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Learning Programs for Biology Education

Branches on the Tree of Life: Rotifers & Nematodes
Study Guide

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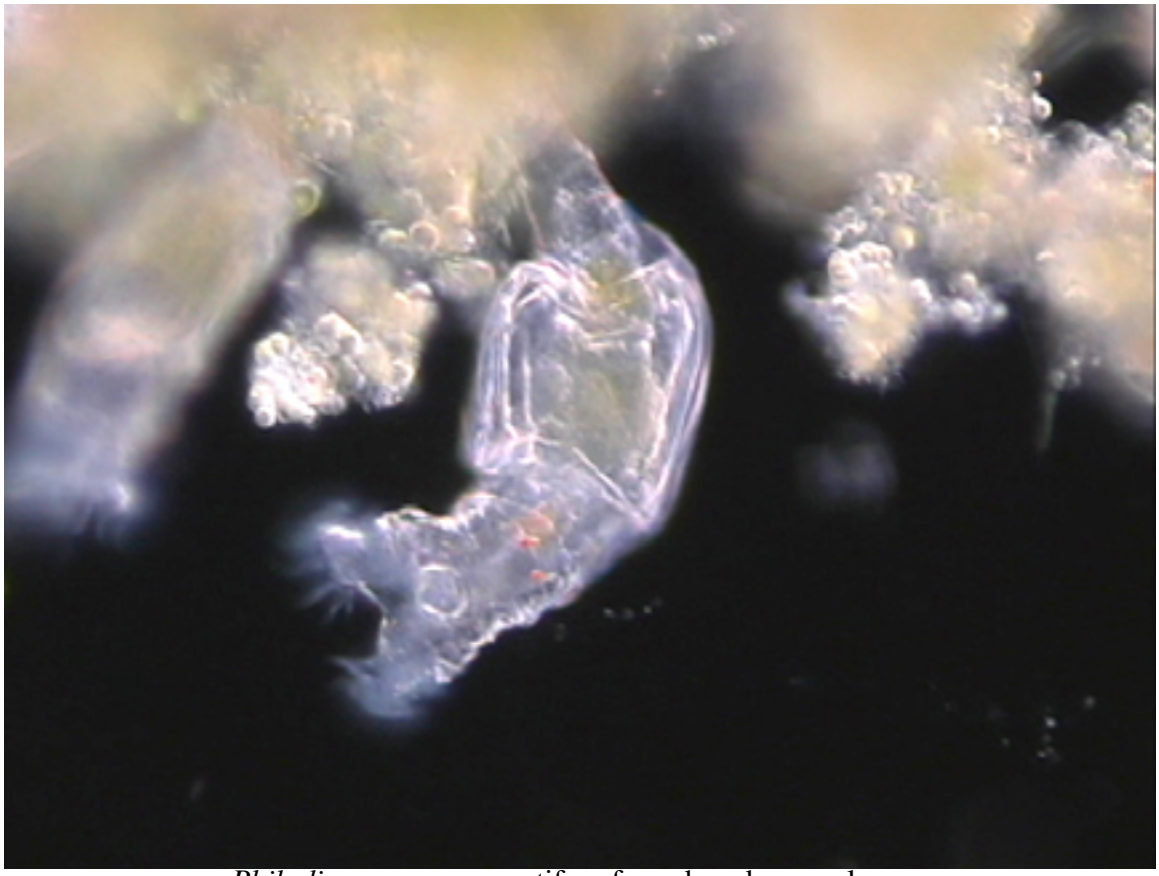
Supplement to Video Program

Cleaning moss from a roof, you might not realize that you are displacing thousands of animals – but you are. The moss has dried out over the summer, and has remained dry for five rainless months, so it may seem silly to expect to find anything alive – but take a look!



Philodina, a common rotifer of pond, and moss clumps.

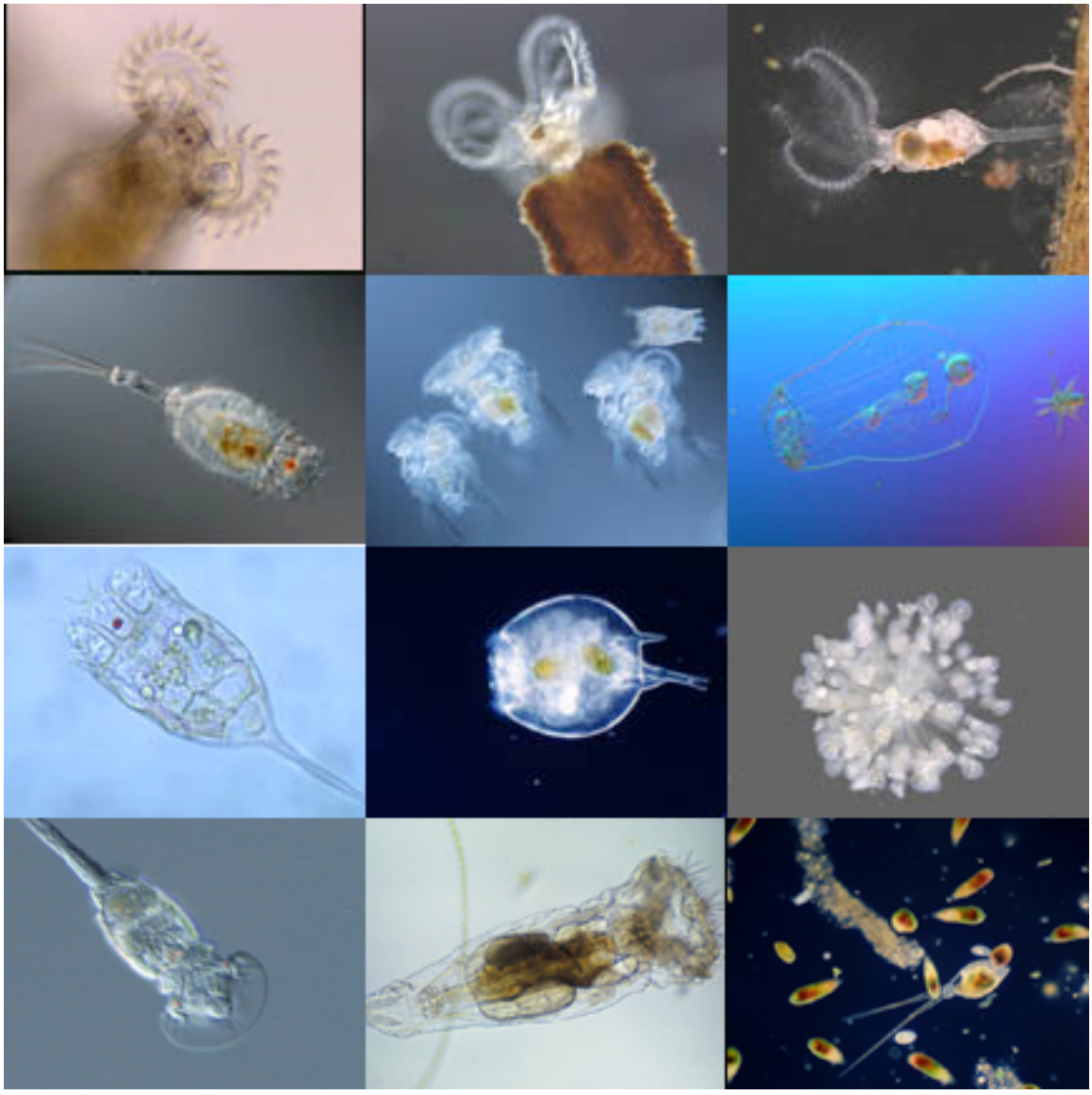
Protozoans are the first visible organisms to emerge from their **cysts**, the protective cases they produced when the moss dried out. Twenty minutes later, the single cells have been joined by some tiny animals that have come out of dormancy. These are **rotifers**, the smallest members of the animal kingdom.

