28.3 Phylum Arthropoda (Arthropods)

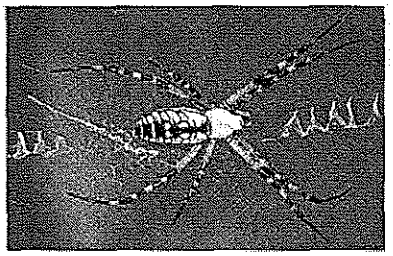
Arthropods have paired, jointed appendages and a hard exoskeleton that contains chitin. The chitinous exoskeleton consists of hardened plates separated by thin, membranous areas that allow movement of the body segments and appendages. Arthropods are segmented like the annelids, but specialization of segments has occurred. Explain. _____

_____

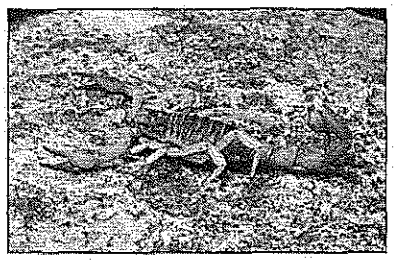
Phylum Arthropoda includes the most common animals in the world—the insects—as well as centipedes and spiders, which are also terrestrial. The crustaceans, including lobsters and crabs, are aquatic. The arthropods are divided into three subphyla, as shown in Figure 28.9 and the following classification table.

Figure 28.9 Arthropod diversity.
Subphylum Chelicerata contains (*a*) spiders, (*b*) scorpions, and (*c*) horseshoe crabs. Subphylum Uniramia contains (*d*) millipedes, (*e*) centipedes, and (*f*) insects. Subphylum Crustacea contains crayfish, (*g*) crabs, (*h*) shrimp, and (*i*) barnacles, among others.

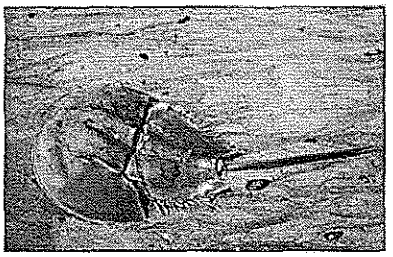
SUBPHYLUM CHELICERATA



a. Class Arachnida: spider, *Argiope rafaria*

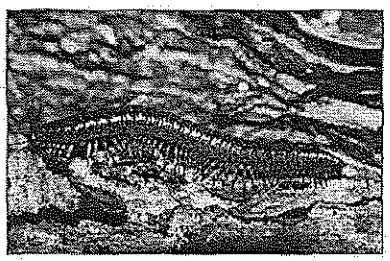


b. Class Arachnida: scorpion, *Hadrurus hirsutus*

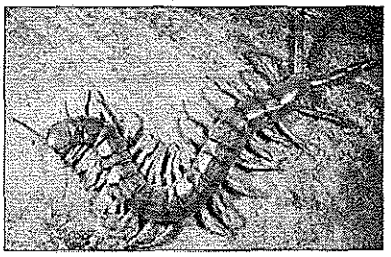


c. Class Merostomata: horseshoe crab, *Limulus polyphemus*

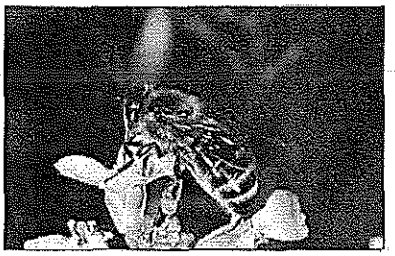
SUBPHYLUM CHELICERATA



d. Class Diplopoda: millipede, *Ophyiulus pilosus*

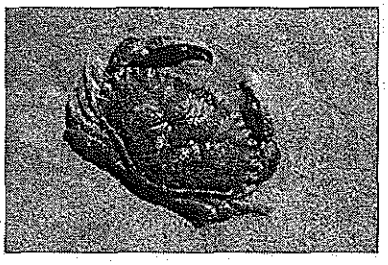


e. Class Chilopoda: centipede, *Scolopendra* sp.

