Arthropods

Lec13
fish310

Classification

Phylum Arthropoda

Class Crustacea
- Subclass Malacostraca
  - Order Isopoda—pillbugs, woodlice
  - Order Amphipoda—sand fleas
  - Order Euphausiacea—euphausiids (krill)
  - Order Stomatopoda—stomatopods
  - Order Decapoda—crabs, lobsters, shrimp, hermit crabs
- Subclass Branchiopoda—brine (fairy) shrimp, clam shrimp, water fleas
- Subclass Ostracoda—the ostracods
- Subclass Copepoda—the copepods
- Subclass Pentastomida
- Subclass Cirripedia—the barnacles

Class Crustacea

- Head bear 5 pairs of appendages, including 2 antennae

- Development includes a triangular larval form (the nauplius)

Defining Characteristics

Classification

Phylum Arthropoda

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- Subclass Copepoda—the copepods
- Subclass Pentastomida
- Subclass Cirripedia—the barnacles

Subclass Malacostraca

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

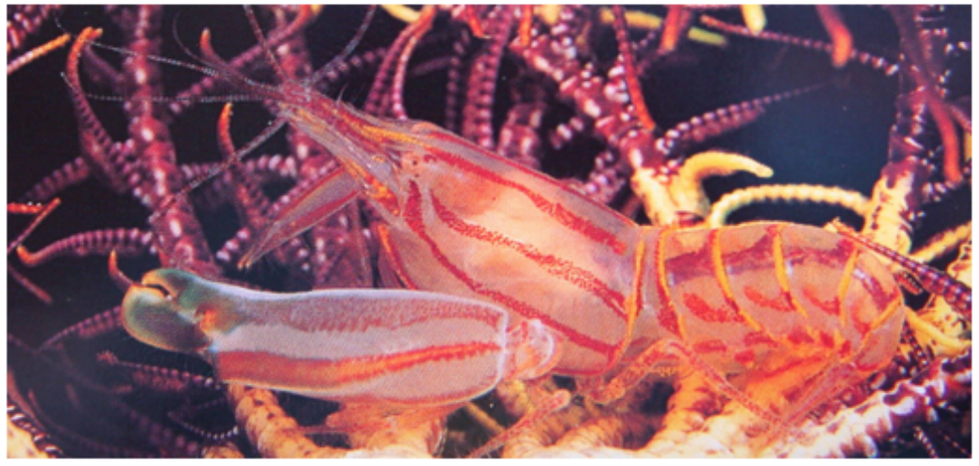
- Thorax with 8 segments, abdomen with 6 to 7 segments plus a telson

- Appendages on the sixth abdominal segment are flattened to form uropods

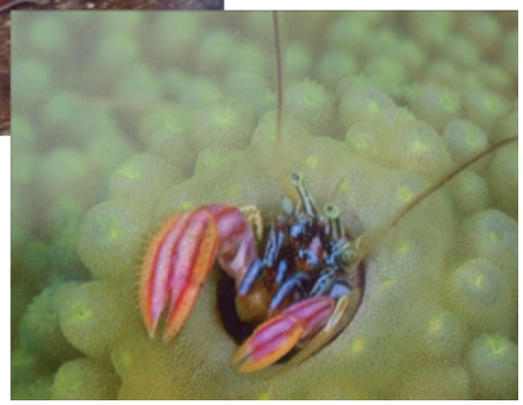
Subclass Malacostraca

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- **Most familiar forms:**
  - **Shrimps**

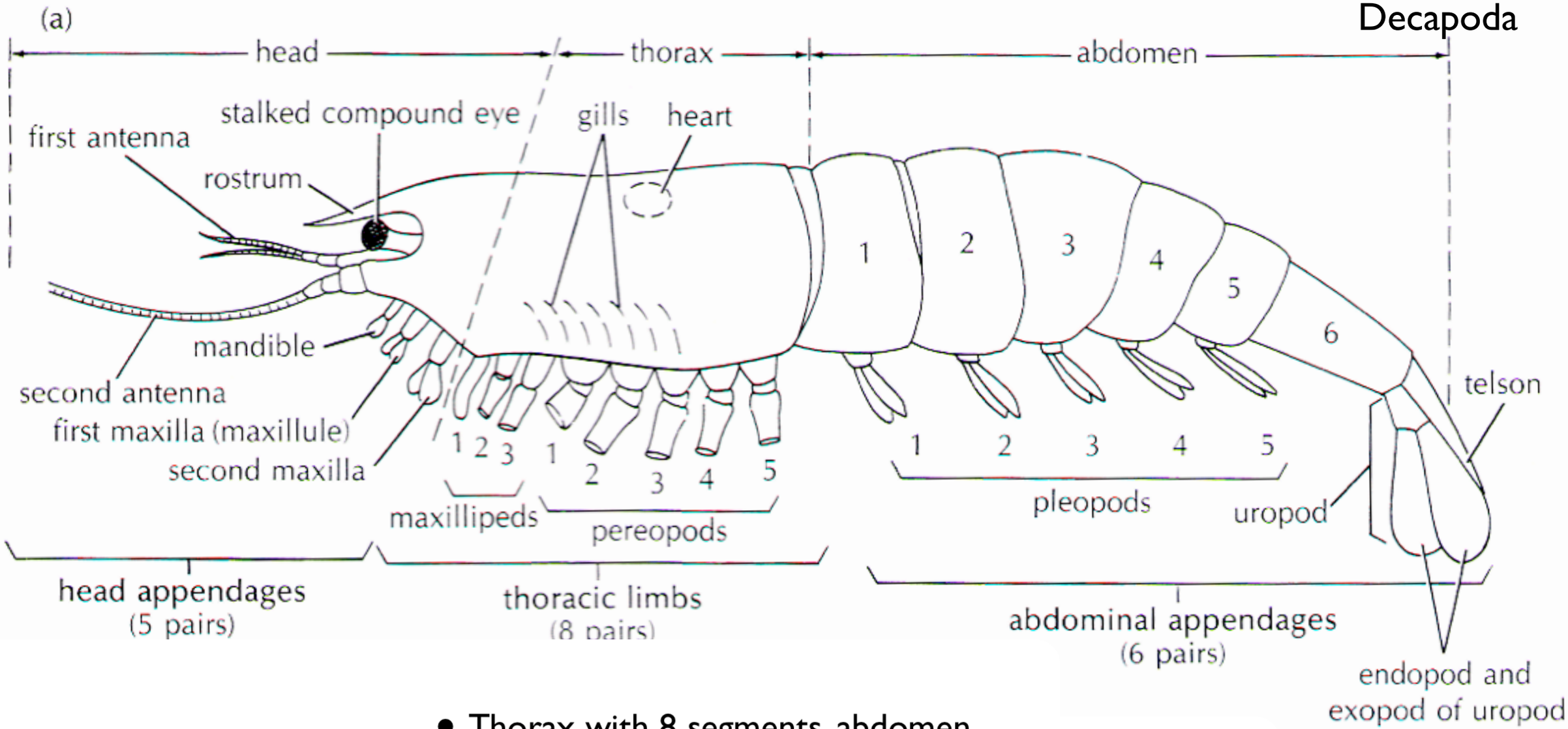


  - **Crabs**
  - **Lobsters**



Subclass Malacostraca

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda



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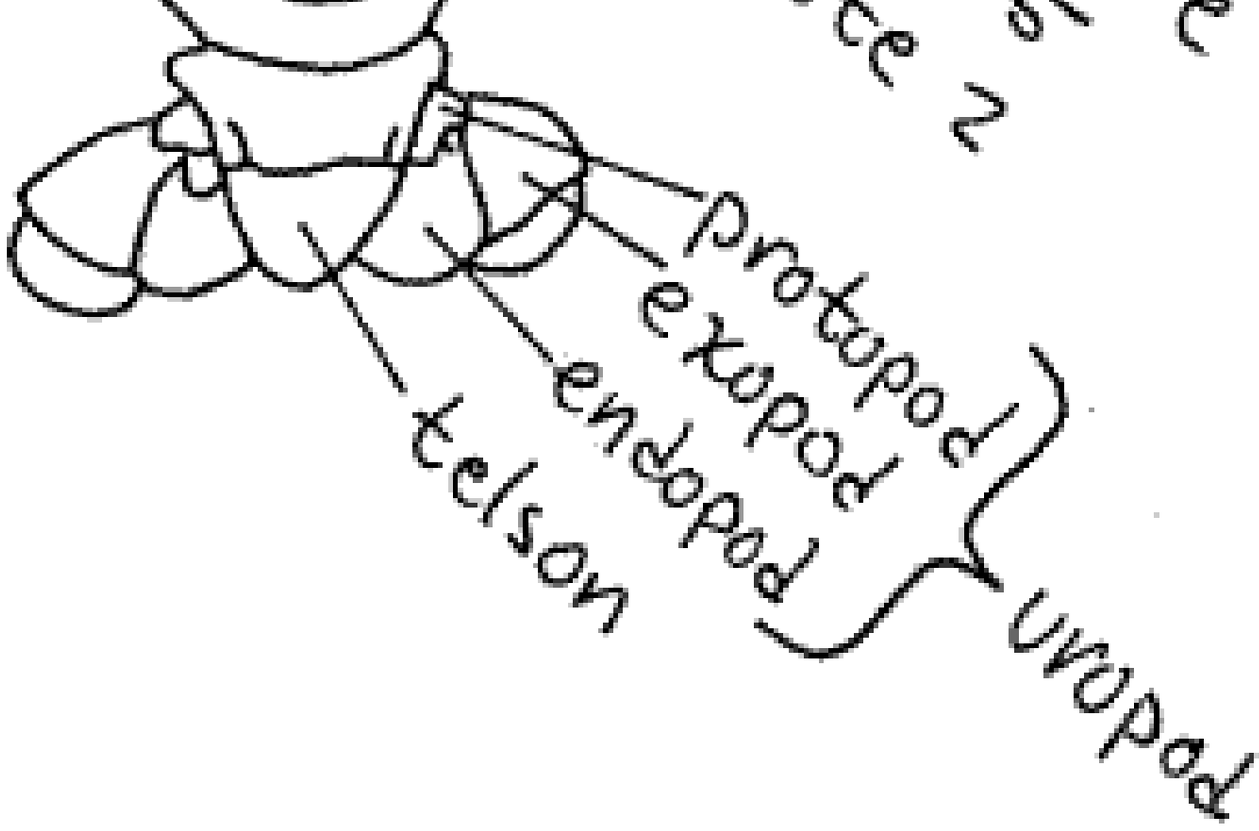
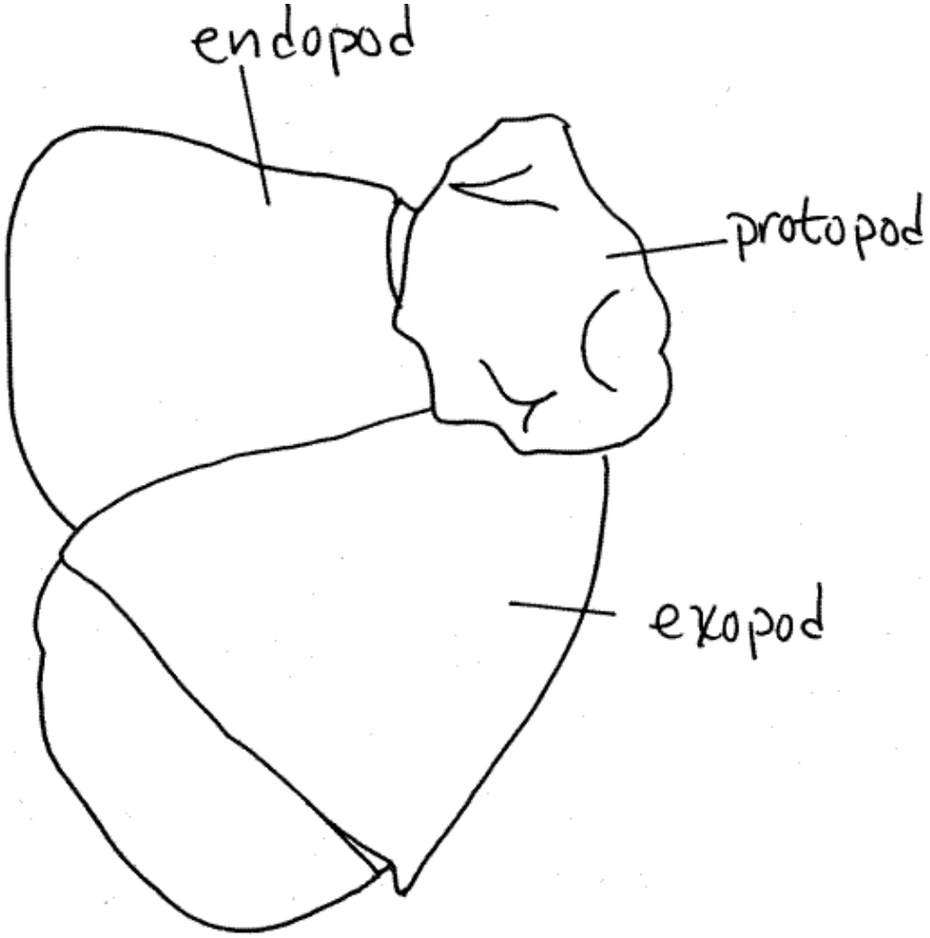
- Appendages on the sixth abdominal segment are flattened to form uropods



Uropod



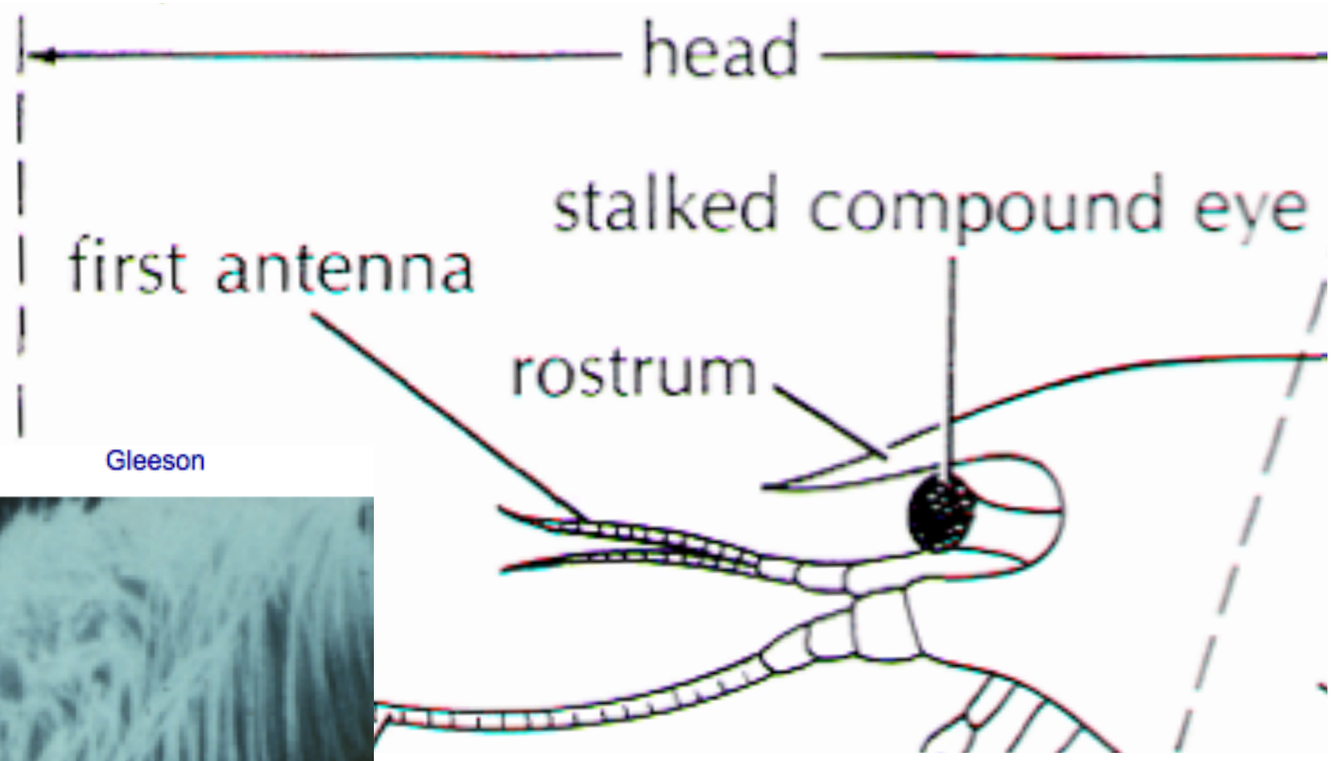
Invertebrate Zoology OnLine

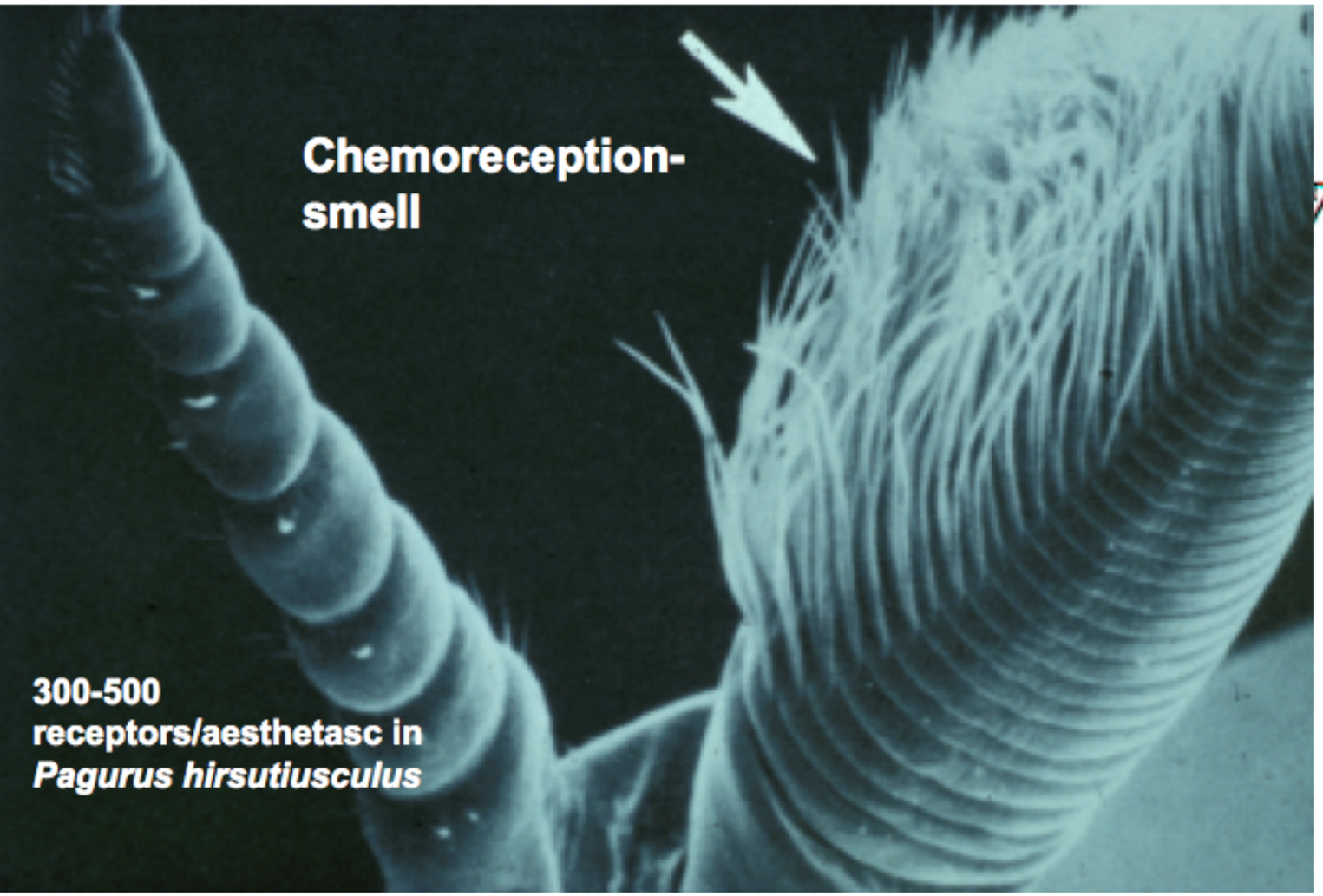
Richard Fox, Lander University

http://webs.lander.edu/rsfox/invertebrates/

Subclass Malacostraca

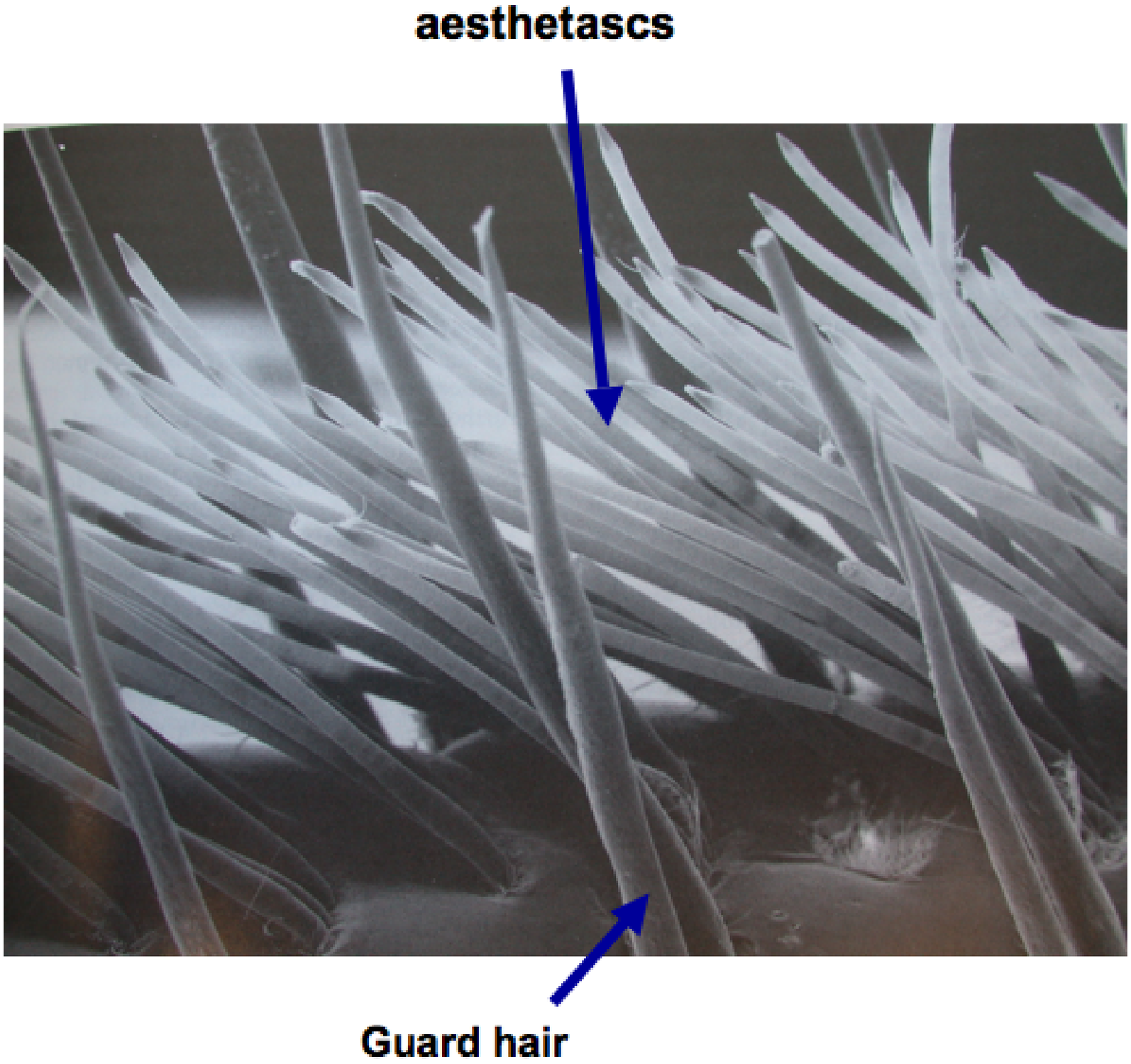
Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda





Subclass Malacostraca

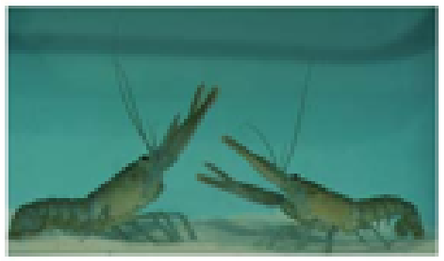
Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

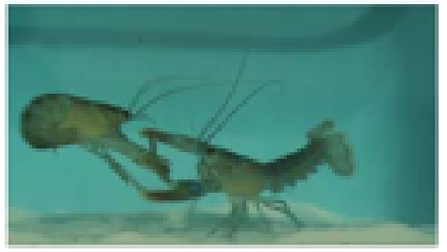


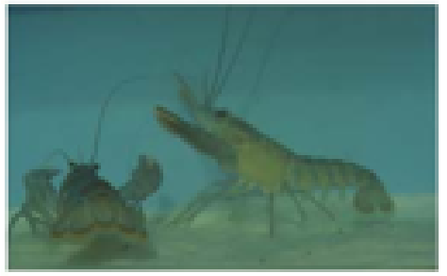
The olfactory pathway for individual recognition in the American lobster *Homarus americanus*

Meg E. Johnson* and Jelle Atema†

Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543, USA







- Lobsters with shaved aesthetascs did not recognize opponents

??

