

What Is an Insect? Anatomy and Adaptations

Overview

Through the use of wooden or cardboard models, students learn the basic or primitive anatomy of an insect. Subsequently, they substitute parts that have been modified by natural selection or other evolutionary forces to allow the insect to survive in different habitats. These modifications include changes in locomotory structures, mouthparts, and respiratory apparatus.



Title

What Is an Insect? Anatomy and Adaptations

Investigative Question

What is the external anatomy of an insect and how has this basic design been modified through evolutionary history to allow insects to occupy different habitats and niches?

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Objective

Students construct the basic external anatomy of an insect and evaluate how various body parts have modified over time to perform unique functions.

Materials

One set of basic insect parts and one set of modified parts made from the templates included at the end of this activity; wood or cardboard, a large (at least 3-foot square) felt board, metal blackboard, bulletin board, or other display area on which the insect parts can be assembled and viewed by the class.

For the introductory activity: slides or photographs of macro-invertebrates; a projector.

Time

One 50-minute class period.

Advance Preparation

1. Use the templates to create a set of basic insect parts and a set of modified parts. These may be made from cardboard or wood; perhaps a shop class would be interested in constructing these. The parts are of two kinds: those used to construct a "generic" or primitive insect that has all the basic parts of an insect's body and a set of "replacement parts" that illustrate insect adaptations for surviving in various habitats.

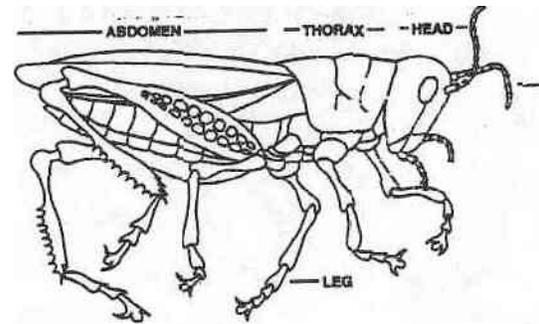
Basic parts are marked with an A; parts that allow the constructed insect to adapt are marked B. Separate the pieces into these two groups before beginning the activity.

2. Make approximately ten copies of the student pages. Cut along the lines to separate the insects.

3. Familiarize yourself with the basic script that is the foundation for this activity.

Introducing the Activity

Appoint a student to serve as recorder at the chalkboard. Show the class a photo of a grasshopper and a dragonfly and ask what parts they have in common. Include all suggestions, even if a term is somewhat unscientific (e.g., stomach, neck). Announce that we are now going to assemble an insect from its basic parts—an insect prototype. We will then see how those basic structures have changed over evolutionary time to allow insects to survive in a variety of habitats. Insects, there can be no doubt, have proved to be highly successful adapters.



Procedure

Note: Throughout the activity, emphasize that individuals do not adapt in the evolutionary sense (they cannot change their structure or form to suit different conditions), but populations of species do. Genetic variation in populations is caused by mutation or other genetic changes and can lead to differential survival of offspring that carry those genes. Sometimes a genetic variation makes a species better adapted to life in a particular place. That, in a nutshell, is natural selection.

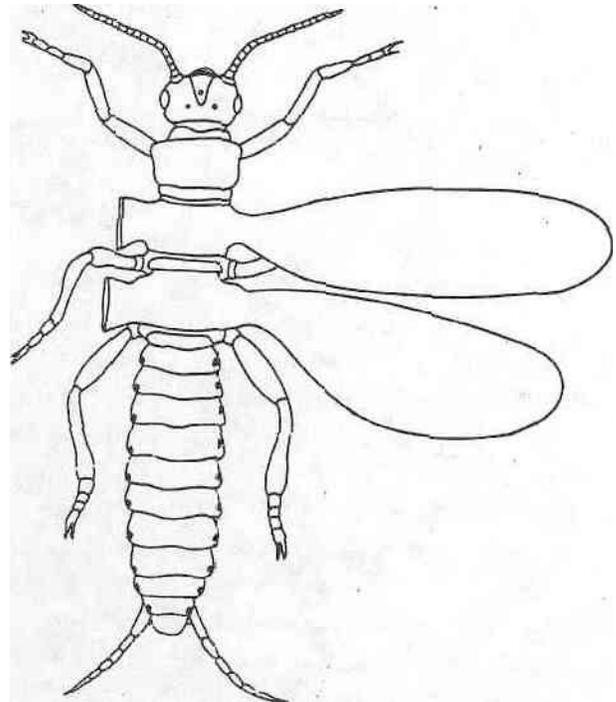
1. Instructions for this activity are given in the form of an annotated script that includes teacher comment and expected student responses. The script, of course, only minimally suggests how to present the activity and you are encouraged to expand and elaborate.
2. Distribute all insect parts labeled A at random. "We are going to create an insect from its parts. Several of you hold a piece of this insect puzzle, and before we are done, we will have completed an insect. Let me begin by saying that an insect's body is composed of individual segments. An example is one segment of the abdomen. These segments may be grouped together to perform specific functions, for example, the thorax. We call this process of grouping *tagmosis*. An insect's body has three groups of segments: head, thorax, and abdomen." Write these words on the chalkboard.
3. "We are ready to begin building an insect body, with what part should we begin? That's correct, the head! [Student places the head on the board.] What functions does the insect's head perform? [Students should mention sensory functions and food ingestion.] Let's move on down to the next body region, the thorax. How many segments of the thorax are there? [Three students should be holding segments of the thorax and come forward. Each segment is numbered and should be placed in order (1, 2, 3) behind the head.] What is the function of the thorax? [Students should mention locomotion,

although in the absence of legs and wings this may not occur to them.] Now, we need the last part of the insect's body, the abdomen. Who has the abdomen? [The abdomen is placed following the last segment of the thorax.] What are the functions of the abdomen? [Students should mention reproduction, digestion, excretion, and respiration.] Note the black dots on either side of the thorax and abdomen. Any idea what they might be? [Students are not likely to know.] Well, these are spiracles, or the openings into the insect's breathing or tracheal system. Unlike humans who use lungs and blood to move oxygen to the cells, insects rely on a series of tubes or tracheae. These tubes get progressively smaller until each cell is supplied with oxygen. Now, let's look at what we have created. We have a hollow tube, made up of segments grouped into three body regions, head, thorax, and abdomen, in a process called *tagmosis*—the grouping together of individual segments to form body regions that have particular functions."

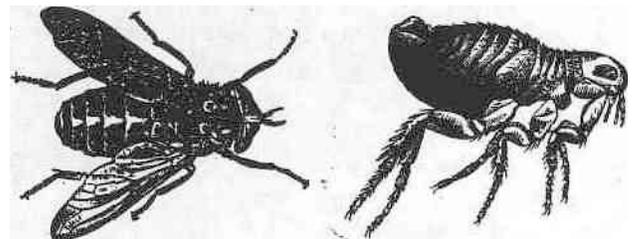
4. "It's time to add other structures that make this organism an insect. An important point to remember is that insects are *bilaterally symmetrical*, that is, one side is exactly the same as the other side. Let's go back to the head and begin adding appendages. What is found on an insect's head? That's right, antennae, and how many antennae are there? [There may be some confusion here because an insect also has cerci on its abdomen that look like antennae; however, the model antennae are larger than the cerci.] Two! [Students place the antennae on the head.] And what are some of their functions? [Students should mention all the senses except sight.] Now we come to the thorax, the locomotory part of the insect. Let's start with the legs. How many are there [six] and where are they located on the thorax? [Students should reason, with help, that the thorax has three segments and six legs, so one pair of legs goes on each segment of the thorax. Each leg has a label on its underside to indicate its position on the thorax.] Now

that we have the legs in place, let's look at the wings. How many wings does our generic (primitive) insect have? [Students hold up four wings and come forward to put them on the thorax.] But wait a minute. If these go on the thorax, we don't have enough wings to go around. Which segment of the thorax doesn't get wings? Any guesses? Well, an easy way to remember this is that the segment of the thorax attached to the head has no wings. Thus, the middle and last segment are the wing bearers. [Students place the forewings on the middle segment of the thorax and the hindwings on the last segment of the thorax.] Well, are we finished? What's left? [Two students hold cerci.] These structures are cerci and they function as antennae (among other things) on the rear end of an insect. They are attached to the eleventh segment of the abdomen. If you blow on the rear end of a cockroach, it runs away because it felt your breath with its cerci!"

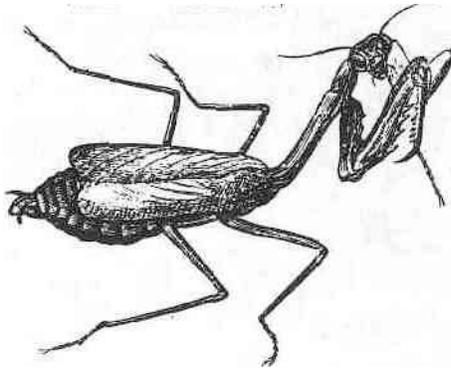
5. "We have completed our generic insect. That is, we have an insect that has all the parts that an insect should have. We call this the *primitive* condition. However, very few insects have all the parts that we see here, and others have parts that have changed. A rough time to perform other functions. We call this process adaptation. Remember that individuals cannot adapt, only populations can change through the processes of genetic alteration and natural selection. Let's look at various ways our 'primitive' insect can be adapted to live in different places."