The first person to see and describe rotifers was **Antony Van Leeuwenhoek** (lay-wen-hook) over 300 years ago.

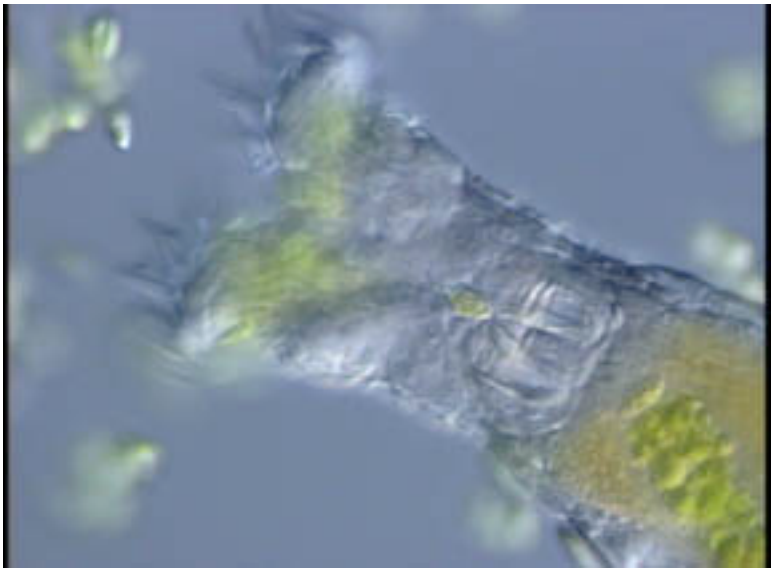
When Leeuwenhoek wanted to amaze his friends he would take them to a flowerpot on his porch, and with the eye of a sewing needle, pick up some scummy water from the big saucer that held the pot.

Then, using one of his single-lens microscopes, he would show them that the thin film of water in the needle's eye contained tiny living animals.

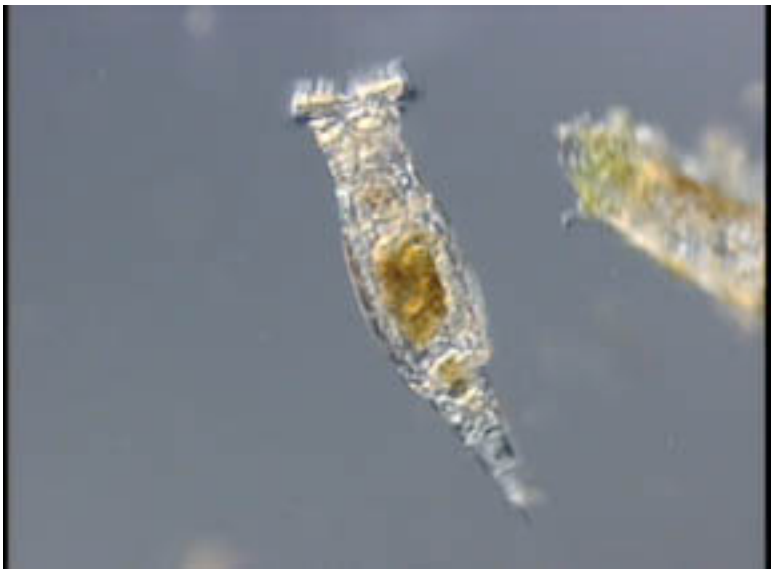
Closer, the little beasts appeared to have two sets of rotating wheels—an illusion produced by tufts of **cilia** that beat in a wave. The apparent rotation gave these animals their name—Rotifers.



Modern biologists have identified around two thousand kinds of rotifers in phylum Rotifera. A dozen of them are pictured above.

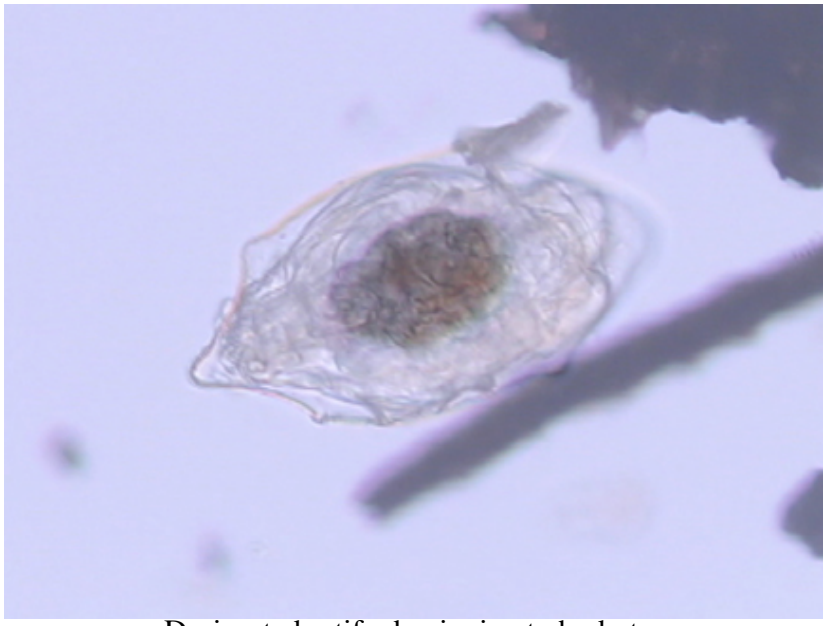


This rotifer is pulling in water from some distance. Swept up in the inflow is rotifer food – tiny **algae** cells and **bacteria**. The food is sorted and carried down a cilia-lined esophagus to the rotifer's grinding jaws; then it's on to the intestine where the food is digested. After the nutrients have been absorbed, the undigested material is eliminated.



