EXPLORING THE INTERNAL ANATOMY AND PHYSIOLOGY OF INSECTS

INTRODUCTION

Many people believe that insects are only slightly more alive than the soil. "Insects are very simple creatures." "They are destructive." "They do nothing but eat." These statements are far from the truth. (Figure 1.)

Few people realize the complex nature of an insect's life. An insect's internal anatomy* and physiology rival those of the most complex organisms. An insect's body processes are astounding. Insects must breathe, eat, and sense the world around them to remain alive. Most insects have the same senses as do humans; some have additional senses. However, insects sense the world differently than do humans, and the location of their sense organs is often bizarre.

This topic explores the internal structure and functions of an insect's body. It also examines an insect's senses.

FIGURE 1. I JUST DON'T GET ANY RESPECT! DON'T YOU KNOW I'M A COMPLICATED COCKROACH?

*Underlined words are defined in the Glossary of Terms.

ORGAN SYSTEMS

All organisms must conduct certain body processes to survive. For example, they must eat, breathe, and coordinate activities. These body processes occur in different organs of the body. While certain groups of organs digest food, others breathe or transmit information. An organ system includes all the organs used to conduct one process. For example, the digestive system includes the organs that work together to digest food.

Insects have many of the same organ systems as do vertebrates. This section discusses the circulatory system, digestive system, excretory system, respiratory system, skeleto-muscular system, reproductive system, endocrine system, and nervous system of insects.

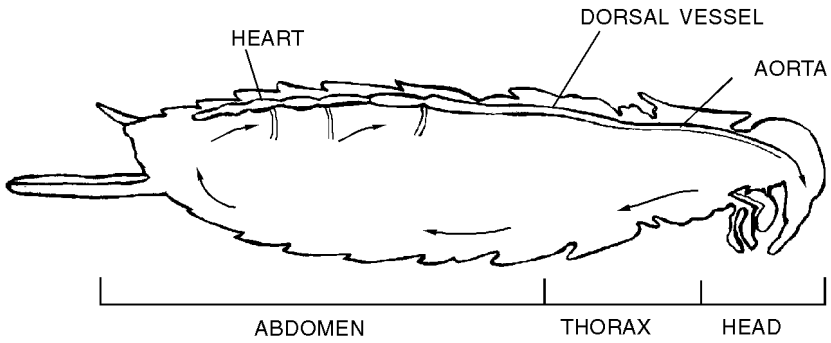
Circulatory System

An insect has an open circulatory system. A human has a closed circulatory system in which the blood flows within vessels and arteries. An insect's blood flows freely through its body cavity.

Also, unlike most animals, an insect's circulatory system does not provide the cells with oxygen. An insect's cells receive oxygen directly from the respiratory system. The insect's circulatory system simply transports food to the cells and removes waste from them.

An insect's circulatory system includes a heart, a dorsal vessel, smaller blood vessels, sinuses (singular, sinus), and hemolymph (blood). Figure 2 illustrates the circulatory system of a cricket.

FIGURE 2. CIRCULATORY SYSTEM OF A CRICKET.
(Arrows show direction of blood flow through the heart and body.)



The dorsal vessel, immediately under the upper part of the exoskeleton, extends the length of the insect's body. The heart is in the abdomen and is an enlarged part of this dorsal vessel. From the heart region to the head region, the dorsal blood vessel is the aorta.

The heart pumps by contracting from one end to the other with a wave-like motion, forcing the hemolymph through it. The hemolymph flows forward through the aorta, towards the head, and then unrestricted through the body cavity.

The hemolymph flows freely through these sinuses and eventually collects in pools around the heart. It returns to the heart through small openings (ostia). The heart then pumps the hemolymph, and the cycle begins again.

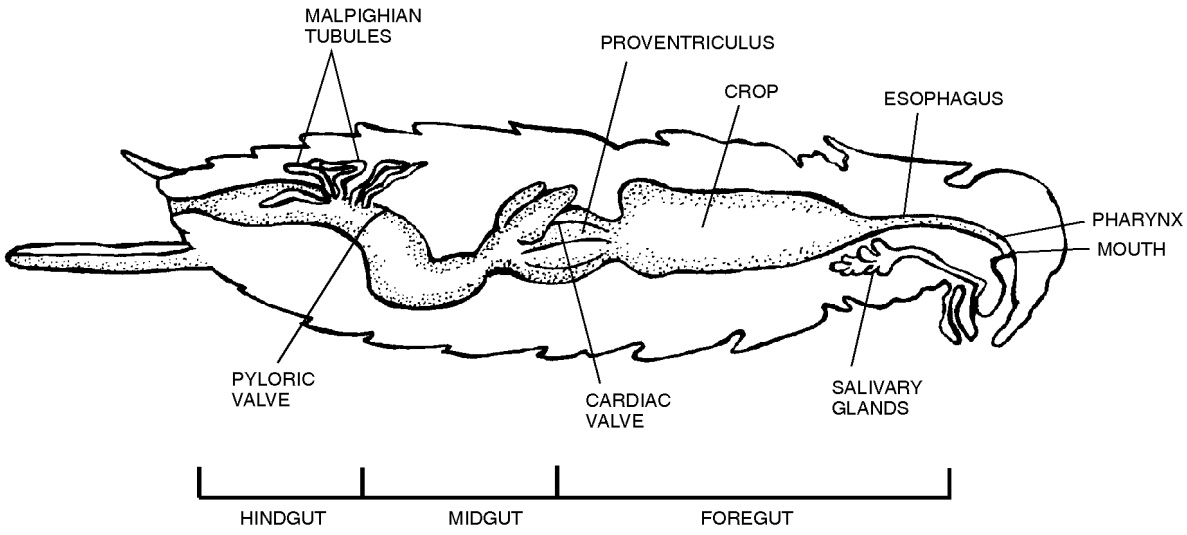
The heart beats from 14 to 160 times per minute, depending on the insect species, its level of activity, and the environmental temperature.

