Introduction

Arthropods, including insects, spiders, and crustaceans, are protostomial ecdysozoans. They are, perhaps, the most abundant and diverse group of animals on the planet. They have managed to occupy nearly every habitat, including freshwater, marine, terrestrial and aerial environments. They also include some very important (to us) parasitic forms, such as fleas, mosquitoes, ticks, mites, lice, etc. As ecdysozoans, they secrete chitinous exoskeletons that are shed periodically (ecdysis; Fig. 32.12, p. 635) to allow growth. Most likely a paraphyletic group, some biologists divide the arthropods into separate phyla. In this laboratory exercise you will be introduced to arthropod diversity, systematics, and anatomy.

PHYLUM CHARACTERISTICS

1. bilaterally symmetric, segmented body (eucelomate protostome), but segments often fused as tagmata
2. exoskeleton of cuticle composed of chitin plus protein and lipids, often calcified; exoskeleton must be shed at intervals for growth (ecdysis; Fig. 32.12, p.635)
3. jointed paired appendages, typically one pair per body segment; appendages often modified for specialized functions
4. complete digestive system with mouth parts modified from paired appendages of head segments
5. open circulatory system with a dorsal heart
6. nervous system includes anterior brain a fused double ventral nerve cord; sensory organs often well-developed
7. sexes usually separate; marine forms often exhibiting planktonic larval stages
8. probably the most successful phylum in terms of diversity and sheer numbers; found in virtually all habitats (marine, freshwater, terrestrial, and aerial) available in the biosphere

ARTHROPODAN SYSTEMATICS (Table 33.5, p. 658)

Subphylum Trilobitamorpha
1. trilobites (Fig. 33.28, p. 657)

2. body divided into head, thorax, and abdomen regions, each region being composed of a number of segments
3. body also longitudinally trilobed
4. head with one pair of antennae and one pair of compound eyes, no mandibles
5. paired appendages are biramous
6. most probably scavengers
7. all extinct

Subphylum Cheliceriformes
1. first pair of appendages modified to form chelicerae
2. other appendages include pair of pedipalps and four pairs of walking legs; no antennae; no mandibles
3. head segments and thorax segments often fused as a cephalothorax

Class Chelicerata
Subclass Merostomata
1) horseshoe crabs (Fig. 33.30, p. 658)
2) body composed of cephalothorax (= prosoma) and abdomen (= opisthoma)
3) shield called a carapace covers the cephalothorax
4) possess pair of compound eyes plus simple eyes
5) appendages bear gills; sharp telson
6) primarily marine predators on mollusks and worms

Subclass Arachnida
1) spiders (Figs. 33.31c & 33.32, p. 659), scorpions (Fig. 33.31a, p. 659), mites (Fig. 33.31b, p. 659) and ticks
2) body divided into cephalothorax and abdomen (though these are fused in mites and ticks)
3) abdomen lacks gills
4) four pair of uniramous walking legs; possess simple eyes
5) excretion via malpighian tubules
6) primarily terrestrial predators, some are bothersome parasites

Class Pycnogonida
a. sea spiders (not true spiders)
b. differ from Class Chelicerate by having a very reduced abdomen and a unique proboscis
c. probably diverged early from the chelicerates

**Subphylum Crustacea**

1. water fleas, brine shrimp, copepods, barnacles (Fig. 33.38c, p. 664), pill bugs, beach hoppers, krill (Fig. 33.38b, p. 664), and decapods (Fig. 33.29, p. 657; Fig. 33.38a, p. 664)
2. body divided into three major tagmata, head, thorax, and abdomen; often head and thorax fused as a cephalothorax frequently bearing a carapace
3. appendages biramous, modified for various functions: first two pairs of appendages are antennae; one pair of mandibles and two pairs of maxillae
4. most with compound eyes
5. primitive crustaceans exhibit nauplius larva stage
6. most are aquatic (mainly marine) and have gills for gas exchange

**Subphylum Myriapoda**

1. centipedes (Fig. 33.34, p. 660) and millipedes (Fig. 33.33, p. 659)
2. all appendages are uniramous
3. elongate with many body segments
4. head appendages include one pair of antennae, one pair of mandibles and two pairs of maxillae
5. gas exchange via tracheal tubes
6. terrestrial

**Class Chilopoda**

a. centipedes (Fig. 33.34, p. 660)
   b. each body segment bears one pair of walking legs
   c. first pair of body segment appendages (behind the head) modified as poison claws
   d. body dorsoventrally flattened
   e. terrestrial predators

**Class Diplopoda**

a. millipedes (Fig. 33.33, p. 659)
   b. each body segment bears two pairs of walking legs
   c. body cylindrical
   d. generally herbivores or grazers on dead plant material

**Subphylum Hexapoda**

1. insects (Fig. 33.37, pp. 662 – 663) including grasshoppers (Fig. 33.35, p. 660), dragonflies, praying mantis, butterflies, bug, bees, termites, lice, fleas; body with distinct head (= six fused segments), thorax (= three segments), and abdomen (# of segments variable)
2. head appendages include one pair of antennae, one pair of mandibles, and one or two pairs of maxillae
3. three pairs of walking legs (thorax segments)
4. thorax often with one or two pairs of wings
5. development may involve incomplete metamorphosis (e.g., grasshoppers) or complete metamorphosis (e.g., butterflies, Fig. 33.36, p. 661)
6. most terrestrial; some aquatic (freshwater).