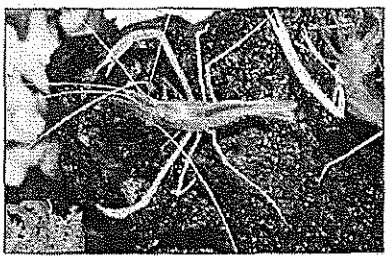


f. Class Insecta: honeybee, *Apis mellifera*

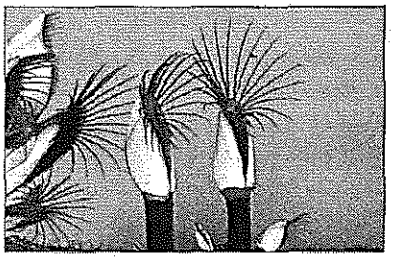
SUBPHYLUM CRUSTACEA



g. Class Malacostraca: crab, *Cancer productus*



h. Class Malacostraca: shrimp, *Stenopus* sp.



i. Class Maxillopoda: barnacles, *Lepas anatifera*

CLASSIFICATION: THE ARTHROPODS

PHYLUM ARTHROPODA
Chitinous exoskeleton with jointed appendages specialized in structure and function; well-developed central nervous system with brain and ventral paired nerve cord; reduced coelom; hemocoel.

Subphylum Chelicerata
Chelicerae and pedipalp attached to head; no antennae, mandibles, or maxillae. Four pairs of walking legs attached to a cephalothorax.
- Class Arachnida: spider, scorpions
- Class Merostomata: horseshoe crabs

Subphylum Uniramia
One pair of antennae, one pair of mandibles, and one or two pairs of maxillae attached to the head. Uniramous appendages attached to the body.
- Class Diplopoda: millipede
- Class Chilopoda: centipede
- Class Insecta: insects (bees, beetles, flies, grasshoppers)

Subphylum Crustacea
Compound eyes, antennae, antennules, mandibles, and maxillae attached to head. Usually five pairs of walking legs attached to cephalothorax.
- Class Malacostraca: crabs, shrimp, lobsters, crayfish
- Class Maxillopoda: barnacles

Observation: Diversity of Arthropods

1. Examine various specimens of arthropods, and complete Table 28.5.
2. In the last column, note the number and type of appendages attached to the thorax and/or abdomen.

Table 28.5 Arthropod Diversity

Common Name of Specimen	Subphylum	Appendages (attached to body)

Anatomy of Crayfish

Crayfish belong to a group of arthropods called crustaceans. Crayfish are adapted to an aquatic existence. They are known to be scavengers, but they also prey on other invertebrates. The mouth is surrounded by appendages modified for feeding, and there is a well-developed digestive tract. Dorsal, anterior, and posterior arteries carry hemolymph (blood plus lymph) to tissue spaces (hemocoel) and sinuses. In contrast to vertebrates, there is a ventral solid nerve cord.

