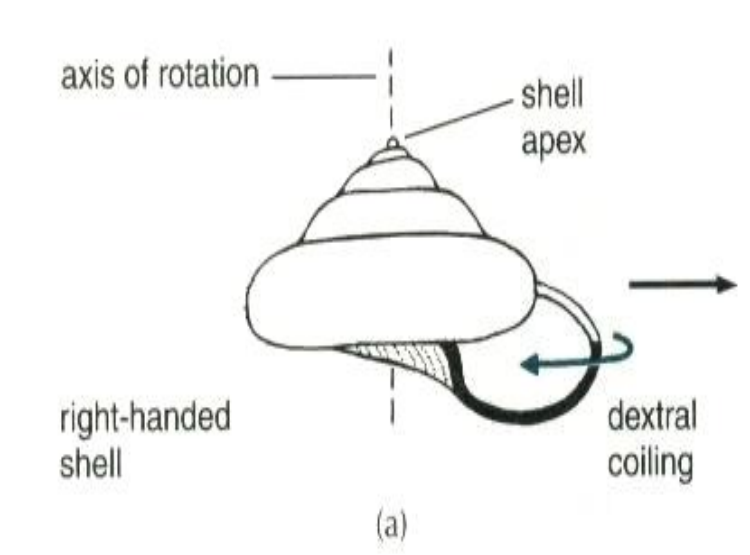
Coilingالالتفاف

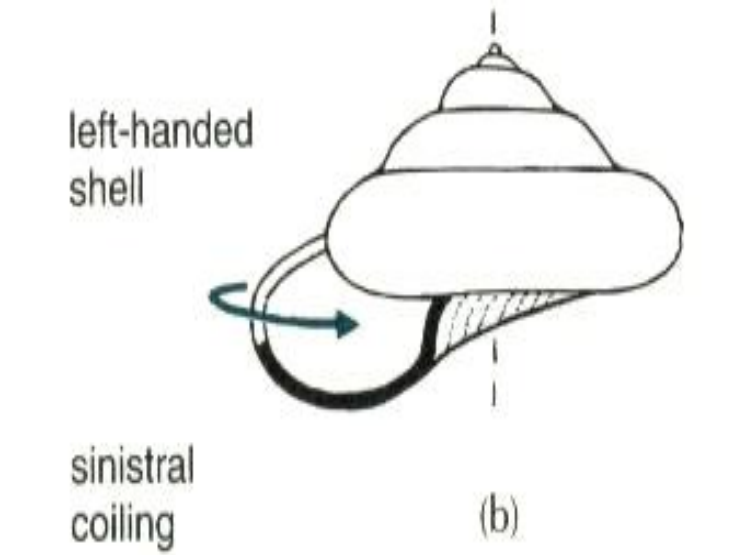
- Coiling – spiral winding of shell and visceral mass
- Can occur during larval stages at the same time as torsion, but is not the same as torsion
- Coiling evolved before torsion did
- All living gastropods evolved from نشات من coiled, torted ancestors اسلاف even if they no longer show these traits الصفات.

Coiling Continued

- Early gastropods were planospiral (whorls were flat on a single plane)
  - These shells are not very compact (each whorl lay completed outside the previous one
- Conispiral shells evolved (succeeding whorls lies to the side of preceding السابقة whorls)
  - This creates a very unbalanced shape (weight hangs over to one side)
  - Solved this problem by shifting the shell upward and posteriorly with the shell axis oblique to the longitudinal axis of the foot
  - Weight of the shell leaning يميل against one side has caused the gill, auricle, and kidney on the right side to be lost (bilateral asymmetry)

Dextral and Sinistral Coiling





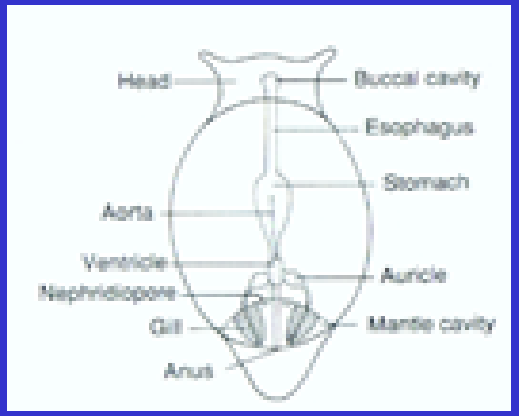
- The shell is usually carried on the left side of the body and coils to the right (dextral)
- Few species are (sinistral)
  - Shell coils to the left

- Early gastropods were planospiral (whorls were flat on a single plane)

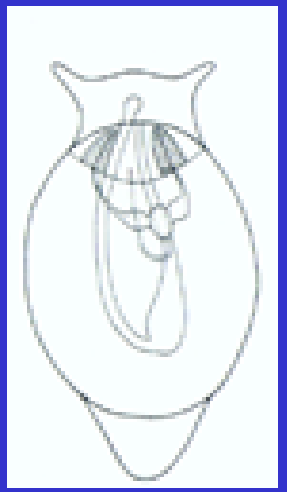
- Conispiral shells evolved (succeeding whorls lie to the side of preceding السابقة whorls)

Gastropod characteristics

- 1. Torsion - primitive bilateral symmetry lost during development
- Twisting of visceral mass, mantle, and mantle cavity



After torsion



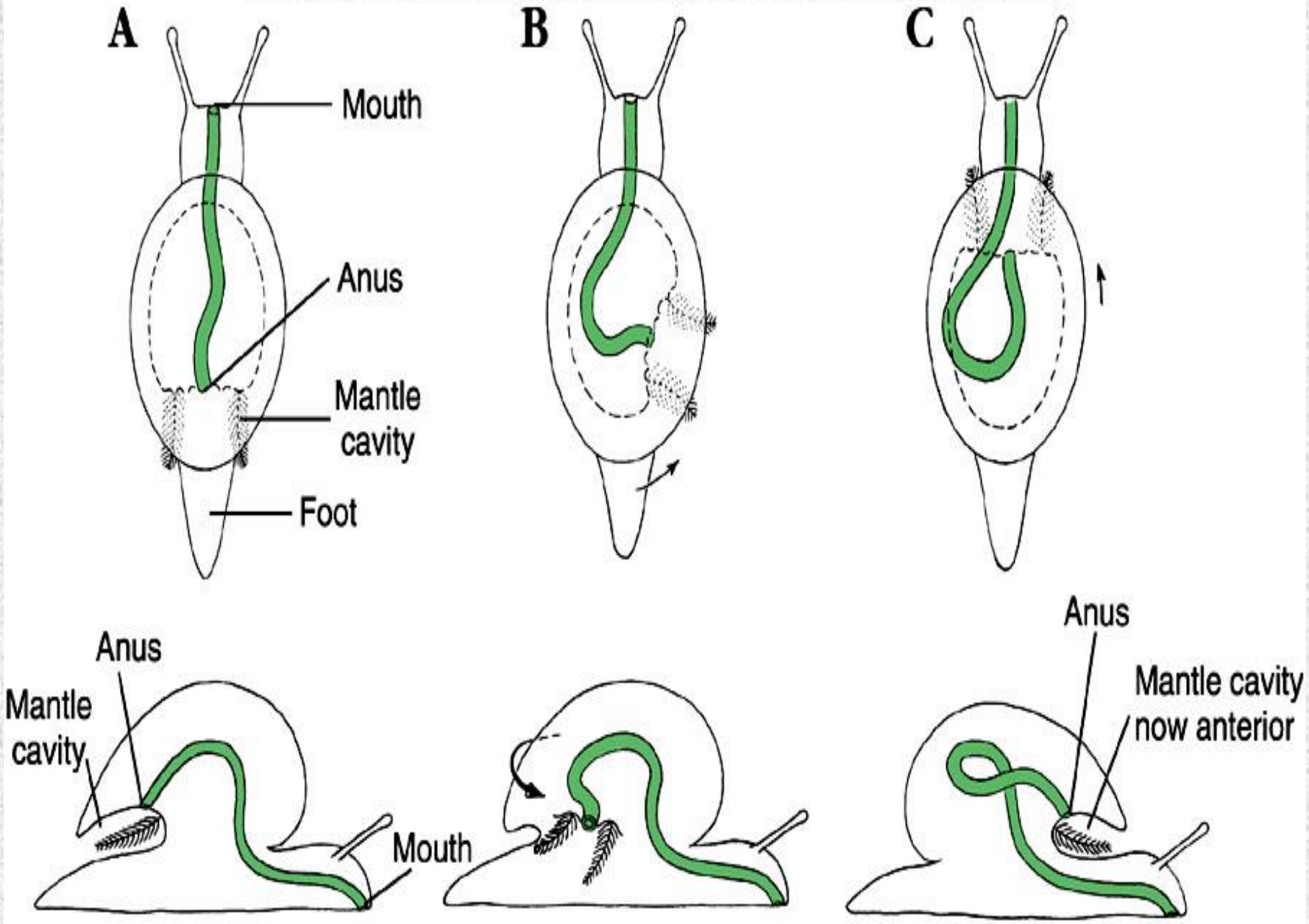
- **Torsion الالتواء**
- **Only gastropods undergo torsion**
- **Torsion is the rotation of the visceral mass, mantle, and shell 180˚ with respect to the head and foot of the gastropod. This brings the mantle cavity and anus to an anterior position above the head.**