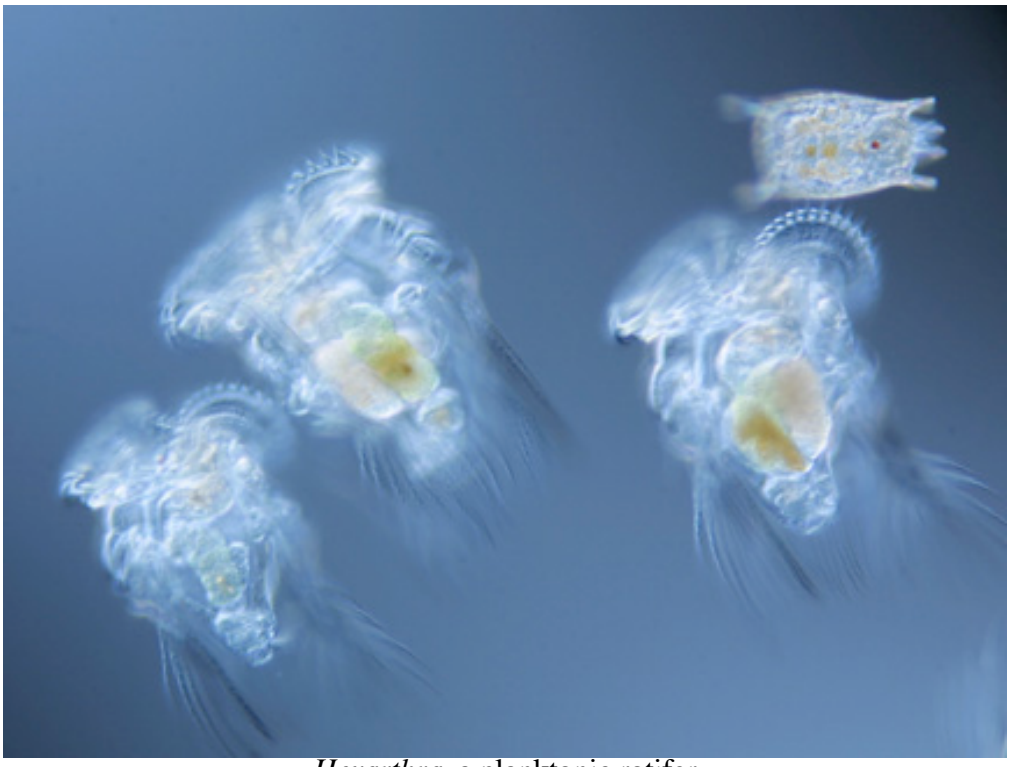
A rotifer will spend a lot of time on a good feeding station, anchored by its foot. But if disturbed the animals will release its hold and become a free-swimmer, propelled by its wheel organs. This species can also crawl over surfaces like an inchworm.

In rotifers, a lot of the internal space is taken up by reproductive organs that produce eggs. These eggs requires no sperm to develop into an embryonic rotifer. This kind of reproduction, where eggs develop into embryos without fertilization, is known as **parthenogenesis**. Without male genes, all of the embryos will become females.



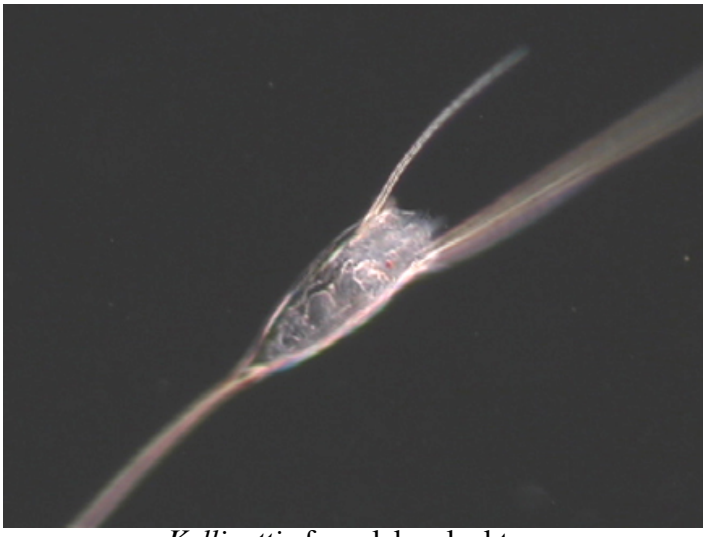
Desiccated rotifer beginning to hydrate.

Leeuwenhoek's flower pot would have eventually dried out – not the best environment for small water animals. If you can find a similar environment, scan the dried scum for desiccated rotifers. Just add water – and in minutes the dormant rotifer hydrates and comes to life.



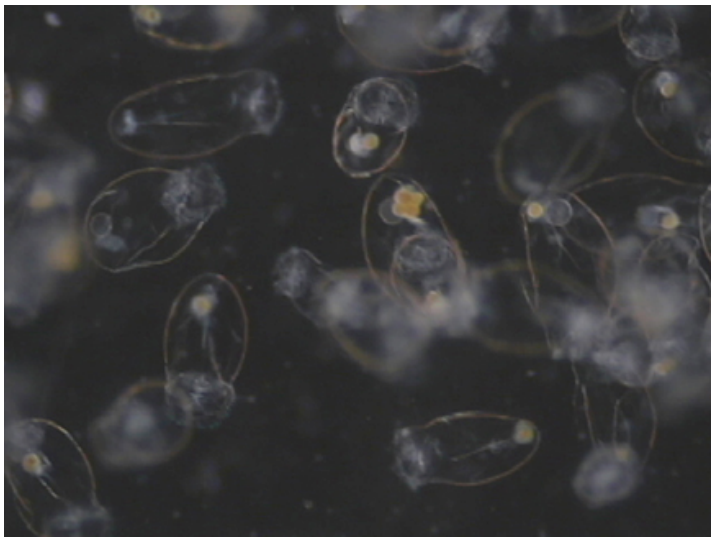
Hexarthra, a planktonic rotifer

In the open water, a touch can mean that you are about to become someone's snack, so at the slightest warning these rotifers flip their appendages and jump away – even if touched by one of their own kind the automatic response kicks in.

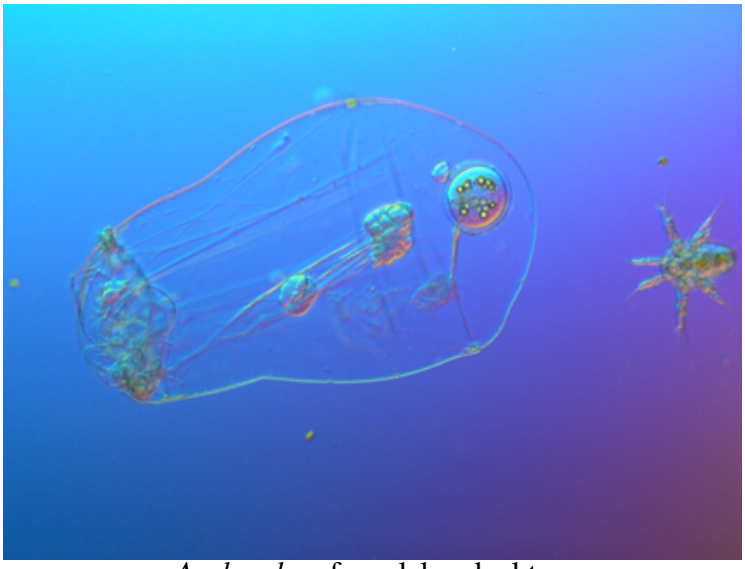


Kellicottia from lake plankton

This rotifer has evolved a different defense strategy – sharp spines. Spines have another use as well – they help slow the tiny animal's rate of sinking.

