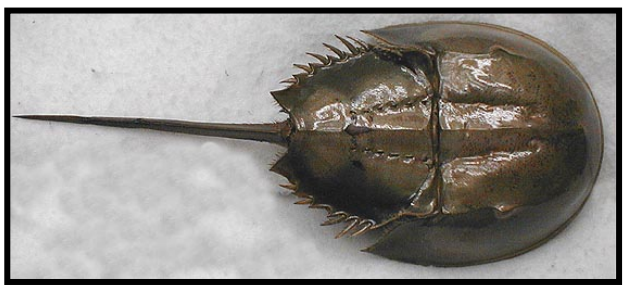



Phylum Arthropoda

“joint-footed” animals

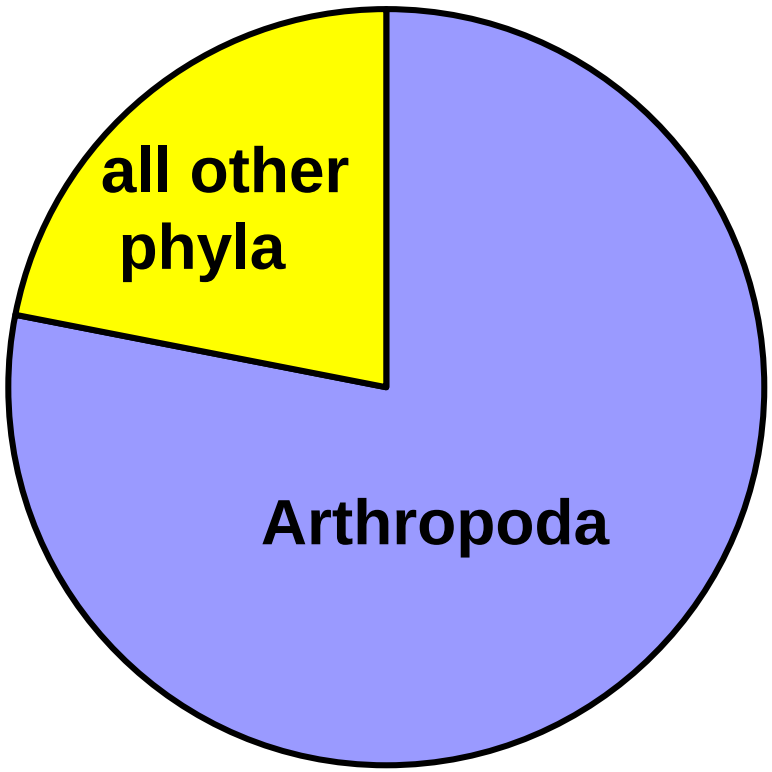






Phylum Arthropoda

- the largest phylum
- comprises ~80% of all known animals



Arthropoda Characteristics

Triploblastic

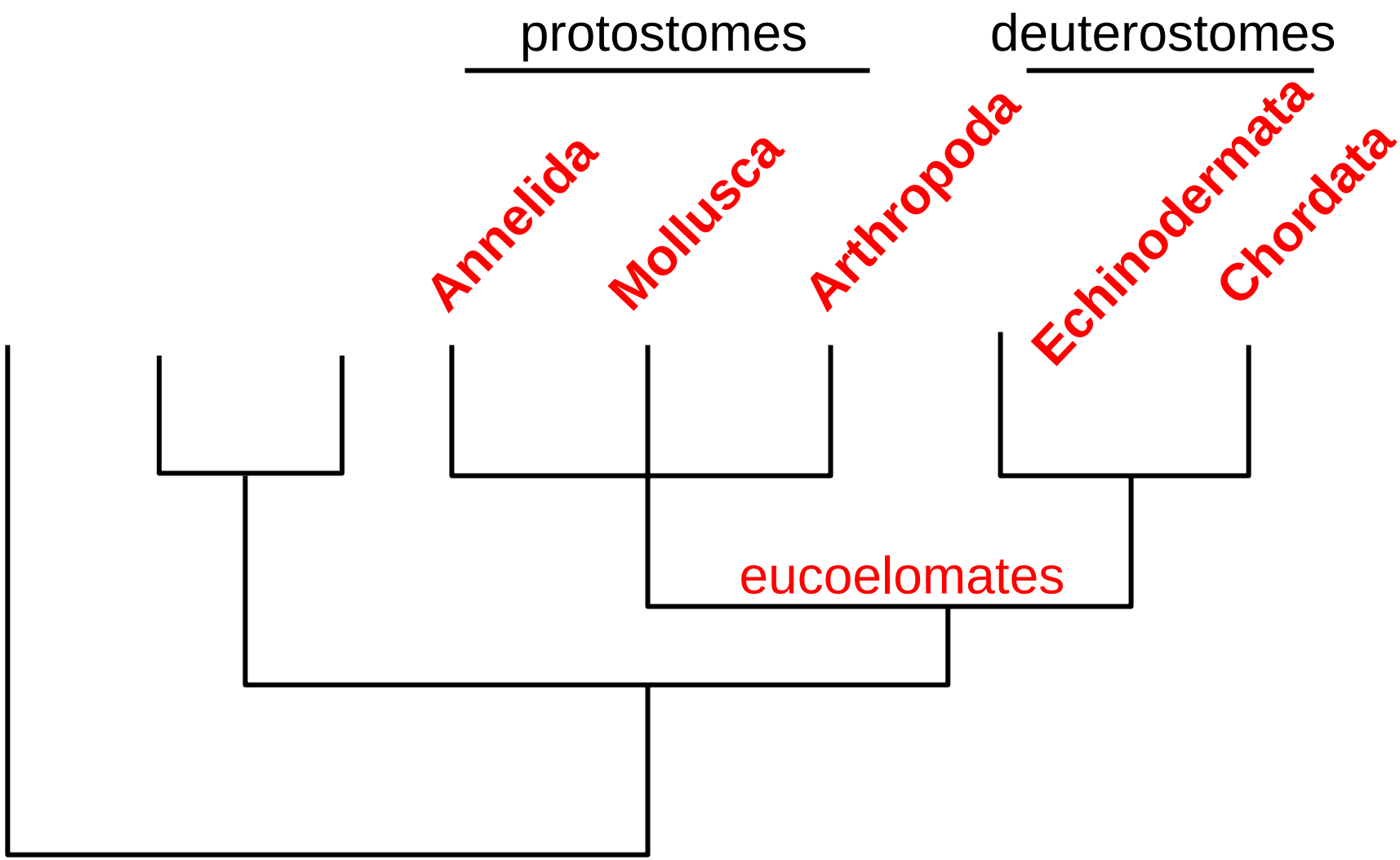
Organ level of organization

Bilateral Symmetry

Cephalization

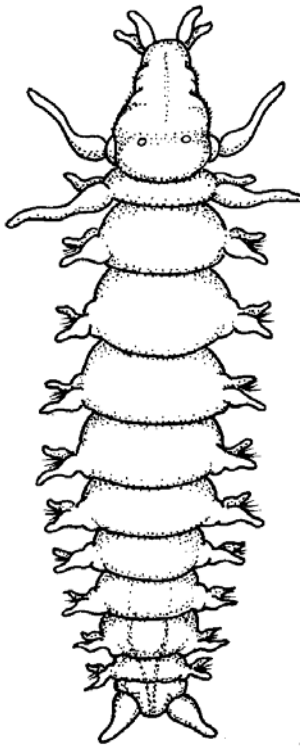
Eucoelomate

Protostome


protostomes
deuterostomes
Annelida
Mollusca
Arthropoda
Echinodermata
Chordata
eucoelomates

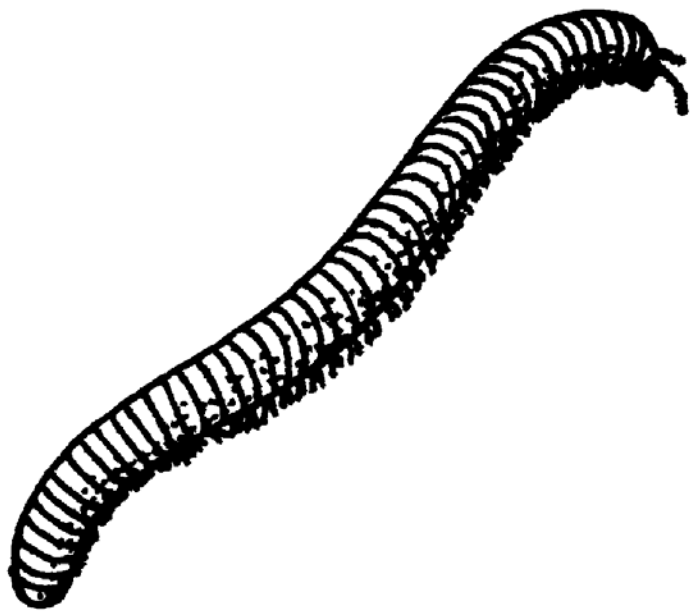
Similarities Between Arthropods and Annelids

1. Segmentation: Arthropods and Annelids are both segmented



I. Livingstone © BIODIDAC

Annelid



J. Soucie © BIODIDAC

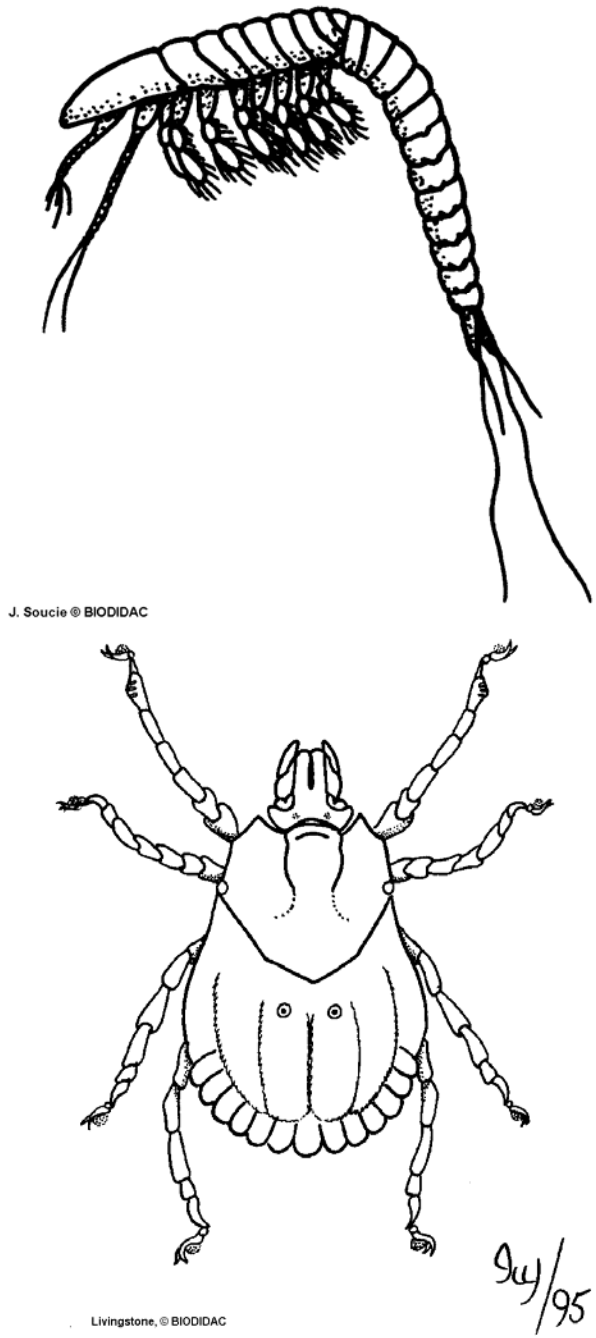
Primitive Arthropod

Similarities Between Arthropods and Annelids

1. Segmentation

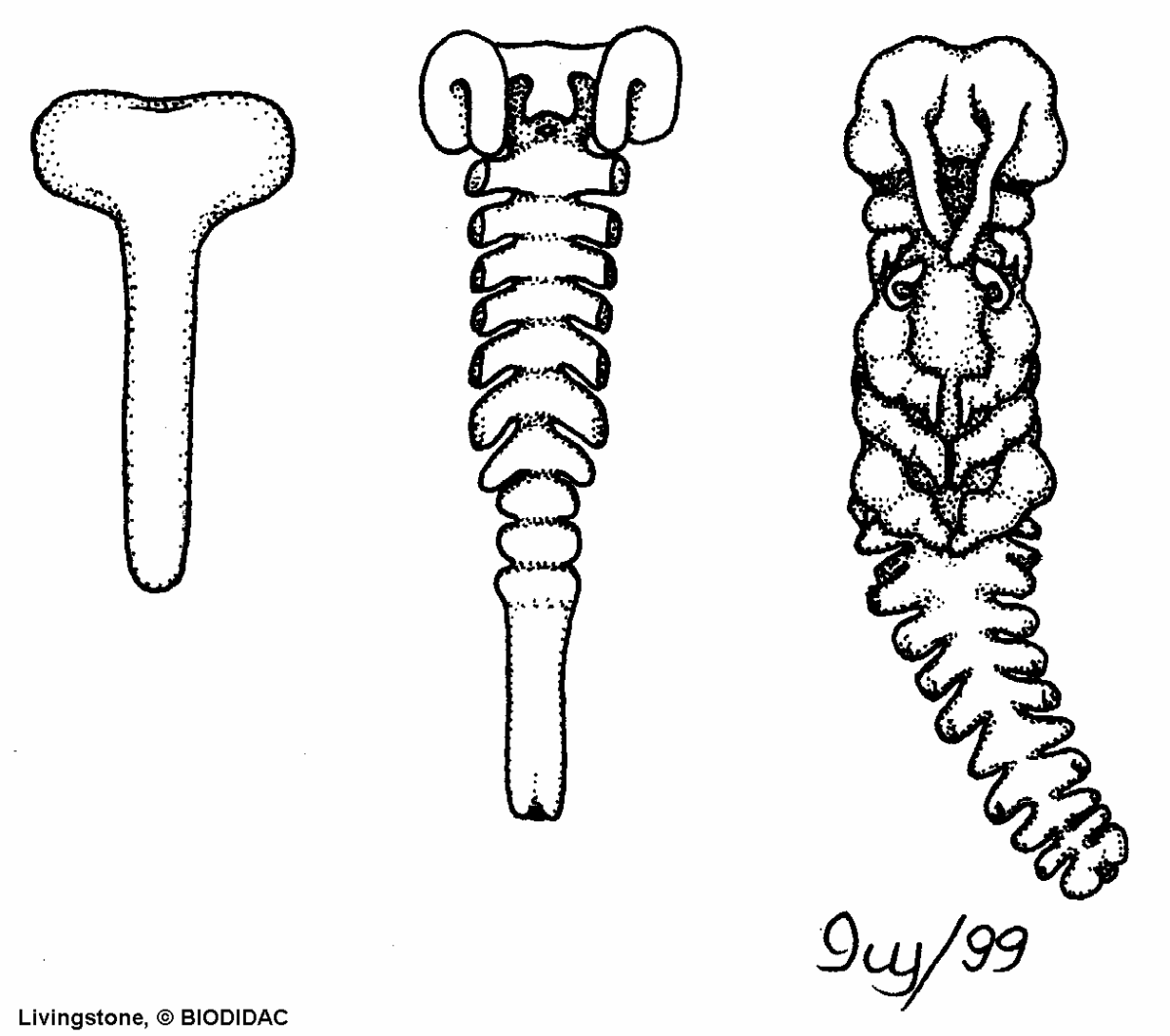
Segmentation is reduced in Arthropods through:

1. Disappearance of segments
2. Fusion of segments
3. Structural and functional differentiation of segments



Tagmatization: The fusion and specialization of metameric segments.