An insect's blood (hemolymph) is colorless. It has no red blood cells nor does it carry oxygen or carbon dioxide. Hemolymph only carries food to the cells and waste materials from the cells.

Digestive System

Figure 3 illustrates the basic parts of an insect's digestive system, as represented by a cricket. In all insects, the alimentary canal reaches from the mouth to the anus. It consists of the foregut, midgut, and hindgut.

FIGURE 3. DIGESTIVE SYSTEM OF A CRICKET.



The foregut contains the salivary glands, pharynx, esophagus, crop, and proventriculus (if present). When an insect ingests food, its salivary glands immediately release chemicals into the mouth to help digest the food. After the insect swallows, the food enters the pharynx and then the esophagus. At the end of the esophagus is the crop, a food storage compartment. Some insects have a proventriculus after the crop. The proventriculus screens or further grinds the food.

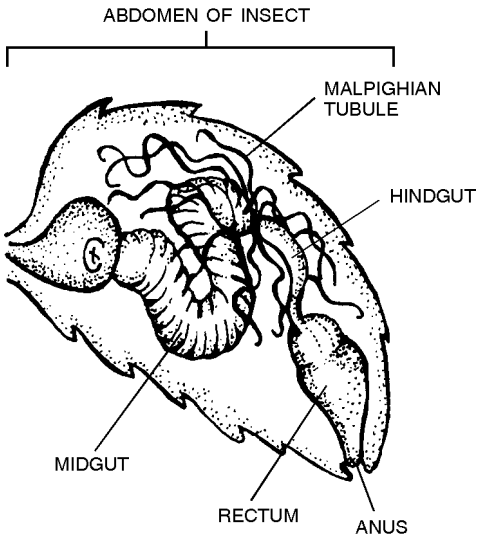
After leaving the crop or proventriculus, food enters the midgut through the cardiac valve. The midgut contains the stomach where digestion takes place. The stomach releases many enzymes, which break food into smaller pieces (nutrients) that the insect's body can use.

Special cells that line the stomach absorb these nutrients and then release them into the hemolymph. The hemolymph transports the nutrients to all cells of the body. The remaining undigested food enters the hindgut through the pyloric valve.

The hindgut contains the ileum, colon, rectum, and anus. These organs extract excess water and salts from the undigested food and return them to the hemolymph. The remaining undigested food exits the alimentary canal through the anus.

Excretory System

FIGURE 4. EXCRETORY SYSTEM OF AN INSECT.



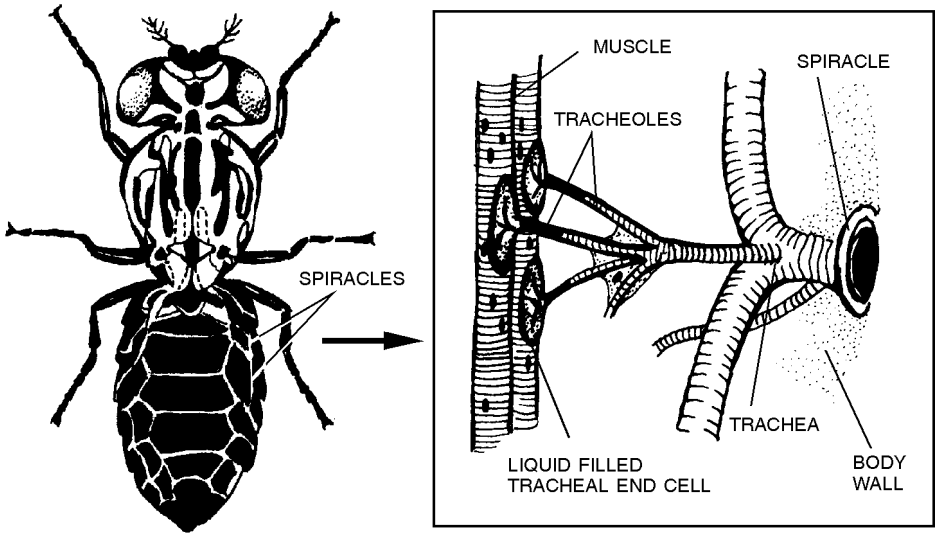
Groups of organs called Malpighian tubules form an insect's excretory system. A Malpighian tubule has an open end attached to the hindgut and a closed end extending into the body cavity (Figure 4). A few insects (such as the aphid and springtail) do not have any Malpighian tubules, while a honey bee may have 150.

Malpighian tubules function similarly to kidneys. These tubules extract uric acid (a nitrogen waste product), other waste products, and water from an insect's hemolymph. The Malpighian tubules excrete these wastes into the hindgut, immediately behind the pyloric valve.

Respiratory System

Unlike a human, an insect's respiratory system is separate from its circulatory system. Oxygen reaches an insect's cells directly, without the hemolymph transporting it. Figure 5 illustrates the respiratory system of a fly.

FIGURE 5. RESPIRATORY SYSTEM OF A FLY.



An insect's respiratory system includes spiracles, tracheae, tracheoles, tracheal end cells, and sometimes air sacs. The spiracles (small breathing holes) are located on the sides of the abdomen and thorax. Usually, there are ten pairs of spiracles - two pairs on the thorax and eight pairs on the abdomen.