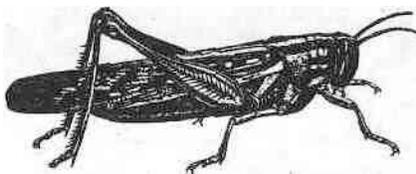
6. "Let's begin by removing the two hindwings of our insect. What have we created? [A fly, because flies have only two wings.] What if we remove the remaining wings? What type of insect might we now have? [Possible answers: silverfish, flea, certain bugs, or any nymphal insect that has incomplete metamorphosis. Ask a student to distribute copies of the fly and flea (Student Page 1) so the class sees what these insects look like.] Yes, a flea."



7. "Now that we have removed the wings, let's look at adaptations of insect legs. We will leave off the wings so we can clearly see the body. [Pass out the six pairs of insect legs. Students will bring up the legs in pairs and place them in the appropriate place on the model as you continue with the dialogue.] Let's begin with a pair that is easy to identify. Who holds insect legs that might be adapted for grasping? [Students holding mantis front legs replace the forelegs on the model as a student distributes the mantis drawings. Continue distributing drawings after each new insect is created.] What kind of insect do we now have? That's right, a praying mantis! Simply by changing one pair of legs we have changed the type of insect.

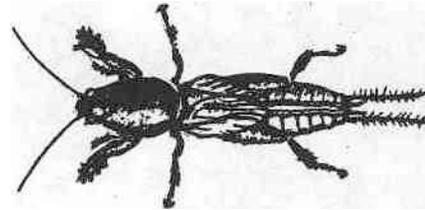


Let's try another pair. [Students holding the jumping hindlegs of an insect replace the hindlegs on the model as you replace the mantis legs with regular walking legs.] What insect do we now have? A grasshopper! Do you see how adaptation works?

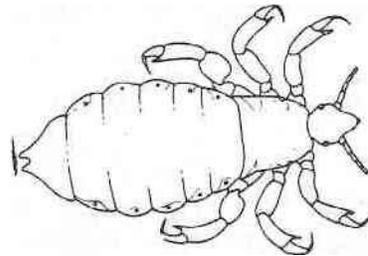


Let's try a more difficult one. [Students holding insect legs adapted for digging replace the front legs as you replace the jumping legs with regular walking legs. The identification of this insect will prove more difficult, so prod the class to think about

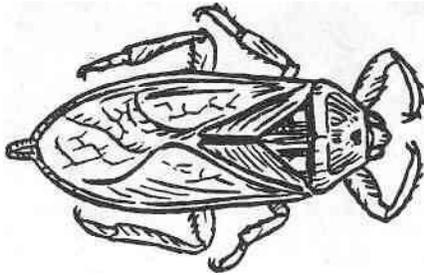
legs adapted for digging—use the examples of a back-hoe, a shovel, or a mole. Where do you suppose this insect lives? [in the soil] That's right, it tunnels through the soil much like a mole. In fact, we have created a mole cricket!"



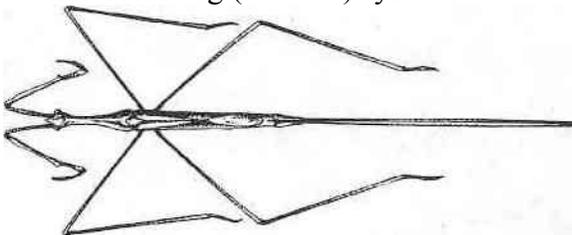
8. "Let's look at an insect that is a pest of humans. [Pass out the rest of the insect parts. Students who receive legs adapted for holding on should replace the digging legs and the new head should replace the old head.] Now imagine that all six legs look just like these. And we have a different type of head and mouthparts. Where do you think this insect lives? [Students will speculate but will not likely have the correct answer.] Let's look more closely at this insect's adaptations. It has a head adapted for piercing and sucking. Piercing and sucking what? [Students should eventually say blood—human blood.] Let's look more closely at its legs. Did you know that the space between the two claws is the same diameter as a human hair? So where does this insect live? [m human hair—on the head.] That's correct. This is a head louse. It grabs a hair with each of its six legs and sucks blood from us."



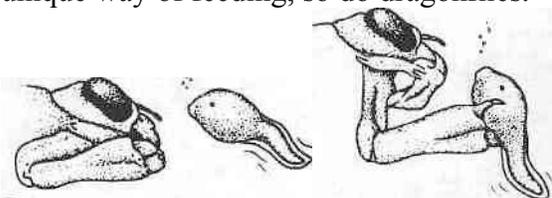
9. "Now let's look at a series of adaptations that allows insects to live in aquatic habitats. [Remove the louse legs and replace them with the original walking legs; leave the new head. Students now replace the hindlegs on the model with the swimming legs.] We now have an insect that lives in water—note the broad, paddlelike hindlegs—and how do you think it gets its living? [Students may be able to deduce that it is a predator that uses its head and beak to pierce prey and suck out their insides.] Let's go one step further. [Students with the other set of grasping legs come forward and replace the front legs.] We have now created a real species of aquatic insect. It has a piercing-sucking set of mouthparts, front legs adapted for grabbing prey, and hindlegs adapted for swimming. We have created a giant water bug!



Let's go even further and look at another adaptation for living in water. If we add the long tube to the rear end of this giant water bug, [Student adds the tube.] we have created yet another kind of aquatic insect, a water scorpion. What do you think this tube is for? [a snorkle for breathing] That's right, it's a breathing tube and functions just like a snorkle. The tube is connected into the insect's breathing (tracheal) system."



10. "Now we are going to be even more specific. [Replace the piercing head with the chewing head, replace all legs with normal legs, and remove the breathing tube.] What do you think an insect that has these structures along its abdomen would use them for? [Students should place the abdominal gills along the abdomen and speculate on their function. Answers may include a swimming aid; the actual purpose is to extract oxygen from the water] That's right, they are used to help the animal breathe under water. Just like a fish, these are gills. Now let's replace these gills with three large, leaflike structures on the end of the abdomen. [Students add these structures to the abdomen and speculate on their use. Once again, these are gills.] Yes, these are also gills, but these are found only on a specific insect—damselies. But to create a real damselfly, we must add another type of mouthpart. [Students add dragonfly/damselfly nymph mouth-part to the model.] A damselfly uses this mouthpart, an adapted lower lip called a labium, to reach out and grab prey and drag it back to its mouth. When not in use, this mouthpart is folded up and stored under its head. Not only do damselflies have this unique way of feeding, so do dragonflies.



[To demonstrate, stand sideways in front of the class, fold your right arm against the midline of your body and hold your hand over your face to represent the mouthparts of dragonfly and damselfly nymphs. To feed, the 'mouthpart' is extended forward, grabs the prey, and drags it back to the mouth, hidden under the folded up structure.] The only difference between dragonfly and damselfly nymphs is that dragonflies do not have these large gills on the outside. They actually take in water through the rectum, extract the oxygen, and expel the water. If they expel it with force, they can be jet-propelled!"

11. "We have one final adaptation to make on our insect model, [Remove the mouthpart and ask a student to add a bubble to the end of the abdomen.] Okay, what do you think this is? [Students will be unlikely to know what the structure is.] Let me give you a hint. This insect also lives underwater, but it has no gills. Because it has no gills, it goes to the surface of the water and gets a bubble of air and brings it down below the surface! This is actually an air bubble that functions like a gill. The bubble of air is usually carried under the wing covers and over the surface of the body between water-repellent hairs; it often protrudes out the back end, as we see here. The bubble is in contact with the spiracles (the openings to the insect's breathing system). As the insect uses oxygen, more oxygen diffuses in from the surrounding water. Eventually the bubble collapses and a new bubble must be obtained from the surface. Several kinds of aquatic beetles use a coating of air and a bubble to breathe under water."

12. "As you can see, we have investigated several types of insect adaptations, but this is only the tip of the iceberg! Just about anything that can be done, has been done by the insects! They did it first!"

Assessing the Activity

Ask each student to sketch an imaginary insect with an adaptation for aquatic life. Beneath the drawing, the student adds a sentence or two explaining how that adaptation helps the insect survive in a particular environment. Share these in class, perhaps grouping adaptations that have similar functions.

Extending the Activity

Generate with the class a list of human activities that parallel insect adaptations: chemical warfare, camouflage, snorkling, pretending to be something you are not, armor, courtship behavior, paddling a canoe, relying on an oxygen tank, etc. Students then write two paragraphs comparing and contrasting a human activity with an insect adaptation.

State Goals

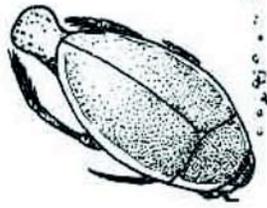
11,12

Concept

Insects have a "primitive state" (all its structures in a basic condition). These structures change through time as species become adapted for living in different habitats.

Safety and Waste Disposal

No dangerous or hazardous materials are used.