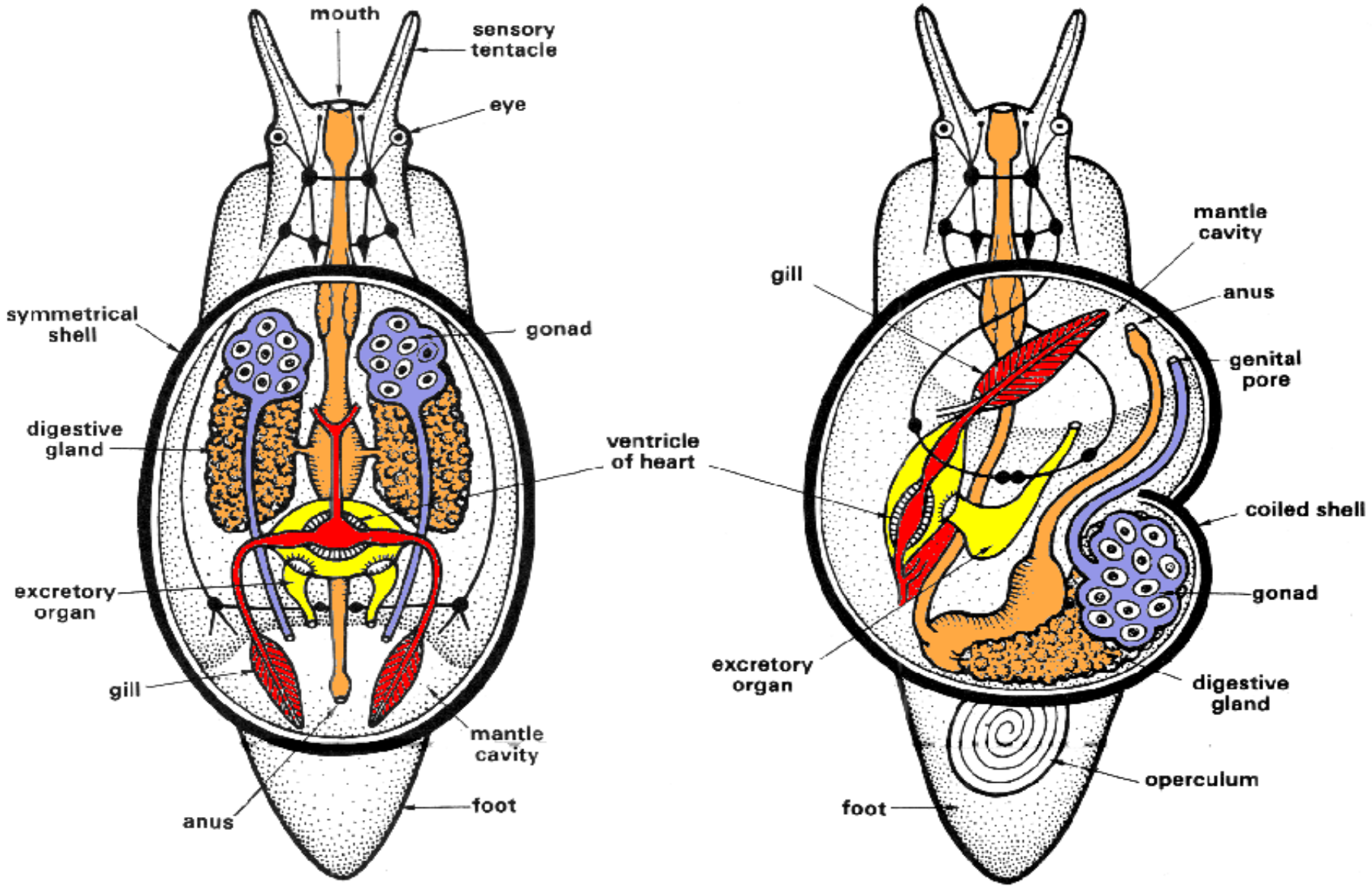
Steps of Torsion

- Two step process that occurs during the veliger stage
- 1st step is quick (as short as a few minutes)
  - Asymmetrical foot retractor muscle contracts and pulls يسحب the shell and enclosed viscera 90 degrees counterclockwise معاكس لحركة عقارب الساعة

2nd - step is slow and takes place over the rest of the development as tissues differentiate

Shell and visceral mass rotate another 90 degrees leaving the anus above the mouth and head





Construct of a gastropod as it would be if torsion and asymmetrical growth did not occur in early development.

Diagram of prosobranch snail in dorsal view, showing torsion and asymmetry of the organ systems.

Results of Torsion

- Anus and mantle cavity become anterior and open just above the head and mouth
- Left gill, kidney, and heart auricle are now on the right side and vice-versa
- The nerve cord is now twisted into a figure eight

Detorsion

- In some groups of gastropods (Opisthobranchia pulmonates الرئويات خلفيات الخياشيم there is a degree of secondary detorsion or rotation towards the original position, this may be only partial detorsion or full detorsion
- Their anus open to the right side or even the posterior

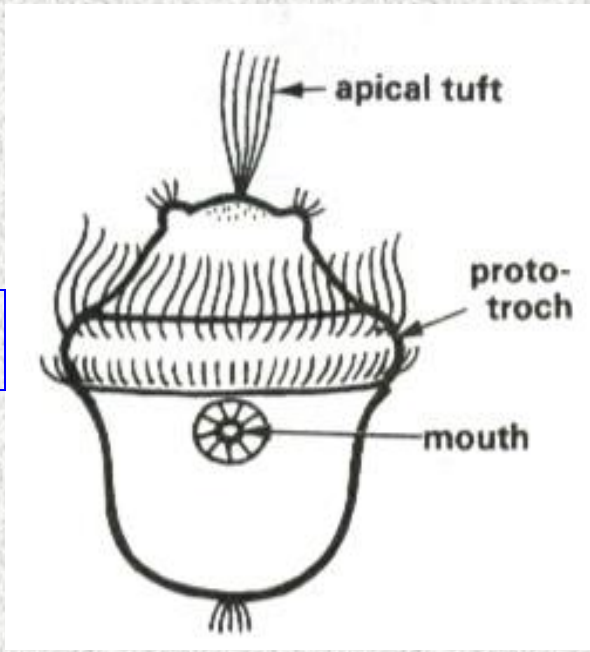
Problem with Torsion

- Fouling – wastes النفايات والقاذورات being drawn into تنجرف the gills – is a problem after torsion
- Many organisms have lost the right gill
- Water is brought in يأتى through the left and travels over ينتقل lungs and then over anus as it leaves through the right side
- Sense organs of the mantle cavity work better when they are facing the direction of travel يواجهون اتجاه الانتقال (The opposite direction)

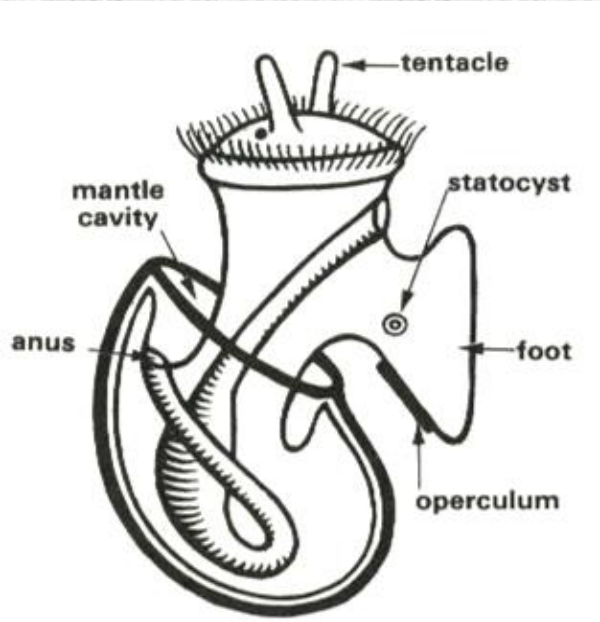
Reproduction

- Life begins as a trochophore larvae which then develops into a veliger larvae
  - The veliger is where most of the organ systems develop
  - During development the process of torsion begins

Trochophore



Veliger



Feeding Habits

- Varied feeding habits, but all involve some use of the radula
- Most are herbivores – rasping off particles of algae from hard surfaces
- Some are scavengers feeding on dead and decaying flesh
- Others are carnivores that use radula teeth to tear flesh

Internal Form and Function

- **Respiration through ctenidium (gills) in the mantle cavity**
  - **Two ctenidia is the primitive condition**
  - **Some forms lack gills all together and respire across the skin**
  - **May have siphon to bring in water**
  - **Pulmonates have lungs that open to the outside through the pneumostome**
    - Aquatic Pulmonates must surface to breathe in and out

