Freshwater Invertebrates

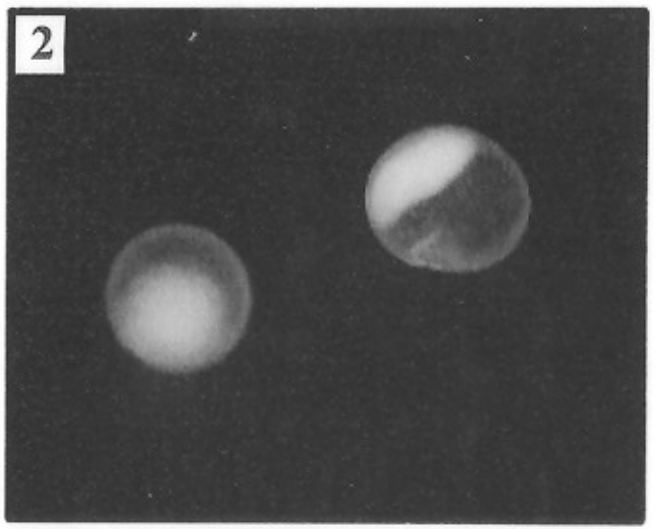
from the

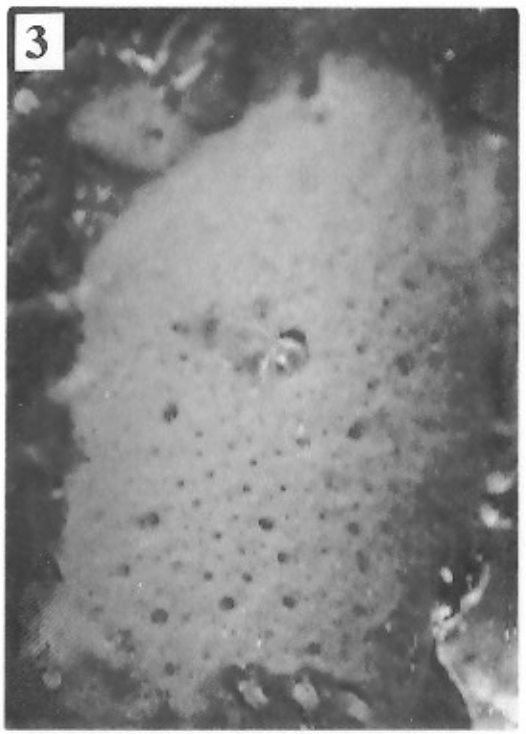
Iowa Great Lakes Region

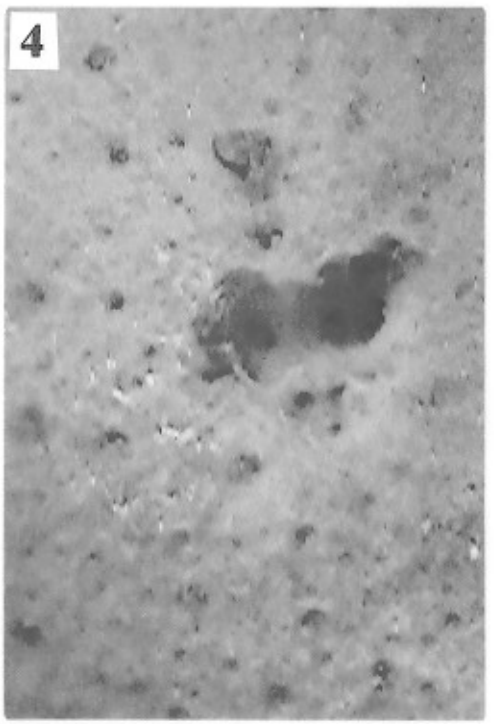
by Charlie Drewes

Porifera

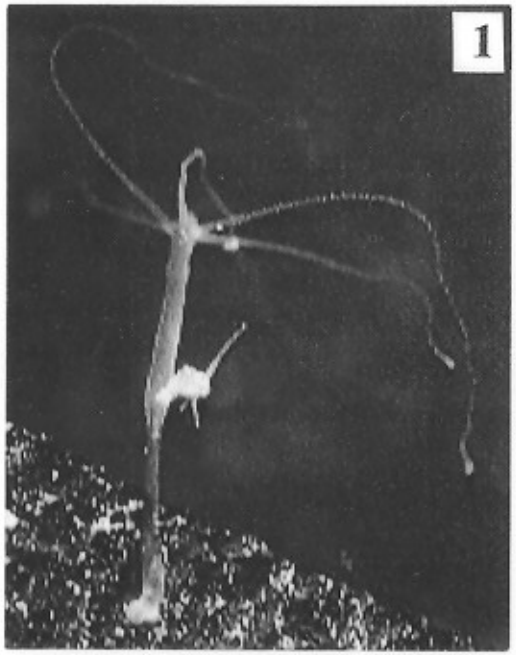
Freshwater **sponges (Phylum Porifera)** are found in unpolluted lakes and ponds. They attach to aquatic plants, rocks, submerged logs, and tree branches. Colors are variable - usually green, gray, cream, yellowish, or brown. Their size is highly variable. A sponge may begin as a tiny, flattened inconspicuous patch and grow into a large mass, such as the living sponges surrounding dead cattail stems, shown in the photo **[1]**. The shape of the sponge is maintained by the presence of many, tiny needle-like spicules. Special cells in the sponge use silica to make spicules. Flagellated choanocyte cells that line a complex internal canal system within the sponge create water currents. Water, along with tiny suspended food particles, is drawn into this internal canal system through many small openings, called ostia **[3,4]**. Thus, sponges are filter feeders. Water is expelled though one or more large openings, called oscula **[3,4]**. Sponges can reproduce sexually. Egg cells, fertilized within the canal system, develop into spherically shaped, free-swimming, flagellated larvae **[2]**. Sponges can also reproduce asexually, either by fragmentation or by formation of many small, spherically-shaped gemmules. Each gemmule is a mass of undifferentiated cells that may withstand freezing or drying.

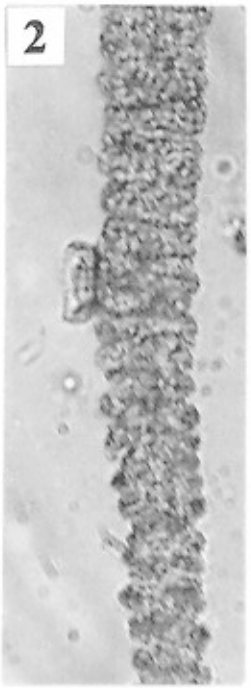




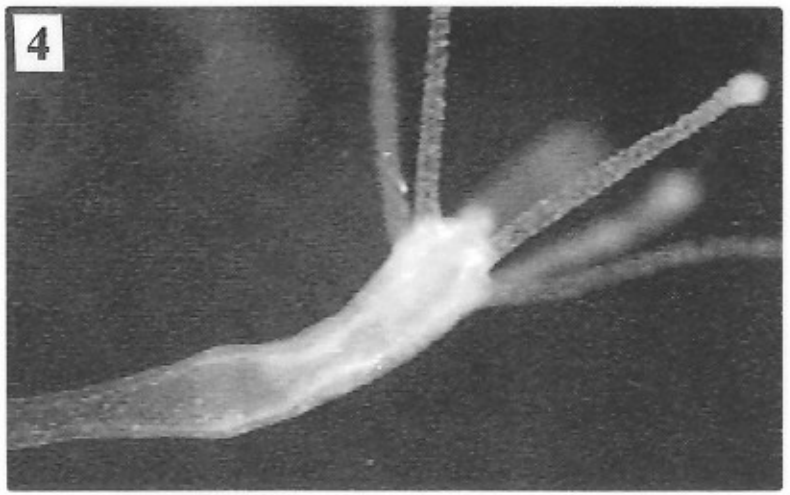


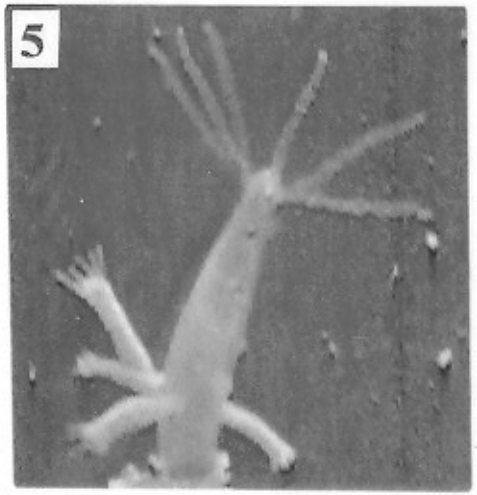
Cnidaria





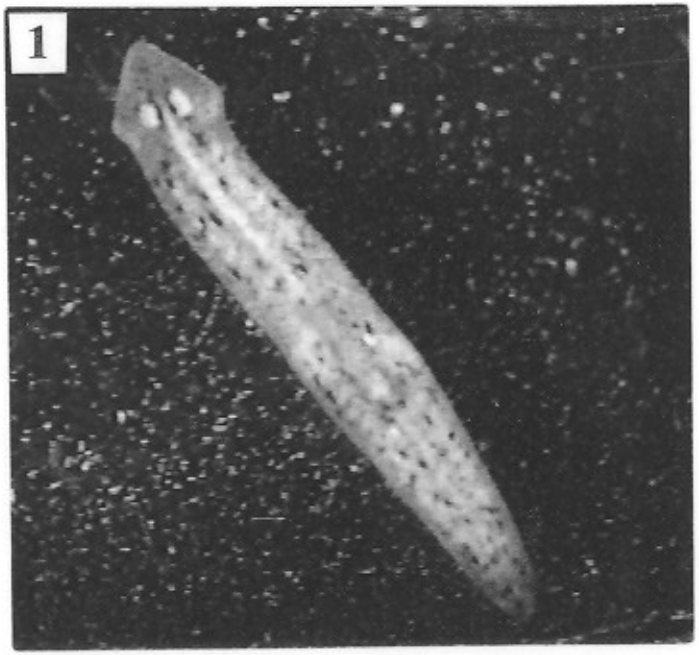
Hydra (Phylum Cnidaria, Class Hydrozoa) are abundant in many types of unpolluted streams, rivers, ponds and lakes. Colors are commonly cream, gray, tan, orange, red, brown, or green. Green hydra contain symbiotic algae. Often, hydra (about 1-15 mm in length) are found attached to submerged rocks or vegetation by means of a basal disc located on the aboral end **[1]**. The opposite end (oral end) bears numerous tentacles that radiate out from a central body axis. Thus, these animals' bodies are radially symmetrical. The outer cell layer of the hydra's tentacles contains bulging clusters of tiny stinging capsules, called nematocysts **[2]**, which are used for defense and prey capture. On the tentacles and body stalk of some hydra, one may notice numerous flattened, cylindrical bulges that smoothly and continuously glide over the external body surface. These are usually ciliated protozoans, ***Trichodina***, which are ectosymbionts. The hydra mouth, located at the base of the tentacles **[3,4]**, opens into a long sac called the gastrovascular cavity **[4]**. Prey usually consist of small invertebrates, including swimming zooplankton such as copepods and daphnia. When these animals bump into an outstretched tentacle, they stick to it and are immobilized by nematocyst poison. The prey, while still alive, are then moved by the tentacles to the hydra's mouth and ingested. Since the digestive tract is incomplete, undigested food is regurgitated through the mouth, as shown in the photo below **[4]**. Contractile cells in the tentacles and body stalk allow the animal to produce a variety of slow movements and great amounts of lengthening or shortening. Hydra commonly reproduce asexually by budding. Typically, one or more buds with short tentacles form about midway along the body stalk **[1,5]**. Sexual reproduction also may occur, but there is no larval stage. Much research has focused on these animals' exceptional capacity to regenerate lost body parts.

