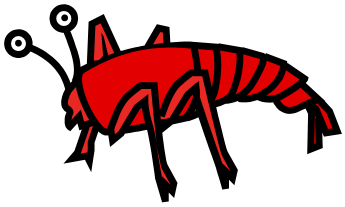
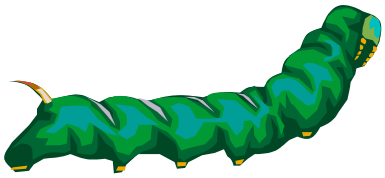
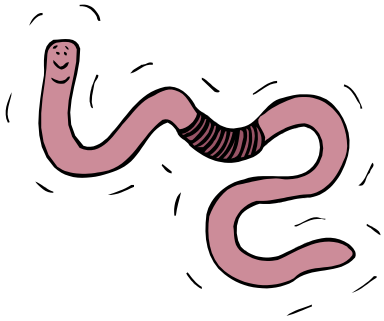
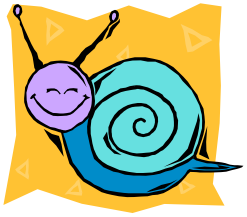


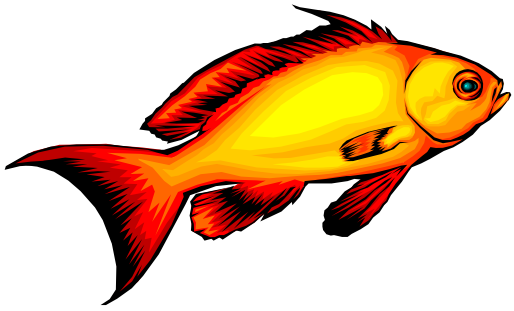


CRITTER CARE

Live Organisms







AQUATIC SNAILS

Many kinds of aquatic snails make excellent additions to an aquarium. All snails have spiral shells that get bigger toward the opening as the snail grows. The snail secretes new shell around the opening and moves in, abandoning the narrow reaches at the tip of the spiral in which it lived as a youth.

The muscular part of the snail that protrudes from the shell is the foot. Its mouth is on the foot right where a human's foot has a couple of toes. Because of this interesting structure, snails are called gastropods, which mean stomach (*gastro*) foot (*pod*). The snail scrapes algae from the surfaces over which it travels. A few snails in your aquarium will graze on the algae that grows on the sides and make it possible to see what's going on inside.

Snails lay gelatinous globs of nearly transparent eggs. These may be stuck to plant material or the sides of the aquarium. After a couple of weeks, they will hatch, and the tiny larvae will swim freely around the aquarium. Soon they begin to grow a shell, which weighs them down and makes them pedestrian. You may find your aquarium swarming with tiny snails. Snails are quite cooperative about providing opportunities to observe their life cycle.

What to do when they arrive. Immediately upon arrival, open bag and place in cup or similar upright container to prevent tipping. Rinse snails with de-chlorinated or spring water prior to transferring to aquarium. Snails will feed on algae or decaying plant matter naturally found in the aquarium.

CRAYFISH

Crayfish are marvelous classroom organisms. They are exciting and easy to care for. Through close observation, students can learn interesting details about animal structures while developing sensitivity to the needs of living organisms. Crayfish can act like living magnets, keeping students in at recess and drawing students into your classroom from all over school. In short, crayfish can bring new life to your classroom.

Crayfish are crustaceans. Their appearance is bizarre—they are festooned with a bewildering array of walking legs, pincers, and other appendages for eating, feeling, and attending to other crayfish business. Equipped with thousands of sensory bristles, some sensitive to chemicals and the others to touch, crayfish can smell, feel, and hear acutely, even though they are completely covered in a hard shell. They are aquatic, but can survive fairly extended sojourns on dry land as long as their gills remain moist. In order to meet the crayfish up close and personal, let's review some of this animal's natural history.

Crayfish like it dark and cool, and during much of the daylight they will be found alone, withdrawn under a rock or a clump of vegetation, waiting for dark, at which time they come out to forage for food. Crayfish are omnivorous; eating just about anything they can find or catch, dead or alive. Large food is held and torn to pieces in the large pincers and conveyed to the mouth by the smaller specialized legs near the head. That's what crayfish mostly do: loaf all day and look for food all night.

Crayfish are terrific animals for your students to study. They walk, swim, eat, hide, breathe, mate, molt, and die right in the classroom. Your crayfish container is a microcosm of life on Earth, and students will learn a lot by sharing time with crayfish.

Reproduction. But there are times in a crayfish's life when the routine is broken. Males and females, spurred on by messages communicated to each other, join periodically for mating, especially in the spring. Males can be told from females by the generally larger pincers and narrower tails, but these characteristics are not absolute. To tell for sure, you must pick them up and look underneath. Males have two pairs of modified swimmerets (the small leg-like appendages under the tail) that are white-tipped and lay between the last pair of walking legs. The females have longer, softer-looking swimmerets (for holding the eggs) and a little white pore centered between the walking legs. Sometime after mating the female lays about 200 eggs, which she carries in a mass under her tail.

After several weeks the eggs hatch, and a hoard of minute, perfectly formed, ravenous baby crayfish emerge. At first they continue to ride along under the female's tail, eating tiny waterborne bits of food, but soon they leave this security and head out on their own. During these early days many are eaten by fish, insects, and other crayfish, but some always survive to fulfill their destiny.

Pregnant crayfish. You think you might have a pregnant crayfish? Here are some things to consider.

- A peaceful environment with plenty of cover in or under which to hide will provide security for the mothers. You might want to go one step farther and separate the two females so each has a basin of her own. That way you will be able to tell whose offspring belong to which female
- When the eggs hatch it will be even more important for there to be lot of structure in the habitat. Plan to put in a bunch of plants or even plastic plants in which the babies can hide. Rocks, pebbles, flower pots, and the like are good, too. The thing you want is lots of places for the babies to hide from each other. They are notorious for eating each other. As you know, crayfish are at risk just after they have molted, and the little ones love to snack on their just molted brothers and sisters. That's the way it goes in the crayfish world.
- If you have some flake fish food, a little bit crumbled up into dust will be a good food source for the babies. They will find the tiny bits that fall into the gravel on the floor of the habitat.
- One more thing, don't give up on the eggs. It might be 4–6 weeks before they hatch. You may not know when your females laid their eggs, in which case it will be a surprise when they hatch.

Molting. Another ponderable: think about the problem of living inside a suit of armor. Crayfish can't grow unless the shell (comprising the carapace, or main body shell, tail shell and leg shells) can be removed. And this is exactly what crayfish do. Periodically (quite often early in life) the crayfish slides out of its old, hard shell in a process called molting. The "naked" crayfish that emerges is actually covered in a complete and perfect shell, but it is soft and flexible, allowing the crayfish to expand and grow. After a day or so the new shell will become hard, again affording the animal the protection of an armored exterior.

In preparation for molting the crayfish withdraws most of the calcium from its shell, and stores it in two white "tablets "in the sides of its head. Calcium is a major hardener in the crayfish shell, as it is in strong human bones and teeth. With this precious supply of calcium the new shell can harden in a matter of hours instead of days or weeks.

Ordering crayfish. There are a number of ways to get crayfish for this activity. Have students catch crayfish from a local creek or pond; buy them from a bait shop; or order them from a biological supply company. In any

case, you will need 10–12 healthy crayfish that are accustomed to still, relatively warm water (as opposed to cold, fast-running streams).

If you purchase the crayfish from a biological supply company, place your order for one dozen medium-size crayfish well before the investigation. Let the company know on what date you plan to introduce the crayfish to your class. Use a local vendor if possible.

Preparing for crayfish arrival. A day or two before you expect the crayfish to arrive, prepare their habitat. Fill two bus trays about one-third full of cold tap water (3–4 cm deep). Keep the trays out of sight in a cool, dark place. Let the water sit for a day or more to release chlorine from the water.

What to do when they arrive. The crayfish will arrive in a cardboard box packed with damp paper or moss. Alert the school secretary to notify you as soon as they come. Immediately upon arrival, cut open plastic bag to provide air. Keeping bag upright, float entire contents in prepared bus tray for 15 to 30 minutes to equalize water temperatures. Carefully remove crayfish from the bag, grasping each from behind to avoid the strong pincers. Aquatic plants shipped with the crayfish can be rinsed in clean de-chlorinated or spring water and used as both food and "hiding" places for the crayfish. Maintain at cool room temperatures, out of direct sunlight.

Handling the crayfish. Practice picking up the crayfish so that you can demonstrate the proper technique for your students. Approach the crayfish from behind. Grasp it firmly on the carapace (body shell) behind the pincers. Pick it up. It may try to reach back, but don't worry—it will not be able to reach you.

Provide aquatic plants. Buy or collect from a local pond some small aquatic plants for the crayfish. We recommend getting 6–12 sprigs of *Elodea,* also known as *Anacharis.* (It looks like a little green feather boa.) You can order it from a biological supply company when you order your crayfish, or you can pick it up locally at a pet store that deals with fish. If *Elodea* is not available, try another inexpensive aquatic plant.

Find a place for the crayfish. Plan where the two bus trays with the crayfish will reside in your room for up to several months. They need to be cool, out of direct sunlight, and safe from being spilled.

Prepare for care and feeding. Crayfish need ample clean, cool water and sufficient food in order to be healthy in your classroom. It is virtually impossible to get the water too cold (short of freezing), but it is easy for it to get too warm. Try to keep the temperature between 5°C (41°F) and 20°C (68°F).

You will feed your crayfish protein in the form of dry cat food that sinks in water. Don't worry if the crayfish don't eat for a week or two; they will eat

when hungry. Always move the crayfish out of their home tray and into a basin with 3–4 cm of water to feed them the dry cat food. Put in one piece of cat food per crayfish. Leave them there for about 1/2 hour. (If they don't eat, they aren't hungry.) Then return them to their home tray, without any of the cat food. The other food source that is always available is the *Elodea* that stays with the crayfish in their home trays.

This feeding routine can be followed every day if the crayfish are actively eating and less frequently if they are not. While they are in the feeding basin, the home tray can be rinsed and filled with fresh water. This should be done about once a week—more often if the water begins to smell bad.

Plan for a new crayfish home. When you have completed the activities, there are several options for disposing of the crayfish. Discuss the options with students and together come up with a plan.

- Set up an aquarium and make the crayfish permanent members of your classroom community.
- Another class might like to have them for a science resource.
- If some of the students would like to take them home, send them off, with parental permission, of course.
- If the crayfish were not collected locally, they should not be released into the local environment.