**Procedures and Assignment**

I. **Arthropod Diversity**
   Examine the arthropods on display. In your lab notebook, record the similarities and differences among the different arthropodan groups. While you won't need to report on these observations in your lab summary, you will be expected be able to distinguish these groups in the lab practical examination. It will be useful for you to refer to the systematics information presented above and in your BIOL 172 textbook.

II. **External Anatomy of Trilobites and Chelicerates**

A. **Fossil Trilobites**
   Examine the fossil trilobites. Draw a diagram of the dorsal surface labeling the following features: eye, cephalon, thorax, and pygidium. Comment on the difference in preservation between the dorsal and ventral surface. How do you account for this difference? From an evolutionary perspective, how might this difference in preservation between the dorsal and ventral surfaces relate to the biology of trilobites?

B. **Horseshoe Crab**
   1. Examine the horseshoe crab. Draw diagrams illustrating both the dorsal and ventral external surfaces of the horseshoe crab. Label the following features: carapace, opisthosoma, compound eye, chelicerae, pedipalps, walking legs, book gills, and telson.
2. Why are the horseshoe crabs considered to be more related to spiders than to true crabs?

C. Garden Spider
Examine the preserved specimen of the garden spider. Draw diagrams illustrating both the dorsal and ventral surfaces. Label the following features: prosoma, opisthosoma, chelicerae, pedipalps, walking legs, book lung opening, spinnerets, spiracle, and anus.

III. Crustaceans
A. Comparing Crayfish and Crabs
Referring to the labeled display specimens, compare the external anatomy of the blue crab with that of the crayfish. Discuss the differences and similarities you observe in their respective anatomies: cephalothorax, abdomen, telson, general body shape, mouthparts, and other appendages. How do you think these differences may relate to their life styles?

B. External and Internal Anatomy of the Crayfish
1. Carefully remove the five legs from one side of the body of the crayfish. Draw the following legs: the first leg (chela), second walking leg, and the fifth leg. Hypothesize the functions of each of these leg types.
2. Remove the chela from the rest of the leg. With a pair of scissors, start at the severed joint and cut along the dorsal and ventral surface of the chela to about 10 mm behind the hinge of the pincer. Cut across from the dorsal incision to the ventral, removing a piece of the shell to expose the interior of the chela. Find the ventral and dorsal plates inside the chela and pull each one with a forceps to determine the function of each. What is the function of each? Why is the ventral plate larger than the dorsal plate?

3. Remove one of the eyestalks and examine it under a dissecting microscope. Draw a diagram of the eye. Then remove the end cap of the lenses from the eye, prepare a wet mount and examine using a compound scope. Draw a diagram to illustrate the corneal lenses.
4. After carefully examining the dissected mouthparts of the crayfish on display, remove the corresponding mouthpart appendages of your specimen, diagram them and label as maxillipeds, maxillae and mandibles.
5. Carefully cut around the edge of the carapace and remove it to expose the internal anatomy from the dorsal surface. Find the following structures: heart, gastric mill, gill chamber, gills, green gland, intestines, cerebral ganglion and gonads. Be able to identify these structures in both a preserved specimen and in the crayfish model.
6. Are the gills isolated from the main chamber of the body cavity? How is the arrangement observed important to the health of the crayfish?

IV. Insects
A. External and Internal Anatomy of the Grasshopper
1. Observe the external anatomy of the grasshopper. Draw a lateral view diagram illustrating the following features: head, thorax, abdomen, antennae, compound eye, legs, wings, and spiracles.
2. Under the dissecting microscope, carefully remove the mouthparts of the grasshopper. Diagram and label the mandibles, maxilla, labrum, and labium.
3. Be able to recognize the following anatomical
structures from the grasshopper model: head, thorax, abdomen, compound eye, antennae, walking legs, wings, spiracles, mandibles, maxilla, labrum, labium, crop, heart, intestine, Malpighian tubules, ventral nerve cord, cerebral ganglion, and ovary.

B. Insect Life Cycles
Examine the plastic-mounted specimens illustrating the development of different insects. Distinguishing between which illustrate complete metamorphosis and which illustrate incomplete metamorphosis, draw labeled diagrams documenting your observations.

C. Comparing Crustaceans and Insects
1. In what major ways do the appendages of the grasshopper differ from those of the crayfish?
2. Describe at least four major differences between crustaceans (as represented by the crayfish) and insects (as represented by the grasshopper).

