BioMEDIA ASSOCIATES
Learning Programs for Biology Education

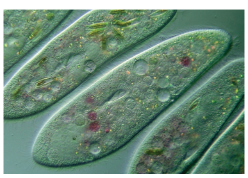
The Biology Classics

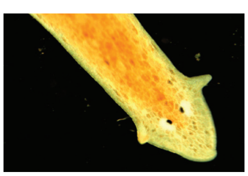
Observation and Examination of Four Classic Organisms
Image and Teaching Guide for DVD and Video Program

Understanding the amazing phenomena of life requires an intimate acquaintance with living things.

This Image/Teaching Guide and the program it accompanies introduces students to four organisms we call The Biology Classics, "classics" not only because they are featured in science textbooks, but because studying them broadens our concept of what it means to be alive.

The Biology Classics can be used in Middle School Science, High School Biology, and classes everywhere living organisms are studied.





The Biology Classics: Paramecium, Hydra, Planaria, Daphnia ©2006 31 minutes Digital Media Files,
DVD Subtitled Enabled ISBN 1-930527-12-8, VHS Closed Captioned ISBN 1-930527-11-X

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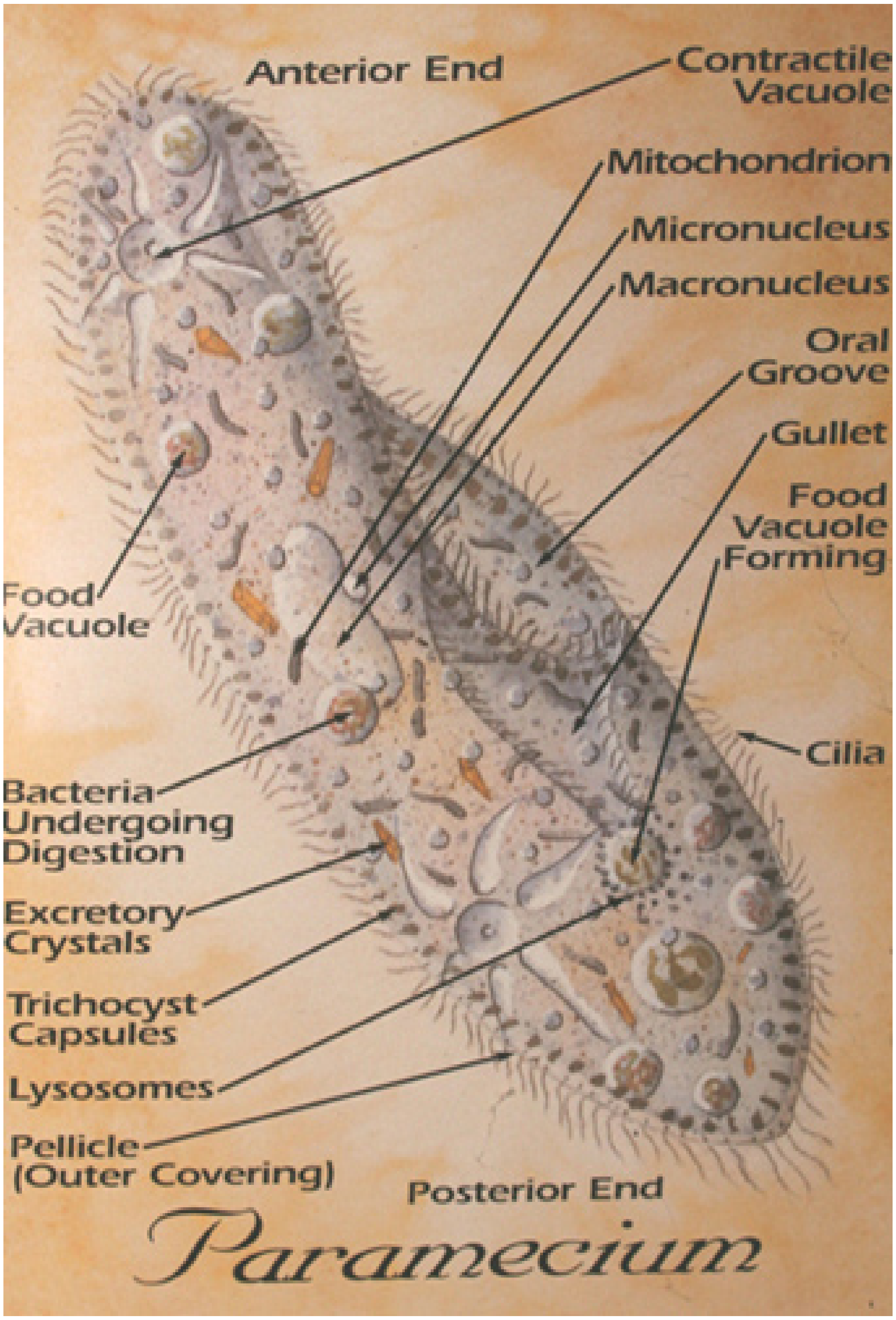
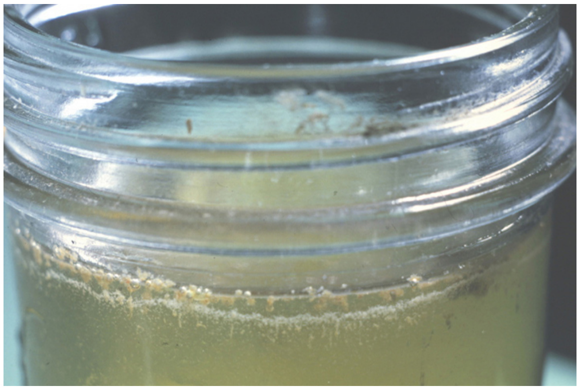
Paramecium