Resolving the question of what to do with the crayfish can be turned over to students. They can do research by writing or calling local experts to find out what they recommend. One expert to talk to might be the company that supplied the crayfish. Local fish and game biologists would be another resource for students to contact.

Crayfish pose no health hazard for students. They do not carry diseases. Occasionally you will see white wormlike animals attached to the crayfish carapaces and pincers. They are harmless to both humans and crayfish. They seem to be opportunists, riding along for a free meal when the crayfish eat.

CRICKETS

Many people recognize crickets without even seeing them. They identify the familiar chirping sound made by the male cricket in his efforts to attract a mate. The sound is most often heard at night when crickets are most active, prowling about looking for food, moisture, and a consort.

Crickets undergo simple, or incomplete, metamorphosis; they molt several times as they grow, each molt revealing larger, more fully developed crickets, until the last molt results in adults.

The female cricket has a structure protruding from the rear of her abdomen that students often think is a long stinger. It is an ovipositor, which the female thrusts into moist earth in order to lay her eggs well below the surface. When the eggs hatch, the nymphs dig to the surface, where they fend for themselves.

Crickets have other interesting features, starting with a pair of spikes that extend out from the end of the abdomen in both sexes. The cricket has two pairs of wings, the front two of which are equipped with rasp-like adaptations that, when scraped together, produce the chirp. The hindmost pair of legs is greatly enlarged, allowing the cricket to spring huge distances when motivated by alarm or other stimuli. On the front most pair of legs is membranes that are sensitive to sound vibrations, so in effect the cricket has its ears on its legs. The antennae are long, lithe, and sensitive. It is fascinating to see the exquisite control the cricket has over these wispy structures as it probes and feels its environment before rushing in.

The cricket most used for classroom cultures is the house cricket. It lives in containers quite well and is content to eat seeds, fruit, grass, and dry dog food. However, crickets are good at escaping confinement. They will gnaw through paper or cardboard quite quickly, and if they are overcrowded, hungry, or thirsty, they will chew through nylon mesh covering a cricket container. For this reason it is necessary to cover the container with metal screen.

Cricket habitat. The FOSS cricket habitat has three chambers. One contains soil that is kept moist. This is where the females will lay eggs. A second chamber contains dry sand. Food should be placed in this area so that it will not mold. The central area is the exercise yard with structures for climbing and hiding.

Crickets need paper, sand, or soil to get around because their feet are not adapted for holding onto smooth surfaces. A large or complex cricket culture

container will allow the crickets to display preference for variables such as moisture, temperature, and structure. Crickets prefer a hot, dry environment. If they are kept in a humid environment, they can develop a fungus, so lots of ventilation is needed. They can go into a moist environment to eat or lay eggs, but they must be able to retreat to dry ground. If you like, you can train a lamp on the central part of the habitat—the crickets will congregate there to bask. And you will probably get a song tossed in as part of the bargain.

What to do when they arrive. Crickets are shipped in a container with crumpled paper. They dislike overcrowding and should be transferred to a terrarium as soon as possible. To remove the crickets from the box, slit the tape. Enclose the box in a plastic bag and shake the crickets into the bag. Then transfer the bag of crickets into the cricket habitat you have made. This will be easier than shaking them directly from a box into the habitat. Crickets may be fed oatmeal, bird seed, small pieces of fruit or lettuce, or dried dog food. Prepare the water fountain provided in the kit.

MEALWORMS AND DARKLING BEETLES (Tenebrio beetle)

The mealworm is not a worm; it is a larva. Any similarity to a true worm is incidental. Mealworm larvae are golden yellow and have 13 segments—a head, three thoracic segments, and nine abdominal segments Mealworm larvae are the counterpart of the familiar caterpillar in the butterfly story. They pull themselves around on six stubby legs, one pair on each thoracic segment.

Mealworms are the larval stage of darkling (aka Tenebrio) beetles. Beetles, along with all their other insect kin (true bugs, flies, bees, wasps, ants, on and on), are members of the phylum Arthropoda, a word meaning jointed legs. Like all members of their phylum, insects wear their skeleton on the outside like a suit of armor. This is practical when they are under attack, but very inconvenient when they are trying to grow. Arthropods solved this problem by molting (shedding) this outer shell-like cuticle periodically. Immediately following the molt, the soft white larva expands before the new larger cuticle hardens. For mealworms this process repeats five times over a 2-month period, after which the larva is about 3 cm long. The final larval molt reveals the next stage, the pupa.

Life cycle. Darkling beetles follow a life history known as complete metamorphosis. Like butterflies and moths, they go through four distinct stages during their life cycle. A female beetle lays eggs, as many as 500 in her brief lifetime of a month or two. The eggs are about the size of the period at the end of this sentence. After a couple of weeks the equally tiny larvae emerge from the eggs.

The larvae are known as mealworms, but of course they are not true worms. The larvae are golden yellow and have 12 body segments. They are the counterpart of the familiar caterpillar in the butterfly story. Mealworms pull themselves around on six stubby legs that are all crowded at the front. The larvae seem to have two purposes in life: eat and grow.

The pupae don't eat and they don't move except for a twitch or two when disturbed. Inside, however, the mealworm is turning into a beetle, much the same as a caterpillar turns into a butterfly while sequestered inside the chrysalis. In 2 or 3 weeks the pupa splits open and out walks a beetle, white at first, but soon turning to brown and finally black after a day. The beetles mate and lay eggs, and the cycle repeats.

Habitat and food. Mealworms and darkling beetles are rarely seen in the wild, but when they are, it is likely to be in a field where wild grasses flourish and seeds are plentiful. They are most often found in barns, grain storage facilities, and food preparation areas. This organism has benefited by living close to human enterprises, because we unwittingly provide a much better environment for the success of mealworms than could be found in the

natural world. For this reason mealworms have become a minor pest in grain storage areas.

Mealworms and darkling beetles are excellent classroom animals—they exhibit interesting behaviors, they are small but not tiny, they don't bite, smell, fly, or jump, and they are extremely easy to care for. Mealworms live right in a container of their food source: bran, cornmeal, rolled oats, breakfast flakes, or chick starter mash. All are excellent foods, but bran and chick starter are recommended. The food must be kept dry. Mealworms can go through their complete life cycle without any added water (they are very efficient at extracting water from the food), but it is recommended that small bits of apple, potato, or carrot be added from time to time.

Mealworms should be kept in large, relatively flat containers. They seem to thrive best when the colony has a large surface area. Keep the bran about 2 or 3 cm (±1") deep in a basin, bus tray, aquarium, or plastic shoe box. If the container sides are steep and smooth, it is not necessary to keep the container covered. Adults and larvae seem to prefer hiding under bits of paper or light cardboard; the pupae give no indication that they care.

The mealworm's preferred environment is very dry, moderately warm, and dark. A bit of apple provides extra moisture for the mealworms and seems to stimulate rapid growth. As the temperature increases, so does the rate at which mealworms advance through their life cycle. Under ideal conditions, in a classroom, the complete life cycle can take place in as little as 3 months, but more likely it will take 4 months. Cold slows the process almost to the point of suspended animation. Mealworms can be put into the refrigerator (not the freezer) for periods of time to stop metamorphosis.

In addition to providing reliable opportunities for observing a complete life cycle in the classroom as in the **Insects Module,** mealworms can also be used for other activities. In the **Environments Module** their response to various environmental factors is investigated. Mealworms can be used for structure/function observations and behavior investigations. And they are just nice to have around to remind us that life on earth takes a seemingly endless variety of forms, and that part of being human is to have compassion and respect for all life.

Food and Water. The mealworm culture must be kept dry. Mealworms can go through their complete life cycle without any added water (they are very efficient at extracting water from their food), but it is recommended that moisture continually be provided in the form of small bits of apple, sweet potato, or carrot. Otherwise the larvae and adults may attack each other in search of additional moisture. If carrot or sweet potato is used as the moisture source, the frass will be orange, adding evidence that the granules are waste rather than eggs.

Mealworm Homes. Large cultures of mealworms (200 or more) should be kept in large, relatively flat containers. They seem to thrive best when the

colony has a large surface area. Keep the bran 5–10 cm (2–4") deep in the clear plastic basin provided in the kit. If you want to expand your mealworm activities, any basin, bus tray, or old aquarium will do. If the container sides are steep and smooth, it is not necessary to cover the container.

The mealworms' preferred environment is very dry, moderately warm, and dark. As the temperature increases, so does the rate at which mealworms advance through their life cycle. Under ideal conditions the complete life cycle can take place in as little as 3 months, but more likely it will take 4. However, students should be able to see their mealworms advance through the three important stages of larva, pupa, and adult in 4 to 6 weeks if the larvae are large and well advanced at the time they are introduced.

Mealworms and darkling beetles are rarely seen in the wild, but when they are, it is likely to be in a field where wild grasses flourish and seeds are plentiful. They are most often found in barns, grain storage facilities, and food preparation areas. This organism has benefited by living close to humans, because we unwittingly provide a much better environment for them than can be found in the natural world.

What to do when they arrive. Mealworm beetles are shipped in a container with a "breathing" cap to provide air. They need no special care but should be used as soon as possible, as they have a rather short life span. Keep beetles at normal room temperatures in low light. Store in a cool place at 45 to 65º F out of direct sunlight. At warmer room temperatures, larvae will soon pupate. Cover loosely with a paper towel to provide crawling space. Add slices of potato or carrot for moisture and add a substrate of bran for food. Replace as necessary or if it becomes moldy.

Mealworm Life Cycle				
Stage	**How long?**	**Food**	**Moisture**	**Other information**
Egg	7–14 days			
Larva	30–90 days	Bran	Apple	5 molts occur
Pupa	10–20 days			
Adult	5–10 days	Bran	Apple	Death: 30 days
Egg	The cycle continues.			

ELODEA (ANACHARIS)

Plants occupy the base of the food pyramid in aquatic systems just as they do in terrestrial systems. Inconspicuous single-celled algae that turn your aquarium green capture the sun's energy and provide food for countless minute animals in the water. If you want to stimulate an algae bloom (population explosion), put a goldfish in an aquarium, place it where it will get direct sun several hours a day, and provide the fish with plenty of food. When you see the water turn green, it's a sign that your aquatic plants are growing beautifully.

FOSS activities also use vascular aquatic plants. The popular goldfish-bowl plant that looks like a green feather boa is *Elodea* (or sometimes *Anacharis*). In nature it is usually rooted to the bottom of a stream or pond, but in your aquarium it can just float around. It is a good food source for amphipods, fish, and crayfish and will contribute to the oxygen in the water as it photosynthesizes. It also provides crannies where small animals can hide from predators.

Care of aquatic plants is easy. Keep plenty of water in their container.