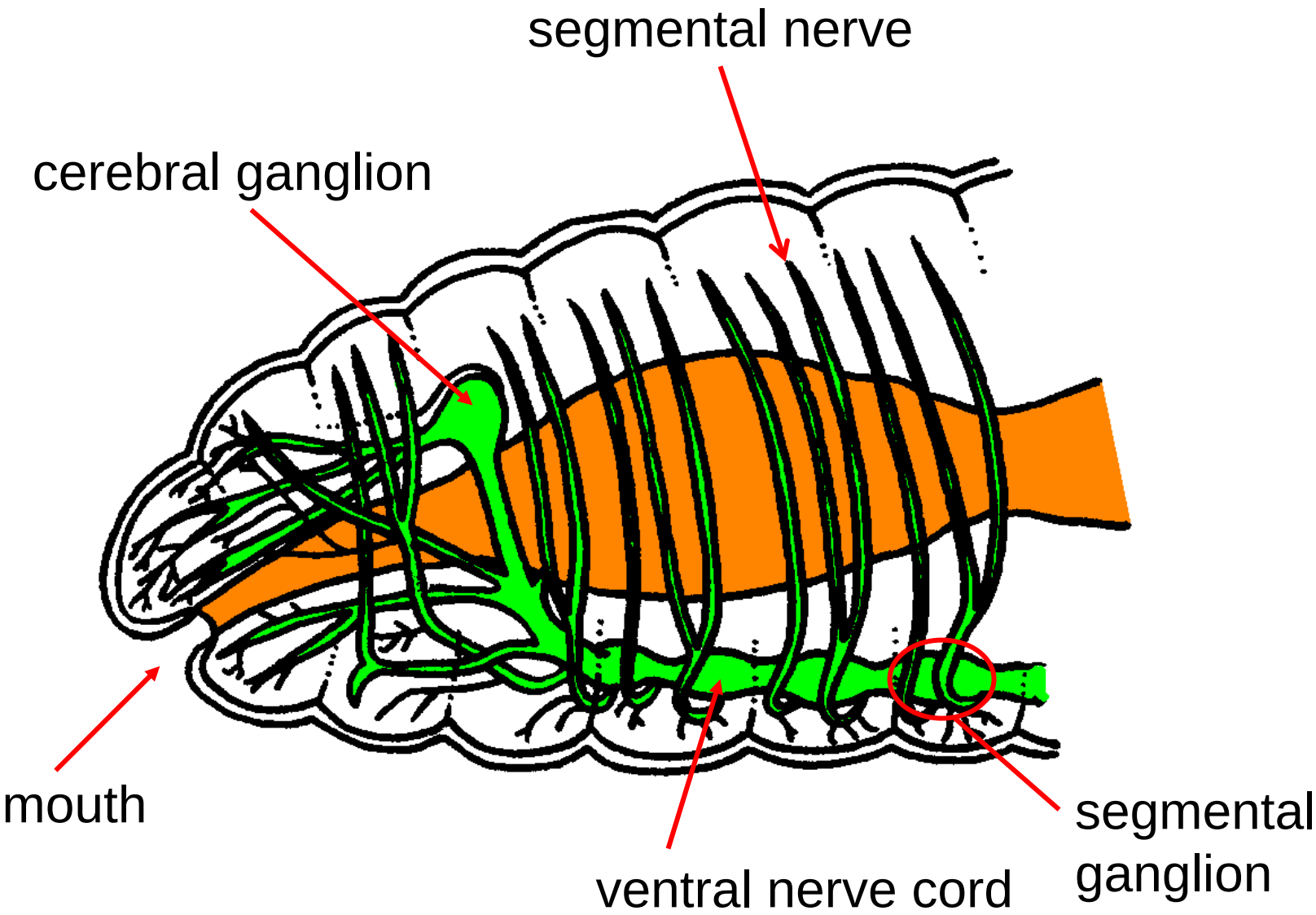
A developing Arthropod embryo



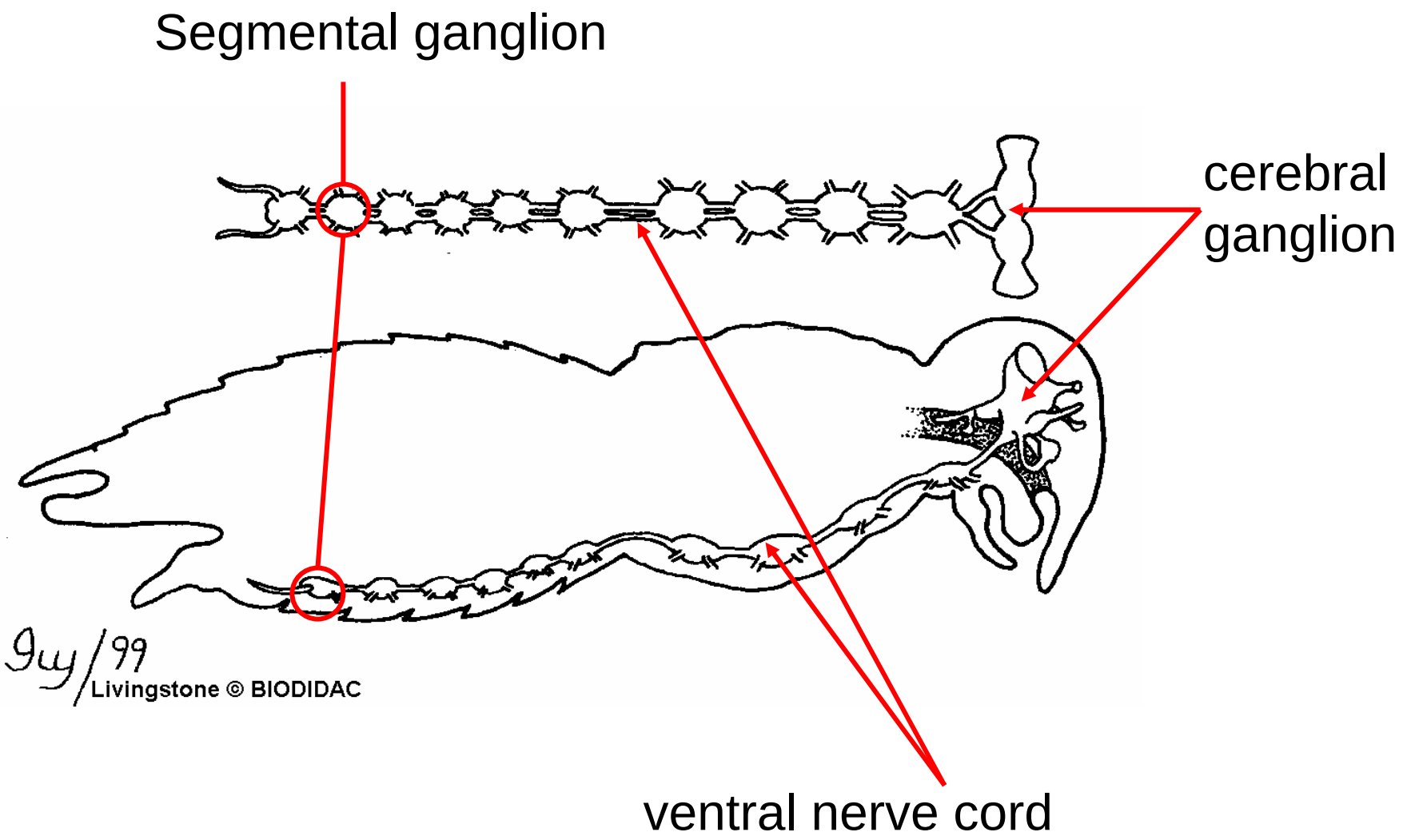
Similarities Between Arthropods and Annelids

2. **Nervous system:** The nervous systems of Arthropods and Annelids consist of a dorsal brain (cerebral ganglion) and a ventral nerve cord with ganglia in every segment.

Annelid Nervous System



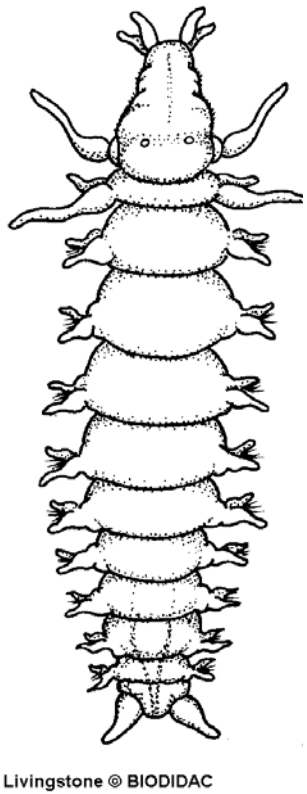
Arthropod Nervous System

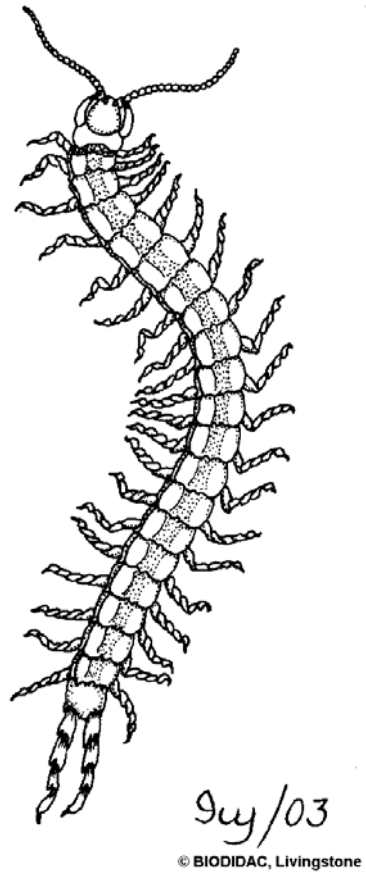


Similarities Between Arthropods and Annelids

3. **Primitive Arthropods have one pair of appendages per segment**

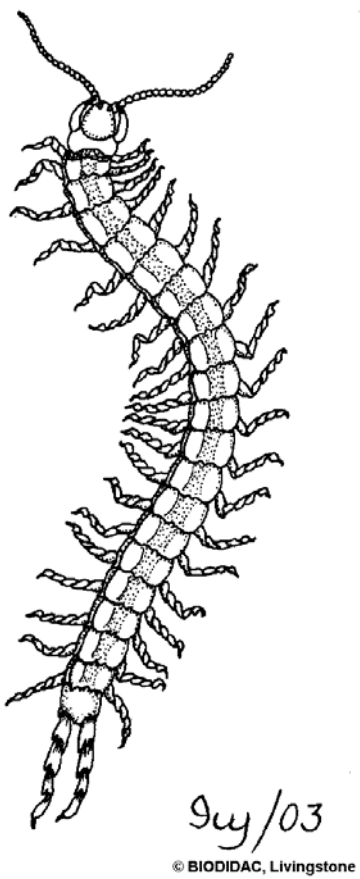
Annelid



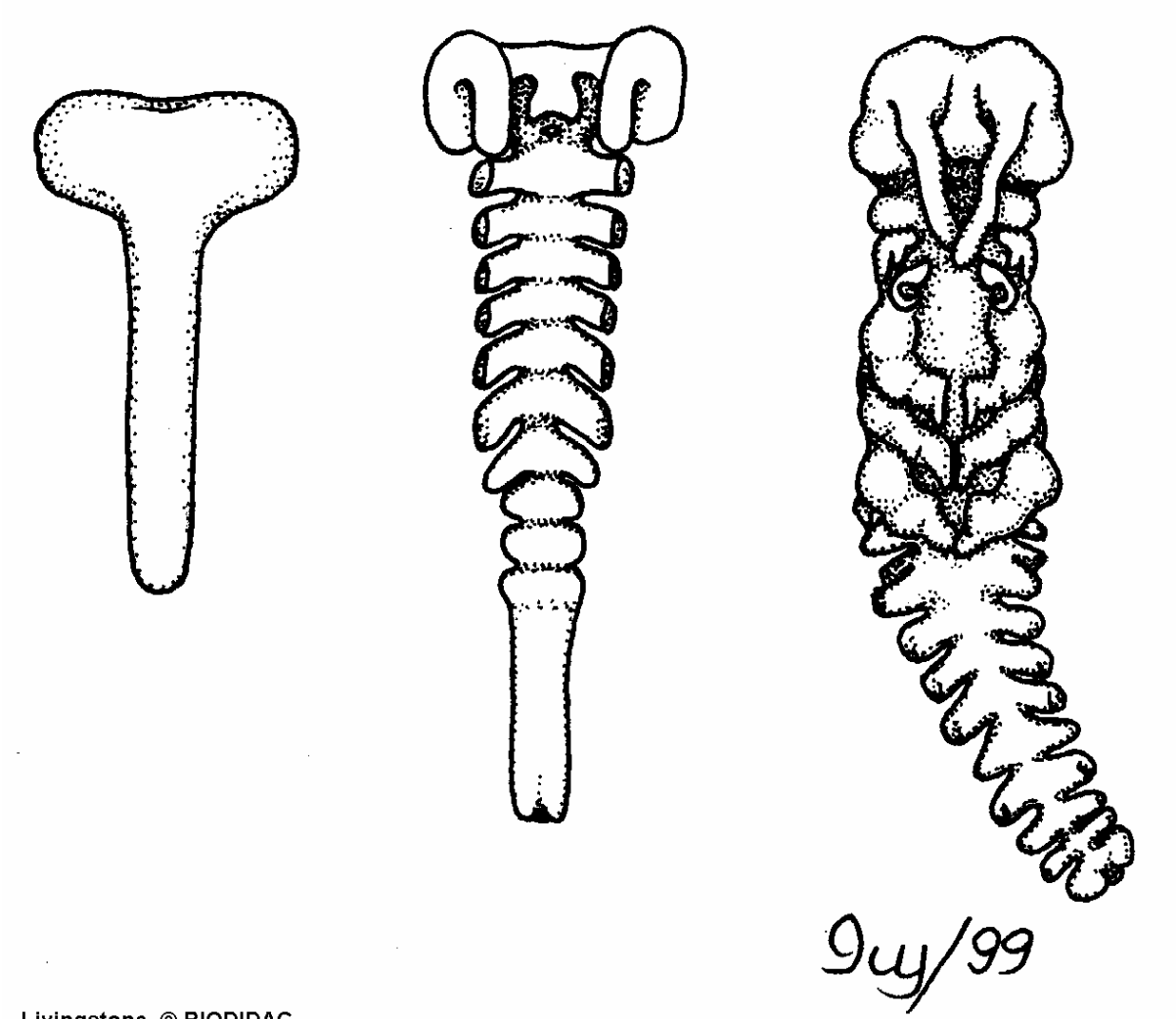


Arthropod

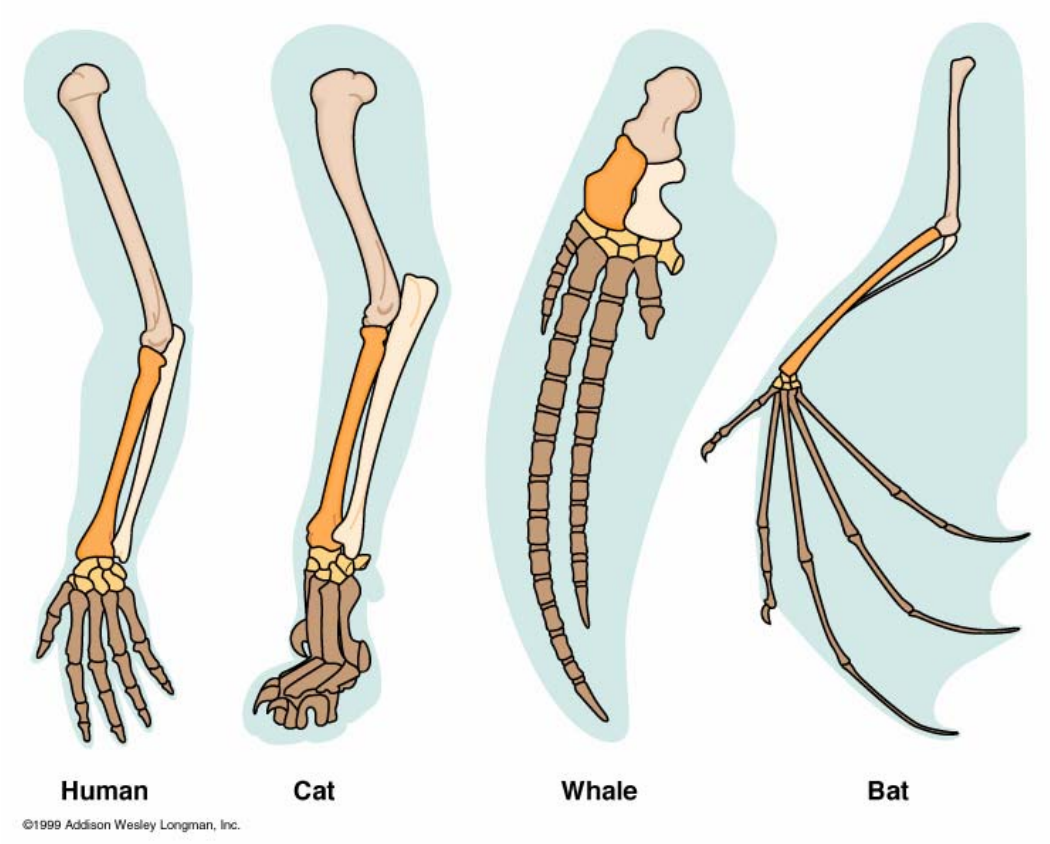
Similarities Between Arthropods and Annelids