Observation: Anatomy of Crayfish

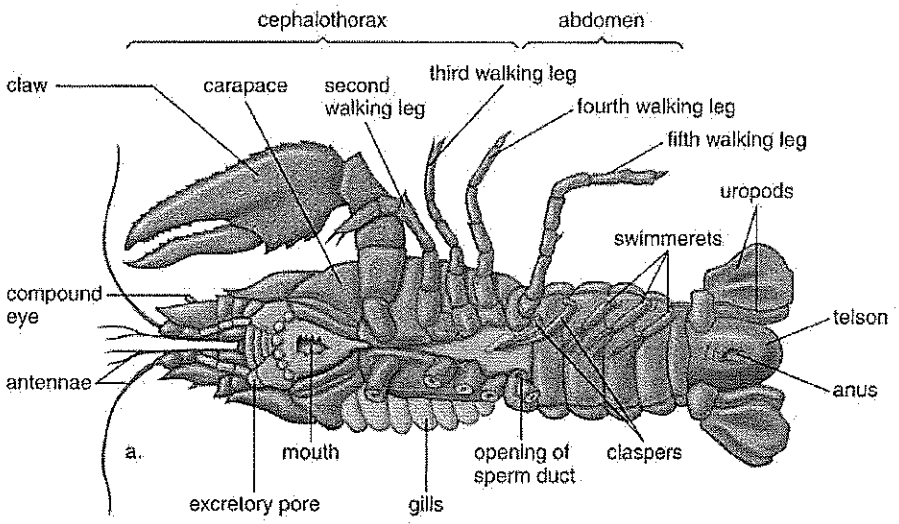
External Anatomy

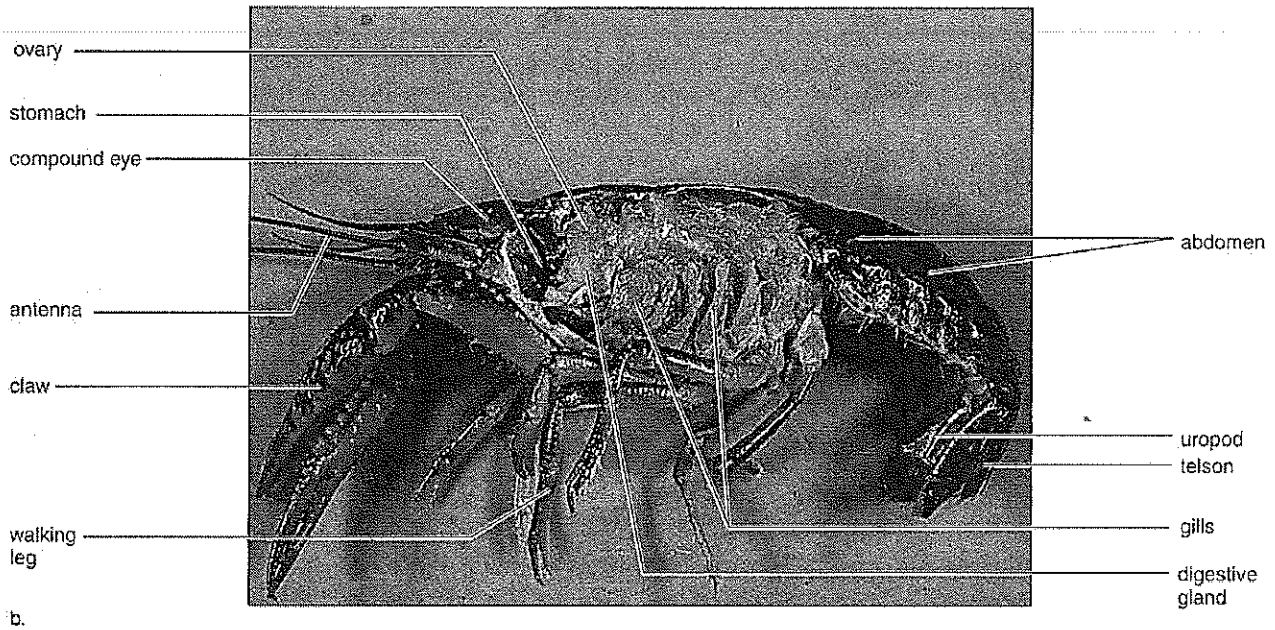
1. Obtain a preserved crayfish, and place it in a dissecting pan.
2. Identify the chitinous **exoskeleton.** With the help of Figure 28.10, identify the head, thorax, and abdomen. Together, the head and thorax are called the **cephalothorax;** the cephalothorax is covered by the **carapace.** Has specialization of segments occurred? _____ Explain. _____

_____

3. Find the **antennae,** which project from the head. At the base of each antenna, locate a small, raised nipple containing an opening for the **green glands,** the organs of excretion. Crayfish excrete a liquid nitrogenous waste.

Figure 28.10 Anatomy of a crayfish.
(*a*) Drawing of external anatomy (male). (*b*) Dissection of internal anatomy (female).





4. Locate the **compound eyes,** which are composed of many individual units for sight. Do crayfish demonstrate cephalization? _____ Explain. _____

5. Identify the six pairs of appendages around the mouth for handling food.
6. Find the five pairs of walking legs attached to the cephalothorax. The most anterior pair is modified as pincerlike claws.
7. Locate the five pairs of **swimmerets** on the abdomen. In the male, the anterior two pairs are stiffened and folded forward. They are claspers that aid in the transfer of sperm during mating.
8. In the female, identify the **seminal receptacles,** a swelling located between the bases of the third and fourth pairs of walking legs. Sperm from the male are deposited in the seminal receptacles. In the male, identify the opening of the sperm duct located at the base of the fifth walking leg.

   What sex is your specimen? _____
9. Examine the opposite sex also.
10. Find the last abdominal segment, which bears a pair of broad, fan-shaped **uropods** that, together with a terminal extension of the body, form a tail. Has specialization of appendages occurred? _____

    Explain. _____

Internal Anatomy

1. Place the crayfish in the dissecting pan.
2. Cut away the lateral surface of the carapace with scissors to expose the **gills** (Fig. 28.10*b*). Observe that the gills occur in distinct, longitudinal rows. How many rows of gills are there in your specimen? _____ The outer row of gills is attached to the base of certain appendages.