More Internal Form and Function

- **Excretion**
  - Most have a single nephridium (kidney)
- **Well developed circulatory system**
  - Open system (during part of its circuit around the body, blood leaves the vessels and directly bathes cells in tissue spaces called sinuses)
  - Heart with a single, muscular ventricle and two auricles
- **Well developed nervous system**
  - Three pairs of ganglia connected by nerves
  - Sense organs: eyes or photoreceptors, statocyts, tactile organs, and chemoreceptors

Reproduction

- Both monoecious and dioecious forms
- Dioecious forms have gonads in spirals of visceral mass and discharge gametes into water for external fertilization
- Monoecious forms usually reproduce by internal, cross-fertilization and deposit fertilized eggs into moist soil
- Larval stage is called the veligar stage

Major Groups of Gastropods

Prosobranchs اماميات الخياشيم	Opisthobranchs خلفيات الخياشيم	Pulmonates الرئويات
•Most marine snails and some freshwater and terrestrial gastropods •One pair of tentacles •Sexes are separate •Operculum often present	•Oddغريبة assortment of organisms including sea slugs, sea hares, and sea butterflies •Mostly marine and shallow-water forms •Show partial or complete detorsion •Two pairs of tentacles •Reduced or absent shell •All are monoecious	•Land and most freshwater snails and slugs •Show some detorsion •Have lost ctenidia and have gained lungs •All are monoecious •Aquatic forms have one pair of tentacles with eyes •Land forms have two pairs of tentacles – the posterior bearing eyes

Class: Bivalvia or Pelecypoda

- L. *bi* – two *valva* – folding door
- Bi-val´ve-a
- Or Pelecypoda=axe foot
- 8,000 species
- Marine and freshewater, benthic
- Head reduced, foot compressed, gill and mantle large
- 1 to 2 pairs of adductor muscles with muscle scar
- Commercially important marine bivalves

Class: Bivalvia or Pelecypoda

- If only posterior adductor muscle present, “monomyarian”
- If both present and equal size, “isomyarian”
- If anterior muscle reduced, and posterior large, “anisomyarian”
- Pallial line; where mantle attached to shell
- Pallial sinus; region where muscles that retract siphon are attached
- Periostracum; outside of shell

Class: Bivalvia or Pelecypoda

- No radula in any pelecypod; suspension or deposit feeder
- Stomach usually has style and style sac
- Excretory organ; pairs of nephridia
- Few brood, mostly external fertilization
- 3 types of gills;
- 1) primitive protobranch gill- subclass Paleotaxodonta
- 2) lamellibranch gill-”W-shape” most bivalves
- 3) Septibranch gill- no gill, subclass Anomalodesmata

Class: Bivalvia or Pelecypoda

- **Subclass based on shell structure and hinge, gills, feeding types**
- **Subclass Paleotaxodonta (teeth in a row) – protobranchiated gill, Intertidal to deep sea**
- **Subclass Cryptodonta (hidden teeth) – protobranchiated gill, valve thin,**
- **Subclass Pteriomorpha – oysters, mussels, scallops, arc shells, pen shells, pearl oysters, thorny oysters, mostly suspension feeders**
- **Subclass Paleoheterodonta – freshwater clams, unionid clams, internal fertilization, glochidia larvae**
- **Subclass Heterodonta – equivalve, eulamellibranchiate gills, usually have siphones (inhalent, exhalent), cockle, clams, jacknife clams, clams, surf clams**

A bivalve, *Pecten* sp.

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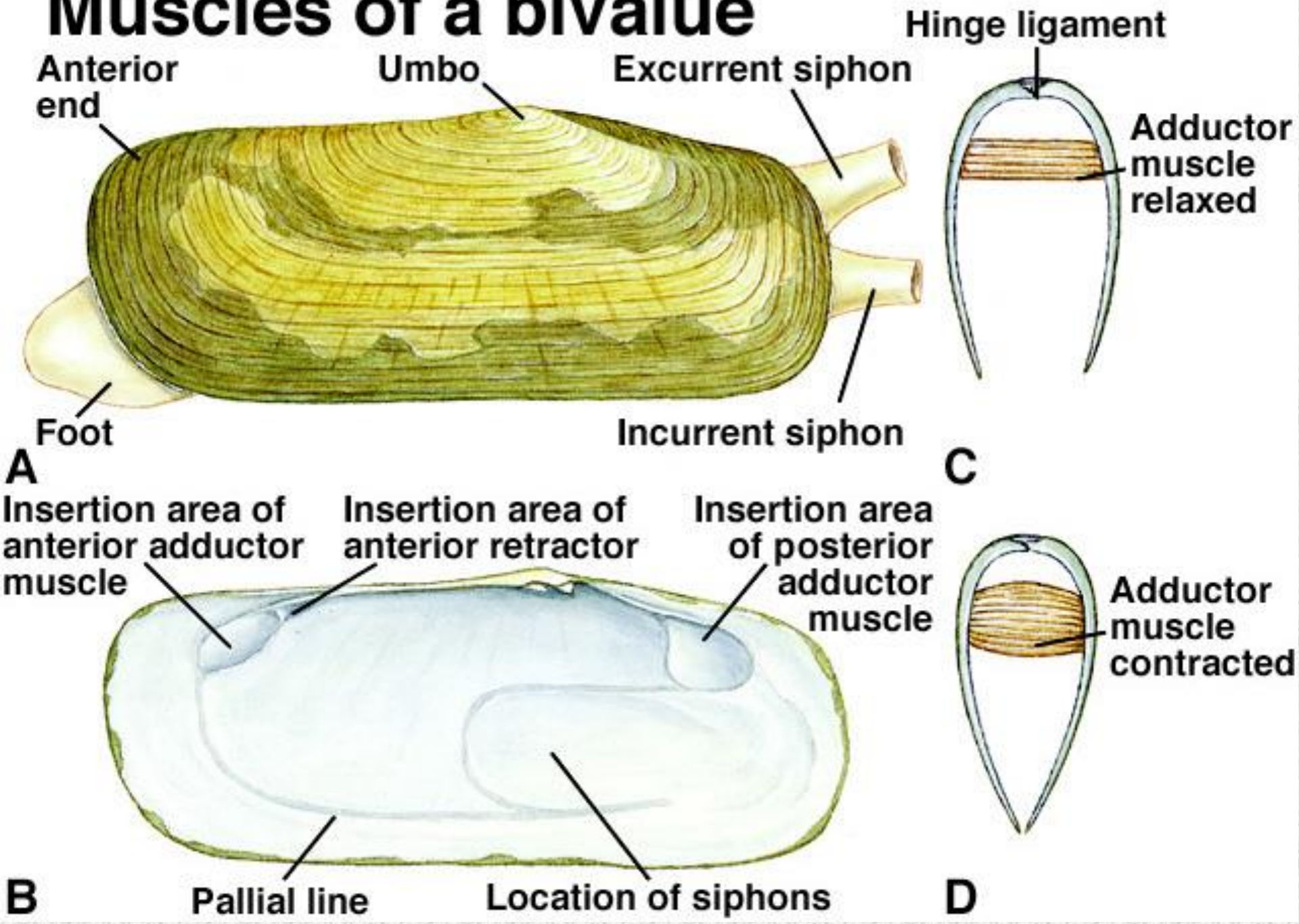
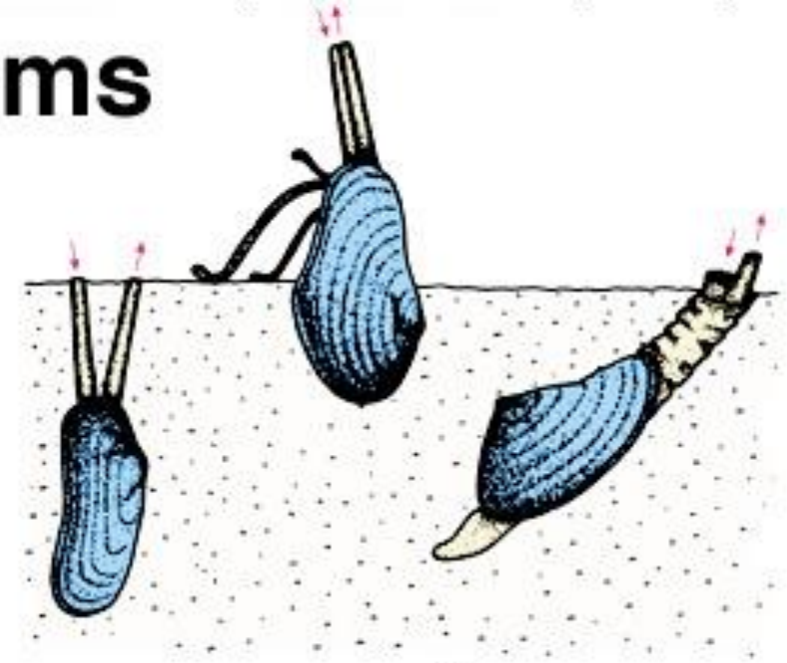
Muscles of a bivalue