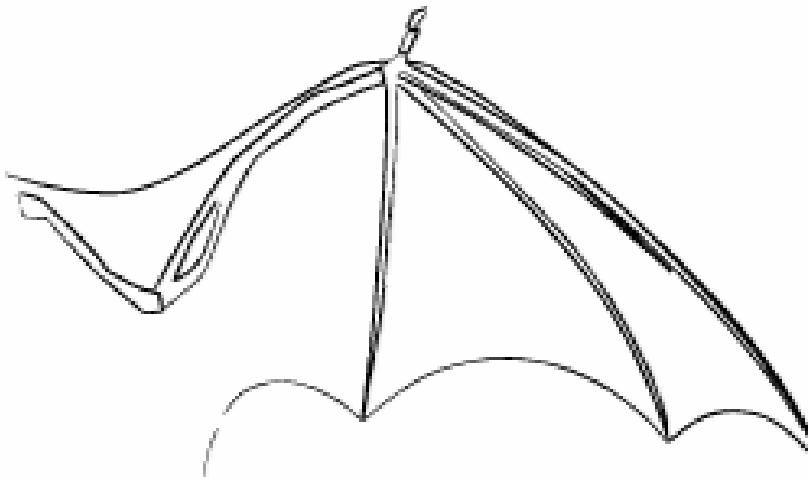
- These appendages are said to be <u>serially homologous</u> to one another.
- Serial homology: the correspondence (in the same individual) of repeated structures having the same origin and development.



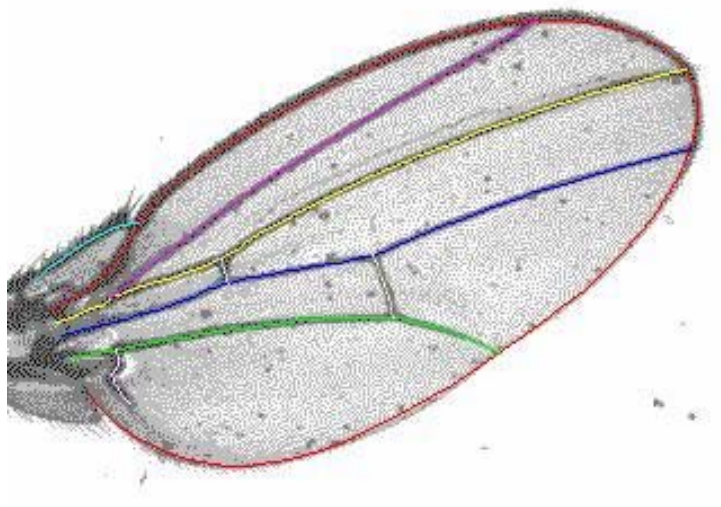
Examples of homologous characters: Vertebrate forelimbs



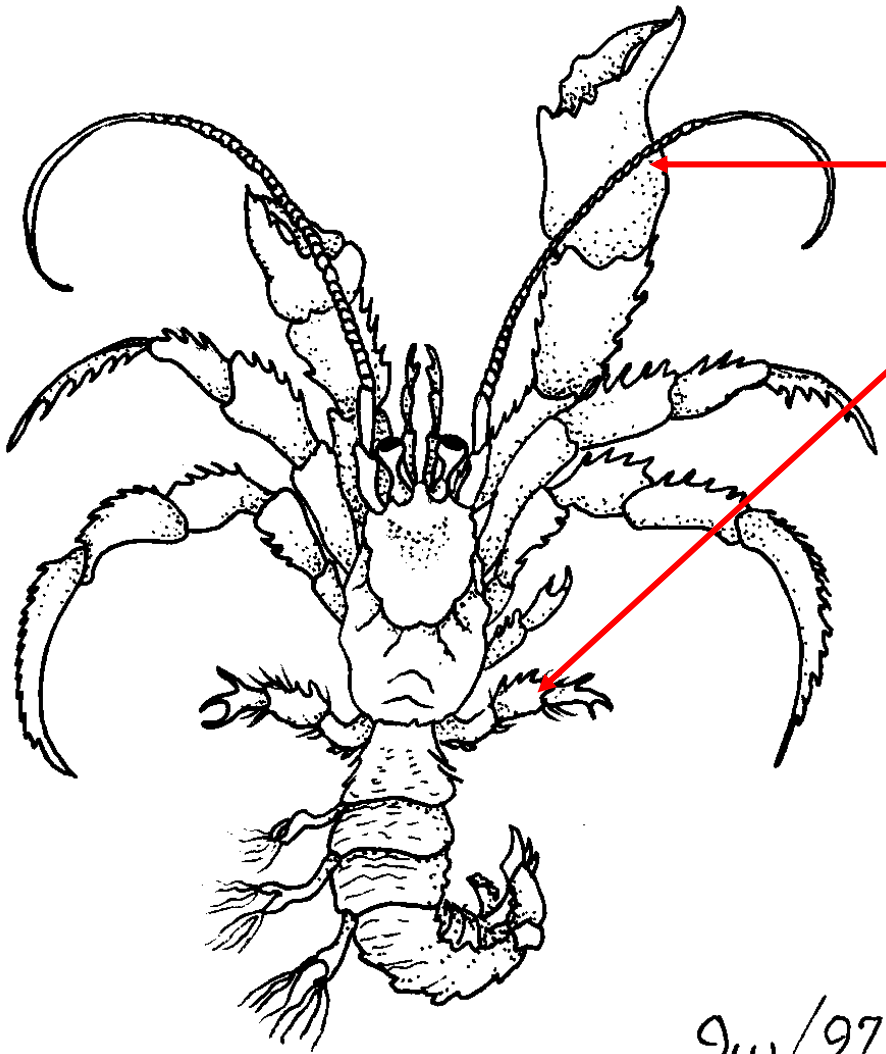
Examples of analogous characters: bat wings and insect wings



Bat wing



Fly wing



serially homologous structures

Homology	Serial Homology	Analogy
- 2 individuals - structures have same developmental origin and same or different functions	- 2 structures on 1 individual	- 2 individuals - structures have different developmental origins but same function
bat wing & hand	cheliped & swimmeret	bat wing & insect wing

Similarities Between Arthropods and Annelids

1. Segmentation
2. Nervous system
3. Paired appendages

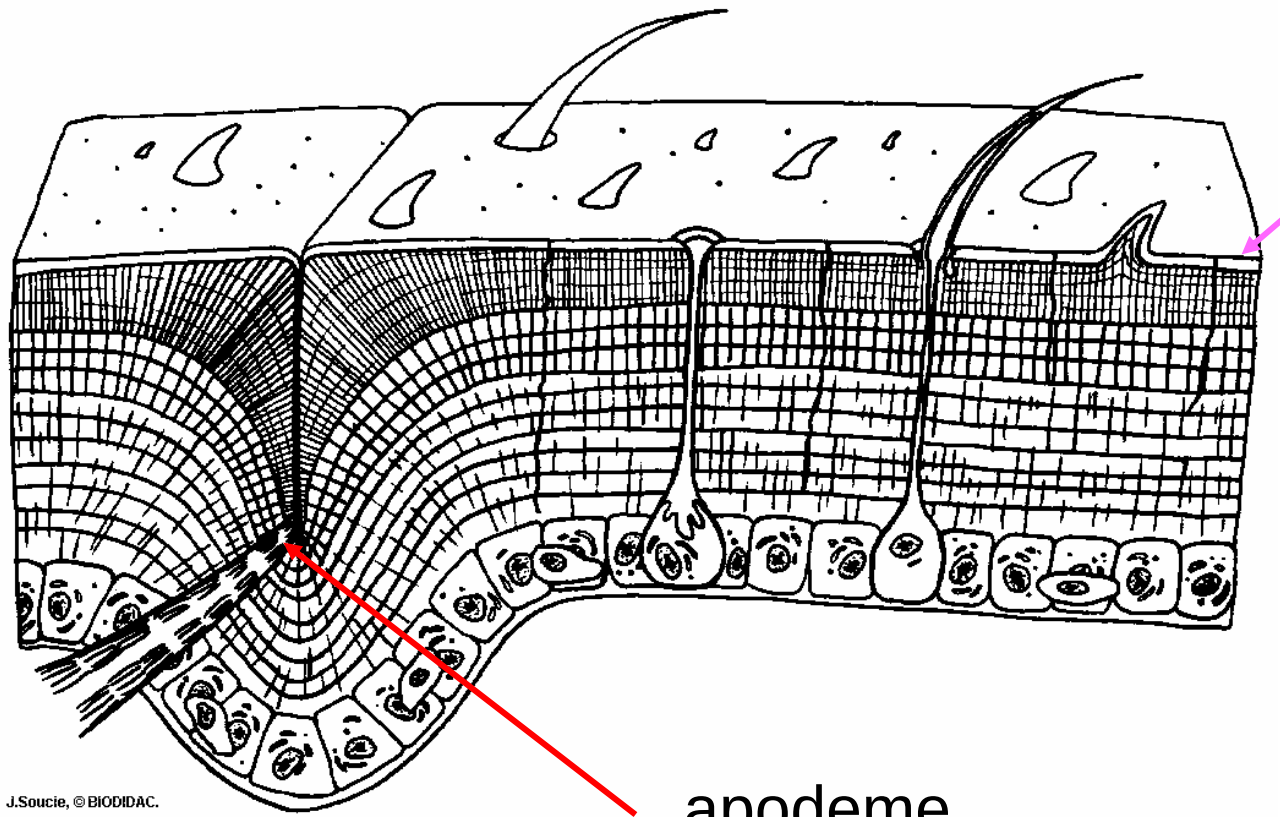
Similarities Between Arthropods and Annelids

•Despite these similarities Arthropods are a much more successful group of animals than Annelids.
•Over 1 million described species of Arthropods (probably 10 million undescribed) compared to 15,000 Annelids.

What characteristics have enabled Arthropods to achieve such great diversity and abundance?

1. Exoskeleton

- hardened external cuticle secreted by the epidermis
- composed of chitin; has internal ridges/projections called apodemes to which muscles attach
- benefits: protection without loss of mobility
- limits growth→ must be “molted”
- limits ultimate body size because of weight


epicuticle
exocuticle
endocuticle
apodeme
J.Soucie, © BIODIDAC.

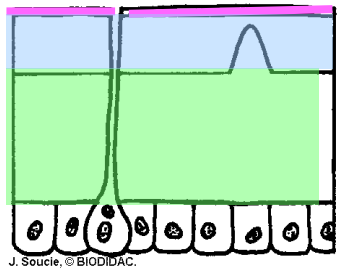
Ecdysis (molting)

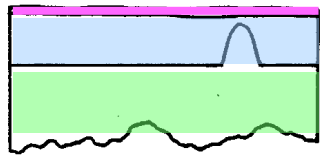
epicuticle

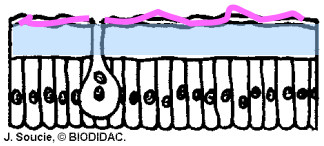
exocuticle

endocuticle

under hormonal control

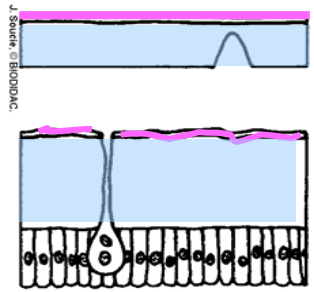




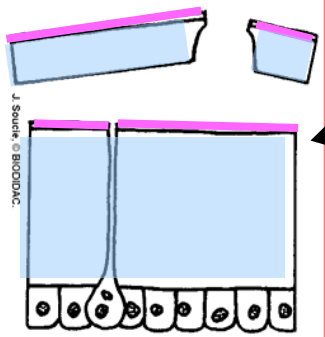


• molting fluid dissolves old endocuticle

• new exocuticle is secreted

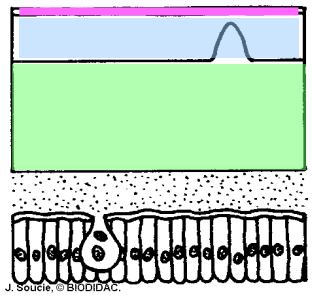


• new exocuticle is formed under the old one



• old exocuticle ruptures

• ecdysis → the animal backs out of old exoskeleton

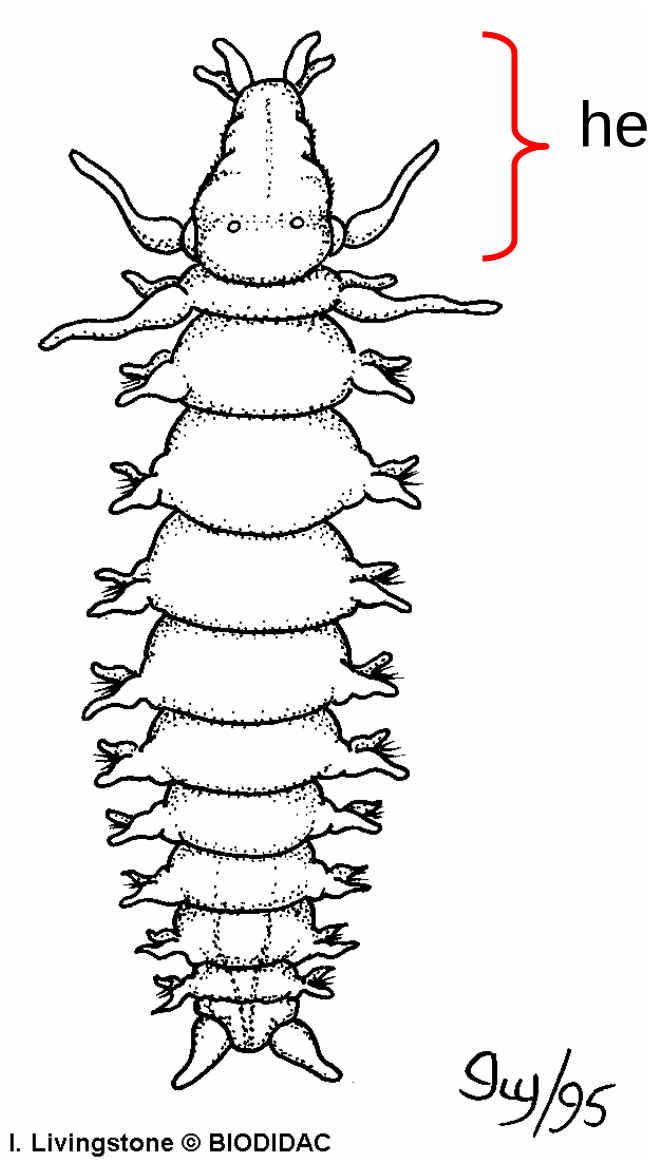


• new endocuticle forms under exocuticle

• exocuticle hardens

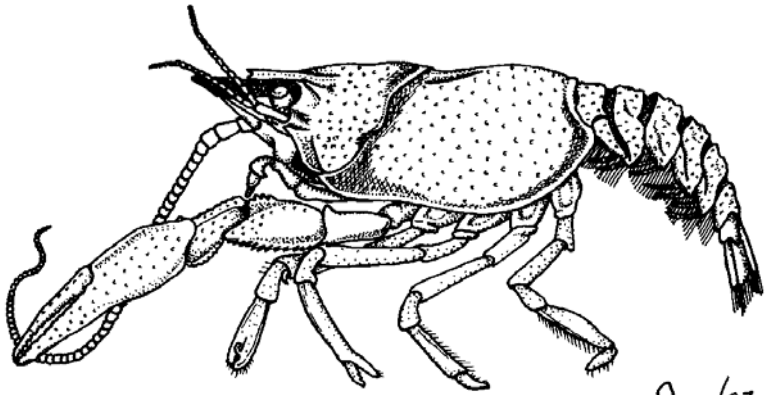
2. Tagmatization and jointed appendages

- The fusion of segments into blocks called tagmata (sing:tagma) that are specialized for certain functions