What to do when the plants arrive. Open bag and rinse plants in de-chlorinated or spring water. Keep Elodea floating in bowl of de-chlorinated or spring water to avoid drying out until it's ready to use.

GOLDFISH AND GUPPIES

Plants and animals that live in water make up the majority of biomass. They have so much more space in which to live. Life undoubtedly originated in the water, and many life-forms have never left it. Living in a dense fluid like water provides a lot of support for organisms, and the free-swimming forms have three-dimensional mobility. And, of course, they never have to worry about where their next drink is coming from.

For many of us a goldfish bowl was our introduction to aquatic animals. The beautiful orange fish are hardy and forgiving in terms of their living requirements. They are good classroom animals, requiring a minimum amount of care to keep them in good shape.

Goldfish weren't always gold; their wild kin are dark gray and olive-green. Goldfish are related to carp, so they have a rather unglamorous lifestyle, spending their time foraging in murky water for a variety of foods, including plants, insects, snails, and the eggs of other fish. The lovely colors and sometimes bizarre shapes of goldfish are the products of selective breeding conducted in China and Japan, where they are native.

A bucket, a bowl, a plastic bag, or a two-story-tall glass box can be an aquarium. A few of the millions of plant and animal species make excellent classroom aquarium organisms. But before we look at the organisms, it is important to think about the factors that make up their environment.

Water. Chlorine in regular tap water can be lethal to both goldfish and guppies. There are two ways to de-chlorinate water. The first is to age the tap water by letting it sit in an open container for at least 24 hours. Chlorine dissolved in the water escapes into the air. Or add de-chlorinating chemicals (included in the kit) to tap water. In some water systems, chloramine, a newer additive, is used in place of chlorine, and it will not leave the water when exposed to air. You must use water conditioners that specifically say they remove chloramine. It might be beneficial to ask at your local pet store or aquarium store just what is recommended in your area to make the water safe for fish. Set aside a pitcher of water to age, so that you will have it ready to maintain the water level of the aquarium. Keep your aquarium covered to reduce evaporation and to keep dust out and fish in.

The water in an aquarium will be fine for extended periods of time. Aged or treated tap water should be added to maintain the proper level, and about once a month half of the water should be removed and fresh water added in order to reduce the concentration of nitrogen-containing chemicals, the excretory products of the animals.

If a fish dies, or if too much food is put into your aquarium, change the water immediately. If you don't, bacteria will proliferate, taking advantage of the bounty of food. The result will be a putrid smell and danger for your fish and other aquarium animals. The bacteria will quickly deplete the oxygen supply in the aquarium, and the animals will suffocate.

Temperature. Unless you get fish that are specifically identified as tropical fish, it will not be necessary to obtain an aquarium heater. For the classroom it is best to stick to temperate-water organisms—they are so much easier to maintain. In fact, it is more important to keep your aquarium from getting too warm. Warm water holds less oxygen in solution, so aquatic organisms are more comfortable in cooler water. Keep your aquarium away from direct sun except for specific purposes.

Aquarium care. Goldfish don't place many demands on the aquarist. They need unpolluted water, but it is not necessary to provide extra oxygen with an air pump. You may experience some mortality when you first introduce new fish into your aquarium, but this is often due to transportation stress. As long as the fish are not crowded, they will be able to get enough oxygen just from what is dissolved at the surface of the water. To avoid crowding, do not exceed one feeder-size (3 cm) goldfish per liter of water for any extended length of time. You should be able to put six to eight guppies in a basin aquarium.

Food. Goldfish will eat a wide variety of foods, but the most convenient is a commercial flake food. This kind of food floats, and the fish will quickly learn to come to the surface to eat. The most important thing about feeding is not to overfeed! Feed your fish once a day as much food as they will consume in 3–5 minutes. Too much food left in the aquarium will foul the water. Fish-feeding cakes—compressed food that disintegrates slowly—are available at pet and aquarium stores if you need to leave the fish unattended for more than 3 days.

Feed the fish when students can observe the feeding behavior. Goldfish like to eat insect larvae, worms, aquatic plants, and snail eggs (all of which they eat in the wild) as well as commercial food. Guppies also eat commercial fish food, as well as finely chopped fish, tubifex worms, earthworms, and *Daphnia*.

Reproduction. Goldfish are very prolific in nature and in special breeding ponds, but don't expect any offspring in the classroom. They need lots of plants and other cover to propagate successfully. If they did lay eggs in the aquarium, they would doubtless eat all of their own eggs during their incessant foraging for food morsels. Goldfish can grow to be 40 cm (16") long and may live more than 10 years. Be prepared for an extended stay when goldfish move into your room.

Guppies are small fish that bear live young. The feeder-guppy females are larger and usually a uniform beige or silver gray. Their abdomens become

quite large when they are gravid (carrying young). The males are smaller and have longer, flowing tails. Males are the ones with spots of multiple colors. Fancy guppies that have been bred for showy colors can be dazzling.

Guppies are quite prolific and will probably give birth during their stay in your classroom. In fact, you may observe the arrival of baby guppies a day or two after the adults are put in their basin aquarium. The stress of transportation may induce a gravid female to release the babies. Adult guppies will eat the young, so you should supply the aquarium with plenty of *Elodea* in which the babies can hide, or move the adults to a separate tank. Students will enjoy watching the baby guppies grow.

What to do when the fish arrive. Float the unopened bag in aquarium of de-chlorinated or spring water for about 15 minutes to equalize the temperature. When temperatures are equal, pour contents of bag through a dip net into another container and transfer fish from net to the aquarium. Discard shipping water. DO NOT USE CHLORINATED TAP WATER!!!

Maintain aquarium at room temperature out of direct sunlight, adding and/or changing water with treated water as necessary to reduce the concentration of nitrogen-containing chemicals naturally occurring in the water.

ISOPODS

Iso is Greek for "similar or equal." *Pod* means "foot." Put them together and you have the isopod, an organism that has an equal number of feet or legs on both sides with all legs similar to one another. Isopods have 14 legs that all function the same. This distinguishes them from closely related organisms that have legs that are modified to perform different functions, such as walking, feeding, feeling, grasping, and so on.

The many different species of isopods around the world share certain characteristics. Isopods are crustaceans, distant kin of shrimps, crabs, and crayfish. Like all crustaceans, isopods have a segmented outer shell (seven overlapping plates) that provides a measure of protection from the environment and predators. Like their aquatic relatives, isopods get the oxygen they need to survive through gill-like structures located at the bases of their legs, rather than through lungs like most terrestrial organisms. That is why isopods must keep moist at all times—if they dry, they die.

Two kinds of isopods are of interest as classroom organisms. The genus *Armadillidium* (arm•uh•duh•LID•e•um) is known casually as the pill bug or roly-poly. It gets these names from its habit of rolling into a tight sphere when threatened or stressed. The pill bug has a highly domed shape, short legs, and inconspicuous antennae. When in its defensive rolled posture, it is hard for a predator to grip, and it is also more resistant to drying out.

Pill bugs move slowly and have a difficult time righting themselves if they roll onto their backs on a smooth surface. They range from light brown to dark gray or black. Often they have white, cream, or yellowish spots on their backs. The largest individuals of this kind of isopod can be 1 cm long, but most are 7 or 8 mm.

The second isopod used extensively in classrooms, genus *Porcellio* (por•sel•E•oh), is commonly called the sow bug or wood louse. These names are potentially confusing because *Porcellio* don't show a particular affinity for swine, nor are they lice. They are relatively flat with legs that extend a little bit beyond the edge of the shell, and they have powerful antennae to sense their environment. They move rather quickly and will use their long antennae and little spike like tail projections to right themselves if they happen to roll onto their backs. Sow bugs come in a surprising array of colors, including tan, orange, purple, and blue, as well as the usual battleship gray. Their size is similar to that of the pill bug.

In the wild, isopods are not usually seen out and about. They are members of that large category of animals known descriptively (not taxonomically) as

cryptozoa, or hidden animals. They are most often found in layers of duff and leaf litter, under rocks or logs, or burrowed a short distance under the surface of the soil. The environment they seek is moist and dark, in or near dead and decomposing wood and other plant material. The former is their main source of food, accounting, perhaps, for their common name of wood lice. Isopods are not, however, above eating fresh strawberries and carrots, making them a minor pest in the garden.

Life cycle. There are both male and female isopods, but only another isopod can reliably tell them apart. After mating, the female lays several dozen eggs, which she carries in a compact white package on her underside between her legs. This package is a specialized brood pouch, the marsupium, in which the eggs develop for 3 or 4 weeks before hatching. A few days after hatching, a swarm of fully formed, minute isopods strike out into the world. They are nearly invisible at first but soon grow to a size that can be seen by the unaided eye. Like all crustaceans that carry a hard outer shell, isopods must shed their shells in order to grow. In the molting process the shell is cast off, and the new soft shell underneath expands before hardening. Interestingly, the whole shell is not shed at once; first the rear (posterior) shell segments are shed, and 2 or 3 days later the front (anterior) ones fall off.

What to do when they arrive. The shipping container contains damp paper to provide moisture. Upon arrival, mist paper slightly. Food should be removed if it shows any sign of mold and replaced with sliced carrot, potato, or apple. Pill bugs and sow bugs can be kept in the shipping container for a few days until ready to use in class. Moisten the paper towels as necessary.

If you are keeping them for a longer period of time, place them in a terrarium with rich, moist soil. Place moist paper towels in the container to provide humidity. Continue to add vegetables, replacing them as necessary to control mold. Keep container at room temperature in low light.

Classroom habitat. Isopods are excellent classroom animals—they exhibit interesting behaviors, they are small but not tiny, they don’t bite, smell, fly, or jump, and they are easy to care for. Isopods can live in just about any vessel, from a recycled margarine tub to a 50-liter aquarium. If the container is smooth-sided, it doesn’t even have to be covered, because isopods can’t climb smooth surfaces at all. A layer of soil covered with some dead leaves, twigs, and bark is great, but isopods will be comfortable with some paper towels or newspaper laid on the soil. They do like to have some structure to crawl under.

Food and water. The most important thing to remember is that the soil must be kept moist at all times—not wet, but moist—so that the isopods don’t dry out. A chunk of raw potato in the container with the isopods serves as a source of both food and moisture. Otherwise they will eat the decomposing leaves and twigs or the paper towels and newspaper.

LAND SNAILS 

The land snail is one of nature's marvels. But many of its finer attributes go unrecognized because of its reputation as a garden raider. Because it takes a toll on our spinach, cabbage, and lettuce as it goes about its business of survival, we find ourselves in a conflict relationship. In the classroom, however, traditional animosities are put aside in the interest of learning more about the diversity of life.