Paramecium makes a great model for introducing students to micro-organisms as well as making a wonderful subject for studying cellular processes. The video observations show processes in action, while the image bank can be used to discuss some of the key structures, either before viewing the observation, or as a review.

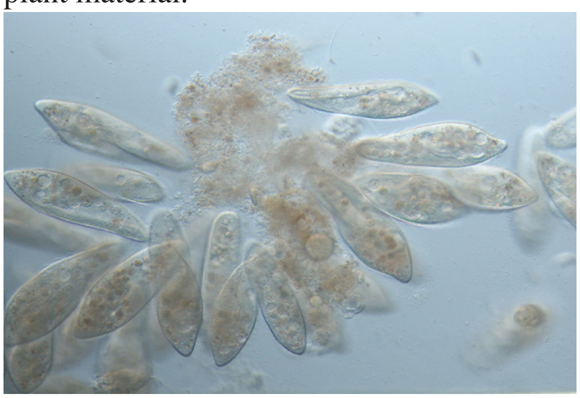
Paramecium responses

1. Jar culture of *Paramecium* containing pond water and decaying vegetation.



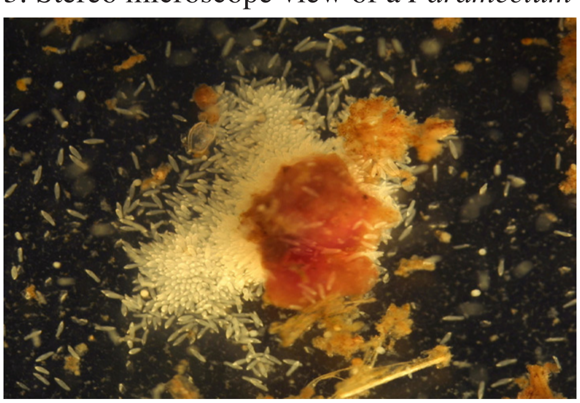
Note the white ring of paramecia just beneath the surface. What are the organisms responding to, causing them to congregate in this way?

2. *Paramecium caudatum* surrounding a bit of decaying plant material.



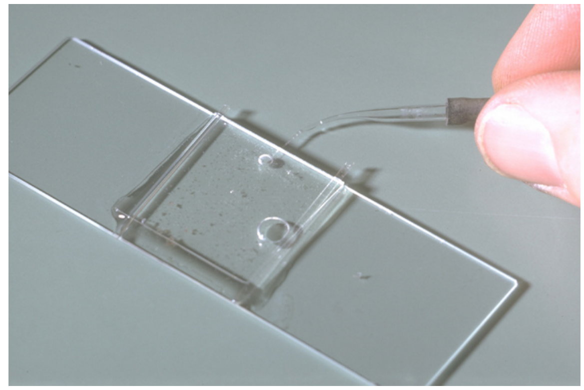
On what are they feeding?
Is it on the organic material, or on something else?