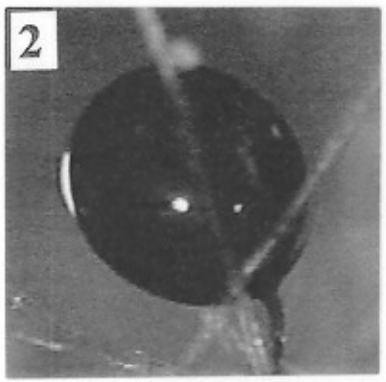


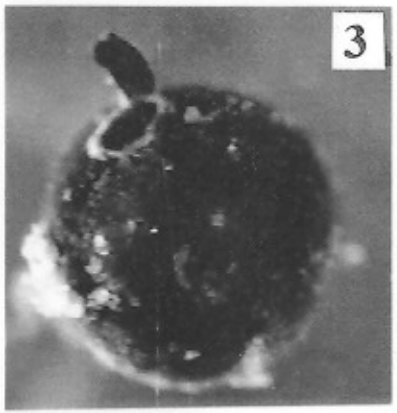


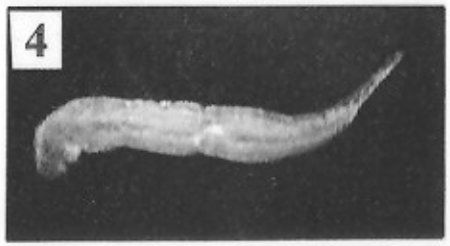
Platyhelminthes

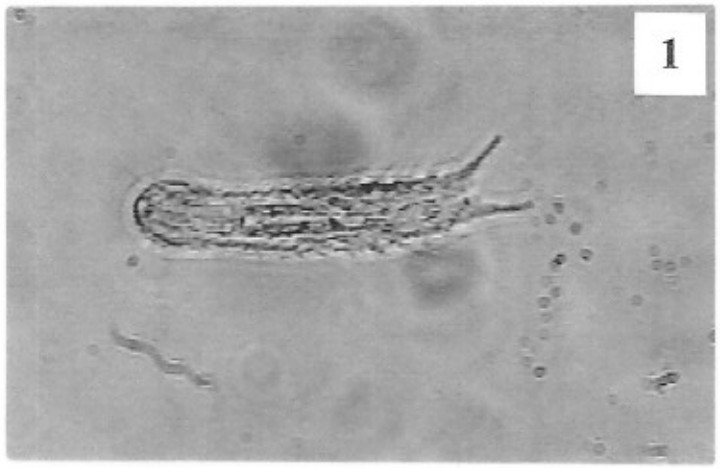
Free-living, non-parasitic **flatworms (Phylum Platyhelminthes, Class Turbellaria)** are common in lakes, streams, ponds, and other freshwater habitats. Some (such as ***Planaria***) are termed macroturbellarians, with body lengths usually from 5-20 mm. Typically, ***Planaria*** are found in shallow water on the underside of submerged rocks or vegetation. Colors may be dark brown, greenish, or tan. ***Planaria*** cannot swim; instead, they smoothly glide over the surface of objects using ciliary motion on the worm's ventral surface. Sometimes they glide upside-down on the underside of the water surface film. The body is non-segmented and bilaterally symmetrical. The head end is triangular- shaped and bears two distinct eyespots that detect light **[1]**. Worms can shorten and change shape using muscle cells whose contractions are controlled by a primitive nervous system. Simple reflexes allow flatworms to make "righting" responses when they are turned upside down. Food, consisting of both living and dead material, is taken into the digestive tract (gastrovascular cavity) by means of a muscular pharynx. Asexual reproduction occurs by a simple process of transverse fission in which the body separates into anterior and posterior halves. New head and tail ends then form by a process of tissue regeneration. Sexual reproduction is also possible after worms exchange sperm; worms are hermaphroditic. After internal fertilization, numerous zygotes are deposited into a small, dark capsule, called a cocoon, which is about 1 mm in diameter **[2,3]**. The cocoon is attached to submerged rocks or plants and, after further development, small worms emerge from an opening in the cocoon **[3]**. There is no larval form. Many species of freshwater flatworms are smaller than ***Planaria***; these are termed microturbellarians. Some microturbellarians, such as the one shown in the photo below **[4]**, prey upon hydra or other soft-bodied invertebrates. Also shown below **[5]** is a microturbellarian that is swallowing an entire orange-colored hydra, along with its attached bud. Reproduction in microturbellarians is usually asexual. The body develops into a linked chain of two or more "zooids" **[4,5]**. Eventually each zooid breaks off and lives independently.





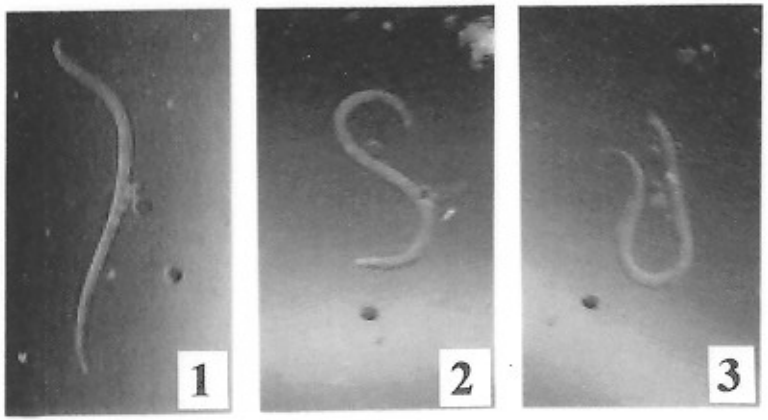






Gastrotricha

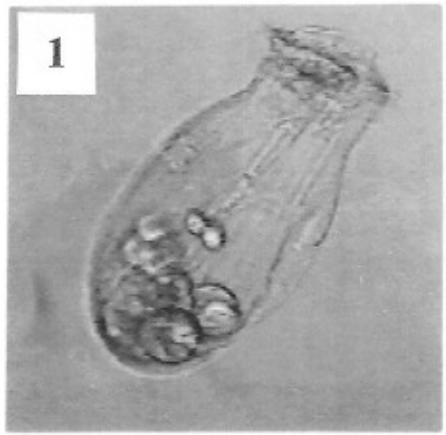
Gastrotrichs (Phylum Gastrotricha) are colorless, worm-like, metazoan animals that colonize submerged materials, especially mud and other bottom debris in many freshwater environments. The gastrotrich body is flattened and very small - often only a few tenths of a millimeter, or less, in length. The head bears cilia and the lateral edges of the body bear fine spines or scales. The posterior end usually has two toe-like projections **[1]**, called furca. Gastrotrichs glide smoothly and steadily by means of cilia located on their ventral surface. The body is capable of shortening, bending, or turning movements. Gastrotrichs have a complete digestive tract. Their diet consists mainly of bacteria as well as some algae and protozoans. Predators of gastrotrichs include midge larvae, hydra, and some protozoans. Gastrotrich reproduction involves a complex and unique series of asexual (parthenogenesis) and sexual phases, both of which occur within the same animal but at different times. Gastrotrichs are usually placed in their own phylum; however, the natural history and biology of this group are rather poorly understood.