Shipworms



A

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B

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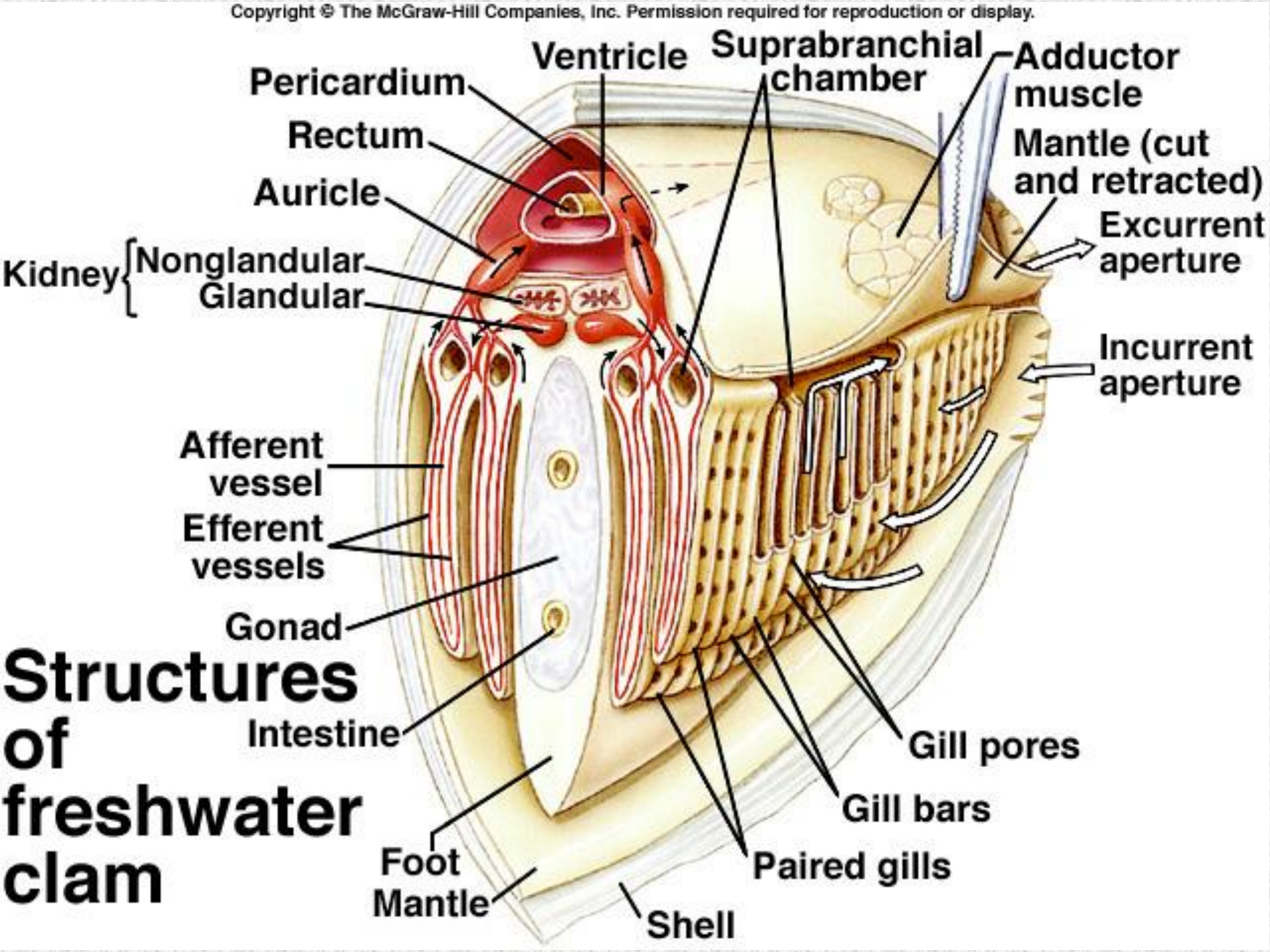
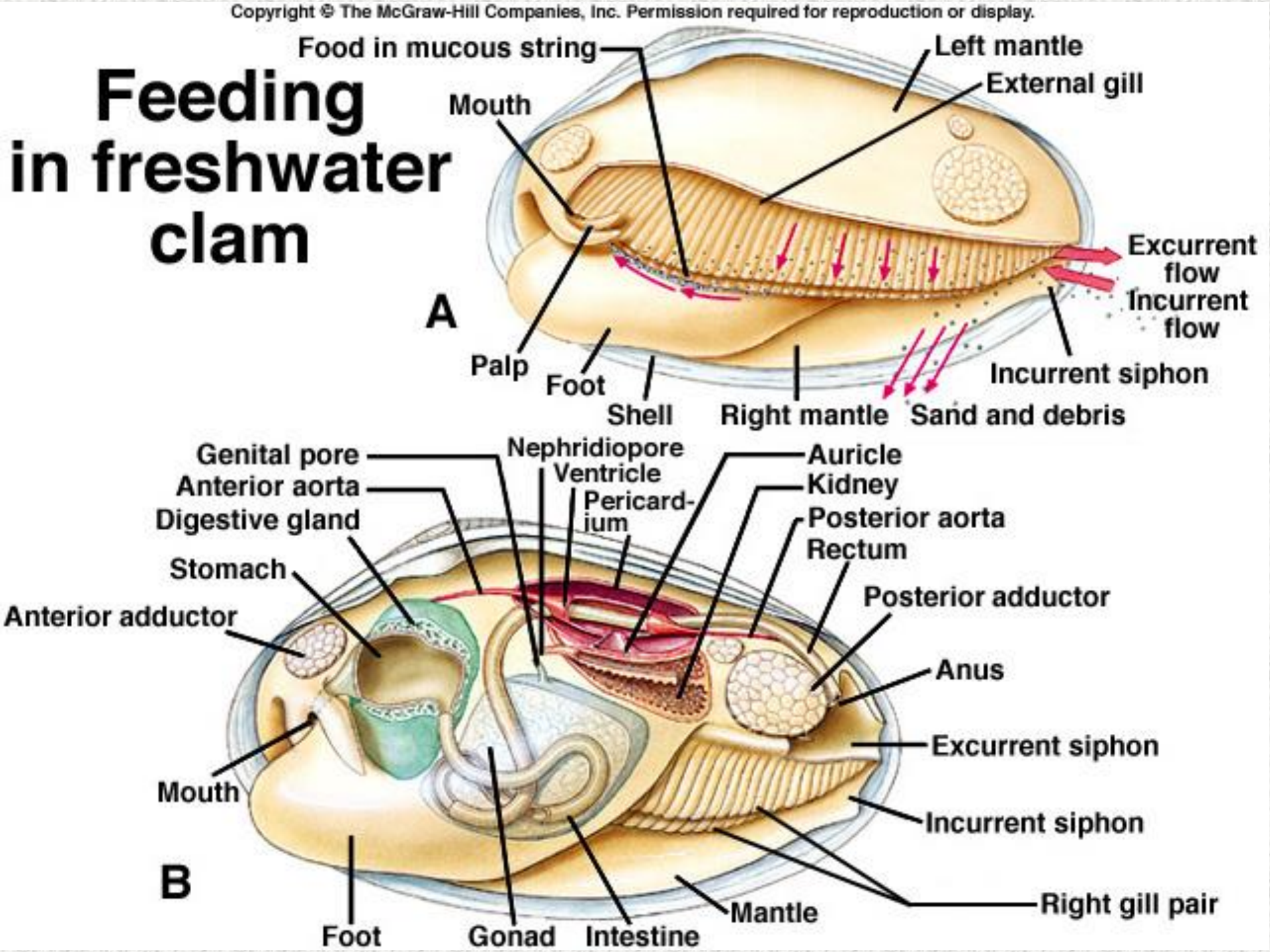
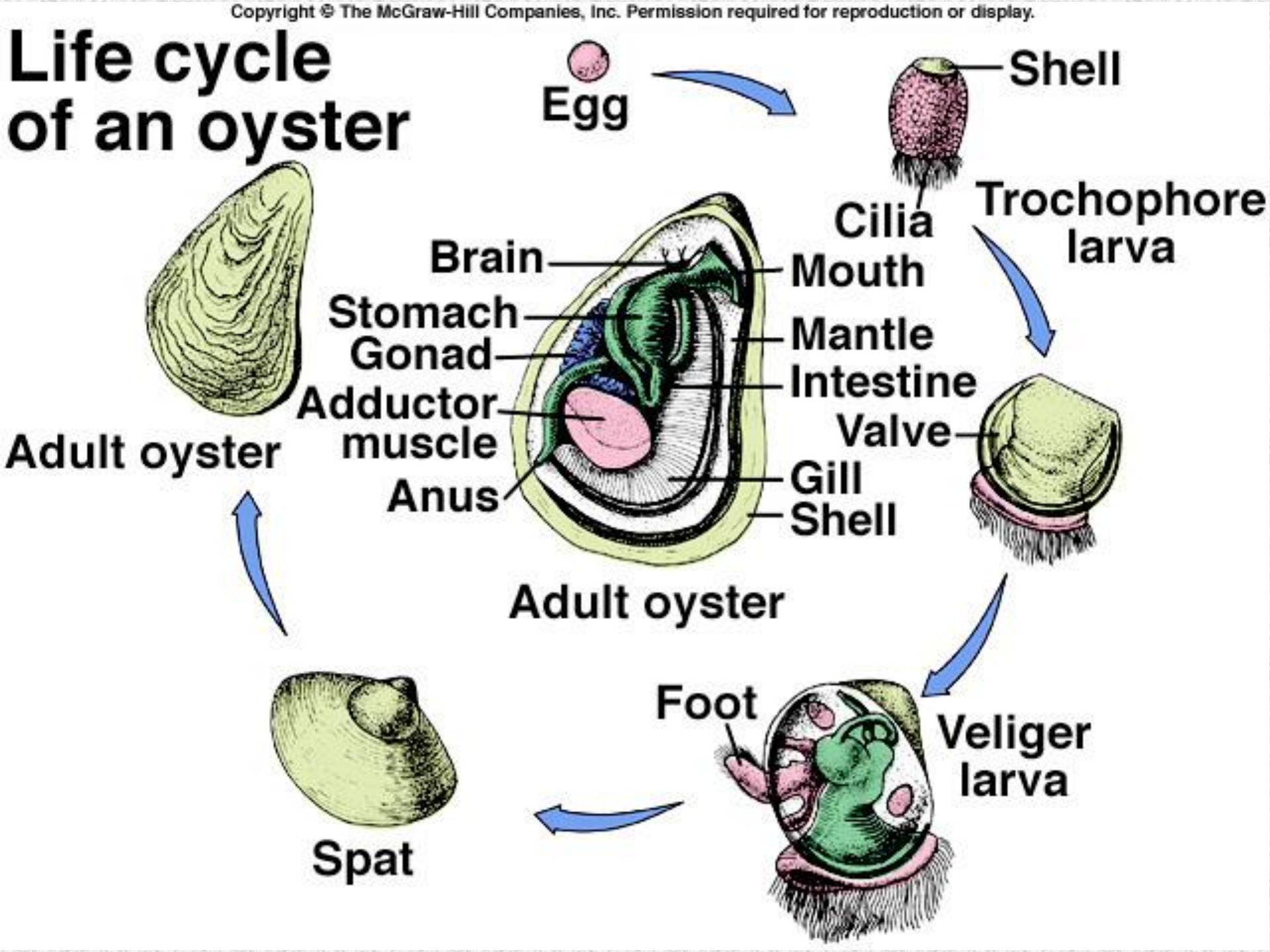