Land snails are gastropods, whose members also include aquatic snails (including marine snails) and slugs. The name means stomach-foot. This makes a degree of sense as the whole clan gets about by gliding on a muscular structure on the bottom of the abdomen, called the foot. The action that produces motion is a well-coordinated, wavelike contraction of muscles on the bottom of the foot that propels the gastropod smoothly forward over just about any surface. The action is not fast by human mobility standards, but you and your students will be amazed by how far snails can travel when your back is turned for what you think is just a moment. A determined snail can easily cover a meter in 5 minutes, so in the course of an evening a snail can travel the length of a football field and back. If the lid came off your terrarium in the evening, you can figure out how far and wide those snails might range in your classroom.

Land snails have several characteristics that make them easily identifiable. They have a single shell, usually coiled, that is a combination shield and humidor. The hard shell resists the efforts of predators and provides a haven during dry times. Snails are a moist gang, and if a snail cannot find a watering hole to renew its water supply, it will retreat to a protected nook, withdraw into its shell, and seal its shell to a solid surface. The snail will lapse into dormancy until rain, dew, or a garden sprinkler once again moistens the environment. This passive state, rather like hibernation but initiated by dry rather than cold, is called estivation.

One indication that snails have been active is the telltale slime trail. Garden snails produce a layer of mucus on which they slide. This makes it easy to track their movement, but also saddles them with a reputation for being yucky. Students may find this fact a bit repulsive at first, but will quickly forget it when they become absorbed in observations of these fascinating creatures.

Most land snails have interesting projections on the fronts of their heads. Students will identify them as feelers or antennae. They will see two long ones on top of the head reaching up, and two smaller ones reaching down. Technically they are tentacles, but "feeler" is a pretty good description of their function because they are touch sensitive. The two longer ones have light-sensitive organs at their tips, making them the snail's version of eyes,

although their function is limited to light perception rather than image generation. The shorter tentacles feel, taste, and smell the environment in the never-ending search for food and water, and in constant vigilance against dangers.

The snail's mouth is on the bottom of the head right up by the short tentacles. Inside the mouth is a specialized eating tool, the radula. The radula is a muscular structure covered by thousands of tiny, sharp teeth. The snail eats by pressing the radula against a leaf or other desirable bit of vegetation and rasping it to scrape away small particles. This action can be seen if students feed a hungry snail some lettuce or apple.

Most other interesting snail structures are hidden inside the shell, but some can be observed with patience and perhaps a flashlight. Snails breathe by taking air into a visceral cavity that is richly supplied with blood vessels—the snail's version of a lung. When the snail extends from the shell, the access pore can be seen opening and closing just below the margin of the shell on one side. Also, the snail's heart can be seen pumping blood by placing a snail on the lens of a flashlight and carefully looking through the translucent shell.

The shell itself is an excellent piece of work. The colors and patterns are lovely, and the coil is a masterpiece of efficient construction. Snails grow by laying down new material around the edge of the roughly circular opening. By extending the length and diameter of the living quarters, the snail can grow and still retreat into its shell as needed. The shell is rich in calcium, so snails need a continual supply in their diet. In the classroom calcium is available from plain chalk or a piece of cuttlebone in the snail terrarium.

Most land snails are hermaphroditic, holding under one shell both male and female reproductive potential. However, snails must mate in order to fertilize each other's eggs. Eggs, the size of BBs, deposited in soil, will hatch in a few weeks into perfectly formed little snails, fully mobile, ready to ravage your garden.

Order the land snails. The largest and friendliest land snail for the classroom is the escargot snail that is naturalized in the West, *Helix aspersa*. If you live in a region where *Helix* has become established in local gardens, collect them locally. If you cannot collect them locally, there are several options listed below for getting land snails. If you encounter any problems, skip Investigation 4 in **Structures of Life** and go on to Investigation 5, **Bess Beetles**, which has been added to the module as an alternative to the land-snail investigation.

- Check with a biological supply company *within your state* to see if they carry *Helix* or another large, active land snail similar to *Helix*. Order the land snails from the supplier within your state.
- If you cannot get *Helix* from within your own state, you may be able to order them from a national supplier. At the time of this printing, the

only states that the U.S. Department of Agriculture (USDA) will authorize to receive *Helix* from another state are Arizona, California, New Mexico, Texas, Utah, and Washington. If you live in one of these states and cannot find a supplier for *Helix* within your state, you can get a USDA permit to purchase them from a national supplier outside your state. See the information later in this document called **GETTING A USDA PERMIT FOR LAND SNAILS**.

- At this time (April 2003), the FOSS project is working with the USDA to develop information for teachers about native or naturalized land snails appropriate for use in different regions of the country. This information will be posted on our website, as soon as it becomes available (anticipated date is September 2003).

What to do when they arrive. Land snails are quite hardy and can survive for many days with little food or water. In your classroom, they will live in two clear terrariums with covers (the same type of basins as used for the hydroponic plants). Once the snails arrive, place moist paper towels on the floor of each terrarium and spray the interior walls with water. Distribute the snails into the terrariums and provide a few small pieces of carrot or other vegetable for them to eat. Snails are strong! Secure the cover with two large rubber bands stretched around the terrariums.

Maintenance. In a natural habitat, land snails eat leaves, mushrooms, fruit, and many other kinds of plant material they find. In the classroom, they must be fed and their habitat must be cleaned. Here's the weekly care and feeding routine.

- Clean the habitat once or twice a week. Gently remove the snails by sliding them off the walls of the terrarium. If they look messy, rinse them quickly under cool water. Spray the walls of the habitat and wipe them clean with paper towels. If you are using paper on the floor of the habitat, replace it with new paper towels.
- Feed the snails twice a week. Replace any old food with new food. Snails eat fruits and vegetables. Place pieces of chalk or cuttlebone in each habitat to provide calcium, which snails need for shell growth and repair.
- Spray the walls of the habitat with water two or three times a week.
- Always keep the cover on the habitat, with two rubber bands (at least) holding it on.
- If you don’t keep the habitat moist or feed the snails, they will estivate for days or weeks at a time. This is not harmful to the snails and makes for a very low maintenance organism.

The question of what to do with the snails when the investigations are complete is a sensitive one and in part is determined by where and how you obtained the land snails. Potentially, the best solution is to keep them in the classroom and institutionalize their care, continually creating an ever more complex and interesting environment for them to live in. Continue informal investigations, particularly watching for life cycle. If you obtained the land

snails from a supplier out of state with a USDA permit process, you must comply with the federal regulations on what to do with the snails. For snails that are not collected locally, release into the environment is never an option. If no other option is possible, the most humane thing to do is euthanize the snails by collecting them in a bag and placing them in the freezer. Then dispose of them in the trash.

WAXWORM MOTHS

The waxworm is the larva of the greater wax moth, a small nondescript flying insect that lays its eggs in beehives, where the growing larvae feed on honey and wax. A robust hive of honey bees can repel the onslaught of waxworms, keeping the damage to a minimum, but waxworms can overrun and destroy a stressed colony.

Waxworms are white to tan, plump, clearly segmented, and moderately active. They are a little softer than mealworms, so they must be treated somewhat more gently, but they are still very easy for first and second graders to handle. The waxworm has 13 segments (head, three thoracic, nine abdominal) and the mandatory six legs. But unlike the mealworm (a beetle), the waxworm has four pairs of leg-like structures called pro-legs—one pair on abdominal segments three through six. These pro-legs are equipped with muscular pads called claspers, which help the larvae hold onto surfaces, and the 13th segment (tail) also has claspers. The waxworm has bristles (stiff hairs) on its body and a row of clearly visible openings called spiracles along each side. The larvae have no lungs—oxygen enters through these spiracles and is distributed through the fluids of the body.

Waxworms, like all moths, make silk. Silk is used as a lifeline, as webbing over which the larvae can walk, and as a material to build a protective cocoon. The silk is produced in a gland under the head and extruded through structures called spinnerets.

Like mealworms, waxworms apply themselves to a career of eating and growing. The medium in which they live in the classroom is also their food—honey or sugar and glycerin mixed with baby food and a trace of vitamins. Any large jar containing 7–10 cm (3–4") of food will culture 100 or more larvae. They prefer to be kept in the dark, but this is not essential. Small numbers of waxworm larvae can be kept on desks in covered cups with a little food for students' close and continual observation.

You can expect some of the waxworms to die, both in the student cups and in the class culture. A dead larva is recognized by its conspicuous inactivity and a change of color from creamy white to tan to gray to black. Dead larvae should be thrown away. A pair of forceps is included in the kit for such operations. If a deceased larva is removed from a student cup, replace it with a healthy one from the class culture.

The waxworm will advance through the major stages of its life cycle in as little as 6 weeks if the temperature is 28–34°C (82–93°F), more slowly at room temperature. After gorging itself as a chubby white larva, the waxworm is prepared to pupate. In the dark it climbs to the top of its container and spins a cocoon on the wall; in the light the larva spins a cocoon in the medium. Inside the cocoon the larvae rest and transform into pupae. After a week or two the adult moths emerge. The adults neither eat nor drink. After mating, the females lay eggs in the culture and die. If you

want to collect the tiny eggs, fold a piece of waxed paper in tight little accordion folds, like a fan, and put it in the container with the adult moths. If the eggs collected in this way are transferred to a container with fresh culture medium, they will hatch after about 10 days, and the cycle will repeat.

Getting waxworms. Waxworms can be obtained from bait stores, pet stores that cater to bird and reptile fanciers, or biological supply houses. The ones from biological supply houses are more suitable, and they arrive in a supply of food medium. Get 75–100 of the largest ones available. See the Materials folio for more information about obtaining insects.

What to do when they arrive. Larvae are shipped in a container with food. If storage is necessary, they may be held in their shipping containers at 35 to 40ºF for a short time. At warmer room temperatures, larvae will pupate in as little as six weeks.

If the waxworms arrive in a nutritional medium, move them to the large plastic jar, medium and all. Screw on the ventilated lid.

If the waxworms are in a neutral medium like sawdust, remove them from the sawdust and put them in the large jar with one cup of homemade medium. Make a tube of dark paper to slip over the jar, or place it in a paper bag or box to keep it in the dark.

Providing warmth. Waxworms do best in temperatures above 28°C (82°F). If this is not the temperature in your classroom, provide a lamp or two for additional warmth. Create a hot spot in your room where the class culture and students' cups of waxworms can be stored in the dark. At normal classroom temperatures the waxworms may stay in the larval and pupal stages for an extended period of time. Pupae may make hard shells instead of cocoons. That's OK; the waxworms are still valuable for comparison with mealworms. Don't give up—even without the lamp trick the wax moths will eventually emerge.