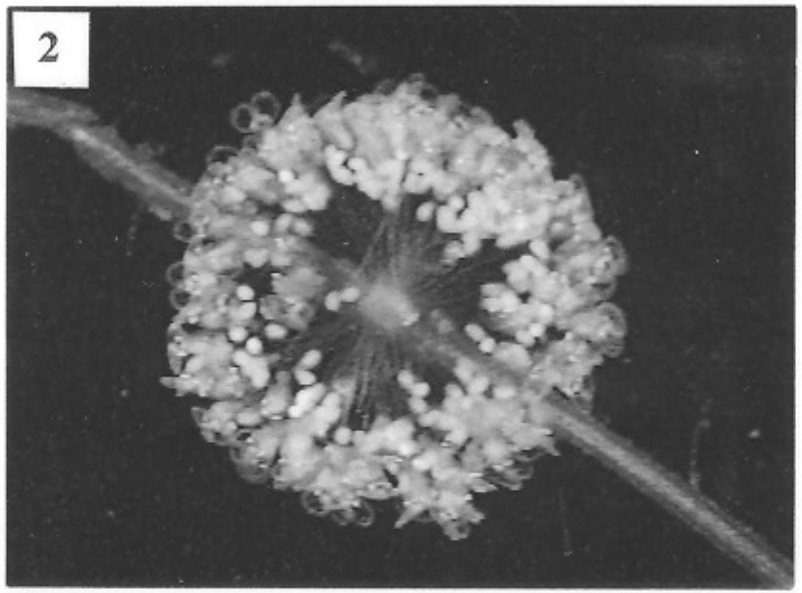
Nematoda

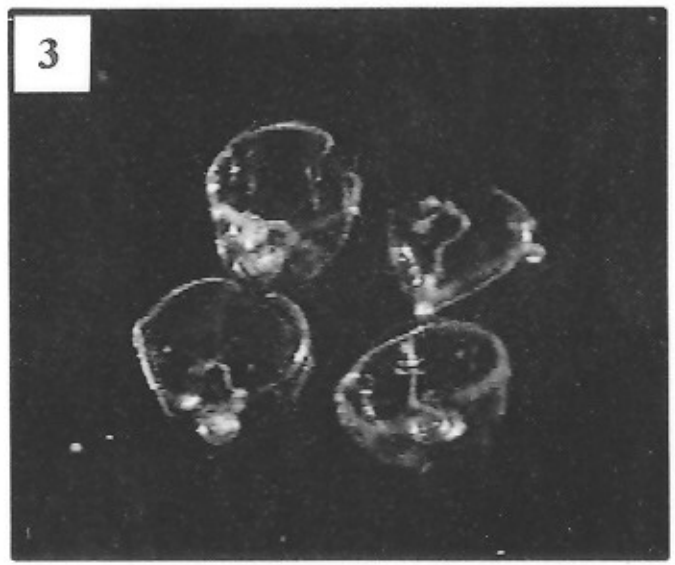
Though easily overlooked and very difficult to identify, **roundworms (Phylum Nematoda)** are abundant within and near all freshwater as well as terrestrial environments. Many species are short (usually a few mm long, or less), free-living, and non-parasitic. Their non-segmented bodies are long and slender, with tapered ends. The body is covered by a relatively smooth and flexible covering, called a cuticle. Worms make repeated bending, thrashing, coiling, or wave-like undulatory movements of their bodies **[1,2,3]** by alternately contracting longitudinal muscles on different sides of their body. Worms have no circular muscles with which to constrict their body diameter. The digestive tract is complete and most worms eat bacteria, algae, and protozoans, as well as dead plant and animal material. Sexes are separate and sexual reproduction is common, although asexual reproduction by parthenogenesis also occurs in some species. Postembryonic development follows a pattern somewhat similar to the process of gradual metamorphosis seen in some insects. That is, worms progress from an egg stage, through four juvenile stages, and then to an adult. All immature worms are highly tolerant to environmental extremes, such as long periods of drying.

Rotifera

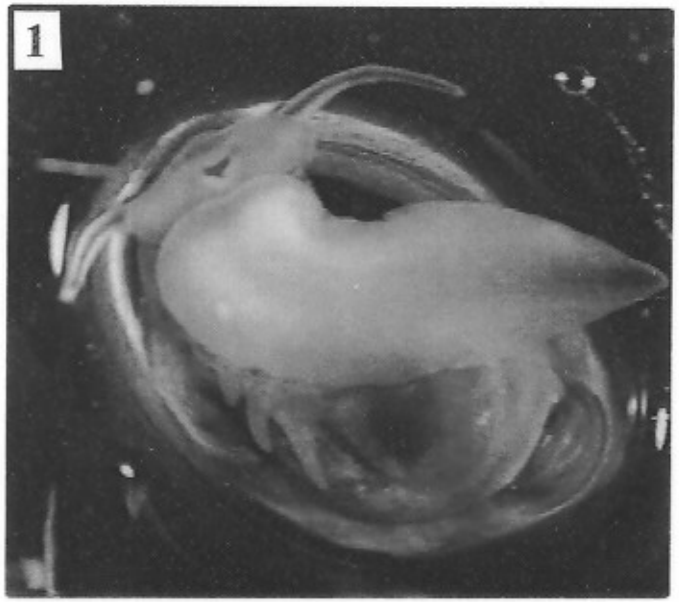


Rotifers (Phylum Rotifera) are also called "wheel animals" because they possess a ciliated ring or disc, called a corona, on their anterior end **[1-3]**. The synchronized beating of these cilia give the appearance of one or two revolving wheels. Most rotifers are between 0.1-0.5 mm in length, but some may be more than 1 mm long. Some rotifer species are sessile and remain attached to submerged plants or bottom substrate by a foot or stalk. In these cases, ciliary beating is used to create water currents that bring suspended food particles toward the animal (filter feeding). Although some species of attached rotifers are solitary, many others are colonial and form large spherical masses of hundreds of individuals that radiate out from central attachment points **[2]**. Other rotifer species are free-swimming and non-colonial **[1,3]**. In these cases, ciliary beating not only creates water currents for food intake but also enables forward swimming with a smooth, gliding motion. Some swimming rotifers are predators that swallow living protozoans or other microorganisms. In other species, the rotifer's body appears as a series of short, concentric cylinders and body shortening occurs by the telescoping action of these cylinders. In all rotifers, food enters the mouth, passes through a pharynx and into the mastax, a special organ of the digestive system with muscular walls and internal teeth that grind up ingested food. Depending on species, reproduction may be sexual, asexual (parthenogenic), or both. There are no larval forms.

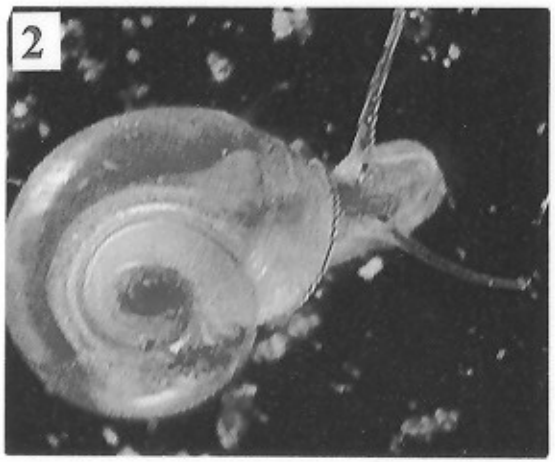


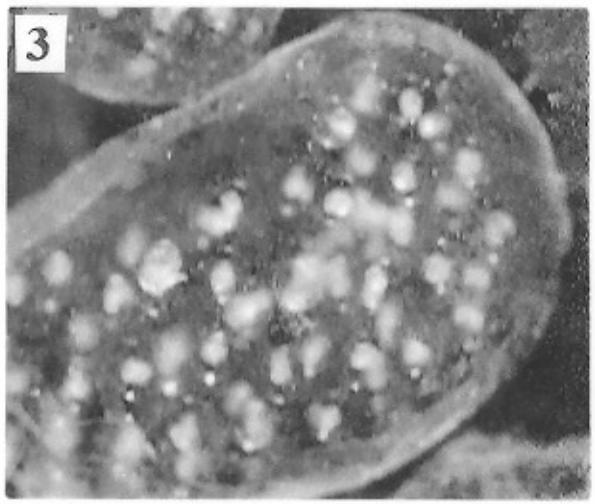


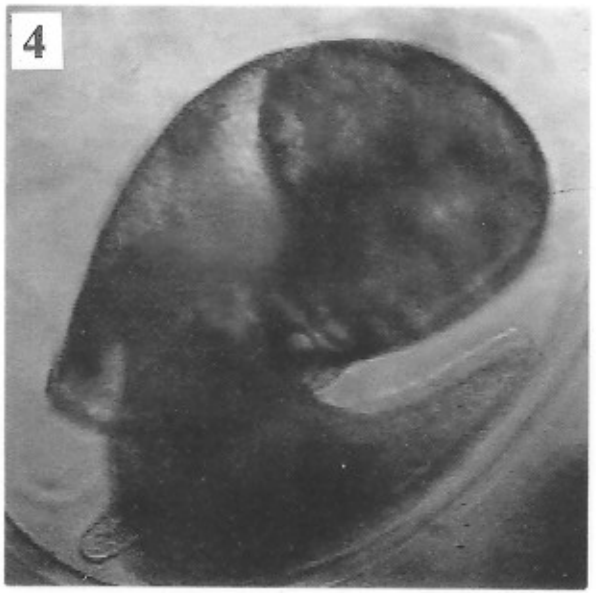
Mollusca (Gastropoda)



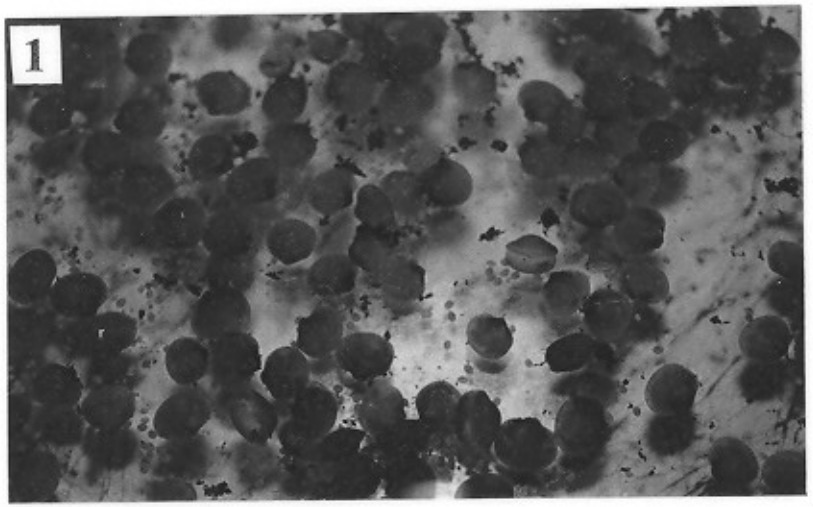
Snails (Phylum Mollusca, Class Gastropoda) are abundant in most freshwater as well as many terrestrial environments. Adult snails vary greatly in size depending on species. Some are as small as 2 mm; others are greater than 50 mm. Most have a spiral or coiled shell **[2]** composed of calcium carbonate and secreted by an underlying mantle **[1]**. The shell has an opening from which a head, body and muscular foot can be extended. The underside of the foot is ciliated, and these cilia, along with muscular waves of the foot, enable the snail to slowly glide along the surface of plants, rocks or other substrate. The head of the snail has a pair of tentacles with eyes near the base of the tentacles **[2]**. Most snails are vegetarians. The mouth **[1]** is often located on the under surface of the body. Within the mouth is a tongue-like, toothed structure, called a radula, which is used to scrape food off rocks, plants, or other surfaces. Some species breathe by means of an internal gill, while others are air-breathing. Air-breathing snails have a small opening (pneumostome) on the side of the body. The pneumostome opens into a "lung," which is an air-filled, highly vascularized mantle cavity. These snails can stay under water for long periods of time and, when needed, they can control their buoyancy, thus causing them to float or sink. The heart consists of an atrium and ventricle. The beating heart is sometimes easily seen through the shell, especially in young snails. In some species sexes are separate. Others are hermaphroditic. Usually, dozens of fertilized eggs are laid at one time within a clear, sticky, gelatinous egg mass **[3]** that is attached to the substrate. Each egg progresses through cleavage stages and embryonic development while contained within a separate capsule in the egg mass. The shell develops in late embryonic stages **[4]** before snails hatch.

