Aquatic Invertebrates in Still and Flowing Waters

SUGGESTED GRADE LEVELS: 4, MS

SUBJECTS: Science

SKILLS: analysis, classification, comparing similarities and differences, generalization, listing, observation, reading

CORRELATION TO NEXT GENERATION SCIENCE STANDARDS: 4-LS1-1, MS-LS2-1

Objectives

Students will: 1) learn to use a dichotomous key; and 2) be aware of and recognize aquatic adaptations of macroinvertebrates.

Method

Students will use a dichotomous key and develop one of their own. Students will utilize the *Aquatic Invertebrates in Still and Flowing Waters* sheet to match adaptations to specific organisms.

Background

To identify organisms, scientists assemble taxonomic information (observable characteristics that describe an organism) and arrange it in a logical form called a key. Although there are dozens of types of keys, we will use the dichotomous key: *dich* meaning two parts; and *tomous* meaning to divide. Thus a dichotomous key consists of two choices that have other choices associated with them. Each couplet has either a name following it (this means you have correctly identified the organism) or gives a number that leads to another couplet further into the key (this means that you have not yet identified the organism in question and must continue).

Illinois' aquatic invertebrates (animals without backbones) demonstrate a wide range of adaptations for living in pond and stream environments. Each of these animals must be able to breathe oxygen, find food, protect itself from predators, move about in its environment and reproduce. Aquatic invertebrates accomplish all of these tasks while spending all or part of their lives in or on the water. Hundreds of species of aquatic invertebrates exist in Illinois, and they use a wide range of strategies to live and reproduce.

Materials

copy of *Aquatic Invertebrates in Still and Flowing Waters* poster sheet for each student; copy of "A Key Activity" for each student; writing materials; copies of "Adaptations" pages for each student; copy of "Adaptations Answer Sheet" for each student; glass bowl; water; needle; pin with plastic head; dishwashing detergent

Procedure

1. Discuss with students the information regarding a dichotomous key which is found in the background section. Select five items in the classroom and have students write a key to only those items. Remind students that each couplet must be a "yes or no" type statement—wings present or wings absent; legs fuzzy or legs smooth, etc. Also, each character must be directly observable. For example, can fly is not a character, but the presence of wings is a useable character. See sample key on next page.
2. Hand out the "A Key Activity" sheet and ask students to complete it. The answers are as follows: A = snail; B = leech; C = scud; D = beetle larva; E = dragonfly.
3. Provide the "Adaptations" pages, "Adaptations Answer Sheet" and poster key sheet to students. Once they have read the information, they should answer the questions provided with each section. Answers are on a separate sheet in this activity.
4. Discuss and do the demonstration in the Surface Tension Activity section.

Extensions

1. Have each student research the habits of one organism depicted on the poster and report to the class.
2. Obtain a copy of the Illinois Department of Natural Resources' *Illinois Aquatic Macroinvertebrates* poster to aid in species identification for this activity. Order at http://www.dnr.state.il.us/teachkids/. Visit a local stream, pond or marsh. Sample the bottom, surface and vegetation for organisms. How many organisms on the poster could you find? How many different kinds of organisms did you sample?

Evaluations

1. Students should submit their answers to the various parts of this activity.
2. Students should write a short paper describing the various adaptations utilized by aquatic macroinvertebrates and give the value of each.
3. Students should be able to name five aquatic macroinvertebrates.

Sample Key

Here is a sample key for the objects book, pencil, eraser, new piece of chalk, box of crayons.

1.	object has a square or rectangular shape with corners	**go to #2**
	object not as above (cylindrical or round)	**go to #3**
2.	object cannot be opened and has a soft, porous surface	**eraser**
	object can be opened	**go to #4**
3.	object is cylindrical, flat on both ends, usually white and leaves residue on hands	**chalk**
	object usually comes to a point on one end with a central core of dark material; does not leave residue on hands	**pencil**
4.	object has paper sheets between two covers	**book**
	object not as above	**box of crayons**

Note that in this key the final statement need not be very specific as it describes the only object that is left.

Activity and poster adapted with permission from the Illinois Natural History Survey, Champaign, Illinois, 1997.