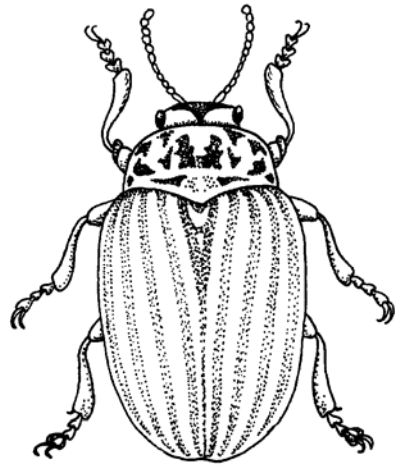
head composed of 3 segments

head composed of 5 fused segments



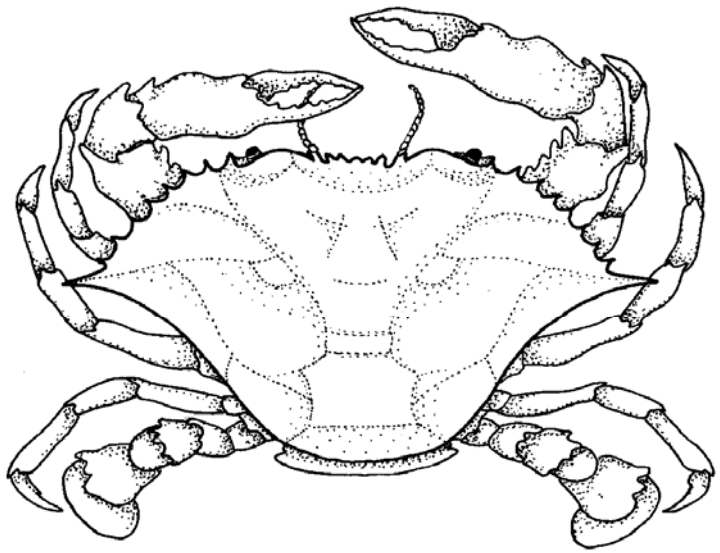
Ivy/03

Livingstone, © BIODIDAC



Ivy/02

© BIODIDAC, Livingstone

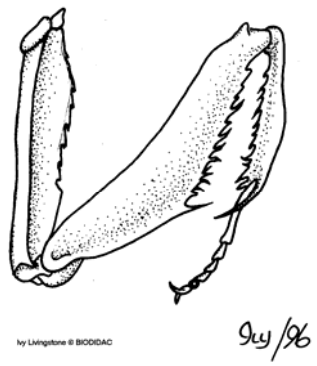


Ivy/97

Ivy Livingston © BIODIDAC

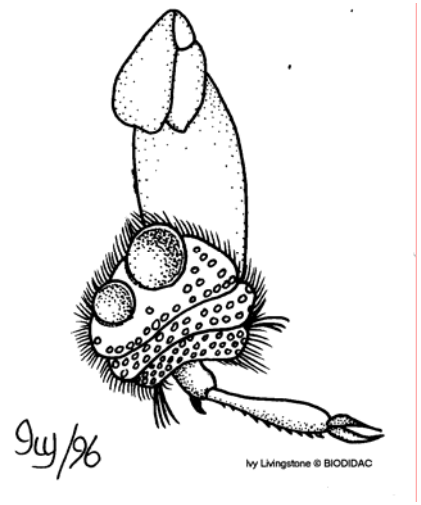
2. Tagmatization and jointed appendages

- usually each tagma has a pair of jointed appendages
- appendages may be highly modified with tagmata being specialized for certain functions (e.g. feeding, moving, sensory)
- appendages are essentially hollow levers that are moved by well-developed striated muscles (flexors and extensors) and are capable of fast, powerful movement

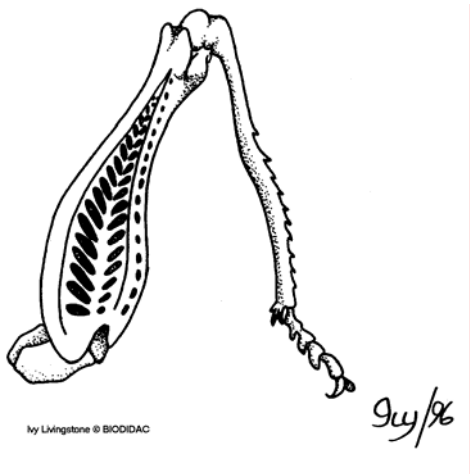


Raptorial leg

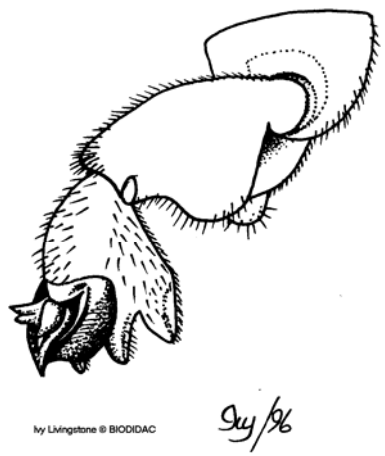
Swimming leg



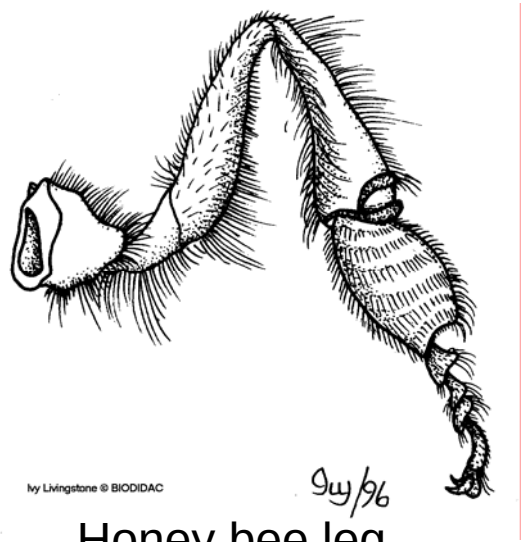
Leg of diving beetle



Jumping leg



Digging leg



Honey bee leg

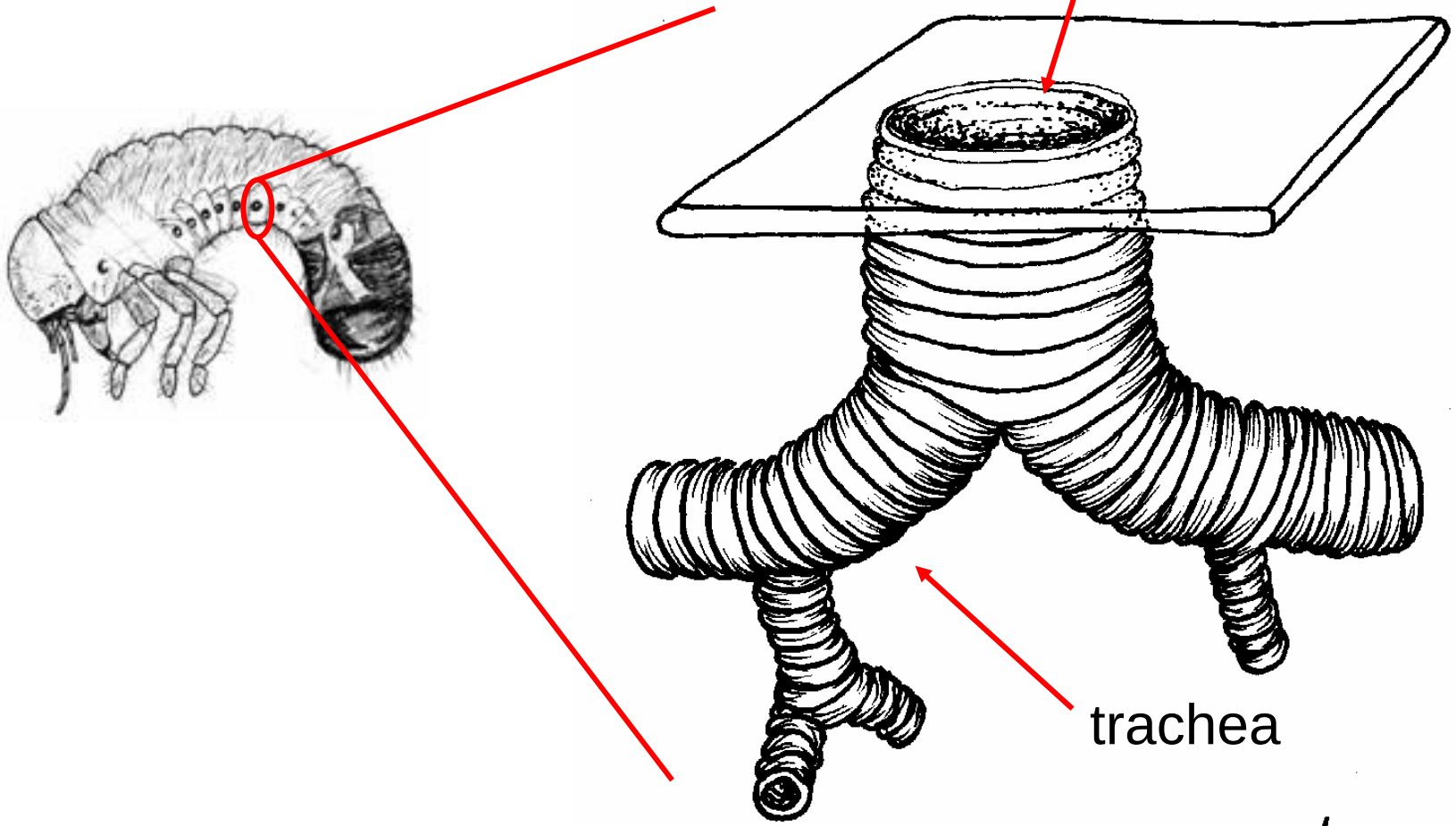
3. Respiratory System

• on land: most have a respiratory system that consists of tubes that deliver air directly to tissues and cells (tracheal system)

• in water: most have gills

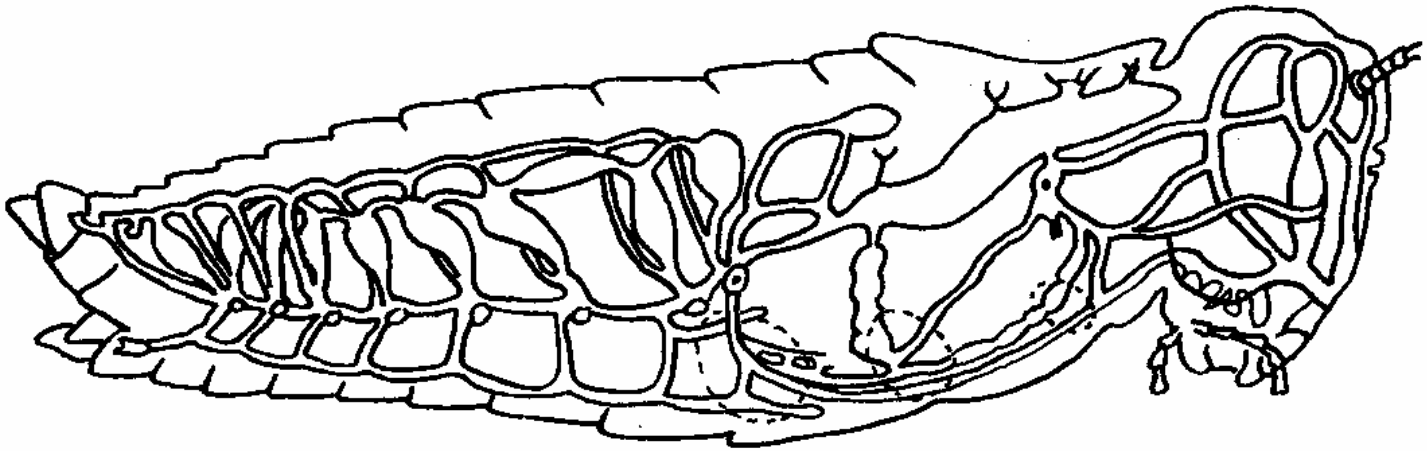
• these systems allow for a higher metabolic rate and level of activity

Insect tracheal system



9y /97

Insect tracheal system



Ivy/97

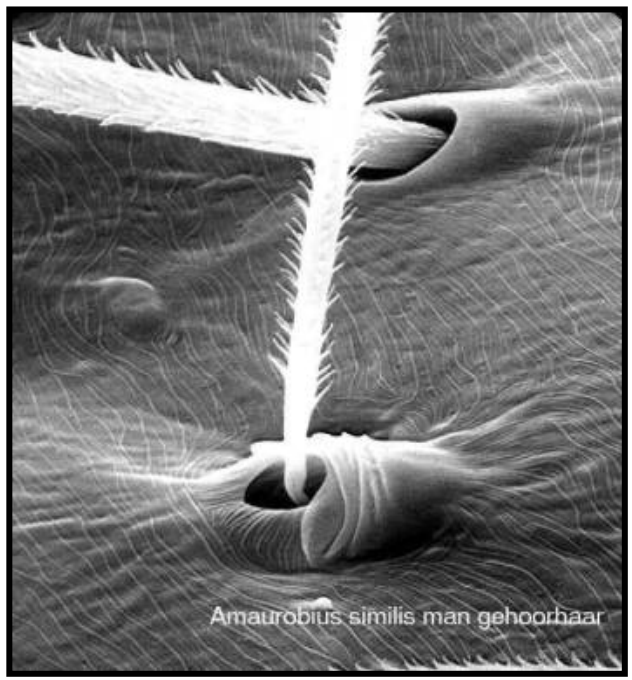
4. Sensory System

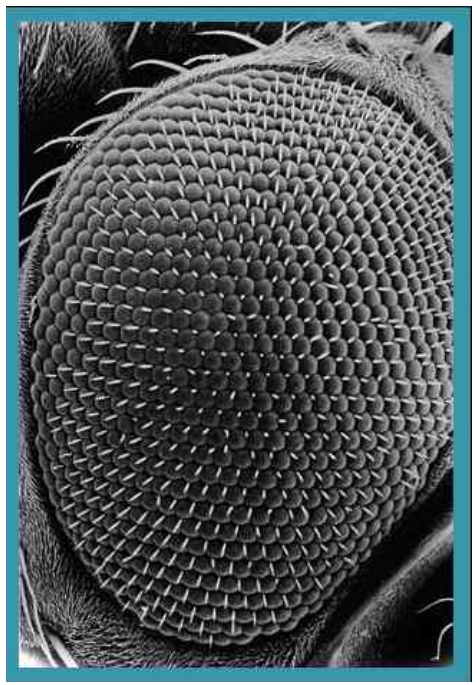
- similar to Annelida

  (ventral nerve cord, cerebral ganglia/brain…)