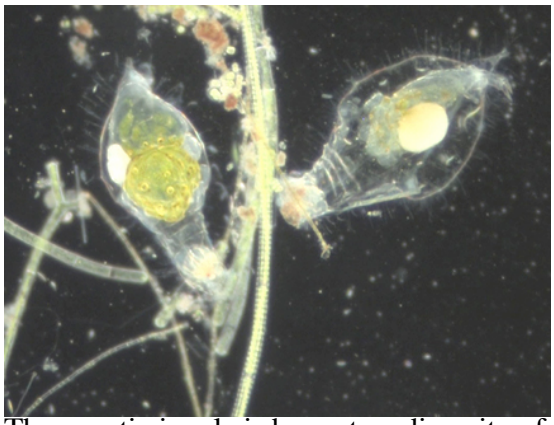


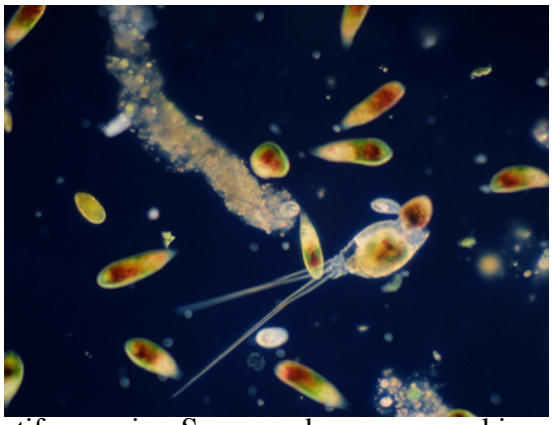
This deep-water species is virtually invisible in a world of dim, filtered light. Only the food in its gut gives it away. Fish may not be interested in such tiny specks, not realizing that the food is in the belly of a much larger organism.



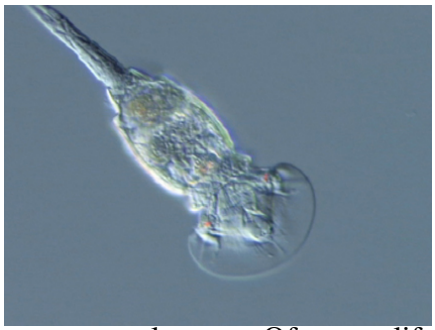
Asplanchna from lake plankton

Each species living in the open water has genetic traits that help it meet the challenges of planktonic life: quick reaction, spines, and cloaking devices are a few of the adaptations that allow these tiny animals to survive in the open water environment.

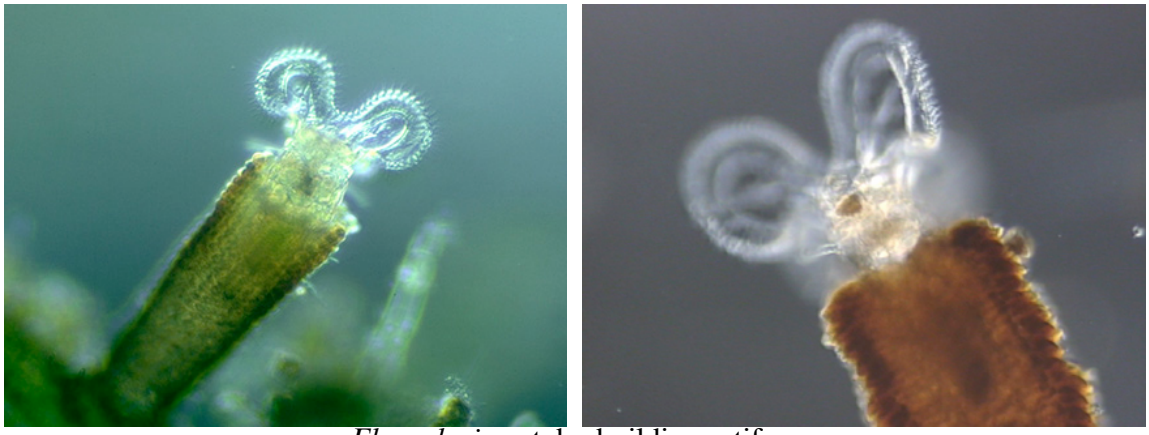




The aquatic jungle is home to a diversity of rotifer species. Some are browsers, working over the plant stems for algae cells and other tidbits. Some have a taste for red euglenoids.

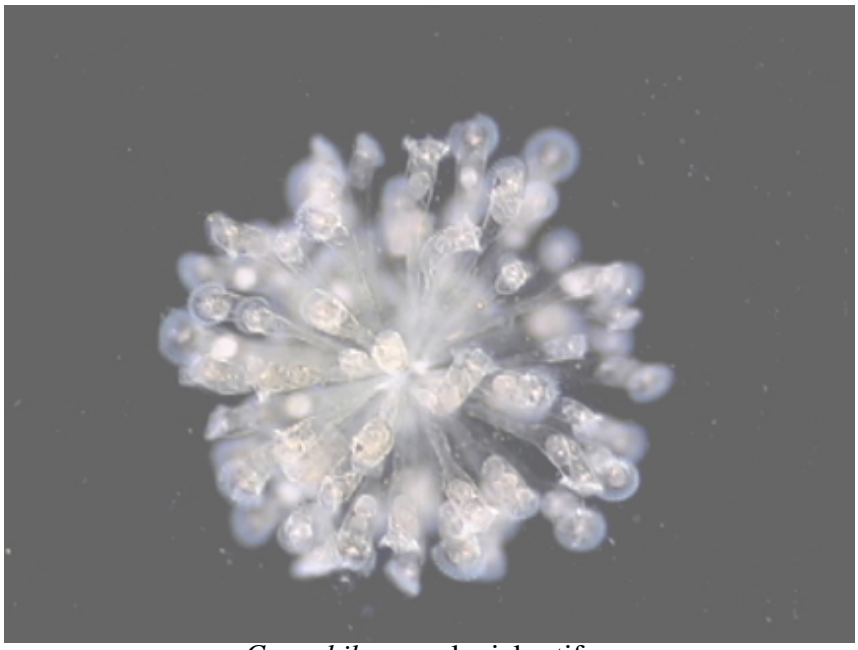


Others scour surfaces like tiny vacuum cleaners. Of course life in the weedy shallows is not without its own dangers. There are predators in these aquatic jungles that will snap up anything in this size range. It's a reality that has influenced the shape and behavior of the rotifers that live here.