Air enters the respiratory system through the spiracles, which the insect closes with valves when necessary. These valves help conserve water in the insect's body. From the spiracles, air enters the tracheae (hard and hollow tubes similar to human blood vessels). Two main trachea extend the length of the body on either side.

From the tracheae, air travels through smaller vessels (tracheoles). The tracheoles end in liquid-filled tracheal end cells where oxygen exchanges for carbon dioxide. In return, the carbon dioxide flows through the tracheoles to the tracheae and through the spiracles. After oxygen is released into the tracheal end cell, it diffuses to other cells in the nearby tissue.

The whole system of tracheae, tracheoles, and tracheal end cells is very large throughout the insect's body. In a small insect, air travels through this system passively by diffusion. A large insect actively helps move air through its respiratory system by moving the abdomen, legs, or wings.

Proportionately, insects need more oxygen than do people, especially when they are in flight. The respiratory system allows the insect to receive large quantities of oxygen. Sometimes, especially in the wing muscles, a tracheal end cell actually indents the muscle, allowing the muscle to receive large amounts of oxygen very quickly. Some insects, particularly flying insects, have large air sacs in their wing muscles to store oxygen for use during flight.

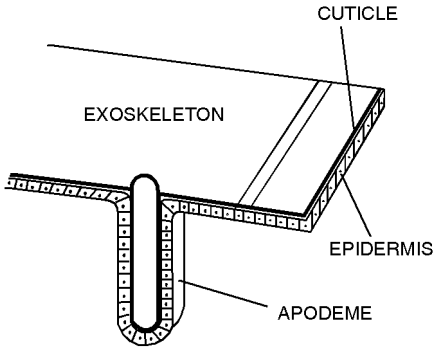
Some tiny aquatic insects do not have spiracles. Oxygen diffuses into their bodies directly through their body walls. Other aquatic insects have gills to aid them in respiration. Dragonfly, damselfly, and mayfly nymphs use gills to extract oxygen from the water around them.

Skeleto-Muscular System

Skeleton

All insects have exoskeletons. The exoskeleton is made of chitin, a water-proof, light, and very strong compound. The exoskeleton may be very hard (beetle) or leathery (caterpillar). Because an insect has no bones, all of its support must come from the exoskeleton.

FIGURE 6. APODEME ON THE INSIDE OF AN INSECT'S EXOSKELETON.



Topics #8424-A and #8424-C describe the exoskeleton in greater detail.

Muscles

An insect has many muscles. A grasshopper has more than 900 different muscles; a caterpillar may have more than 4,000.

The muscles attach to apodemes (projections on the inside of the exoskeleton). Figure 6 shows the location of an apodeme.

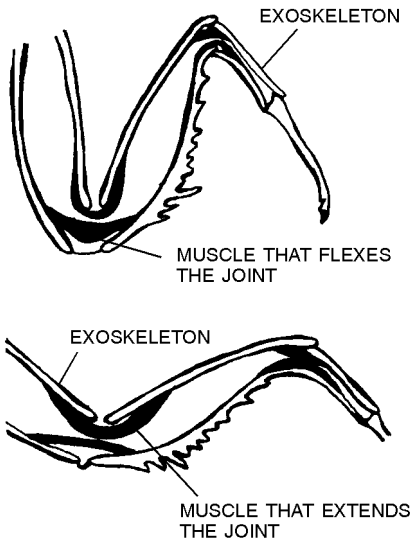
Similar to vertebrate muscles, an insect's muscles bend and straighten appendages. For example, each leg joint has a pair of muscles attached to it. When one muscle contracts, the joint bends. When the other muscle of the pair contracts, the joint straightens.

Figure 7 diagrams the muscles of a praying mantis' leg.

Insect muscles are really no stronger than human muscles, although an insect can carry objects heavier than itself or hop distances many times its body length. It is actually the small size of the insect that allows its muscles to appear much stronger.

The flight muscles of an insect are capable of very rapid contractions. Different insects flap their wings between five and 1,000 beats per second. Butterflies have a relatively slow wing beat, while certain wasps and flies are capable of extremely fast wing beats.

FIGURE 7. PAIRED MUSCLES IN A PRAYING MANTIS' LEG.



For insects with slower wing beats, each wing beat requires a separate nerve impulse. However, for insects with rapid wing beats, one nerve impulse may initiate up to 40 wing beats!

Reproductive System

Insect reproduction varies widely from species to species.

Some insects lay eggs (oviparous reproduction). Other insects do not lay eggs. These insects hold their eggs internally until the young hatch and are born alive (ovoviviparous reproduction).

