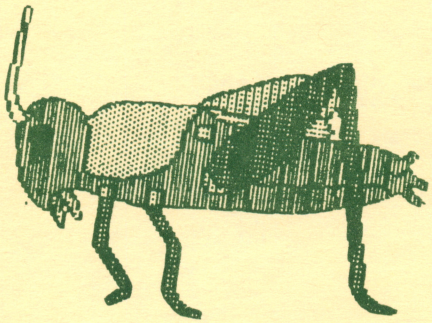
COMPUTER BIOLOGY LAB

GRASSHOPPER DISSECTION



CROSS EDUCATIONAL SOFTWARE

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GRASSHOPPER DISSECTION

INTRODUCTION

"GRASSHOPPER DISSECTION" can be used as a pre-lab or post-lab computer activity. It gives instructions and definitions that a student should know before entering the lab. After a dissection the program can be used as a review, homework, or self-test. The reading level and content are meant for seventh to tenth grade biology students.

GETTING STARTED

All you have to do is put the disk on an Apple or IBM-PC equivalent computer and turn on the power. After a few seconds the screen will show the menu on the next page. A color monitor will help, but the pictures are compatible with black and white.

Hardware notes: The IBM version requires a CGA or monochromatic equivalent graphics card. Hercules cards won't work. To run this program on Tandy computers you will need at least 384 K memory.

COPIES

Purchase of this program entitles the user to have it running on only one computer at a time, unless a site license or lab pack or network license is purchased.

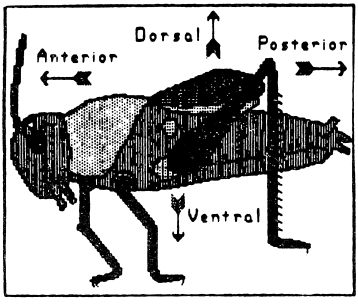
A backup disk is included in case of accident. If the disk doesn't run when you receive it, it will be replaced free. Just mail it back to Cross Educational Software. If the disk fails after being used for 60 days, it could be due to mishandling, such as a scratch or a fingerprint. After 60 days there is an $8.00 charge to purchase a replacment disk.

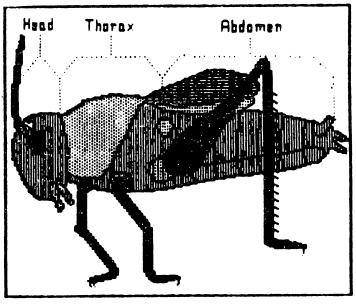
MANUAL AND TESTS

The following pages are a summary of the program. The test pages could be duplicated and given to students if there isn't enough time for all students to run the program during class.

MAIN MENU

1) ORIENTATION
2) STRUCTURES AND FUNCTIONS
3) STUDENT CONTROLLED DISSECTION
4) SELF TEST





1) ORIENTATION: VOCABULARY LIST

ABDOMEN	AIR SAC	ANTENNA
ANTERIOR	AORTA	ARTHROPOD
BRAIN	CHITIN	COMPOUND EYE
CROP	DORSAL	ESOPHAGUS
EXOSKELETON	FEMUR	GANGLIA
GASTRIC POUCHES	GIZZARD	HEART
INSECT	INVERTEBRATE	LABIUM
LABRUM	MANDIBLES	MAXILLAE
MOLT	NERVE CORD	NYMPH
OPEN SYSTEM	PALPI	POSTERIOR
PRONOTUM	SALIVARY GLAND	SIMPLE EYE
SPIRACLE	STOMACH	TARSUS
THORAX	TIBIA	TRACHEA
TYMPANUM	VENTRAL	WINGS

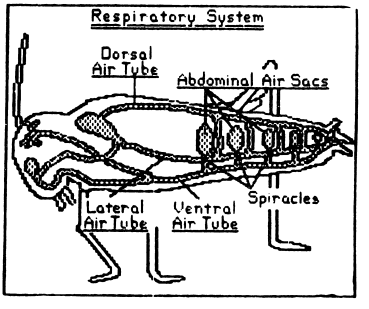
GENERAL BACKGROUND

The grasshopper is an insect. As with all insects it has six legs and three main body parts. These are head, thorax, and abdomen. The grasshopper is an invertebrate, meaning that it has no backbone. It is also an arthropod. This means that the grasshopper has jointed legs and a hard outer covering or exoskeleton made from a tough material called chitin. In order to grow, the grasshopper must shed or molt this exoskeleton. A grasshopper hatches from an egg deposited in the ground. The young grasshopper or nymph looks exactly like an adult except that it is smaller, stubbier, has no wings, and has no reproductive organs.

After a few days the nymph will molt. Its exoskeleton will split and out will crawl the slightly larger nymph. At first the new exoskeleton is soft but it soon hardens. Wings will appear after the first or second molt and the nymph will reach maturity after five or six molts. During the time a nymph is molting and growing, it eats almost constantly to keep up with its large energy needs.

2) DEFINITIONS OF STRUCTURES

A) RESPIRATORY SYSTEM



Spiracle - Opening in grasshopper's abdomen that allows air from outside to enter the air sacs.

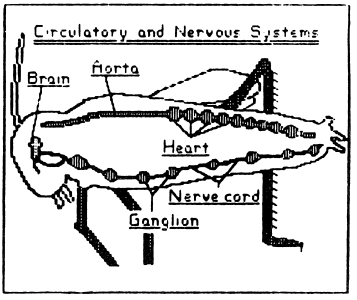
Abdominal Air Sacs = Sac-like structures in the abdomen that take in air and allow for a direct oxygen/carbon dioxide exchange.