Floscularia, a tube-building rotifer.

Floscularia avoids predation using "the third little pig's" defense – a house built of bricks. It mixes detritus particles with cement secreted from a gland, to make the bricks. Each brick is molded into shape by a special organ and cemented in place.

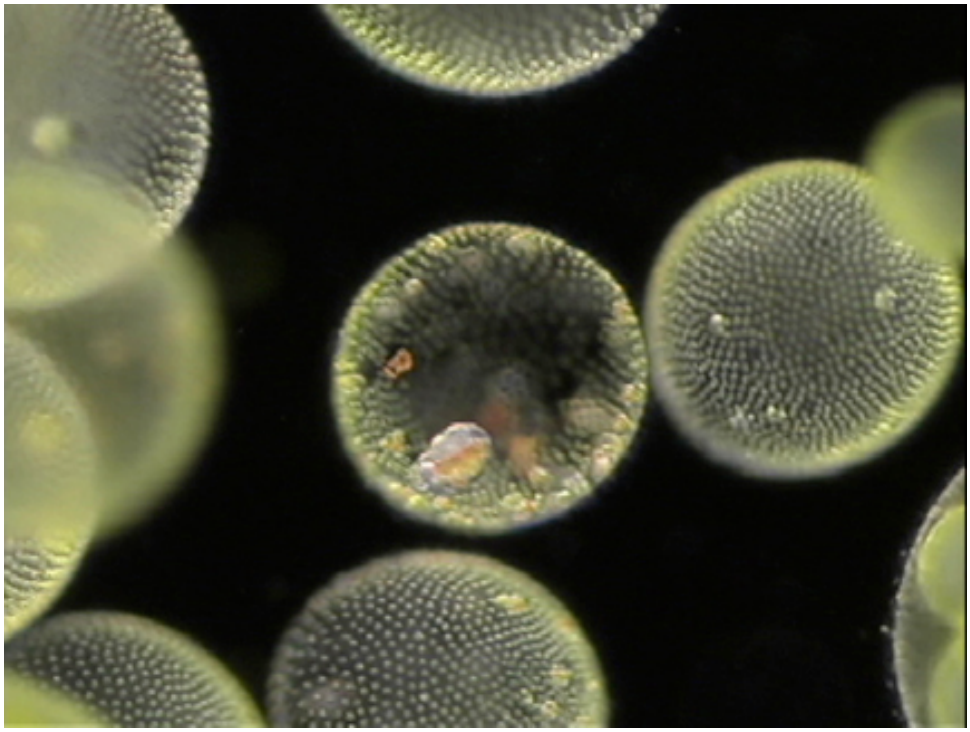


*Conochilu*s, a colonial rotifer.

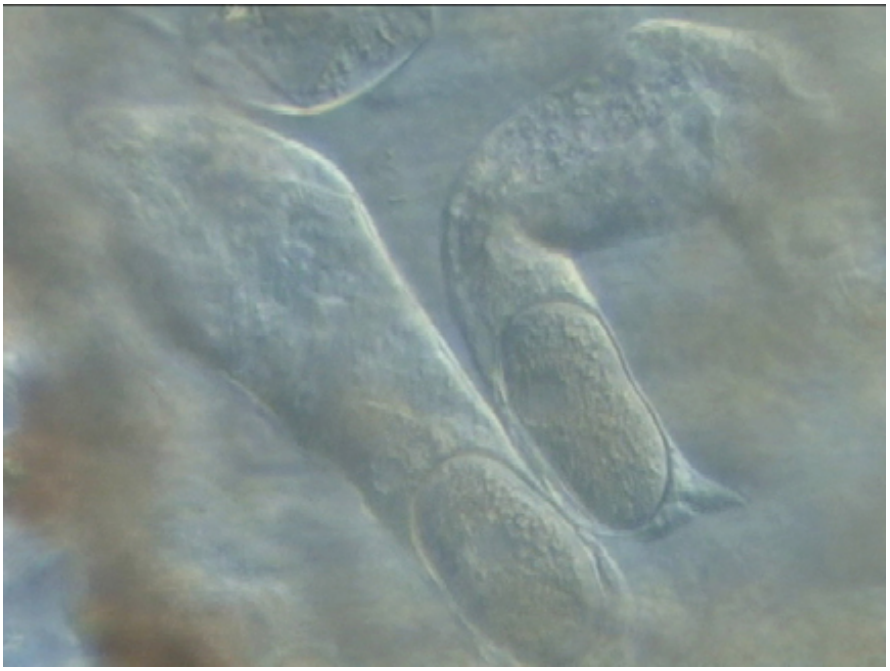
Another strategy for defense is safety-in-numbers. These colonial rotifers secrete a jelly-like substance that fills the center of the colony. If threatened the individuals can pull back into the protective jelly.

The colony grows through reproduction. Newly hatched embryos extend their foot and attach at the hub, where they soon grow into full colony members, ready to feed themselves and assist in producing the protective jelly.

This colony produces no jelly, but the activity of its members may be enough to discourage a predator.

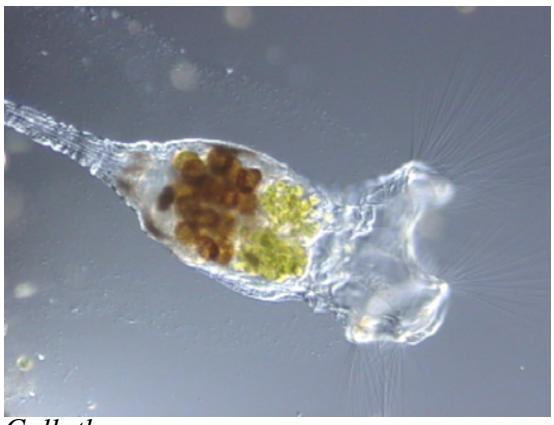


Few rotifers have become parasites, but we found two that have. One inhabits Volvox, eating its cells from the inside.



While filming a small water-worm, two parasites were spotted clinging to the inner wall of the intestine, each with a large egg. Questions for further investigation: does it feed on the intestinal lining, or does it simply feed on the predigested food? And, has it been classified and named?

The wheel organs that gave rotifers their name, are not found in all members of phylum Rotifera.