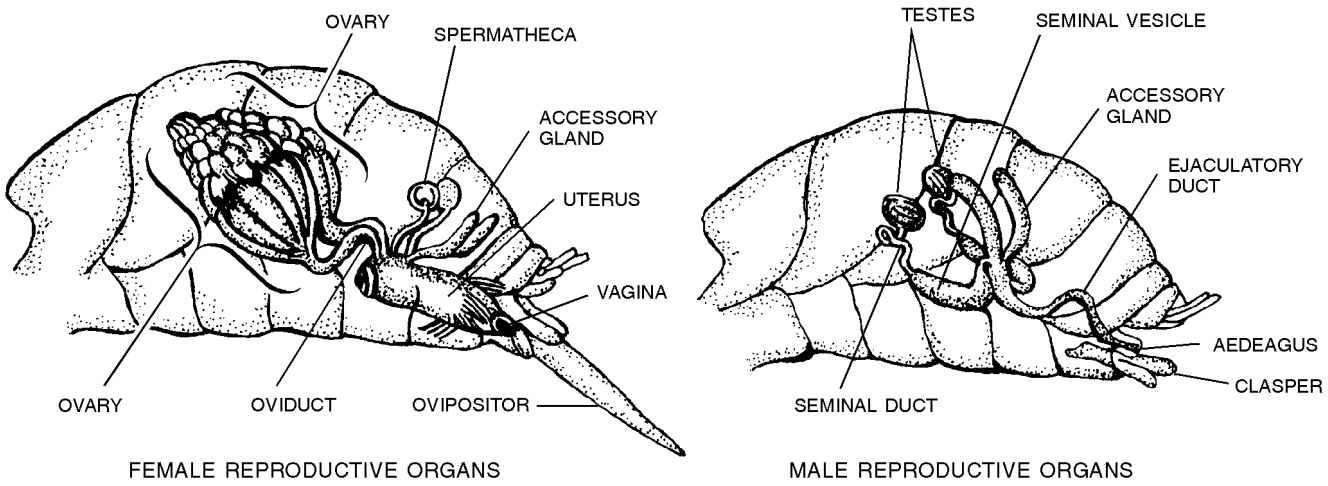
Most insects reproduce sexually. The most common form is bisexual reproduction. The sperm (male reproductive cell) fertilizes the egg (female reproductive cell), which develops into a new insect.

Several insect species reproduce from unfertilized eggs (parthenogenesis). Many bees and aphids have parthenogenic reproduction as well as bisexual reproduction. For example, male honey bees (drones) develop from unfertilized eggs, and females (queens and workers) develop from fertilized eggs.

Insect reproductive organs resemble those of many other animals. Figure 8 illustrates the locations of the male and female reproductive organs of a typical insect species.

The female has a pair of ovaries (singular, ovary) and oviducts, which join and lead to the uterus and vagina. Each ovary produces eggs that travel down the attached oviduct into the vagina to be fertilized. For insects with oviparous reproduction, the female uses her ovipositor to deposit the fertilized eggs outside her body.

FIGURE 8. REPRODUCTIVE SYSTEMS OF INSECTS.



The male has a pair of testes (singular, testis), each attached to a seminal duct. The testes produce sperm. The seminal vesicles store sperm at the ends of the seminal ducts. The seminal vesicles join to form the ejaculatory duct, which leads to the aedeagus, the copulatory organ. A pair of accessory glands add fluid to the sperm.

Insects mate very similar to mammals. The male of some insect species has a pair of claspers to grasp the female during mating.

Fertilization of the eggs usually occurs inside the female's body. The male deposits sperm into the female's spermatheca, a small pouch for storage of sperm (Figure 8). As the female lays eggs, they pass by the spermatheca and are fertilized.

In some species, the female only mates once in her lifetime. She stores enough sperm for all the eggs she will lay.

The female of some insect species also has a pair of accessory glands. These glands secrete a sticky substance that the female uses to glue her eggs to various objects.

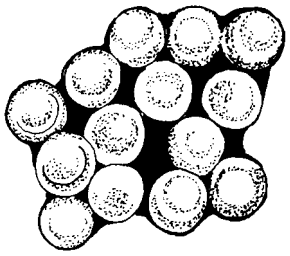
Depending on the insect species, the female lays her eggs on plant leaves, underground, in the open, hidden from view, in the water, on stalks of plants, in a cluster, individually, or in a case. The location of the eggs is helpful in identifying the insect species.

Insect eggs are of many shapes and colors. Some eggs are distinctive enough for entomologists to identify the insect species that laid the eggs.

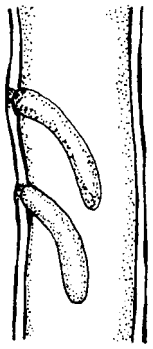
Figure 9 illustrates the eggs of several insect species.

FIGURE 9. EGGS OF SEVERAL INSECT SPECIES.

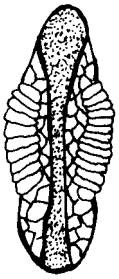
HORSE BOT FLY
(EGGS ON A HAIR)



STINK BUG



SNOWY TREE CRICKET
(EGGS IN A STEM)



ANOPHELES MOSQUITO

CULEX MOSQUITO

Insect eggs also vary in the time required to hatch. Some cicadas require several years to hatch from their eggs! Other insects hatch quickly. Sweet potato whitefly eggs hatch in three or four days.

Environmental temperature has an effect on the rate of hatching for almost all insects. The higher the temperature, the faster the eggs will hatch. The lower the temperature, the slower they will hatch. If the temperature gets too high or too low, the eggs die.

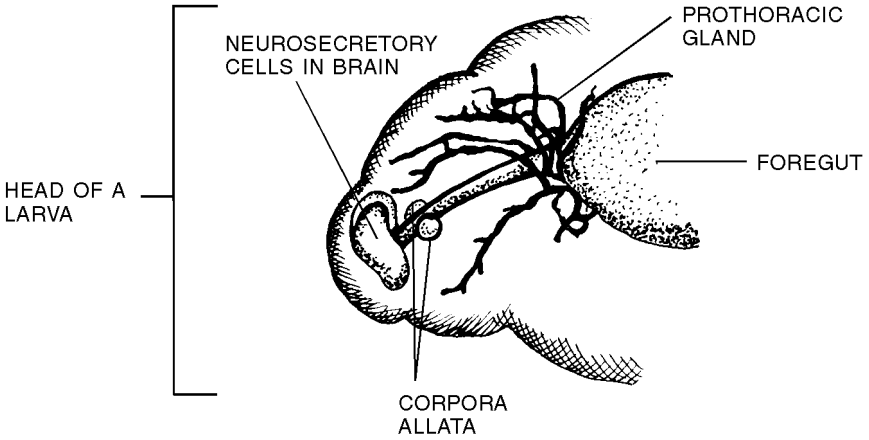
Insects vary greatly in the number of eggs produced by a single female. An Australian queen termite lays nearly 360 eggs an hour, and she may live for 25 to 50 years! Although a female insect lays many eggs, only a few of those eggs survive.