3. Stereo microscope view of a *Paramecium* aggregation.



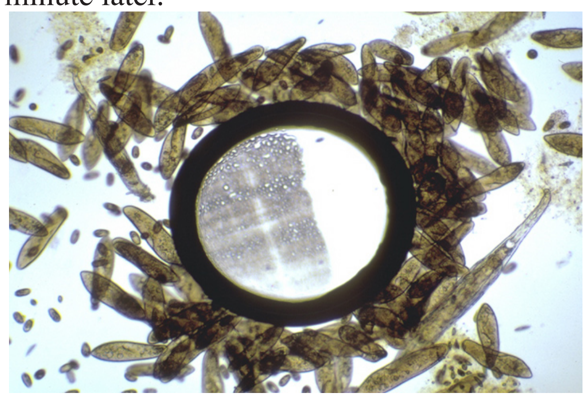
What might cause the organisms to clump in this way?

4. Placing a bubble of CO_2 in a drop of *Paramecium* culture.



Note the coverglass is supported on pieces of capillary tube for ease of introducing the bubble. This also creates a gymnasium scale space for *Paramecium,* allowing the cells to swim freely.

5. Low magnification view of CO_2 bubble one minute later.

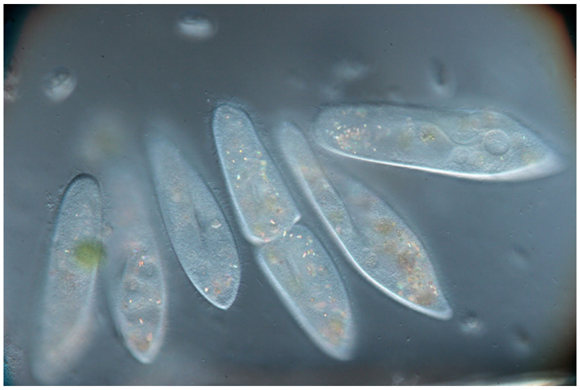


6. A bubble of air creeps under the edge of the coverglass.

In this dark field shot, what might the organisms be responding to? How would you test your hypothesis?

Four Commonly Found Species

7. *Paramecium caudatum*, live (average size 200μ)

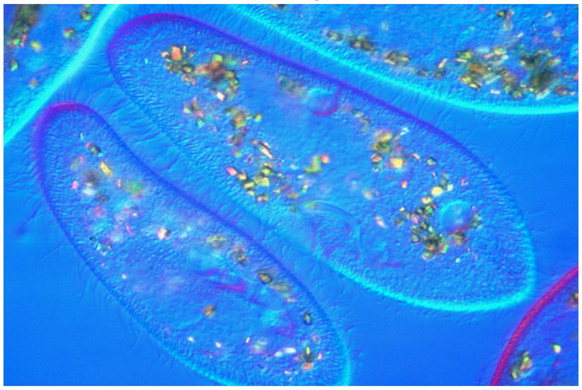


This species, with its characteristic slipper shape, is the one often shown in textbooks. During division, new cell organelles are produced and the macronucleus constricts in the middle. The two halves separate with one going to each new daughter cell. The micronucleus divides by the more precise process of mitosis and the resulting nuclei go to each daughter. What factors might affect the rate of division in these large cells?

8. *P. trichium*, live (average size 90μ)

This species is often found in putrid cultures. The individual shown has been lightly stained with neutral red, an indicator dye that turns red in acids. What function might acid production have in these cells?

9. *P. aurelia*, live (average size 150μ)



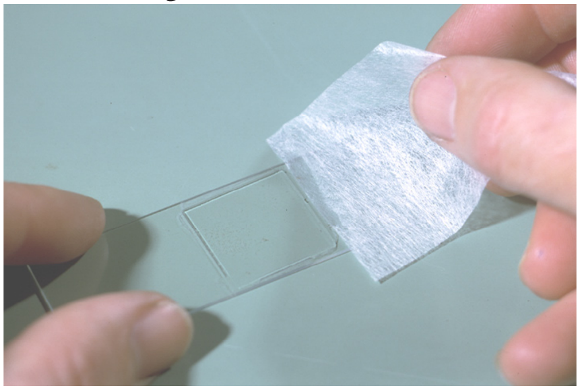
This species is often found in rotting plant infusions. The photo shows Paramecium's method of dealing with certain metabolic waste products that could harm the cell if they were allowed to stay in solution. The wastes are crystallized and show up as bright sharp-edged structures when viewed between crossed polarizers. An easy way to achieve polarized lighting it to remove the lenses from an inexpensive pair of Polaroid sunglasses, place one over the light source, and the other over the eyepiece. The trick is to rotate the lower polarizer until the field turns dark, indicating that the polarizers are in the crosses position.