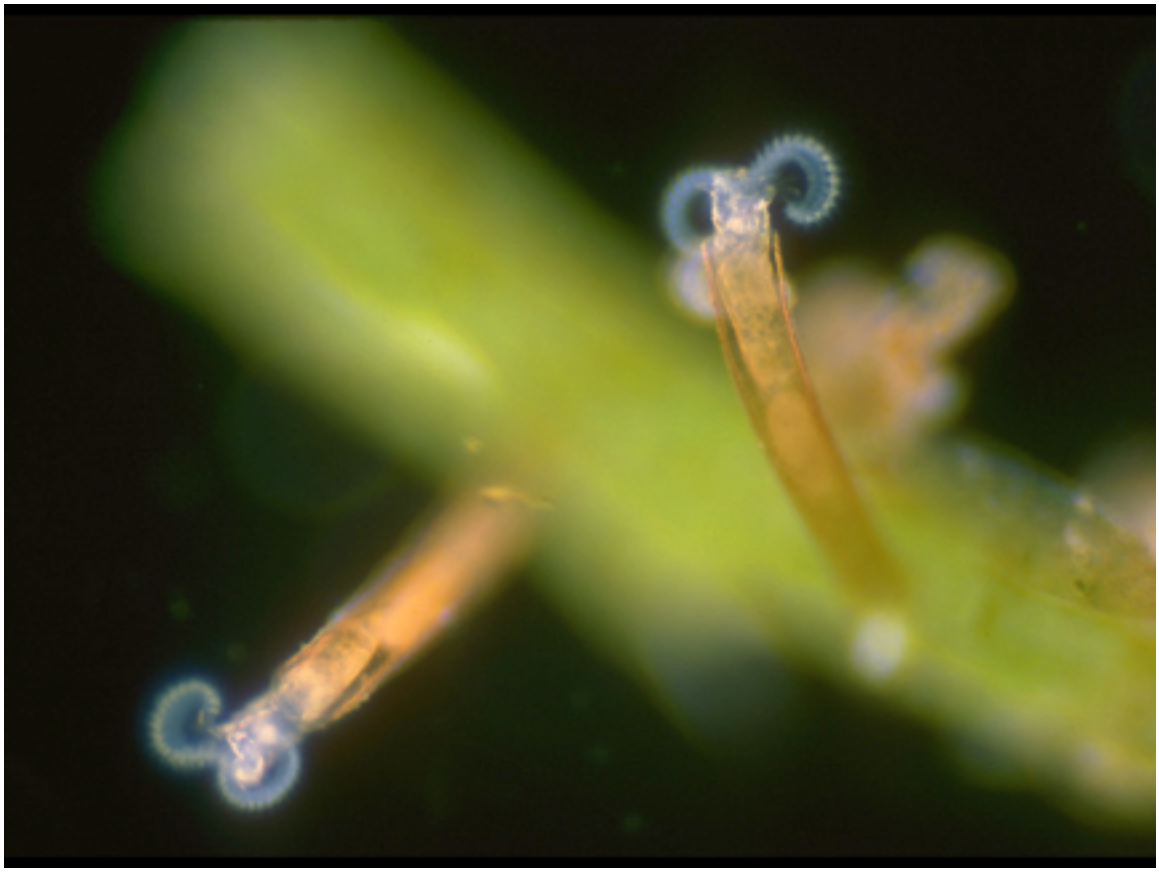
Collotheca

Stephanoceros

This rotifer uses flowing hairs to trap prey. A holding chamber gives the rotifer a chance to evaluate its meal before swallowing. Another extends five fingers, each covered with sensitive hairs that respond to the touch of prey, preventing swimmers from escaping.

Conclusion

Rotifers have been around a long time. Watching them you can imagine time-traveling back to a time when multicellular animals were just getting started.



Nematodes

Looking through the roof moss sample turns up roundworms, or **nematodes**. Moss clumps are prime nematode habitat, but these worms will be found just about anywhere you choose to look.

In ponds, the decomposing remains of plants and animals swarm with roundworms.

They multiply in such inhospitable habitats as vinegar.

You might even find one in your sushi – a reminder that many kinds of nematodes are **parasites** of animals.

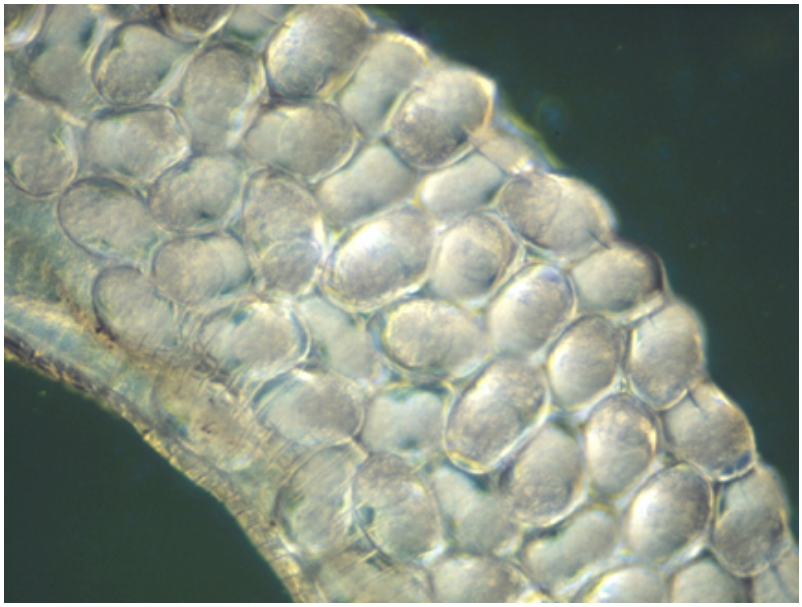
One thing that makes these diverse lifestyles possible is a body form that fits just about anywhere. Nematodes easily slither through mats of organic material, nibbling off a bit of food here and there.

Nematode anatomy

A nematode's body is a "tube within a tube." The outer tube made up of skin and muscles, the inner tube – a straight intestine with an anus at the rear.