   Which ones? _____
   These outer gills are the **podobranchia** ("foot gills"). How many podobranchia do you find in your specimen? _____
3. Carefully separate the gills with a probe or dissecting needle, and locate the inner row(s) of gills. These inner gills are the **arthrobranchia** ("joint gills") and are attached to the chitinous membrane that joins the appendages to the thorax. How many rows of arthrobranchia do you find in the specimen? _____
4. Remove a gill with your scissors by cutting it free near its point of attachment, and place it in a watch glass filled with water. Observe the numerous gill filaments arranged along a central axis.
5. Carefully cut away the dorsal surface of the carapace with scissors and a scalpel. The epidermis that adheres to the exoskeleton secretes the exoskeleton. Remove any epidermis adhering to the internal organs.
6. Identify the diamond-shaped heart lying in the middorsal region. A crayfish has an open circulatory system. Carefully remove the heart.
7. Locate the **gonads** anterior to the heart in both the male and female. The gonads are tubular structures bilaterally arranged in front of the heart and continuing behind it as a single mass. In the male, the testes are highly coiled, white tubes.
8. Find the **mouth;** the short, tubular **esophagus;** and the two-part **stomach,** with the attached **digestive gland,** that precedes the intestine.
9. Identify the **green glands,** two excretory structures just anterior to the stomach, on the ventral segment wall.
10. Remove the thoracic contents previously identified.
11. Identify the **brain** in front of the esophagus. The brain is connected to the ventral nerve cord by a pair of nerves that pass around the esophagus.
12. Remove the animal's entire digestive tract, and float it in water. Observe the various parts, especially the connections of the digestive gland to the stomach.

13. Cut through the stomach, and notice in the anterior region of the stomach wall the heavy, *toothlike projections*, called the **gastric mill**, which grind up food. Do you see any grinding stones ingested by the crayfish? _____

If possible, identify what your specimen had been eating. _____

Anatomy of Grasshopper

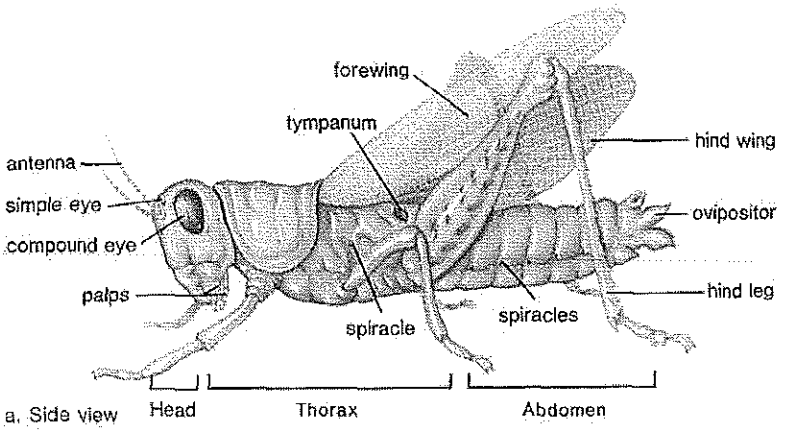
The grasshopper is an **insect.** Insects are adapted to life on land. In insects with wings, such as the grasshopper, wings are attached to the thorax. Respiration is by a highly branched internal system of tubes, called tracheae.