Diving Beetle



Flea



Praying Mantis



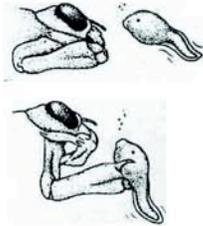
Fly



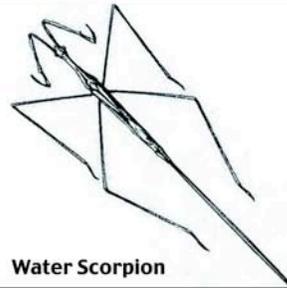
Grasshopper



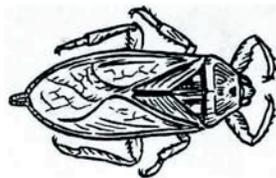
Mole Cricket



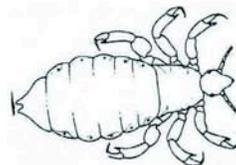
Damselfly labia catching prey



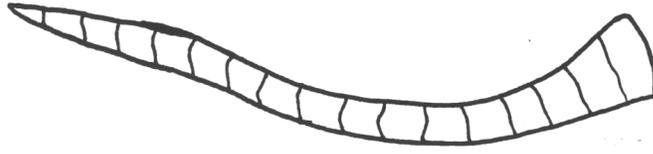
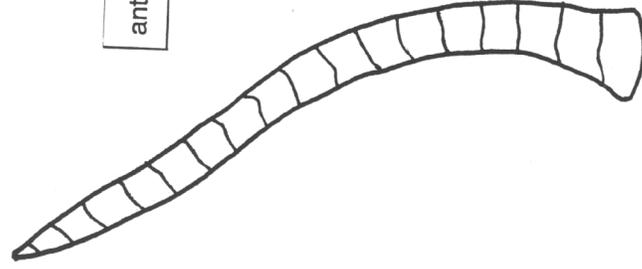
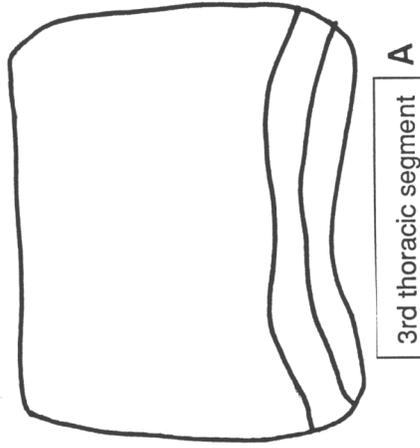
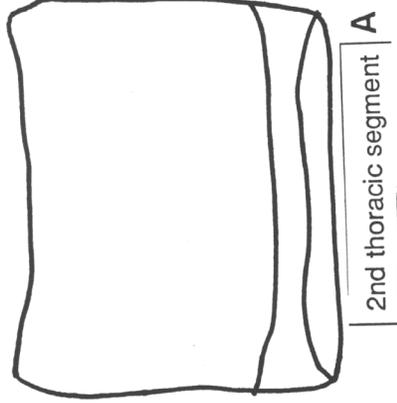
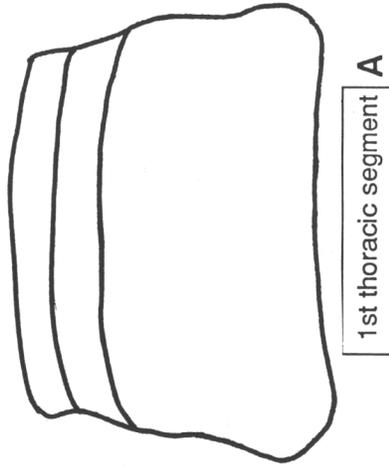
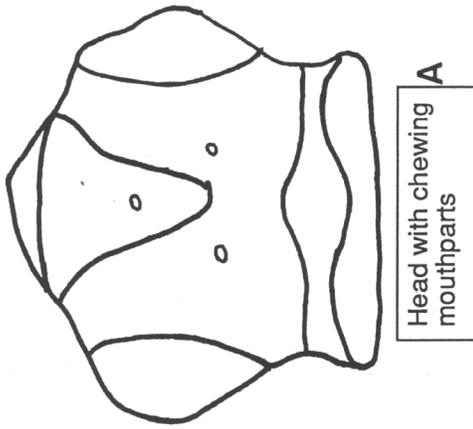
Water Scorpion