- Aesthetascs of contain chemoreceptors necessary for individual recognition

URINE RELEASE IN FREELY MOVING CATHETERISED LOBSTERS (*HOMARUS AMERICANUS*) WITH REFERENCE TO FEEDING AND SOCIAL ACTIVITIES

THOMAS BREITHAUPT[1,*], DANIEL P. LINDSTROM[2] AND JELLE ATEMA[3]

[1]*Fakultät für Biologie, Universität Konstanz, Postfach 5560 (M618), D-78457 Konstanz, Germany,* [2]*Gordon College, Wenham, MA 01984, USA* and [3]*Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543, USA*

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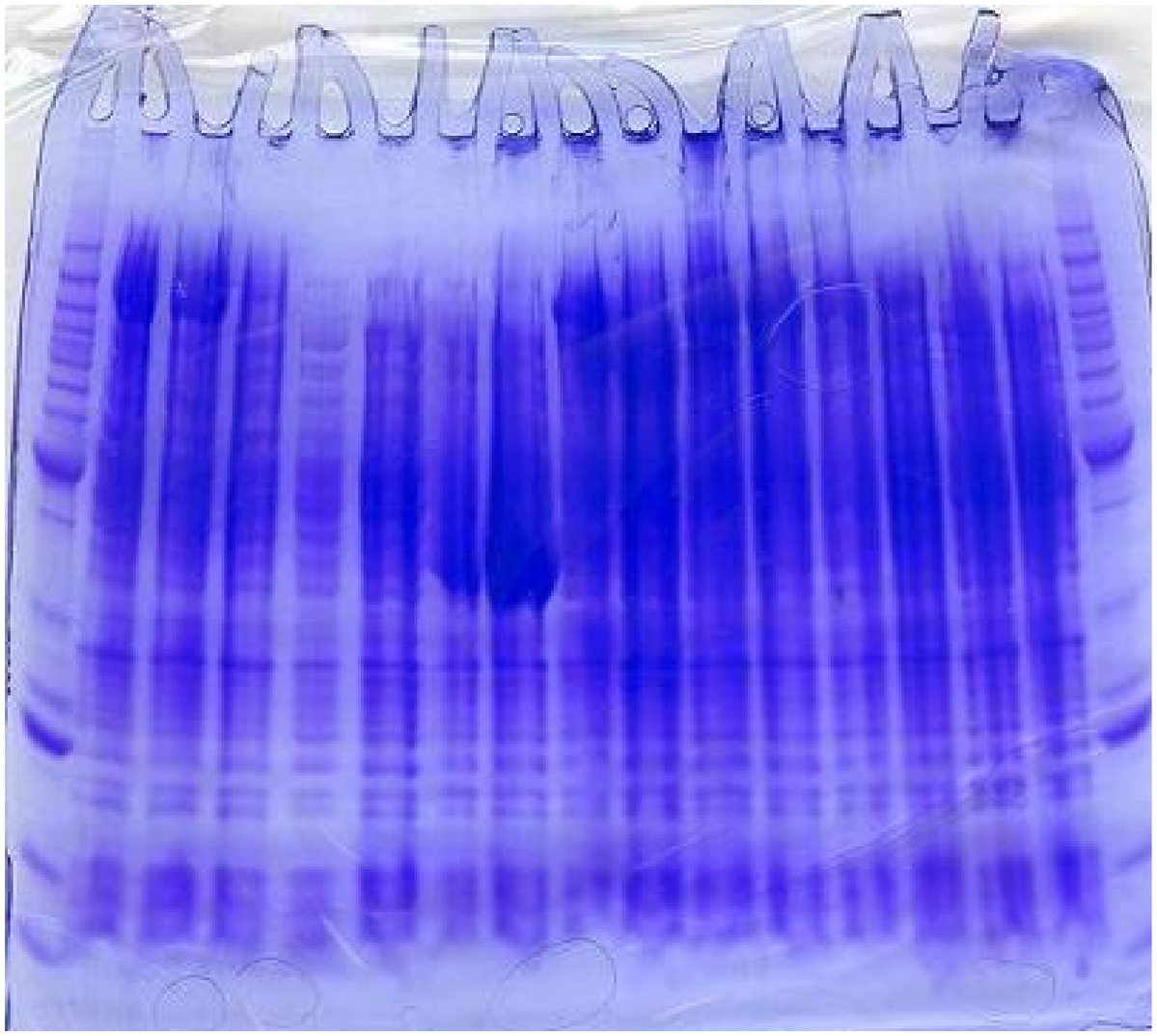
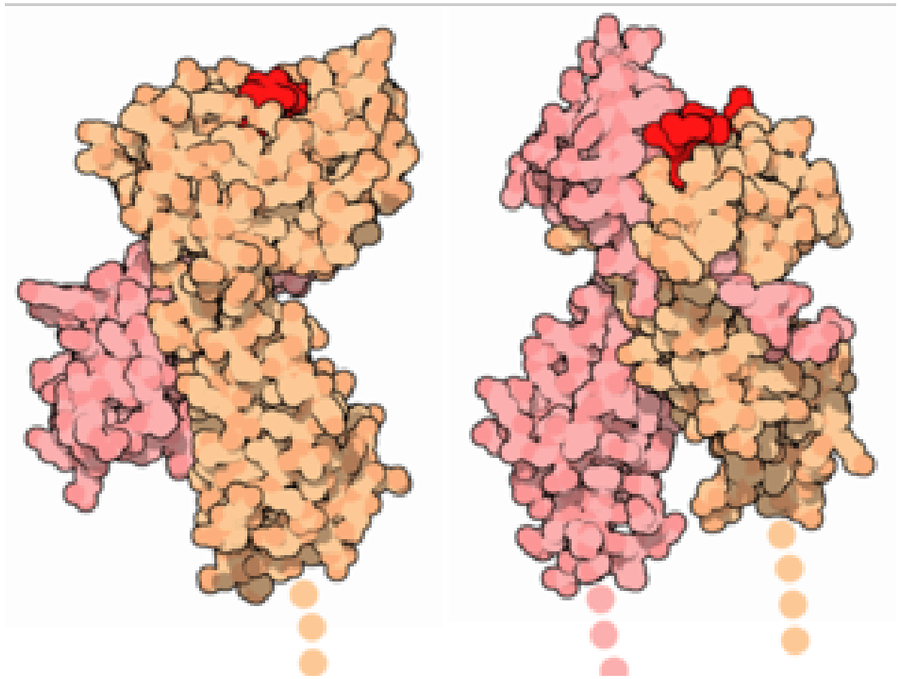




Subclass Malacostraca

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

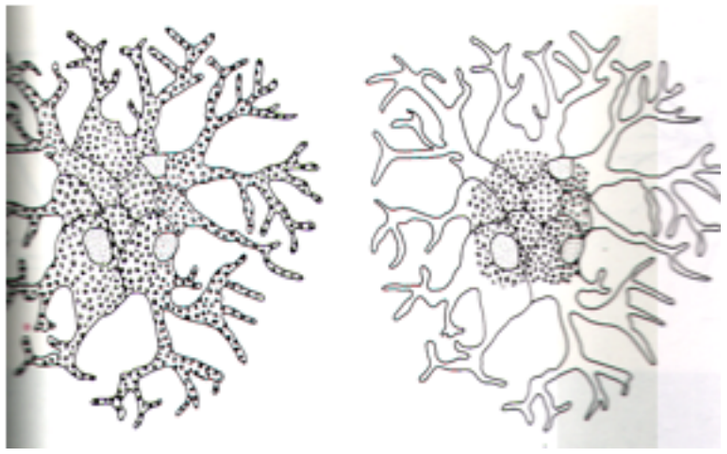
Chromatophores

Group of cells

Pigment granules move within cells

White, red, yellow, blue, brown, and black pigments have been observed.
-Red, yellow, blue - derived from diet
-astaxanthin- organic pigment conjugated in exoskeleton
Boiling breaks this conjugation
Food dye

Controlled by hormones from sinus gland



Classification

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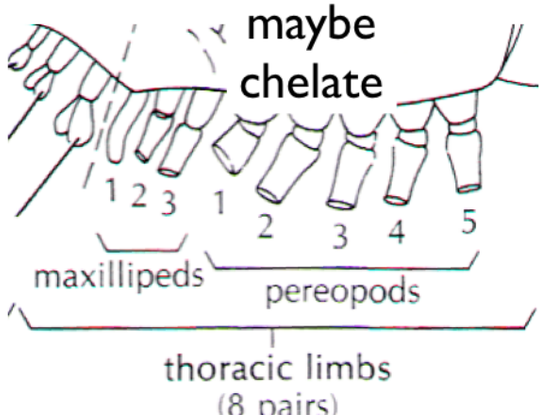
- Subclass Pentastomida
- Subclass Cirripedia—the barnacles

Subclass Malacostraca

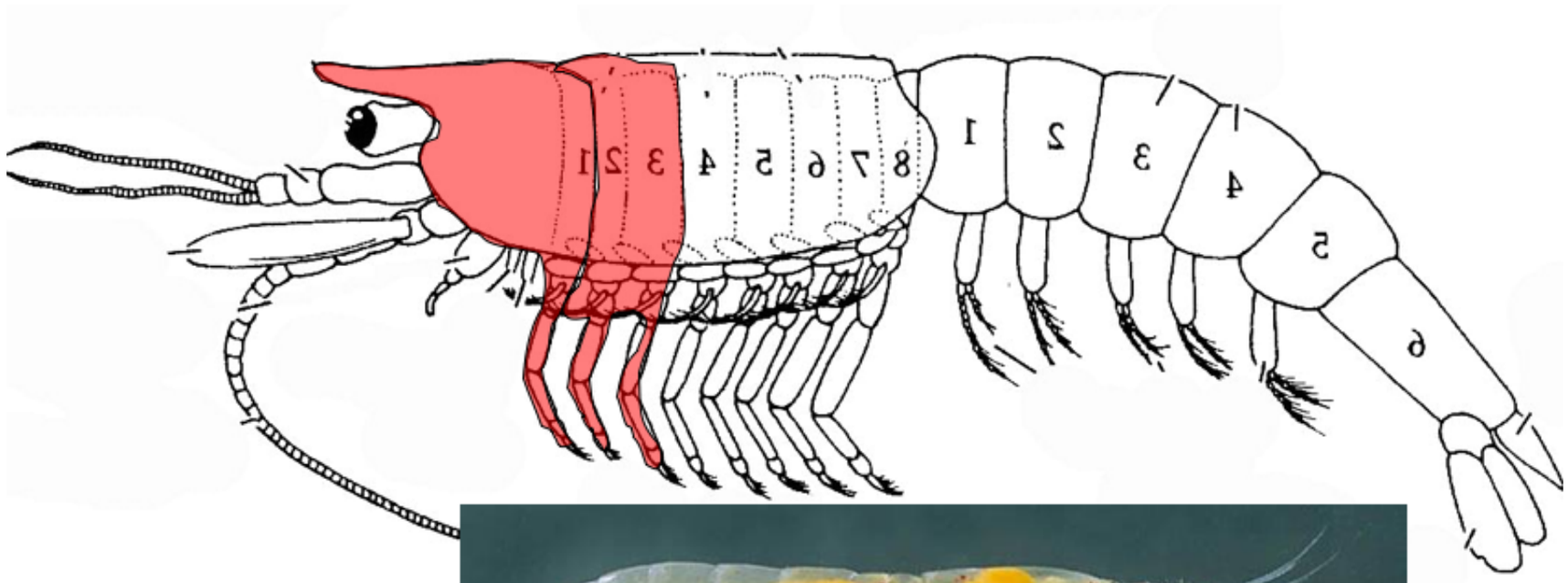
Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- Order Stomatopoda
- Order Isopoda
- Order Amphipoda
- Order Euphausiacea
- Order Decapoda

Decapods



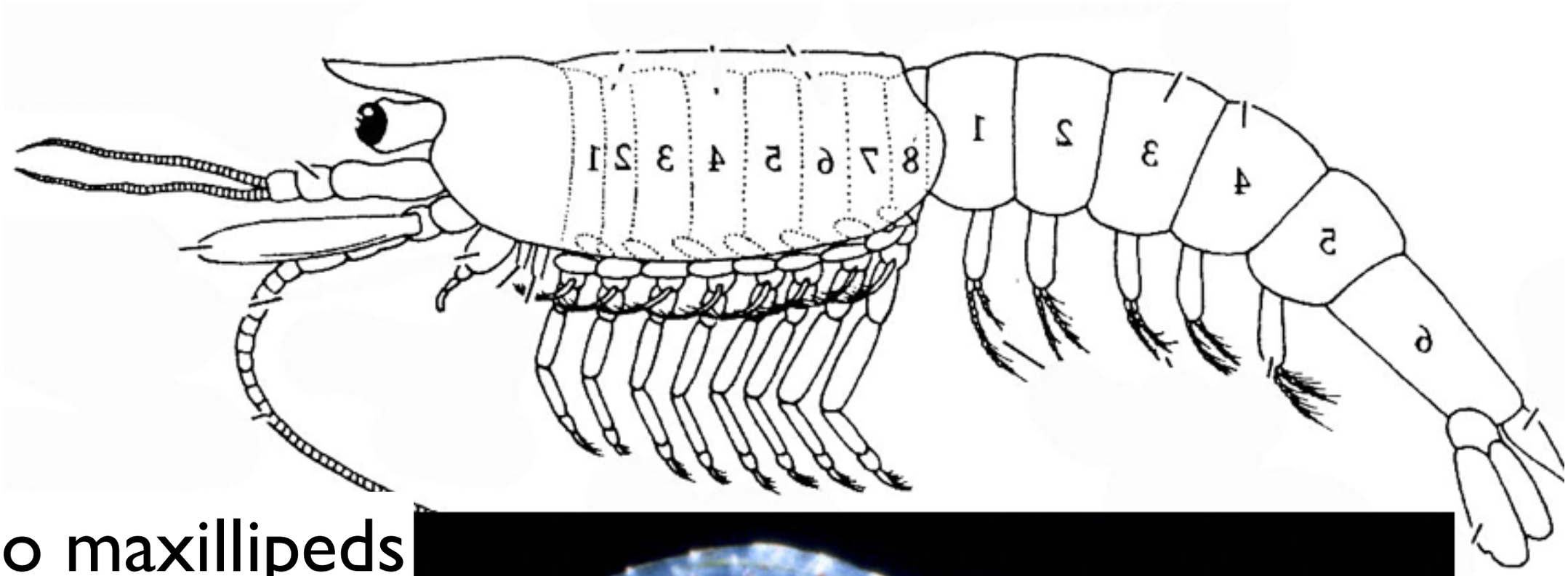
Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda



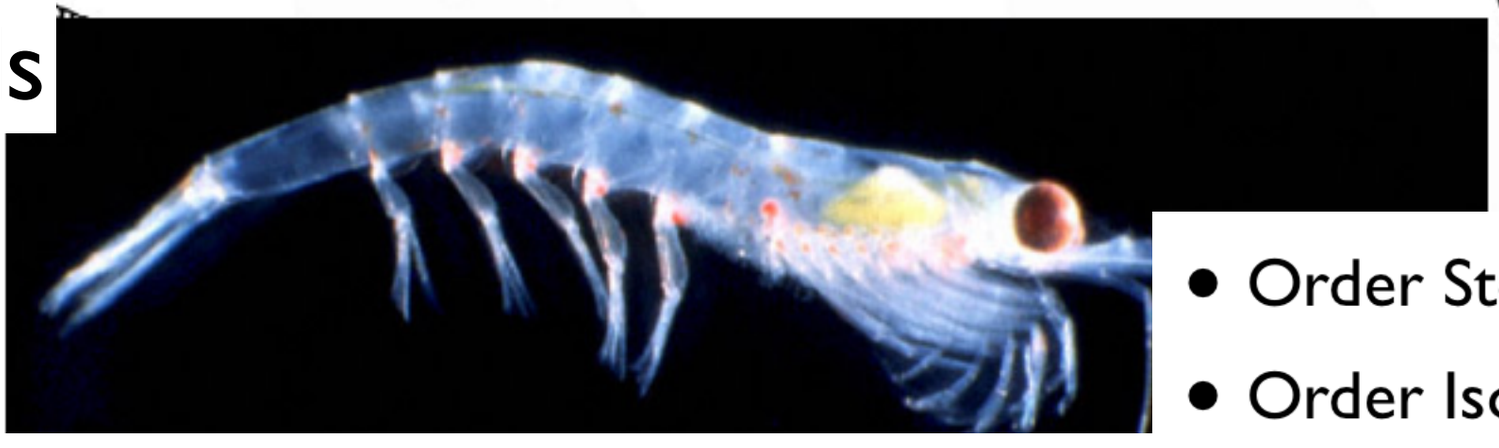
- Order Stomatopoda
- Order Isopoda
- Order Amphipoda
- Order Euphausiacea
- Order Decapoda

Euphausiid (krill)

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda



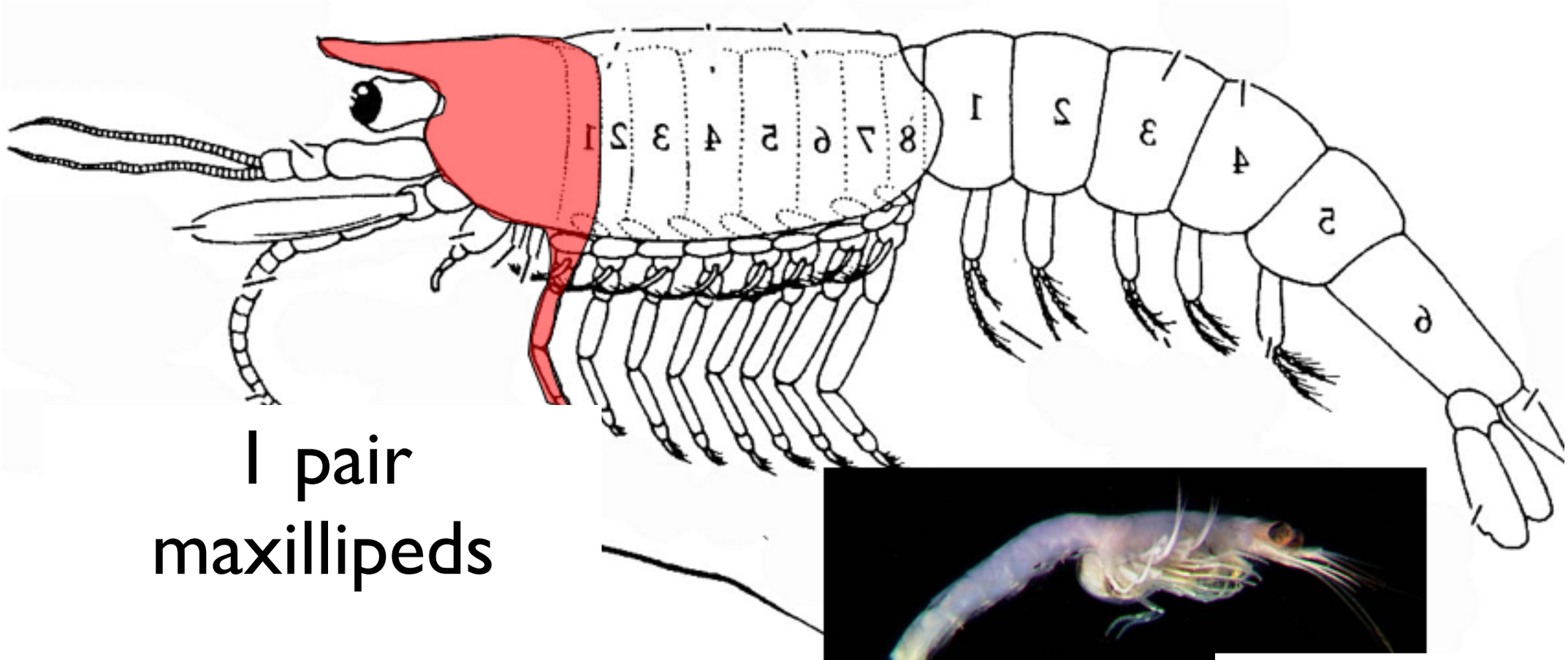
No maxillipeds



- Order Stomatopoda
- Order Isopoda
- Order Amphipoda
- Order Euphausiacea
- Order Decapoda