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Aquatic Invertebrates in Still and Flowing Waters
Teacher's Answer Sheet

Breathing Under Water

crayfish: gills

leech: uses skin

mosquito larva: uses respiratory tubes

Finding Food

water tiger: predator

mussel and snail: scavenger or filter feeder

Protection from Predators

protective shells or cases: 4, 8, 16, 18, 20, 39, 48

camouflage or cryptic behavior: 3, 4, 5, 6, 7, 8, 10, 16, 18, 20, 21, 29, 30, 37, 38, 46, 48, 50, 51, 52

Locomotion

question 1 22-air bubbles, 23-paddle-shaped legs, 25-hairs on legs, 30-hairs on legs, 31-hairs, 32-hairs, 33-hairs, 35-hairs on legs, 44-paddle-shaped gills, 45-hairs, 47-paddle-shaped legs and hairs

question 2 3, 6, 7, 8, 10, 11, 12, 13, 17, 19, 20, 21, 27, 30, 35, 36, 38, 46, 50, 51

question 3 leech: suction cup; limpet: flat underside of body; snail: flat underside of body; flatworm: flat underside of body

question 4 earthworm - pushes way through substrate with muscular body

mussel - pulls with muscular foot

burrowing mayfly - spadelike feet, constructs a burrow

sludge worms - muscular body, constructs tubes

Life Cycles and Reproduction

question 1 crayfish: 3, 51; water flea: 31; snail: 39, 48; mussel or clam: 16, 18

question 2 Unless the mussel was able to change its behavior and use another species to raise its glochidia, the mussel species would become extinct after the adult mussels died out.

question 3 damselfly: 1, 21; stonefly: 7, 41; mayfly: 6, 13, 15, 40; dragonfly: 50, 43

question 4 1

question 5 30. The adult, male giant water bug will defend itself from other predators, and in the process, protect the eggs.

question 6 phantom midge larva: 22; midge larvae: 29, 37; mosquito life cycle: 2, 42, 44, 45

question 7 adult beetles: 19, 23, 35; larval beetles: 10, 11, 17, 46; dobsonfly: 12; caddisfly: 8, 20

Getting Around

question 1 can fly: 1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 19, 20, 21, 22, 23, 24, 29, 30, 35, 38, 40, 41, 42, 43, 44, 45, 46, 47, 50

cannot fly: 3, 4, 5, 14, 16, 18, 25, 26, 27, 28, 31, 32, 33, 34, 36, 37, 39, 48, 49, 51, 52

question 2 Answers could include: find new feeding area, avoid competition, avoid overcrowding, avoid predators, occupy unused habitats, find a mate.

Special Adaptations

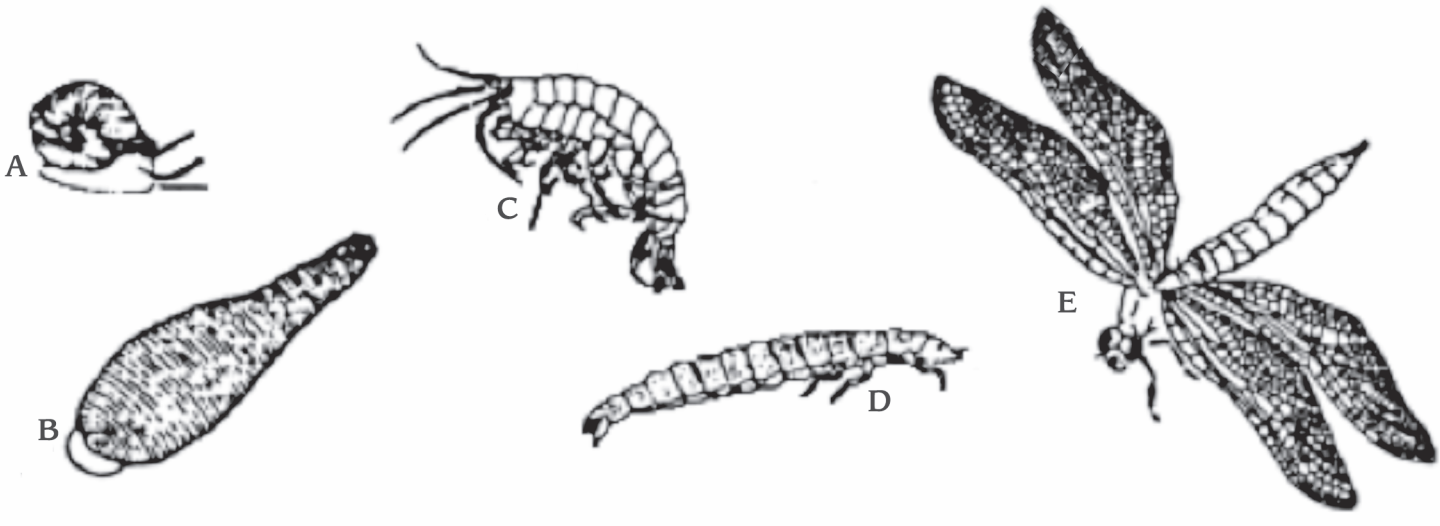
question 1 23; look down for prey and up for enemies and bodies of insects floating on the surface