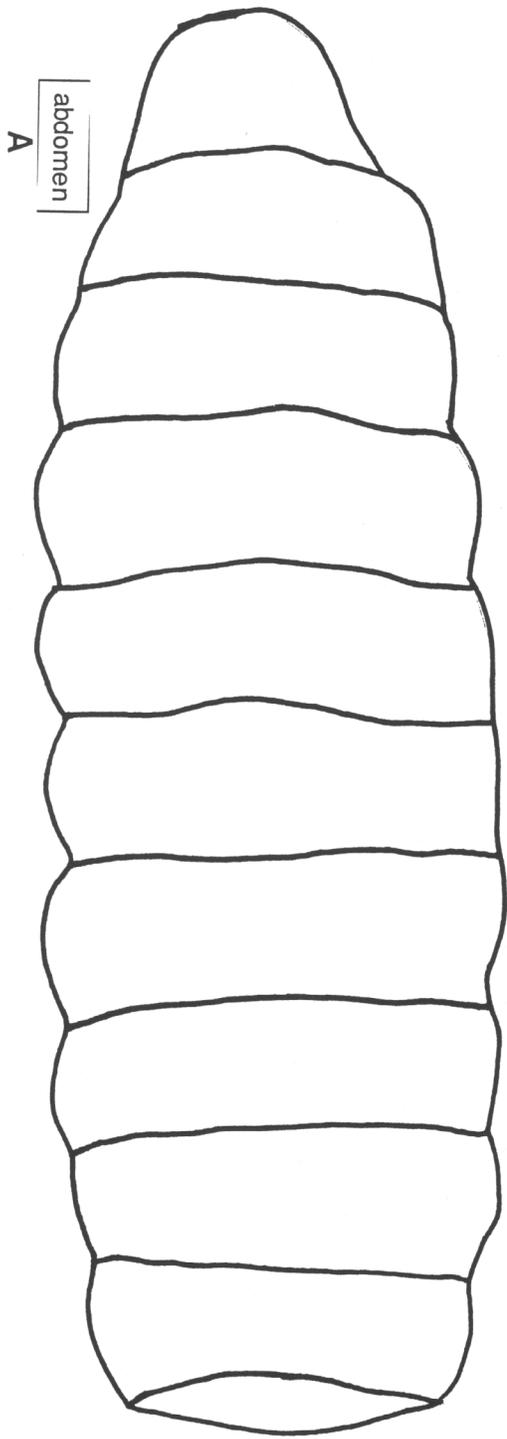
Water Bug

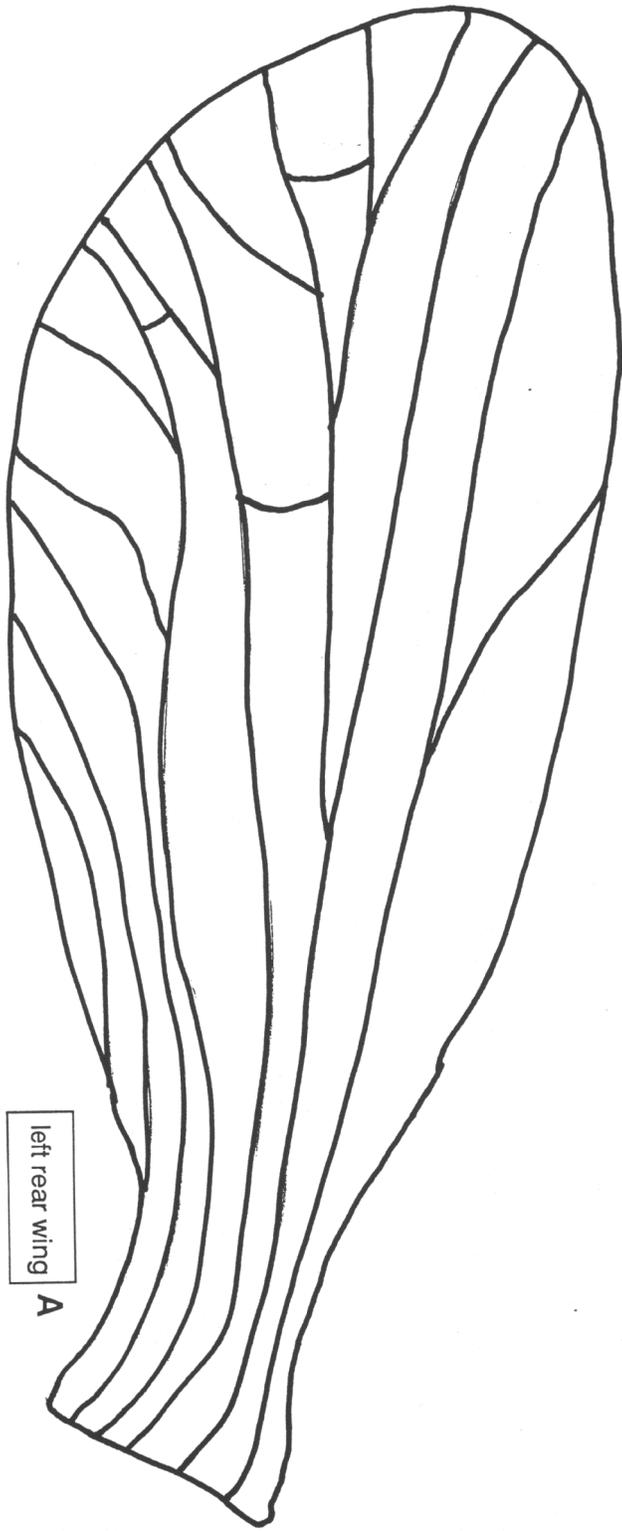


Louse



Template for Activity 5
Stream Module

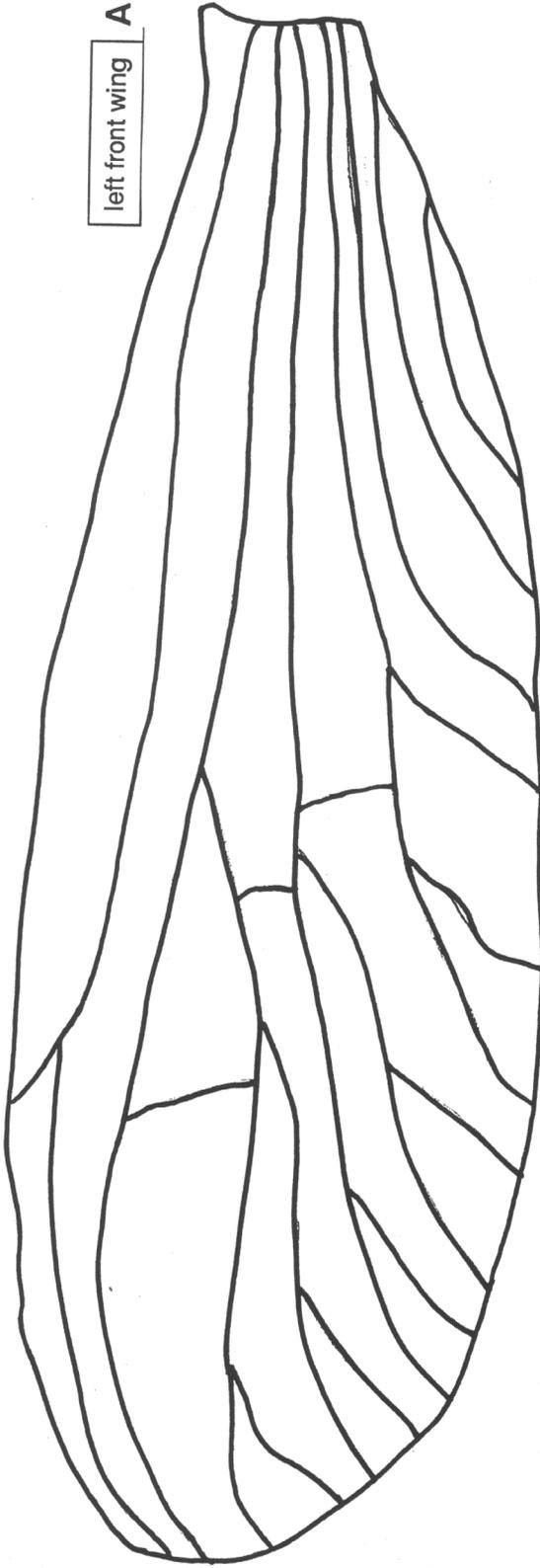




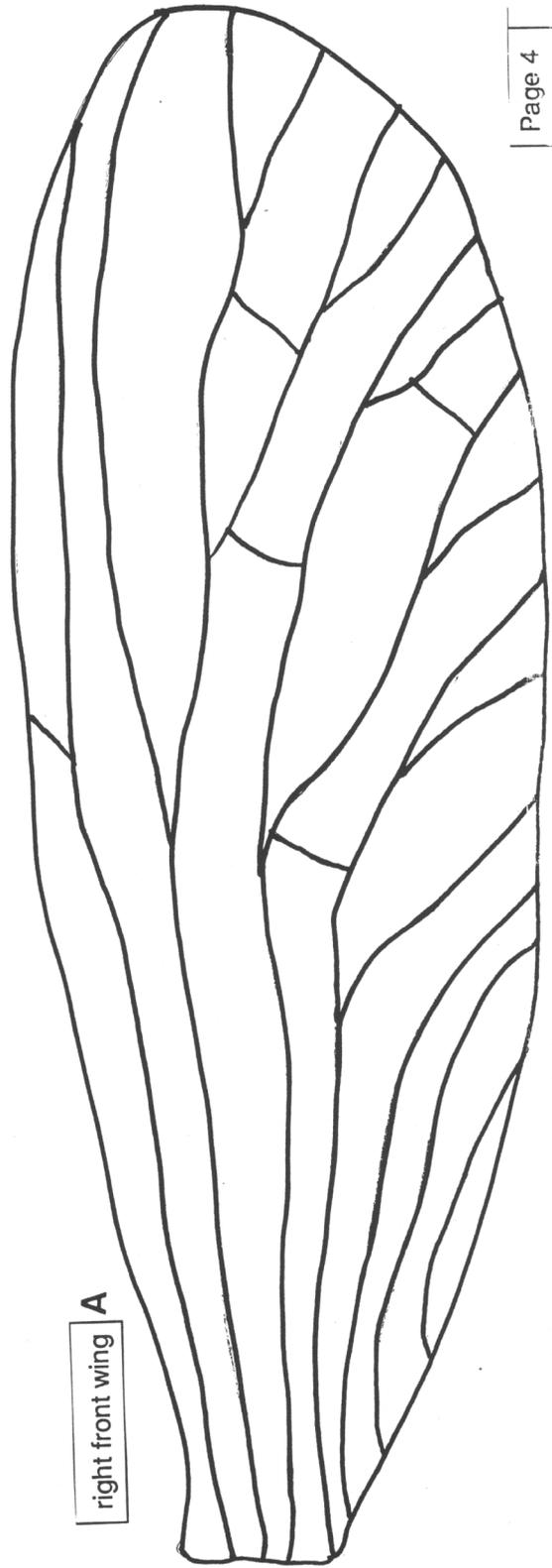
left rear wing

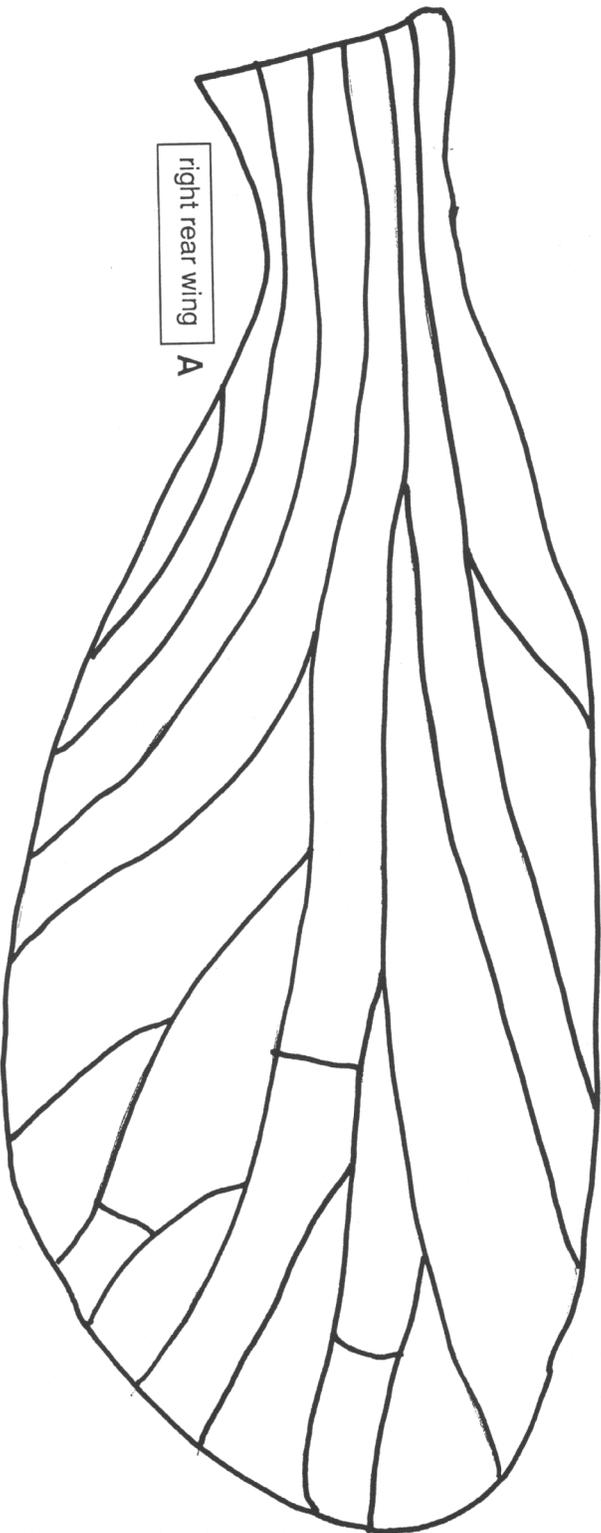
A

left front wing A



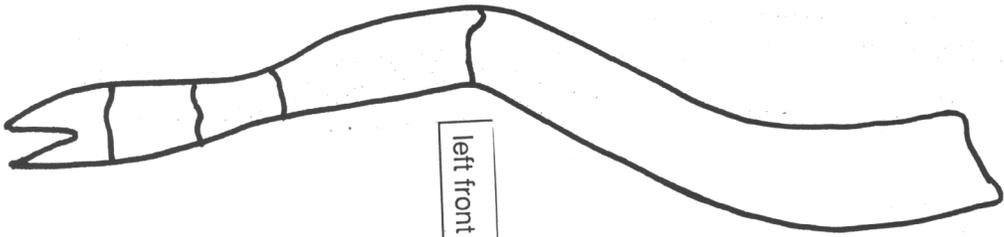