Preparing waxworm medium. This recipe makes enough waxworm medium for students to put into their cups and for the classroom culture.

4 oz. glycerin
1/4 cup sugar
1/4 cup hot water
1 box (8 oz.) baby cereal (oat)

Dissolve the glycerin and sugar in hot water. Cool the solution. Pour the whole box of cereal into a large bowl. Pour the solution in a very thin stream into the cereal while stirring enthusiastically—it should take about 2 minutes to dribble all of the liquid if you are pouring slowly enough. The medium will be somewhere between sticky, lumpy, and crumbly, and it will smell very pleasant. Store it in a plastic bag.

Waxmoth mating. When a significant number of adults have emerged, put them all in an empty 2-liter jar where they can mate and lay eggs. The moths are inactive early in the day, so plan to transfer them in the morning. Cover the jar with a ventilated lid. Have it sitting loosely on the jar during the transfer. Screw it on securely after transfer is complete.

If you want students to continue watching the life cycle of waxworms, prepare a batch of medium to nurture the next generation. Follow the recipe above, or use any stored medium that you haven't used. Clean out the original class waxworm jar and make it ready for the next generation.

Plan for the end of the cycle. The humane way to end the cycle of waxworms is to put the culture in a freezer overnight and then dispose of the medium. Rinse the jar thoroughly.

BESS BEETLES

One out of every four animals in this world is a beetle. Poke around in a field, under the surface of the ground, in trees, gardens, rotten stumps, or wood piles, and you are likely to run into a beetle of some sort. We may know them as hungry munchers of grain supplies or house foundations, but they serve vital roles in the food web as scavengers and decomposers. In the classroom, they take on the starring role in students' investigations into structure and function.

Bess beetles, formally known as *Odontotaenius disjunctus*, are classified in the insect order called Coleoptera. Coleoptera is the largest order of organisms, including over 350,000 species. With so many opportunities, you are sure to know several. Ladybird beetles, fireflies, scarabs, and darkling beetles (the mealworm adult stage) are all Coleoptera. They all have hard, shell-like forewings, or elytra, from which their name is derived. In Greek, *koleos* means "sheath," and *ptera* means "wing." This unique structure functions as a tough protector of the beetle's delicate hind wings and soft abdomen. When the beetle decides to fly, the hind wings unfold and do their job. At rest they tuck themselves back under the hard elytra. These tough elytra also protect beetles as they squeeze through narrow passageways and burrow into decaying wood or sandy soil.

Adult beetles are up to 4 cm long (about 1.5 inches), shining black with a series of grooves running the length of the elytra. Students will observe the usual six legs and three body parts common to all insects. Some students may identify four body parts on their beetles. They have just discovered another characteristic of Coleoptera, which have two thoracic segments. Like a knight in articulated armor, the thorax of this beetle has two sections, allowing its hard body to move more freely.

If you look for information on bess beetles, you'll find that they have several aliases. Betsy beetle, bess-bug, patent leather beetle, and passalid beetle are all names for a beetle commonly found in decaying logs from Texas to Florida and as far north as Canada. They are considered beneficial organisms, important in recycling dead wood. There are only two species of passalids in the U.S., while over 500 species of passalids can be found in the tropics.

A bess beetle has tiny, gold-colored fringe on its legs and on the edges of its body. The exact function of the fringe is unclear, although it may help keep the beetle clean. Protruding from the beetle's head is a small horn. Most noticeable to students are the beetle's strong mandibles and feathery antennae. The mandibles allow the beetle to chew through the hardwood that serves as both food and shelter. It will rarely bite the hand that holds it. In the unlikely event it does, it is more of a surprising nip than a bite. Antennae "drive" the beetle. Students will observe the beetle using antennae to explore the air. It is assumed that they use their antennae to sense odors

in the environment—decaying wood or other beetles of the same species—but this has not been well-studied.

Bess beetles are somewhat social insects, with colonies living together in decaying stumps and logs. They prefer hardwood—oak, elm, and other deciduous trees—that is well decayed and falls apart easily. The beetles chew their way through the wood, making tunnels, or galleries, as they go. In the classroom, a layer of decayed wood in a high-walled basin and a daily spray of water is all they need.

Life cycle. All beetles go through several stages of development called metamorphosis. Life starts as an egg. The wormlike larva emerges from the egg. The larva eats and grows. Next the larva enters a resting stage, the pupa. Finally, the pupa changes into the hard-shelled adult.

Unfortunately, maintaining a reproducing colony is not easy. One difficulty is distinguishing males from females, hard to do based on external observations, although females tend to be a bit larger. Another difficulty is keeping adult pairs in an undisturbed container so they can construct a family burrow system. Bess beetles are very sensitive to air movement, almost more so than light, so every time the decaying hardwood is replenished, the beetles will be disturbed. Bess beetles live in pairs within the colony and share housekeeping and larval care over long time periods. They delicately carry eggs through the tunnels in their mandibles. Larvae eat a well-chewed mixture of beetle feces and wood. When the larvae pupate, which may take up to a year, they are moved to a separate chamber for their protection. All this keeps the beetles very busy for the 14–16 months of their adult life.

When adult bess beetles are disturbed, they produce a squeak by rubbing their forewings (elytra) against their abdomen. Students will be able to hear this stridulating. Stridulating is apparently used for communication between members of the colony, and it is especially useful because most of the beetle's life is spent in darkness. Studies suggest that the sounds for defense are different than the sounds for courtship. The larvae also make sounds, using a different mechanism.

Eating. Bess beetles chew wood, which is indirectly a food source. Unlike termites, bess beetles don't have symbiotic bacteria in their gut that help them digest the cellulose in decaying wood. Bess beetles process wood in their digestive system, and then a fungus grows on the beetles' feces. It is this fungus that give beetles nourishment.

Mites. Eating fungus that grows on decaying wood, providing care for larvae, communicating through sounds—these are all fascinating features of bess beetles. But they have another interesting feature—they have coevolved with at least one kind of mite. Mites are commonly found hitchhiking on the body of the bess beetle. Some of these mites are found only on bess beetles, suggesting a relationship that has evolved along with

the organisms. It's not clear that the beetles benefit from the mite, but because of their exoskeleton, they aren't harmed in any way. It may be that the mites live on secretions given off by the beetle, or they may just find protection from the beetle while they share the decaying wood. The mites are not known to damage the beetles, don't bite or harm students, and do not leave the classroom habitat basins. Should mites get on a student's hand, they are easily brushed off.

What to do when they arrive. Keep the bess beetles in a well-ventilated plastic container, provide them with decaying hardwood from oak, elm, or other deciduous trees (no conifers), and mist the wood and container several times a week to maintain the moisture. It may also help to keep some sphagnum moss on top of the wood to maintain the moisture. Hardy, easy to maintain, harmless, and fascinating, bess beetles have the characteristics for a successful classroom critter.

BRINE SHRIMP

Brine is a salt solution—usually a saturated salt solution. And we have all seen a shrimp or two, even if only in cocktail sauce. Brine shrimp might therefore sound like some kind of pickled seafood delicacy, but that's not the case. Brine shrimp, also called fairy shrimp and sea monkeys in some contexts, are tiny but important organisms found in salt ponds and saline lakes.

Artemia salina is the scientific name for brine shrimp. Like their distant cousins the lobster and crab, brine shrimp are aquatic crustaceans. Unlike their marine relatives, brine shrimp live only in bodies of salt water that are isolated from the ocean. They are found reliably in the Great Salt Lake in Utah and Mono Lake in California, but they can appear in unlikely temporary salt ponds after a torrential rain in the desert.

Brine shrimp are small unsubstantial-looking creatures of 1 cm (1/2") or so in length. They glide smoothly through the water, propelled by what appear to be two wings along their sides. Viewed under a microscope, the "wings" are revealed to be 11 pairs of appendages that undulate and act as paddles. As brine shrimp glide along, they feed on microscopic organisms suspended in the water: algae, yeast, and bacteria.

There are both male and female brine shrimp. Following mating, the female will develop either live young or eggs in her egg sac. A female's first batch of young are born alive. After that, eggs form and are released into the water. Eggs may hatch soon thereafter, or they may lapse into a dormant state. The eggs are amazing in their ability to completely dry out and maintain their viability. Brine shrimp eggs can lie in the desert for 10 years or more, waiting for the right environment, and then spring into life to start their life cycle again.

Just after hatching, the larval brine shrimp, called a nauplius, is no bigger than the period at the end of this sentence. This is the stage that students will look for as evidence of hatching. They will suddenly see that the tiny dark points in the water are making jerky little movements. The nauplius grows fairly rapidly when conditions are favorable (food, oxygen, and the right concentration of salt), molting its outer shell frequently. It takes 3 to 6 weeks for the shrimp to reach maturity.

A key factor in the environment of brine shrimp is salt. They are adapted for life in a wide range of salt concentrations (as low as 25 parts of salt per 1000 parts of water to as high as 300 parts per 1000), but their optimum salt environment is around 80 parts per 1000. This is more than twice as salty as the ocean, which is about 35 parts of salt per 1000. Brine shrimp are one of the most salt-tolerant animals in the world. Conditions as salty as this result when a body of water has streams running into it, but not out.

Salts carried in by natural erosion over countless years raise the salt concentration to the levels preferred by brine shrimp.

What to do when they arrive. We strongly recommend that you test the suitability of your local tap water and the viability of your brine shrimp eggs a week or so before you plan to do the investigation. Put 150 ml of aged tap water in two cups. Add two 5-ml spoons of salt to one cup and label it "2 spoons," and four 5-ml spoons of salt to the other cup and label it "4 spoons." Transfer 1 level mini-spoon of brine shrimp eggs to each cup. Put the lids on and gently swirl the cups to wet the eggs.

If al goes well, in 24 to 48 hours, at room temperature, you should see the tiny brine shrimp swimming about. You must look closely: Any movement of the water will interfere with your ability to see hatched shrimp, so leave the cup on the table and look into it from the side and down from the top (take the lid off). Eggs float, but larvae swim about.

If no eggs have hatched after 72 hours, purchase bottled spring water and try again. If you still have no success, the viability of the eggs is suspect. Viability is certain for a year or two, so if your eggs are old, replace them. Eggs can be purchased from **Delta Education** (go to **Environments**) or from tropical fish stores.