Ventral Air Tube - Tube which carries oxygen and carbon dioxide along the ventral surface.

Dorsal Air Tube - Tube which carries oxugen and carbon dioxide along the dorsal surface.

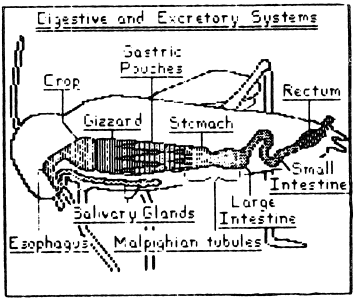
Lateral Air Tube - Tube which connects the abdominal air sacs together.

B) CIRCULATORY / NERVOUS SYSTEM



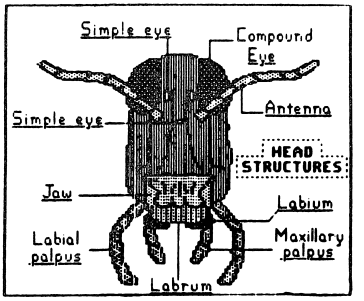
Nerve Cord- Runs along ventral surface connecting ganglia.
Ganlia (singular ganglion)- A group of nerve cells in the central nervous system.
Brain- In the grasshopper this is simply an enlarged ganglion.
Aorta- Vessel-like structure located near the dorsal surface. Carries blood toward the anterior end.
Heart- Tubular organ found near the dorsal surface. Takes blood from the posterior and pumps it toward the anterior.

C) DIGESTIVE / EXCRETORY SYSTEM



Gizzard- Muscular organ used for grinding food particles.
Gastric Pouches - Sack-like glands that release digestive enzymes into the digestive system.
Small Intestine- The short narrow tube that carries waste from the large intestine to the rectum.
Esophagus - Tube that carries food from the mouth to the crop.
Stomach- Area where food is digested.
Rectum- An area that serves as a storage area for waste. It eventually forces the waste from the body.
Salivary glands- Found in the thorax. They excrete saliva into the mouth area.
Crop- An area that serves as a storage place for food. It connects the esophagus to the stomach.
Large Intestine - A wide tube that connects the stomach with the small intestine. Carries wastes.
Malpighian Tubules - Kidney-like tubes found around the stomach area. They remove wastes from the blood and deposit them in the intestine.

D) HEAD AND MOUTH PARTS



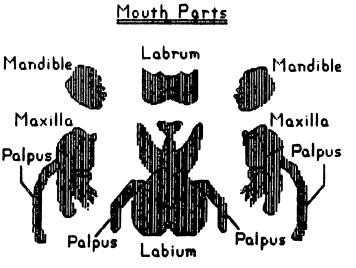
Labium- Lower lip which helps in holding food as it is being chewed.

Simple Eye - Three of these smaller eyes are found on the grasshopper.

Maxillary Palpi (singular Palpus) - Contribute to the senses of touch and smell.

Jaw - Mandibles which crush food.

Compound Eyes - Made up of hundreds of six-sided lenses. Enable the grasshopper to see from front and sides.



Labial Palpi (singular Palpus)- Contribute to senses of touch and smell.

Antenna (plural antennae)- Contain nerve endings which help in touch and smell.

Labrum - Upper lip part. Helps hold food as it is being chewed.

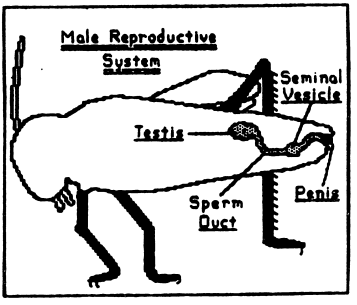
Palpi (singular palpus) - Contribute to senses of touch and smell.

Maxilla (plural maxillae) - Grinds food.

Mandible - Jaw-like structures which crush the food.

E) REPRODUCTIVE SYSTEM

MALE



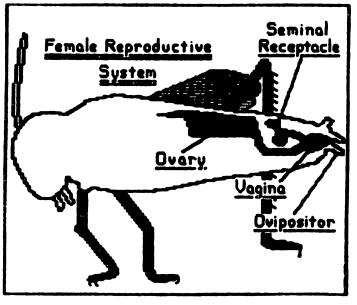
Testis (plural Testes) - Produces sperm cells in the male.

Sperm Duct- carries sperm cells during mating process.

Penis- Male reproductive organ.

Seminal Vesicle- Stores sperm cells until mating.

FEMALE



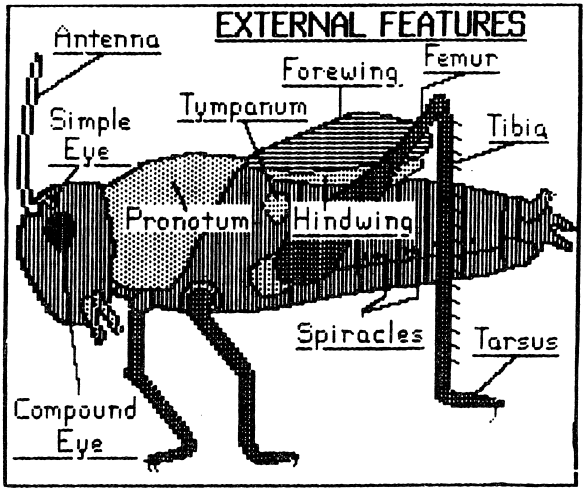
Ovary- Produces egg cells in female.