Isopods, amphipods

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

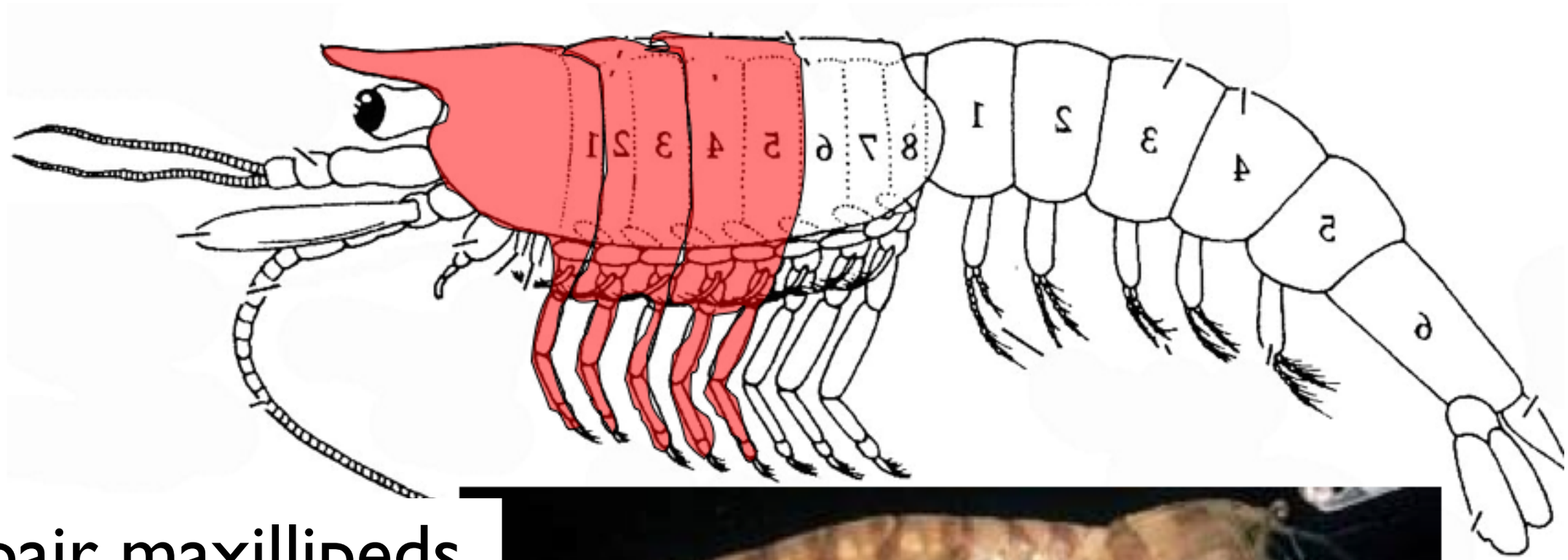


1 pair maxillipeds

- Order Stomatopoda
- Order Isopoda
- Order Amphipoda
- Order Euphausiacea
- Order Decapoda

Stomatopods

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

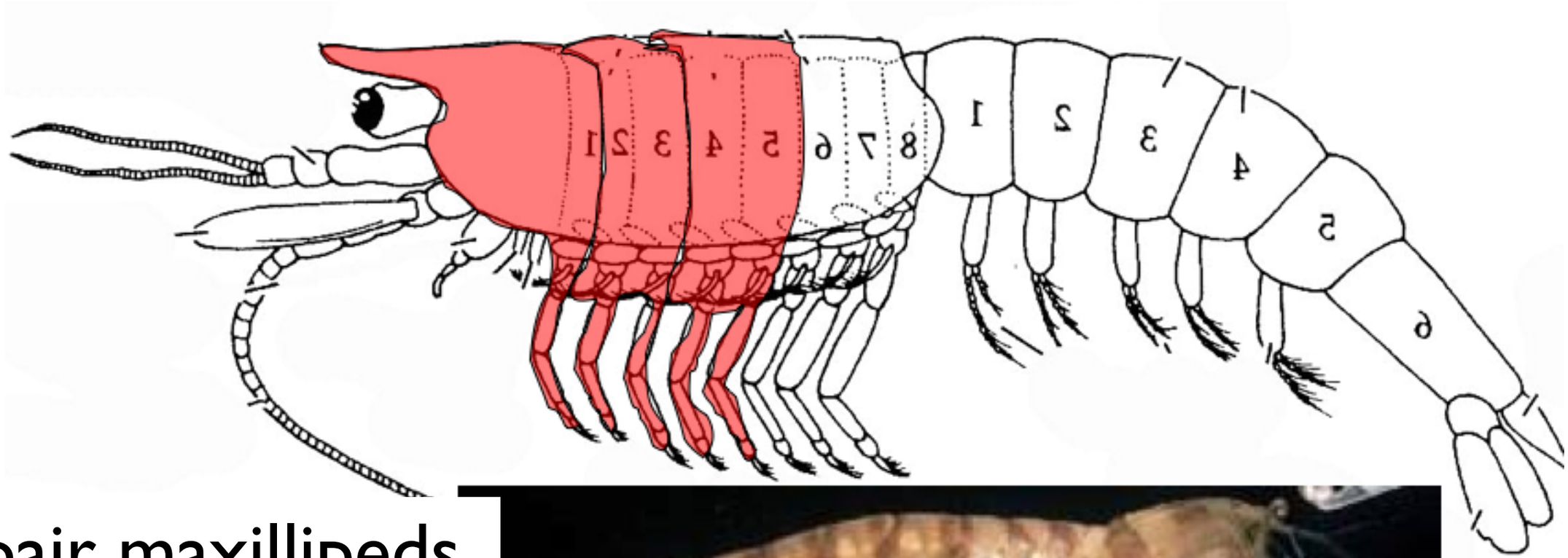


5 pair maxillipeds

- Order Stomatopoda
- Order Isopoda
- Order Amphipoda
- Order Euphausiacea
- Order Decapoda

Stomatopods

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda



5 pair maxillipeds

subchelate

2nd - *raptorial*

Order Stomatopoda

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

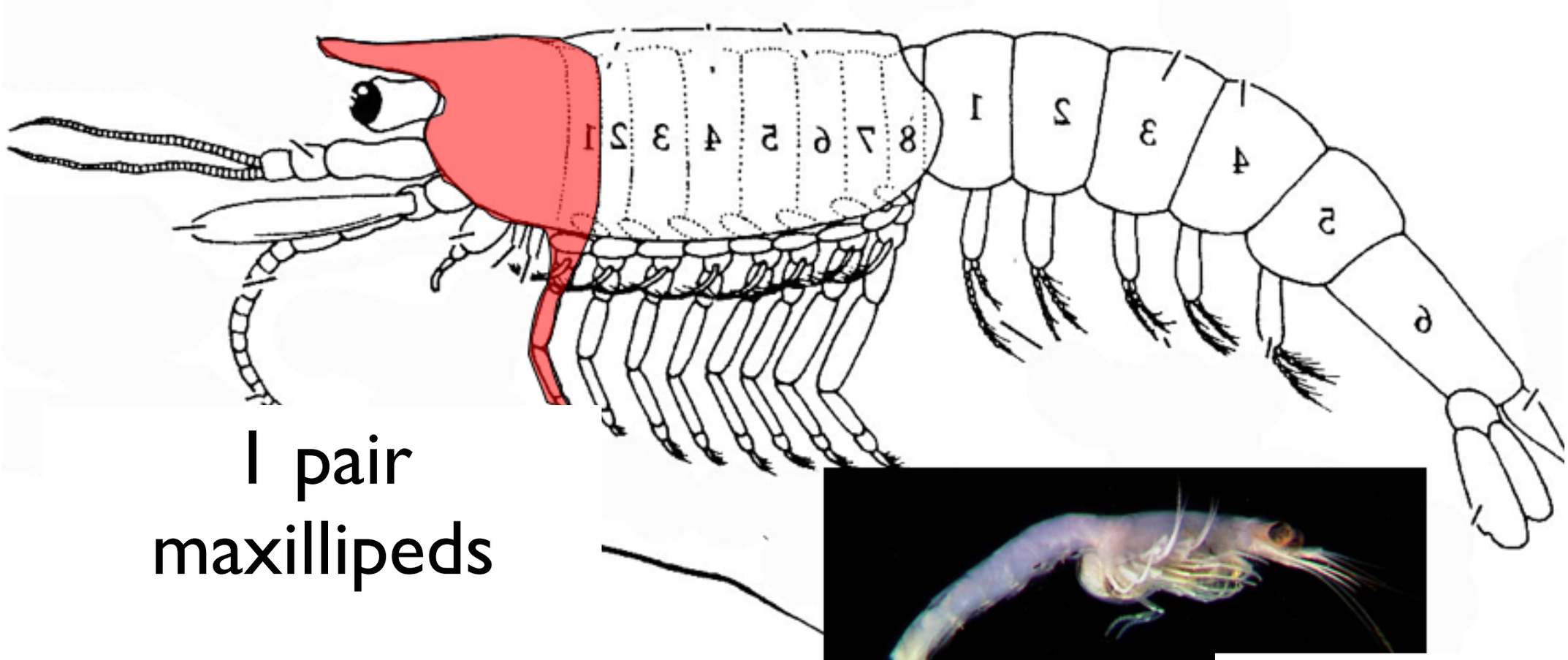
Order Stomatopoda

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- **Humans: 3 color receptors**
- **Mantis shrimp: 10-11, plus 6 filters for at least 16 types**
- **Color and polarized light in center part**

Isopods, amphipods

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda



1 pair maxillipeds

- Order Stomatopoda
- Order Isopoda
- Order Amphipoda
- Order Euphausiacea
- Order Decapoda

Order Isopoda

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

Order Isopoda

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

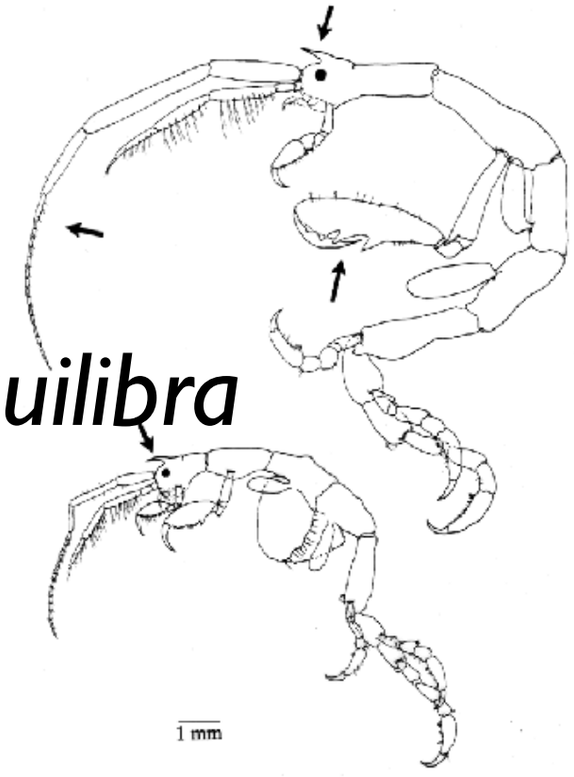
- > 10, 000 species
- most are marine, some terrestrial (pill bugs)
- no carapace
- single pair of _____

Order Amphipoda

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

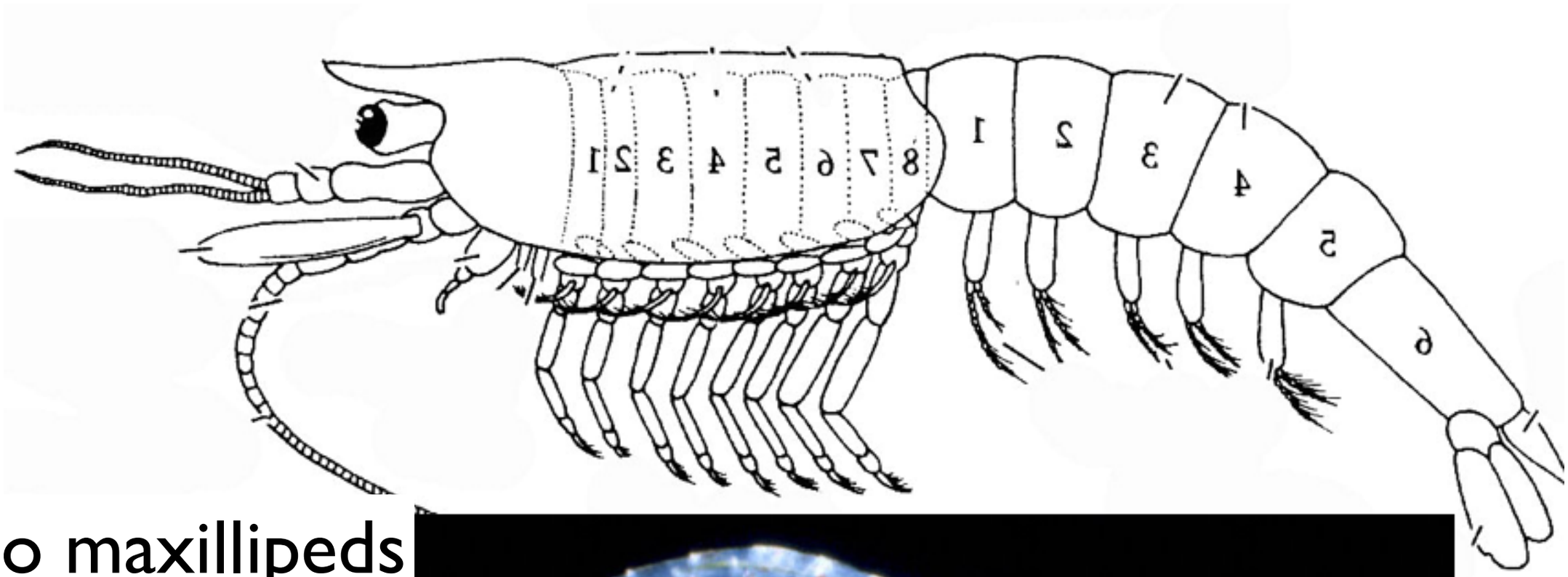
- Tend to be flattened laterally
- Sessile compound eyes
- Gills found on thorax, attached to pereopods

Caprella equilibra

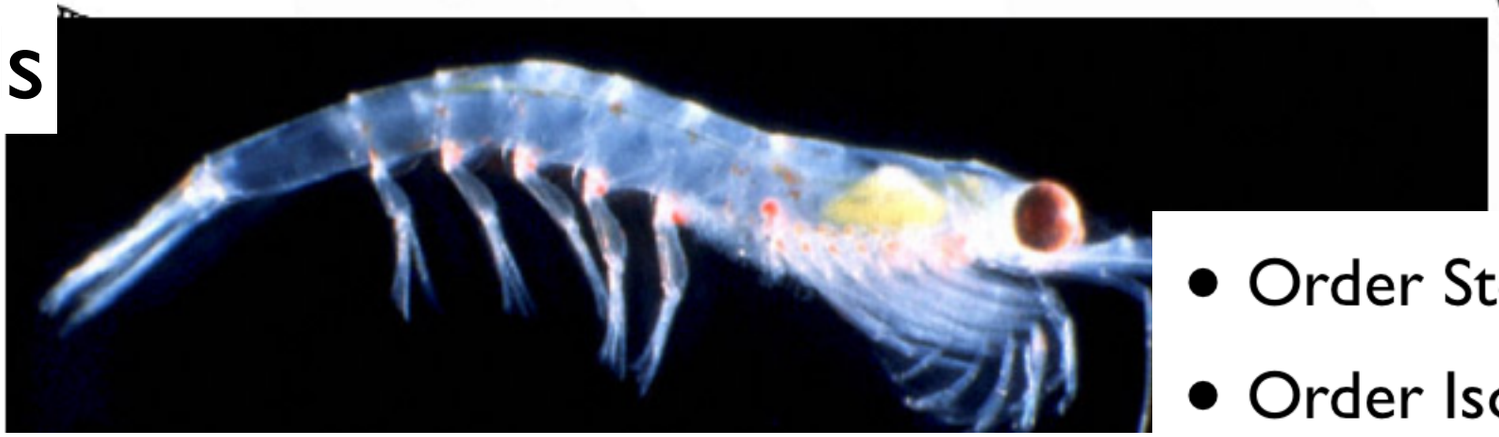


Euphausiid (krill)

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda



No maxillipeds



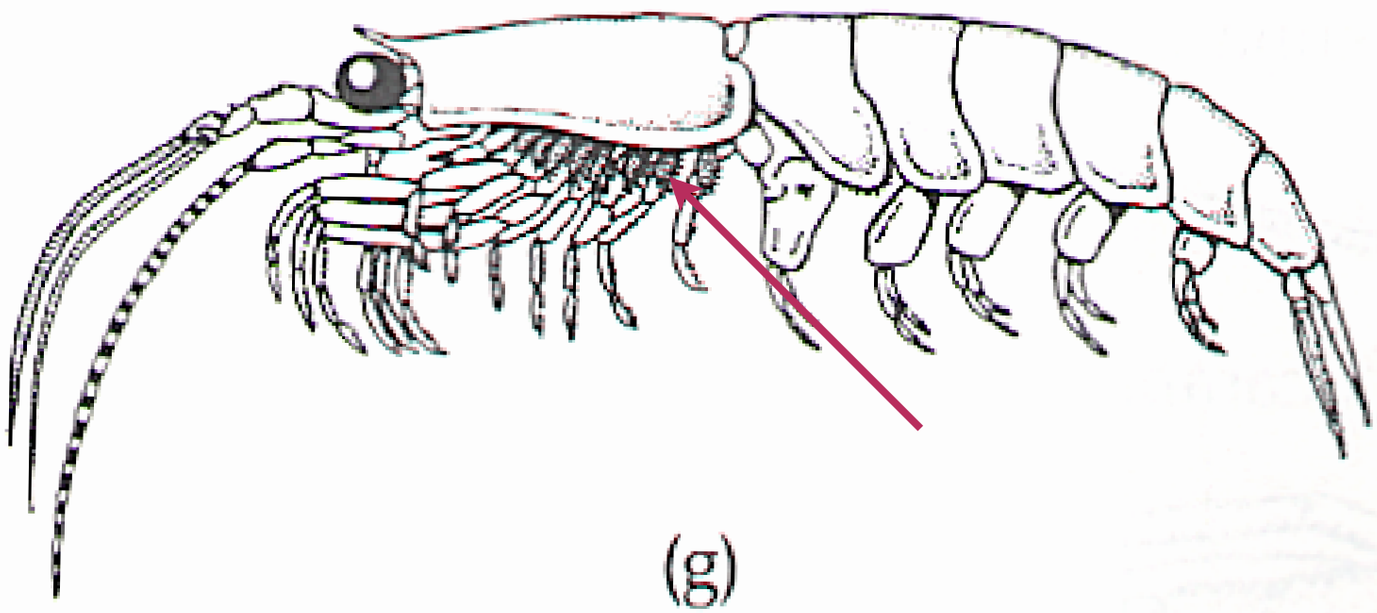
- Order Stomatopoda
- Order Isopoda
- Order Amphipoda
- Order Euphausiacea
- Order Decapoda

Order Euphasiacea

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- 85 described species
- Diet of seals and baleen whales
- Can survive > 200 days without food in lab

significance?



Order Euphasiacea

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

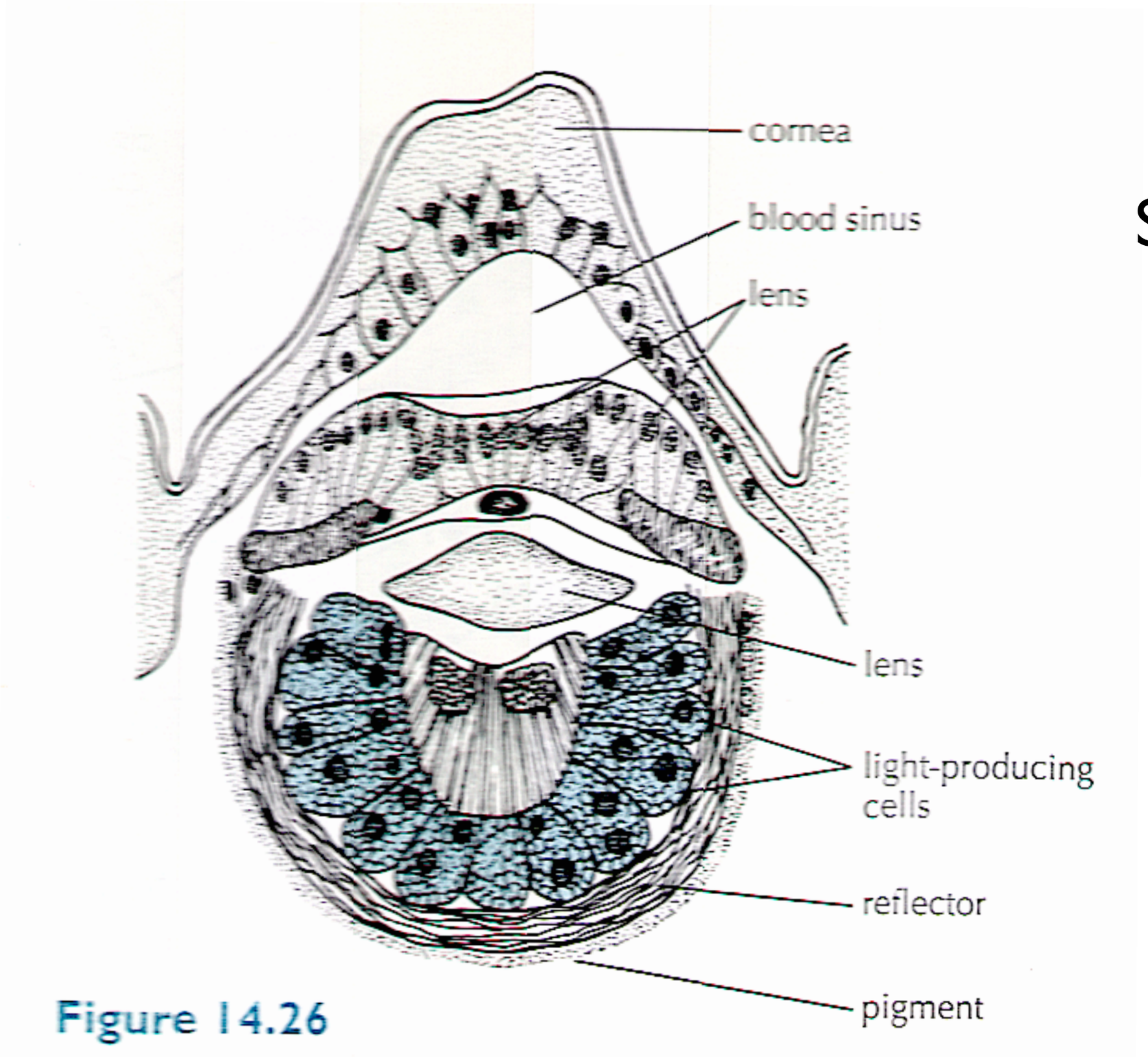


Figure 14.26

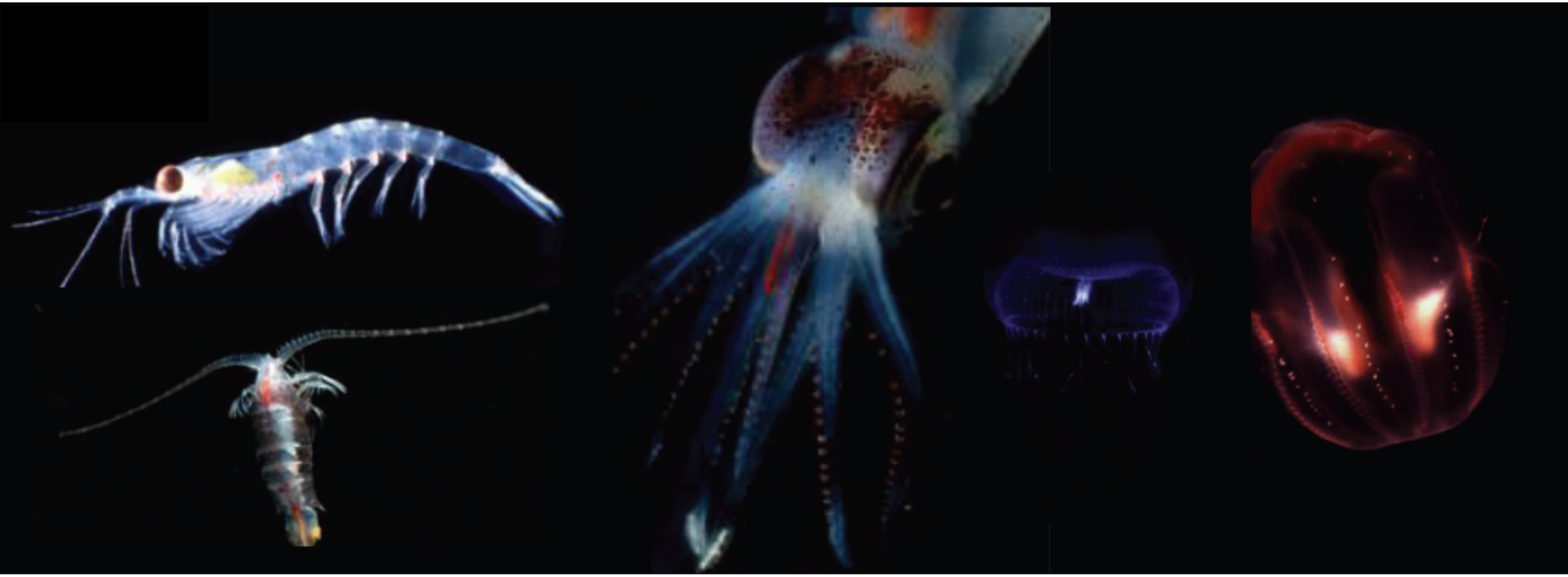
Species specific

and...