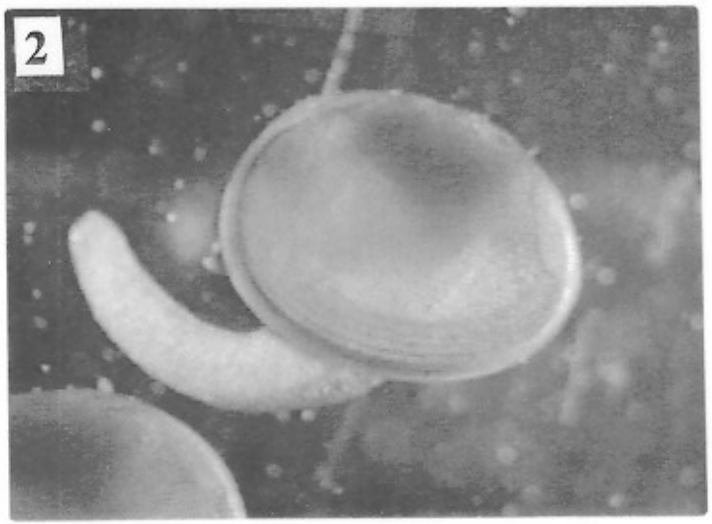




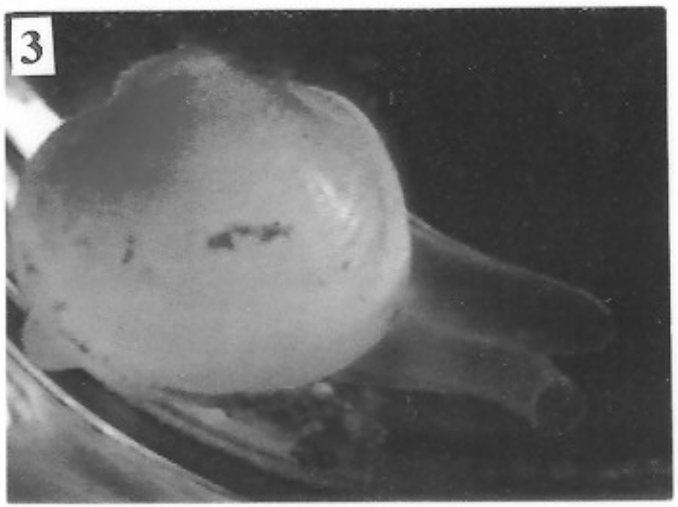


Mollusca (Bivalvia)



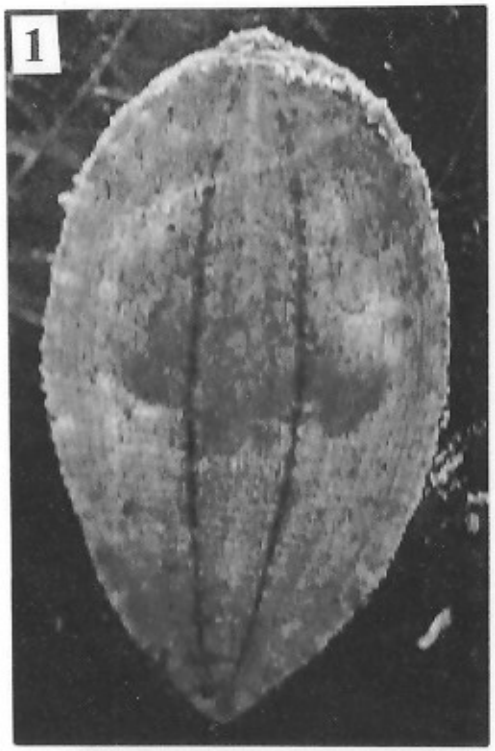


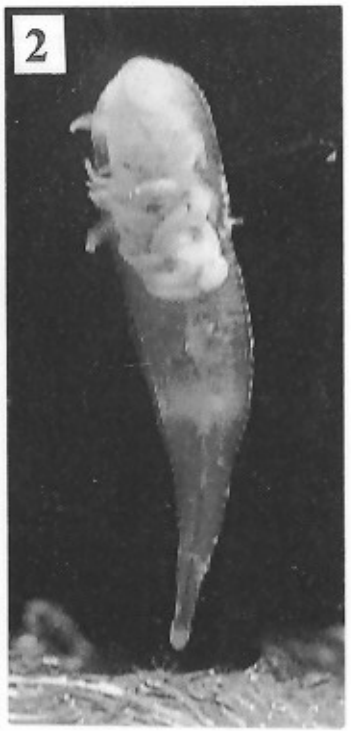
Fingernail clams, also called pea clams (**Phylum Mollusca, Class Bivalvia**), are common inhabitants of streams, lakes, and ponds. Their body is enclosed in two, calcareous shell halves that are joined by a hinge. The shell is secreted by underlying mantle tissue. During spring, mature fingernail clams, all less than 8 mm in length, may be found in great abundance buried in muddy sediments **[1]**. They filter feed by using an incurrent siphon **[3]** to draw in significant water volumes that contain organic debris and other suspended food particles. In-flowing water also provides a source of dissolved oxygen that is taken up by internal, ciliated gills. Water flows out through an excurrent siphon **[3]**. A long, muscular foot, when extended from the shell **[2]**, is used for thrusting movements that efficiently propel the clam through mud. When a clam is disturbed its foot and siphons are rapidly withdrawn into the shell and the shell is tightly closed by muscles that join the two halves of the shell. Numerous species of bottom-feeding fish prey upon fingernail clams. The clam's circulatory system consists of a three-chambered heart (two atria and a ventricle), blood vessels and blood sinuses. Fingernail clams are hermaphrodites and may self-fertilize. Numerous embryos may be seen developing internally in gill chambers (termed marsupia). There is no free-living larval stage in fingernail clam development. Internal structures, including the beating hearts, are often visible through the translucent shells of adult and embryonic clams.

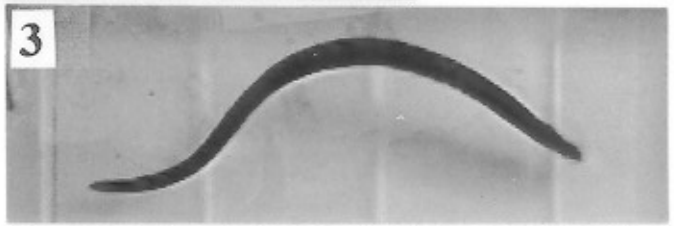


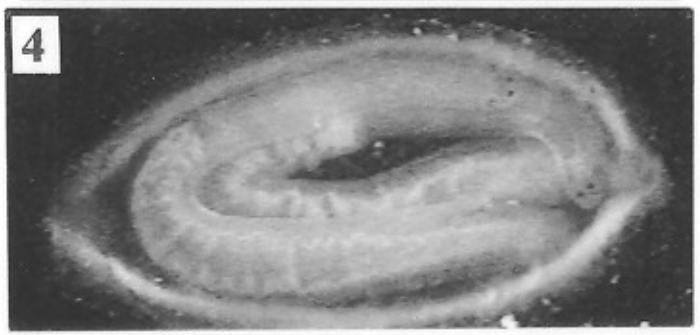
Annelida (Hirudinea)

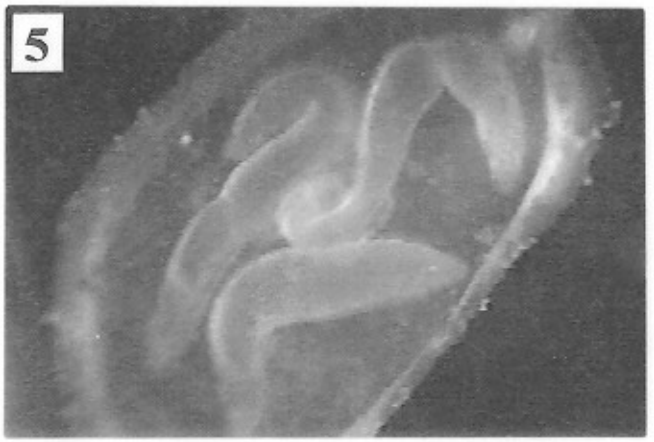
Leeches (Phylum Annelida, Class Hirudinea) are common in most freshwater environments, such as ponds, lakes, streams, and rivers. Body length varies from about 5 mm in small species up to 45 cm in giant species. Shapes may be broad **[1]** or long **[2]**, but most are highly flattened. Relatively few leech species are parasitic and blood-sucking. Many are scavengers or predators. A sucker on each end of the body allows them to securely attach to objects. Predatory leeches eat a wide variety of small invertebrates such as oligochaetes, snails, or insects. Leeches move by peristaltic crawling or by inch-worm movements in which anterior and posterior suckers alternately attach to the substrate. Numerous species produce alternating contractions of longitudinal muscle in dorsal and ventral portions of their body wall, resulting in wave-like (sinusoidal) undulations of their flattened body. These movements are used to swim in open water **[3]** or to produce water currents that improve gas exchange across the body surface. All leeches have exactly 34 segments, but they may appear to have many more because segments are subdivided into numerous ring-like divisions, called annulae. Like earthworms, leeches are hermaphroditic and cross-fertilize. Most species deposit fertilized eggs in small, flattened, transparent sacs called cocoons (several mm or more in length), which are attached to rocks or other submerged debris **[4,5,6]**. In the cocoons, fertilized eggs become embryos that elongate **[5]** and differentiate into small, adult-like leeches **[4]** that eventually emerge from the cocoon **[6]**. Note the tiny, dark eyespots in late embryonic leeches in the cocoon **[4]**. A few species do not deposit cocoons but carry hatched leeches on their body until they are large enough to live on their own **[2]**. No larval forms are present during leech development.