Ovipositor- External structure found only on females. Helps to dig hole and deposit eggs.

Vagina- Receives sperm cells during mating process.

Seminal Receptacle- Stores sperm cells until eggs are laid.

F) EXTERNAL FEATURES



Antenna (plural antennae) - Contain nerve endings which help in touch and smell.

Spiracle - Opening in abdomen through which air passes on the way to air sacs.

Pronotum- Hard chitinous shield of the thorax.

Hindwing- Membranous wing used for flying by grasshopper.

Forewing- Hard protective wing that covers the hindwing.

Tympanum- Membrane that acts as eardrum.

Compound Eyes- Made up of hundreds of six-sided lenses. They enable the grasshopper to see from front and sides.

Simple Eye- Three of these smaller eyes are found on the grasshopper.

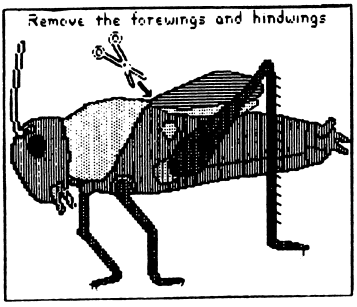
Tarsus- A three part footlike structure at the end of the tibia.

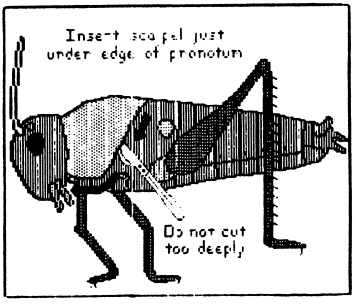
Tibia- the thin and spiny middle portion of the leg.

Femur- the large muscular first section of the leg.

DISSECTION GUIDELINES

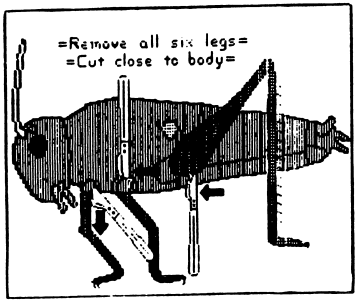
We shall begin by removing the wings of our specimen. Using the scissors, cut off the forewings and hindwings close to the body. Take care not to cut into the body of the grasshopper.

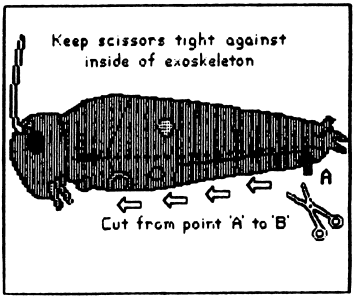




After the wings have been removed, the pronotum should be taken off. To remove the pronotum, carefully pry up the edges while using your scalpel to cut it loose. Keep the scalpel flat against the inside of the pronotum while cutting and prying it loose. Continue cutting around the entire perimeter of the pronotum until it can be removed. Be careful not to cut into the body cavity!

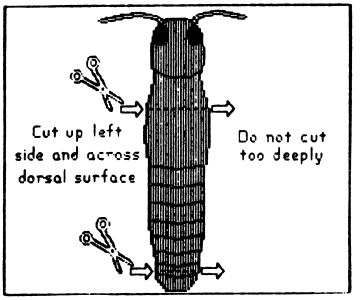
The grasshopper's six legs should be removed next. Using your scalpel or scissors, cut off each of the legs at the point where it is attached ot the body. After all of the legs have been removed the specimen will be much easier to handle.

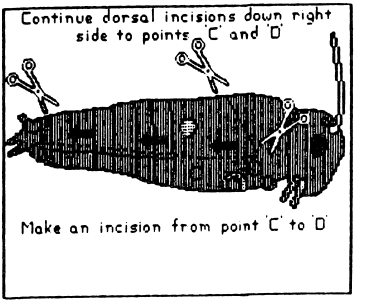




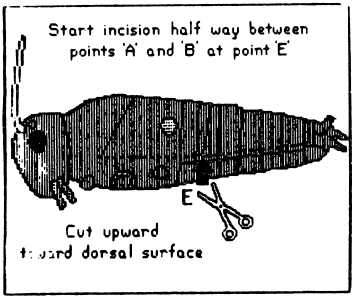
Now we are at the point where we must remove a major portion of the exoskeleton. Using your scissors, carefully puncture the exoskeleton with its tip. Do not insert the point too deeply! Make an incision from point 'A' toward the anterior to point 'B'. Keep the point of the scissors tight against the inside of the exoskeleton so as not to damage any of the underlying organs. Once the incision from point 'A' to point 'B' is complete we may continue on to the next step.

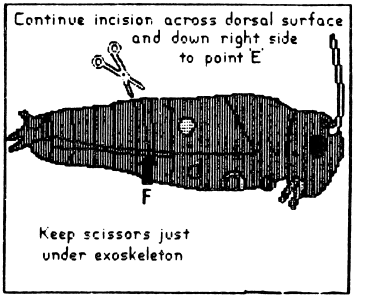
Starting at 'A', make an incision toward the dorsal surface. This incision should continue over the entire dorsal surface. Returning to 'B', make another incision similar to the one from point 'A', upward and over the dorsal surface. Do not cut too deeply!