Endocrine System

The insect's endocrine system produces chemicals (hormones) that have an effect on the insect's growth and reproduction. Figure 10 illustrates the organs of the endocrine system.

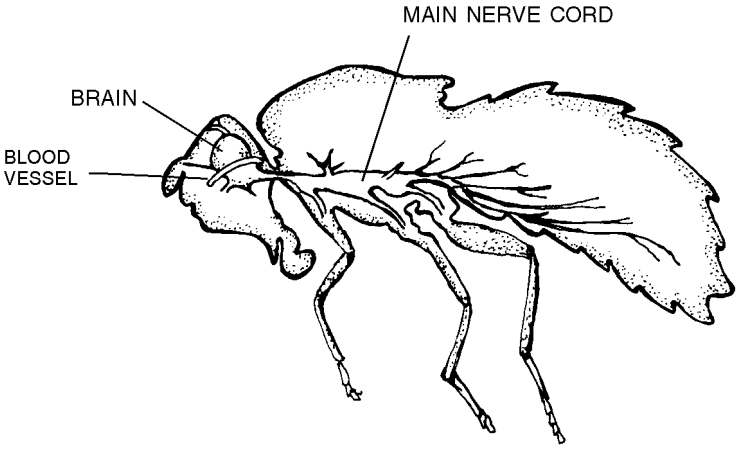
Three basic organs (neurosecretory cells, corpora allata, and prothoracic glands) comprise an insect's endocrine system. These glands secrete hormones that affect growth and change in insects. Topic #8424-C discusses these hormones and their functions in greater detail.

FIGURE 10. ENDOCRINE SYSTEM OF AN INSECT.



Nervous System

FIGURE 11. NERVOUS SYSTEM OF A FLY.



Insects have a ventral, or lower, nervous system. The nervous system includes a brain (located in the head) and two nerve cords (extending from the brain down either side of the body). These main nerve cords connect with smaller nerves that extend across the body. Other small nerves extend to all parts of the body. These small nerves carry impulses from the main nerves to muscles and other tissues. They also carry impulses from sense organs to the main nerves. Figure 11 diagrams the nervous system of a fly.

Insects usually have several ganglia (singular, ganglion) along the main nerves in each body segment. Sometimes, a ganglion may be as large as the brain. Ganglia help control local movement within each body segment. For example, a ganglion helps coordinate leg and wing movement without requiring nerve impulses to travel to and from the brain. In an insect, the ganglia can function independently of the brain. In fact, many insects live for a time after having their heads removed.

INSECT SENSES

An insect receives information about its environment through its senses. Most insects have five senses. However, what and how they see, hear, taste, smell, and feel may be very different from humans. Scientists separate an insect's senses into three types: chemical (taste and smell), mechanical (touch, gravity, temperature, balance, and hearing), and electromagnetic (vision).

Chemical Senses

The chemical senses include taste and smell. Groups of cells called chemoreceptors provide the insect with information about taste and smell. Chemoreceptors are located on its mouthparts, antennae, or tarsi.

Many insects are very sensitive to particular chemicals. For example, some insects can taste a difference between two forms of the same sugar! Some can detect weak concentrations of chemicals released by other insects located several miles away!

The senses of taste and smell are very important to insects. These senses help guide an insect's mating behavior, food selection, and habitat choice. These senses also are important for communication among insects.

Mechanical Senses

Insect mechanical senses include those of touch, gravity, temperature, balance, and hearing. These senses help an insect avoid danger, move about, communicate, and reproduce.

Touch, Gravity, and Temperature

The sense of touch includes the feelings of movement and pressure. An insect feels movement with small hairs (hair sensilla) located all over its body. When these hairs bend, even slightly, the insect detects movement. An insect detects air and water movement, as well as movements of its own body, with hair sensilla.

Insects also have small sense organs called campaniform sensilla (singular, campaniform sensillum) to detect pressure and gravity. Campaniform sensilla are scattered throughout the insect's body wall. When something exerts pressure on an insect, its campaniform sensilla respond and alert the insect. The campaniform sensilla also detect gravity.

Insects detect temperature with other sense organs located in their body walls. Many scientists believe that certain insects detect relative humidity. However, the scientists do not know exactly what organ(s) perform this function.

Scientists are uncertain if insects feel pain as humans do. An insect responds to damaging things (such as being near acids or having its leg caught) by moving away or struggling to free itself. This shows that the senses alert the insect to danger and try to preserve its life.

Balance

Insects have a very good sense of balance. Special hairs called tactile setae (singular, tactile seta) in the leg joints give the insect information about its location and help it keep its balance.