right front wing A





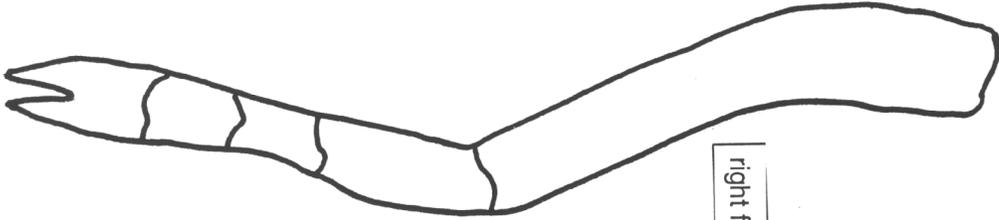
right rear wing

A



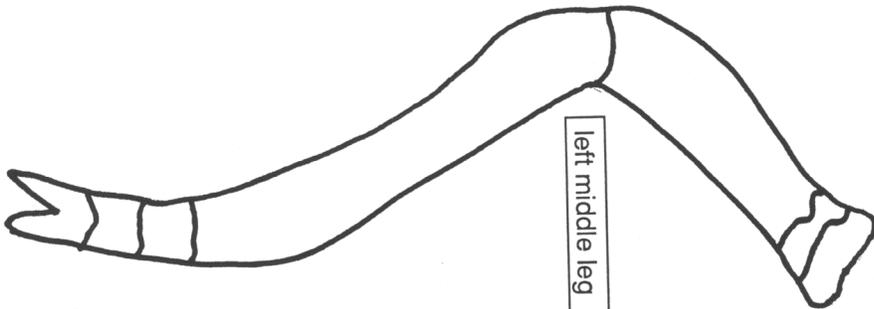
left front leg

A



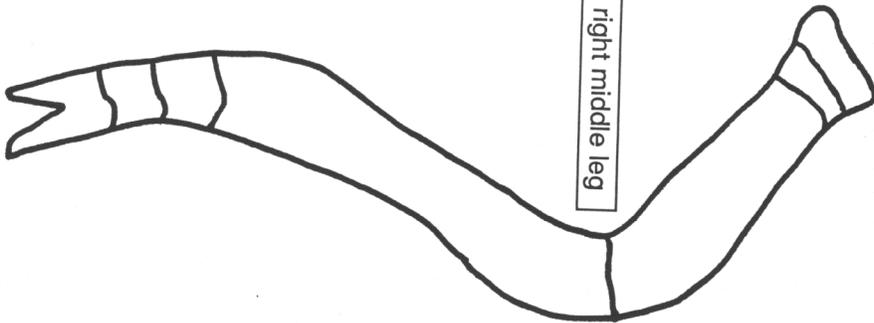
right front leg

A



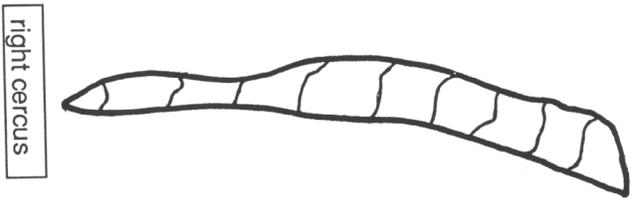
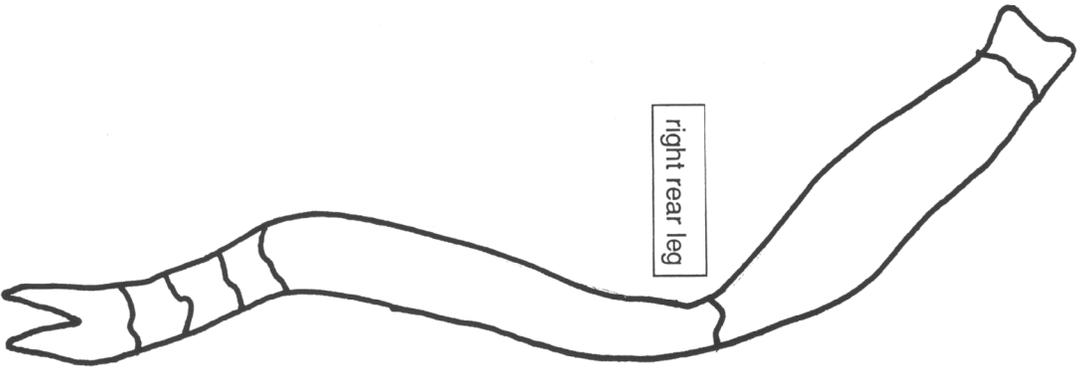
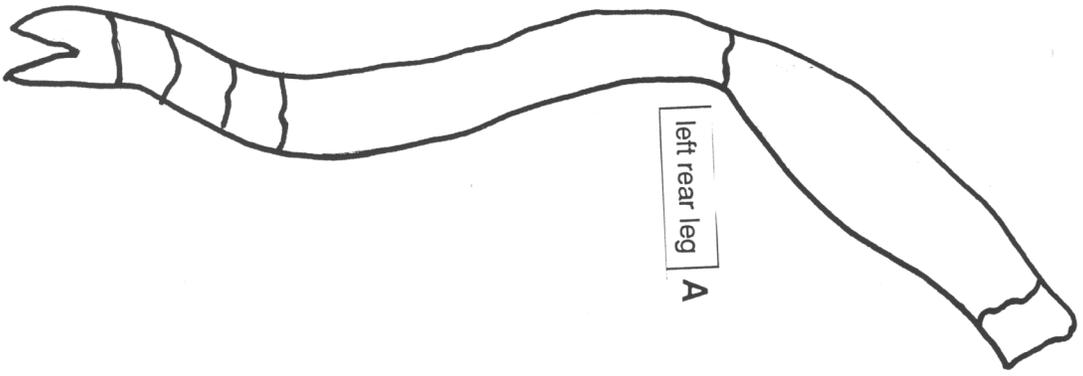
left middle leg