- possess a variety of sensory organs

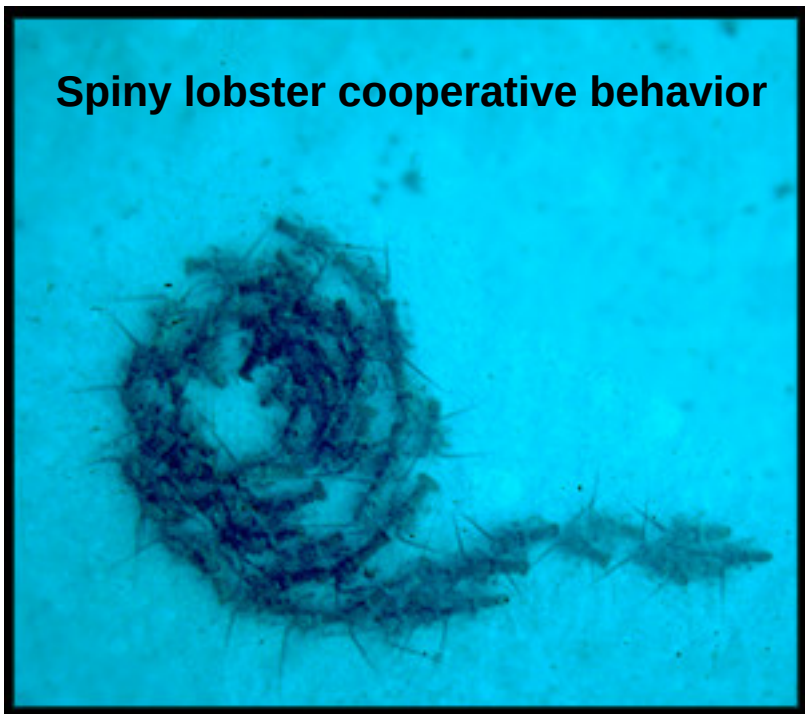
  (e.g. simple and compound eyes, antennae, chemoreceptors, sensory hairs…)





5. Complex Behavior

- have complex innate behaviors and some are capable of learning
- some even show communication and cooperation

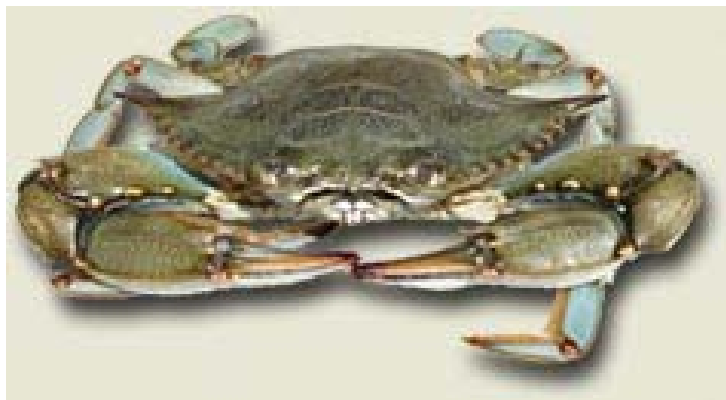


Dr. Herrnkind: http://bio.fsu.edu/~herrnlab/

6. Metamorphosis

• most have a larval stage that differs morphologically and behaviorally from the adult

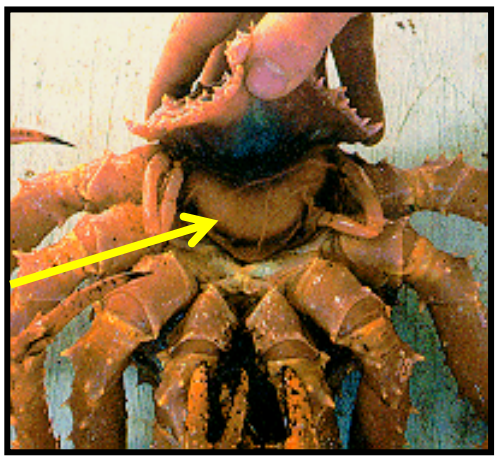
• reduces competition between larvae and adults by allowing them to occupy different ecological niches



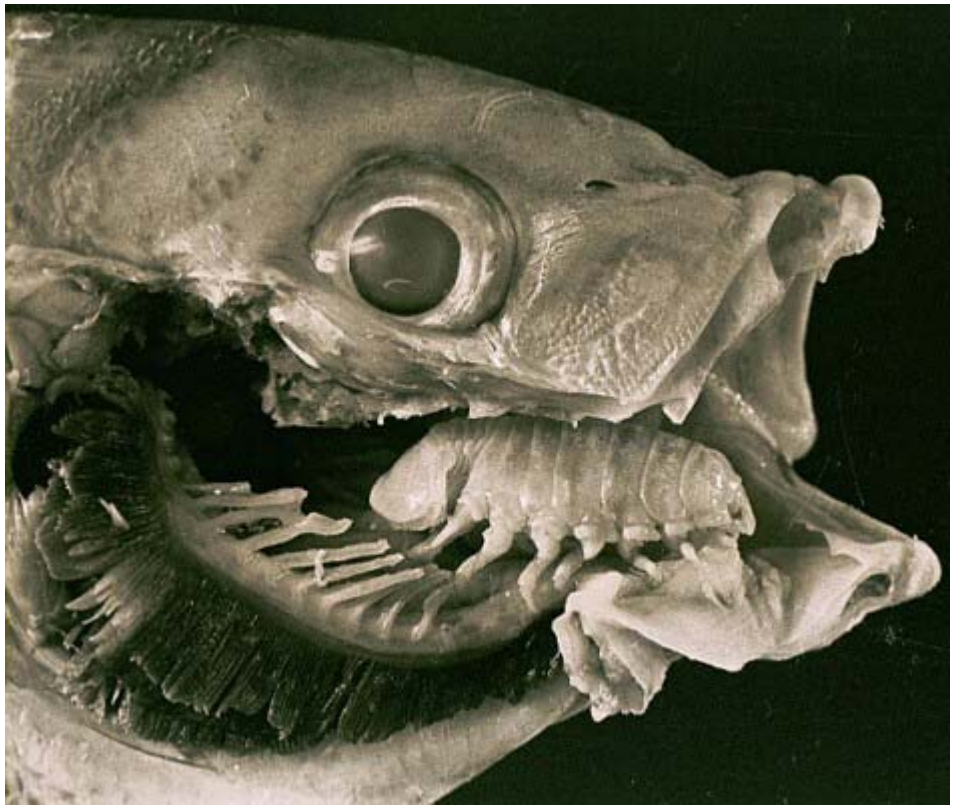
Arthropoda Characteristics

Feeding and Digestion

- Free living and parasitic forms



Cymothoa exigua



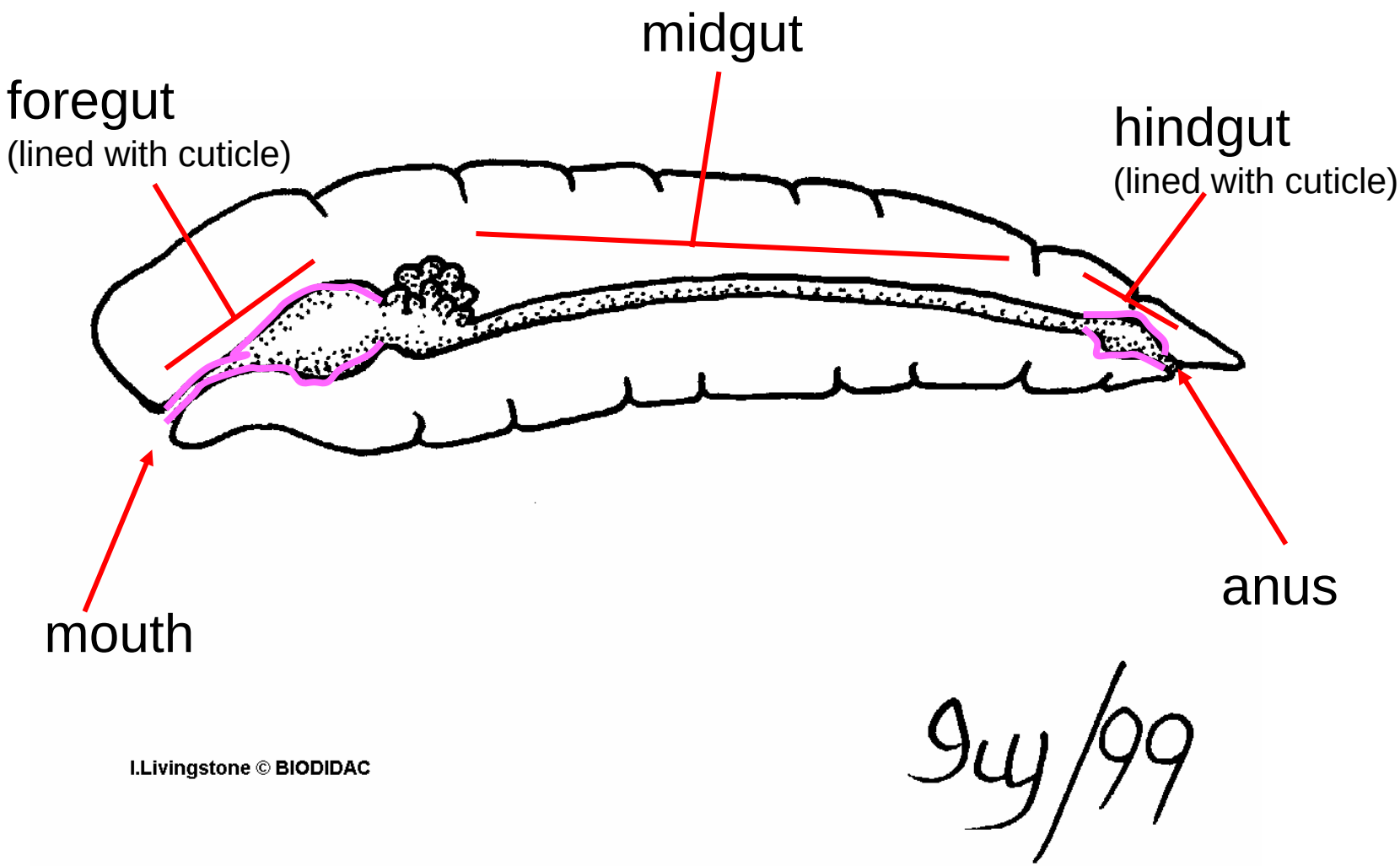
The only known case of a parasite substituting itself for a hosts organ