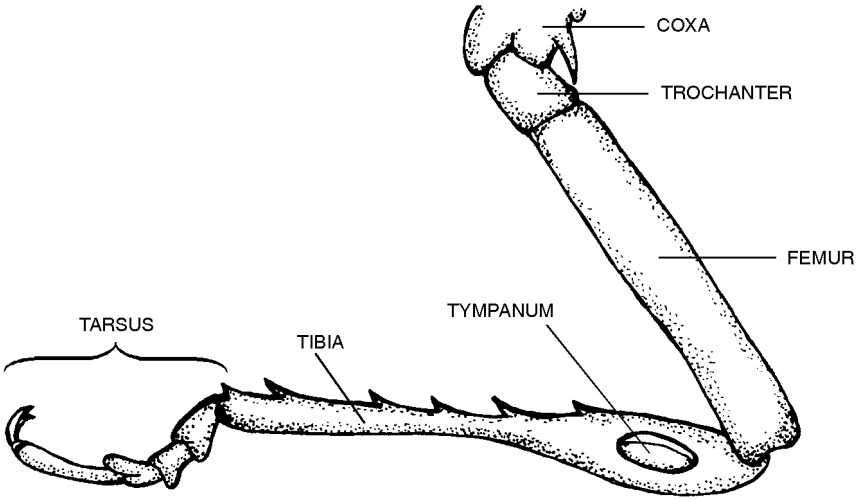
Hearing

Insects hear with either hair sensilla or tympanal organs. Many insects in the fly family hear through the hair sensilla (on the antennae). Other insects (such as crickets and grasshoppers) hear through tympanal organs (on the thorax, abdomen, or leg).

Tympanal organs have a very thin membrane imbedded in an insect's body wall. This membrane has air on either side of it, allowing it to vibrate to sound waves. Tympanal membranes can sometimes detect sound waves in the ultrasonic range.

Figure 12 shows a tympanum on a long-horned grasshopper's front leg.

FIGURE 12. TYMPANUM OF A LONG-HORNED GRASSHOPPER (FRONT LEG).



Electromagnetic Sense

Vision is an insect's electromagnetic sense. Insect vision occurs in either in simple eyes or compound eyes.

Topic #8424-A discusses these eye types in greater detail.

Simple eyes (ocelli) do not form an image, but they can distinguish between light and dark. Compound eyes have many visual organs (ommatidia). Each ommatidium forms a separate image. Scientists believe an insect can see a composite image similar to one that a human sees in a kaleidoscope.

Figure 13 shows the location of the ocelli and compound eyes of a honey bee.

Figure 14 illustrates the compound eyes of a fly.

FIGURE 13. OCELLI AND COMPOUND EYES OF A HONEY BEE.

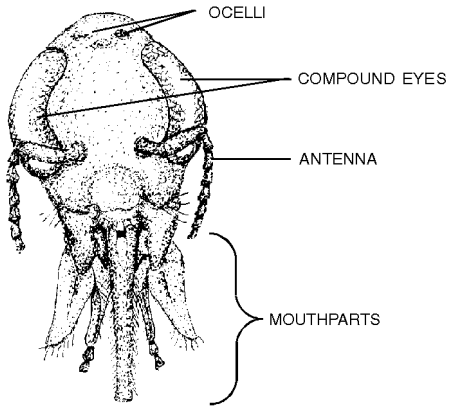
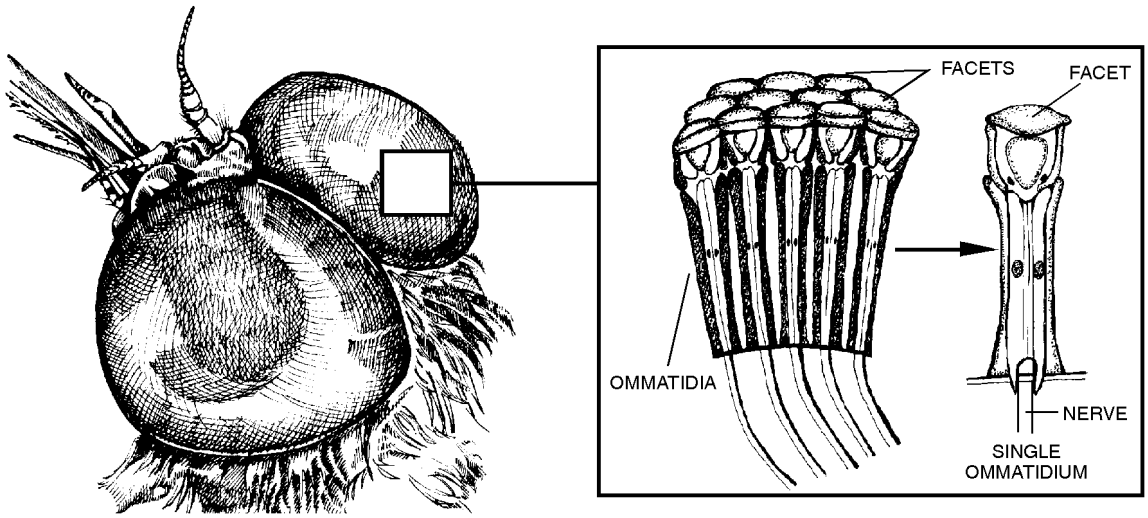


FIGURE 14. COMPOUND EYES OF A FLY.



Some insects see color but often in a different light range than do humans. For example, honey bees can see the blue, yellow, and ultraviolet light ranges, but they cannot see red or infrared light. Other insects (such as certain weevils) see only far-red and near-infrared light. Scientists believe many insects are color blind.

SUMMARY

An insect's internal anatomy and physiology rival those of the most complex organisms. Because insects must conduct the same basic processes as do other organisms, they have many similar organ systems and senses. This topic examined the functions of six insect organ systems.