question 2 22; respiration is happening

Surface Tension Activity

Answers could include: body that repels water; small body with large, wide feet; hairs on feet or shape of feet that make them take up more surface area, like snowshoes; long legs that spread out weight.; 23, 24, 39, 42

A. Below are drawings of five organisms and a key. Use the key to correctly identify the organisms.



1.	legs absent	go to 2
	legs present	go to 3
2.	protective shell present	snail
	protective shell absent	leech
3.	wings present	dragonfly
	wings absent	go to 4
4.	3 pairs of jointed legs	beetle larva
	more than 3 pairs of legs	scud (tiny crustacean that swims sideways)

Answers: A = B = C =

D = E =

B. Select five different organisms that could be found in or around a stream, lake or wetland and make a key to these organisms.

What is that critter?

Scientists who locate, describe, name and determine the relationships among species are called taxonomists or systematists. In biology, the purpose of classification is to provide a system for organizing a large body of information about living organisms. We rely on a hierarchical system, a series of levels that become increasingly exclusive. As information becomes more specific, fewer organisms can be included (and more excluded) until an individual unit, the species, has been identified. If these relationships are sketched out, they will form a "Family Tree."

The Animal Kingdom is divided into vertebrates and invertebrates. The *Aquatic Invertebrates* poster includes: sponges, molluscs (snails, limpets, clams, mussels), arthropods (insects, arachnoids, crustaceans), segmented worms (leeches, earthworms) and flatworms.

Characteristics of Aquatic Invertebrate Groups

sponges—colony of tiny organisms appearing as masses attached to sticks

molluscs—soft, unsegmented body, muscular foot and usually a secreted hard shell

snails and limpets—one-part shell

clams and mussels (bivalves)—hinged, two-part shell

arthropods—hard, chitinous (made of a hard protein called chitin) exoskeleton with segmented body parts and segmented legs

crustaceans—jointed legs on cephalothorax (head and thorax fused), other appendages on abdomen, 2 pairs of antennae

insects—3 pairs of jointed legs on thorax, 1 pair of antennae

arachnoids—4 pairs of jointed legs on same segment as mouthparts (cephalothorax), no antennae

segmented worms—soft, segmented body with no legs

earthworms—no sucker-like disk

leeches—sucker-like disk on posterior end for attachment

flatworms—soft, flat, unsegmented body

Breathing Under Water

All aquatic invertebrates must breathe oxygen. The best source of oxygen is the air. Many aquatic invertebrates take their oxygen directly from the air, even though they live in the water. They must come to the surface and capture air on their bodies (e.g., under the wing covers), with their legs or with hydrophobic hairs (hairs that repel water) on the outside of their bodies. Some will gulp air directly through breathing tubes.

Water also contains dissolved oxygen. Most of this oxygen is picked up by the water at its surface where it comes into direct contact with the air. Any agitation of the water's surface, such as by wind or current, will increase the amount of dissolved oxygen in the water. Aquatic plants also release oxygen into the water during photosynthesis. In addition, cooler water can hold more dissolved oxygen than warmer water.

Many aquatic invertebrates take oxygen directly from the water through internal or external gills, directly through the skin or through the use of a bubble of air which they take below the surface attached to their bodies. These bubbles can extract oxygen from the water and function as physical gills. Insects either breathe through gills or from the surface. Insects that breathe air do not have lungs but breathe through holes, or spiracles, that are either located along their bodies or at the end of the breathing tubes. The spiracles open into a network of tubes, called tracheae, that take oxygen to the insects' cells. Crustaceans have gills covered by their exoskeleton and pump water over the gills by fanning some of their legs. Worms can exchange oxygen directly through their skin, while snails collect air in their shell at the surface, breathe through gills or pump water through their bodies. **Answer Question 1**.