Order Euphasiacea

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

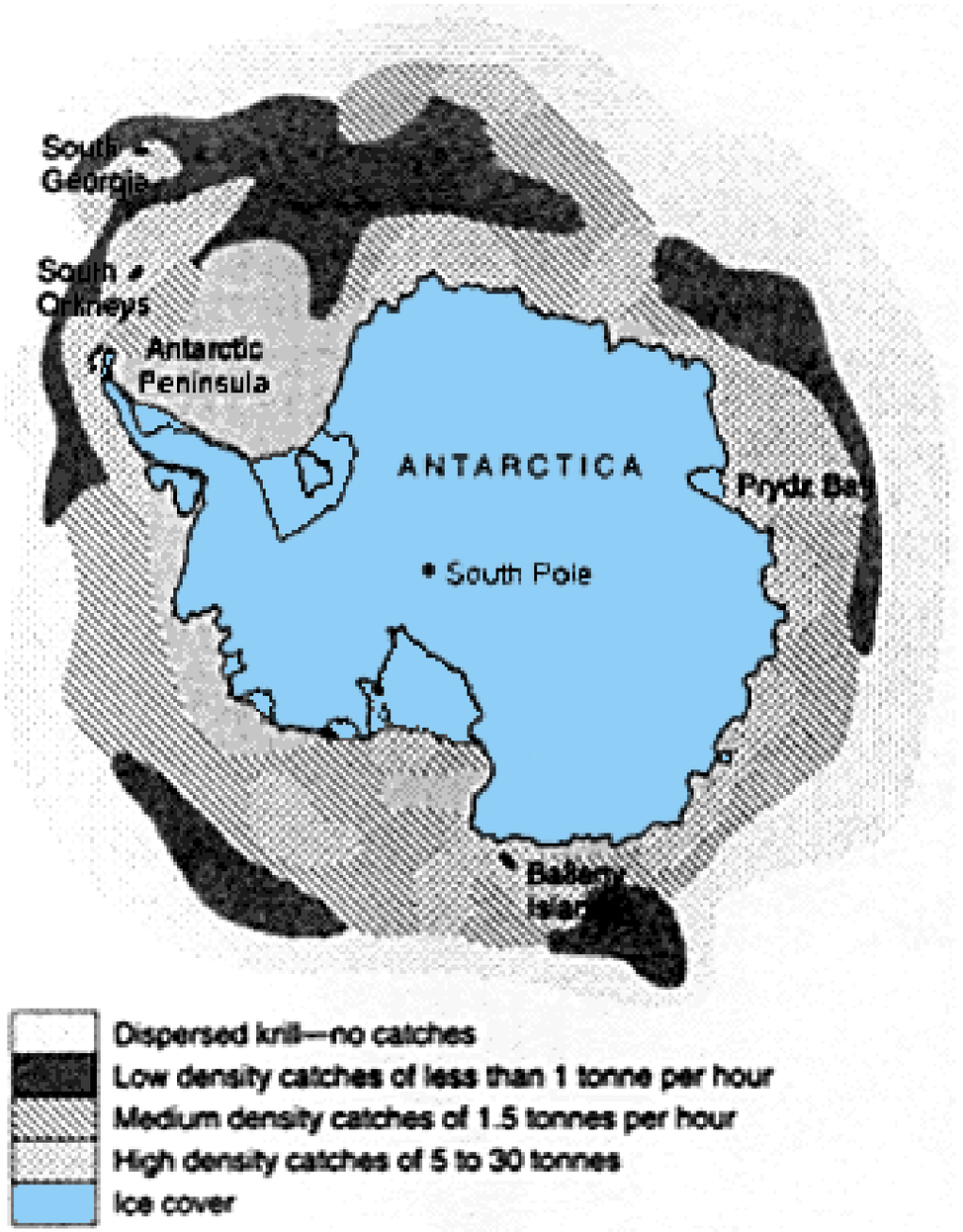
- Chemiluminescence reaction - luciferin is activated by a luciferase enzyme.
- Krill probably do not produce this substance themselves but acquire it as part of their diet that contains dinoflagellates.



Economy

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- Japan, Russia and South Korea
  - largest consumers



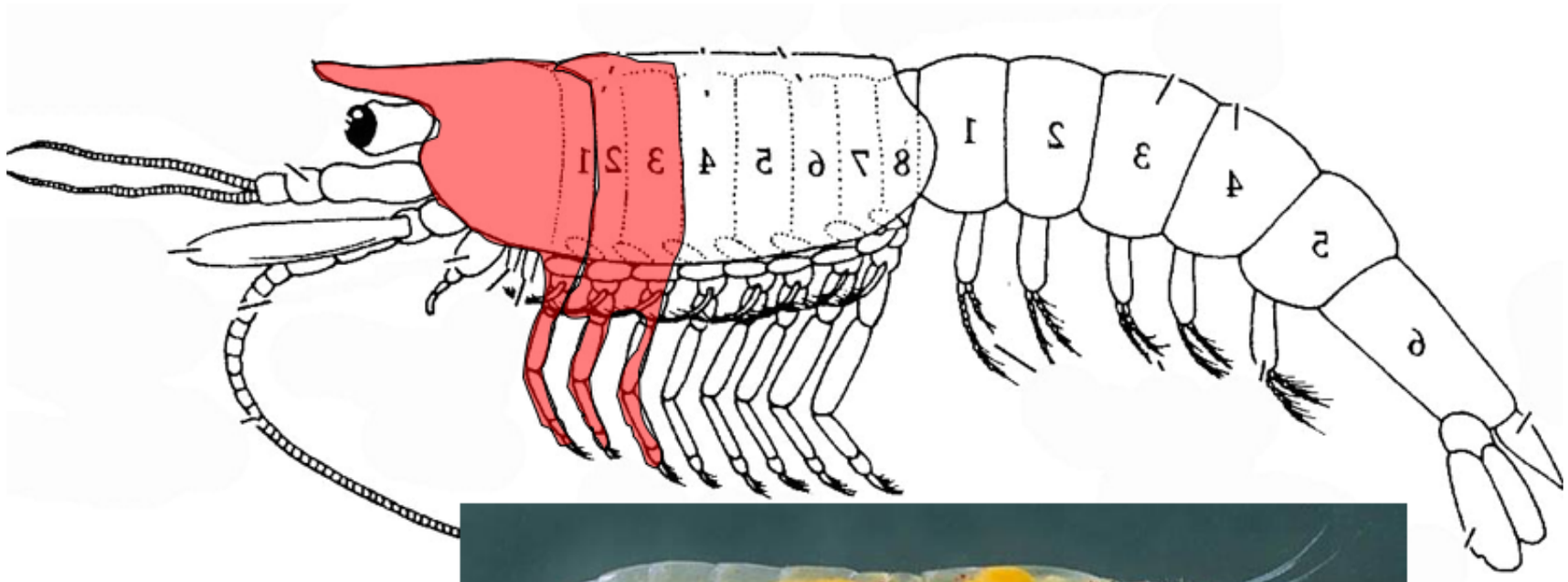
Subclass Malacostraca

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- Order Stomatopoda
- Order Isopoda
- Order Amphipoda
- Order Euphausiacea
- Order Decapoda
  - Infraorder Penaeidea
  - Infraorder Caridae
  - Infraorder Astacidae
  - Infraorder Palinura
  - Infraorder Anomura
  - Infraorder Brachyura

Decapods

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda



- Order Stomatopoda
- Order Isopoda
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- Order Decapoda

Subclass Malacostraca

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- Order Stomatopoda
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- Order Decapoda

- Infraorder Penaeidea
- Infraorder Caridae
- Infraorder Astacidae
- Infraorder Palinura
- Infraorder Anomura
- Infraorder Brachyura

Infraorder Penaeidea

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- ~350 species
- Only decapods that do not brood embryo

Infraorder Caridae

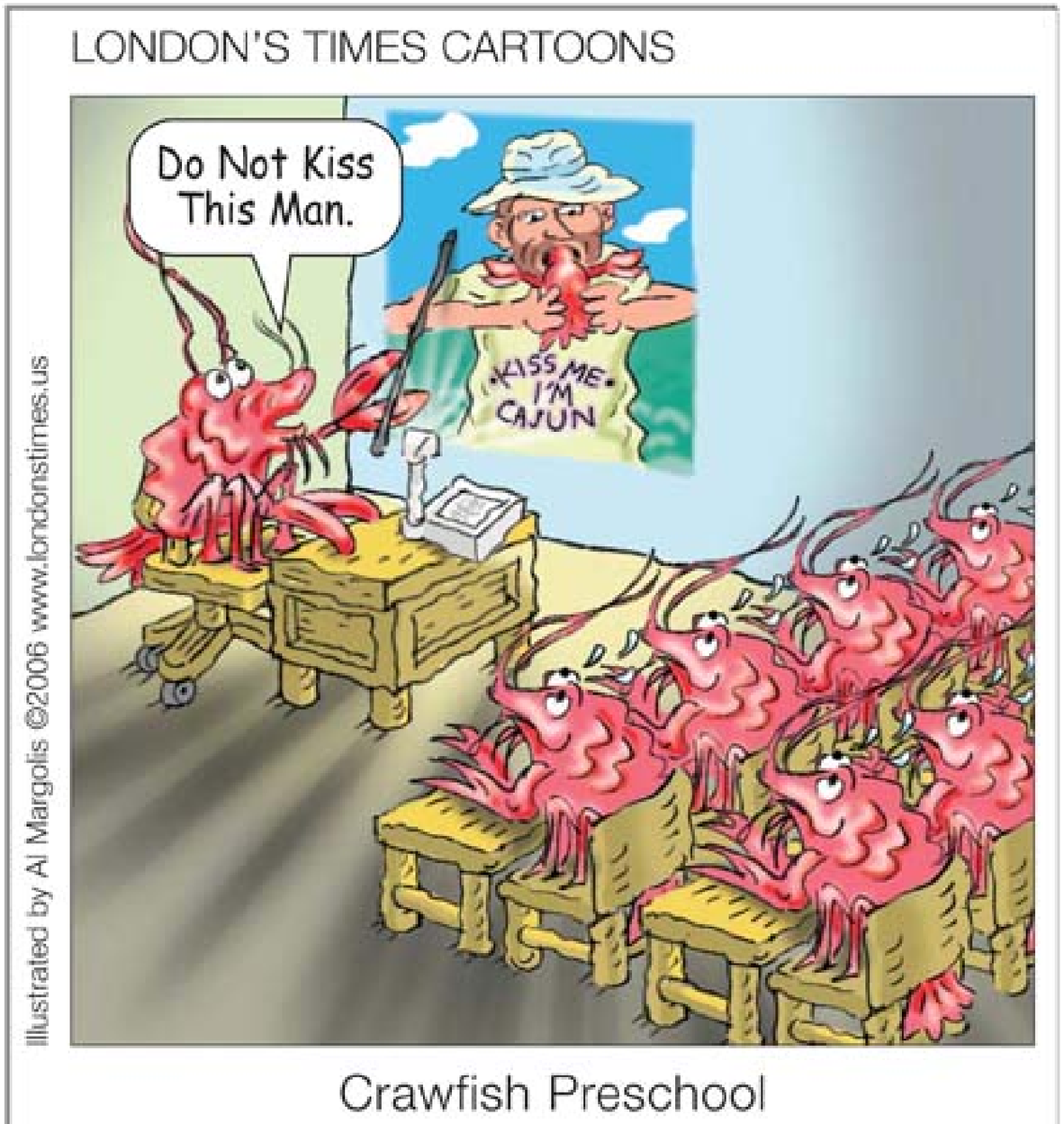
Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- about 1600
- included Crangon shrimp

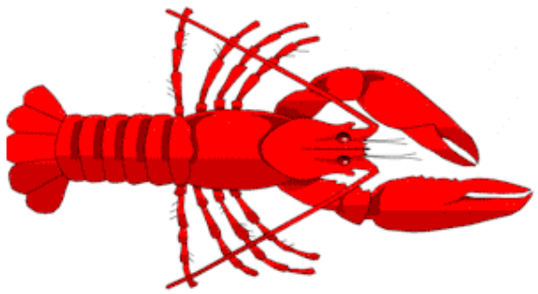
Infraorder Astacidae

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- Includes Homarus (lobster), crayfish



Crawfish Preschool



Infraorder Astacidae

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

- Includes Homarus (lobster), crayfish

Genetic defect causes a blue lobster to produce an excessive amount of a protein that wraps around a small, red carotenoid molecule

Forms a blue complex known as crustacyanin which gives the lobster shell a blue color

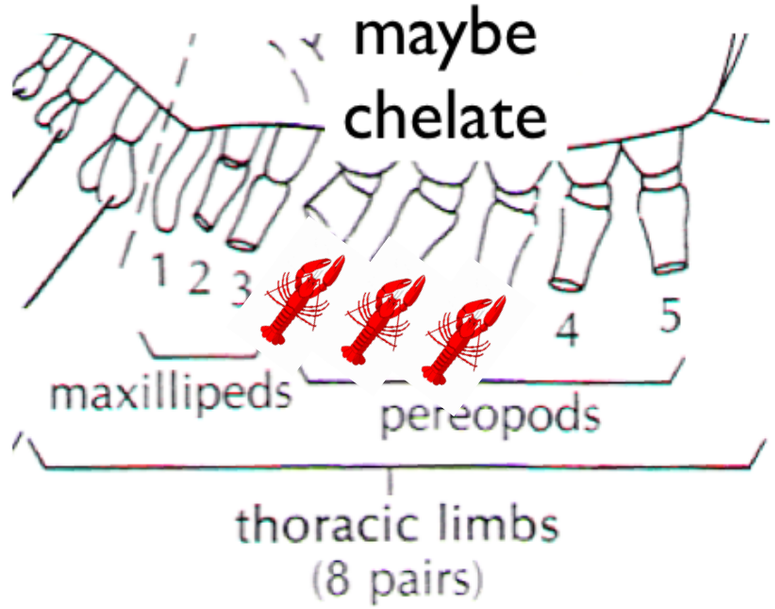
Infraorder Palinura

- include spiny lobster (tropical)

Stomatopoda
Isopoda
Amphipoda
Euphausids
Decapoda

Infraorder Palinura

- include spiny lobster (tropical)



Spiny lobsters can be easily distinguished from *Homarus* by their very long, thick, spiny antennae, and by the lack of chelae.

Infraorder Anomura

Anomalies

- ~1600 species
- include hermit crabs,
- King crabs (*Lithodes, Paralithodes*)
- Porcelain crabs (*Petrolisthes, Porcellana*)
- sand crabs, mole crabs

Last pair of pereopods often hidden in gill chamber

Infraorder Brachyura

- about 4500 species
- Spider crabs
- Cancer crabs
- Blue crab (*Callinectes*), green crab (*Carcinus*)
- Fiddler crabs

Snow crab or opilio, *Chionoecetes opilio*

Red king crab, *Paralithodes camtschaticus* **(Anomura)**

Class Crustacea

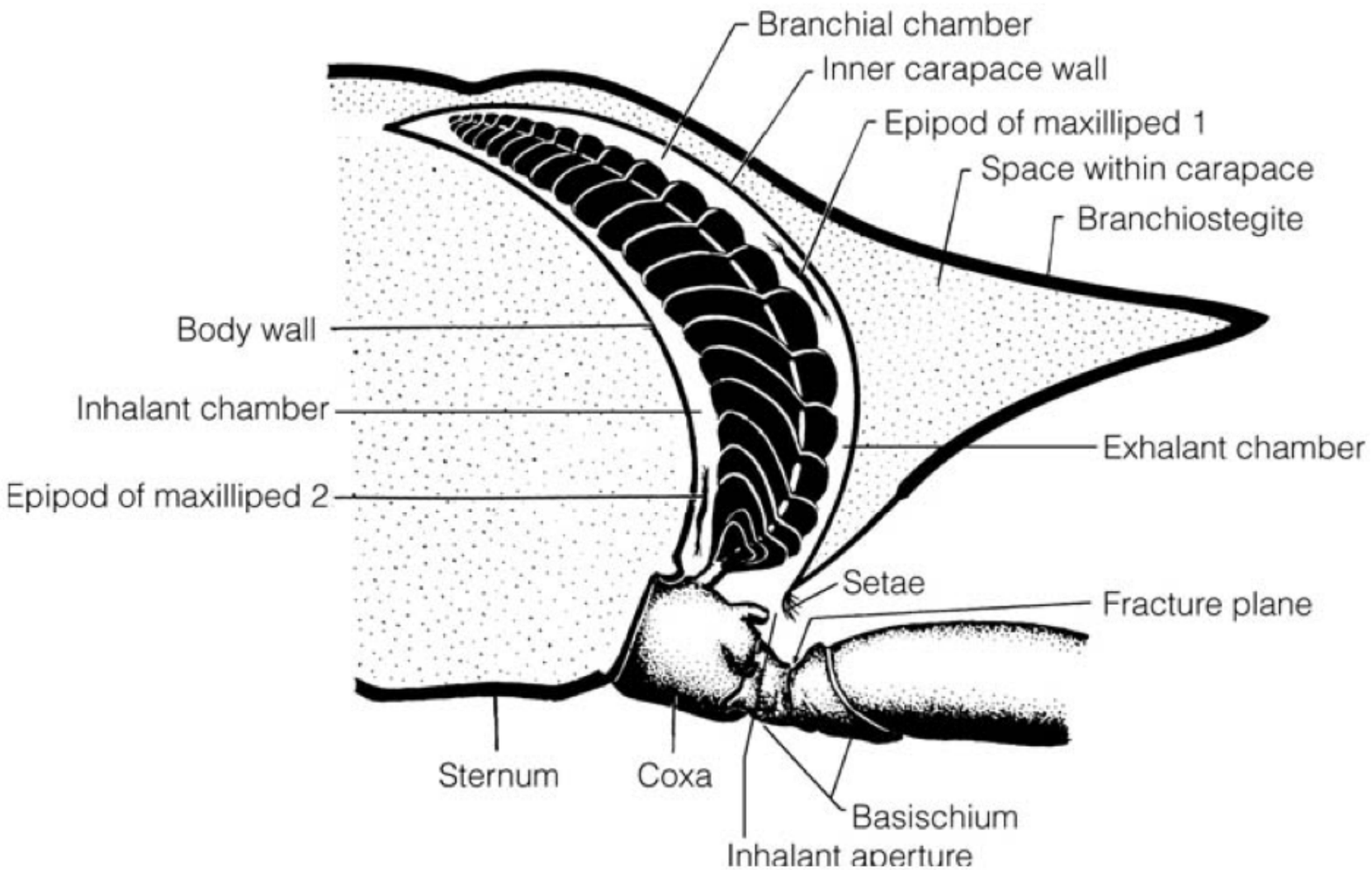
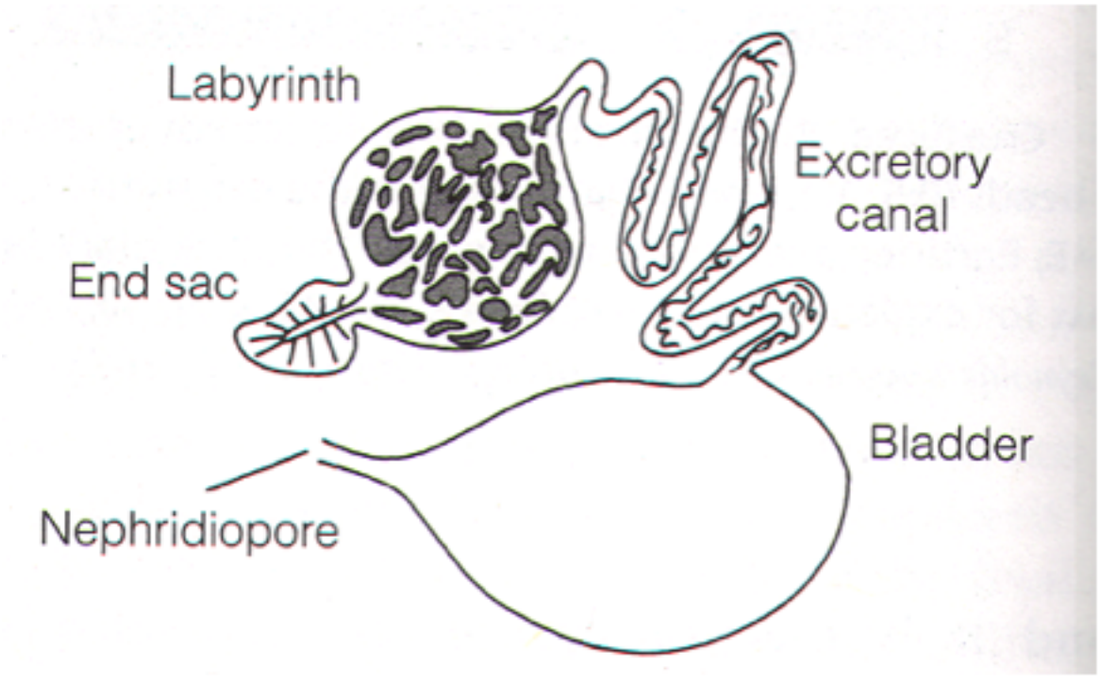