10. *P. bursaria*, live (average size 100μ)

The green Paramecium is host to the symbiotic alga, *Chlorella*. Unlike other Paramecium species, *P. bursaria* moves toward light and is often found on the side of a culture jar facing a window. What advantage might be gained from this behavior?

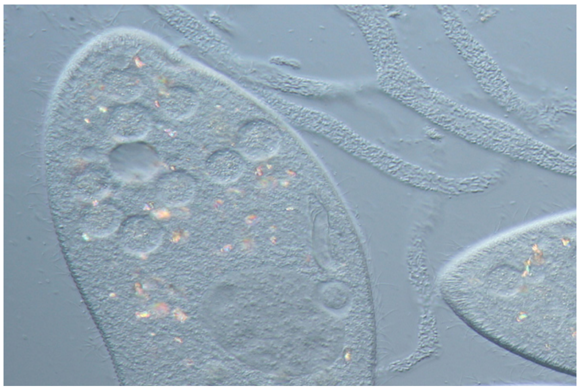
Paramecium Cellular Structures and Processes

11. Flattening the cells



The best way to see cell structure in a living *Paramecium* is to slightly flatten the organism. This not only restrains the cell, but spreads out the cytoplasm so that the organelles are more easily obscured. An easy way to flatten the cells is to wick water from under the coverglass using a bit of tissue paper. As the coverglass lowers, it's important to watch the cells in order not to go too far, squashing them. Water will continue to evaporate from around the edges of the coverglass, so for prolonged study, seal the edges with warm petroleum jelly

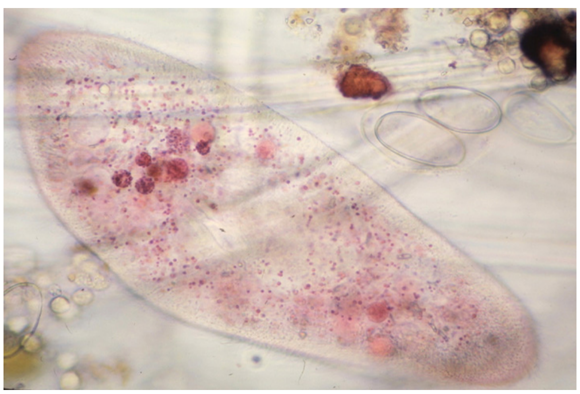
12. Flattened *Paramecium*, food vacuole content



A restrained *Paramecium* shows the mouth (cytostome) and a number of food vacuoles, the content of which shows what they have been eating—bacteria.

Are these the same bacteria making up the bacterial strands seen nearby? The video observation shows how *Paramecium* feeds, and how food vacuoles are produced. Why is it necessary to isolate the digestive process in food vacuoles?

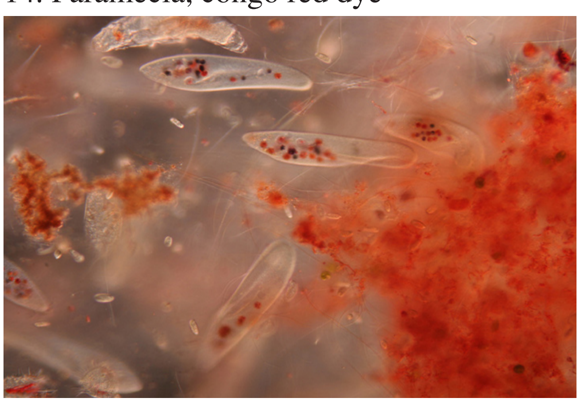
13. *Paramecium* stained with neutral red



In this bright field view, acidic regions of the living cell show up red due to use of the vital stain, neutral red. The smallest bodies are lysosomes, the cell organelles that ferry digestive enzymes and acids from their manufacture point (the golgi apparatus) to food vacuoles.