Finding Food

The aquatic environment supports herbivores, predators, omnivores and scavengers, just like the terrestrial environment. Herbivores may graze on aquatic algae, mosses or other aquatic plants. Predators may chase down their prey, or wait in ambush for prey to pass by as they hide camouflaged in plants or under rocks. Also, predators often have large, sharp mouthparts or grasping claws. Omnivores will eat just about anything, plant or animal. Scavengers feed on dead and decaying plants and animals. Some invertebrates (filter feeders) filter fine particles of food out of the water using netlike structures or by pumping water through their bodies. **Answer Question 2**.

Protection from Predators

To avoid predation, some aquatic invertebrates wear protective shells or build protective cases of sand, pebbles or plant material. Some rely on camouflage, while others hide under rocks or depend on their ability to flee. **Answer Question 3**.

Locomotion

Aquatic invertebrates have many adaptations that allow them to move about their environment—they may swim, burrow or climb about on rocks or plants. Swimming invertebrates may have legs modified to function as paddles. These may have groups (patches) of hairs that act very much like feathers on the wing of a bird and allow the aquatic invertebrate to "fly" under water.

Some invertebrates crawl about on the substrate (bottom surface) of the pond or stream, or on plants and logs. They may have claws that help them cling to the various surfaces. Animals that crawl on the substrate of a swiftly flowing stream must be able to cling tightly or will be washed downstream.

Leeches, a type of worm, can cling to the substrate by a suction cup type of appendage. Snails, limpets (a type of snail with an uncoiled shell) and flatworms cling to the substrate by adhering to the surface by the flat underside of their bodies.

Many aquatic invertebrates burrow into the substrate of the stream or pond. Aquatic earthworms push their way through the soil with muscular contractions of their bodies. Mussels pull their shell along and through the bottom material using a muscular foot. Some invertebrates, such as burrowing mayflies, have legs that are spade-like. Burrowing invertebrates, such as sludge worms or burrowing mayflies, and some midge and caddisfly larvae may construct tube-like homes on the bottom.

The water's surface is a unique habitat that many aquatic invertebrates are able to exploit. The surface of the water behaves as if there is a film across it. This film-like property of water is called surface tension. Very lightweight animals are able to walk right on the surface of the water and have difficulty breaking through the surface tension. **Answer Questions 4-7**.

Life Cycles and Reproduction

Some aquatic invertebrates, such as aquatic worms, mollusks and most crustaceans, live their entire life in water. Others, like crayfish, can leave the water for short periods of time. Those that dig burrows with chimney-like entrance holes live near the water and return to water to reproduce. Crayfish mate during the late winter or early spring. Later in the spring the female lays her eggs, carrying them in a mass under her tail. The mass of eggs looks very much like a raspberry, and so a female carrying eggs is said to be "in berry." When the young crayfish hatch, they ride under their mother's tail for a week or more, after that the fully formed but miniature crayfish are on their own. Very young crayfish often can be found hiding and feeding in masses of algae or other plants in shallow water.

Water fleas are tiny crustaceans. Most of a population are females that reproduce parthenogenically—the eggs develop without fertilization by a male. Water fleas hatch internally and are born alive. Occasionally, males are produced and mate with some of the females. The eggs produced in this manner are cysts capable of lying dormant for years before hatching.

Aquatic snails, such as the ram's horn snail and the limpet, are hermaphrodites—they are both male and female. Any two snails of the same species can mate and fertilize each other's eggs. In the river snail, the males and females are separate. Most aquatic snails in Illinois lay gelatinous masses of eggs on plants and substrate. A few species of snails will give birth to live, fully formed young.

Even though fingernail clams look like miniature versions of mussels, they reproduce very differently. Fingernail clams are hermaphrodites. Sperm is released into the water and picked up by the gills, where eggs are fertilized. The eggs then develop in a brood pouch (a sac-like cavity for developing young), and the fingernail clams later give birth to fully formed fingernail clams, smaller versions of the adults. Most freshwater mussels are either male or female. The males release sperm into the water, and it is picked up by the females as they draw water in through their siphon. The eggs are fertilized in the gills, where early development takes place. Later, thousands of tiny larvae are released into the water and attach to the gills of fishes. These larvae, or glochidia, live for a short time as parasites on the gills of fishes, obtaining nutrients from the fishes, until they are ready to transform into adults. Some species of mussels are so specialized that their glochidia attach to the gills of only one species of fish.