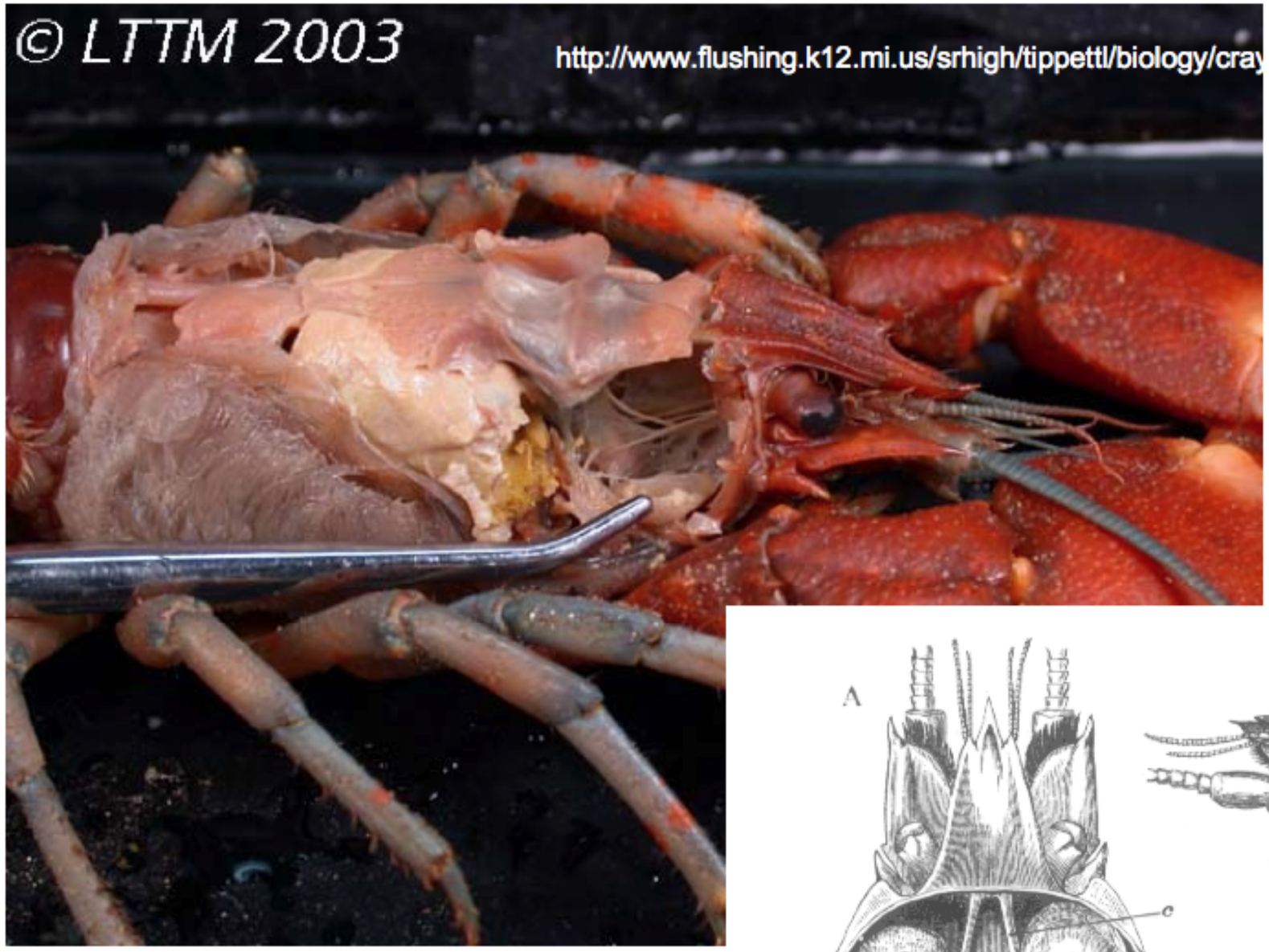
Figure 19-36: **Decapod gas exchange. Cross section through the gill chamber of a crab showing a gill attached to the coxa.**

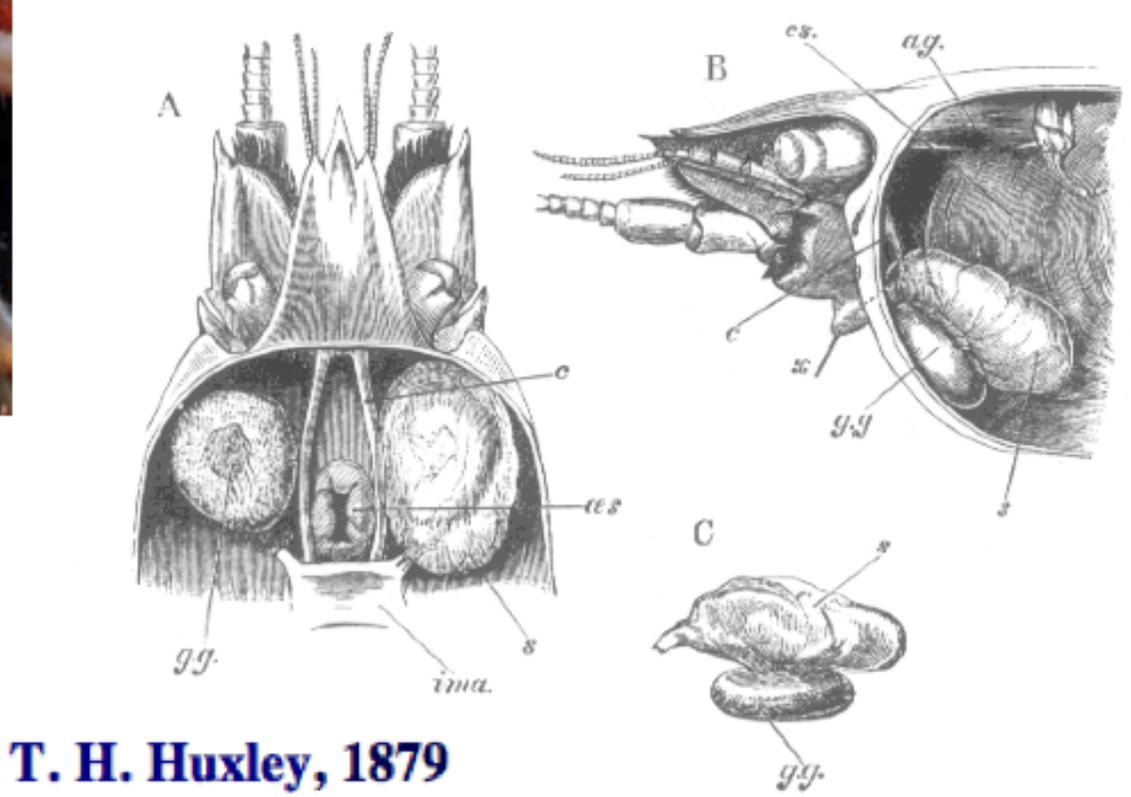
Excretion



- Paired saccate nephridia
  - Minor role in nitrogen excretion
  - *Ion balance*
  - Ion concentrations different: Calcium, potassium higher in hemolymph; magnesium, sulfate lower
- In segment of either 2nd antennae or 2nd maxillae
  - Open at base

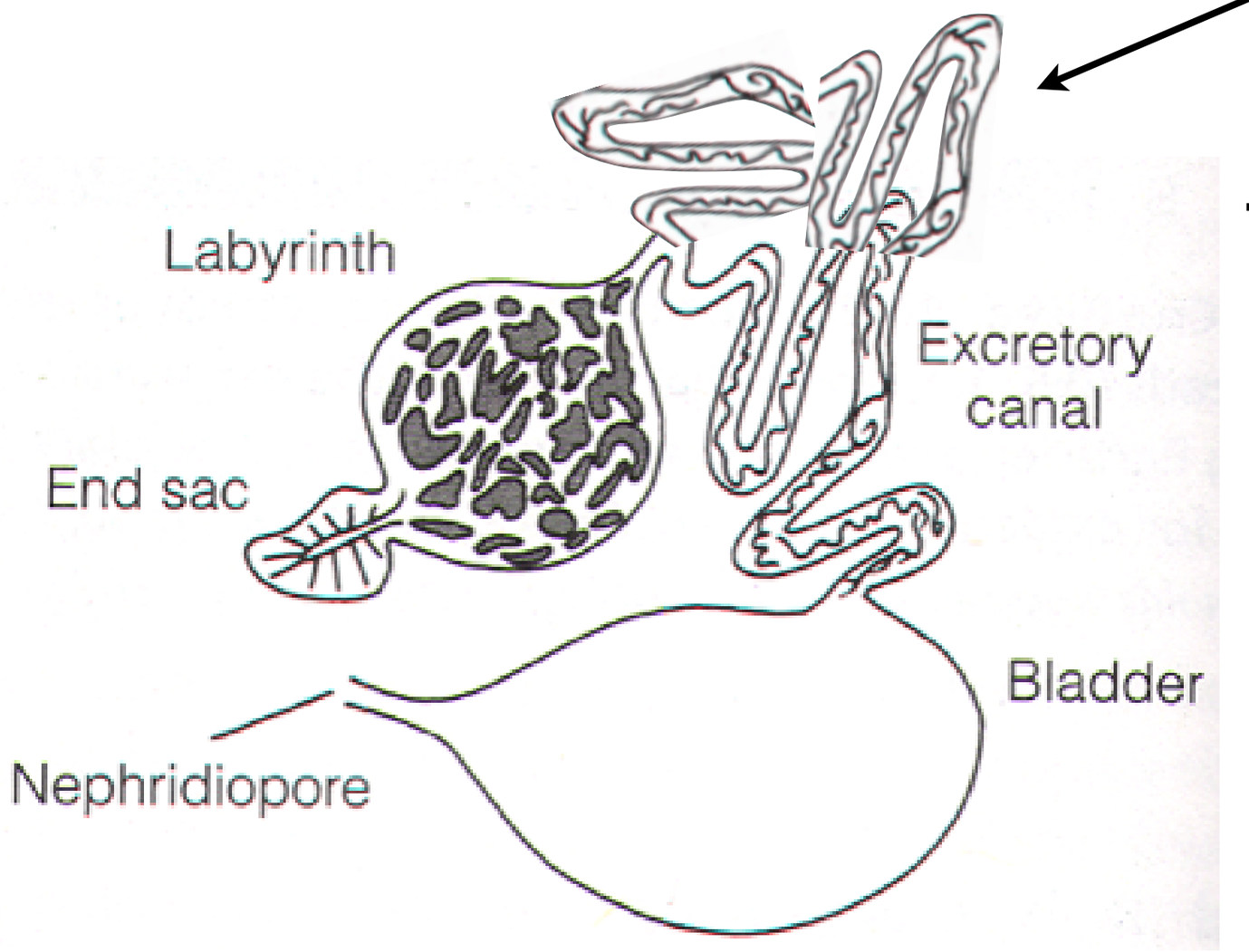
Excretion





From*The Crayfish*, by T. H. Huxley, 1879

Freshwater?



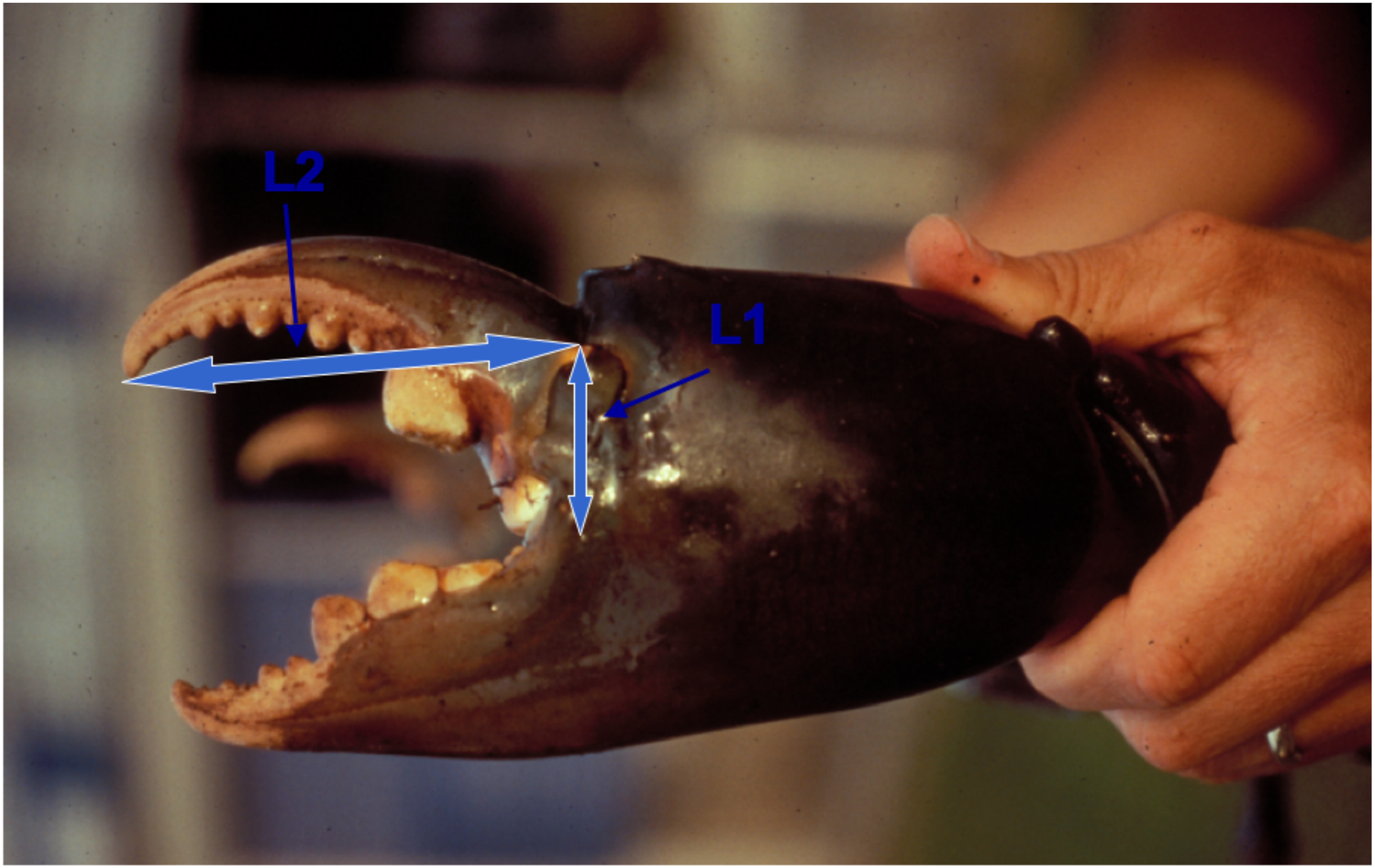
longer canal for increased absorption


Advantages?

Muscles

- **Arthropod: pinnate fiber orientation**
  - **2X force per volume**
- **Longer sarcomeres**

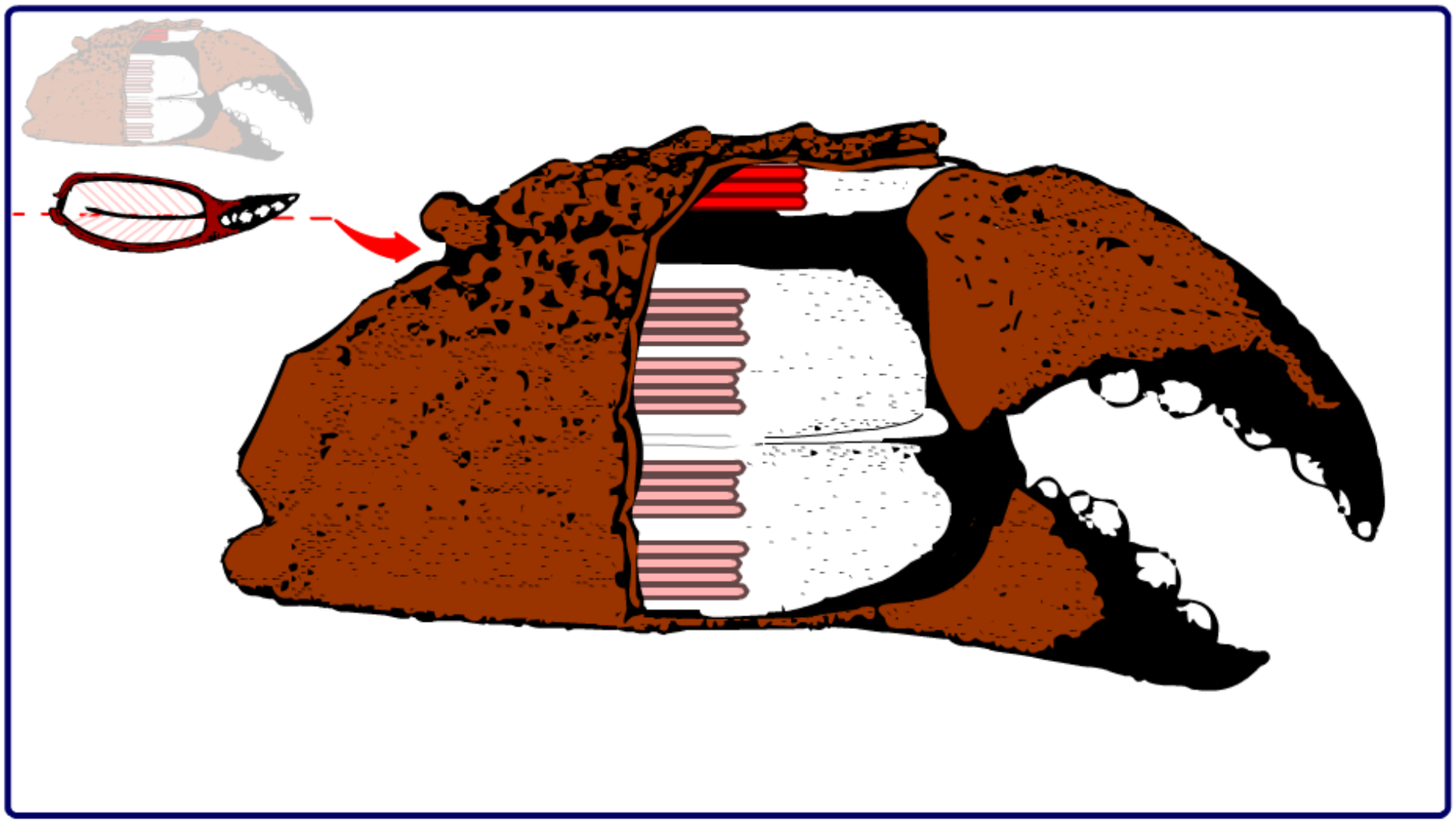
- **Tradeoff: human forearm ~140º of motion**
  - **Crab ~70º**



Mechanical advantage
= L1/L2

D. Armstrong

Decapod claw form and function (subphylum Crustacea, phylum Arthropoda)



Choose a view:

- Side view
  - claw motion
  - claw mechanics
  - labels
  - other claw forms
- Top view
  - claw motion
  - labels
- Claw evolution
  - from leg to claw
  - evolutionary stages
  - compare the parts