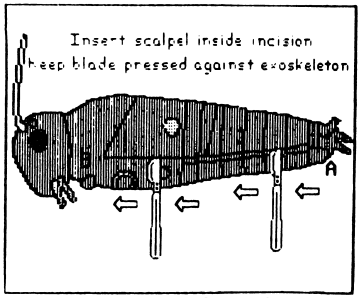
Continue the incisions from points 'A' and 'B' down the oposite side of the grasshoppr to points 'C' and 'D'. Notice that points 'C' and 'D' are located in the same positions as points 'A' and 'B' but on the opposite side. After the two incisions to points 'C' and 'D' are complete, start at point 'C' and make an incision to point 'D'. Make sure to keep the point of the scissors just under the exoskeleton!

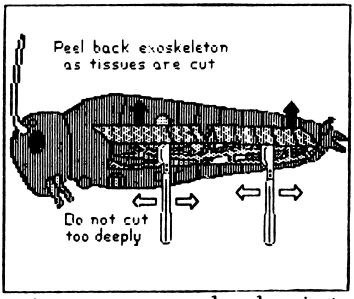




We shall now proceed to the final incision. Returning to the left side of the grasshopper, start an incision about half way between points 'A' and 'B'. Notice this point 'E' in the diagram. This incision should continue across the entire dorsal surface. Continue this incision over the dorsal surface and down the right side of the grasshopper. This incision should stop at point 'F'. Notice that point 'F' corresponds to point 'E' but it is on the opposite side of the grasshopper. Be certain not to insert the scalpel too deeply. This could very well damage a number of organs in this area. Upon completing this incision, we are finished with all of the preliminary incisions.

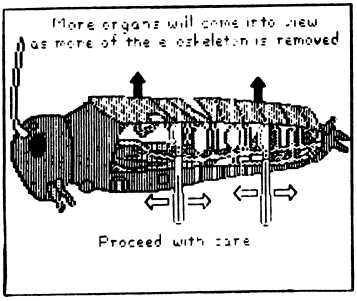
The only thing left to do is remove the portions of the exoskeleton. Returning to the left side of the grasshopper, we may begin to remove the large portions of

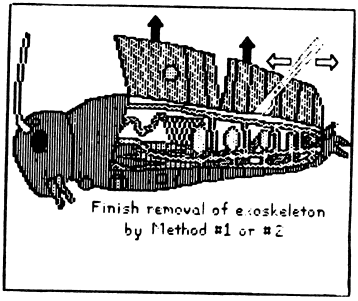




the exoskeleton. Carefully insert your scalpel into the incision made between points 'A' and 'B', being very careful to keep the side of the scalpel tight against the inside of the exoskeleton. Gently move the scalpel along the incision, freeing the exoskeleton from any tissues that may be attached to it. Gradually lift or pry the exoskeleton away from the internal organs as the connecting tissues are cut. Continue moving the scalpel in a back and forth motion along the inside of the exoskeleton. Do not attempt to cut too much of the connecting tissue at one time. Only the very tip of the scalpel should be inserted under the exoskeleton. This procedure will insure that most of the internal organs will remain intact.

As the exoskeleton is pulled back a number of internal organs will become visible. Continue the back and forth motion of the scalpel, freeing the exoskeleton from the underlying tissue. As more and more of the exoskeleton is freed from the connecting tissue it should make the cutting even easier.



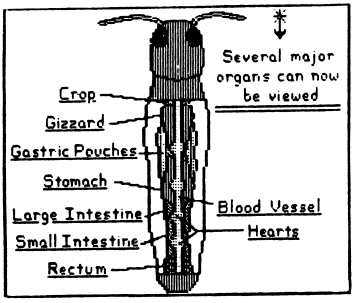


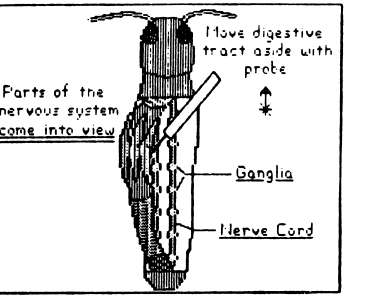
Once you have reached the dorsal surface, you should have little problem in removing the rest of the exoskeleton. You may finish the removal of the exoskeleton by one of two methods.

Method 1: Continue removal of the exoskeleton along the dorsal surface and down the right side of the grasshopper ending at the incision between 'C' and 'D'.

Method 2: After you reach the dorsal surface you may turn the grasshopper to the right side and repeat the same procedure starting at the incision made by points 'C' and 'D' and ending at the dorsal surface.

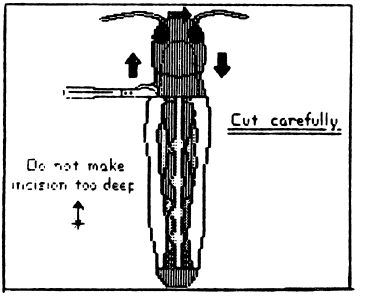
Carefully remove any large sections of connecting tissue that might remain attached to the internal organs. If the specimen is a female you might observe the ovary filled with a large mass of eggs. This mass would be located on the dorsal surface of the intestine, just below the hearts and blood vessel. If your grasshopper does contain an egg mass, you may want to remove it to see the digestive system beneath it.