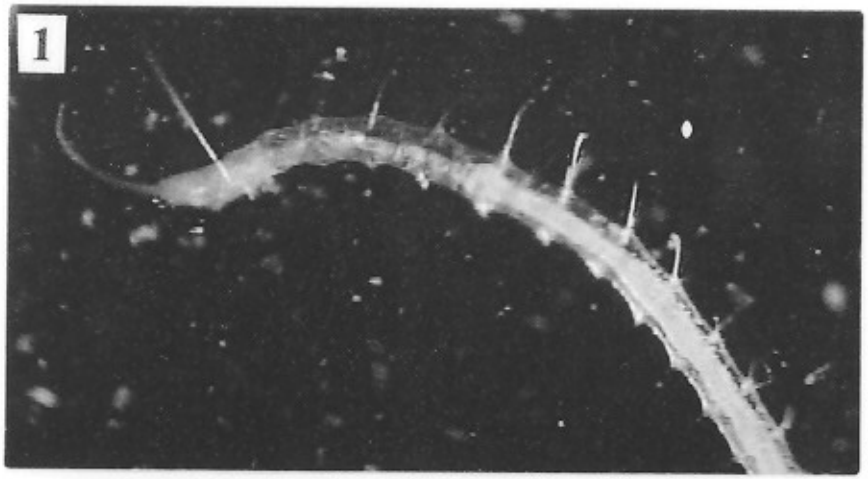


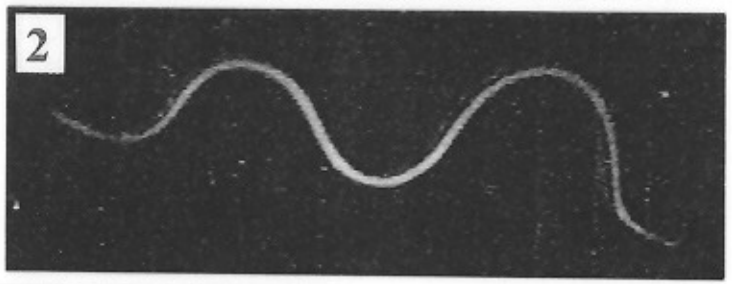


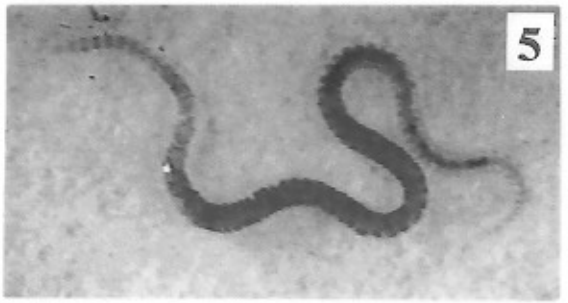


Annelida (Oligochaeta)

Freshwater **oligochaetes (Phylum Annelida, Class Oligochaeta)** are segmented worms that are in the same class as terrestrial earthworms, but they tend to be smaller and more slender. Body lengths and number of body segments vary greatly. Some species may be only a mm or two in length and have less than 10 body segments. Others such as the blackworm, ***Lumbriculus*** **[5]**, have several hundred segments and may be 8-10 cm long. A few species secrete thin mucous tubes in which they reside. Many species burrow in sediments, while others crawl on the surface of submerged rocks, debris, and emergent vegetation. Most freshwater oligochaetes eat small microorganisms or detritus. Some species have distinct eyes, but many do not. One small species, ***Pristina*** **[1]**, has an unusual proboscis-like appendage on its anterior end. All oligochaetes bear numerous bristles, or chaetae (also called setae), on their body segments. Short, ventral chaetae are used to increase traction during crawling; longer dorsal chaetae in some species may act to detect or discourage predatory attack **[1]**. Some oligochaetes can swim using waves of sinusoidal body undulation **[2, *Nais*]** or helical body twisting **[6, *Dero*]**. Oligochaetes have a complete digestive tract and, typically, a closed circulatory system with a pulsating dorsal blood vessel that functions as the main organ for pumping red blood **[3]**. In some worms, such as **Dero [3]**, the tail end protrudes up into the water column and functions in oxygen uptake, much like a "gill." Soft-bodied oligochaetes are favorite prey for many freshwater vertebrate and invertebrate predators. To escape predation, oligochaete worms use "startle' responses to rapidly withdraw head or tail segments when they are disturbed. Some species, such as ***Lumbriculus*****,** have remarkable powers of segmental regeneration. Note the lighter tail and head segments that regenerated on the more darkly pigmented fragment in ***Lumbriculus*** **[4]**. Reproduction may be sexual, asexual by fragmentation, or asexual by transverse fission. Sexual reproduction involves cocoon formation. Worms hatch from cocoons with adult-like appearance; no larval stages are present.

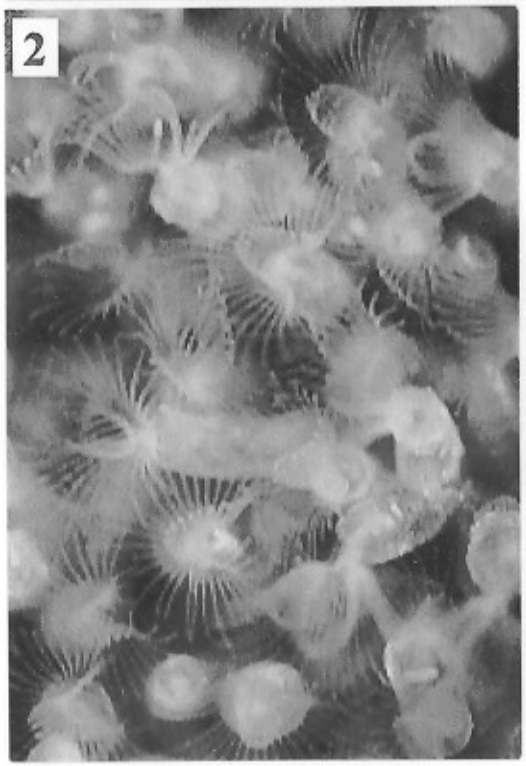


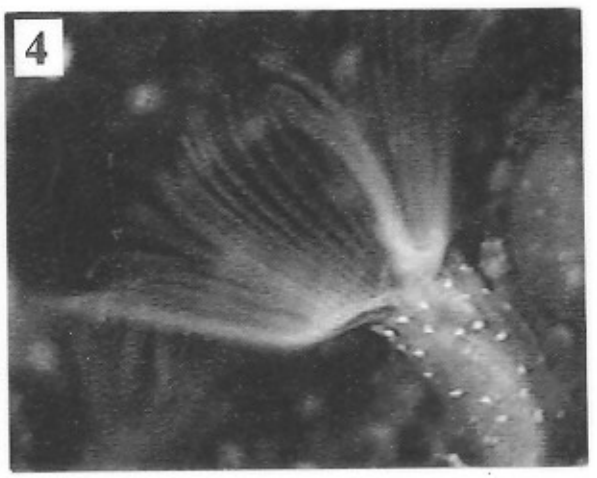




Bryozoa

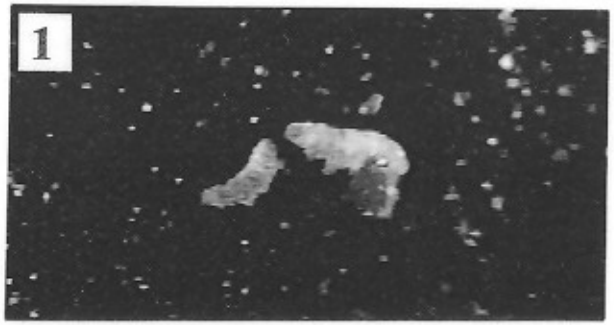
Bryozoans (Phylum Bryozoa) are also called "moss animals." Bryozoans form dense, branching colonies on the surface of rocks, logs, or other submerged objects. They are common in lakes and ponds but also thrive in flowing water. A bryozoan colony may consist of several hundred or thousand individuals, called zooids **[1-4]**. Bryozoans are filter feeders. Each zooid has a large feeding structure, called a lophophore (about 1 mm in length) that can be extended from (or withdrawn into) a protective outer tube. The lophophore bears two rows of tentacles arranged in a horseshoe-shaped pattern **[3,4]**. Cilia on the tentacles create water currents that bring small particles to a mouth at the base of the tentacles **[4]**. Vibration or touch of a colony usually causes many or all zooids to rapidly withdraw into their tube-like dwelling for several seconds or minutes. Through asexual reproduction, bryozoans produce great numbers of small, dark, oval structures called statoblasts **[5]**. Statoblasts are often found floating on the water surface where they may be readily dispersed to new environments by water runoff, wind, or bird-life. Statoblasts are capable of withstanding environmental extremes such as freezing and drying. Asexual reproduction in bryozoans also occurs by budding. Finally, bryozoans may sometimes reproduce sexually, resulting in formation of a ciliated larva that contains one or more young zooids. After release from the colony, the larva swims away, settles down on a new surface, and develops into a new colony.