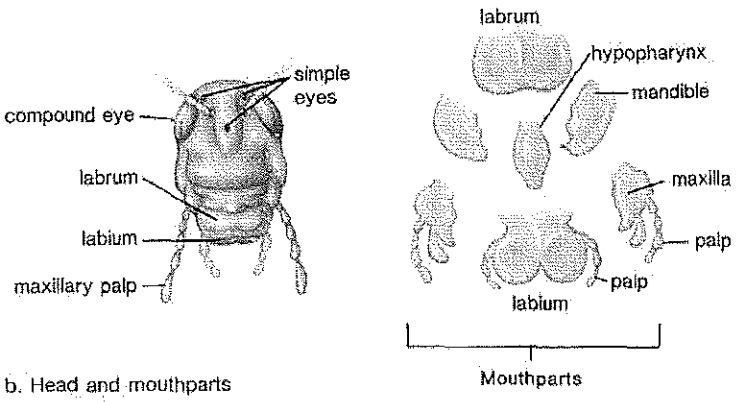
Observation: Anatomy of Grasshopper

External Anatomy

1. Obtain a preserved grasshopper (*Romalea*), and study its external anatomy with the help of Figure 28.11. Identify the head, thorax, and abdomen.
2. The grasshopper's **thorax** consists of three fused segments: the large anterior **prothorax,** the middle **mesothorax,** and the hind **metathorax.** Identify the first pair of legs attached to the prothorax. Then find the second pair of legs and the outer pair of straight, leathery **forewings** attached to the mesothorax. Finally, locate the third pair of legs and the inner, membranous **hind wings** attached to the metathorax. Each leg consists of five segments. The hind leg is well-developed and used for jumping. How many pairs of legs are there? _____

Figure 28.11 External anatomy of a female grasshopper, *Romalea*.
(*a*) The legs and wings are attached to the thorax. (*b*) The head has mouthparts of various types. (b) Modified from T.T. Storer and R.L. Usinger, *General Zoology*. Used with permission of California Academy of Sciences, Golden Gate Park, San Francisco, CA.





3. Is locomotion in the grasshopper adapted to land? _____

   Explain. _____

   _____

4. Use a hand lens or dissecting microscope to examine the grasshopper's special sense organs of the head. Identify the **antennae** (a pair of long, jointed feelers), the **compound eyes,** and the three, dotlike **simple eyes.**
5. Remove the **mouthparts** by grasping them with forceps and pulling them out. Arrange them in order on an index card, and compare them to Figure 28.11*b*. These mouthparts are used for chewing and are quite different from those of a piercing and sucking insect.
6. Identify the **tympana** (sing., **tympanum**), one on each side of the first abdominal segment (Fig. 28.11*a*). The grasshopper detects sound vibrations with these membranes.
7. Locate the **spiracles,** along the sides of the abdominal segments. These openings allow air to enter the tracheae, which constitute the respiratory system.
8. Find the **ovipositors** (Fig. 28.12*a*), four curved and pointed processes projecting from the hind end of the female. These are used to dig a hole in which eggs are laid. The male has **claspers** that are used during copulation (Fig. 28.12*b*).

Internal Anatomy

1. Detach the wings and legs of the grasshopper used in the Observation. Then turn the organism on its side, and use scissors to carefully cut through the exoskeleton (dorsal to the spiracles) along the full length (from the head to the posterior end) of the animal. Repeat this procedure on the other side.
2. Cut crosswise behind the head so that you can remove a strip of the exoskeleton. If necessary, reach in with a probe to loosen the muscle attachments and membranes.
3. Pin the insect to the dissecting pan, dorsal side up. Cover the specimen with water to keep the tissues moist.

Figure 28.12 Grasshopper genitalia.
(*a*) Females have an ovipositor, and (*b*) males have claspers.

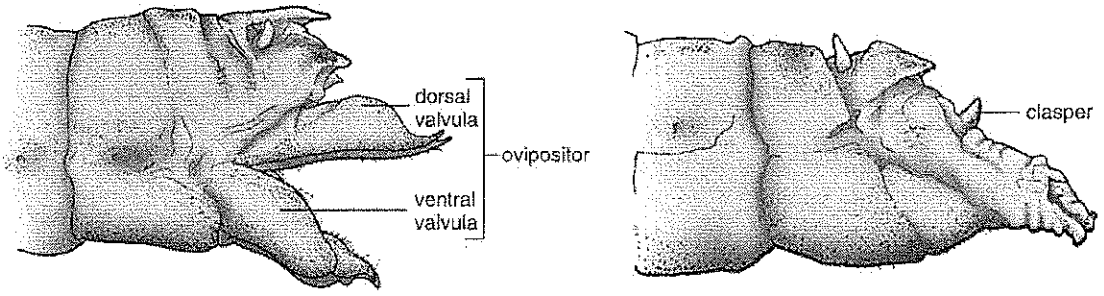
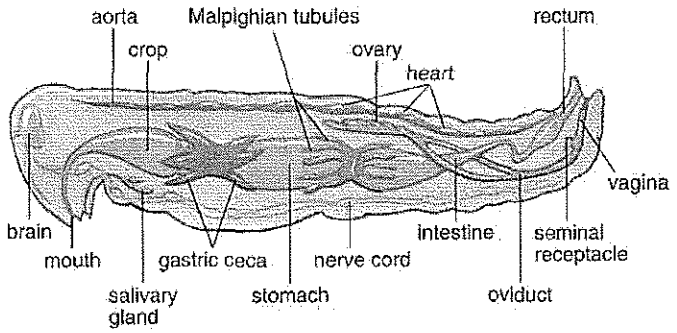


Figure 28.13 Internal anatomy of a female grasshopper.
The digestive system of a grasshopper shows specialization of parts.