The circulatory system transports food to all parts of the insect's body. It is made up of five organs: heart, dorsal vessel, smaller blood vessels, sinuses, and hemolymph. The digestive system transforms food into nutrients for the insect to use. It is made up of the alimentary canal, including the organs of the foregut, midgut, and hindgut.

The excretory system removes nitrogenous wastes from the insect's body. The Malpighian tubules form this organ system. The respiratory system supplies oxygen and removes carbon dioxide from the insect's body. The spiracles, tracheae, tracheoles, tracheal end cells, and air sacs form the insect's respiratory system.

The skeleto-muscular system provides support and mobility for the insect. It is made up of the exoskeleton and all the muscles of the insect's body. The reproductive system produces the next generation of insects. Different organs make up the male and female reproductive systems of insects.

The endocrine system secretes hormones to regulate the insect's growth and reproduction. The corpora allata, neurosecretory cells, and prothoracic glands are parts of the endocrine system. The nervous system coordinates body functions. It includes the brain, ganglia, and various nerves.

Also explored in this topic were chemical (taste and smell), mechanical (touch, gravity, temperature, balance, and hearing), and electromagnetic (vision) senses.

References:

Borror, Donald J., Charles A. Triplehorn, and Norman F. Johnson. *An Introduction to the Study of Insects*, Harcourt Brace Jovanovich Publishers: Orlando, Florida, 1989.

Campbell, Neil A. *Biology*, Benjamin/Cummings Publishing Co., Inc.: Menlo Park, California, 1987.

Little, V. A. *General and Applied Entomology*, Second Edition, Harper and Row, Publishers: New York City, New York, 1957.

Pfadt, Robert E. (editor). *Fundamentals of Applied Entomology*, Macmillan Publishing Company: New York City, New York, 1985.

Glossary of Terms

Accessory gland - one of a pair of glands in the reproductive system of many insects, which adds special fluids to the sperm or egg

Aedeagus - the copulatory organ of a male insect; the insect's penis

Air sac - an insect's respiratory organ containing a pocket of air that indents large muscles, especially the wing muscles

Alimentary canal - the entire digestive system of insects, which extends from the mouth to the anus

Anatomy - the structure of an organism

Anus - the abdominal opening of the alimentary canal

Aorta - the section of the dorsal blood vessel between the heart and the brain

Bisexual reproduction - reproduction involving both male and female; formation of a new individual from an egg and a sperm

Campaniform sensillum (plural, campaniform sensilla) - one of many small sense organs in an insect's body wall that detects pressure and gravity

Cardiac valve - the valve between the foregut and the hindgut in the digestive system of insects

Chemoreceptor - a sense organ for taste and smell in insects

Circulatory system - the organ system responsible for distributing food to an insect's cells

Clasper - one of a pair of appendages on the abdomen of males of certain insect species; used to grasp the female during mating

Colon - an organ of the hindgut; located between the ileum and the rectum

Copulatory - relating to sexual intercourse

Crop - an organ of the foregut; responsible for grinding food

Digestive system - the organ system responsible for converting food into nutrients

Dorsal vessel - the main vessel of an insect's circulatory system, which extends the length of the upper part of the body

Drone - a male honey bee

Ejaculatory duct - a part of the insect male's reproductive system located between the seminal vesicles and the aedeagus

Endocrine system - the organ system responsible for producing hormones

Esophagus - an organ of the foregut located between the pharynx and the crop

Excretory system - the organ system responsible for extracting waste material from the hemolymph and excreting it outside the body

Foregut - the first section of an insect's alimentary canal

Ganglion - a bundle of nerves resembling a knot

Gill - an aquatic insect's respiratory organ used to extract oxygen from water

Hair sensillum (plural, hair sensilla) - a hair-like sense organ extending from the insect's body wall

Heart - an insect's circulatory system organ used to pump hemolymph

Hemolymph - an insect's blood

Hindgut - the last portion of an insect's alimentary canal

Ileum - an organ of the hindgut located between the pyloric valve and the colon

Infrared - characteristic of a light having a longer wavelength than that of visible light
Malpighian tubule - one of the pair of organs forming the excretory system of an insect
Midgut - the middle section of an insect's alimentary canal
Nervous system - the organ system responsible for coordinating all body processes
Neurosecretory cell - one of a group of hormone-secreting cells in an insect's brain; an organ of the endocrine system
Nutrient - a particle of food in a form used by the body
Organ system - a group of organs working together to perform one body function
Ostium (plural, ostia) - one of the pores in an insect's heart through which hemolymph enters
Ovary - one of a pair of primary female reproductive organs that produces eggs
Oviduct - one of the organs of a female insect's reproductive system
Oviparous - egg-laying
Ovoviviparous - bears active young
Parthenogenesis - sexual reproduction whereby a new individual develops from an unfertilized egg
Pharynx - an organ of the digestive system between the mouth and the esophagus
Physiology - the study of life processes and activities
Prothoracic gland - one of a pair of glands located in the thorax; a part of the endocrine system
Proventriculus - one of the organs of the foregut located between the crop and the cardiac valve (not found in all insects)
Pyloric valve - a valve separating the midgut from the hindgut
Queen - the female of a social insect colony that is capable of reproduction
Rectum - one of the organs of the hindgut; located between the colon and the anus
Relative humidity - a measure of the amount of water vapor in the air
Reproductive system - the organ system responsible for producing offspring
Respiratory system - the organ system responsible for exchanging oxygen and carbon dioxide
Salivary gland - one of a pair of organs in the foregut that secretes some digestive enzymes
Seminal duct - an organ of the male's reproductive system; connects a testis with a seminal vesicle
Seminal vesicle - one of a pair of storage organs in the male's reproductive system that temporarily stores sperm
Sinus - one of the many small spaces scattered among the insect's organs; functions as part of an insect's circulatory system
Skeleto-muscular system - the organ system of insects that supports the body and allows the insect to move about
Spermatheca - a small, pouch-like, sperm-storing organ of the reproductive system of certain female insects
Spiracle - one of several pores in an insect's abdomen used for exchange of oxygen and carbon dioxide
Tactile seta (plural, tactile setae) - a sensory hair that responds to touch
Testis (plural, testes) - an organ of the male's reproductive system; produces sperm
Trachea (plural, tracheae) - one of the insect's main respiratory organs connecting the spiracles to the tracheoles
Tracheal end cell - a respiratory organ located at the end of each tracheole
Tracheole - a respiratory organ connecting each tracheae with a tracheal end cell in the insect
Tympanal organ - a sense organ responsible for hearing in some insects
Ultrasonic - characteristic of sound waves that are too high-pitched for humans to hear
Uric acid - a nitrogen waste product formed by an insect's cells and extracted from the hemolymph by the Malpighian tubules
Vagina - the terminal organ of a female's reproductive system, which opens to the outside of the body
Wing beat - one complete "up-and-down" stroke of a wing
Worker - a male of a social insect society, which performs most of the work for the colony