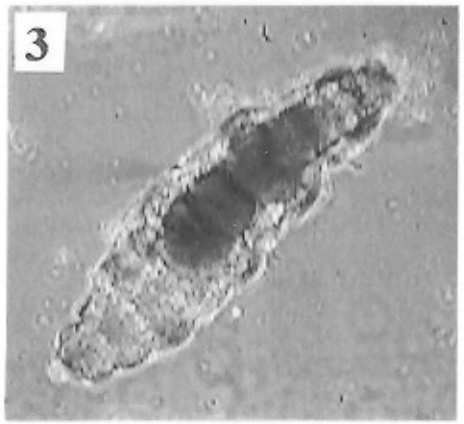


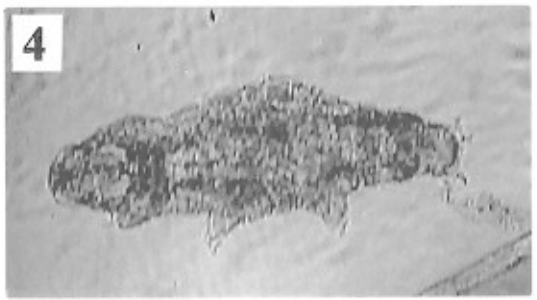


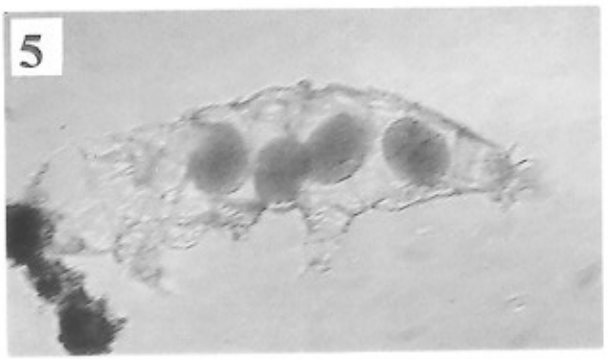
Tardigrada

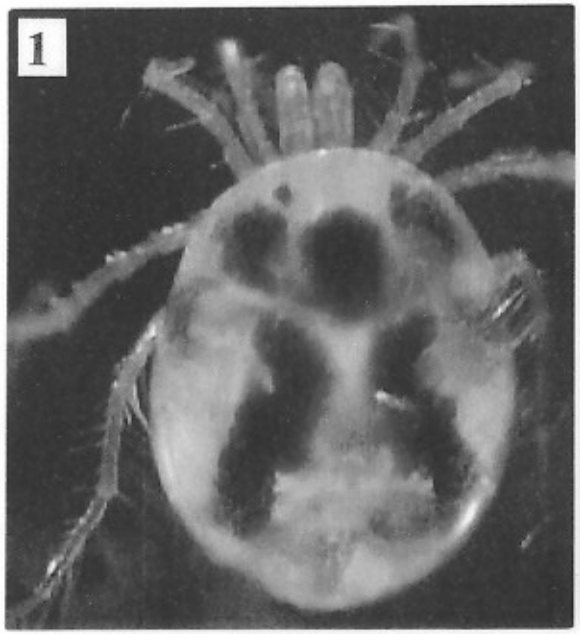
Tardigrades (Phylum Tardigrada) are also called "water bears." They are common inhabitants of ponds and temporary puddles, as well as mosses and other terrestrial environments. They are relatively small - usually about 0.2-0.5 mm in length. Many species are white or colorless. Tardigrades look like miniature caterpillars with five body segments and four pairs of legs **[1-4]**. The most anterior segment (head segment) has one or more pairs of sensory appendages and a pair of eyespots. Each of the three thoracic appendages, as well as the caudal segment, has a pair of legs **[4]**. Conspicuous claws on the tips of the legs are used to cling to objects or substrate **[2,4]**. Tardigrades crawl over the surface of submerged plants or debris by means of slow but coordinated movements of their legs. Tardigrades have mouthparts for piercing or sucking. Most feed on plants such as mosses, although some species are carnivorous. The tardigrade digestive tract consists of a mouth, salivary glands, muscular pharynx, stomach, intestine, rectum, and anus or cloaca. The body surface is covered by a flexible cuticle that is highly permeable to water. Reproduction may be asexual (parthenogenesis) or sexual. Some species have separate sexes while others are hermaphroditic. Eggs are sometimes deposited within the old cuticle after a tardigrade has molted **[5]**. With favorable conditions, eggs develop immediately but, with unfavorable conditions, development may be suspended. Such eggs are resistant to environmental extremes. During drought conditions, tardigrades do not die but shrivel up into a wrinkled mass called a "tun." Their metabolism is then suspended and they go into a state called "cryptobiosis." Various types of cryptobiosis may also be initiated by changes in temperature, dissolved salts, or oxygen availability. During the cryptobiotic state, tardigrades may survive extreme exposure to low temperatures, high pressure, ultraviolet radiation, x-radiation, carbon dioxide and hydrogen sulfide. Tardigrades may remain viable in a cryptobiotic state for more than 100 years.





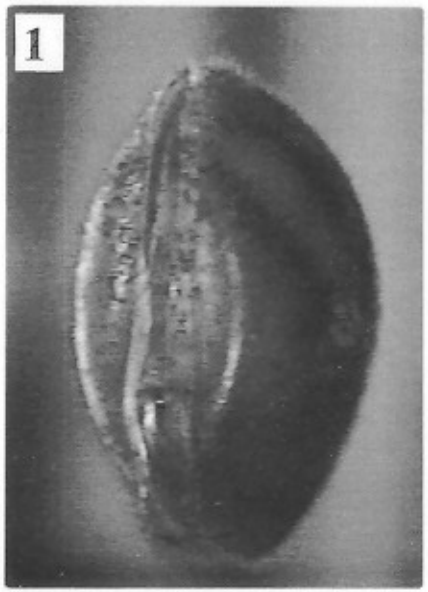






Arthropoda (Arachnida)

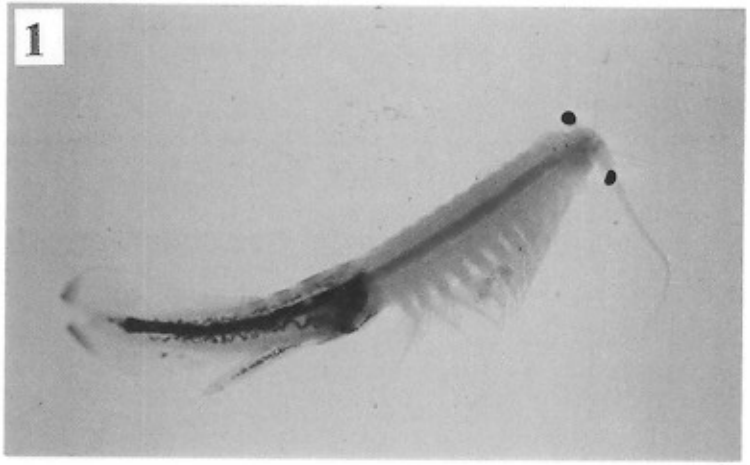
Water mites (Phylum Arthropoda, Class Arachnida) are often highly abundant in many freshwater environments, especially those containing rooted vegetation. Water mites are usually 0.5-3.0 mm long and colors may be orange, red, or brown. The head, thorax, and abdomen are fused together into a single unsegmented body mass, which is usually globular in shape **[1,2]** but may be flattened in some species. There are usually a pair of widely-spaced and darkly-pigmented eyes on each side of the head region. Water mites use the coordinated movements of their four pairs of legs to rapidly and efficiently swim underwater. Most mites are carnivorous or parasitic. Sexes are separate and masses of fertilized eggs (usually red) are deposited by the female on vegetation or stones. After embryonic development, larval stages swim free and find aquatic insect hosts upon which they feed as parasites. Eventually, the larvae undergo metamorphosis into nymph and adult stages. A few species of mites deposit their eggs in the tissue of sponges where development occurs.



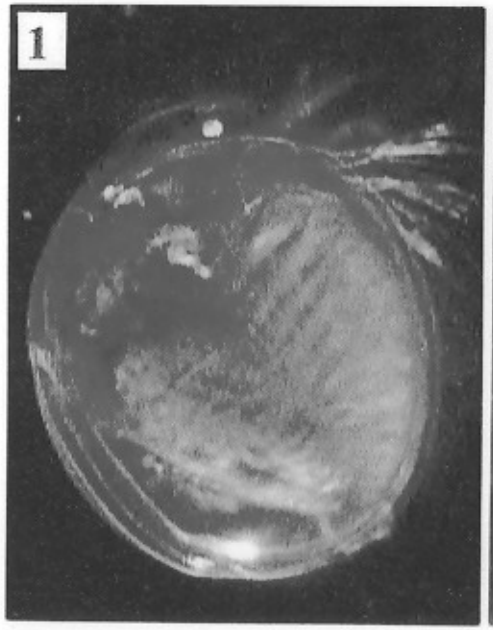
Arthropoda (Ostracoda)

Ostracods are a relatively small subgroup of crustaceans, also referred to as **seed shrimp**. They are abundant in the bottom substrates of most freshwater environments. They are usually 1 mm, or less, in length. The ostracod body is enclosed in an oval, bivalve shell that is hinged on one side. Shell colors vary from light to dark, but often they are light-colored with dark splotches. An osctracod's body consists mostly of its head, which bears four pairs of appendages **[1]**. The remainder of its body is highly reduced in size and there are no signs of body segmentation. Two pairs of antennae, when extended from the shell, are used for swimming, clinging and digging. Movements are rapid and frequent. When disturbed, appendages are quickly withdrawn into the shell and the shell is tightly closed for several seconds or minutes **[2]**. Ostracods are scavengers, feeding on small particles of living and dead material. In some but not all species, males may be rare and reproduction is by parthenogenesis. Typically, eggs are deposited on submerged objects where, if conditions are favorable, they develop and hatch into nauplius larvae. Larvae then undergo a series of instar stages before reaching the adult stage. In unfavorable conditions, such as cold or drying, development of eggs is suspended indefinitely until favorable conditions return.

Arthropoda (Branchiopoda, anostracans)



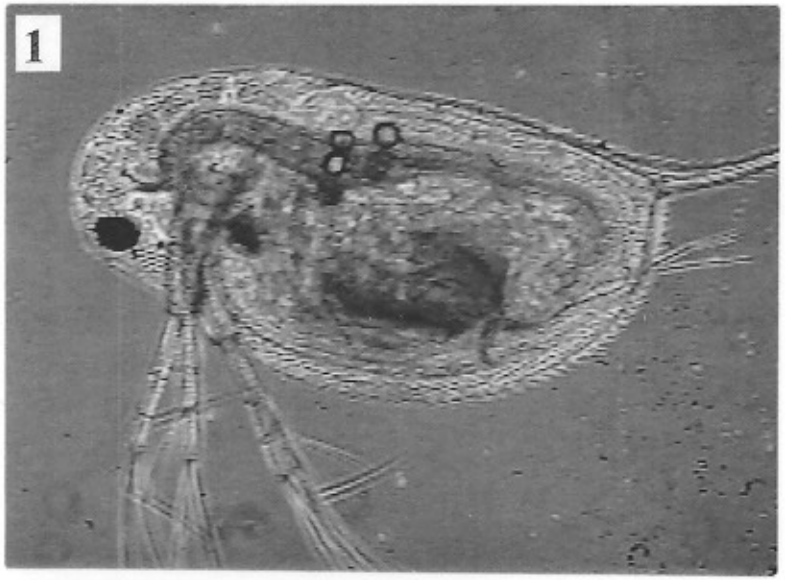
The **anostracans** are one of several subgroups of so-called "branchiopod crustaceans." In branchiopod crustaceans, the base of each thoracic appendage is a flattened, paddle-like structure that functions in locomotion and respiration. The anostracan subgroup includes numerous species of fairy shrimp and the well-known brine shrimp (***Artemia***). Fairy shrimp have slender, delicate bodies (up to several cm in length) and possess a pair of large compound eyes, numerous pairs of thoracic legs, and no carapace **[1]**. Fairy shrimp swim by making constant, wave-like movements of their legs. While they swim they also eat by filtering out small food particles from the water. Most swim gracefully with an upside-down orientation but they also can make rapid darting movements to escape predators. Fairy shrimp are highly adapted for life in temporary ponds, prairie potholes, woodland pools, or flooded farm fields. Their growth and reproduction may be completed within a life span of a few weeks. Fertilized eggs are carried in a brood sac where development is partially completed to a "resting egg" stage. Resting eggs that survive drying and freezing are the sole means for survival until the next wet season. Then, the resting eggs hatch into nauplius larvae. Adults eventually appear after a period of rapid development that includes several nauplius and multiple instar stages. **[NOTE**: This fairy shrimp specimen was collected from a flooded field in Monona County, IA. This photograph was kindly provided by Eugenia Farrar and Jane Hey.]