Structures of freshwater clam

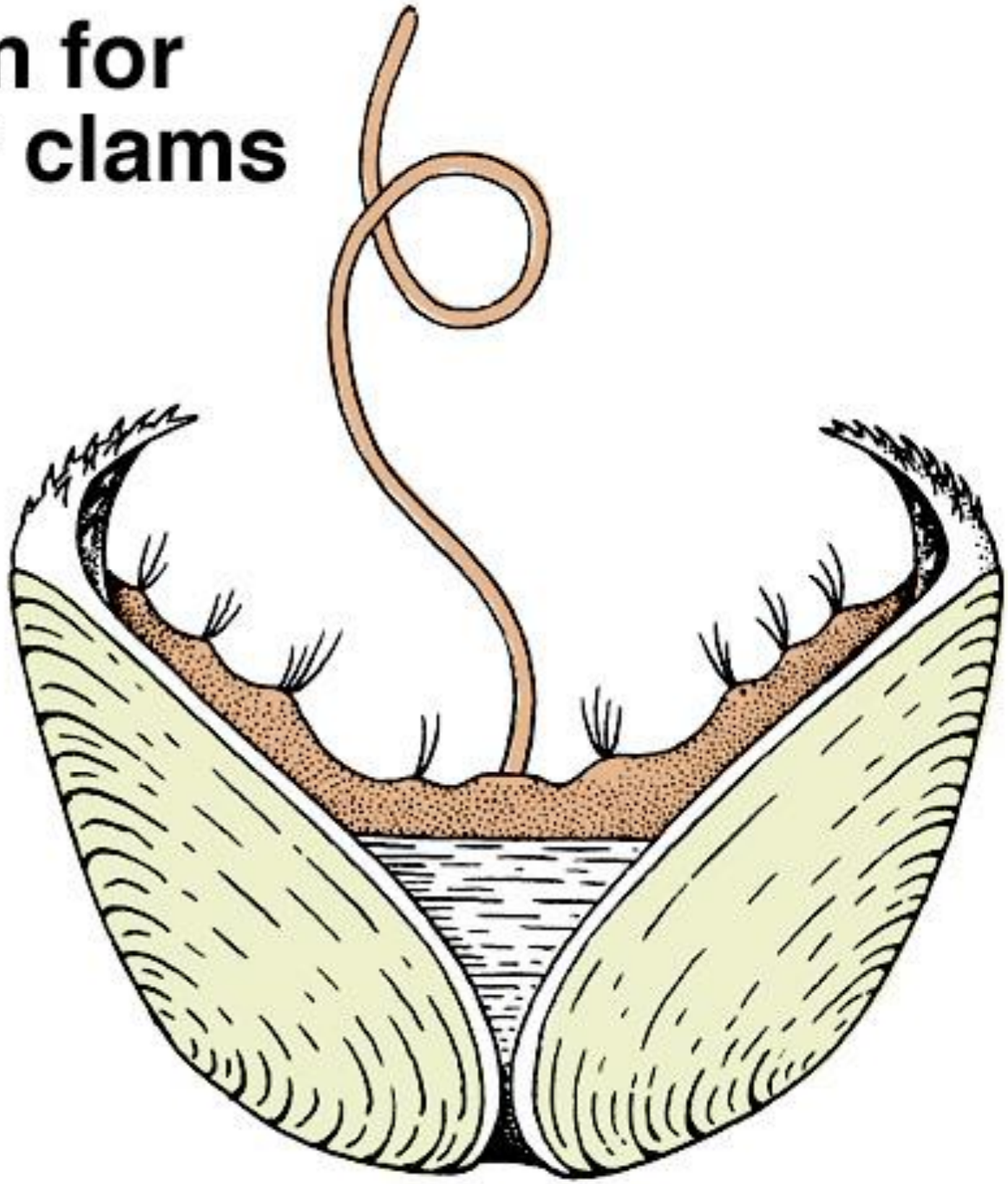
Feeding in freshwater clam



Life cycle of an oyster



Larval form for freshwater clams



Giant clam (*Tridacna gigas*)

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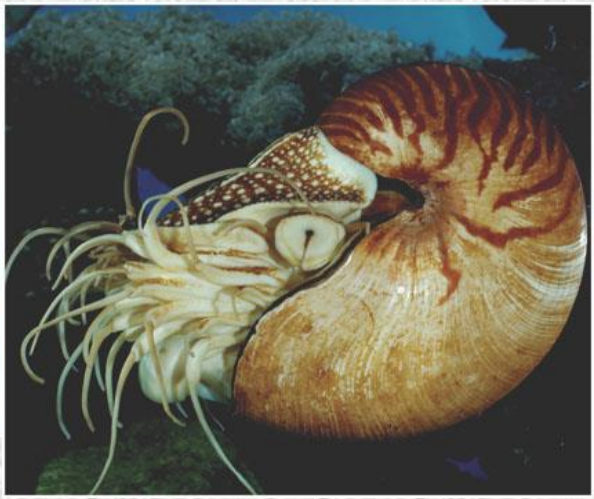
Class Cephalopoda

Class Cephalopoda

- Cephalopods include octopuses, squid, nautiluses and cuttlefish.
- Marine carnivores with beak-like jaws surrounded by tentacles of their modified foot.
  - Modified foot is a funnel for expelling water from the mantle cavity.