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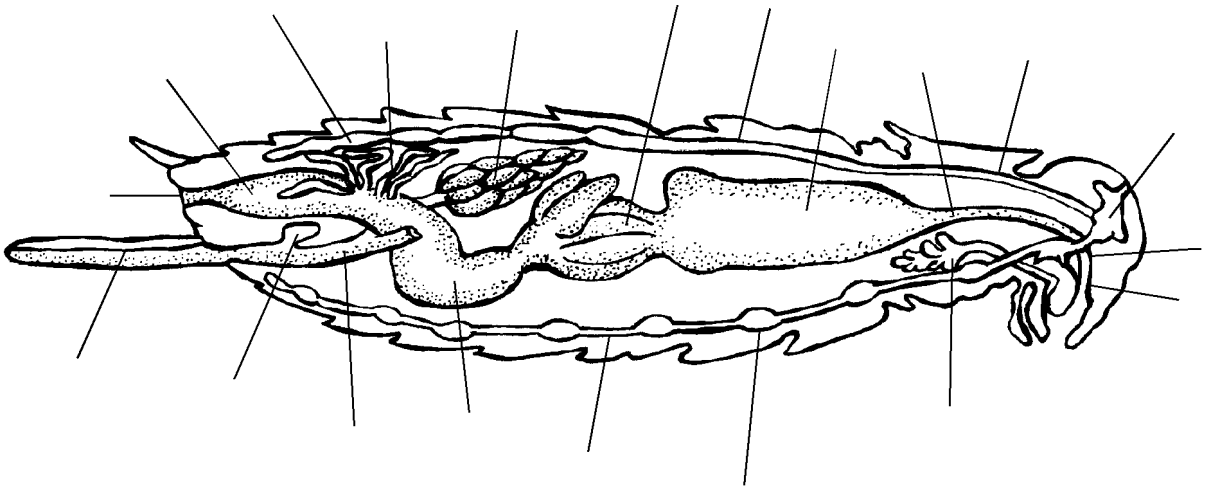
TOPIC MASTERY

Labeling:

1. Label the illustration with the listed terms.



ANUS	ESOPHAGUS	MIDGUT	PHARYNX
AORTA	GANGLION	MOUTH	PROVENTRICULUS
BRAIN	HEART	OVARY	SALIVARY GLANDS
CROP	HINDGUT	OVIDUCT	SPERMATHECA
DORSAL VESSEL	MALPIGHIAN TUBULE	OVIPOSITOR	VENTRAL NERVE CORD

True/False: Circle the T for true or the F for false. Correct any false statement.

T F 2. An insect's circulatory system carries oxygen to the body's cells.

T F 3. All insects have alimentary canals.

T F 4. A grasshopper has more than 4,000 different muscles.

T F 5. In parthenogenic reproduction, a fertilized egg develops into a new individual.

T F 6. The higher the temperature, the longer it takes an insect egg to hatch.

T F 7. All insects have ventral (upper) nervous systems.

T F 8. Insects usually have several ganglia in each body segment.

T F 9. An insect tastes and smells through chemoreceptors.

T F 10. Scientists believe some insects can detect relative humidity.

Matching: Place the letter preceding the phrase in the space preceding the numbered term:

_____	11. Anatomy	a.	a particle of food in a form used by the body
_____	12. Hemolymph	b.	an insect's blood
_____	13. Infrared	c.	the structure of an organism
_____	14. Nutrient	d.	a nitrogen waste product
_____	15. Oviparous	e.	the life processes and activities of an organism
_____	16. Ovoviviparous	f.	an "up-and-down" stroke of a wing
_____	17. Physiology	g.	a bundle of nerves resembling a knot
_____	18. Uric acid	h.	bears active young
_____	19. Ganglion	i.	egg-laying
_____	20. Wing beat	j.	a light of longer wavelength than that of visible light

ENHANCEMENT OR SKILL ACTIVITIES

Laboratory Exercise:

Obtain a preserved specimen of an insect species.

Dissect the insect and identify the different internal body parts (discussed in this topic).

Draw and label the internal body parts.

Prepare written examples of how knowledge of the internal anatomy of insects is helpful to an insecticide applicator.

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