Aquatic insects are a very diverse group and demonstrate a wide variety of life cycles and reproductive strategies. Many aquatic insects have immature stages that live in the water, but adult stages that live near water. Some insects have incomplete metamorphosis (egg, nymph, adult) in which the immature stage (nymph) lives in the water. It resembles the adult but lacks wings. The older nymphs have "wing pads" that are the developing wings. When they molt into adulthood, with their functional wings, they leave the water. Dragonflies, damselflies, true bugs, giant water bugs, water scorpions, water boatmen, water striders, stoneflies and mayflies demonstrate this type of life cycle. Some aquatic insects demonstrate complete metamorphosis (egg, larva, pupa, adult), in which the eggs hatch into a larval stage that is very different in appearance from the adult. For example, flies, which include mosquitoes and midges, have soft-bodied larvae without segmented legs. When ready to transform into an adult, the larva must enter a pupal stage in which it encloses itself in a case and undergoes many structural changes.

The female giant water bug deposits her fertilized eggs, which may number more than 100, onto the back of the male with a waterproof glue that she secretes. The male then carries them with him for 10 days or more until they hatch.

Because dragonflies and damselflies are highly predaceous, getting the sexes together is tricky. Males have a unique way to get around this problem, taking sperm from the tip of his abdomen and placing it in a receptacle near the base of his abdomen. He will then seek out a female and grab her behind the head with

claspers on the end of his abdomen. She will reach around with her abdomen and couple with the sperm receptacle. After she has been inseminated, both fly off, still in tandem, and she lays her eggs in the water. Often the male does not let go until she has completed laying her eggs, thus preventing other males from fertilizing her eggs. **Answer Questions 8-14**.

Getting Around (Dispersal)

Adults of many aquatic insects can fly, simply crawling out of the water and flying to a new pond or stream. Crayfish are capable of leaving a stream and trekking across land. In some species of invertebrates, the immature stages live in water, while the adults are terrestrial. Many invertebrates must rely on occasional flooding to locate in a new area. Sometimes the sticky eggs or tiny young of snails hitch a ride on the feet of ducks and other water birds. To move about within a pond or stream, invertebrates can crawl or swim. One means of dispersal that is commonly used by invertebrates in a stream is to simply allow the current to carry them downstream. This drifting takes very little energy, and the invertebrates can quickly move to a new area. **Answer Questions 15 and 16**.

Special Adaptations

Whirligig beetles swim on the surface film of quiet waters. Each of their compound eyes is divided into two parts. The lower part views under the water while the upper portion looks up into the air. **Answer Questions 17 and 18**.

Surface Tension Activity

The surface of a quiet marsh or pond presents no barrier to a raccoon searching for crayfish or a heron attempting to spear an elusive tadpole. To the small creatures of the world, however, the water's surface presents a firm, but flexible, surface and many plants and animals are well adapted for living at or near this surface. Surface tension results because water molecules are more strongly attracted to each other than to the air above. The surface of the water, therefore, is a tight boundary consisting of a dense film of water molecules.

Demonstrating Surface Tension

To complete this activity you will need a clear glass bowl (2/3 full of water), a sewing needle and a straight pin with a large, plastic head.

Carefully lower the dry needle onto the water's surface. It will float. Warning: once the needle is wet, or if it is not placed on the surface carefully, it will sink. The fact that the metal needle floats on the surface film demonstrates surface tension. Many animals take advantage of this surface tension. Look closely at the poster and determine which animals are making use of this unique habitat.

With the point of the pin in your hand, gently push the head against the surface and observe what happens through the side of the bowl of water. The water will dimple down, but if you push too far, the head of the pin will break through the surface, allowing the water's surface to once again become level. As you slowly pull the pin back out, notice that the water sticks to the bottom of the pin and raises up for a short distance before it breaks free from the pin head. This phenomenon also illustrates surface tension.

Altering the Surface Tension

With the needle floating on the surface, add a little diluted dishwashing detergent to the water. What happens? What do you think would happen to the animals that live in a pond or lake if the water was polluted with soap or other chemicals that altered the surface tension? **Answer Question 19**.

Use the *Aquatic Invertebrates* poster and poster key sheets to help you answer these questions.

QUESTION 1

Hypothesize how these organisms may breathe.

crayfish (#3, 51)

_____.

leech (#5)

_____.

mosquito larva (#45)

_____.

QUESTION 2

Aquatic invertebrates may be predators, herbivores, scavengers or filter feeders. Some may fall into more than one category.