All *marine predators*

Foot is in the head region

- Modified for expelling water from mantle cavity

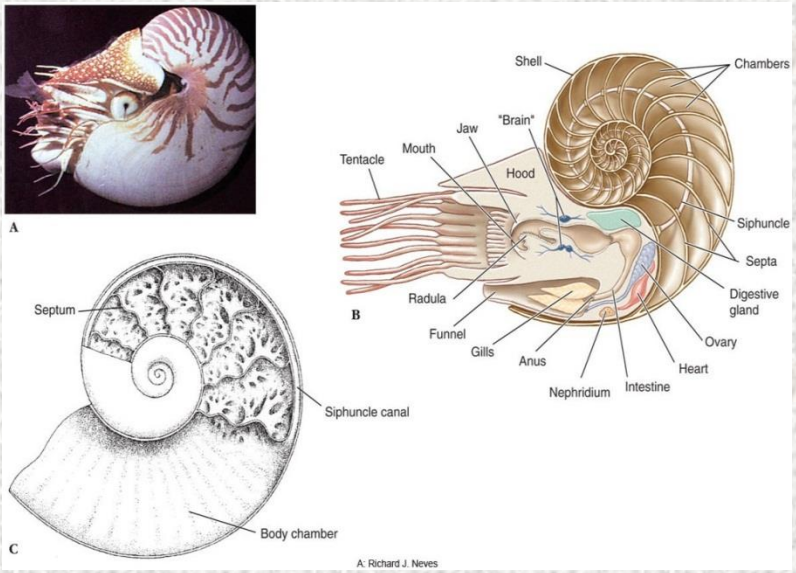
Range from 2 cm to the giant squid

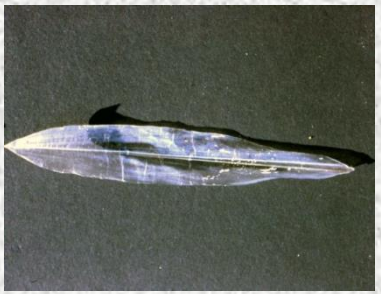
- Largest invertebrate

Cephalopods

- Mostly marine
- Octopuses mostly intertidal
- Squids are deep-sea animals

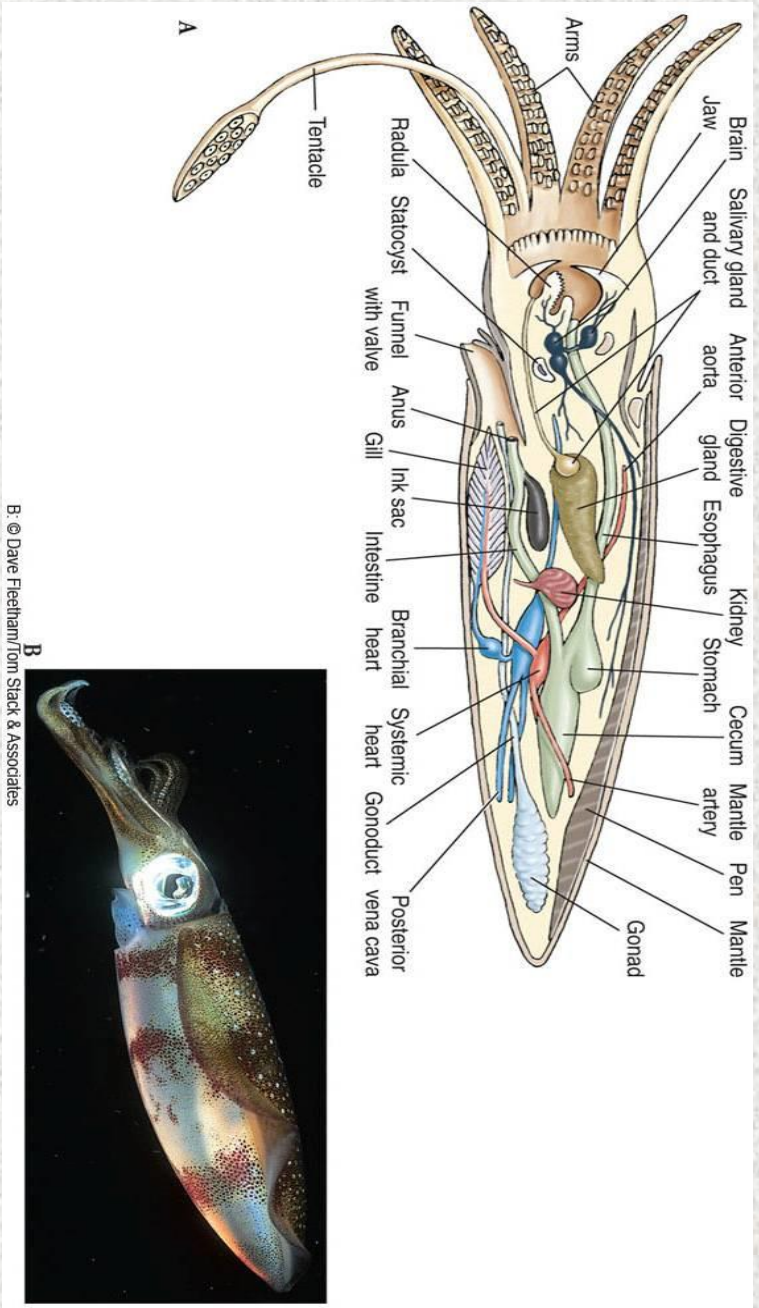
- ***Form and Function***
  - ***Shell***
    - *Nautiloid shells* have a gas chamber allowing them to swim
      - **Nautilus shell is divided into chambers**
      - **Living animal only inhabits last chamber**
      - **Cord of living tissue, the *siphuncle,* connects chambers to visceral mass**
    - *Cuttlefish shell* is enclosed in mantle
    - *Squid shell* is a thin strip called the pen, enclosed in mantle
    - *Octopus* has completely lost the shell



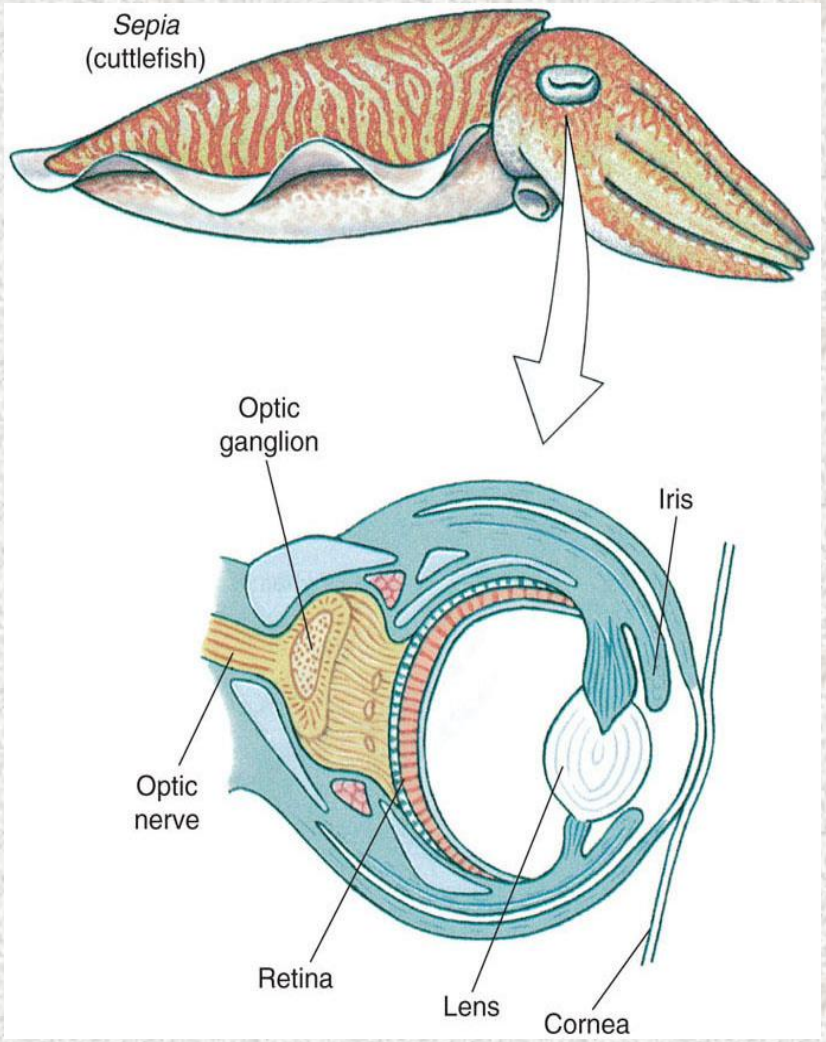


- ***Locomotion***
  - ***Cephalopods*** **swim by forcefully expelling water through a ventral funnel or siphon**
  - **Control direction and force of the water, thus determining its speed**
  - **Lateral fins of *squids and cuttlefishes* are stabilizers**
  - ***Nautilus*** **swims mainly at night by changing internal pressure and jet propulsion**
  - ***Octopuse*****s mainly crawl on the bottom but can swim backward by spurting jets of water**
    - Some with webbing between their arms swim with a medusa-like action

- ***Respiration and Circulation***
  - **Except for nautiloids, cephalopods have one pair of gills**
  - ***With higher oxygen demands,* cephalopods have a muscular pumping system to keep water flowing through the mantle cavity**
  - **Circulatory system has a network of vessels conducting blood through gill filaments**
  - **Accessory or *branchial hearts* at the base of each gill increase pressure to blood going through gill capillaries**