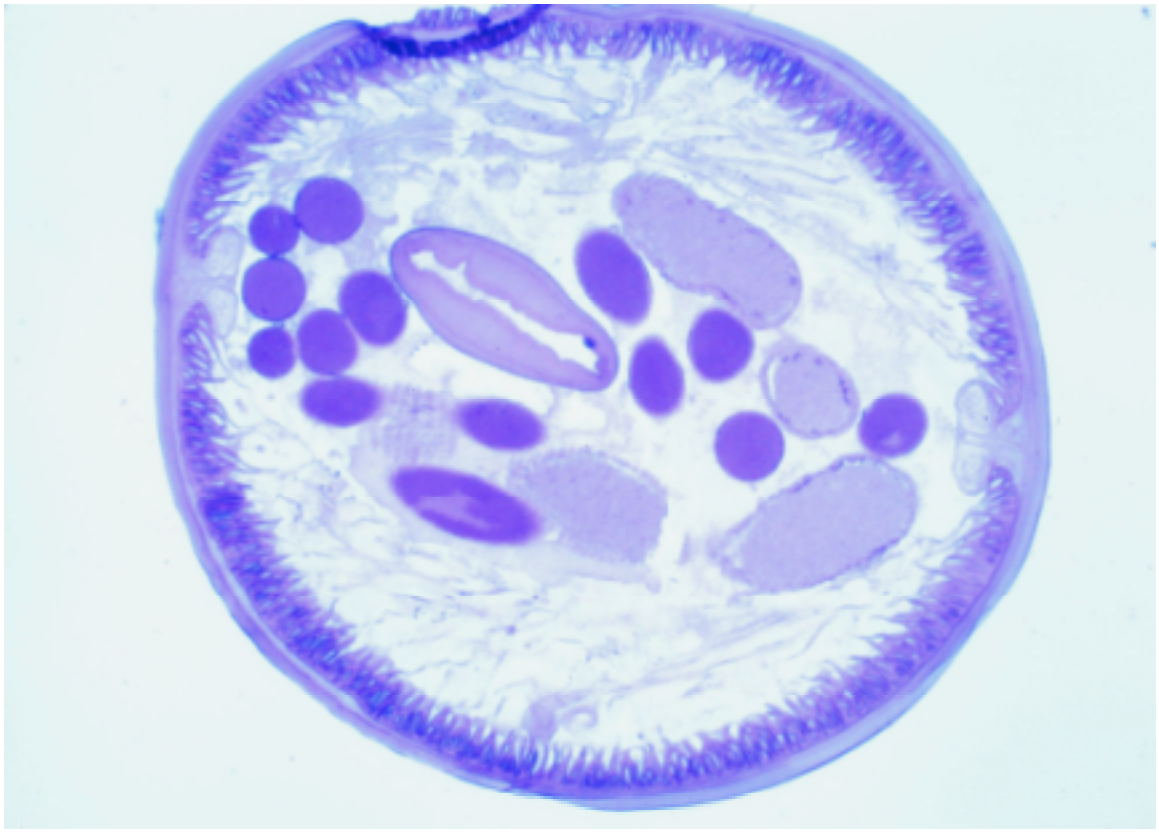
Behind the mouth, a muscular pharynx grinds the meal and passes it on to the intestine for digestion. Nutrient molecules released by digestion pass through the gut wall into a fluid that bathes the worm's cells.

In female worms, **ovaries** lie along the digestive tract, with a special **pore** for mating.



In many kinds of nematodes the **eggs** are simply spewed out. In others, they hatch in the worm's uterus and the young are born alive.

A cross section through a nematode shows its tube within a tube construction and the structures that make locomotion possible.

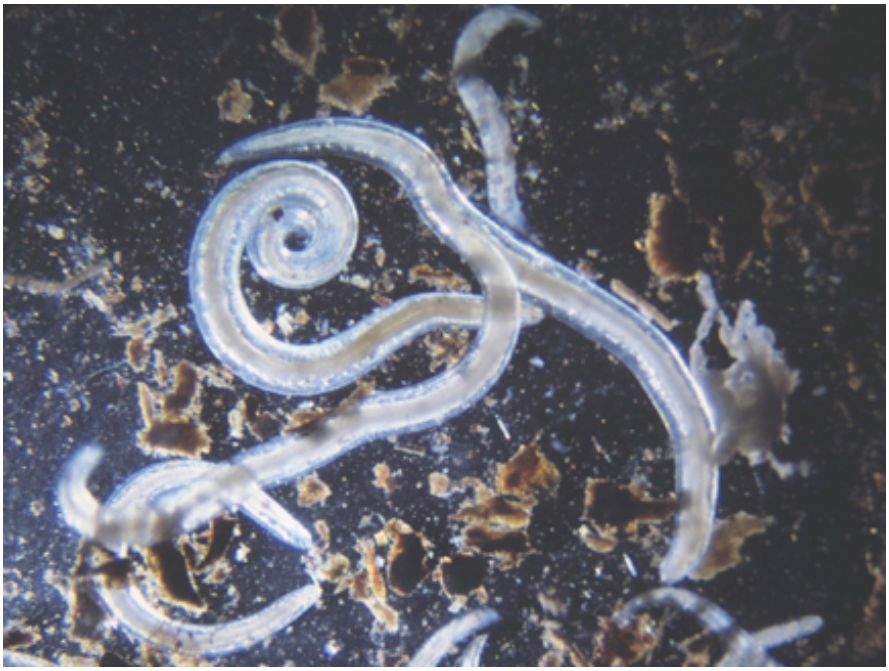


The section reveals: outer cuticle, epidermis, and beneath, rows of **muscles**.

These muscles, controlled by nerves that run the length of the worm, make possible “the nematode wiggle.”

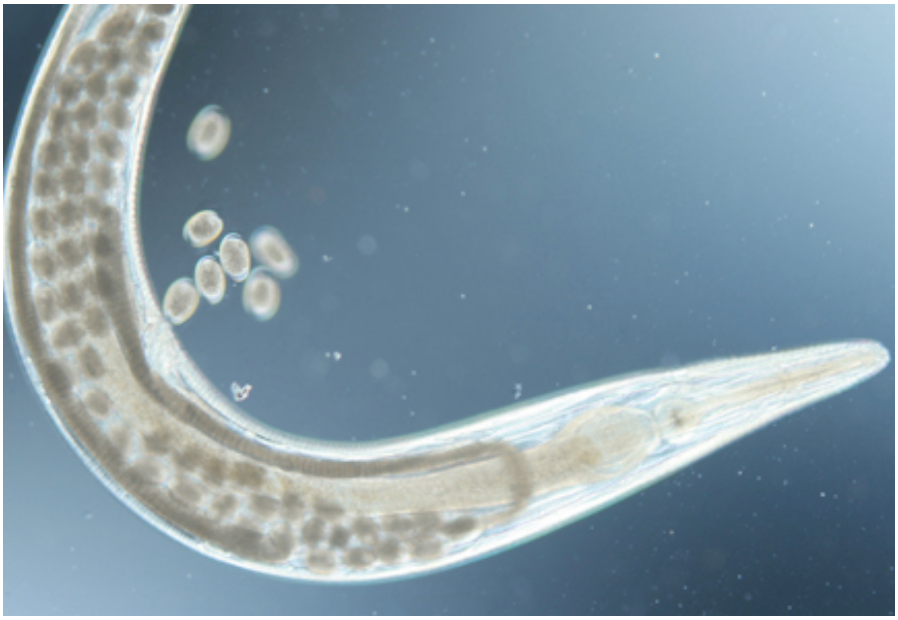
Plants are at risk of damage by nematodes. Many a fine tomato plant has wilted and died under roundworm attack.

Nor have animals escaped the nematode invaders. Take the common millipede, an inhabitant of moldering leaf piles.



The millipede’s intestine is filled with digesting leaf material, but also with nematodes that make their home here, feeding on predigested scraps and bacteria.

The relationship between the millipede and its intestinal guests probably began when some free-living round worms were accidentally eaten and survived the millipede's digestive enzymes, gaining access to a rich concentration of predigested food.



The worms become permanent residents. Only their eggs leave the intestine where they can be accidentally ingested by another millipede.