A

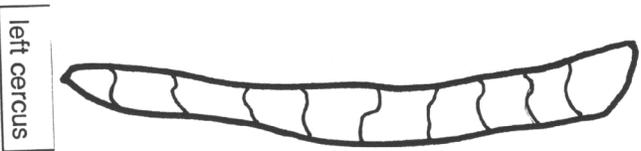


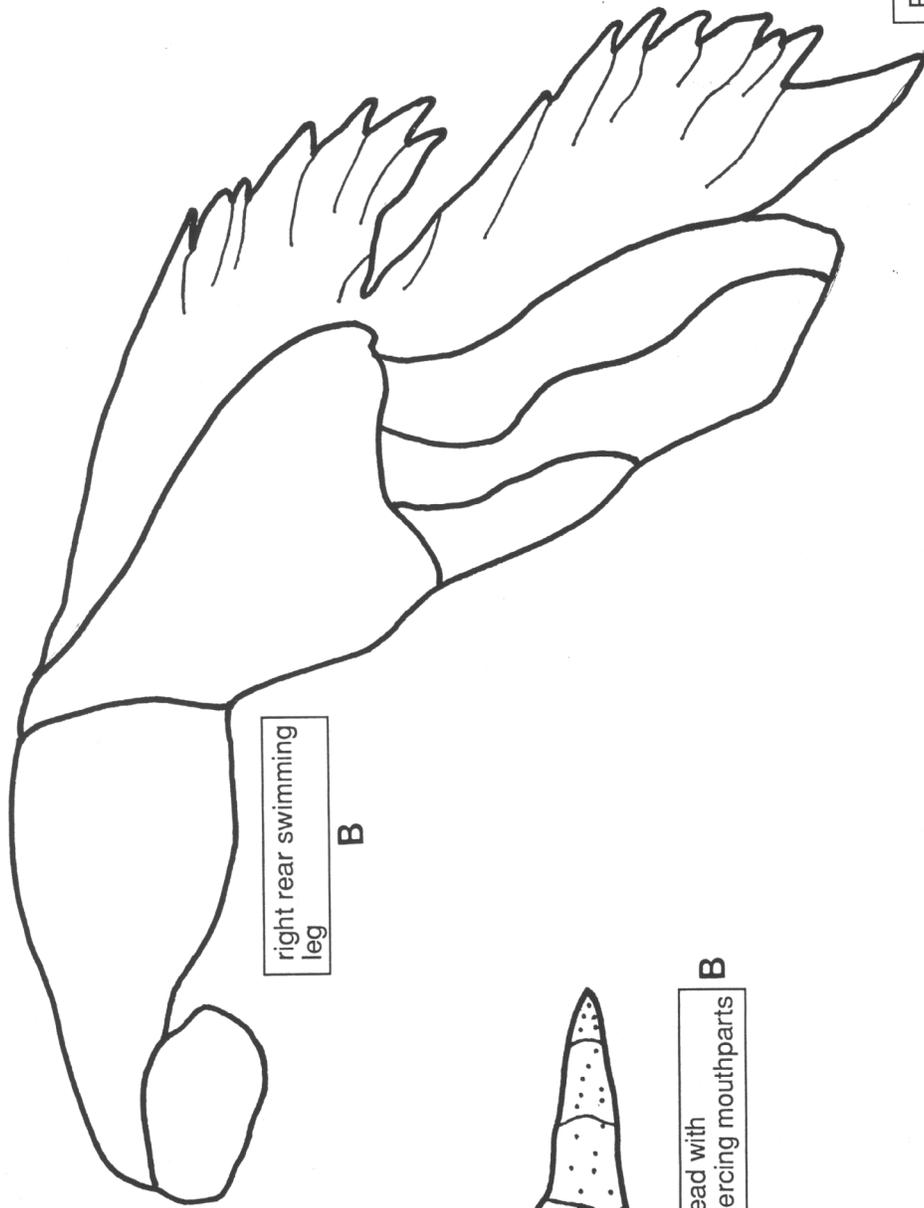
right middle leg

A



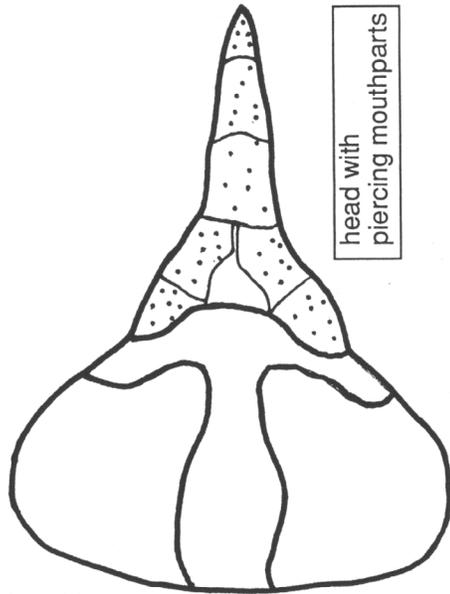
A





right rear swimming leg

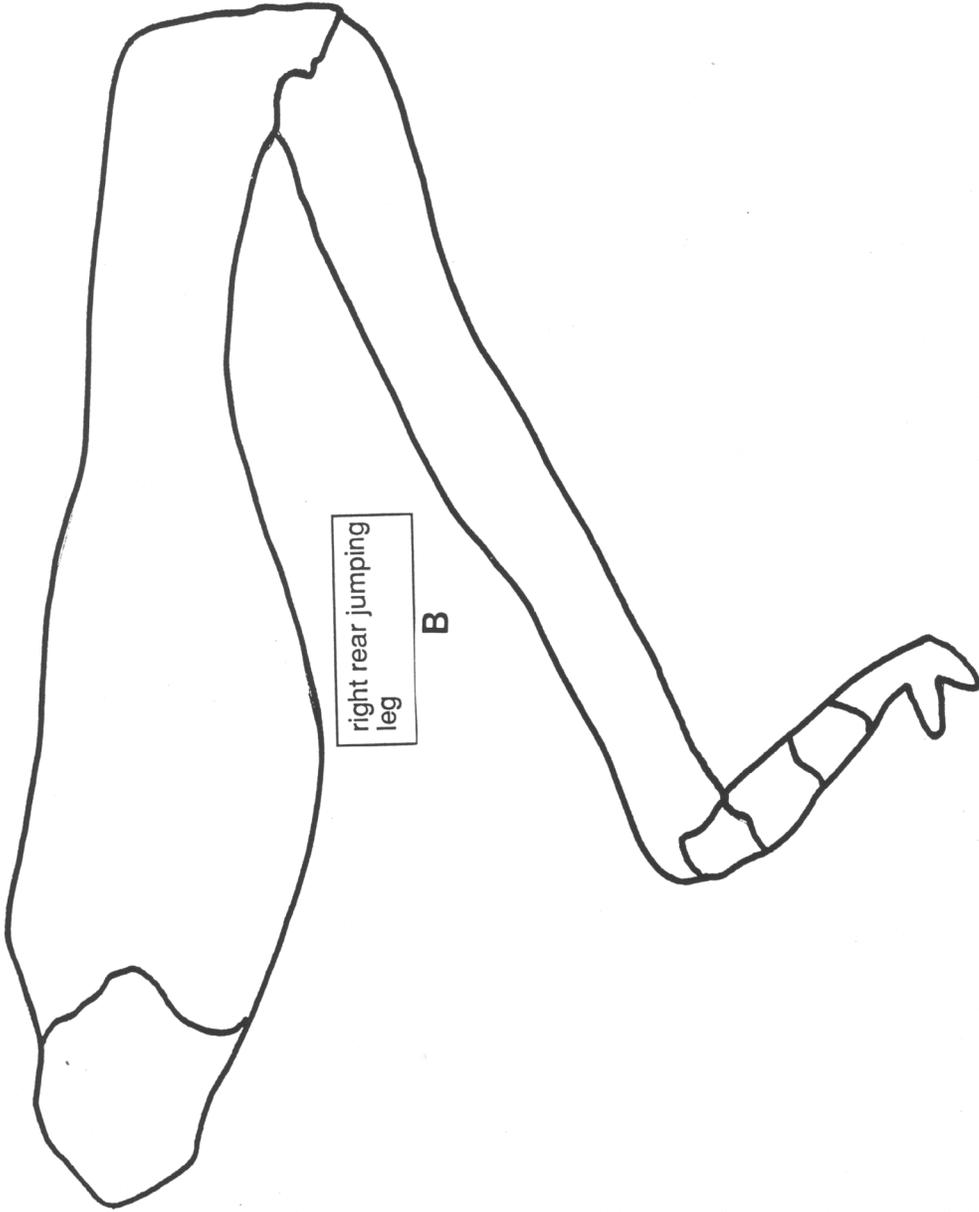
B



head with piercing mouthparts

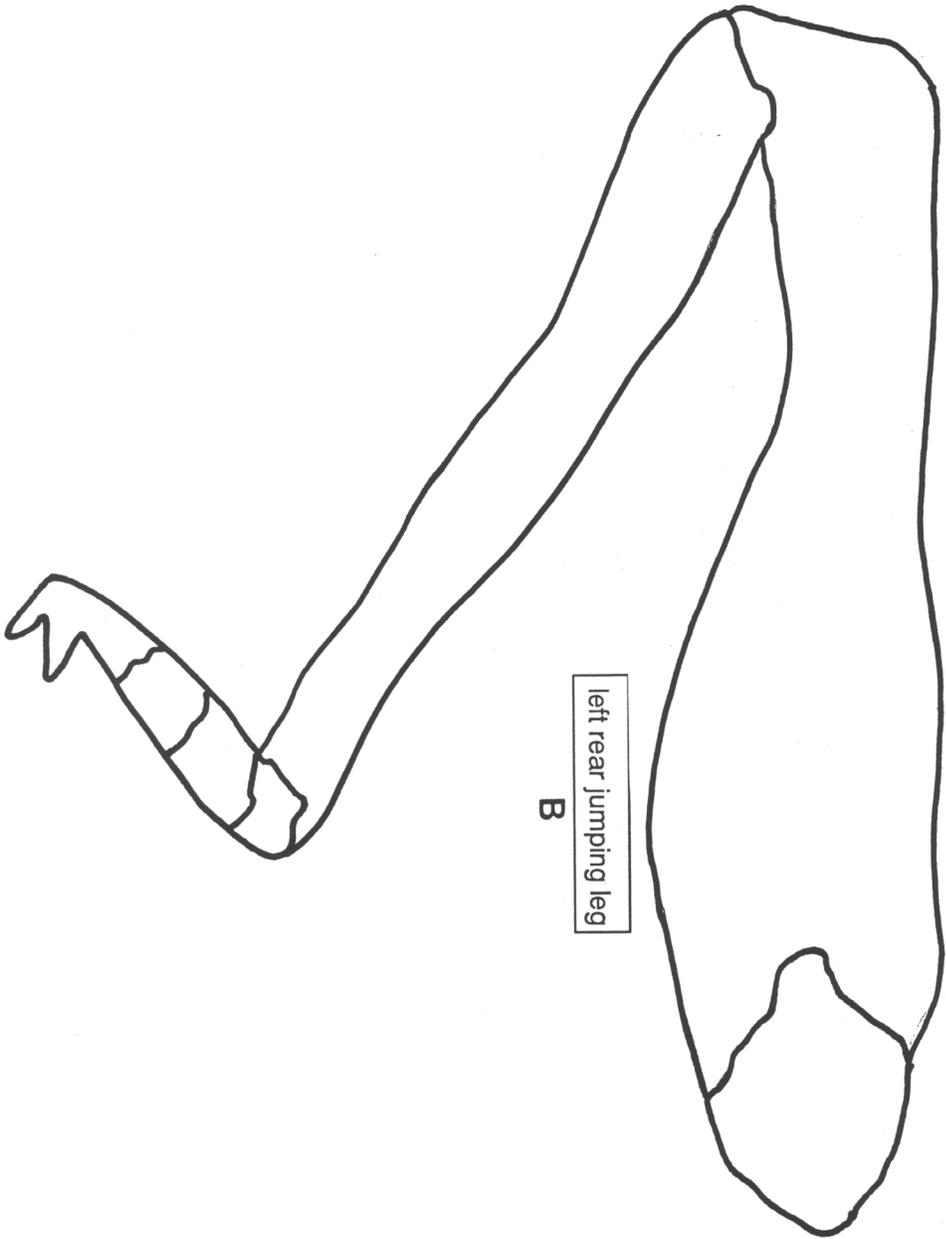
B





right rear jumping
leg

B

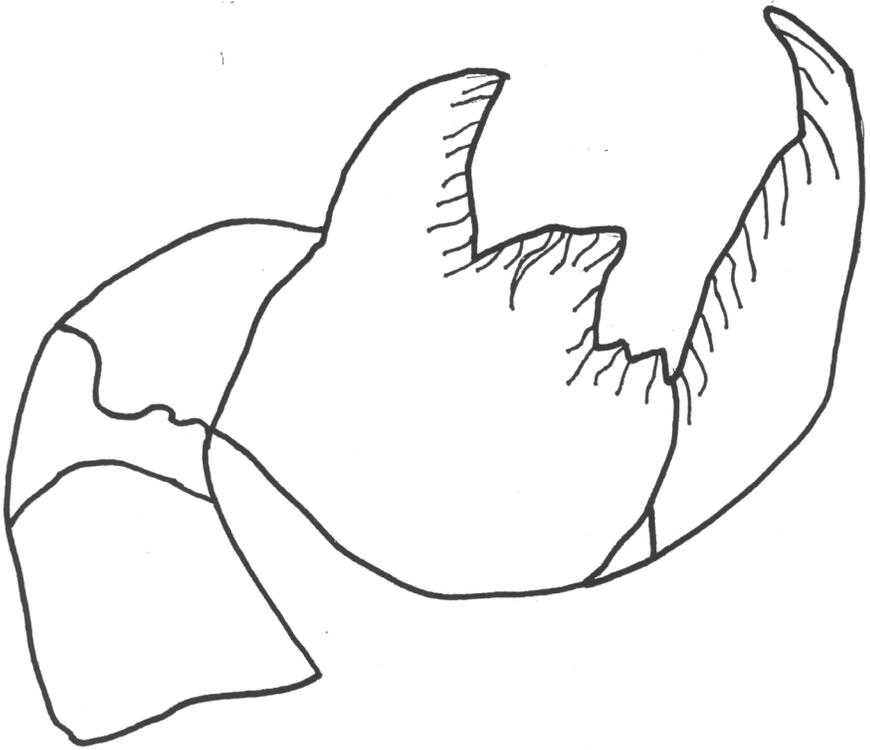