Hatching brine shrimp. Brine shrimp are easy to hatch, and with luck you can raise them to maturity and keep a stable population going in your classroom for months. They start life fueled by the energy stored in the eggs, but soon they must feed or perish. After the first week of life, they must move to a large container (plastic or glass—no metal) with a new water supply prepared using this formula:

4 liters of water
250 ml of rock salt
30 ml of Epsom salts
15 ml of baking soda

Food: For food, a pinch of baker's or brewer's yeast once a week should be fine. Mark the water level on the container. As water evaporates, add more tap water—not salt water—to keep the salt concentration the same. Put the container near a window or under a light during the day and watch the brine shrimp grow. Adult brine shrimp can be purchased from a tropical fish store. They are sold as fish food.

In addition to environmental investigations involving salinity, brine shrimp are useful for light investigations; they are light seekers. Brine shrimp can be studied as part of a food chain and can be used to demonstrate life cycle.

EARTHWORMS AND REDWORMS 

Worms are a varied lot. You may have heard of roundworms, flatworms, tapeworms, earthworms, and who knows what other kinds of worms. None of them conjures up a particularly warm or pleasant feeling in most people. Worms have low reputations in human circles, often associated with some not-so-pleasant circumstances. But this activity may turn all that around as you dig into the subject of earthworms.

Earthworms are members of the phylum Annelida, or ringed animals. They are fairly simple life-forms, put together from a number of disk-like segments stuck together like a long flexible roll of coins. Earthworms have no internal skeleton like a fish, no hard protective exoskeleton like an insect, and no shell into which they can withdraw. Worms are flexible, elongated bundles of muscle, uniquely suited for life underground.

The characteristic wriggling of earthworms is accomplished by the contraction of two kinds of muscles. When the short muscles that circle each segment (like lots of rings on a finger) contract, the worm gets thinner and longer. When the long muscles that connect the entire segments contract, the head and tail are pulled toward each other, and the worm becomes short and fat. Depending on which end of the worm is anchored, the worm can move along the surface of the ground or through its burrow effectively in either direction, head first or tail first.

Earthworm organs are quite different from ours, making it possible for them to live their very different lifestyle efficiently. Earthworms have five pairs of simple hearts that pump blood throughout the body. They have no lungs. Instead the blood flowing close to the worm's surface absorbs oxygen and releases carbon dioxide directly through the moist skin (called the cuticle). For this reason earthworms can live for some time in water if the oxygen supply is adequate. They don't drown per se, but they may suffocate if the oxygen content is low. This is why worms leave the soil and crawl out on the sidewalk during a heavy rain—they are seeking oxygen. Earthworms are not adapted to feed in water, however, so they would starve to death in due course.

Instead of a nose, ears, and eyes, earthworms have a nervous system throughout their bodies that controls actions in response to environmental stimuli, such as vibrations, heat, cold, moisture, light, and the presence of other worms. They have no brain, however, so worms do not ponder their lowly lot in life, nor do they plan a strategy for obtaining their next meal or crossing the sidewalk safely.

Reproduction. Like all animals earthworms have effective strategies for begetting their own kind. With earthworms it is not a matter of boy meets girl, but rather a simpler matter of worm meets worm. All worms carry two sets of sexual organs, but they cannot fertilize their own eggs—mating is still

a necessary part of reproduction. Mature earthworms have an enlarged band some distance from the head. This enlarged clitellum plays an important role in reproduction.

In mating, two worms approach each other nose to nose. With their bodies touching, they slide past each other until their heads are a bit past the clitellum. Both worms pass sperm through an opening located between the head and the clitellum, into a temporary holding receptacle in the other worm. The two worms separate. The clitellum secretes a liquid that solidifies into a flexible tube. As the tube lengthens, the worm backs out of it. Soon the tube covers the front part of the worm. The worm lays a few eggs inside the tube, deposits some of the stored sperm, and withdraws from the tube, leaving the eggs and sperm inside the tube. The ends of the tube pinch off to form a cocoon, and the whole thing shrinks to a tidy package about the size of a fat grain of rice. The cocoon is left alone sitting on or just under the surface of the soil. The worm continues to produce cocoons until the sperm is used up. Cocoons are durable, can overwinter in cold climates, and can wait out hot dry spells in arid environments. After 3 weeks (ideal conditions) or longer the cocoon opens, and out sallies the next generation.

Food. Earthworms feed on decomposing organic material, mostly vegetation, from the surface of the soil and within the soil itself. In the process of burrowing and feeding they process tons of soil in a typical pasture or garden, improving the quality of soil for plants and other animals. There are some 1800 species of earthworms worldwide. Some are tiny, no more than 2 cm (1”) at maturity. At the other end of the scale are the Australian giants that average about 3 m (10’) in length, and the record holder, a South African gargantuan measuring 7 m (22’) in length. Not to worry—the largest earthworms in North America are the common night crawlers, which can reach a length of little more than 30 cm (12”).

What to do when they arrive. Worms may be kept in shipping container for short periods. Upon arrival, mist with water to moisten, but do not make soil wet. Worms can be kept in the refrigerator for short periods of time. To maintain worms for a longer period of time, keep at room temperature in diffused light, feeding crushed dead leaves or cornmeal sprinkled over the surface of the soil. Add rich soil (preferably humus) as needed, and remove any mold as it appears.

MILKWEED BUGS 

Milkweed bugs are true bugs; beetles, moths, flies, and butterflies are not. Bugs have the usual complement of structures that they share with just about all other insects: six legs, three body parts (head, thorax, and abdomen), and two antennae. True bugs (order Hemiptera) do not have mouths for biting and chewing food—they have a tube-like beak for sucking fluids. The milkweed bug in nature sucks nutrients from milkweed seeds, but those in the classroom have been bred to feed exclusively on sunflower seeds.

Another characteristic of bugs generally and milkweed bugs specifically is the stages they go through from hatching to maturity. Bugs go through simple metamorphosis. The insect emerges from an egg looking like a tiny version of the adult, with slight differences in body proportions and incompletely developed wings. The immature bugs are called nymphs. Newly hatched nymphs are analogous to the larvae of insects that go through complete metamorphosis, in that their prime directive is to eat and grow. As with all insects, in order to grow the nymphs must molt periodically. Just after molting the bug is creamy yellow with bright red legs and antennae. Within a few hours the body turns dark orange, and the legs and antennae resume their usual black color. The crispy little molts can be seen in the milkweed bug habitat about a week after the bugs hatch. Students may think their milkweed bugs are dying or that spiders and ants have invaded the habitat. It may take a while for students to figure out what the molts really are.

Life cycle. Milkweed bugs advance through five nymphal stages (instars) as they mature. Each molt produces a larger nymph that is more completely developed. As the bugs grow, the dark wings appear on the backs of the bugs as black spots. Other black markings start to appear and eventually develop into the characteristic patterns of black and orange by which the adults of the two sexes can be identified. The last molt reveals the adult. There is no pupal resting stage as in insects that undergo complete metamorphosis—the large nymph simply molts, and away walks the adult.

Milkweed bugs continue to feed as adults, inserting their long beaks into sunflower seeds to suck out oils and other nutrients. Mating is easily observed, as the two mating bugs remain attached end to end for an extended time. It is possible to distinguish female and male adults by body markings. Look on the ventral (belly) side of the bugs. The tip of the abdomen is black, followed by a solid orange segment (with tiny black dots at the edges). If the next two segments following the orange band have solid black bands, the bug is a male. However, if the segment following the orange band is orange in the middle, making it look like it has two large black spots on the sides, followed by a segment with a solid black band, the

bug is female. (See the Milkweed Bug Male and Female poster.) Males tend to be smaller than females. Look for mating bugs to identify males and females—there will always be one of each in such pairings.

Several days to 2 weeks after mating, the female lays a cluster of 50 or more yellow eggs (which turn orange fairly quickly) in a wad of cotton. The eggs can be removed to a new culture container or left in the habitat to continue the life cycle.

Milkweed bug habitat. Culturing milkweed bugs is fairly easy. The bugs require no soil or green plant material. Just about any container is suitable for a habitat. Because milkweed bugs can walk on any surface, including smooth plastic, glass, metal, wet surfaces, and all textured surfaces, the habitat must be closed tightly, and the ventilation holes must be tiny so the first instar nymphs can't escape.

We suggest a plastic zip bag for the habitat container. Use a pin to poke a hundred holes in the bag, and install a water container in the bottom. To add interest, put a branch in the bag and attach a bundle of raw, shelled sunflower seeds and a cotton ball to the branch. Hang the bag from a paper clip next to a wall out of direct sunlight.

Maintenance. Maintenance is minimal. Keep an eye on the water level, and when it gets low after 3–4 weeks, add water and perhaps replace the wick. A new bundle of 20 to 30 sunflower seeds each month should be adequate for a modest culture of 25 bugs. The culture may start to look a little messy after a month as little brown spots of waste appear on the walls of the bag and the molts start to accumulate. Transfer the branch, water fountain, and bugs to a new bag to renew the aesthetic appeal of the culture.

Ordering milkweed bug eggs. Milkweed bug eggs must be ordered from a biological supply company. Specify at the time of order when you want the eggs delivered. See the Materials folio for more information about obtaining insects. Conduct Part 1 as soon as the eggs arrive—they will hatch in a week or less after you receive them. Color is an indicator of maturity. If the eggs are pale to school-bus yellow, it will be a few days until they hatch. If the eggs are pumpkin-orange to red, they will hatch in the next couple of days.

What to do when they arrive.

- **Eggs** are shipped on a wad of floss. If you are unable to begin the investigation when the eggs arrive, they may be kept in the container at cool room temperatures or refrigerated for short periods; otherwise they will hatch within one week. If the eggs have hatched upon arrival, add a few sunflower seeds and hatched nymphs to the vials for distribution to the students.
- Keep **adult males and females** in separate containers. A 1/2-liter container with small air holes can be used for a few days. Add a few sunflower seeds and a moist paper towel wick for moisture. To keep

adult milkweed bugs for a longer period of time, place in milkweed bug habitats with sunflower seed packets, water fountain, twigs, and floss for eggs.

End the life cycle. As long as the four needs are attended to, new generations of milkweed bugs will continue to flourish in the habitat. At some point you may want to end the cycle. Although the bugs would probably soon perish if released into the environment, it is not suggested that you do so, as they were not originally from the environment. Place the bag in the freezer overnight to kill the bugs; discard the bag in the trash.

PAINTED LADY BUTTERFLIES

Painted lady butterflies can be purchased from a biological supply house as small fuzzy larvae—maybe as small as 1 cm (1/2") long. They arrive in a plastic container with a centimeter or two of green goop that looks like guacamole. The ventilated lid holds a piece of filter paper over the top of the container. Keep the lid and paper on the container at all times. The painted ladies will spend all of their larval days, perhaps 2 weeks or a little more, in the container eating the food layer, molting, and growing to a length of 4 cm (1-1/2") or a little more. They require no special attention other than to keep them in a well-lighted area, but out of direct sun and safe from temperature extremes. After the larvae are about 2 cm (3/4") long, it is all right for students to remove the larvae from the containers from time to time for close observation of structures and behaviors.