VOCABULARY
head
 thorax
 abdomen
 chelicerae
 book gills
 jointed appendages
 simple eye
 compound eye
telson
 carapace
 exoskeleton
 chitin
 chela
 maxillipeds
 maxillae
 mandibles
 cephalothorax
tagmata
 uniramous
 biramous
 antennae
 tracheal system
malpighian tubules
 ecdysis
 complete metamorphosis
 incomplete metamorphosis

SYSTEMATICS TO KNOW
Phylum Arthropoda
 Subphylum Trilobitomorpha
 Subphylum Cheliceriformes
 Class Chelicerata
 Subclass Merostomata
 Subclass Arachnida
 Class Pycnogonida
 Subphylum Crustacea
 Subphylum Myriapoda
 Class Chilopoda
 Class Diplopoda

Lab Summary
Your lab summary should consist of the following:
1. Descriptive title.
2. Short introduction identifying main objectives of the lab activity.
4. Results and Discussion section including information requested in the Procedures and Assignment section above and following the appropriate protocols for presenting figures and tables in a laboratory report. Be sure to follow all of the rules from producing figures for lab reports (one figure per page). Corresponding to each figure, there should be a short paragraph within the text portion of this "Results and Discussion" section that describe the significant features of the figure. Be sure to answer all questions asked throughout the Procedures and Assignment section of this lab description.
5. Short conclusion summarizing what you learned by carrying out this study.
Crayfish: Abdominal Region

Crayfish
Body Appendages

Note: This art reflects material for advanced study
Number in () indicates total number of appendages of type.

Body Appendages (abdominal region)

swimmerettes [pleopods—pairs 1–5 (10)]

1st pleopod of male (2)  2nd pleopod of male (2)  3rd pleopod of male  2nd pleopod of female

sense organs

typical arthropod limb

pleopod pair (6) [uropod (2)]  antennule (2)
Crayfish: Mouth & Posterior Cephalothorax

Crayfish
Body Appendages
Note: This art reflects material for advanced study
Number in () indicates total number of appendages of type.

Mouth Part Appendages

mandible (2)
1st maxilliped (2)
maxilla (4)
2nd maxilliped (2)
3rd maxilliped (2)

Body Appendages (posterior cephalothorax)
walking legs (peripods) (10)

2nd walking leg
[Note cheliped (pincer) not illustrated]
Crayfish: Male Reproductive System

Crayfish
Lateral View—Internal Dissection

Male Reproductive System

green gland
digestive gland
gastric mill

heart
ostia
testis
vas deferens
Crayfish: Female Reproductive System

Crayfish
Lateral View—Internal Dissection

Female Reproductive System

- position of gastrolith (if present)
- green gland
- mandibular muscle (retracted)
- rostrum
- cardiac muscle
- cardiac ossicle
- mandibular muscle
- pyloric ossicle
- pyloric muscle (cut)
- gills (retracted)
- ovary
- heart
- ostium
- digestive gland
- sternal artery
- abdominal artery
- position of oviduct
- mid-gut (intestine)
- flexor muscles
- hind gut (intestine)
- extension muscles
Crayfish: Surface Dissections

Crayfish
Surface Dissections

Dorsal Surface Dissection

- base of antenna
- compound eye
- rostrum
- stalk
- position of mandibular muscle
- gastric mill
- ophthalmic artery
- antennary artery
- heart
- branchiostegite
- ostium
- dorsal abdominal artery
- gonad (ovary or testis)

Lateral Surface Dissection

- gastric mill
- gonad (ovary or testis)
- gills

Thoracic Body Segments

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Crayfish: Ventral View

Crayfish
Ventral View

Male

walking legs (peripods)
copulatory appendages
3rd - 5th pleopods (swimmerettes)
1st pleopod
2nd pleopod
male genital aperture
tergum* of 2nd abdominal segment

Female

antennule
opening of green gland
walking legs (peripods)
sternum of last thoracic segment
chela
antenna
3rd maxilliped
cheliped (peripod)
female genital aperture

Body Regions

"Head" "Thorax" abdomen
cephalothorax

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Grasshopper: Lateral Aspect (Left Wings Removed)

Grasshopper
(Romalea microptera)

Lateral aspect (left wings removed)

Body Regions
Grasshopper: Lateral and Frontal Aspects of Head

Grasshopper
(Romalea microptera)

Lateral Aspect of Head

Frontal Aspect of Head
Grasshopper: Dorsal & Lateral and Ventral Aspects of Head and Thorax/Ventral Aspect of Thorax

Grasshopper
(Romalea microptera)

Dorsolateral and ventral aspects of the head and thorax

Ventral aspect of thorax
Grasshopper: Dorsal Aspect of Ventral Dissection/Ventral Aspect of Dorsal Dissection

Grasshopper
(Romalea microptera)

Dorsal aspect of ventral dissection

Ventral aspect of dorsal dissection

Digestive, tracheal, and reproductive systems (right ovary removed)

Circulatory and muscular systems

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