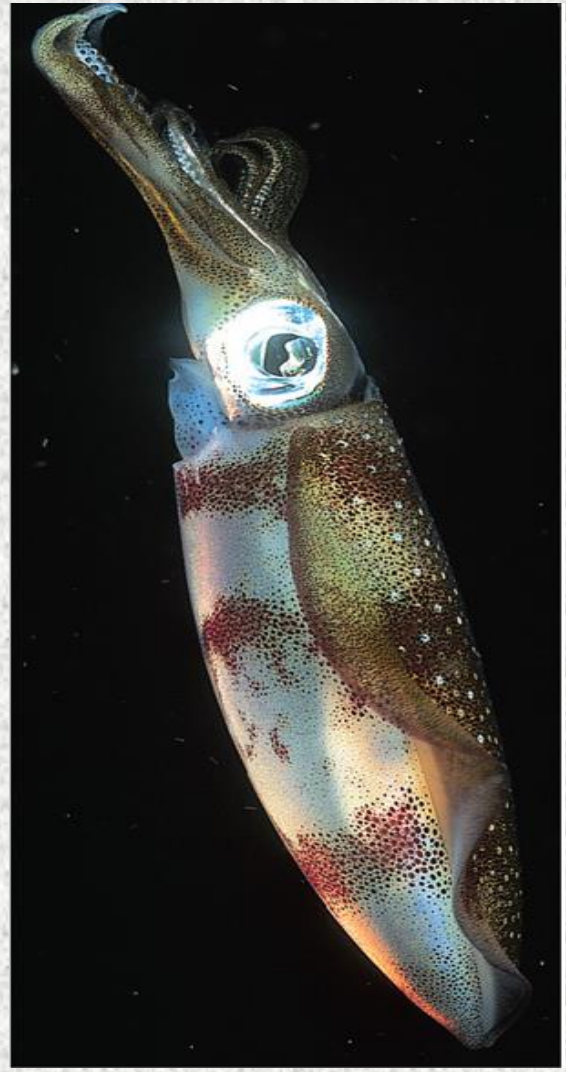


- ***Nervous and Sensory Systems***
  - ***Cephalopod brain* is the largest of any invertebrate**
  - ***Squids* have giant nerve fibers**
  - ***Sense organs are well-developed***
    - Eyes are complex, complete with cornea, lens, and retina
  - **Can learn by reward and punishment, and by observation of others**
  - **Cephalopods lack a sense of hearing but have tactile and chemoreceptor cells in their arms**

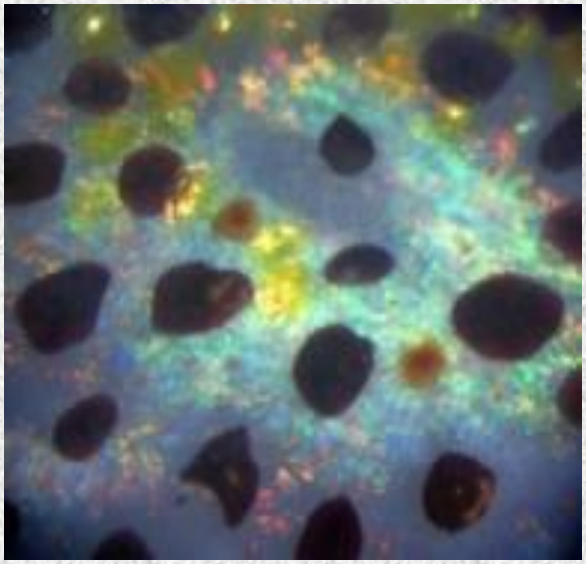


Class Cephalopoda – Communication

- **Visual signals allow cephalopods to communicate.**
  - **Movement of body and arms**
  - **Color changes effected by chromatophores (cells in the skin containing pigment granules).**
    - Chromatophores can change shape alternately dispersing and concentrating pigment.

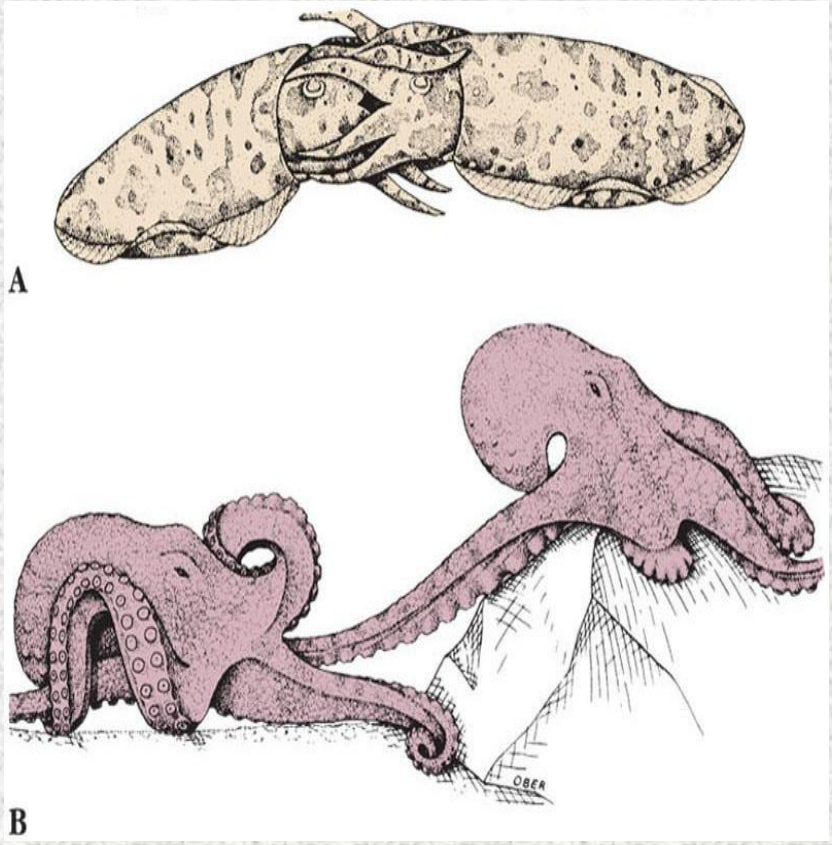


- **Communication**
  - Use ***chemical and visual signals*** **to communicate**
  - ***Chromatophores*** **are cells in the skin that contain pigment granules**
  - **Contractions of the muscle fibers attached to the cell boundary causes the cell to expand and *change the color pattern***
  - **Color patterns can be changed rapidly**
  - ***Deep-water cephalopods*** **have elaborate luminescent organs**
  - ***Ink sac*** **empties into rectum;**
    - Contains ink gland that secretes sepia حبر when animal alarmed قلق



Class Cephalopoda - Reproduction

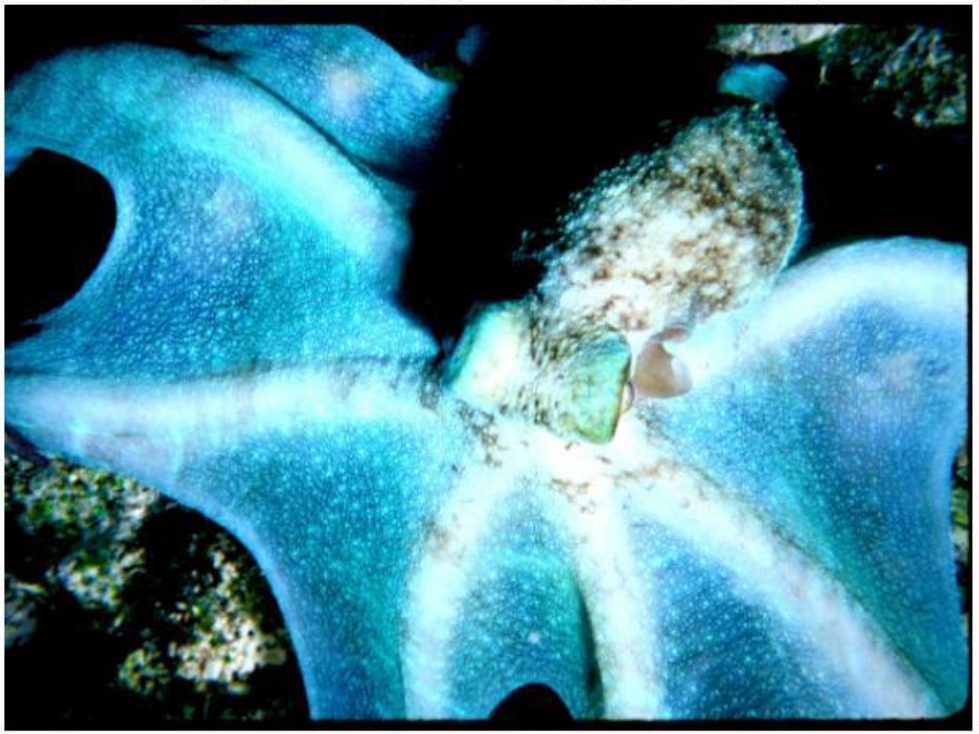
- Sexes are separate in cephalopods.
- Juveniles hatch directly from eggs – no free-swimming larvae.
- One arm of male is modified as an intromittent organ, the hectocotylus.
  - Removes a spermatophore from mantle cavity and inserts it into female.