Life cycle. In due course the larva receives a biological message to climb to the top of the container, spin a little knob of silk onto the filter paper, and attach its rear end firmly to the knob. The larva hangs head down and assumes a characteristic J shape, indicating that pupation is only a few hours away. If you are vigilant, you might be able to observe the final molt as the fuzzy outer skin splits near the head to reveal the smooth, curiously molded, slightly iridescent pupa ensconced in its chrysalis. As the pupa writhes around, the skin is pushed up and off the body until it is a crunchy little nub pressed up against the paper. The painted lady lapses into a period of relative quietude, hanging motionless except for brief fits of wriggling, especially when disturbed. At this time the pupae attached to the paper should be moved to a larger cage.

For a week or 10 days the pupa undergoes dramatic physical and biochemical transformations. The chrysalis gradually darkens until it is dark gray-brown, and the orange color of the wings starts to show through. This is when you can expect the adult to emerge, which happens quickly. The chrysalis shell splits near the bottom (head end), and the butterfly reaches out with its legs and grasps the outside of the chrysalis. The head comes out, and then the abdomen and wings are pulled free of the chrysalis shell. The emergence takes a minute or less.

The fresh new butterfly clings to the chrysalis shell with its soft, crumpled wings hanging down. Over the next hour or two the abdomen pulses as it pumps fluid into the veins of the wings, expanding them to their fully extended shape. During this time the butterfly ejects a splat of red liquid. Students may be alarmed, thinking it is blood, but it is a waste fluid that the butterfly unloads as it prepares for its new life. In 3 or 4 hours the butterfly takes wing as a flying insect.

Maintenance. Painted lady butterflies don't require much as adults. They will drink dilute sugar solution and fly around looking for mates. Place the cage where sunshine will fall on it for a few hours each day. If mallow, a common weed in many parts of the country, is available, you can place a small bouquet of leaves in a vial of water. After the butterflies mate, they will lay eggs on the mallow leaves. If you want to raise a second generation of painted lady butterflies, provide mallow leaves for the larvae to eat.

After a month the adults will die, not because of any ill effects caused by captivity, but because that is their normal life span. Even though it is never advisable to release study organisms into the environment, if a painted lady butterfly "escapes," it will not be an environmental disaster—painted ladies are already well established throughout the country.

Order butterfly larvae. Painted lady butterfly larvae are available from several biological supply companies. They arrive in a container of food and will advance through their entire larval stage without ever leaving the container. They are usually sold three to five in a container. It is nice to have about ten larvae (two containers), but the activity will be a great success with one container. The larvae can usually be delivered about 2–4 weeks after you call in your order.

Use local larvae. If you have local painted lady larvae, or another species of butterfly larvae available, use them instead of commercially available larvae. You will need to research appropriate food sources for each type of butterfly larvae.

What to do when they arrive. Butterfly larvae are shipped with their own food in the shipping container. Warmer temperatures will encourage larvae to grow more quickly. Maintain container out of direct sunlight. No further care is necessary, as they will pupate within 7 to 10 days. (See above)

Prepare a feeding station. A butterfly feeding station can be made from a standard insect water fountain. Use a hole punch to make a hole in the center of the cap of a vial. Roll up an 8-cm (3") square of paper towel and push it through the hole in the cap. Push the vial into the plastic vial holder to prevent the fountain from tipping over.

Butterflies feed by sipping nectar through their long coiled proboscis. A substitute nectar can be made with sugar and water. Put 1/4 teaspoon of sugar in a vial and fill it with water. Attach the wick cap to the vial. Cut a crude flower from a piece of red or orange paper, make several crisscross cuts in the center, and push the vial through. The flower will attract the butterflies and give them a place to land.

Provide mallow leaves (optional). When adults emerge, provide a bouquet of fresh mallow leaves in the cage. Use the hole punch to punch a few holes in a plastic cup lid. Fill the cup with water and snap on the lid.

Stick leaves and small branches of mallow through the holes. Females will lay eggs on the mallow leaves.

Watch for egg hatching. The eggs hatch in a week or so, and it is possible to start the whole process over again. Larvae will thrive if you transfer them to fresh mallow leaves. They must be kept in a covered container because they are very mobile. A supply of mallow leaves can be kept in the refrigerator. If you do not want to let the eggs hatch, put them in the freezer for a few days.

Discuss death. Butterflies don't live long. After 3 weeks they will be tattered and tired. With luck they will have fulfilled their destiny by producing eggs. Discuss the inevitability of the death of the butterflies and that it is not caused by captivity or the result of any failing on the part of the caregivers. Butterflies just don't live very long.

SILKWORM MOTHS 

Silk is a natural fiber of exceptional strength, texture, and luster. When silk fibers are spun into thread and woven into fabrics, the result is an exquisite commodity. Silk was first made in China, and for centuries the methods of production were cloaked in secrecy, so valuable was the technology to those who controlled the art and industry of silk making. Eventually, however, the secret and the organisms escaped the control of the Chinese, and thriving silk industries were established in Japan, Arabia, and Spain. Even today, with the vast array of synthetic fibers that rival silk in many ways, the demand for the real thing is still high.

Although the larvae of most moths and butterflies produce silk, that produced by *Bombyx mori* is the silk of commercial importance. The silkworm moth lived in nature 4500 years ago when the Chinese silk industry was in its infancy, but as years passed, the insect became so domesticated that it can no longer fend for itself in the wild. It can no longer fly, move more than a few centimeters to find its food, or defend itself against predators.

As the silkworm prepares to pupate, it spins a protective cocoon. About the size and color of a cotton ball, the cocoon is constructed from one continuous strand of silk, perhaps 1.5 km long (nearly a mile). If the silkworm were allowed to mature and break through the cocoon, the silk would be rendered useless for commercial purposes. So the encased insect is plunged into boiling water to kill the inhabitant and dissolve the glue holding the cocoon together. The end of the silk is then located and the cocoon unwound onto a spindle to be made into thread.

Life cycle. A silkworm starts its life as a tiny egg laid by the female moth. The egg is just about this size: . The egg, laid in the summer or early fall, remains dormant until the warmth of spring stimulates it to start developing. When silkworms first hatch in the spring, they are tiny—3 mm or so (about 1/8")—and hairy. They require young tender mulberry leaves during their first few days. As they grow, they can eat tougher leaves, and late in their development they will eat any mulberry leaf you can supply.

The larvae advance through five stages of growth, called instars. The silkworm literally outgrows its skin five times, and molts its outgrown skin. With the first molt the silkworm loses its hairy exterior, and for the rest of its larval life its skin is soft and smooth.

Silkworms grow rapidly, eventually reaching the size of your ring finger. Then they spin beautiful oval white or yellow cocoons in which they pupate. After 2–3 weeks the creamy-white adult moths emerge from the cocoons. They clamber around, vibrate their wings rapidly, and mate, but they don't fly or attempt to escape from their container. During the adult phase of the

life cycle, the silkworm moths do not eat or drink. After mating, the female lays a profusion of eggs, and the moths die.

Males and females look slightly different, and students will be able to tell them apart with a little practice. The female has a larger abdomen. The male has a much larger pair of antennae, which look like long rakes or comb-shaped eyebrows, and vibrates its wings rapidly to attract a female.

Finding mulberry Leaves. The success of this investigation rests on your ability to get leaves of the fruitless mulberry tree to feed the growing larvae. Mulberry trees thrive in arid areas of the country. They are common shade trees in the Southwest, but they become increasingly scarce as you proceed north and east. Fruitless mulberry trees don't survive in areas that are subjected to extended periods of hard freeze. If you live in Wisconsin or Maine, for instance, you will probably not have access to a local supply of leaves. If you are not sure about mulberry trees in your area, ask around to see what you can find out. Contact a nursery person or agricultural agent to find out if you have mulberry trees. Or strike up an acquaintance with a teacher living in Phoenix or Los Angeles and arrange for their class to ship a box of leaves each week for the month you are raising silkworms. At any rate, locate your source of leaves before starting this investigation. The first 10 days the larvae will need catkins or young tender leaves, but after that the larvae will eat any leaf you can provide. Keep leaves in the refrigerator. Feed the silkworms once or twice a day.

Think about the timing of the investigation. The silkworm eggs must hatch when mulberry leaves and catkins (flowering portion of the mulberry tree) are available. If you are not sure when mulberry trees begin budding in your area, ask a colleague or inquire at a nursery. See the background section for more specific information.

Obtain silkworm eggs. Eggs of the silkworm must be obtained from a colleague who worked with silkworms last year, or ordered from a biological supply company (see the Materials folio for more information about obtaining insects). Order 50 eggs. If you purchased eggs from a biological supplier, plan to conduct this part as soon as the eggs arrive, because they will hatch 1–2 weeks after you receive them.

What to do when they arrive. Purchased silkworm eggs usually arrive loose in a vial. Working on a large piece of white paper, use the little paintbrush to divide the eggs into eight piles, and put one pile into each of eight vials. Cap the vials. Keep them in a warm place out of direct sunlight until you are ready to introduce them to students.

Eggs from a colleague may be stuck to paper. If this is the case, cut or tear the paper so that each piece has 10–15 eggs, and put the bits of paper into the vials.

Habitat. A shoe box is all that you need to make a silkworm habitat. Choose a place in the room where the silkworms will be warm but not in direct sunlight. Place the shoe box in an open plastic bag, or drape a sheet of plastic over the box. The idea is to reduce evaporation from the leaves a bit without developing a humid environment.

If the eggs are scattered all over the box, that is OK, but the larvae should be placed on a leaf. New larvae must be rounded up each day and delivered to a fresh mulberry leaf.

Larva. Silkworm larva are delicate at first and should not be handled for the first 2 weeks except with a tiny paintbrush. By the time the larvae are 2 cm (1") long, students can carefully pick up and gently hold them. The larvae seem to survive better if they are kept together in a single culture early in life—later they can be kept in pairs or small groups on students' desks.

Plan for spinning. Get a medium-size corrugated cardboard box and a couple of paper egg cartons. Open the egg cartons and attach them to the inside walls of the box. The silkworms will spin in the depressions in the egg cartons. The silkworms must all be in this box for spinning their cocoons. The time for this will be signaled by the first larva that starts to spin, either in your class habitat or, more likely, in one of the group habitats.

Prepare for silkworm moths. Once the larvae spin cocoons, they require no further care. The moths will emerge in a couple of weeks and can be handled by students. They do not eat or drink—they mate, lay eggs, and die.