4. Identify the heart (Fig. 28.13) and aorta just beneath the portion of exoskeleton you removed. A grasshopper has an open circulatory system. Remove the heart and adjacent tissues.
5. Locate the **fat body,** a yellowish fatty tissue that covers the internal organs. Carefully remove it.
6. Find the **tracheae,** the respiratory system of insects. Using the dissecting microscope, look for glistening white tubules, which deliver air to the muscles.
7. Identify the reproductive organs that lie on either side of the digestive tract in the abdomen. If your specimen is a male, look for the testis, a coiled, elongated cord containing many tubules. If your specimen is a female, look for the ovary, essentially a collection of parallel tapering tubules containing cigar-shaped eggs.
8. Locate the digestive tract and, in sequence, the **crop,** a large pouch for storing food (a grasshopper eats grasses); the **gastric ceca,** digestive glands attached to the stomach; the stomach and the intestine, which continues to the anus; and **Malpighian tubules,** excretory organs attached to the intestine. Insects secrete a solid nitrogenous waste. Is this an adaptation to life on land? _____

   Explain. _____
9. Work the digestive tract free, and move it to one side. Now identify the **salivary glands** that extend into the thoracic cavity.
10. Remove the internal organs. Now identify the ventral **nerve cord,** which is thickened at intervals by ganglia.
11. Remove one side of the exoskeleton covering the head. Identify the brain, which is anterior to the esophagus.

Conclusion

Compare the adaptations of a crayfish to those of a grasshopper by completing Table 28.6. Put a star beside each item that indicates an adaptation to life in the water (crayfish) and to life on land (grasshopper). Check with your instructor to see if you identified the maximum number of adaptations. _____

Table 28.6 Comparison of Crayfish and Grasshopper

	Crayfish	Grasshopper
Locomotion		
Respiration		
Nervous system		
Reproductive features		
Sense organs		

Insect Metamorphosis

Metamorphosis means a change, usually a drastic one, in form and shape. Some insects undergo what is called *complete metamorphosis*, in which case they have three stages of development: larval stages, the pupa stage, and finally the adult stage. Metamorphosis occurs during the pupa stage when the animal is enclosed within a hard covering. The animals that are best known for metamorphosis are the butterfly and the moth, whose larval stage is called a caterpillar and whose pupa stage is the cocoon; the adult is the butterfly or moth (Fig. 28.14*a*). Grasshoppers undergo *incomplete metamorphosis*, which is a gradual change in form rather than a drastic change. The immature stages of the grasshopper are called nymphs rather than larvae, and they are recognizable as grasshoppers even though they differ somewhat in shape and form (Fig. 28.14*b*).

If available, examine life cycle displays or plastomounts that illustrate complete and incomplete metamorphosis.