The water tiger (#46) is best described as a(n)

_____.

What feeding category would include the freshwater mussel (#16) and river snail (#48)?

_____.

QUESTION 3

Find three aquatic invertebrates that have protective shells or cases and five that demonstrate camouflage or cryptic behavior (hiding).

protective shells or cases #_____ #_____ #_____

camouflage or cryptic behavior #_____ #_____

#_____#_____ #_____

QUESTION 4

Find three invertebrates that swim through the water and list one special adaptation that helps each to swim.

#_____ Adaptation _____

#_____ Adaptation _____

#_____ Adaptation _____

QUESTION 5

Find five invertebrates that crawl on or cling to the substrate (rocks, logs, plants, etc.) using legs equipped with claws.

#_____ #_____ #_____#_____ #_____

QUESTION 6

Find a leech (#5), a limpet (#4), two snails (#39, 48), and a flatworm (#49) on the poster. Name a method of locomotion or attachment used by each.

leech _____ limpet _____

snails _____ flatworm _____

QUESTION 7

Find examples of aquatic earthworms (#14, 28), mussels (#16), burrowing mayflies (#15) and sludge worms (#26) and compare their different adaptations for burrowing.

earthworms

_____.

mussel

_____.

burrowing mayfly

_____.

sludge worms

_____.

QUESTION 8

Find the following animals on the poster.

crayfish #_____ water flea #_____ snail #_____

mussel or clam #_____

QUESTION 9

What would happen to a species of mussel if it could only use one species of fish to raise its glochidia and that fish species disappears from the stream or pond?

_____.

_____.

_____.

QUESTION 10

Find both nymph and adults of dragonflies, damselflies, stoneflies and mayflies on the poster.

	adult #	nymph #
dragonflies	_____	_____
damselflies	_____	_____
stoneflies	_____	_____
mayflies	_____	_____

QUESTION 11

On the poster find the pair of damselflies in the process of laying eggs.

#_____

QUESTION 12

Look for the giant water bug male with eggs attached. How does this arrangement aid in the survival of young giant water bugs?

_____

_____

_____

QUESTION 13

Find larvae of phantom midges and other midges and a complete life cycle (egg, larva, pupa, adult) of the mosquito.

phantom midge larva #_____

midge larvae #_____

mosquito life cycle #_____

QUESTION 14

Find three adult beetles, three larval beetles and one larva each of the dobsonfly and caddisfly.

adult beetles #_____ #_____ #_____

larval beetles #_____ #_____ #_____

dobsonfly larva #_____

caddisfly larva #_____

QUESTION 15

Find five invertebrates that can move to a new pond or stream by flying at some stage of their life cycle and five that cannot.

can fly #_____ #_____ #_____ #_____

#_____

cannot fly #_____ #_____ #_____ #_____

#_____

QUESTION 16

Name one reason why an aquatic invertebrate would disperse to a new location.

_____

_____

QUESTION 17

Find the whirligig beetle on the poster and notice the divided eyes. Why do they need to look in both places?

_____

_____

#_____

QUESTION 18

Find the phantom midge larva on the poster and look for the air bubbles. What do the bubbles mean?

_____

_____

#_____

QUESTION 19

What types of adaptations can you think of that would enable an invertebrate to live on the surface of the water? Find two invertebrates that live on the surface film.