Prepare for mating and egg laying. Get a large flat box, or cut a taller one down to about 10 cm (4"). Line the bottom with paper. As the adults emerge, move them to this new box. The moths will stay in the open box. The females will lay eggs on the paper, making them easy to collect.

Collect eggs. The eggs will remain viable for a year with minimal care. Seal them in a labeled zip bag and put them in the refrigerator (not the freezer!) as soon as all the moths have died. If you don't refrigerate the eggs, they will still hatch, but over an extended period of time instead of all at once.

LADYBUGS

Questions and Answers:

Larva

Adult

Q. Can you give me more information about their life?
A. There is information about the spots, the predators, the things they eat and why the Asian Ladybug comes into people's houses. Next, you can go to the **Science Fair Information** page. This page has all the scientific information about a ladybug called Hippodamia convergens. There is info about their wings, antennae, legs, reproduction and more. This particular ladybug is native to all of North America and parts of South America. Next, if you want to see pictures of ladybugs, well, they are all over the website! But you will find most of them here on the **Pictures of Ladybugs and Larva page.** If you need pictures of what the ladybug likes to eat, go to **Garden Eaters**.

Q. What can we expect to see and how can we care for them, so that we can watch the life cycle?
A. Depending on the species, and the temperatures, the ladybug larva can hatch out of the egg in 4-10 days. When the larva hatches out, they are so incredibly small, you will not want to move them or touch them. Depending on the species again, the first food of the larva is to eat the egg case that they just hatched out from.
After that anything is fair game, including the other larval siblings. You may also notice that the egg cases if left have turned white and dried out. After two days, bring aphids to the larva in the bug box, the smallest aphids possible. Don't add water quite yet. The larva could drown if over sprayed. They will get enough moisture from the aphids. After about four days, you will probably begin noticing the changing. They are growing and shedding the first of several skins. This process is called "in-star". Because insects have an exoskeleton (outside skeleton), when the larva grow, they have to basically bust out of the exoskeleton to get bigger. The soft exoskeleton that is revealed dries and hardens, protecting the larva once more until it has grown too big on the inside once more. This happens about 5-7 times in the larval stage, depending on the species and the amount of food available. After about 10-14 days, the larva will affix itself to a stable structure to begin the metamorphosis, the process by which the larva of an insect completely transforms in appearance into the adult form of the species. This process can take 7-14 days depending on temperature, type of species, the amount of food eaten during the larval stage and humidity. When the adult ladybug emerges from the pupa, it is in a very vulnerable state. The ladybug's body is very soft and wet as the new exoskeleton still must dry

and harden. The colors and spots look dull, but once it is dry the colors are bright and the ladybug will present the world with its new life.

Q. Do ladybugs build their own home?
A. No. Ladybugs reside where insect pest populations are high, such as in crop fields, gardens, and in the canopies of trees.

Q. How do ladybugs protect themselves?
A. Nature has uniquely designed a warning system of colors. Red, yellow and black are colors that warn predators that the insect they are about to eat might not be a good lunch choice. The colors can warn of danger such as poisonous, bad taste, or the ability to defend itself against the predators. Colors can also camouflage and warn when there is nothing about the insect that is harmful. Ladybugs can also protect themselves by playing dead. By pulling their legs up "turtle-style", and typically release a small amount of blood from their legs. (This is called reflex bleeding.) The bad smell and the apparent look of death usually deter predators from their small ladybug snack. After the threat of danger has passed, the ladybug will resume its normal activities.

Q. Can I keep a ladybug as a temporary pet?
A. Keeping a ladybug as a pet to observe will be fun. You can house your ladybug in a bug box or terrarium. Keep the foliage moist, or place a damp paper towel inside so the ladybug can get a drink. You can feed your ladybug moistened raisins or other sweet, non-acidic fruits. This will help maintain their fat reserves until you are ready to release the ladybug in spring.

Q. What is the yellow stuff coming from the ladybug?
Ladybugs can excrete some of their blood as a defense, which is mentioned above. It is yellow and smells bad. There is that "color" defense again and it does smell quite unpleasant.

Q. It is almost spring, why are ladybugs coming back into my house?
A. They have probably been hibernating under the sliding of the house or apartment and the warmer temperatures have caused them to emerge- it's just that they are going in the wrong direction. You would think that they would be trying to get out of the house, but they are coming in. It happens. This happens because of the variation in temperatures from the interior of the home verses the outside temperatures. The ladybugs are merely confused.

Q. How did the ladybug get its name?
A. In Europe, during the Middle Ages, insects were destroying the crops, so the Catholic farmers prayed to the Virgin Mary for help. Soon the Ladybugs came, ate the plant-destroying pests and saved the crops! The farmers began calling the ladybugs "The Beetles of Our Lady”, and they eventually became known as "Lady Beetles"! The red wings represented the Virgin's

cloak and the black spots represented her joys and sorrows. They didn't differentiate between males and females.

Q. Are all ladybugs girls?
A. No. There are boy ladybugs and girl ladybugs. It's almost impossible for the average person to tell them apart. But here are some clues that might help. First, females are usually larger than males. Second, if you observe one ladybug riding atop another ladybug, they are in the process of mating. A male ladybug will grab the female's elytra (hard wings) and holds on tight. There are photos on the Ladybugs Mating Page to help you. An entomologist (bug scientist) can see the difference between males and females under a microscope.

Q. What are boy ladybugs called?
A. Boy ladybugs are called ladybugs, too.

Q. Can two different species mate to produce a new species?
A. A. Ladybugs are typically "species specific". That means that they can only reproduce successfully with members of their same species. The male and female reproduction parts are termed "lock and key" which means that the male's aedeagus (insect penis) will only "fit" with the female of his same species. New species evolves over time through a process called evolution. It can also occur more rapidly through genetic mutations that have continued to appear in successive generations.

Q. What are ladybug babies called?
A. Ladybug babies are the larva. They look like little black and orange alligators with small spikes. You can see a picture on the **Pictures of Ladybugs and Larva page**.

Q. Are there different kinds of ladybugs?
A. Yes. There are hundreds of different kinds all over the world. There are about 500 different kinds in the United States and nearly 5000 worldwide. They come in all different colors, reds, yellows, orange, gray, black, brown and even pink.

Q. Are ladybugs poisonous?
A. No. Ladybugs are not poisonous to humans. However, they can have toxic effects on some animals. Ladybugs have a foul odor which deters some predators from eating them and their bright colors also help as a deterrent. In nature, red and orange, are warning colors that indicate to another animal or insect that the potential "lunch item" might not be a good choice.

Q. What animals and insects prey upon the ladybug??
A. There are lots of animals and insects that prey upon ladybugs. Some insect-eating birds, like martins, swallows, swifts and crows. Insect-eating insects prey on ladybugs like dragonflies, assassin bugs, parasitic wasps, and ants. Other predators include tree frogs, anoles, parasites, fungus and mites. Ladybugs certainly have their shares of problems!

Q. At the beginning of September, thousands of ladybugs were found in Lake Michigan. Why were they in and around the lake?
A. Periodically, all kinds of different insects can be found flowing in and around Lake Michigan. Although, during the early part of this month, the Lake Michigan area experienced some strong weather patterns. Insects can be carried on strong air currents created by storms, only to be "dropped off" somewhere else.

Q. Why do ladybugs come into my house in the winter time?
A. Ladybugs are attracted to the light colored houses, especially, homes that have a clear southwestern sun exposure. Older homes tend to experience more problems with aggregations due to lack of adequate insulation. The ladybugs come in through small cracks around windows, doorways and under clap boards. They want to hibernate in a warm, comfortable spot over the cold months of winter. Ladybugs gather in groups when they hibernate, so if you see one, you can be sure more will follow. The best way to keep them out is to repair damaged clap boards, window and door trim and to caulk small cracks.

Q. Once the ladybugs are in my house, will they eat anything?
A. No. Ladybugs don't eat fabric, plants, paper or any other household items. They like to eat APHIDS. Aphids are very small, but very destructive pest that feed on plants. (If you have rose bushes, you have probably seen aphids.) Ladybugs, while trying to hibernate in your house, live off of their own body fats. They, also, prefer a little humidity. But our homes are usually not very humid during the winter. In fact, they are rather dry causing most of your ladybug guests to die from dehydration. Occasionally, you might witness a ladybug in your bathroom getting a drink of water. Now, that's a smart lady!

Q. How can I get them out of my house?
A. If you don't have a lot, just leave them. They will leave when spring arrives. Disturbing them will only cause them to stress out leaving yellow markings on your walls. The yellow stuff, you see, is not waste matter, but rather, their blood. Ladybugs release a small amount of their blood which is yellow and smells, when they sense danger. Some people have said that it does stain on light colored surfaces.

Q. But, I really want the ladybugs out of my house!
A. Use a "shop vacuum". This type of vacuum is easy to use for collect ladybugs. When using this to vacuum up ladybugs, use a clean bag or pad the bottom with a cloth. After all is clean, release the unwelcome guests outside.

Q. Is there anything else I can use to get the ladybugs out of my house?
A. Yes. There is a product called a Ladybug Black Light Trap. It uses radiating black light to attract and contain the ladybugs.

Q. Do the spots tell you how old they are?
A. No. Different ladybugs have different numbers of spots. Some have no spots while some have as many as twenty four. Ladybugs generally complete their life cycle within one year. The spots are with them all their life. They don't get more spots as they get older, nor do they lose spots.

Q. Does the number of spots tell you what kind of ladybug it is?
A. Yes and No. An entomologist can use the spots as a guide in determining what kind of ladybug it is, but it is not the only piece of information gathered. For an average person the spots can greatly help, but the shape and coloration are going to be just as important. Some different types of ladybugs may have the same number of spots.

Q. What are the life cycle stages of a ladybug?
A. Egg, Larva, Pupa, and Adult. The first three stages vary from 7-21 days each depending on the weather, and food supplies. The adult stage lasts between 3-9 months depending on weather, length of hibernation, food supplies and, of course, predators.

Q. What do ladybugs eat?
A. Ladybugs eat Aphids. Aphids are soft bodied insects that suck the juices out of plants. If you have roses in your garden, you have seen aphids. Aphids also come in a variety of colors and not all ladybugs like all the "flavors" of aphids. Ladybugs will also feed on scale insects and plant mites.

Q. How do ladybugs know which ones they like?
A. They sense for food with their antennae.

Q. Why are ladybugs considered a "beneficial" insect?
A. Ladybugs feed on aphids and other soft bodied insects that feed on plants. The ladybug feeds on these pests as the adult ladybug and as the larva. One ladybug can eat as many as 50 aphids a day. Now, that's a hungry lady!