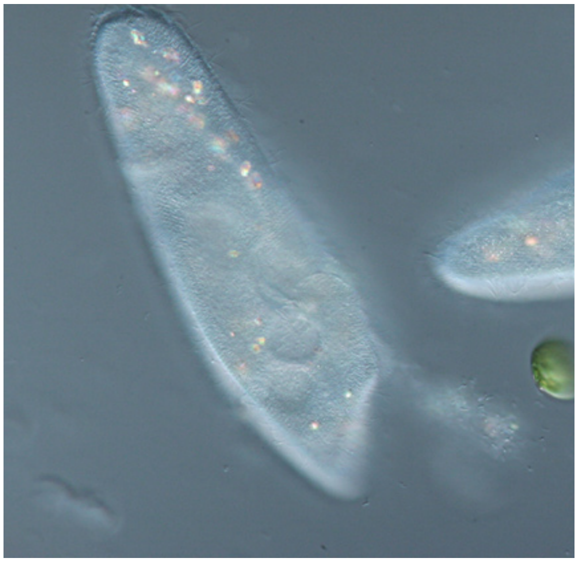
If lysosomes were to leak, what would happen to the cell?

14. Paramecia, congo red dye



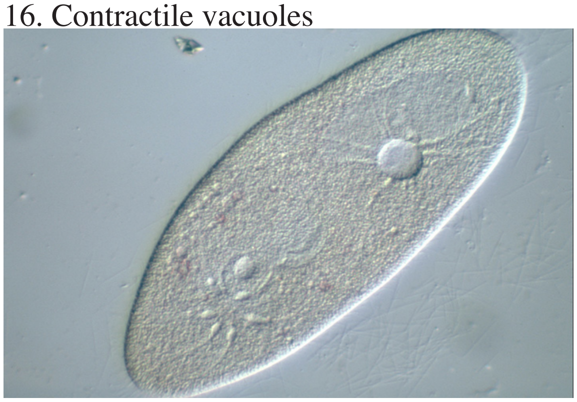
Another way to visualize food vacuoles is to mix a tiny amount of congo red dye into a drop of paramecia on a microscope slide.

15. *Paramecium* defecates



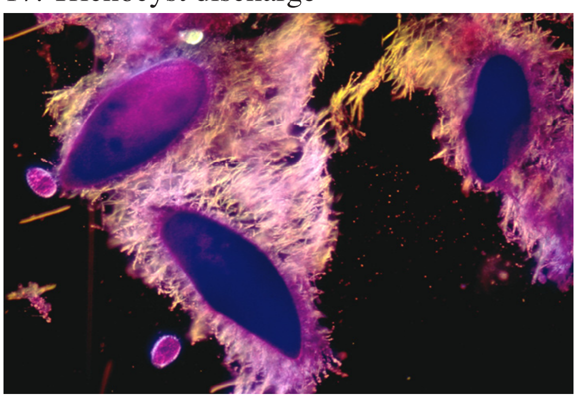
Following digestion and absorption of the nutrients into the cytoplasm there may be undigested material left in a food vacuole (bacteria cell walls, for example). Food vacuoles migrate to an anal pore near the posterior end of the cell and squirt out the stuff—the process of cellular defecation. Rid of its cargo, the vacuole membrane rejoins the cell's outer membrane.

16. Contractile vacuoles



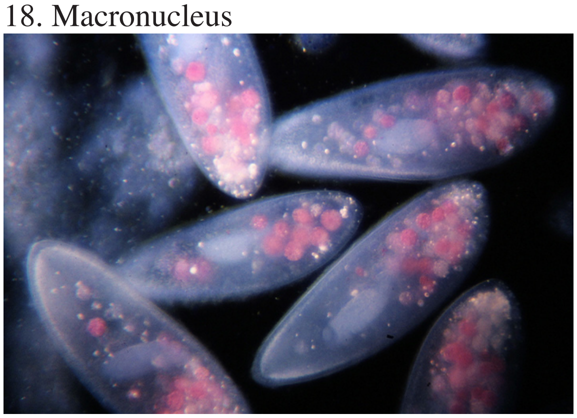
A cell living in fresh water must deal with water entering the cell by osmosis. Contractile vacuoles at each end of *Paramecium* squirt water back into the pond.

17. Trichocyst discharge



Trichocysts are paramecium's defensive weapons. The encapsulated trichocysts fire upon contact with a predator, and also when encountering harmful substances such as crystal violet dye as shown here.

18. Macronucleus



Dark field images of *Paramecium* show the macronucleus—the large bluish structure.