relaxed muscle fiber

contracting muscle fiber

Heather Kroening
August 2000

http://tinyurl.com/clawfun

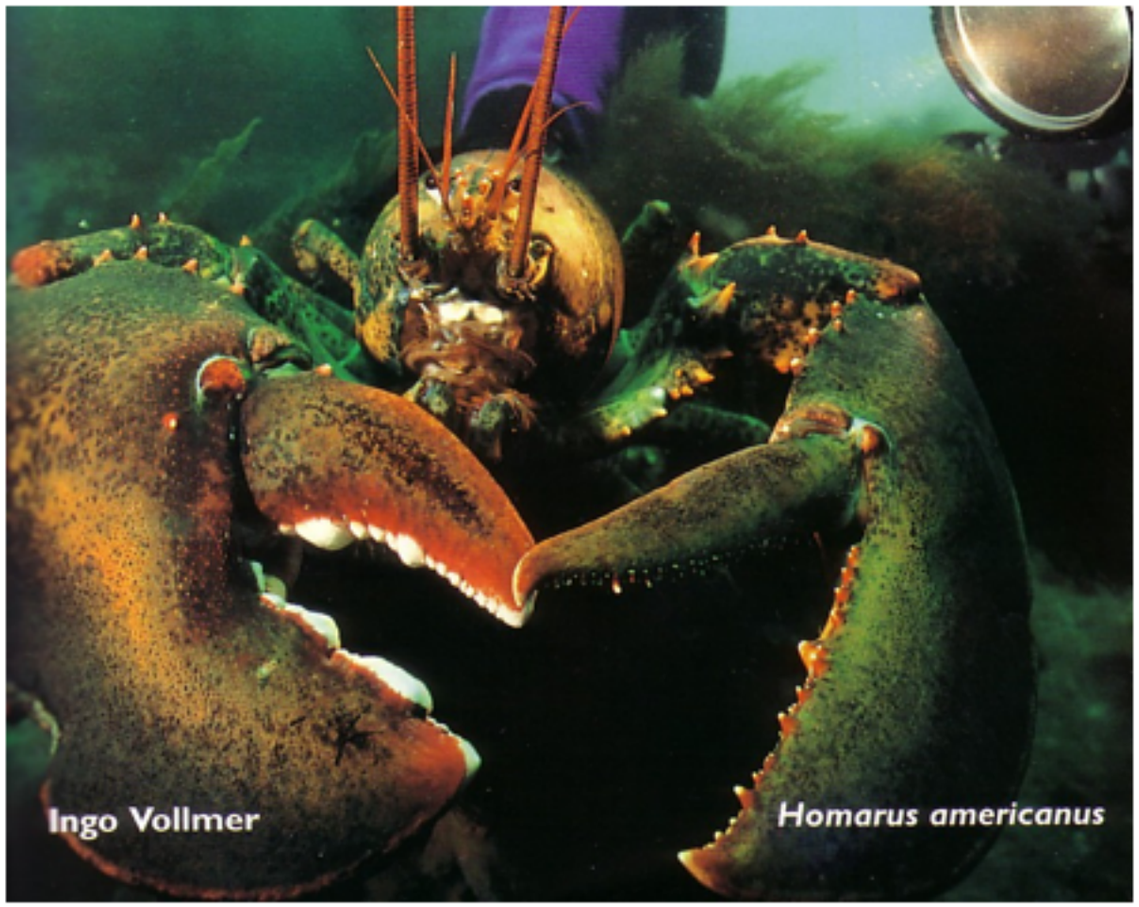
Muscles

***Homarus* - handedness determines crusher & cutter**

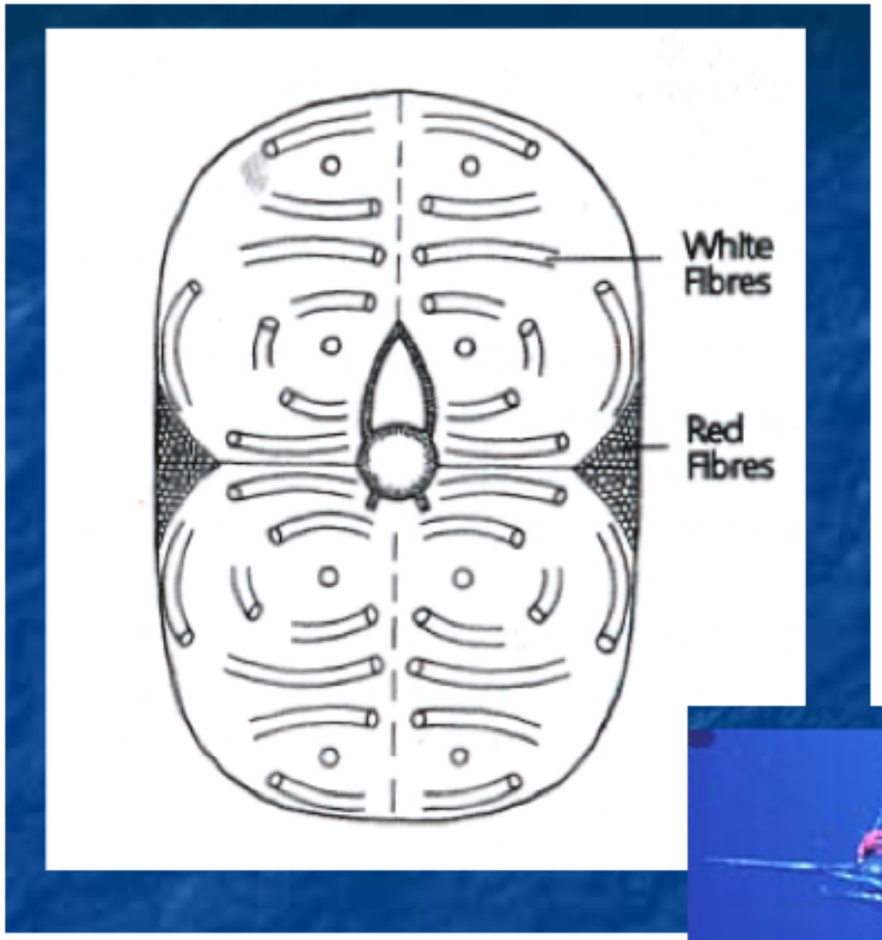
Cutter ~75% fast

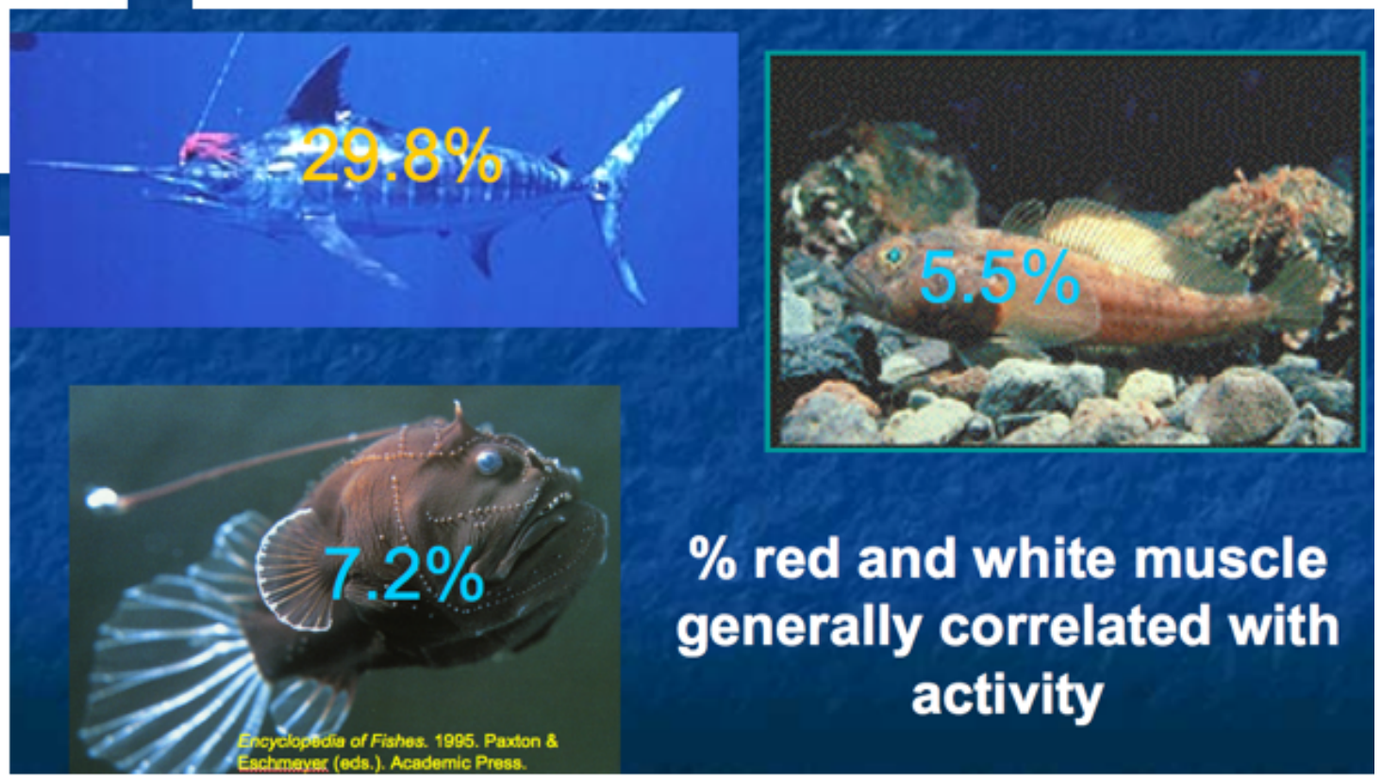
Crusher 100% slow

5X stronger

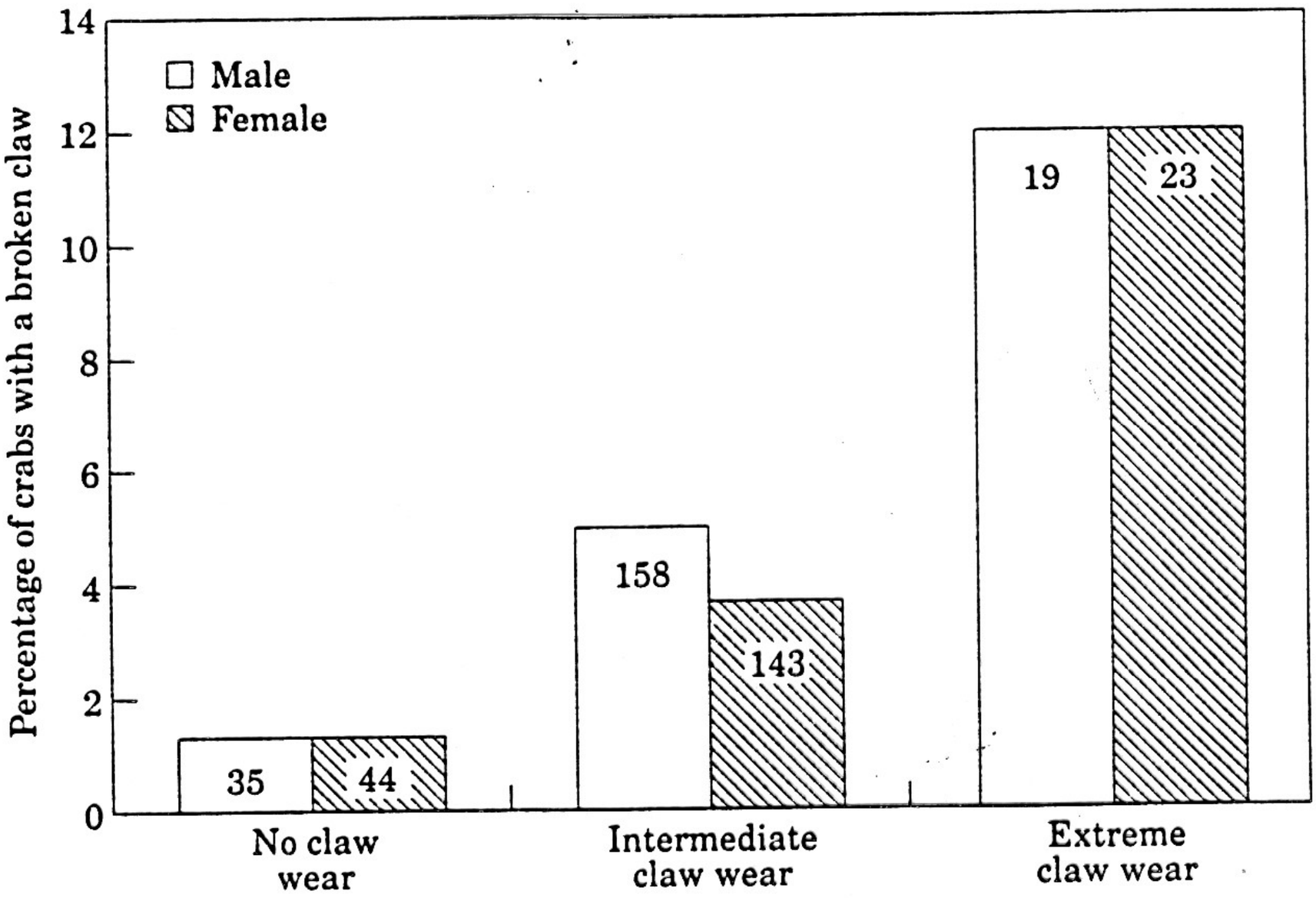


Muscle


White Fibres
Red Fibres


29.8%
5.5%
7.2%
Encyclopedia of Fishes. 1995. Paxton & Eschmeyer (eds.). Academic Press.
% red and white muscle generally correlated with activity

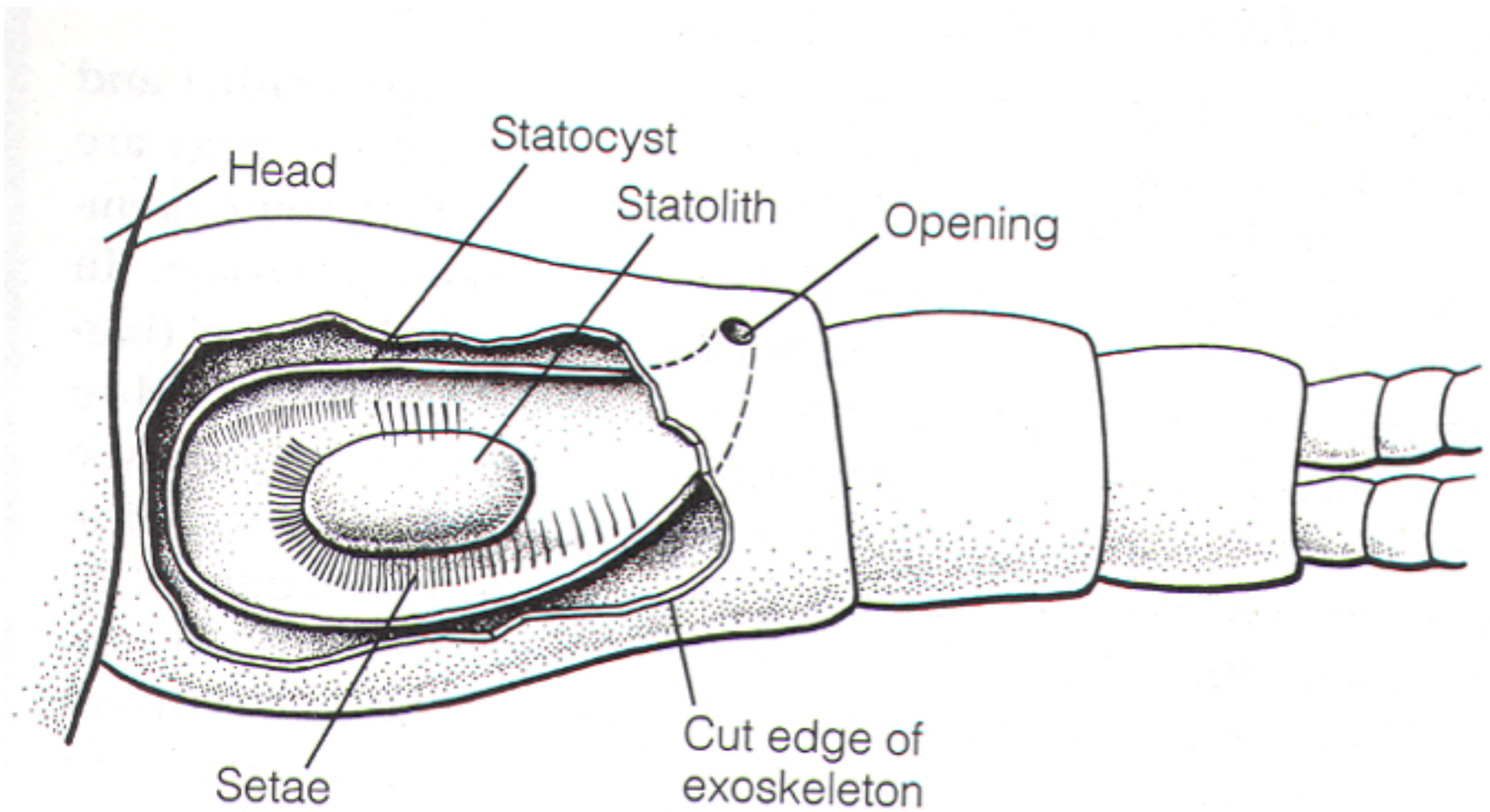
Claw damage



Breaking hard shelled prey has its risks

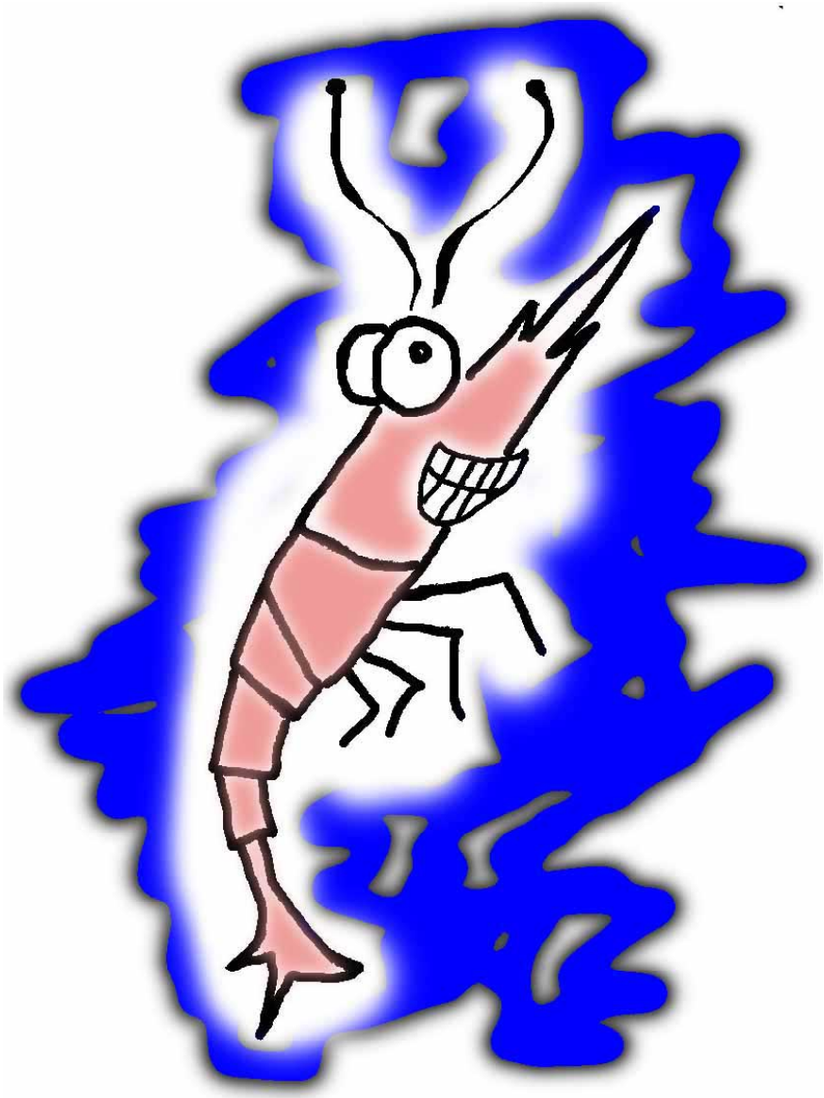
Statocysts

- Statocyst- equillibrium receptors
  - Cavity with heavy particle, statolith, rests on setae that detect displacement

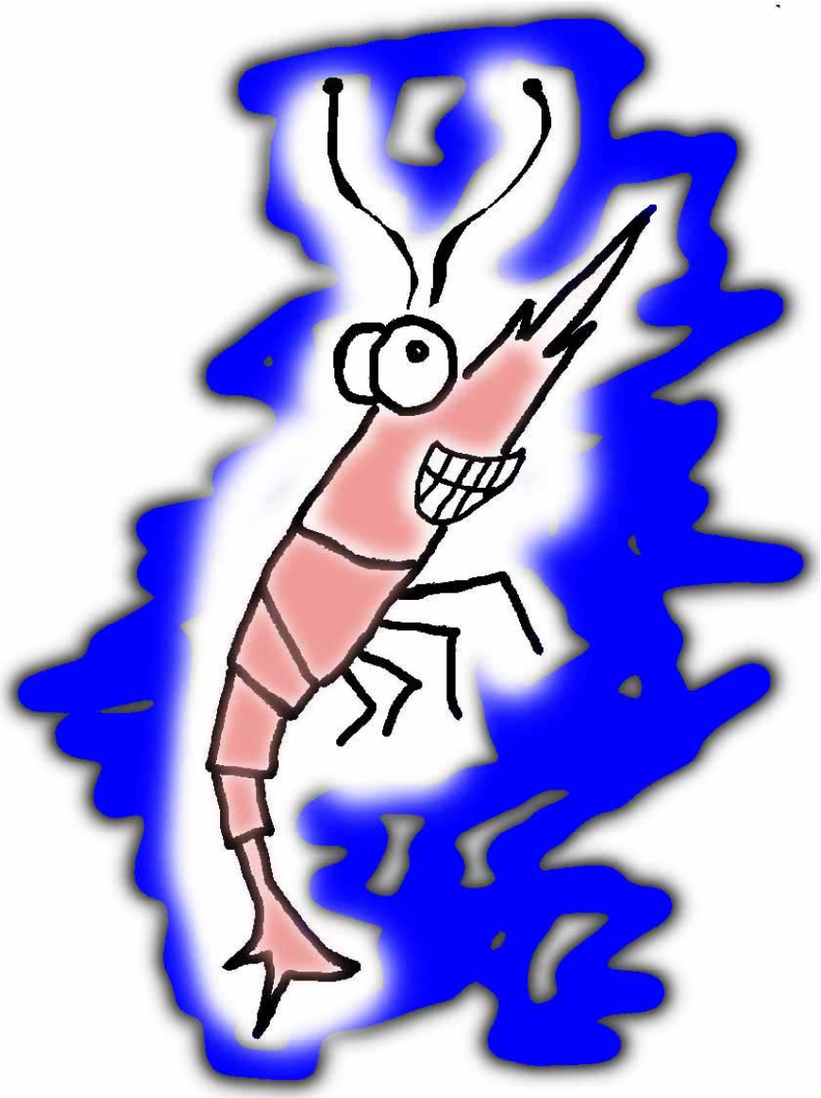


What happens when molt?