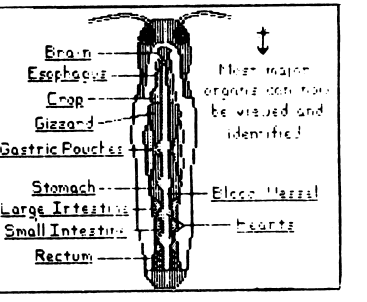


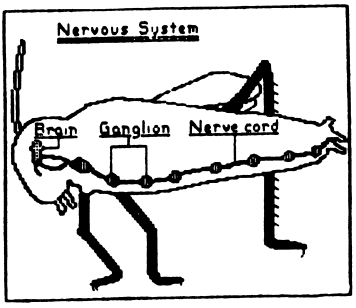


Looking down at the dorsal surface of the grasshopper, you should be able to observe the digestive canal. A number of organs should be identified. Using your probe, carefully separate as much connective tissue as possible from the digestive tract. Insert the probe very carefully under the digestive tract. Roll the tract over to one side exposing the nerve cord and ganglia. The nerve cord appears as a fine white thread with slight swellings in it. These swelling are the ganglis. Be careful not to stretch the tract too far. It will tear if moved too far to the side.

We shall now make an incision to expose the remainder of the crop and esophagus. This incision will also expose the brain. Using your scalpel, carefully make an incision as illustrated in the picture. Be very careful not to cut too deep! After this section of exoskeleton has been thoroughly loosened, it may be removed using your forceps. Some connective tissue holding this piece of exoskeleton in place may have to be cut.







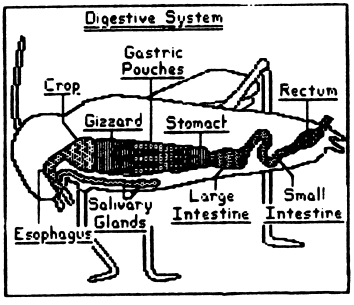
The nervous system of the grasshopper is basically quite simple. The simple brain actually has very little control over the grashopper's body. The control lies in the ganglia which are found in each segment.

The ganglia act as nerve centers for nearby body parts. These body parts (internal or external) are controlled by the ganglia.

Many insects also have a number of external nerve cells which relay information to the internal nervous system. This allows the insect to respond to external stimuli.

Because the brain is responsible for little control over the body, an insect can still remain alive for a time after the head is cut off.

DIGESTIVE SYSTEM

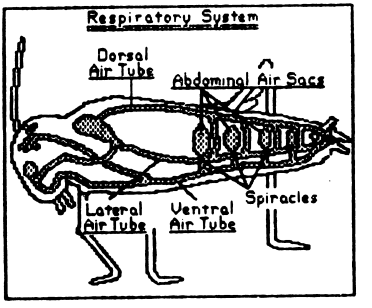


As the food is cut up by the action of the mandibles, it is sucked into the mouth. There it passes through the esophagus and into the crop where it is stored for a short period of time. The salivary glands secrete juices which mix with the food and make its passage through the esophagus much easier. From the crop the food passes into the gizzard. In the gizzard the food particles are shredded and ground by the plates of 'teeth'. These teeth are made up of chitin, the same type of material that makes up the exoskeleton of the grasshopper.

The partially digested food is then screened through thin plates before it passes into the stomach. On the outside of the stomach the gastric pouches can be found. These gastric pouches secrete enzymes into the stomach. The enzymes complete the digestion of the food particles. The digested food is then absorbed through the stomach wall.

The digested food then is stored for a short time in the large and small intestines. The food then proceeds to the rectum where excess water is removed from the undigested material and the mixture is formed into small pellets which are released from the body.

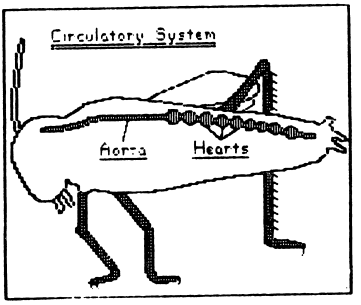
RESPIRATORY SYSTEM



Each abdominal segment of the grasshopper is made up of an upper and lower plate. These plates are joined by a flexible membrane which allows each segment to expand and contract. This flexible membrane, besides joining the upper and lower plates, also connects the segments to each other. This allows for a great deal of movement in the abdomen.

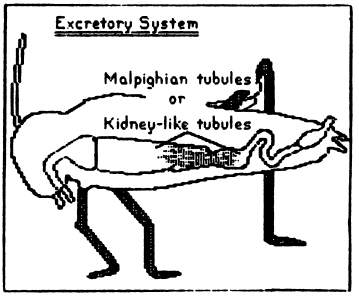
On most of the abdominal segments tiny openings called spiracles can be found. These spiracles lead to the air tubes or trachea, which form a complex network inside of the grashopper. Through the movement of the wings and abdomen, air is forced into and out of the air sacs. The oxygen diffuses from the air tubes into the body tissues of the grasshopper and the carbon dioxide diffuses out.

CIRCULATORY SYSTEM



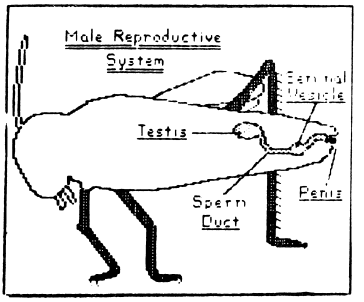
The circulatory system of the grasshopper is an open system. This means that the blood is not contained within a closed system of blood vessels from the time it leaves the hearts until it returns to the hearts. Instead, the blood is pumped to the anterior end of the grasshopper by the contractions of the hearts. The blood is then forced out of the aorta and into the body cavity near the head. The blood flows toward the posterior end of the grasshopper bathing all of the internal organs as it goes. During this process oxygen is picked up from the air tubes and spaces, and carbon dioxide is released. Upon reaching the posterior of the grasshopper, the blood is returned to the hearts to be circulated again.