19. Micronucleus

A flattened *P.trichium* shows the micronucleus tucked into an indent in the macronucleus. The micronucleus contains a pristine set of chromosomes used in sexual reproduction. The macronucleus holds many copies of each chromosome. During fission the macronucleus simply pulls apart with each daughter cell receiving at least some copies of each chromosome. However, after many generations of random parceling out of chromosomes, and imbalance can occur, which along the buildup of mutations and viruses, causes the cells to sicken. This is where sex enters *Paramecium's* life cycle.

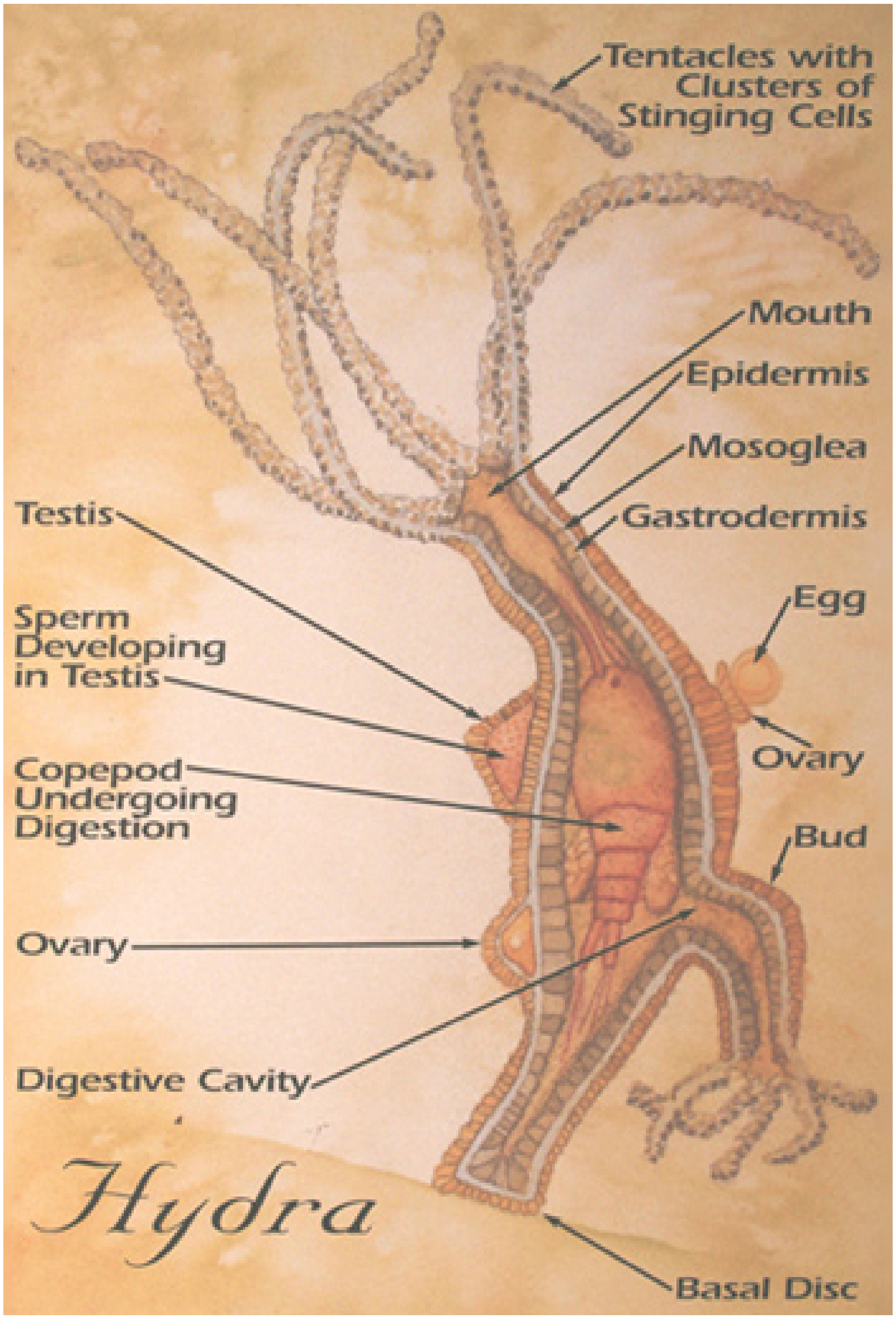
20. Conjugating paramecia

This conjugating pair of paramecia are exchange micronuclei. The cells part and each produces a new macronuclei derived from the sexually transferred micronuclei. This jumpstarts the population, which may then go on for another hundred or so generations of asexual reproduction before requiring another genetic recharge.