_____

_____

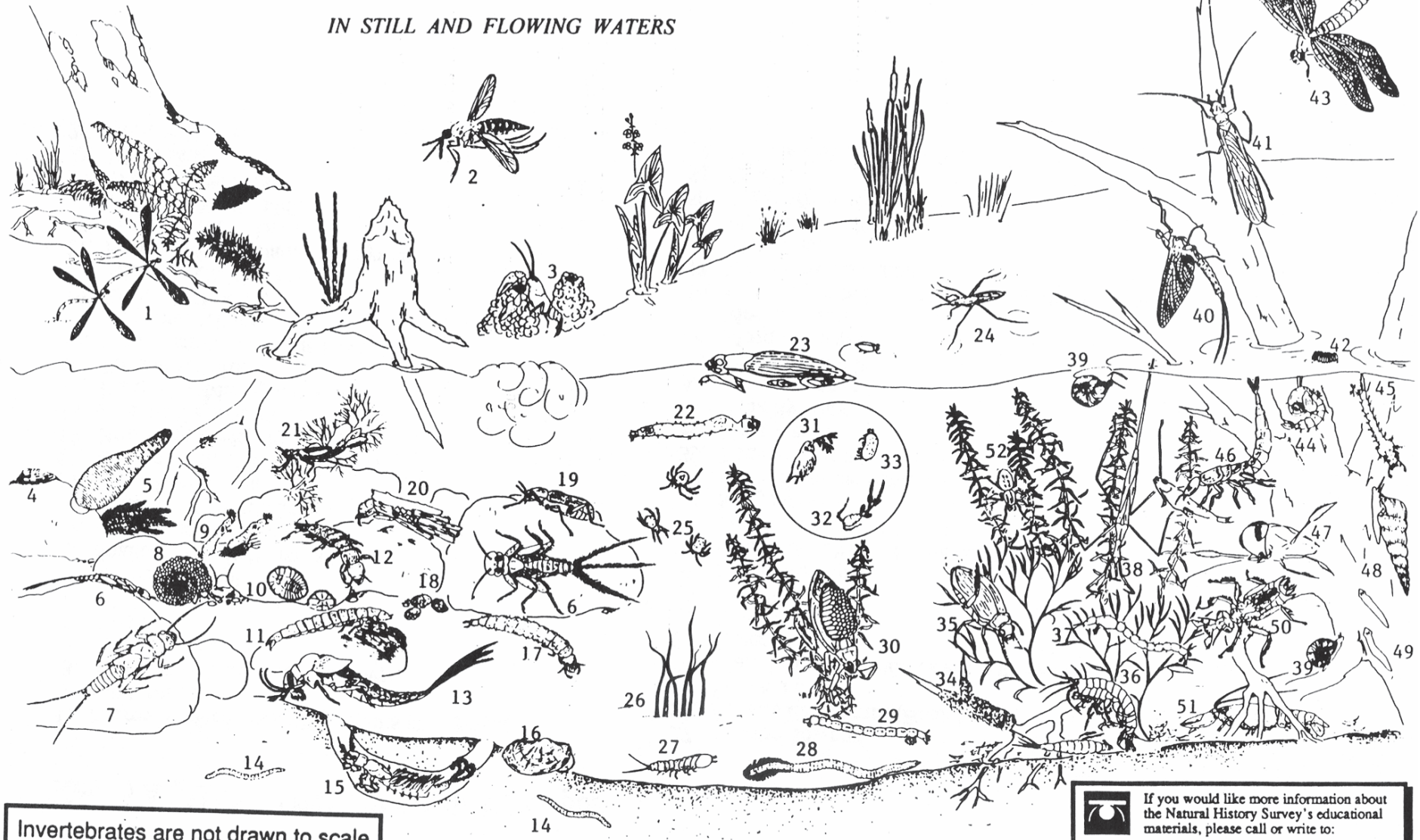
#_____ #_____

Key to
Aquatic Invertebrates in Still and Flowing Waters

1. narrow-winged damselfly, adults laying eggs
2. adult mosquito
3. crayfish with chimney burrows
4. freshwater limpet
5. leech
6. flatheaded mayfly nymph
7. stonefly nymph
8. snailcase caddisfly larva
9. blackfly larva and pupa
10. water penny beetle larva
11. riffle beetle larva
12. hellgrammite (dobsonfly) larva
13. brushlegged mayfly larva
14. aquatic earthworm
15. burrowing mayfly larva
16. freshwater mussel
17. water scavenger beetle larva
18. fingernail clams
19. riffle beetle adult
20. stickcase caddisfly larva
21. narrow-winged damselfly nymph
22. phantom midge larva
23. whirligig beetle adult
24. water strider adult
25. water mites
26. sludge worms
27. aquatic sowbug
28. aquatic earthworm (Branchiura)
29. midge larva
30. giant water bug, adult male with eggs
31. water flea
32. copepod
33. seed shrimp
34. freshwater sponge
35. predaceous diving beetle
36. sideswimmers or scuds
37. midge larva
38. water scorpion adult
39. ramshorn snail
40. mayfly adult
41. stonefly adult
42. mosquito eggs
43. dragonfly adult
44. mosquito pupa
45. mosquito larva
46. water tiger or predaceous diving beetle larva
47. water boatman adult
48. river snail
49. planarians or flatworms
50. dragonfly nymph
51. crayfish
52. fishing spider

AQUATIC INVERTEBRATES

IN STILL AND FLOWING WATERS



Invertebrates are not drawn to scale

Poster drawn by Carie Nixon
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