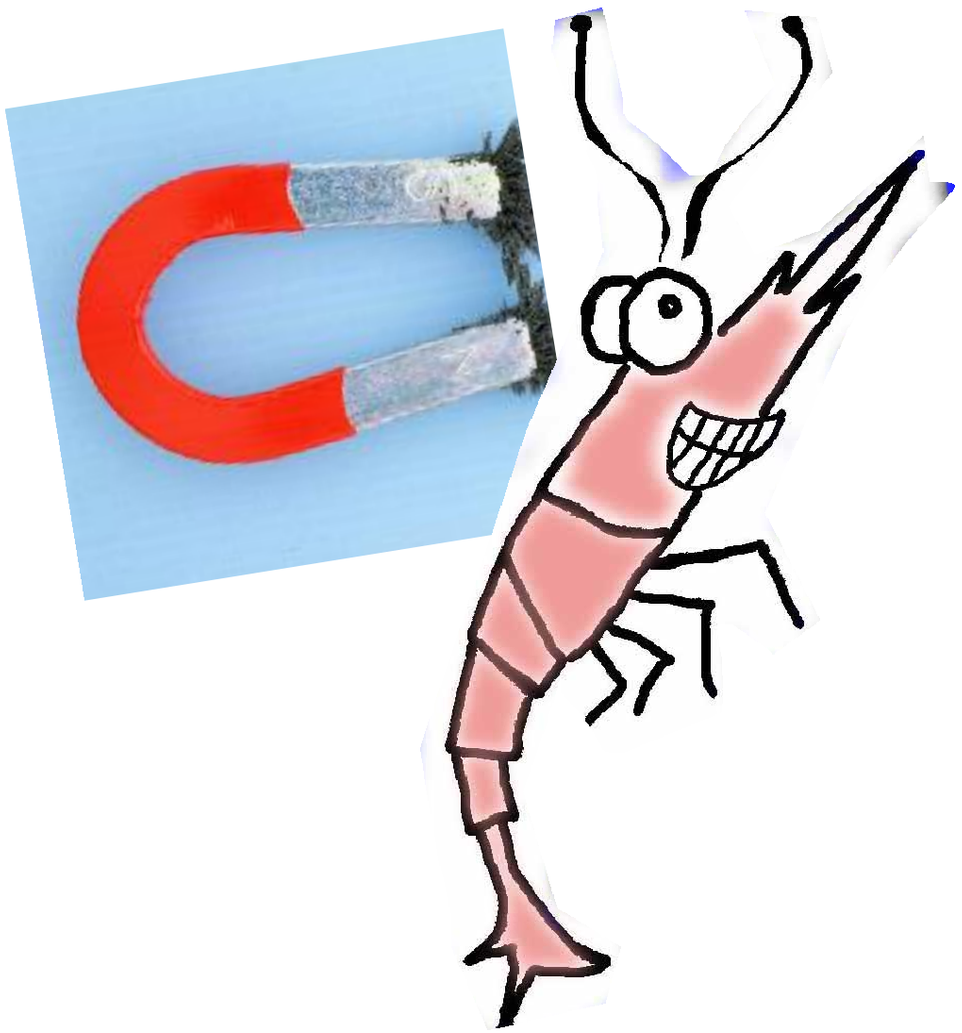
An Experiment



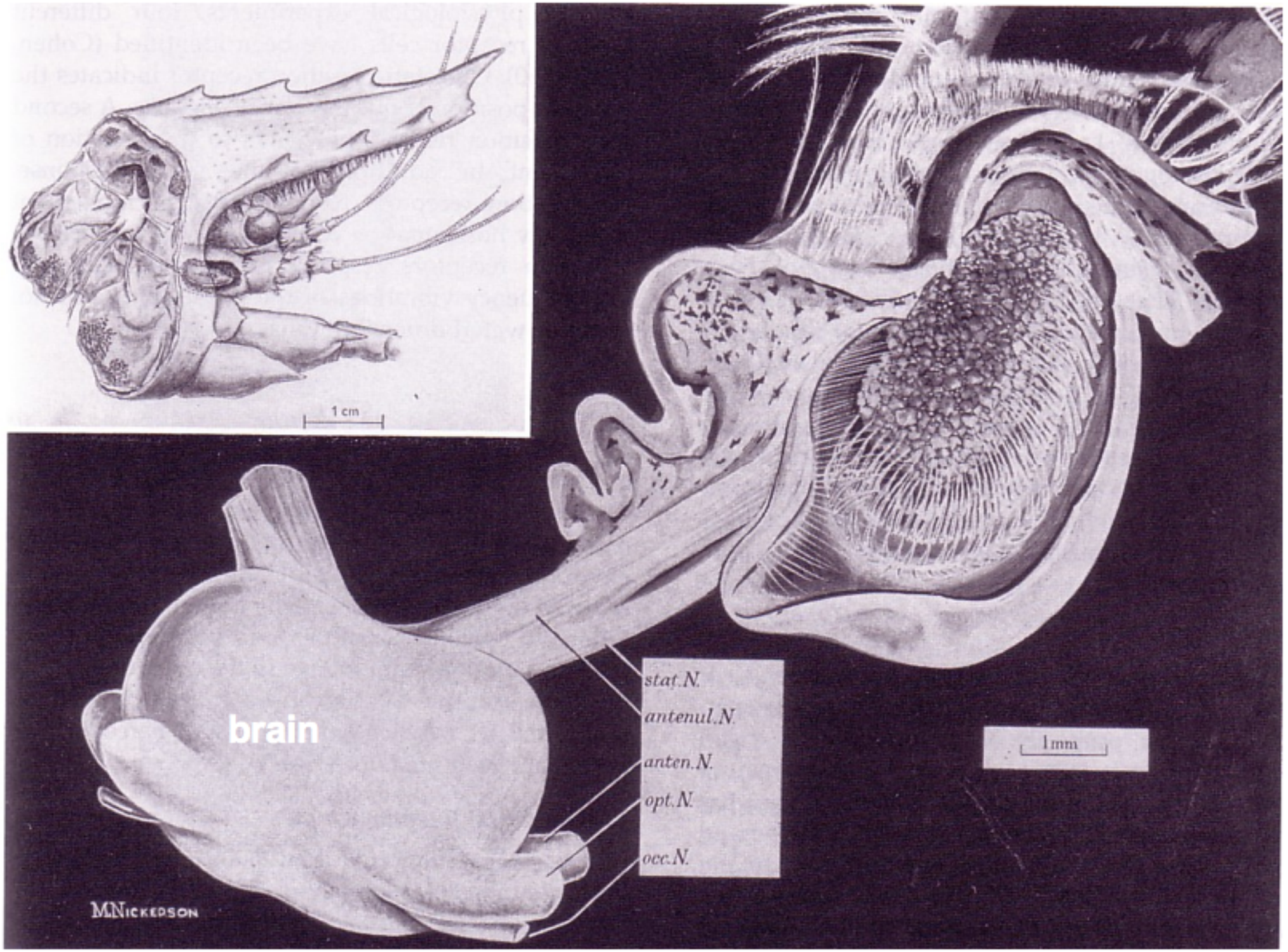
An Experiment



An Experiment



Lobster statocyst



Nutrition

Ancestral feeding

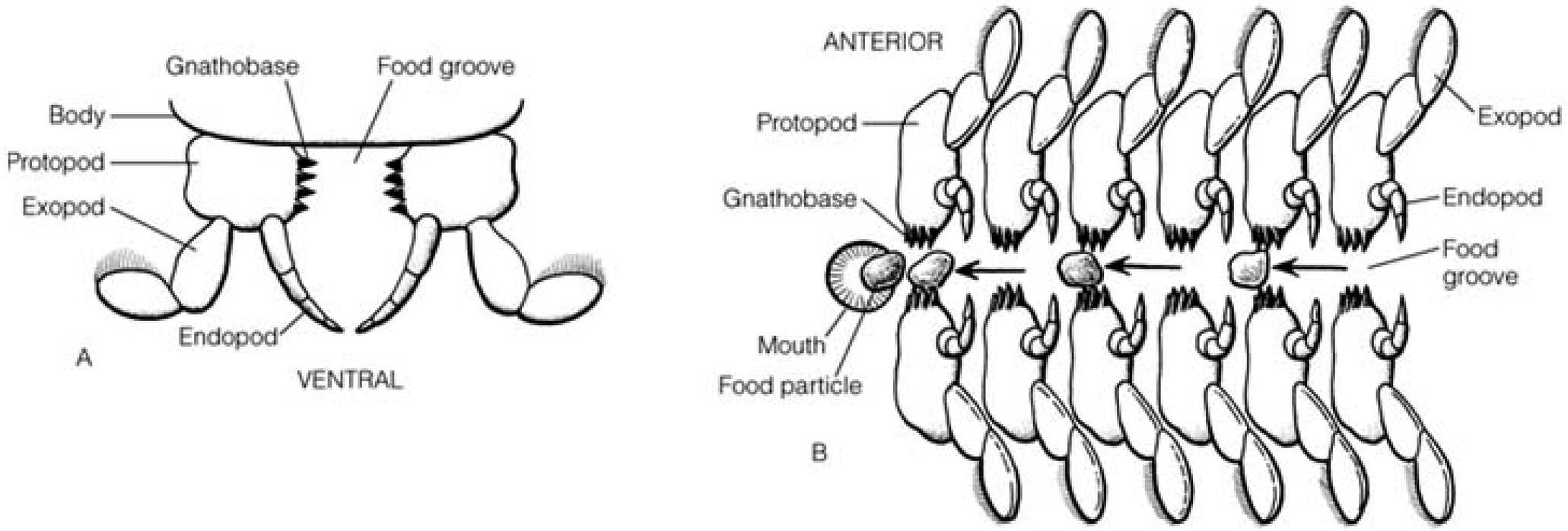


Figure 19-4: **Feeding mechanism of the ancestral crustacean. A, Cross section through a trunk segment showing a typical pair of mixopods. The exopod is a phyllopod, the endopod is a stenopod, and the protopod has a medial gnathobase. B, Ventral view of the anterior trunk, showing the food groove and feeding mechanism.**

Feeding

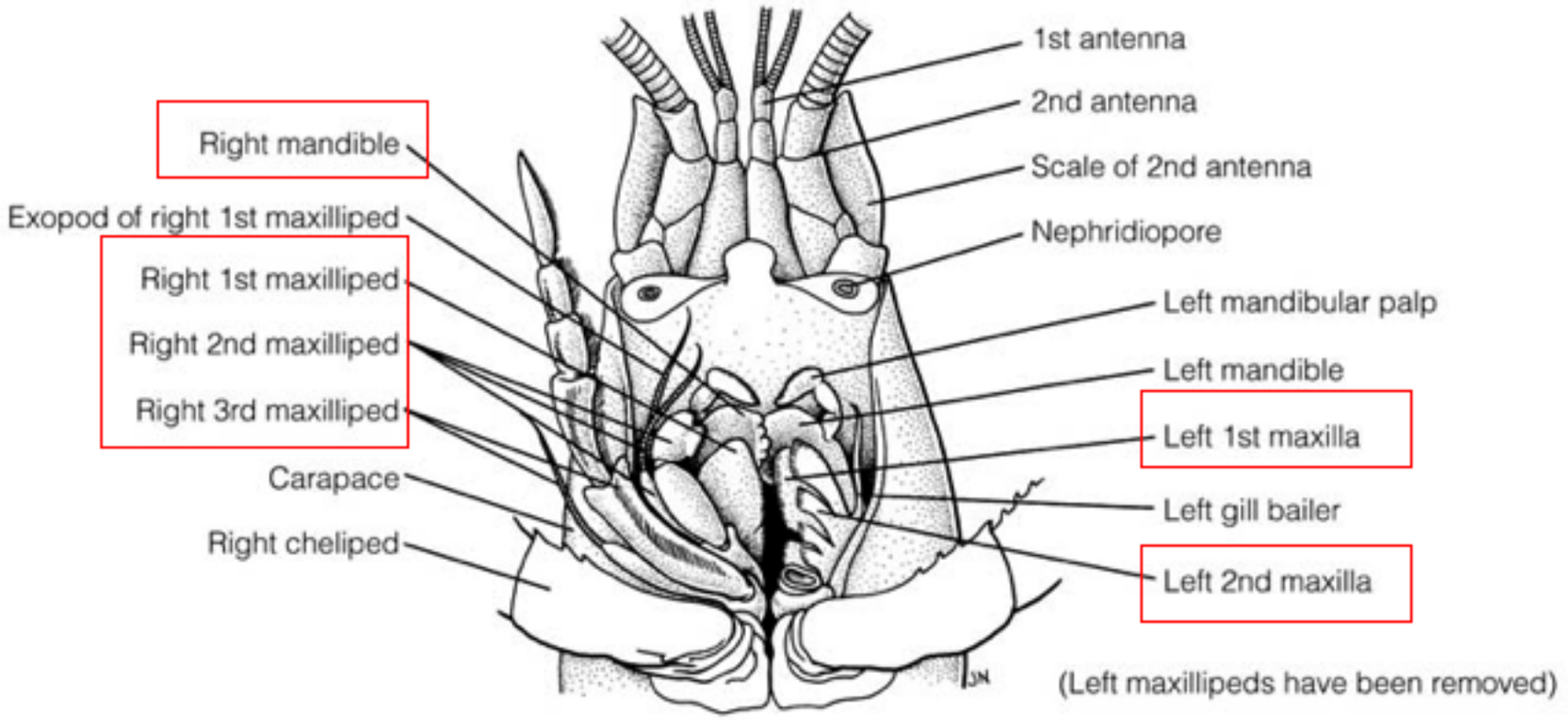
- Buccal Frame is protected by outgrowths of body wall

- Six pairs of appendages are associated with the decapod mouth
  - Mandibles flank
  - Two pairs of maxillae and three pairs of maxillipeds attach posterior to mouth, extending anteriorly

Feeding

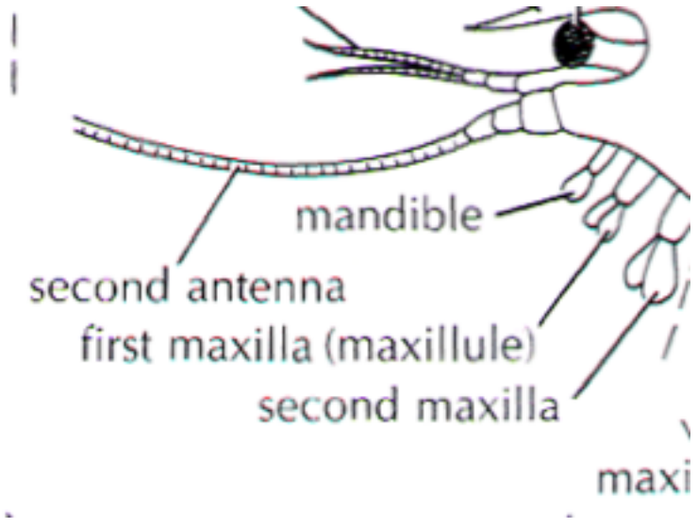
Six pairs of appendages are associated with the decapod mouth

- Mandibles flank
- Two pairs of maxillae and three pairs of maxillipeds attach posterior to mouth, extending anteriorly

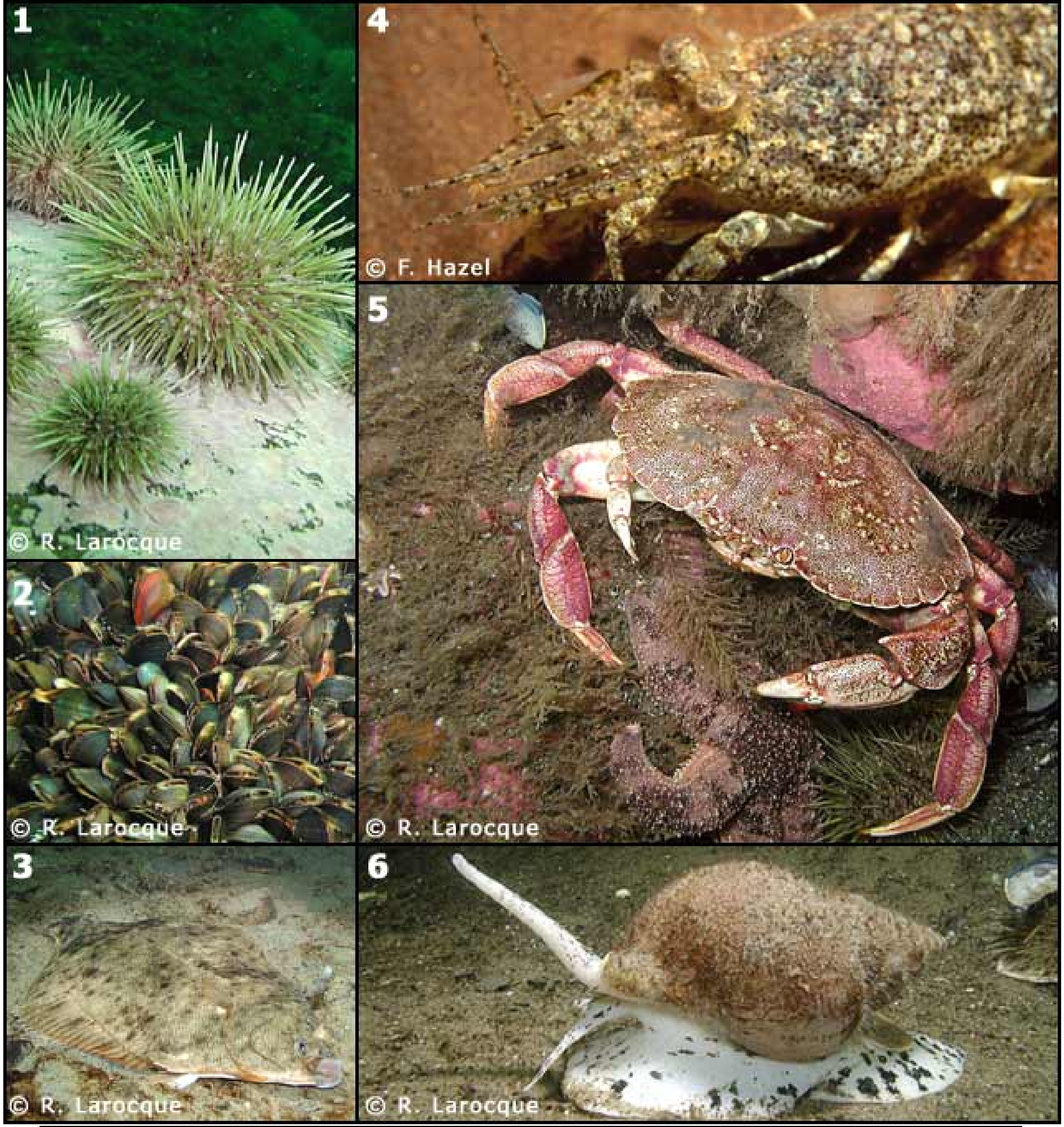


Feeding

- Most are predators and scavengers
- Food is grasped by chelipads and passed to third maxillipeds.
- Mandibles hold food, pieces torn away by maxillae and maxillipeds and transferred to mouth



American Lobster Diet

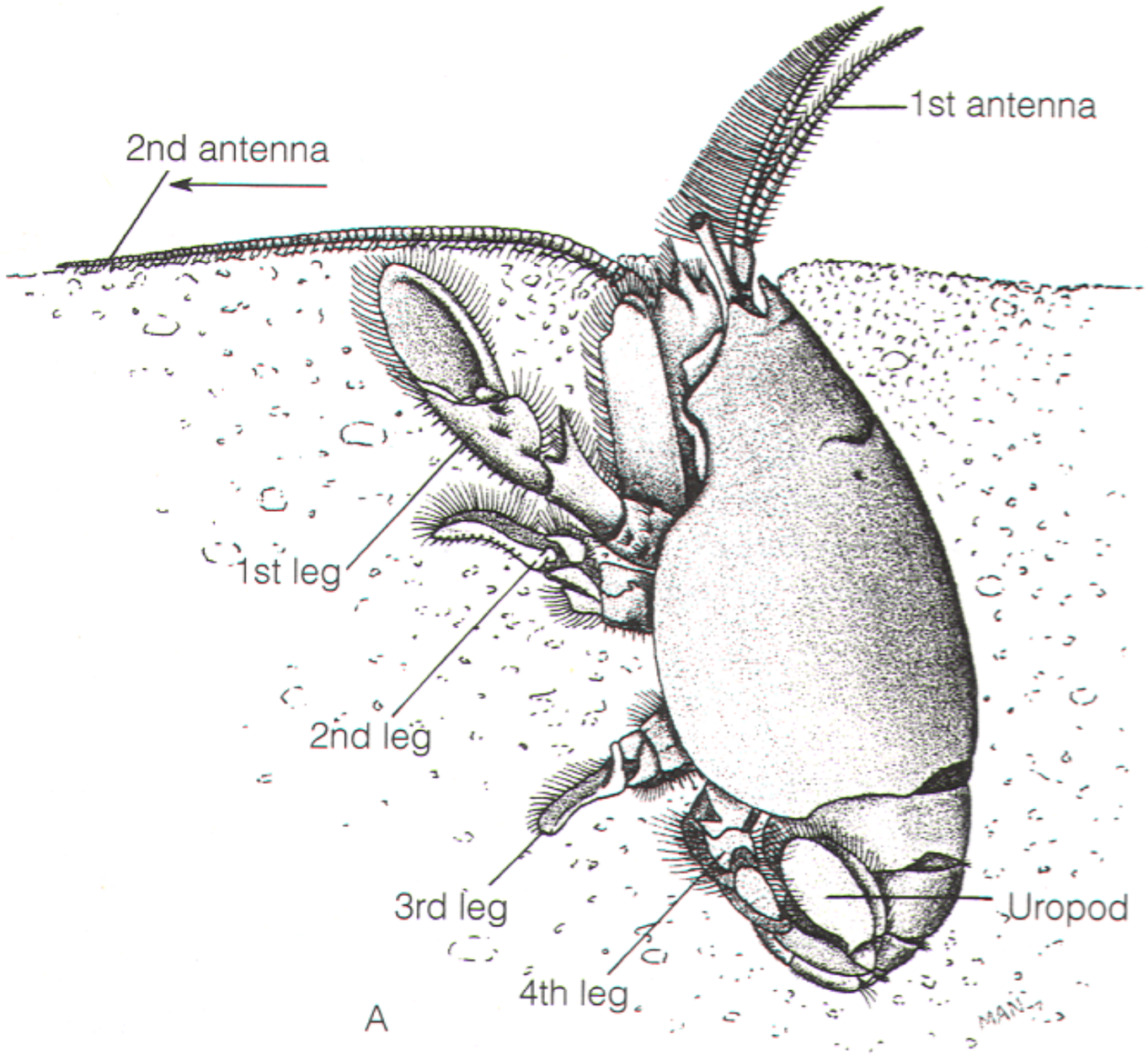


Feeding

- Chelipads are adapted to feeding habits and food preferences of each species
  - Spoon shaped fingers - scrape algae from rocks or feed on detritus from sand and mud
  - Dimorphic chelipads -
- Crusher claw has blunt, molar like teeth
- Cutter claw- ??