left rear jumping leg

B

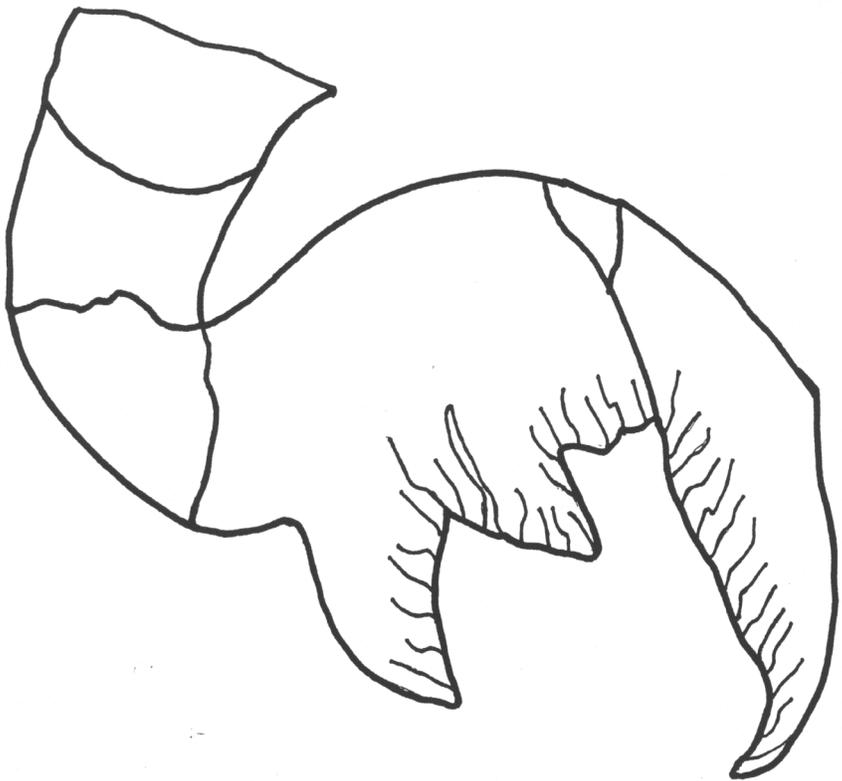
left front digging
leg

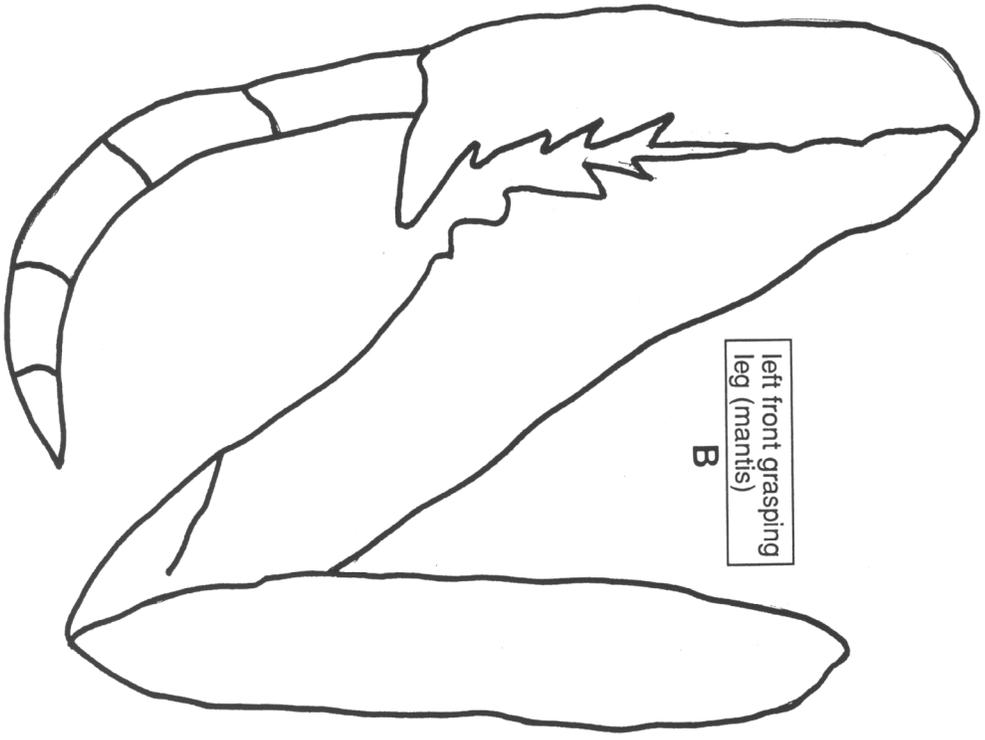
B



right front digging
leg

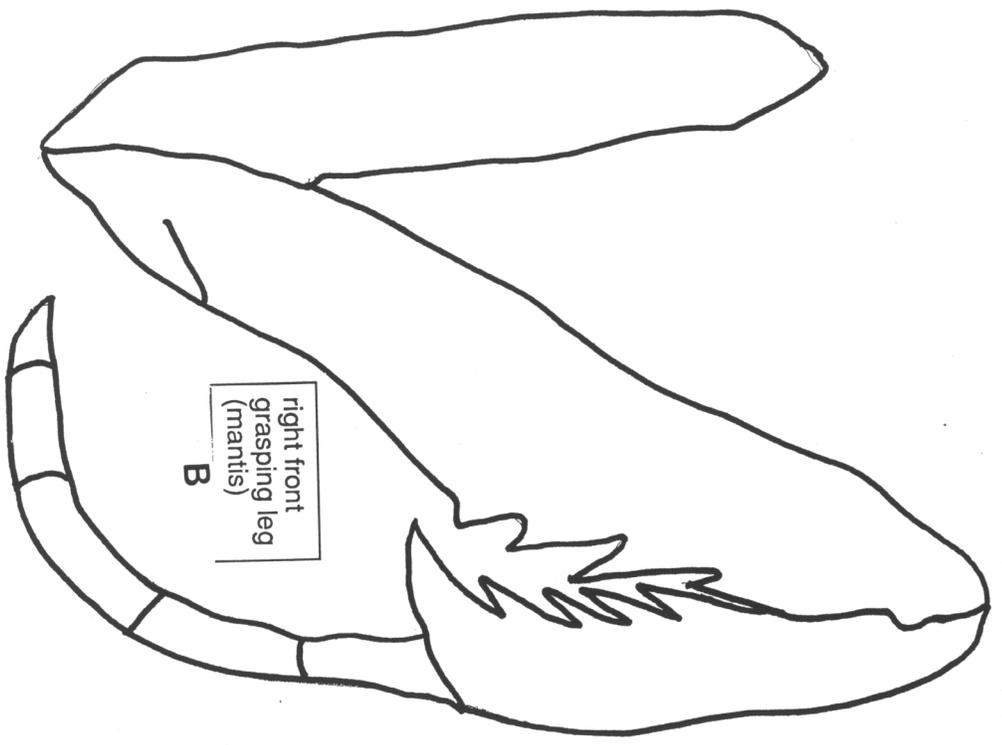
B





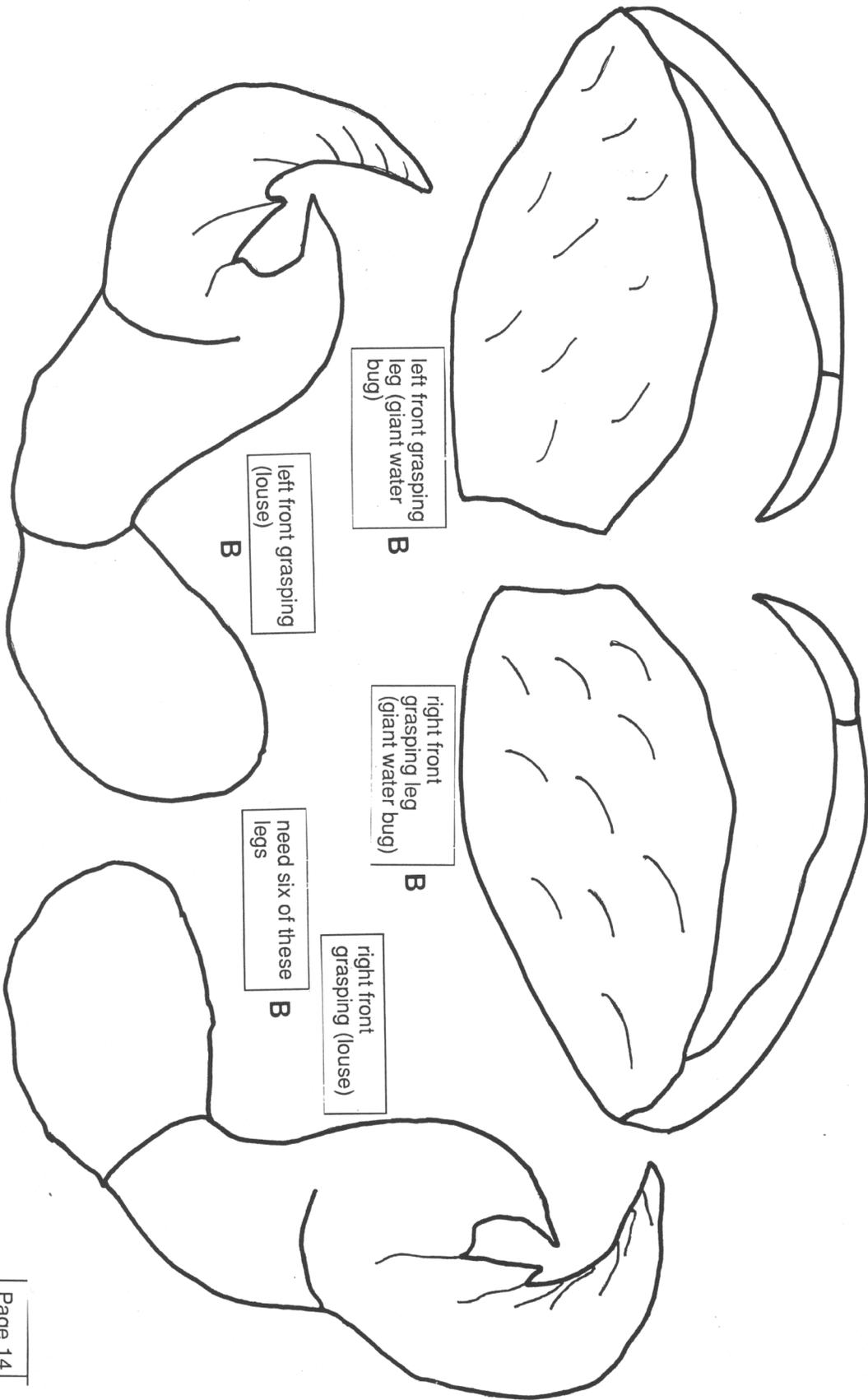
left front grasping
leg (mantis)

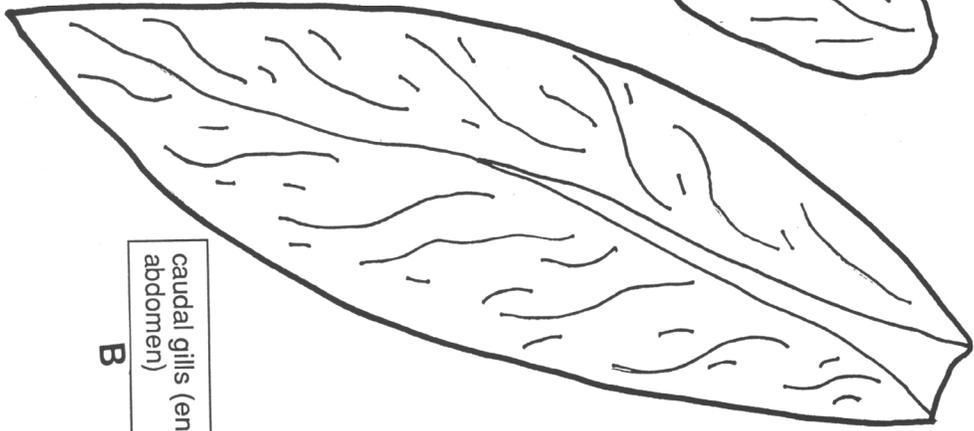
B