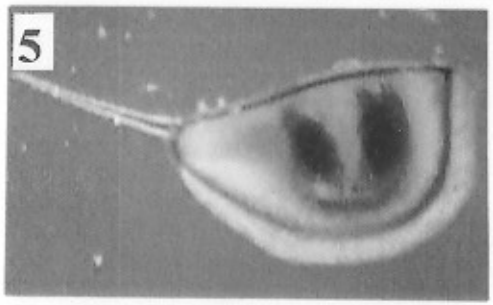
Arthropoda (Branchiopoda, conchostracans)

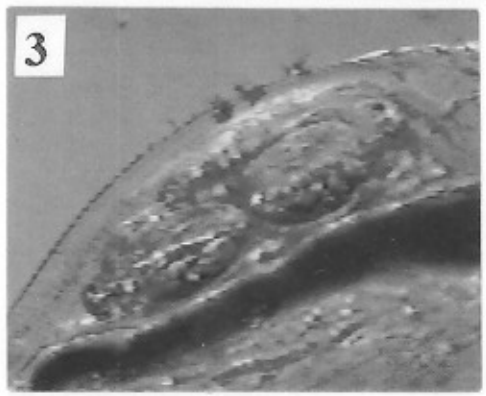
Conchostracans are another subgroup of branchiopod crustaceans. The common name for conchostracans is **clam shrimp**, so named because their bodies are enclosed in a carapace consisting of two, hinged clam-like shells. Body length ranges from a few mm to more 1 cm in length. They have a pair of non-moveable, compound eyes and series of 10 or more pairs of legs **[1]**. As in cladocerans, the second pair of antennae in clam shrimps are enlarged and used as the primary means of swimming. These appendages are also useful for burrowing and feeding within soft mud. Sexes are separate and fertilized eggs are carried temporarily within the carapace in dorsal brood sacs **[2]**. Eggs are then released in a "resting stage" which is able to withstand drying, heat, freezing, and even ingestion by birds. This is a significant adaptation for species survival and dispersal. Resting eggs hatch as nauplius larvae and gradually, through a series of molts, juveniles begin to resemble adult clam shrimp.

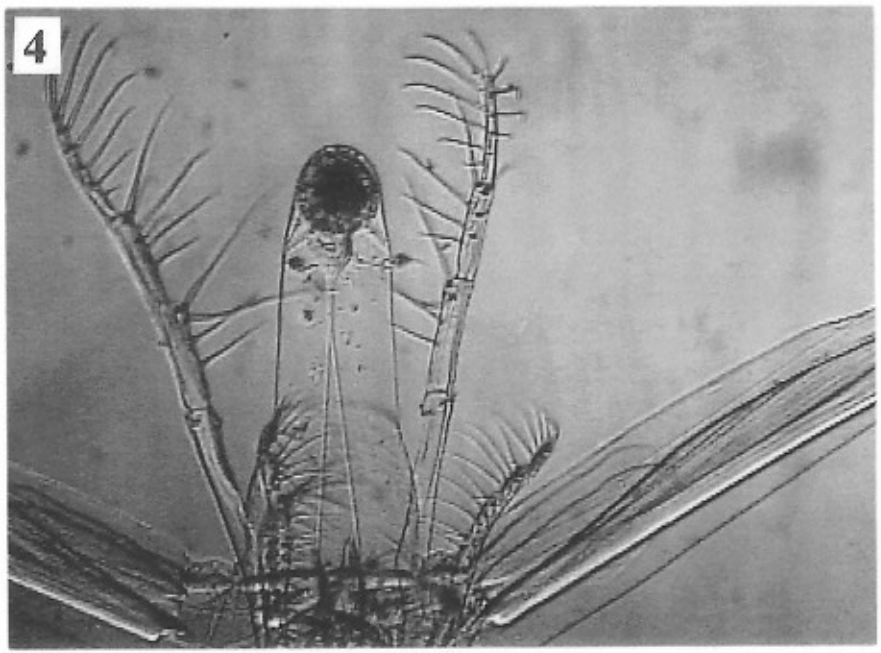
Arthropods (Branchiopoda, cladocerans)



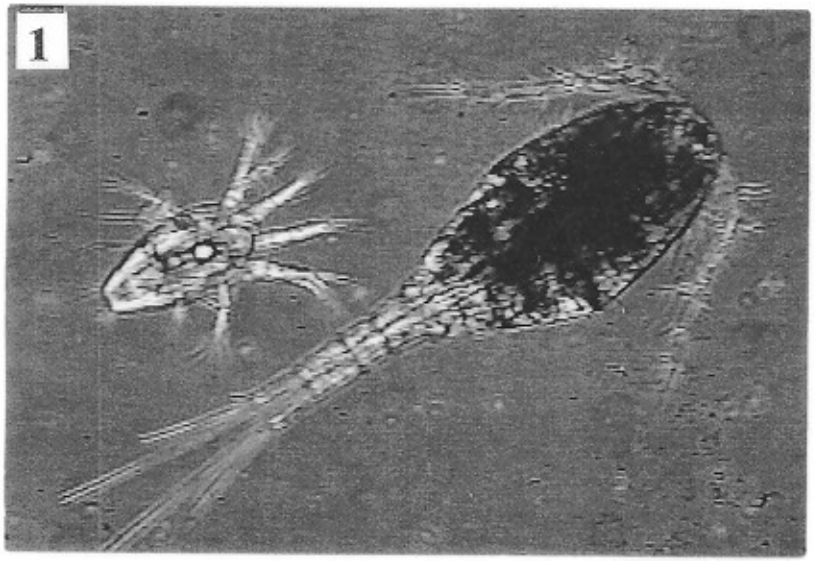
Cladocerans (**water fleas**) are another subgroup of branchiopod crustaceans. One common cladoceran is ***Daphnia*** **[1]**. Cladocerans are dominant zooplankton in lakes and ponds. They consume great amounts of phytoplankton and are principle food sources for many fish. They are readily obtained with a plankton net. The body, usually 0.2-3.0 mm in length, is contained in a bivalve carapace (shell). There is a dorsal heart. The head has a single, compound eye and two pairs of antennae **[1,2]**. The first antennae are small, but the second pair is large and designed for swimming by powerful, jerky strokes. Movements of its short thoracic legs aid in filter feeding. In many species, males are rare during some seasons; then, females predominate and reproduction is parthenogenic. Parthenogenic eggs and developing embryos **[3]** are easily seen through the transparent wall of the brood chamber. Sexual reproduction also occurs. One or two fertilized eggs pass into the brood chamber, and the walls of this chamber thicken and darken to form an ephippium **[5]**. The ephippium separates from the female at the next molt. The ephippium is highly resistant to drying. Some cladocerans exhibit daily vertical migrations in lakes and undergo seasonal changes in their external morphology. One cladoceran, ***Leptodora*** **[4]**, is unusual because of its extremely long body (about 15 mm). Note the first antennae (which straddle the one-eyed head) and the much longer second antennae that act as powerful oars.

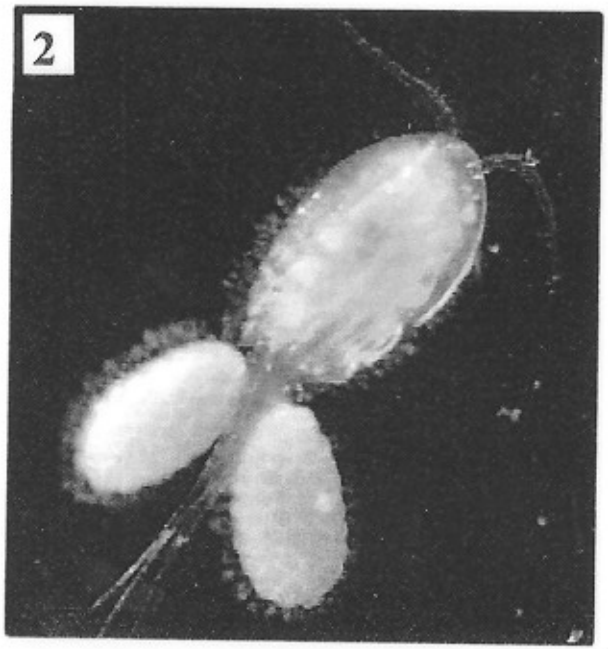


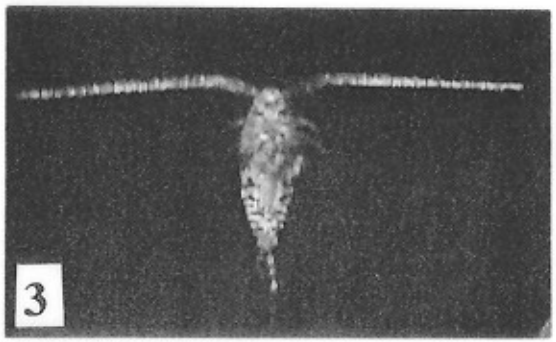


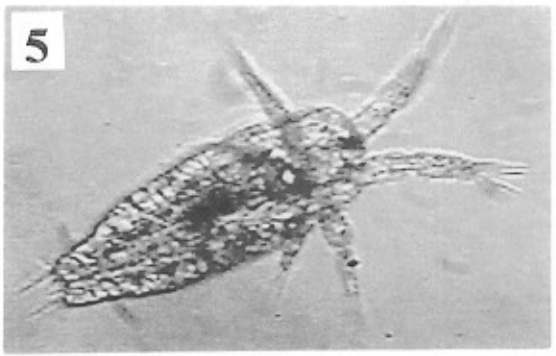


Arthropoda (Copepoda)