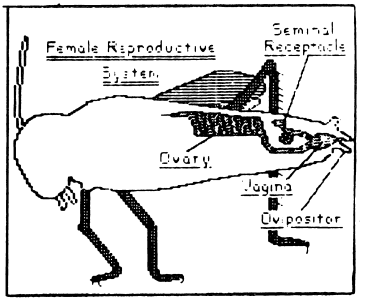
EXCRETORY SYSTEM



The excretory system of the grasshopper is made up of a series of kidney-like tubules called Malpighian tubules. The blood collects the wastes from the cells as it passes over the internal organs. These wastes are then removed from the blood by the Malpighian tubules. The waste material is then passed into the intestine where it is removed from the grasshopper's body.

REPRODUCTIVE SYSTEM

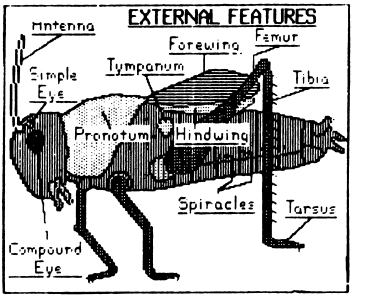




MALE- The main internal reproductive organ of the male grasshopper is the testis (plural testes). This is the organ that produces the male reproductive cells or sperm. The sperm cells move from the testis through the sperm duct and are stored for a time in the seminal vesicle. While mating the sperm is released from the male's body through the penis and is deposited in the female's vagina.

FEMALE- The female grasshopper's main internal reproductive organ is the ovary. This is where the female reproductive cells or eggs are produced. The eggs are forced through the oviducts and into the vagina. The sperm cells that were stored in the seminal receptacles meet the eggs here and fertilization takes place. The fertilized eggs are then deposited in the ground by the female. To aid her in digging the hole, she uses her special 'tool' called the ovipositor.

EXTERNAL FEATURES



The grasshopper has several external features which can be easily found and identified. The pronotum is part of the grasshopper's exoskeleton. It forms a shield covering the sides and dorsal surface of the thorax.

The spiracles can be found on each side of the grasshopper's abdomen. These tiny holes are used for breathing. The spiracles open into air sacs inside the grasshopper's body.

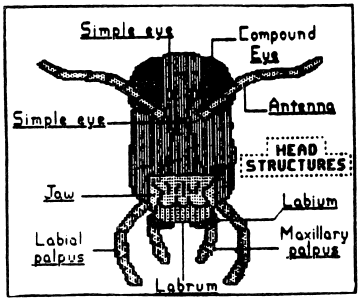
The tympanum can be found at the anterior end of the abdomen. There is one on each side. The tympanum is the ear of the grasshopper. It functions much the same way that an eardrum does in a human. Sound waves cause it to vibrate. The grasshopper then interprets this as sound.

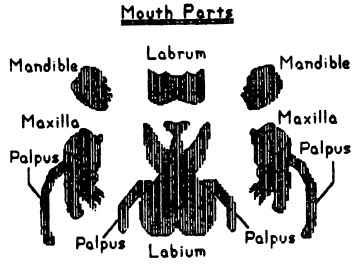
Two pairs of wings can be found on the dorsal surface of the thorax. The front wings are narrow and hard, forming a shield for the delicate hindwings. The pair of hindwings are used by the grasshopper for flying.

The grasshopper has six jointed legs fastened to its thorax. The first two pairs are smaller and are used mainly for walking and climbing. The third pair is the largest and very muscular. This pair is used for jumping. Each leg has three distinctive parts: The femur which is attached to the body, the tibia or middle section, and the tarsus which serves as a foot.

Other external parts including the eyes, antennae, and mouth parts will be discussed with the head structures below.

HEAD STRUCTURES





The head of the grasshopper is actually several segments fused together. On the head we can find the eyes, antennae, and parts of the mouth.

The grasshopper has two types of eyes, simple and compound. There are three simple eyes. (See diagram.) These do not form clear images but simply detect movement and light change. The larger more obvious eyes are the compound eyes. These act as groups of simple eyes. They form images which probably appear as a mosaic-like picture to the grasshopper.

The antenna is the long tube-like appendage on the head of the grasshopper. It is actually a sense organ. The antenna is covered with tiny hair-like structures. These hair-like structures are sensitive to touch and smell.

There are several parts that make up the grasshopper's mouth. The labrum or upper lip helps to hold the food. The labium or lower lip also helps to hold the food. The palpi are attached to the maxillae and labium. They are responsible for the mouth's sense of touch and smell. The maxillae and the mandibles are responsible for cutting, grinding, and crushing the food.

MULTIPLE CHOICE TEST

___ 1. As an insect, the grasshopper has
   a) 2 main body sections
   b) 3 main body sections
   c) 4 main body sections
   d) 5 main body sections

___ 2. The gastric pouches
   a) collect wastes from the body
   b) help in the respiratory process
   c) are found only in females
   d) secrete digestive juices

___ 3. In an open circulatory system:
   a) Blood moves in veins and arteries.
   b) Blood is not contained in vessels.
   c) Blood does not move in the body.
   d) Blood never enters the heart.

___ 4. The body of the grasshopper is controlled by the
   a) ganglia
   b) spiracles
   c) mandibles
   d) gastric pouches

___5. An external feature of the female grasshopper is the
   a) vagina
   b) ovary
   c) ovipositor
   d) seminal receptacle

___ 6. The kidney-like tubules
   a) aid in reproduction
   b) circulate the blood
   c) are found only in the male
   d) remove wastes from the blood

___ 7. Air moves in and out of the grasshopper's body through the
   a) spiracles
   b) ovipositor
   c) mandibles
   d) mouth

___ 8. Which of the following is true of the grasshopper nymph?
   a) It spends its life underground.
   b) It has no digestive system.
   c) It can not see.
   d) It has no reproductive organs.