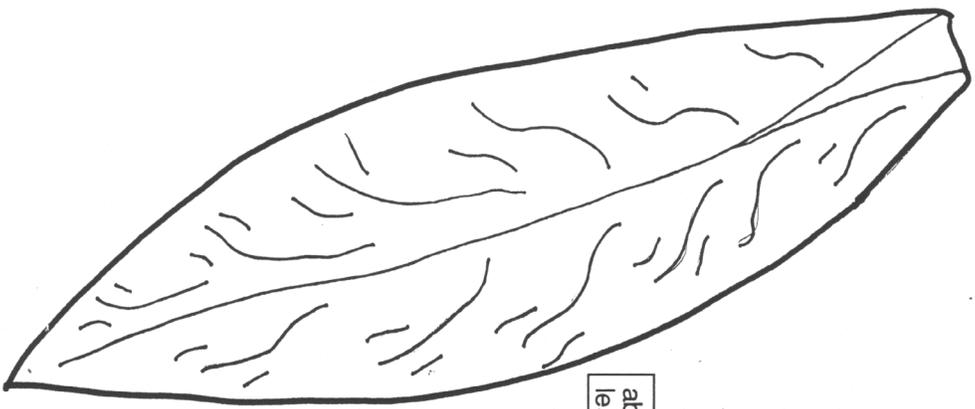
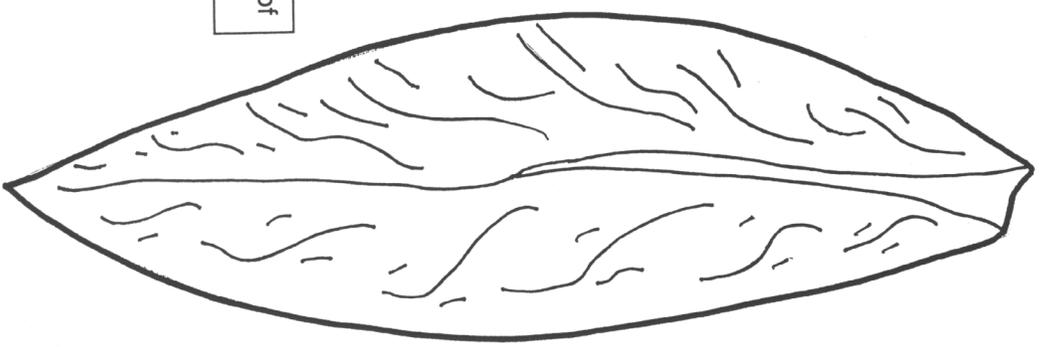
right front
grasping leg
(mantis)

B



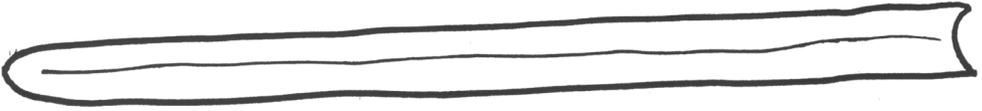


caudal gills (end of abdomen)
B

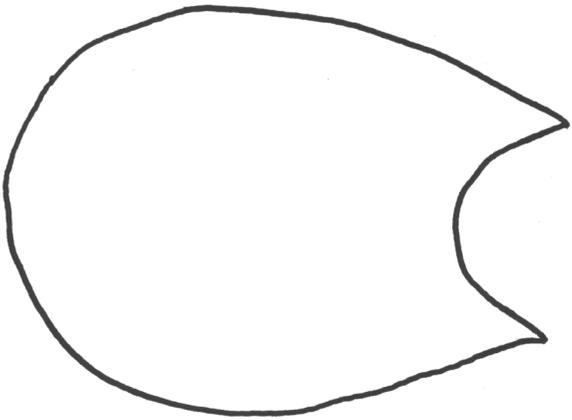


abdominal gills (need at least 8 of these)
B

breathing tube (snorkel)
B



air bubble
B



dragonfly/damselfly
mouthpart (extended)
B