Fiddler feeding

- Brachyurans that feed on organic detritus
- One or two small chelipads that scoop
- Water washes material through _____ filters on second and first maxilliped.
- Mineral particles are pelleted and deposited



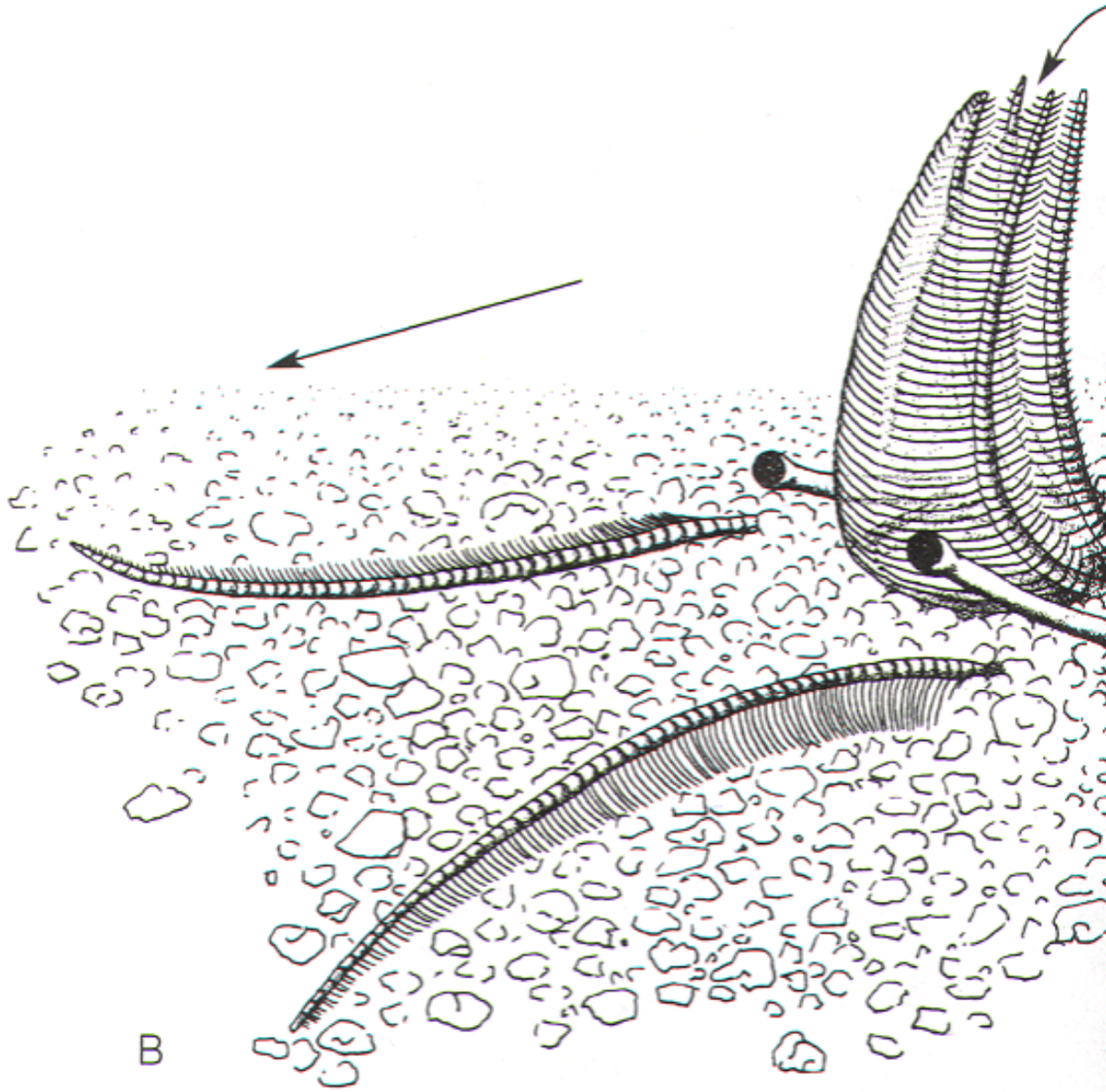


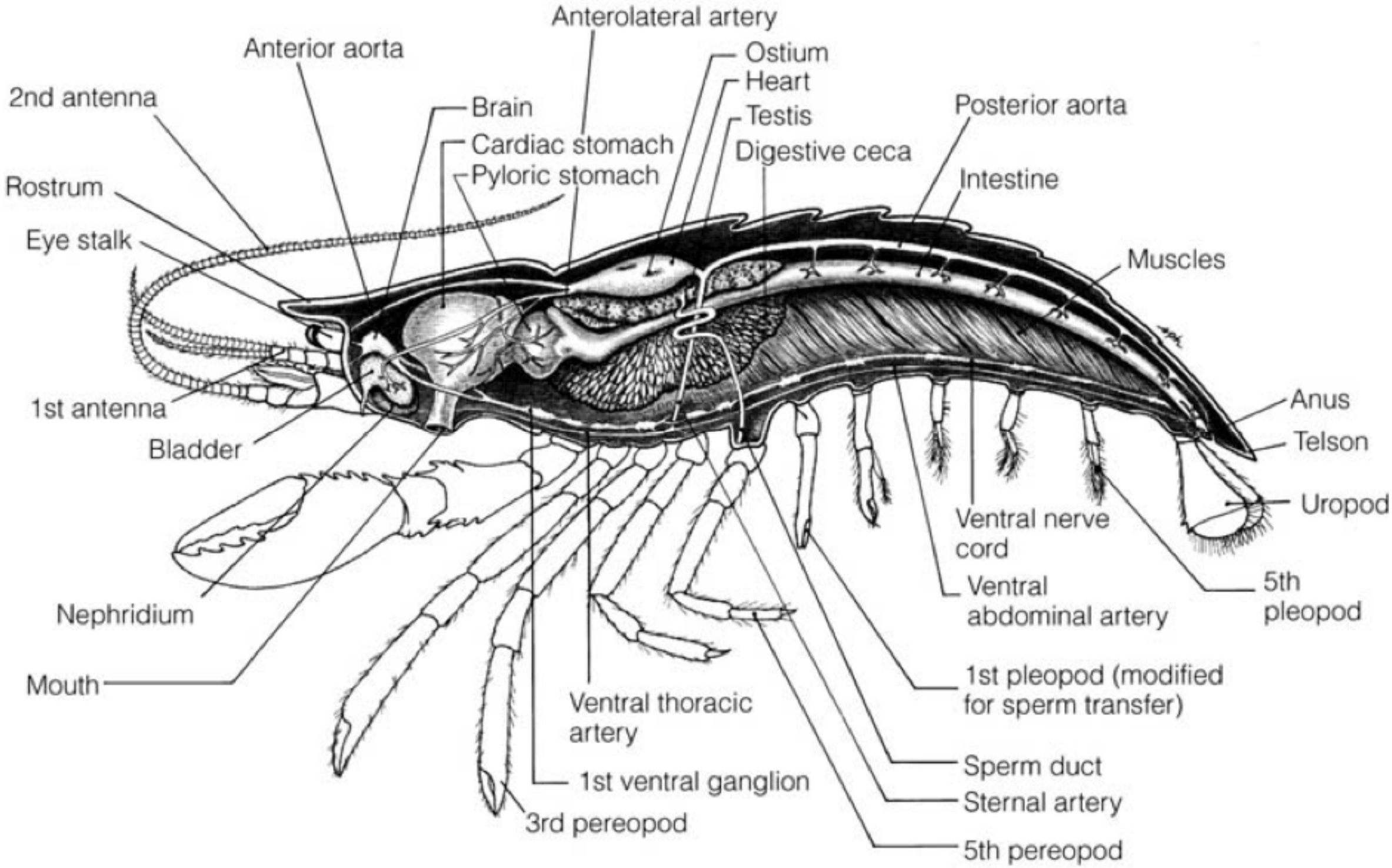
FIGURE 19-29 Decapoda, Anomura: *Emerita talpoida,* the mole crab, in the superfamily Hippoidea. This is a common crab on surf-swept beaches along the east coast of the United States. **A,** Lateral view of the animal buried in the sand. **B,** Surface view of the buried animal. The first antennae form an inhalant siphon to ventilate the gills. The curved arrow indicates the ventilating current. The straight arrow indicates the direction of the receding wave.

Mole crab

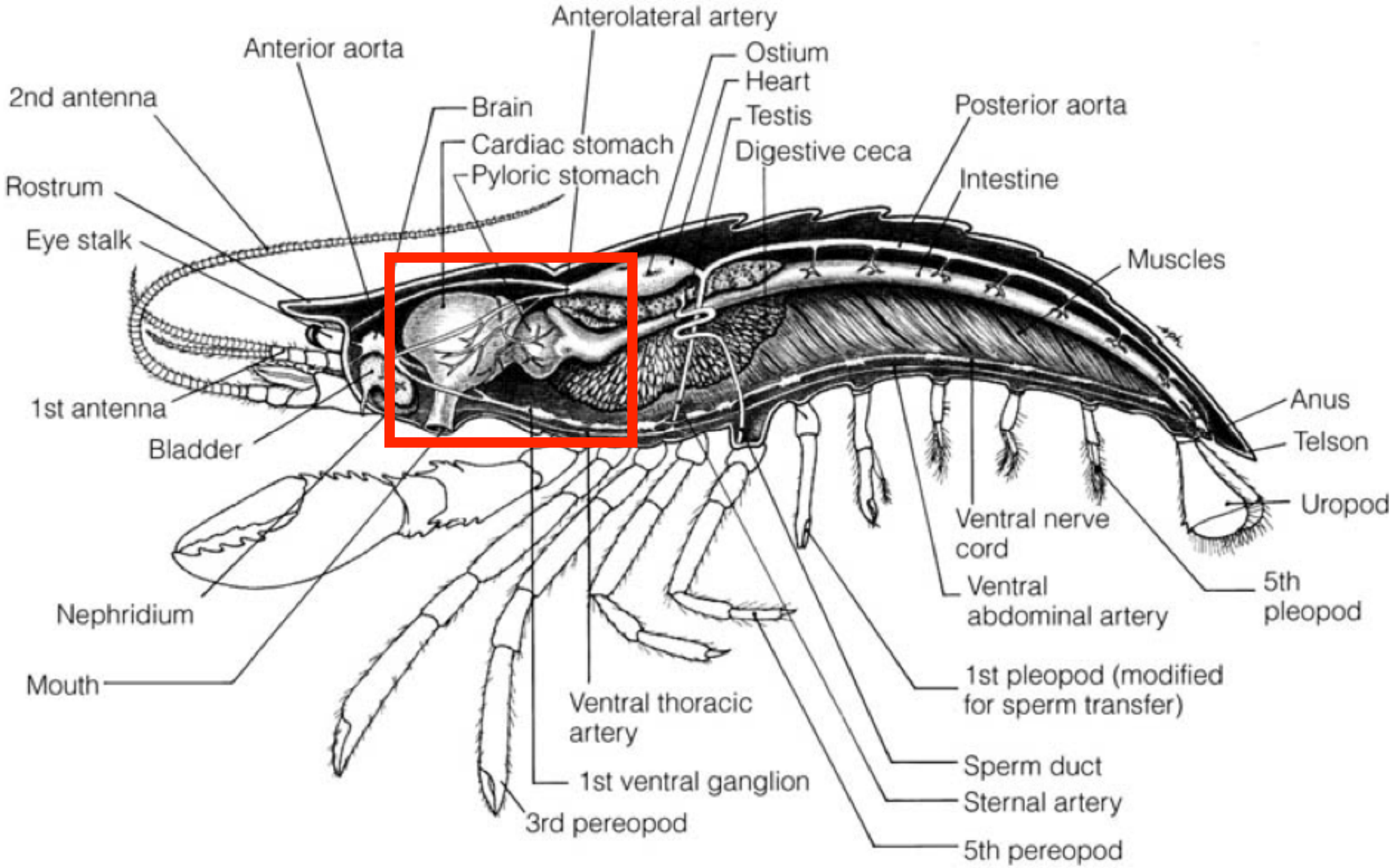
- Uses uropod and fourth leg to dig
- Antennae and eyestalks extended above the sand
- Feeds on receding wave

Digestion

Digestion


Anterolateral artery
Anterior aorta
Ostium
Heart
2nd antenna
Brain
Testis
Posterior aorta
Cardiac stomach
Digestive ceca
Pyloric stomach
Rostrum
Intestine
Eye stalk
Muscles
Anus
1st antenna
Telson
Bladder
Uropod
Ventral nerve cord
Nephridium
Ventral abdominal artery
5th pleopod
Mouth
1st pleopod (modified for sperm transfer)
Ventral thoracic artery
Sperm duct
1st ventral ganglion
Sternal artery
3rd pereopod
5th pereopod

Digestion


Anterolateral artery
Anterior aorta
Ostium
Heart
2nd antenna
Brain
Testis
Posterior aorta
Cardiac stomach
Digestive ceca
Pyloric stomach
Rostrum
Intestine
Eye stalk
Muscles
1st antenna
Anus
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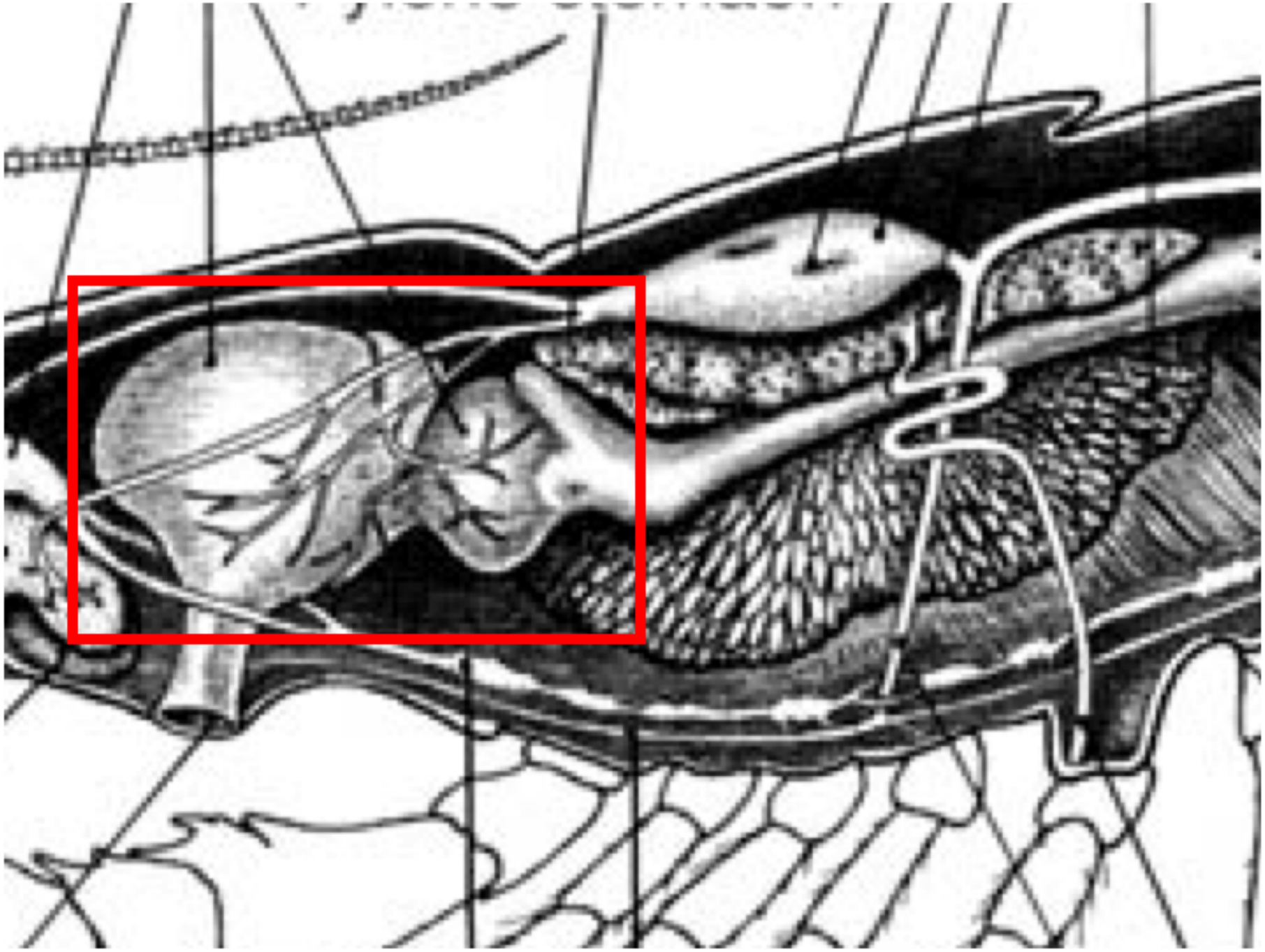
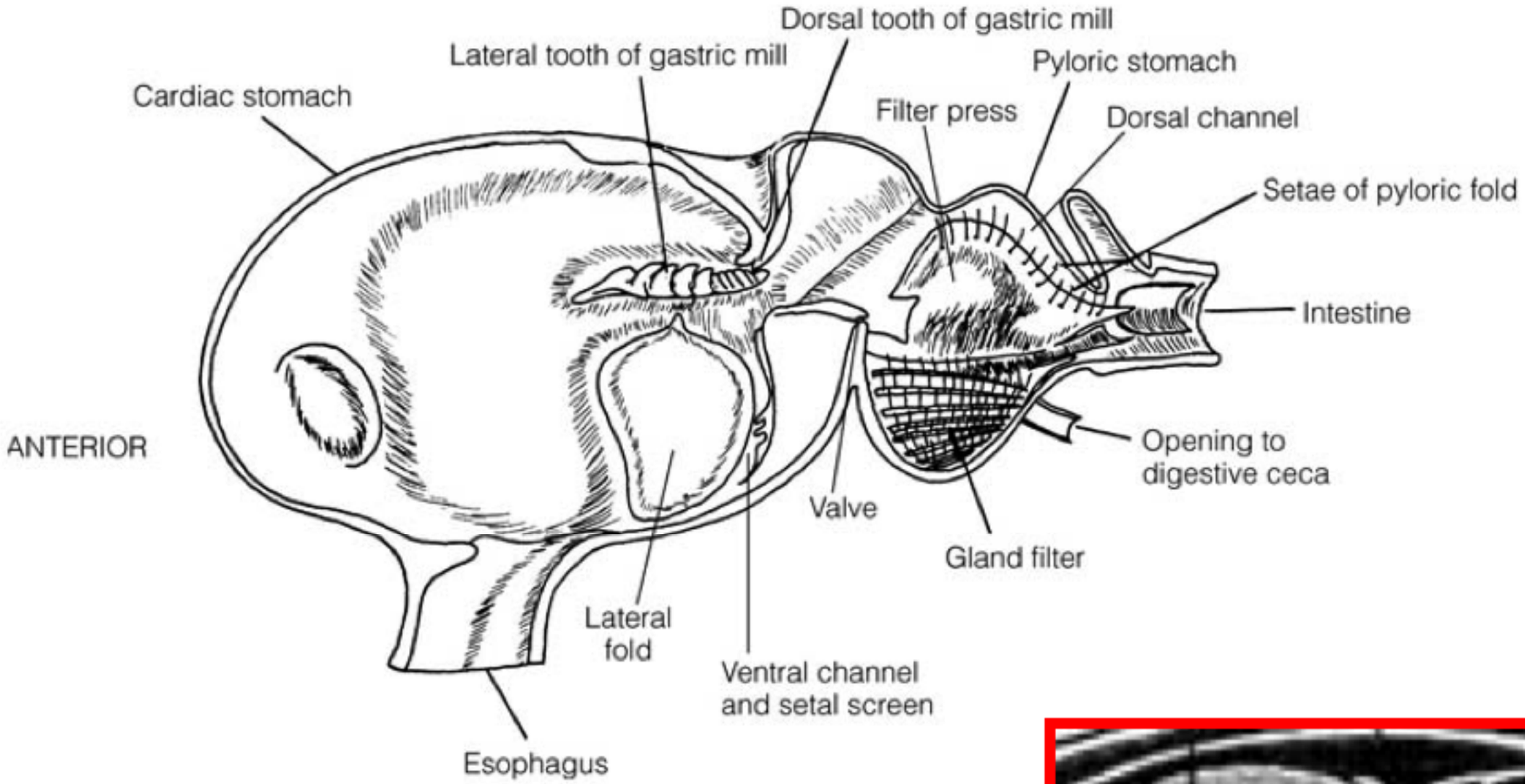
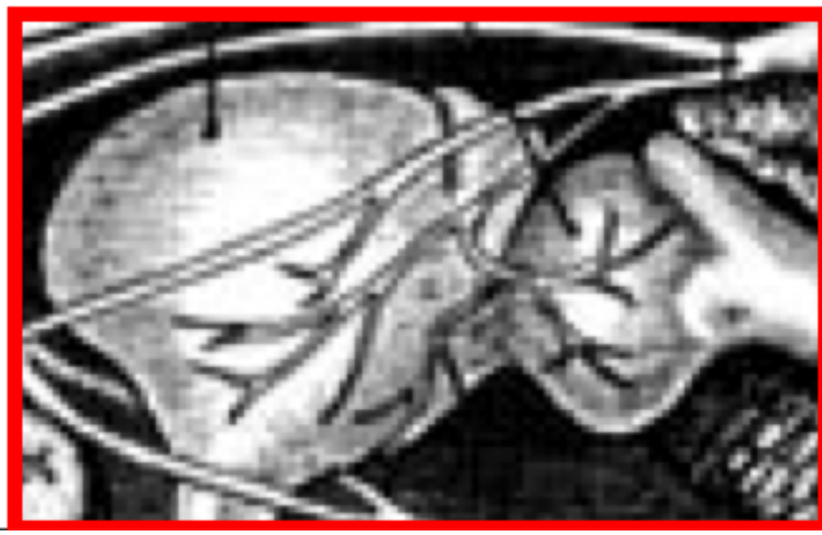
5th pleopod
Mouth
1st pleopod (modified for sperm transfer)
Ventral thoracic artery
Sperm duct
1st ventral ganglion
Sternal artery
3rd pereopod
5th pereopod

Digestion

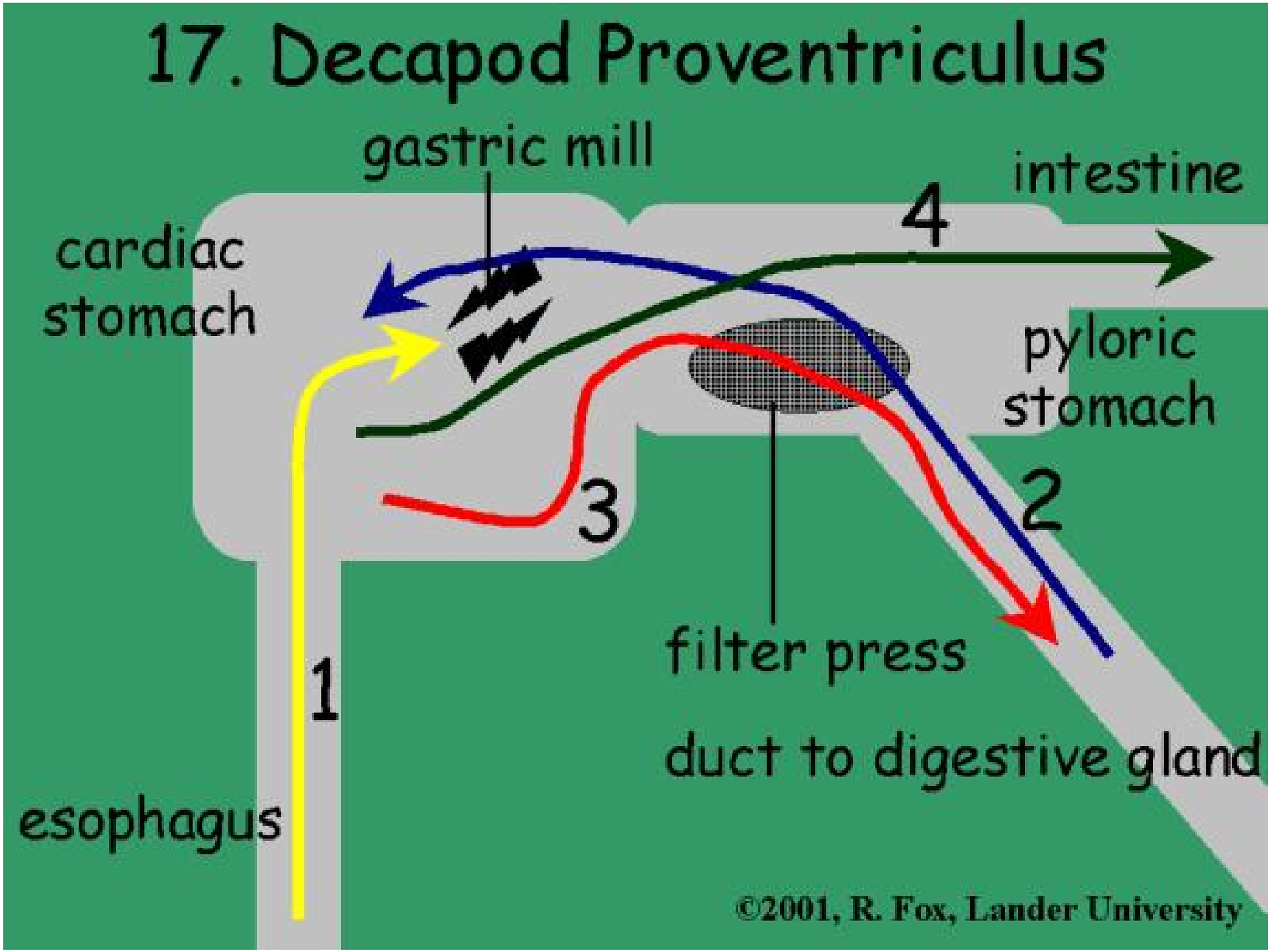


Digestion


Dorsal tooth of gastric mill
Lateral tooth of gastric mill
Pyloric stomach
Cardiac stomach
Filter press
Dorsal channel
Setae of pyloric fold
Intestine
ANTERIOR
Opening to
digestive ceca
Valve
Gland filter
Lateral
fold
Ventral channel
and setal screen
Esophagus



Digestion


17. Decapod Proventriculus
gastric mill
intestine
4
cardiac
stomach
pyloric
stomach
3
2
filter press
1
duct to digestive gland
esophagus
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