- ***Reproduction***
  - **Sexes are *separate***
  - **In male *seminal vesicle*, spermatozoa are packaged in spermatophores and stored**
  - **One arm of male is modified as an intromittent organ, the *hectocotylus***
    - Removes a spermatophore from mantle cavity and inserts it into female
  - **Fertilized eggs leave oviduct and are attached to stones, etc.**
  - **Large, yolky eggs undergo *meroblastic cleavage***
    - Hatch into juveniles with *no free-swimming larval stage*

Class Cephalopoda - Locomotion

- Cephalopods swim by expelling water from the mantle cavity through a ventral funnel.
  - They can aim the funnel to control the direction they are swimming.



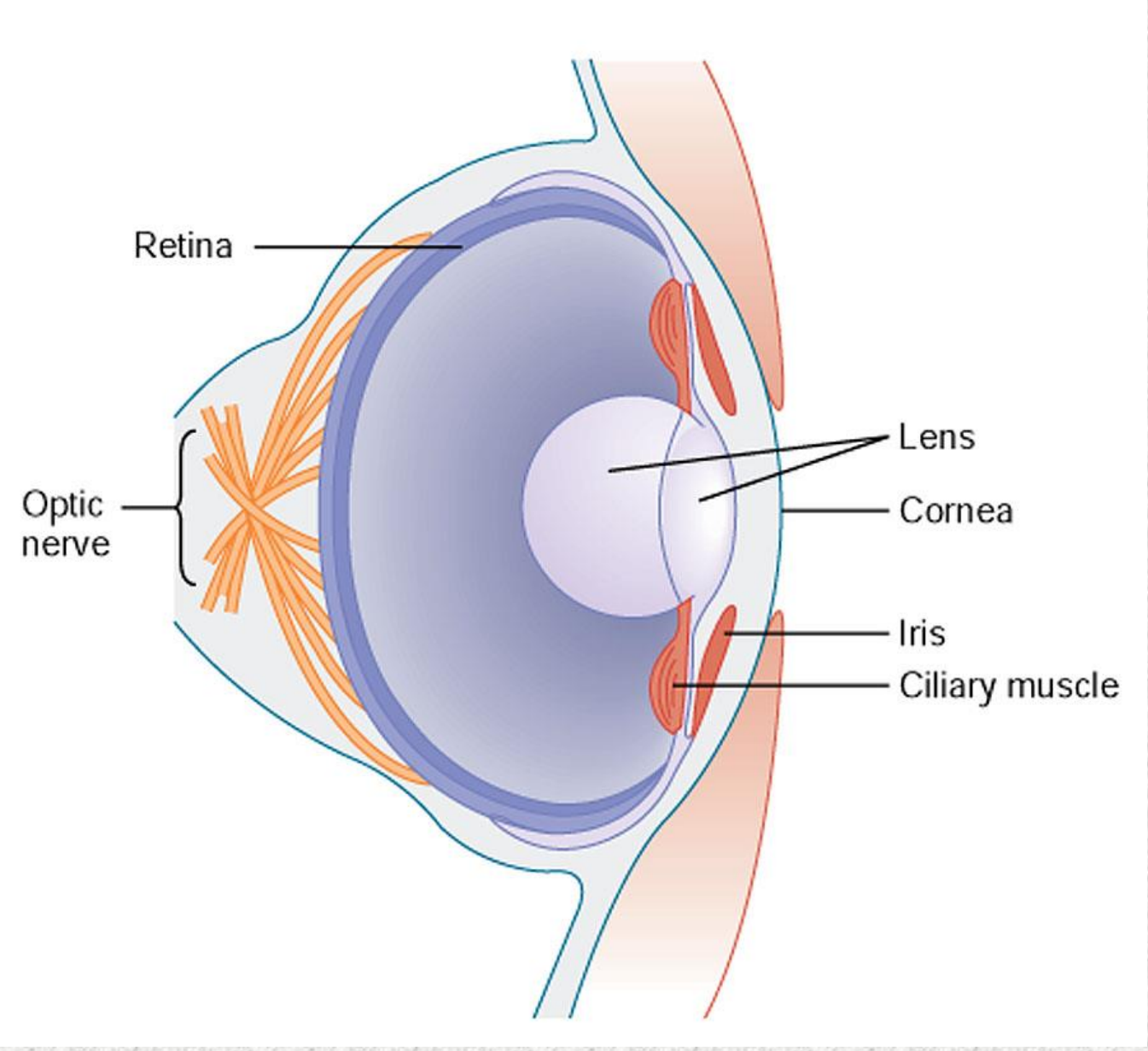
Class Cephalopoda

- Cephalopods have a closed circulatory system.
- Nervous and sensory systems are more elaborate in cephalopods than in other molluscs.
  - The brain is the largest of any invertebrate.

Class Cephalopoda

- Most cephalopods have an ink sac that secretes sepia, a dark fluid containing the pigment melanin.
  - When a predator tries to attack, the animal ejects the ink into the water where it hangs between the animal and the predator screening a quick escape.

Cephalopod Eye



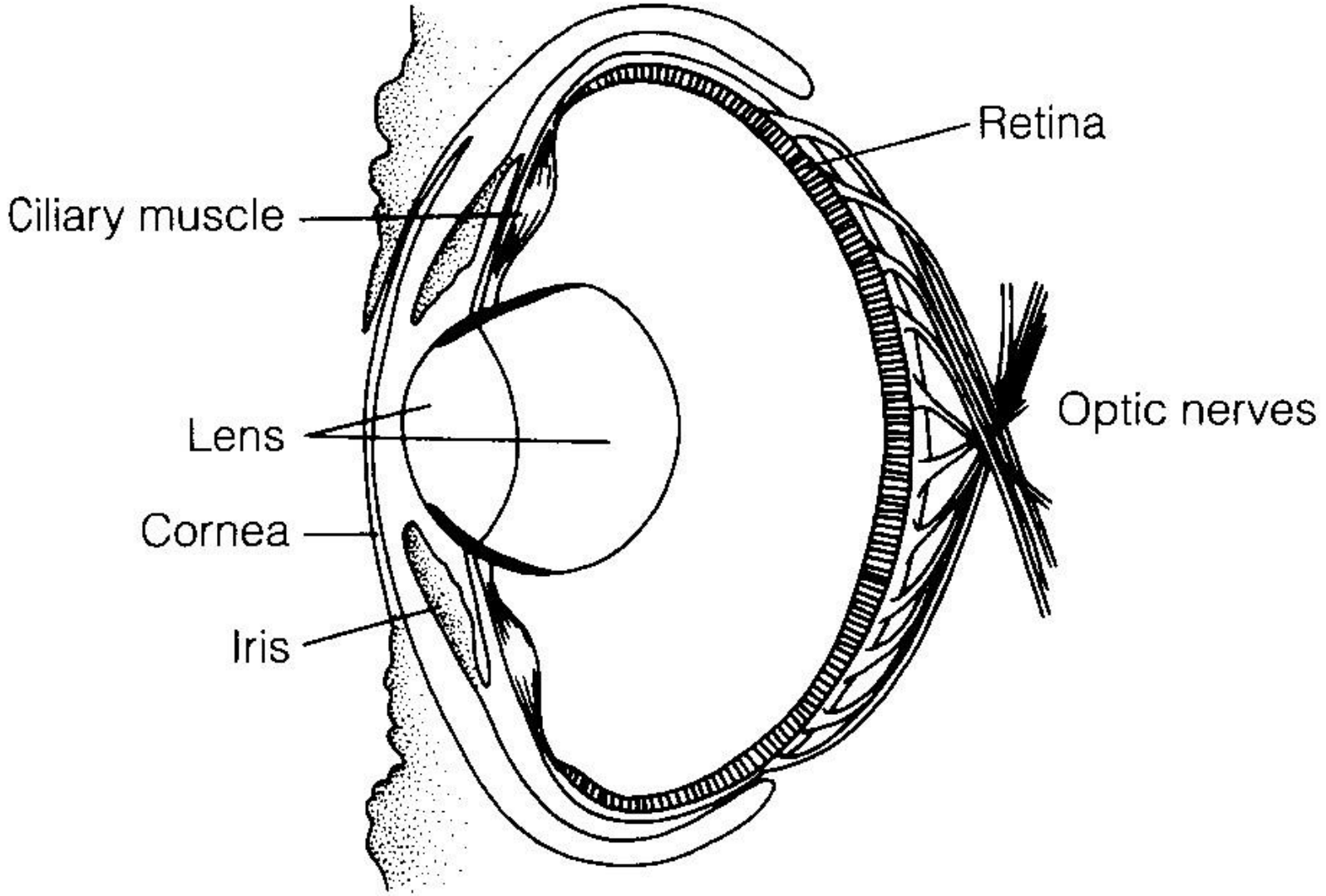


FIGURE 12-82 The eye of *Octopus* in cross section. *(After Wells, M. J. 1961. What the octopus makes of it; our world from another point of view. Adv. Sci. London. 20:461–471.)*