___ 9. The crop of the grasshopperer
a) grinds and mixes food
b) absorbs food particles
c) serves as a holding area for food
d) holds waste products

___10. The aorta is part of the
a) reproductive system
b) circulatory system
c) respiratory system
d) excretory system

TRUE - FALSE TEST 1

___ 1. The brain controls the whole body.

___ 2. The gizzard crushes and grinds food.

___ 3. Mandibles help the nervous system.

___ 4. Abdominal movement helps breathing.

___ 5. The hard shell of the grasshopper is called the exoskeleton.

___ 6. The blood of the grasshopper carries oxygen.

___ 7. The ovipositor is found only in female grasshoppers.

___ 8. The head of the grasshopper is located at the anterior end.

___ 9. The wings of the grasshopper are found on the on the dorsal surface.

___10. The testes are part of the male's reproductive system.

TRUE - FALSE TEST 2

___ 1. Ganglia control body parts that they are near.

___ 2. The gizzard stores food for later use.

___ 3. The labrum is one of the mouth parts.

___ 4. The abdomen is covered with hard plates.

___ 5. The hard shell of the grasshopper is made of bone.

___ 6. The blood of the grasshopper carries carbon dioxide.

___ 7. The ovipositor is found only in male grasshoppers.

___ 8. The head of the grasshopper is located at the posterior end.

___ 9. The wings of the grasshopper are found on the on the ventral surface.

___10. The testes produce sperm in the male grasshopper.

TRUE - FALSE TEST 3

___ 1. Nerve cords connect one ganglia to another.

___ 2. The gizzard absorbs waste products.

___ 3. The labium helps the excretory system.

___ 4. Abdominal plates are connected by flexible tissue.

___ 5. The hard shell of the grasshopper is made of chitin.

___ 6. The blood of the grasshopper never leaves the arteries or veins.

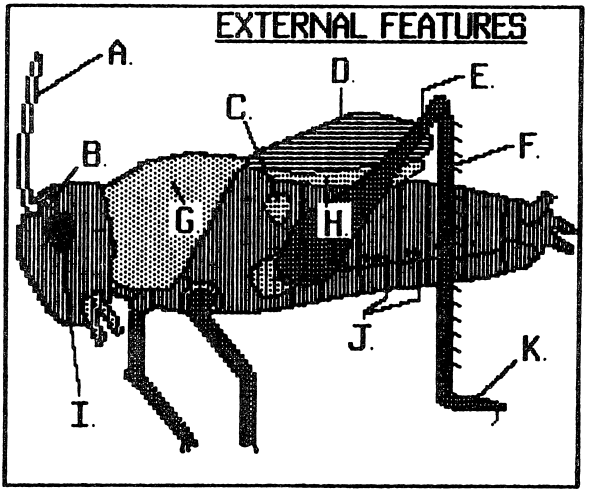
___ 7. The ovipositor is found in both male and female grasshoppers.