Arthropoda Characteristics

Digestive System

- complete with regional specialization

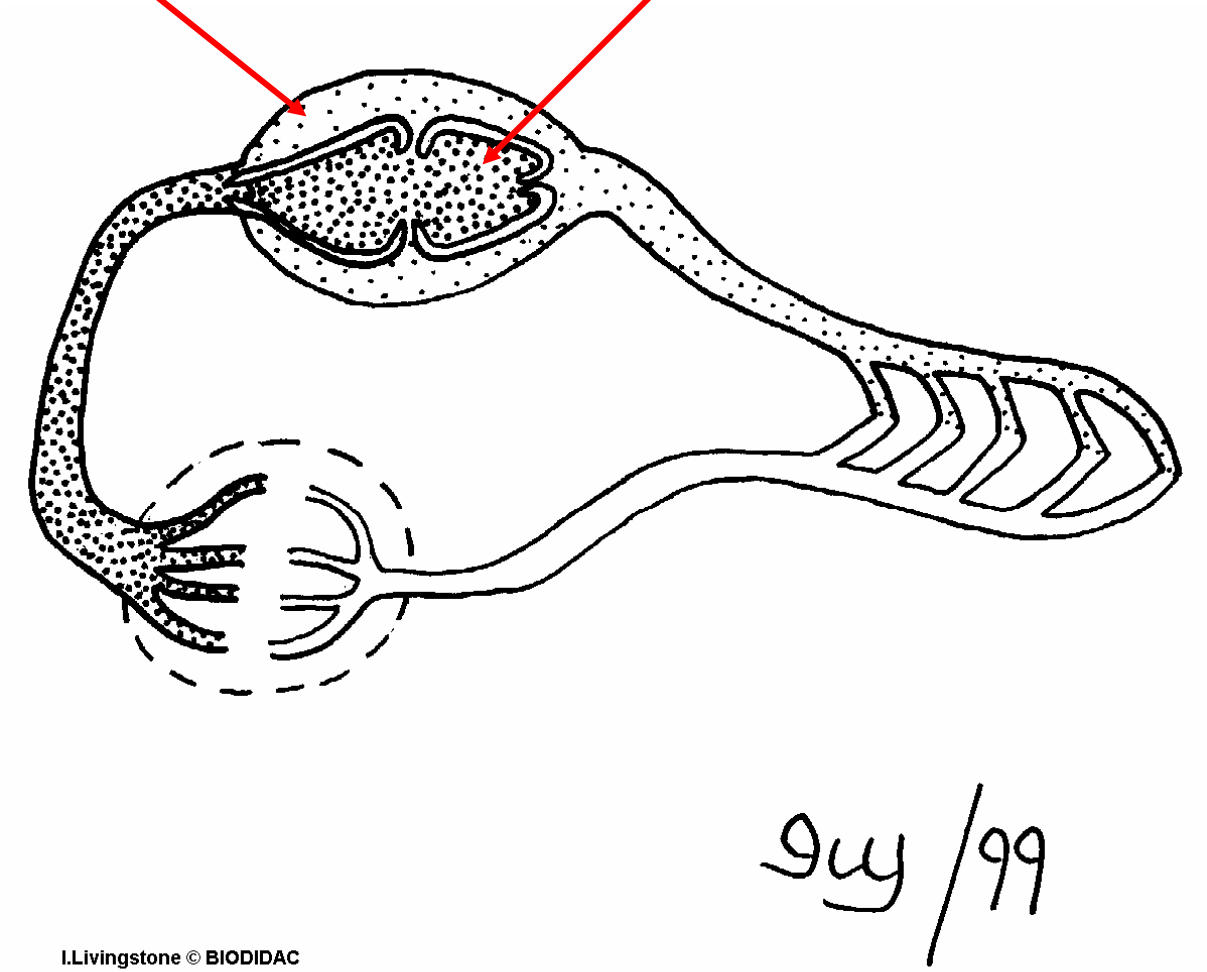
Generalized Arthropod Digestive System

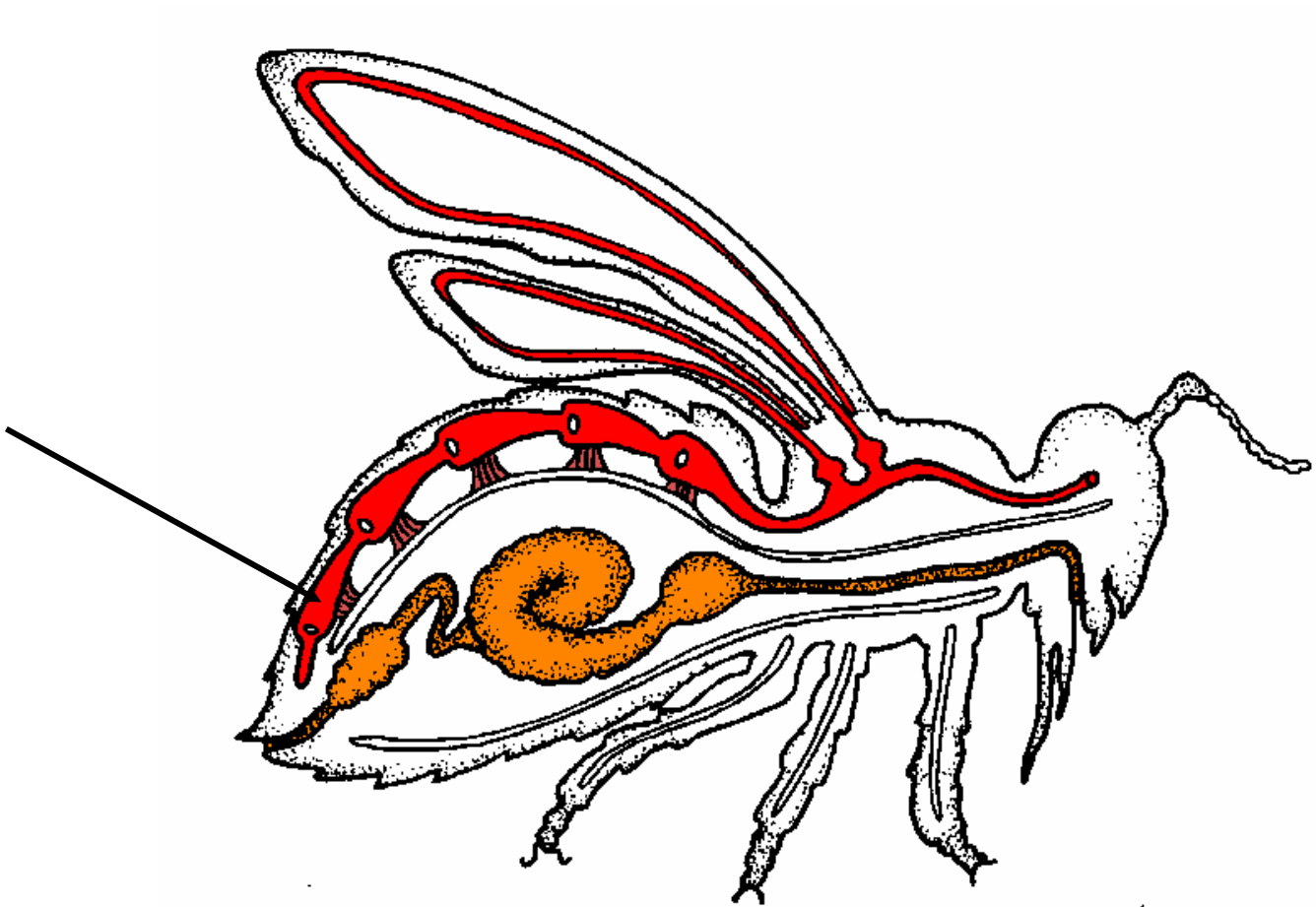


Arthropoda Characteristics

Circulatory System

- open circulatory system consisting of a hemocoel (main body-cavity) filled with hemolymph (blood)


pericardial sinus
heart
I.Livingstone © BIODIDAC



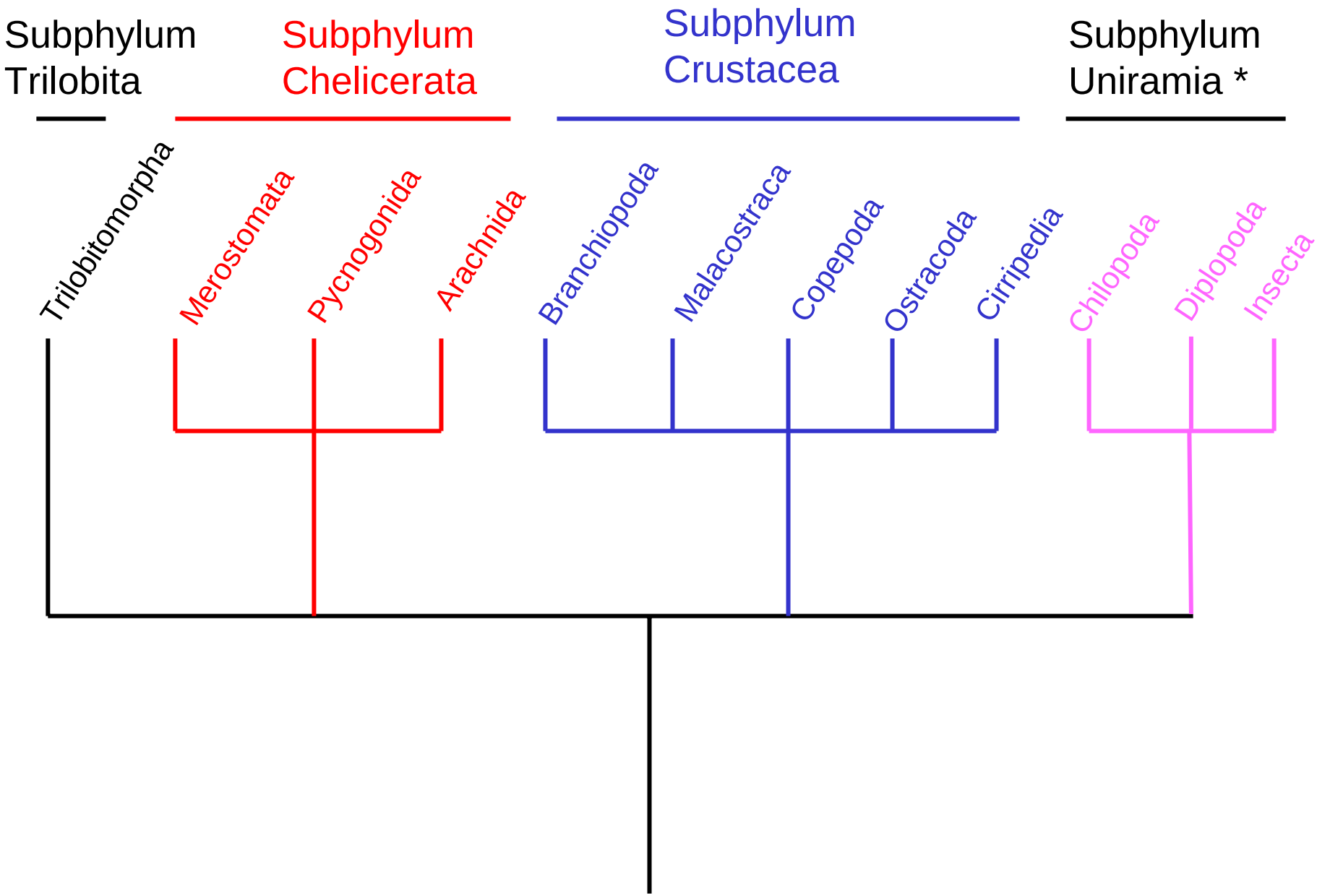
Arthropoda Characteristics

Excretion

- usually glands, some classes have specialized excretory systems

Reproduction

- usually sexual and dioecious
- usually internal fertilization


Subphylum Trilobita
Subphylum Chelicerata
Subphylum Crustacea
Subphylum Uniramia *
Trilobitomorpha
Merostomata
Pycnogonida
Arachnida
Branchiopoda
Malacostraca
Copepoda
Ostracoda
Cirripedia
Chilopoda
Diplopoda
Insecta

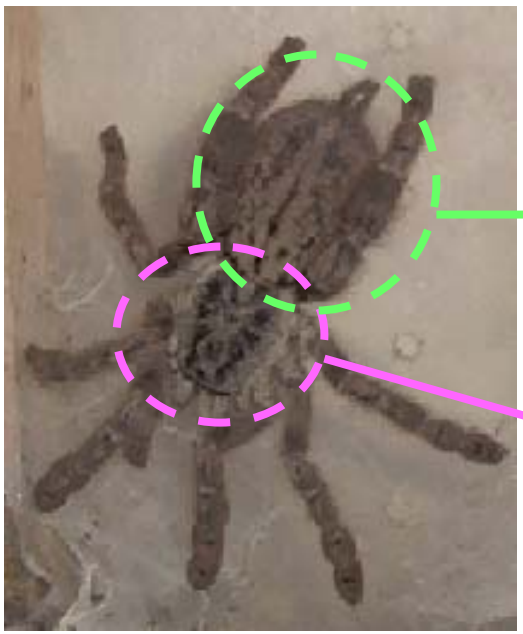
Subphylum Trilobita

(Class Trilobitmorpha)

- all are extinct
- the most diverse of the extinct arthropod groups (~5000 genera)

Subphylum Chelicerata

- no antennae
- 6 pairs of appendages:
  - 1st pair = pincer, fang-like chelicerae
  - 2nd pair = pedipalps
  - 3rd – 6th pair = walking legs
- body divided into 2 tagmata



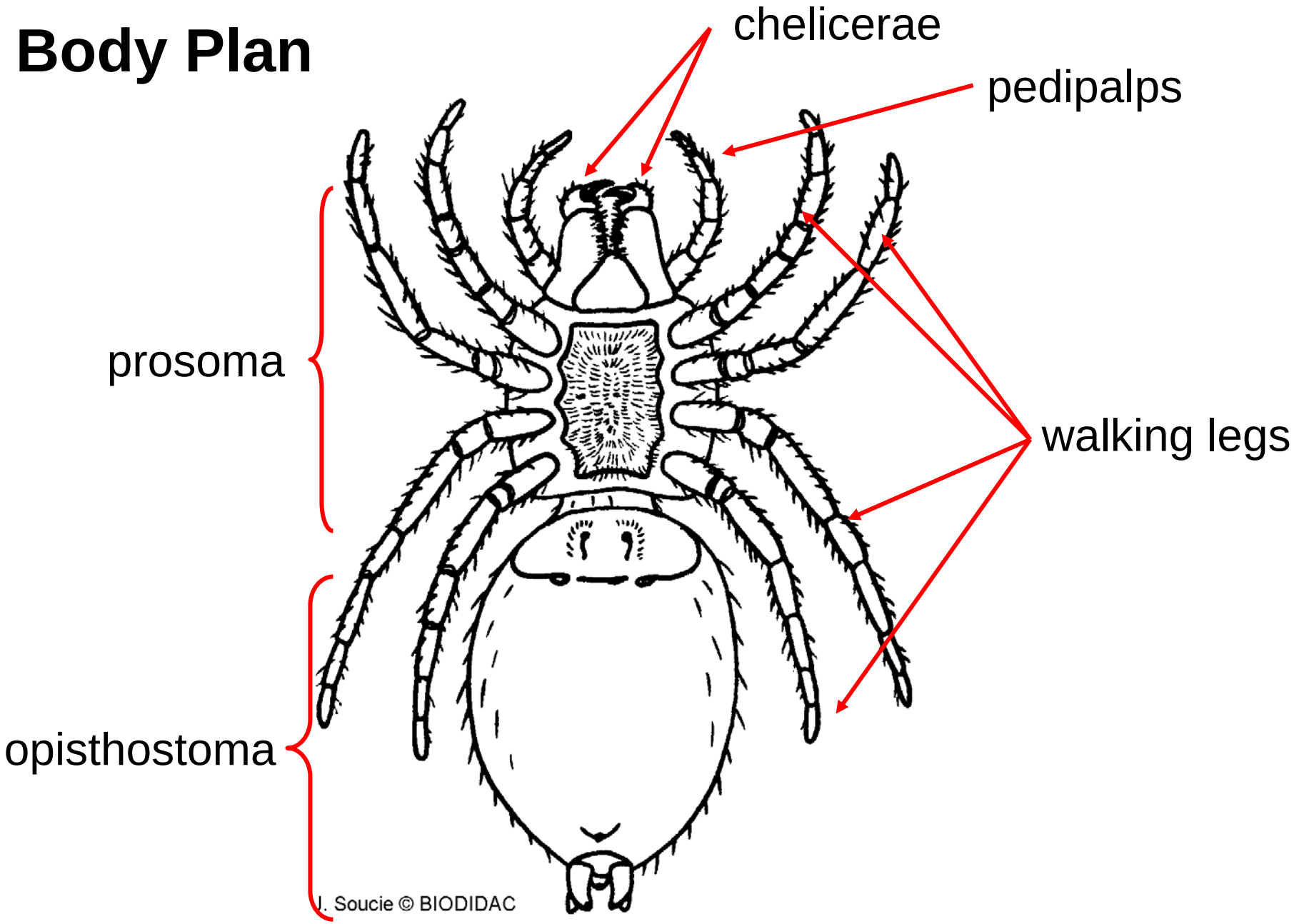
opisthosoma:

consists of the abdomen

prosoma:

consists of the head and all the legs

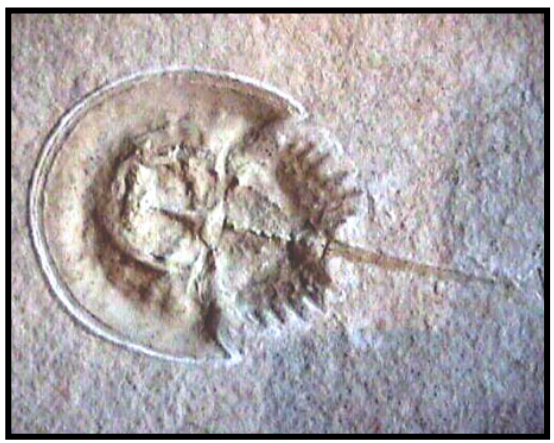
Body Plan


chelicerae
pedipalps
prosoma
walking legs
opisthostoma
J. Soucie © BIODIDAC

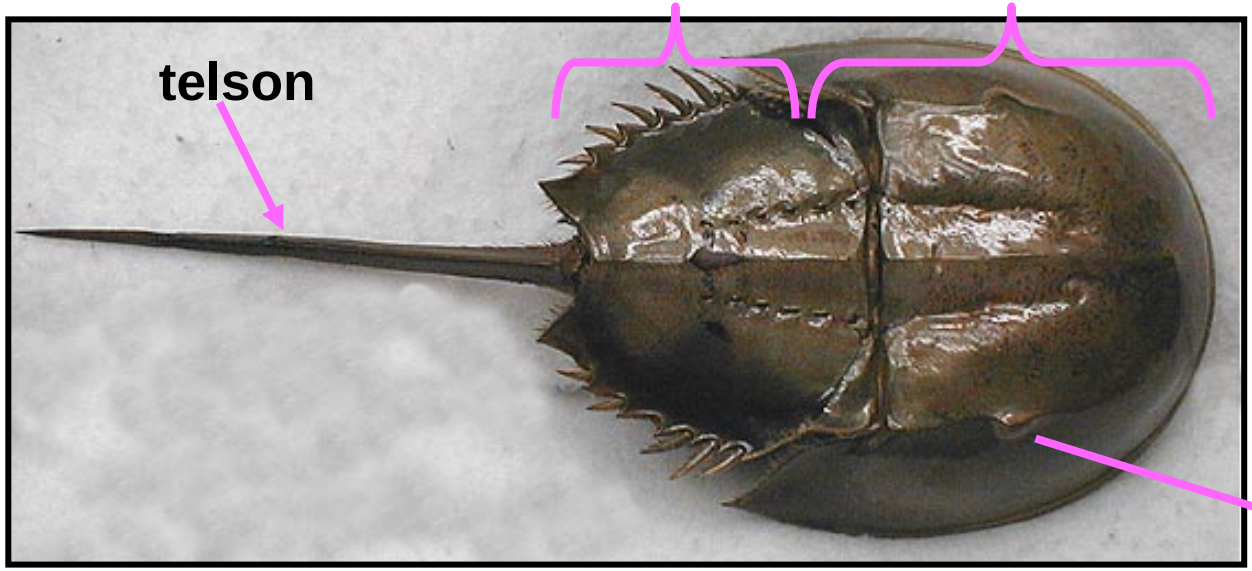
Subphylum Chelicerata

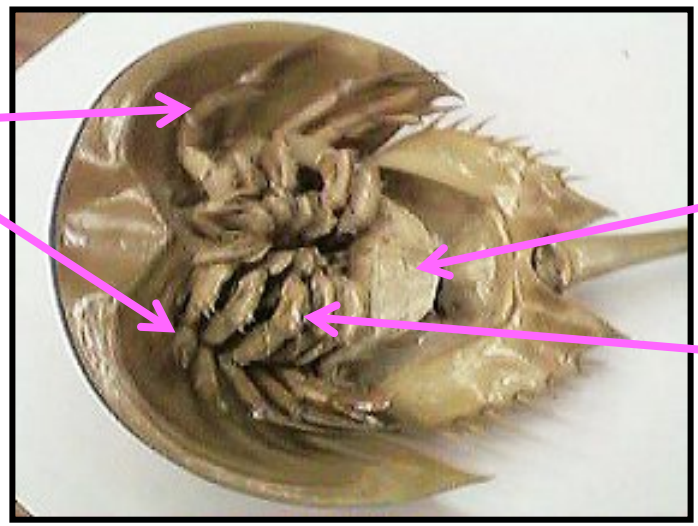
Class Merostomata

Horseshoe crabs have been essentially unchanged for ~250 million years



Class Merostomata





Class Merostomata

Subphylum Chelicerata

Class Arachnida

Class Arachnida

spiders, scorpions, ticks, mites, chiggers, daddy longlegs

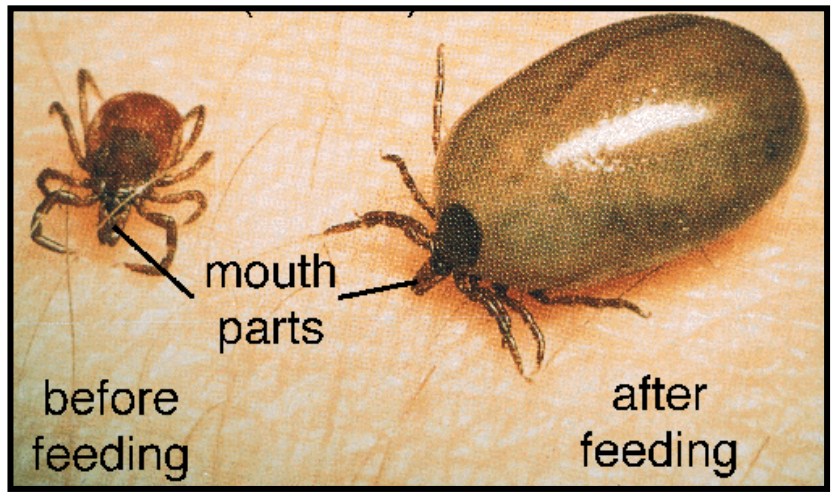
They usually have several adaptations for life on land:

- book lungs or tracheal system or both
- waxy cuticle

pedipalps

Class Arachnida

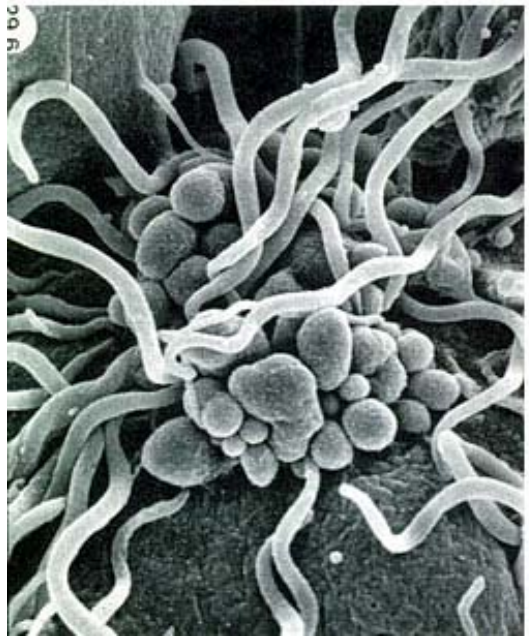
- arachnids as parasites
- chiggers (mites) and ticks



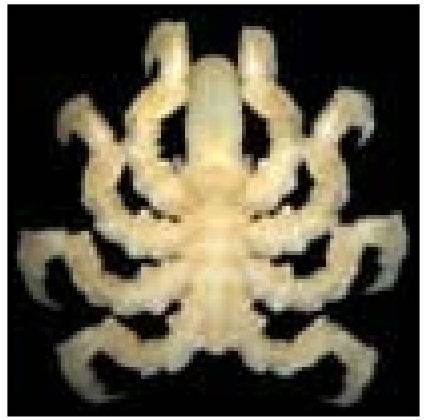
Class Arachnida

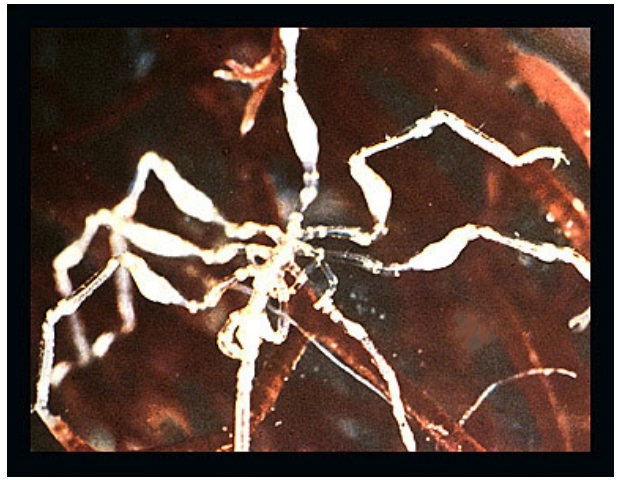
- arachnids as disease vectors
- Lyme disease is caused by infection with a bacteria that is transmitted by tick bites

Deer tick



Borellia

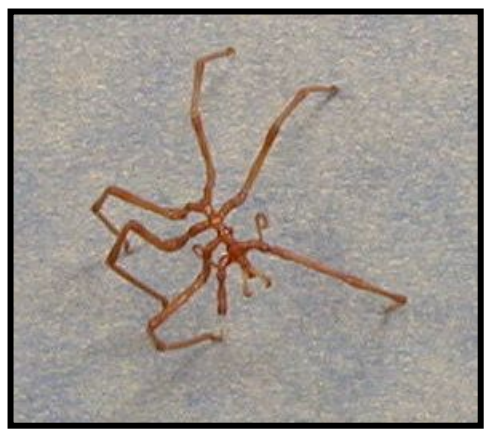




Subphylum Chelicerata

Class Pycnogonida

- sea spiders
- ~1000 marine species
- males carry the eggs



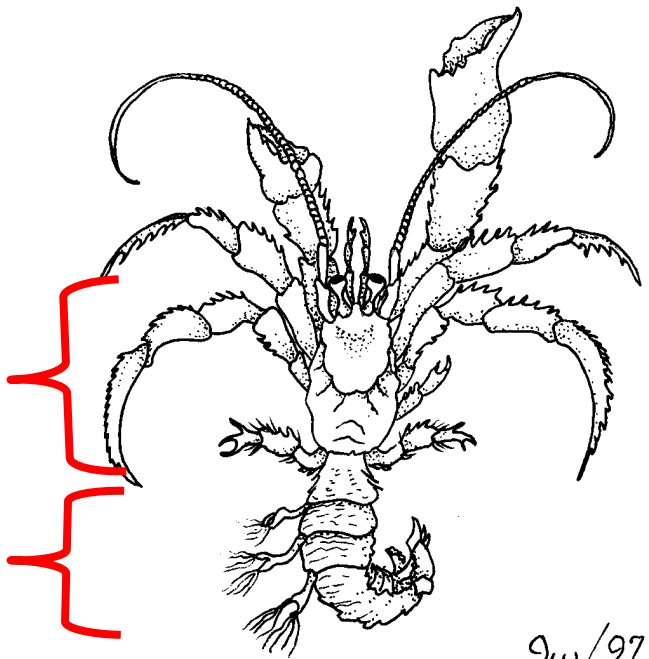
Subphylum Crustacea

- most are marine, some terrestrial and freshwater
- head has 2 pairs of antennae
- appendages are primitively biramous

  (have 2 major branches)
- body divided into 2 tagmata:

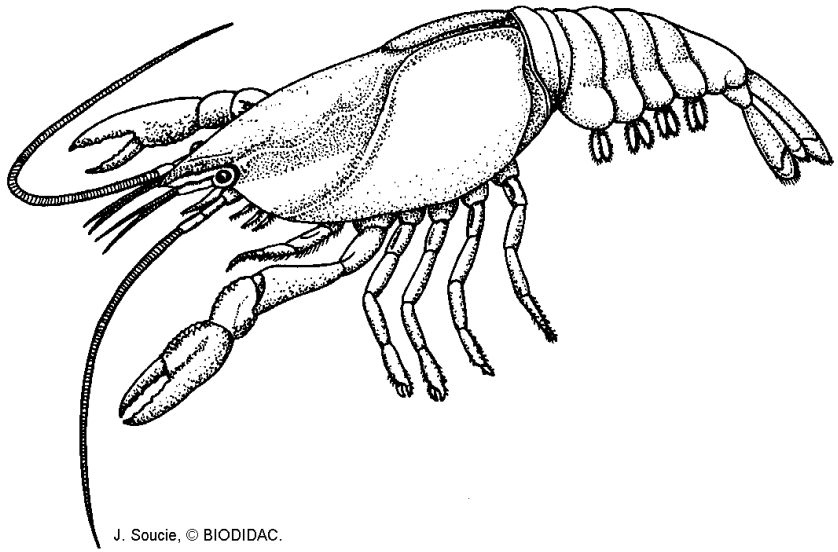
cephalothorax:
consists of the head and the thorax

abdomen



Subphylum Crustacea

- have mandibles, 2 pairs of maxillae, and 1 pair of legs per segment

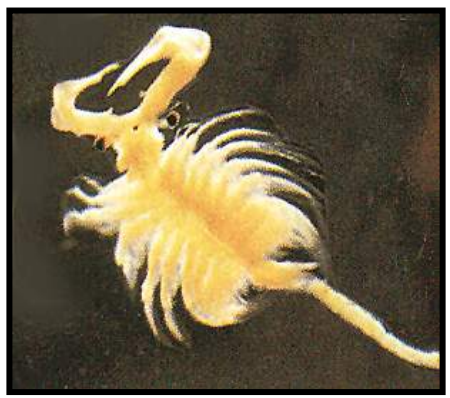


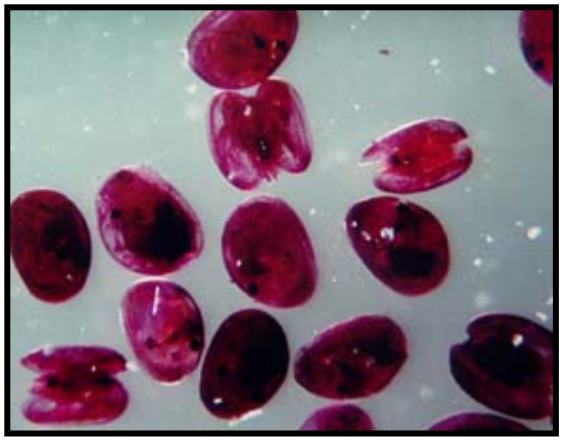
- <u>cephalothorax:</u>
  - 2 pairs of antennae
  - mandibles
  - 1st and 2nd maxillae
  - 3 pairs of maxillipeds
  - 5 pairs of walking legs
- <u>abdomen</u>
  - usually has 6 segments
  - # 1-5 have pairs of swimmerets
  - last segment has a pair of uropods and a telson

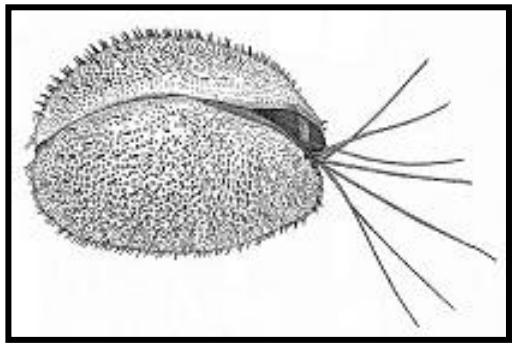
Subphylum Crustacea

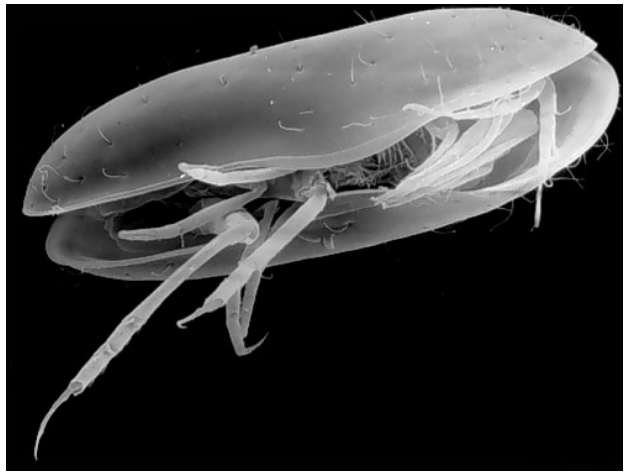
Class Branchiopoda

- sea monkeys and water fleas
- marine and freshwater
- important zooplankton







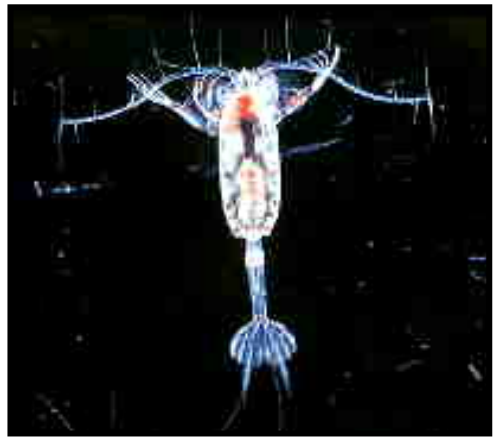


Subphylum Crustacea

Class Ostracoda

- have a bivalved carapace
- marine and freshwater
- reduced number of appendages