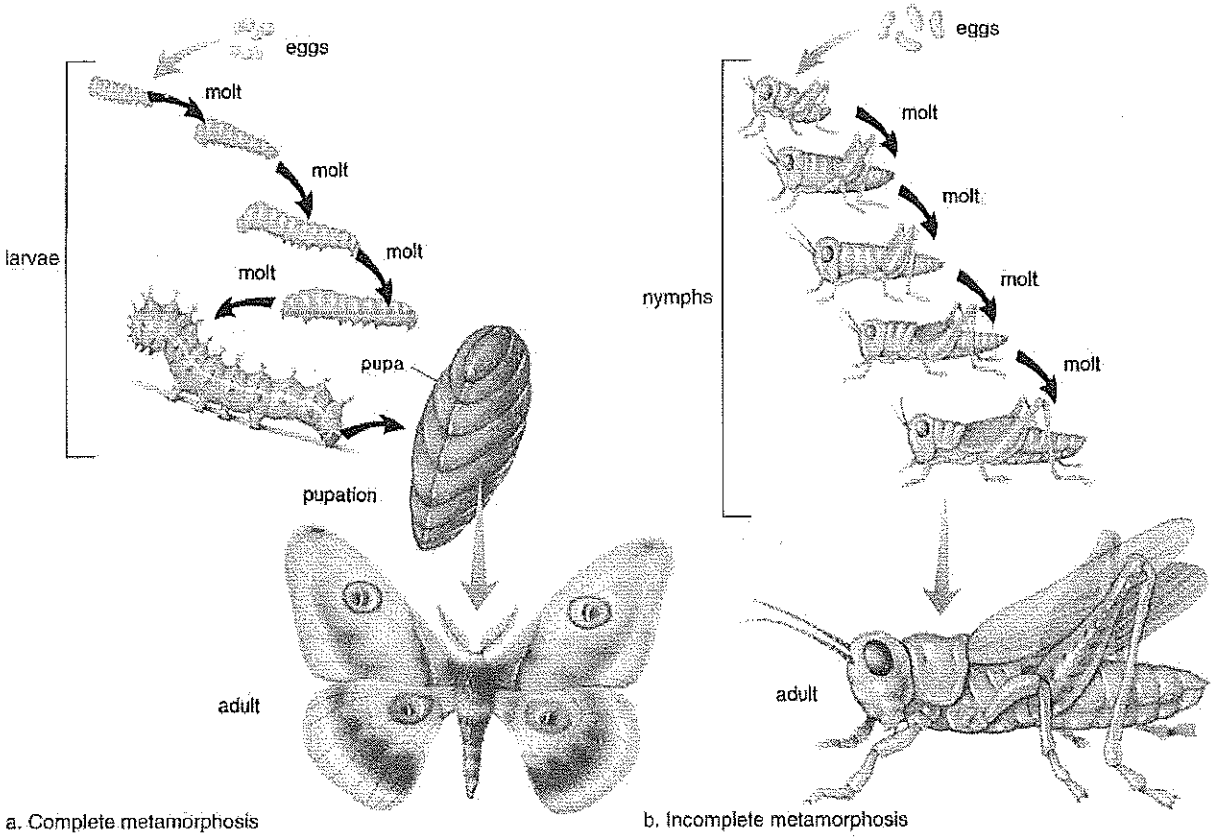
Observation: Insect Metamorphosis

Observe any insects available, and state in Table 28.7 whether they have complete metamorphosis or incomplete metamorphosis.

Table 28.7 Insect Metamorphosis

Common Name of Specimen	Complete or Incomplete Metamorphosis

Figure 28.14 Insect metamorphosis.
During (*a*) complete metamorphosis, a series of larvae lead to pupation. The adult hatches out of the pupa. During (*b*) incomplete metamorphosis, a series of nymphs leads to a full-grown grasshopper.



Conclusions

- With reference to Figure 28.14, what stage is missing when an insect does not have complete metamorphosis? _____ What happens during this stage? _____
- What form, the larvae or the adult, disperses the species in flying insects? _____ How is this a benefit? _____
- In insects that undergo complete metamorphosis, the larvae and the adults utilize different food sources and habitats. Why might this be a benefit? _____
- With reference to insects that undergo incomplete metamorphosis, which form, the nymphs or the adult, have better developed wings? _____ What is the benefit of wings to an insect? _____

Laboratory Review 28

1. Jointed appendages and an exoskeleton are characteristic of what group of animals?
2. Crayfish belong to what group of arthropods?
3. A clam belongs to what group of molluscs?
4. Molluscs, annelids, and arthropods are all what type of animal?
5. A visceral mass, foot, and mantle are characteristic of what group of animals?
6. All the animals studied today have what type of coelom?
7. In a clam, the intestine passes through what organ belonging to another system?
8. The clam is a filter feeder, but the squid is a(n) _____.
9. The annelids are the first of the animal phyla studied to have what general characteristic?
10. Which of the three classes of annelids has suckers as an adaptation to its way of life?
11. What term indicates that earthworms have both male and female organs?
12. The arthropods are the first of the animal phyla to have what general characteristic?
13. What type of excretory organs are attached to the intestine of a grasshopper?
14. Contrast the respiratory organ of a crayfish with that of a grasshopper.

Thought Questions

15. Compare respiratory organs in the crayfish and the grasshopper. How are these suitable to the habitat of each?

16. For each of the following characteristics, name an animal with the characteristic, and state the characteristic's advantages:
    a. Closed circulatory system
    b. Jointed appendages