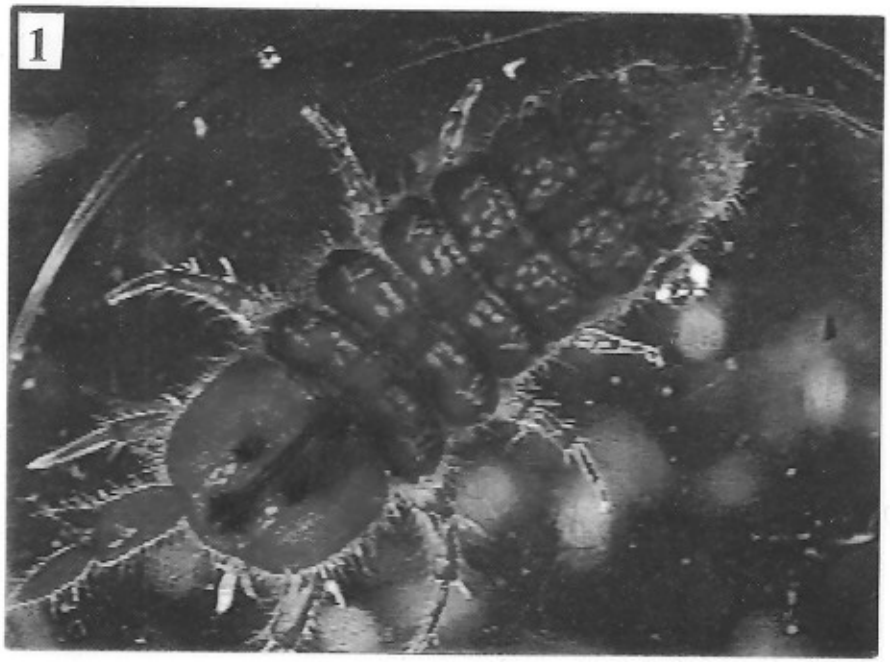






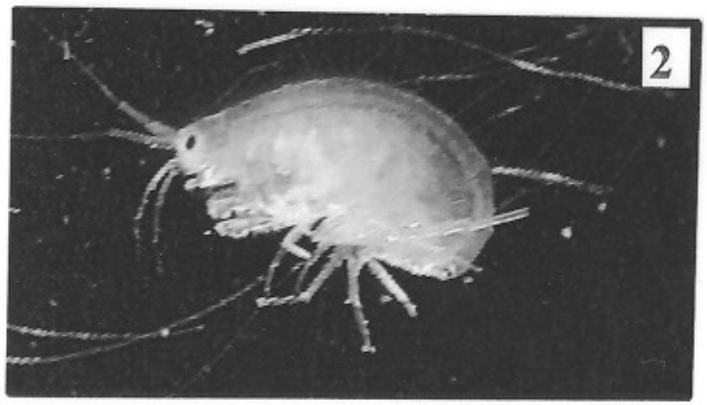


Copepods are abundant inhabitants of nearly all lakes and wetland environments. These small crustaceans, usually 0.5-2.0 mm in length, range in color from gray-brown to bright orange, blue, or red. In most, the body is clearly segmented and divided into a cephalothorax (covered by a carapace), thorax, and abdomen. The head region bears numerous pairs of appendages, including two pairs of antennae. Each thoracic segment also bears a pair of appendages. The end of the abdomen forms two branches **[1,2]**, each with numerous hairs or spines. In many copepod species, the first antennae are long and serve many important functions related to locomotion, reproduction, and food capture **[1,2,3]**. Powerful and synchronized flexion movements of the first antennae and thoracic legs produce jerk-like forward thrusts of swimming. Continuous beating movements of the other head appendages produce slower and smoother swimming movements and provide a constant supply of water that contains suspended food particles. Swimming movements allow some copepod species to migrate vertically, on a daily basis, within deep underwater environments. Most copepods are herbivores that feed on phytoplankton. Because many copepod species are planktonic, they serve as primary food sources for many fish species. Thus, they are considered very important elements in freshwater food chains. Most copepods have a single eye in the middle of the head **[1,2]**. Sexes are separate and, in some species, reproduction is by parthenogenesis. Several kinds of eggs may be produced. Some eggs, termed resting eggs, need not hatch immediately and are able to withstand many types of environmental extremes. In some species eggs are carried by the female in a single egg sac (calanoid-type **[3]**, and harpacticoid-type **[4]**) double egg sac (cyclopoid-type **[2]**). Eggs hatch into a free-swimming nauplius larva with a short body **[1].** This is followed by another nauplius stage **[5]** with a longer body and, then, by several instar stages, before eventually attaining adult body form.



Arthropoda (Malacostraca, isopods)

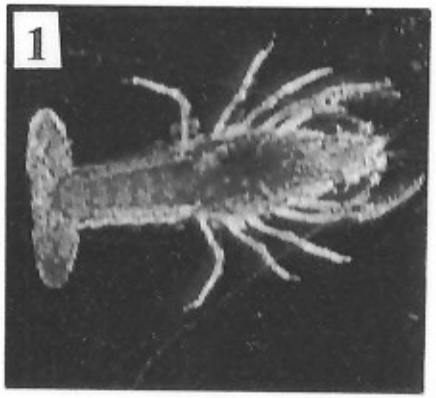
Freshwater isopods are in the same taxonomic group as terrestrial pill bugs, or **sow bugs**. Most freshwater isopods are found in moving water, but a few species are common in ponds and lakes. Body length varies from a few millimeters to about 2 cm, while colors may be black, gray, brown, red, or yellowish. The body is flattened dorso-ventrally **[1]**. It is composed of a head (actually a cephalothorax) with a pair of non-moveable compound eyes, along with seven distinct thoracic segments that each have a pair of walking legs. The more posterior legs tend to be longer. The first pair of antennae is long and the second pair is shorter. Locomotion is by slow crawling. Most do not roll up like terrestrial isopods but they tend to cling to submerged objects (rocks or wood). Many are scavengers that eat dead or decaying animal and plant material of all kinds. Sexes are separate and fertilized eggs develop in a ventral marsupial chamber in the female. Young isopods stay in the marsupium and may be seen crawling on the female's body, but eventually they leave and become independent. Young isopods, which look much like small adults, progress through a series of instar stages and molts before reaching adult size.



Arthropoda (Malacostraca, amphipods)

Freshwater **amphipods** are also called "**scuds**." About 5-20 mm in length, they are abundant and conspicuous inhabitants of most permanent, freshwater environments such as lakes, streams and ponds. They prefer waters that are oxygenated, clean, cold, and unpolluted. They are most abundant near the surface in shallow water and are easily obtained with a dip net. Body color is highly variable but usually white, cream, gray, or greenish. The head contains a pair of unstalked, compound eyes and two pairs of antennae **[2]**. Unlike the dorso-ventrally flattened bodies of isopods, amphipods' bodies are laterally flattened. They have seven pairs of legs. The first two pairs are modified for grasping food. The other five pairs do not have such modifications. Amphipods exhibit several distinctive orientation responses to environmental stimuli. They tend to avoid light and stay in contact with objects (thigmotaxis). Smaller, juvenile scuds consume microbial food, primarily bacteria and algae. Older stages are scavengers that feed on many types of living and dead material. Sexes are separate and reproduction is normally sexual. When mating, a male carries the female on its back for several days. Fertilized eggs remain in a ventral marsupium in the female. Development is direct; that is, young amphipods look like small adults when they emerge from the marsupium. Then, they undergo a series of molts and instar stages before reaching adult size. Natural enemies include fish, amphibians, birds, and aquatic insects.

Arthropoda (Malacostraca, decapods)



Decapod crustaceans include the **crayfishes**, which commonly inhabit running water, ponds, lakes and marshes. The cylindrical-shaped body, ranging from 1-15 cm long, is covered by a thick exoskeleton. The head and thorax are fused into a cephalothorax. There is a pair of stalked, moveable, compound eyes. The body has a total of 19 pairs of appendages, including two pairs of antennae **[4]**, five pairs of mouthparts (mandibles, maxillae, and maxillipeds), five pairs of walking legs (including a pair of chelae, **[1,4]**), five pairs of abdominal appendages (swimmerets), and two pairs of tail fan appendages (uropods and telson, **[4]**). Crayfish have 17-18 pairs of feather-like gills located under the exoskeleton at the base of appendages. Careful inspection of the gill surface may reveal many, small branchiobdellid worms, each several mm in length. These worms are commensals that have similarities to both the oligochaetes and leeches. The pincer appendages (or chelae) on a crayfish are used for crushing food and defense. Crayfish can walk forward, backward, and sideways. A sudden threat often evokes a rapid escape response in which the crayfish rapidly flexes it abdomen downward. The resulting movement of the broad, flat tail fan causes powerful backward swimming, as shown in the video sequence **[2]**. During the day, crayfish hide in mud burrows or under rocks and bottom debris. However, during the night they search for food which includes snails, oligochaetes, small fish aquatic insects, aquatic plants, and dead or decaying organisms. Photos below show ventral views of an adult crayfish attempting to grasp a swimming oligochaete (***Lumbriculus***, **[3]**) and eating a snail (***Helisoma***, **[4]**). The nervous system, sensory structures, and behavior of crayfish are complex and have been extensively studied. Sexes are separate and, several weeks or months after copulation, the female lays eggs. Fertilized eggs remain attached to the ventral surface of the female's abdomen. The young hatch as a first instar stage that also remains attached to the ventral surface of the mother. During several months or seasons, they progress through numerous molts to juvenile **[1]** and adult stages. Enemies of crayfishes include wading birds, turtles, fish, raccoons, and mink.