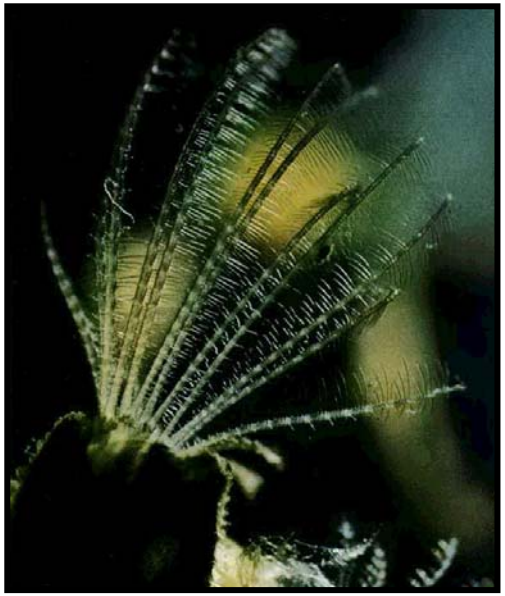




Subphylum Crustacea

Class Copepoda

- mainly marine, some freshwater and terrestrial (e.g. mosses…)
- usually the most abundant animal in the plankton
- median eye
- Extremely long first antennae



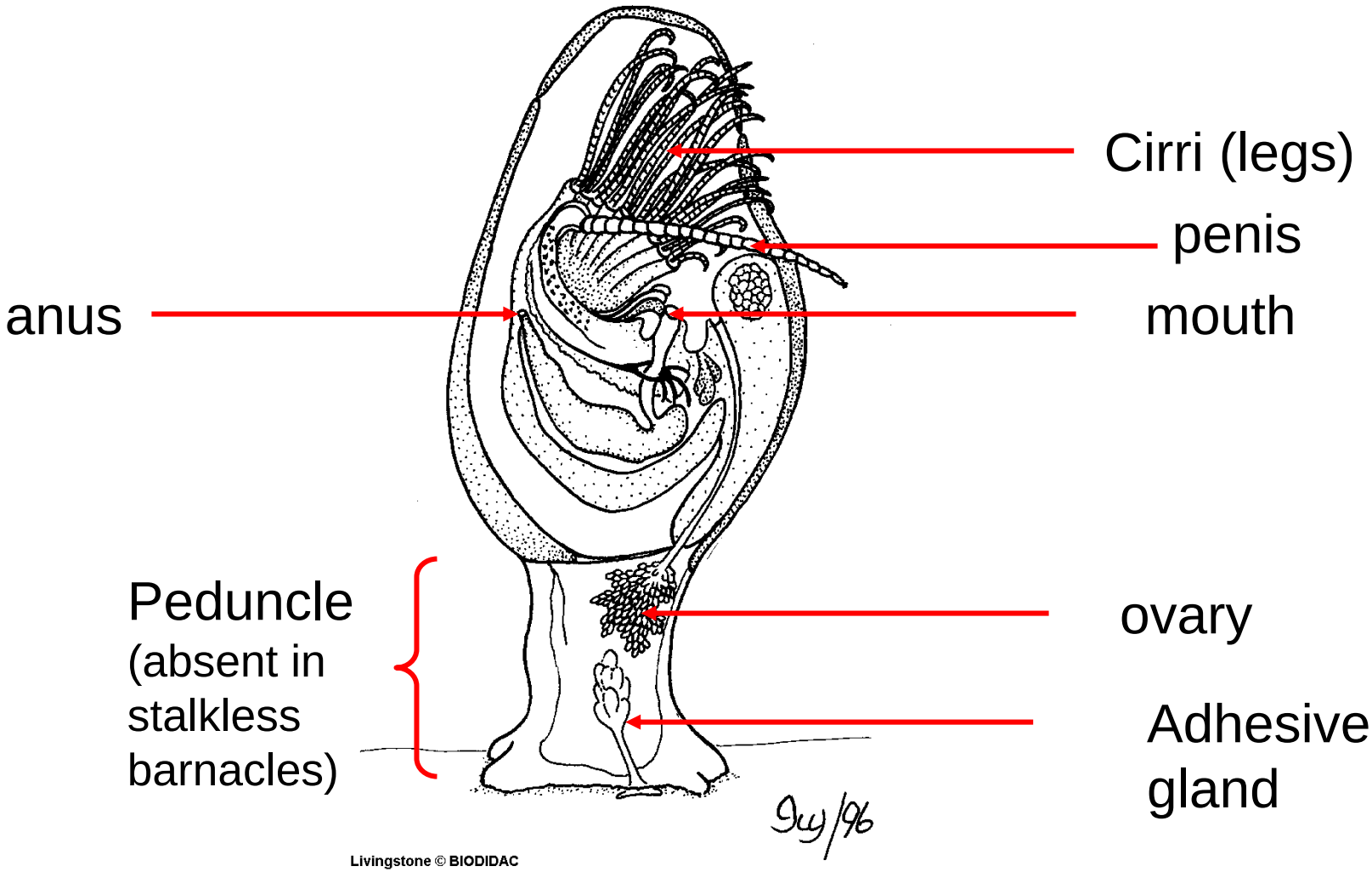
Subphylum Crustacea

Class Cirripedia

- acorn barnacles and gooseneck barnacles
- marine and sessile as adults
- feed with modified appendages called cirri

Class Cirripedia

- **modified body form**



Class Cirripedia

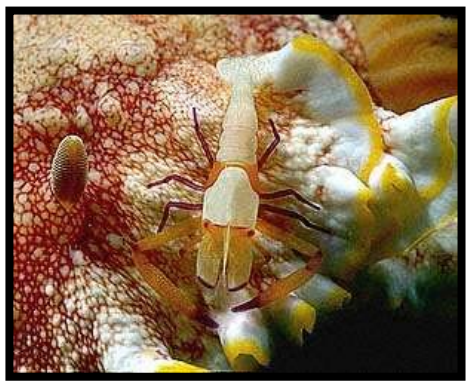
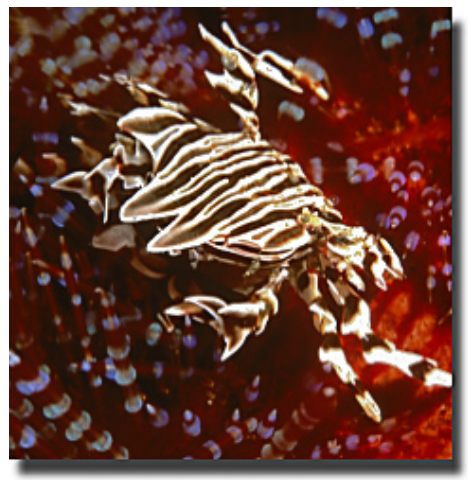
- often form dense mats
- hermaphroditic with long extendable penis to reach neighbors



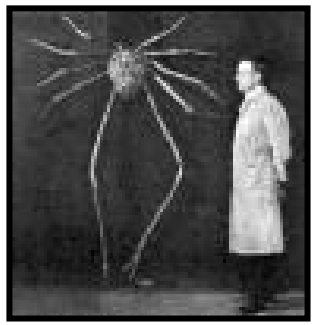

Subphylum Crustacea

Class Malacostraca

- largest class of Crustacea (23,000 species)
- marine, freshwater, terrestrial
- shows great diversity

Class Malacostraca

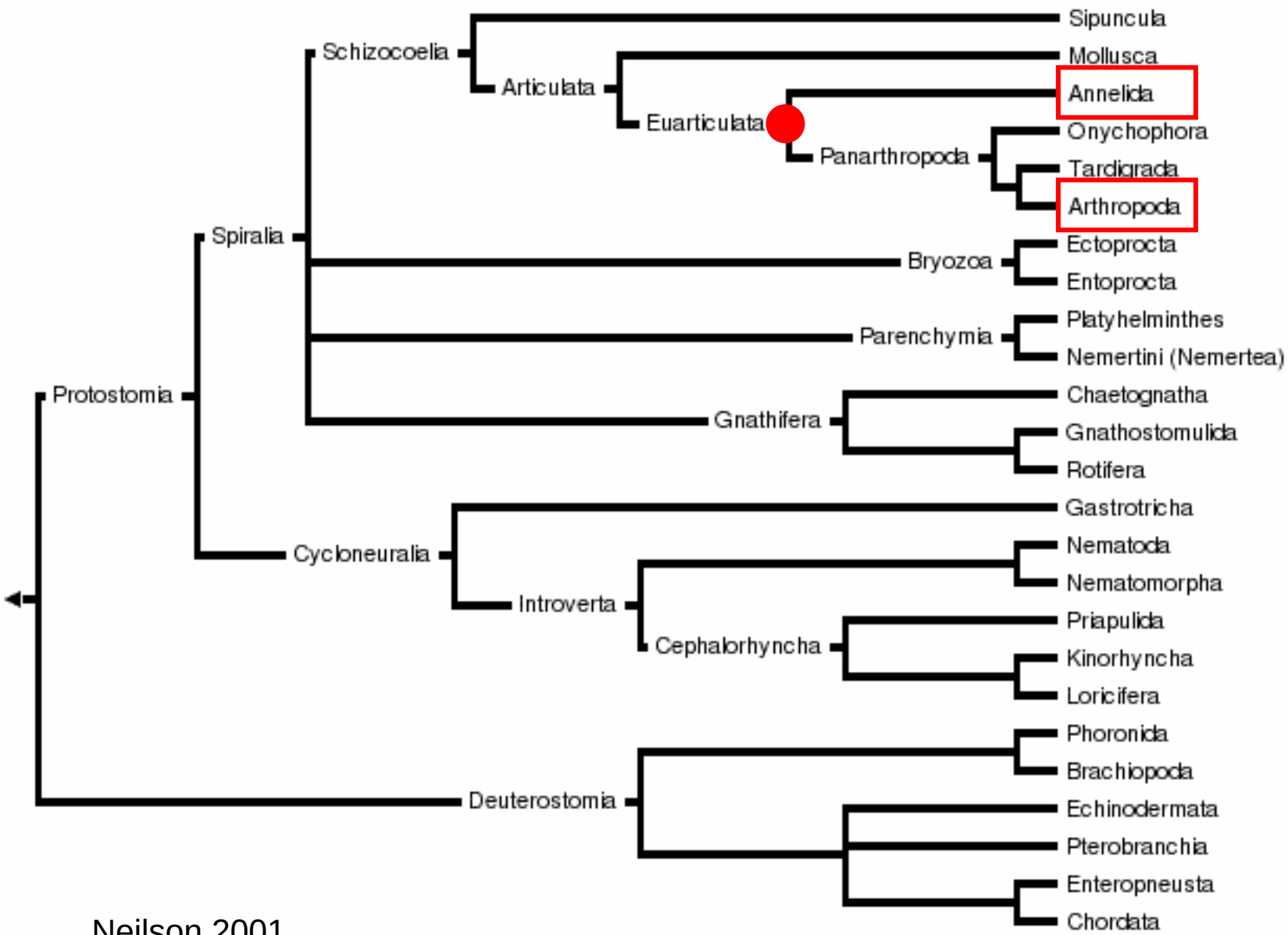


Class Malacostraca contains the largest Arthropods

Who are the Arthropods closest relatives ?

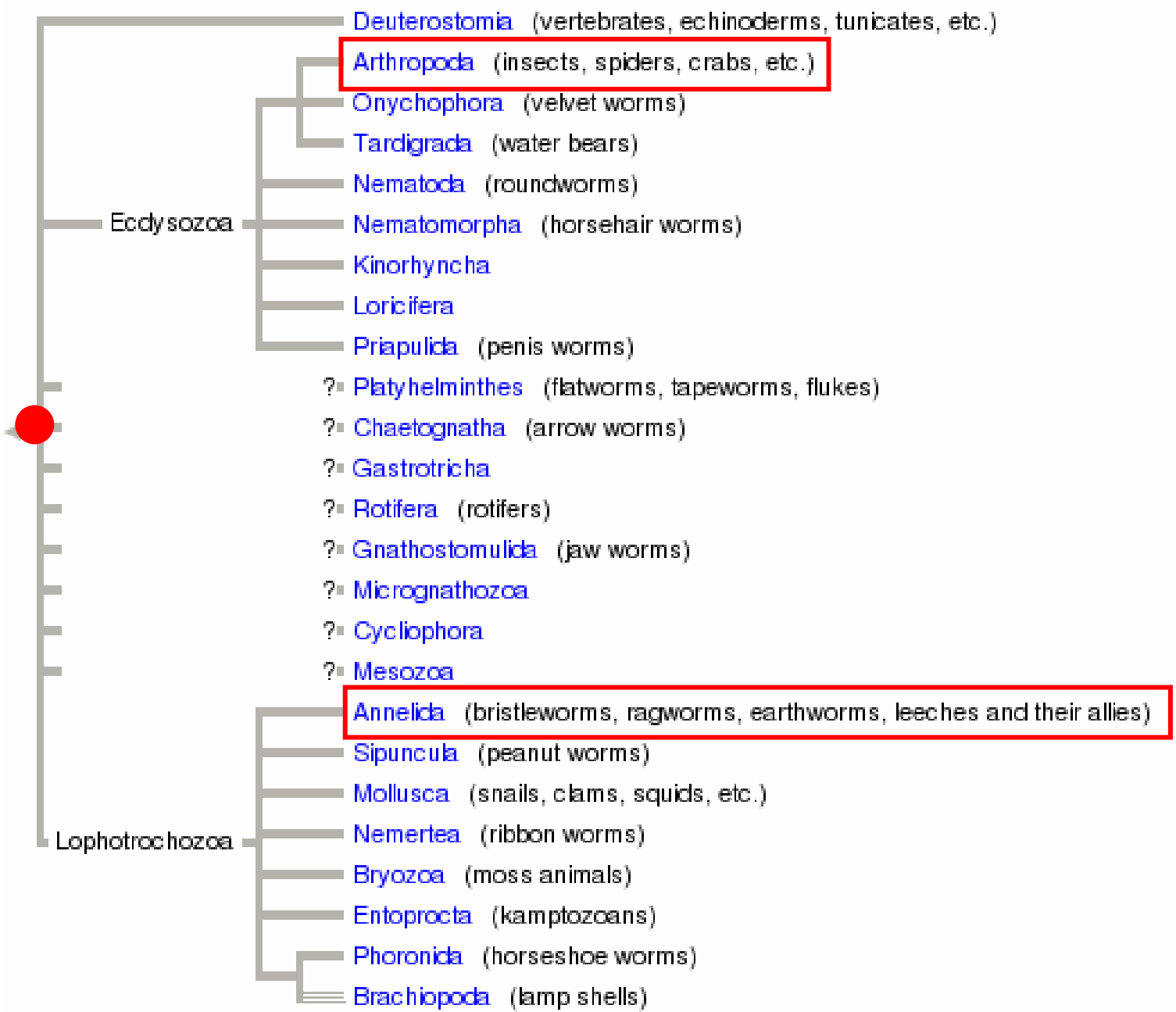
- Traditionally, Arthropods were thought to have derived from an Annelid-like ancestor.

- This hypothesis was based mainly on morphological similarities



Neilson 2001

- A new phylogeny based on RNA sequence data has changed our view of the relationship between Arthropods and Annelids (and many other taxa).
- According to this new view, Arthropods are more closely related to some of the pseudocoelomates (e.g. nematodes) than Annelids.


Deuterostomia (vertebrates, echinoderms, tunicates, etc.)
Arthropoda (insects, spiders, crabs, etc.)
Onychophora (velvet worms)
Tardigrada (water bears)
Nematoda (roundworms)
Ecdysozoa
Nematomorpha (horsehair worms)
Kinorhyncha
Loricifera
Priapulida (penis worms)
?Platyhelminthes (flatworms, tapeworms, flukes)
?Chaetognatha (arrow worms)
?Gastrotricha
?Rotifera (rotifers)
?Gnathostomulida (jaw worms)
?Micrognathozoa
?Cycliophora
?Mesozoa
Annelida (bristleworms, ragworms, earthworms, leeches and their allies)
Sipuncula (peanut worms)
Mollusca (snails, clams, squids, etc.)
Lophotrochozoa
Nemertea (ribbon worms)
Bryozoa (moss animals)
Entoprocta (kamptozoans)
Phoronida (horseshoe worms)
Brachiopoda (lamp shells)