___ 8. The ovipositor of the grasshopper is located near the anterior end.

___ 9. The forewings cover the hindwings.

___10. The testes are found only in the male grasshopper.

EXTERNAL FEATURES TEST



___ 1. HINDWING

___ 2. ANTENNA

___ 3. FEMUR

___ 4. COMPOUND EYE

___ 5. TYMPANUM

___ 6. SPIRACLES

___ 7. TARSUS

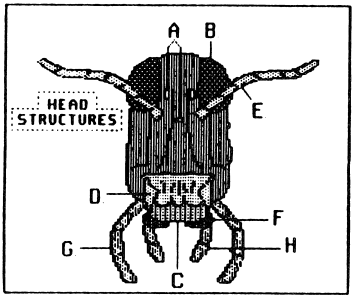
___ 8. SIMPLE EYE

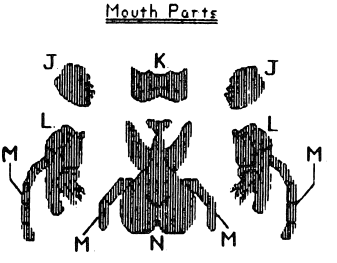
___ 9. FOREWING

___10. PRONOTUM

___11. TIBIA

HEAD AND MOUTH PARTS TEST





___ 1. COMPOUND EYE

___ 2. LABIUM

___ 3. LABRUM

___ 4. SIMPLE EYE

___ 5. LABIAL PALPI

___ 6. MAXILLARY PALPI

___ 7. ANTENNA

___ 8. JAW

___ 9. LABIUM

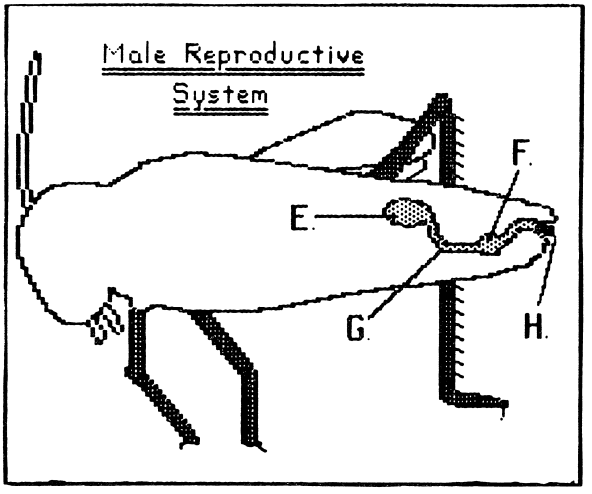
___10. PALPUS

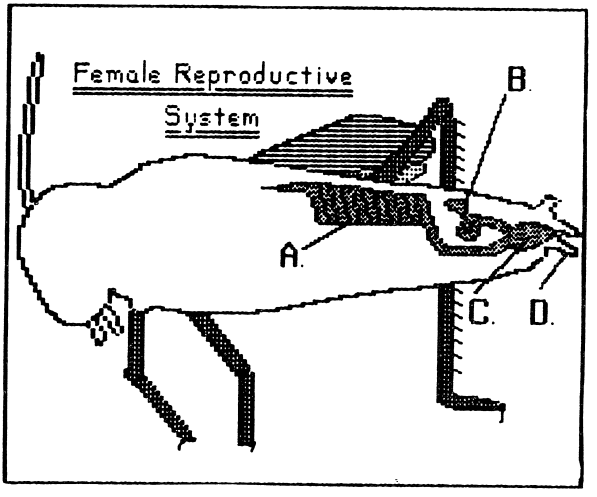
___11. LABRUM

___12. MAXILLA

___13. MANDIBLE

MALE / FEMALE SYSTEMS TEST





___ 1. OVIPOSITOR

___ 2. SEMINAL RECEPTACLE

___ 3. OVARY

___ 4. VAGINA

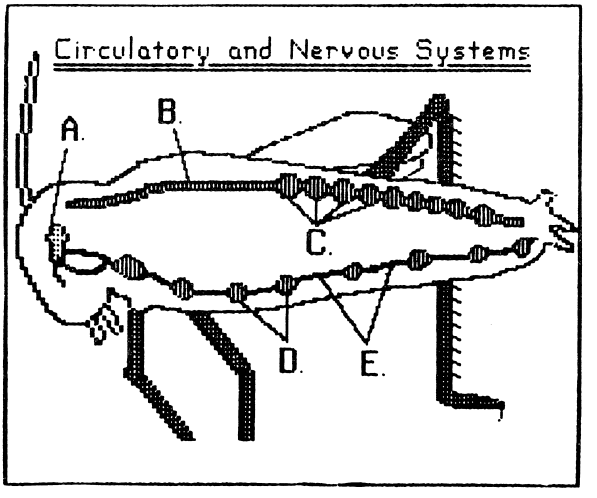
___ 5. SPERM DUCT

___ 6. PENIS

___ 7. TESTIS

___ 8. SEMINAL VESICLE

CIRCULATORY / NERVOUS SYSTEMS TEST



___ 1. NERVE CORD

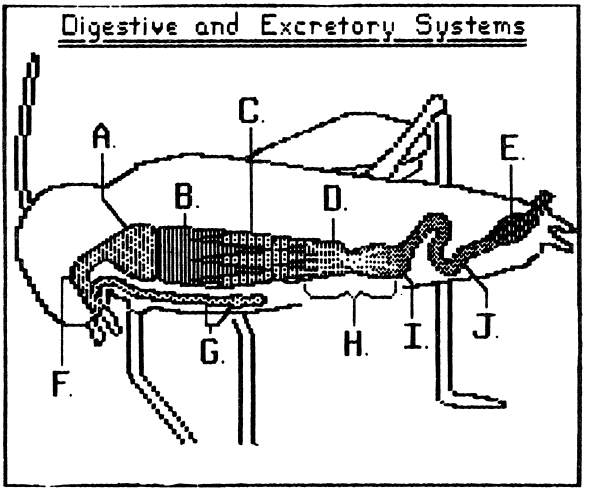
___ 2. AORTA

___ 3. GANGLION

___ 4. HEART

___ 5. BRAIN

DIGESTIVE / EXCRETORY SYSTEMS TEST



___ 1. LARGE INTESTINE

___ 2. CROP

___ 3. SALIVARY GLANDS

___ 4. RECTUM

___ 5. MALPIGHIAN TUBULES

___ 6. STOMACH

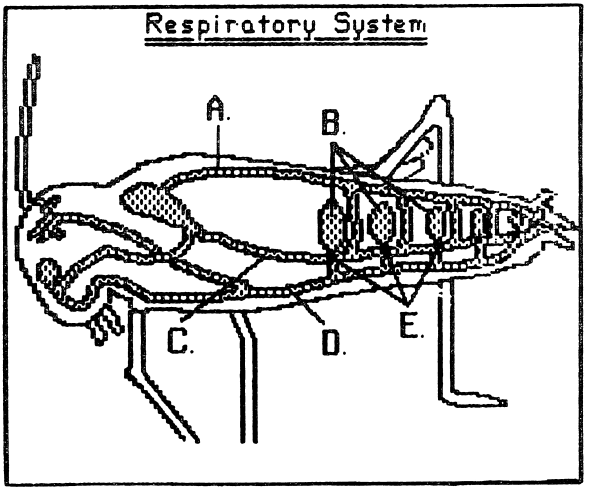
___ 7. ESOPHAGUS

___ 8. SMALL INTESTINE

___ 9. GASTRIC POUCHES

___10. GIZZARD

RESPIRATORY SYSTEM TEST



___ 1. SPIRACLES

___ 2. DORSAL AIR TUBE

___ 3. ABDOMINAL AIR SACS

___ 4. VENTRAL AIR TUBE

___ 5. LATERAL AIR TUBE