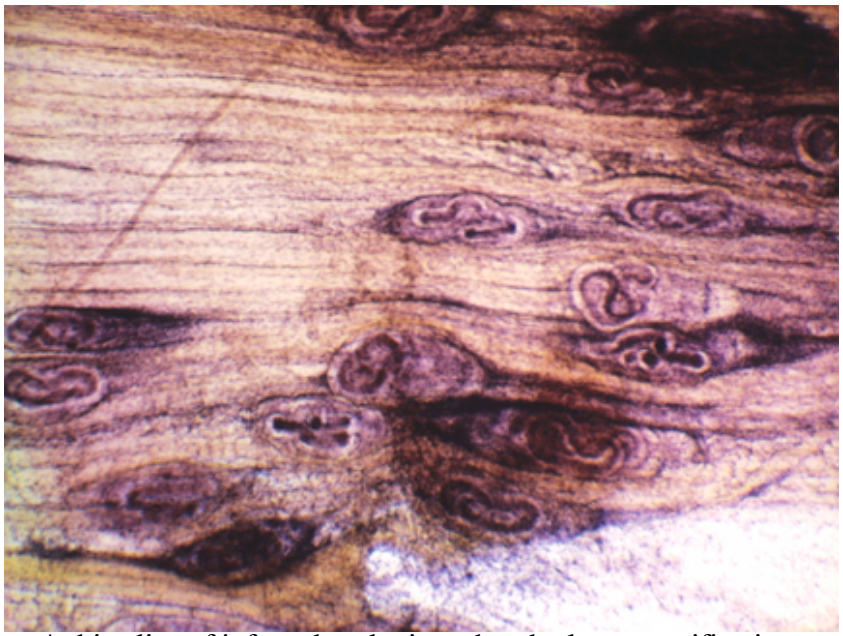
Human pinworms are an itchy nuisance familiar to just about everyone. Pinworms live in the large intestine where they feed on bacteria and the partially digested bits of food that accumulate in the rectum awaiting elimination. Pinworms cause a behavioral response in their human host that insures their own reproduction and dispersal to other humans. They crawl around the anal opening, laying eggs and irritating the sensitive anal tissue. This causes itching – and scratching. Thus eggs get transferred from hand to mouth, re-infecting their host, or another person through contaminated food.

Pinworms are relatively harmless parasites, but there are worms out there you don't want to step on. The larvae of hookworms can burrow through skin. Humans become infected by contact with fecal-contaminated ground.

The hookworm larvae travel through blood vessels to reach the lungs, where they are coughed up and swallowed.

Using their sharp cutting mouth parts they eat into the intestine wall. Complications are severe blood loss, and wounds that allow bacteria to enter the blood stream. Female hookworms convert most of their blood meal into eggs and larvae – ready to infect another person, should her host's feces be deposited on the ground.

The next nematode in our short list of worms to avoid requires the eating of a bit of undercooked pork.

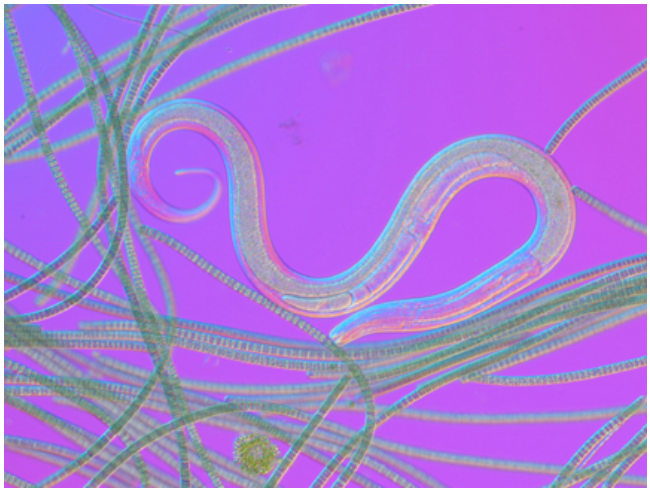


A thin slice of infected pork viewed under low magnification.

Swallowed by a human, the encysted worms are released by digestion, and develop into adults that mate and produce thousands of **larvae** that penetrate the intestinal wall and

travel to the muscles where they form cysts a painful and potentially deadly experience for the human victim of **trichinosis**.

Parasitic nematodes are a major health problem in some parts of the world, but most roundworm species live unseen lives in soils, ponds and oceans. To get better acquainted with this branch on the tree of life, along with rotifers and some other tiny animals, all you need is a pinch of moss.



Notes

This program combines **Rotifers** and **Nematodes,** although the two evolutionary lines are not closely related. Both groups are, however, excellent examples of **pseudocoelomate** animals. In pseudocoelomates, the organs float in a cavity (the pseudocoelome) defined by outer layers of **ectoderm** and **mesoderm**. In true coelomate animals, the organs are part of the mesoderm.

Collecting Rotifers

To collect and study some of the most interesting rotifers requires a net. If asmall plankton net isn't available, an old nylon stocking attached to a coat hanger frame will collect planktonic species such as *Hexarthra* and *Asplanchna* (the sac-like transparent rotifer shown in the program). For species living in the weedy shallows, rinse aquatic vegetation into a jar and examine the fallout with a stereo dissecting microscope, or the lowest power objective of a laboratory microscope. You are sure to find a diversity of rotifers along with **gastrotrichs**, another phylum of microscopic water animals.

A useful reference for identifying microscopic water animals, along with protists and bacteria is Rainis and Russell, *Guide to Microlife* from Grolier Publishing, available from Amazon.com and others.

Notes on Nematodes

Nematodes are possibly the most numerous animals on earth. It's been said that if everything else were to disappear, you could get a good idea of what the biosphere was like, each feature seen as a cloud of nematodes.

To find free-living nematodes look in compost piles, wet leaf litter, aquarium filters and moss clumps. Even dry tree moss will usually contain desiccated nematodes that hydrate and start wiggling a few minutes after adding water.

Although most nematode species are free-living, parasitic nematodes get most of the attention, and for good reason. Intestinal nematodes such as **pinworms**, **whip worms**, and **ascarid** worms are found in all populations of humans and their domestic animals. But the tropics are home to the most devastating parasitic nematodes. Two famous ones are **guinea** worms, and the filarial worms that cause **elephantiasis**.

Guinea worms live in the lymph passages, and grow to four feet in length but barely more than a millimeter in diameter. The tail of the female protrudes through the skin and upon contact with water, squirts out thousands of wiggling larval worms. The tiny worms are eaten by **copepods**. When the copepod is accidentally swallowed with drinking water, the embryonic worm emerges from the digesting copepod, burrows through the gut wall, and takes up residence in the lymph passages where it grows and grows and grows. The folk remedy is to gently wind the worm onto a stick being careful not to break it, causing its death and often the host's death as well, brought on by blood poisoning when the guinea worm's carcass decomposes. The simple preventive is to filter copepods from the drinking water.

Filarial worms are carried from human to human by mosquitoes. They mature in the lymph passages, in time clogging them and producing the grotesque swellings of elephantiasis. The adult worms mate and produce huge numbers of microscopic larvae that are released in the blood where they are picked up by the mosquito vector. A familiar filarial worm in North America is dog **heartworm**, also carried by mosquitoes.

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