Photographs by Bruce J. Russell
Illustrated Organisms by Leslie Russell
For more observations on *Paramecium* and other ciliated protozoans
see the BioMEDIA program, **Branches on the Tree of Life: Protists**.
Preview 16 programs from **Branches on the Tree of Life** at www.eBioMEDIA.com

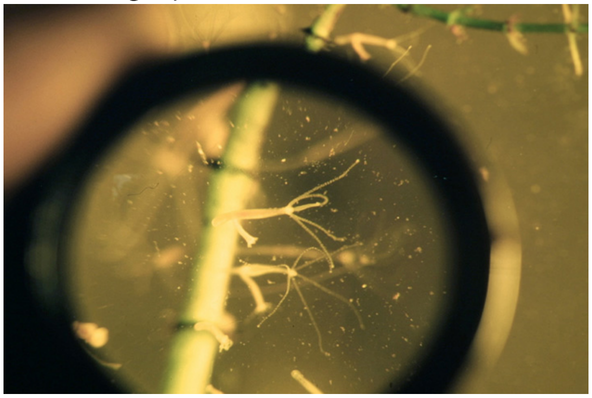
The Biology Classics

Hydra



Hydra belongs to phylum Cnidaria, a branch of life that includes jellyfish, sea anemones and corals. It preys on small water animals such as copepods and waterfleas, capturing them using tentacles armed with stinging cells.

1. Viewing *Hydra* with a hand lens

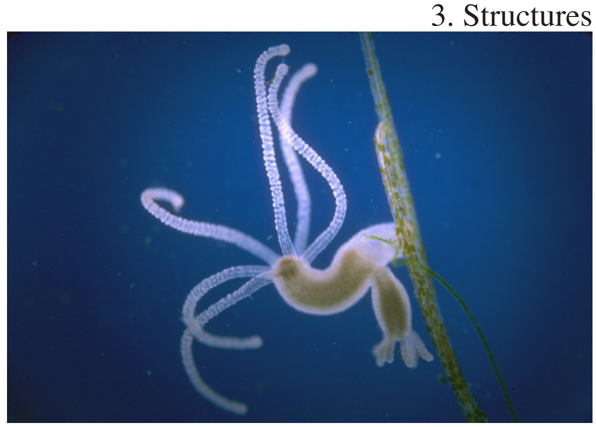


To find hydras, collect aquatic vegetation in a jar. Wait for the organisms to attach to the glass where they can be observed with a hand lens, or picked up with a dropper for microscopic examination.

2. *Hydra*, two cell layers

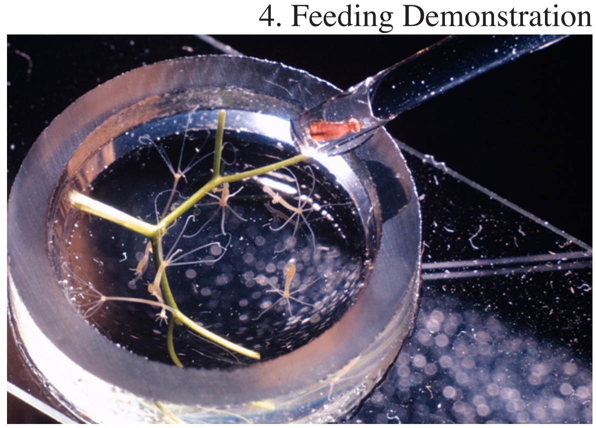
The bodies of hydras and other cnidarians are composed of two cell layers. The outer cell layer, ectoderm, contains elastic cells that allow hydras to drastically change their shapes. The video observation shows how *Hydra* contracts its ectoderm layer helping to mix and churn it meals. The inner cell layer lining the gut (endoderm) contains gland cells that produce acids and digestive enzymes. Between the ectoderm and endoderm is a lining of non-cellular, jelly-like material known as mesoglea. The endoderm layer contains phagocytic cells that engulf bits of partially digested food, finishing off the job in food vacuoles. Nutrient molecules released by digestion are absorbed directly by the endoderm cells. Thus, *Hydra* has two ways of breaking down food: pouring digestive enzymes into a digestive cavity (extracellular digestion, the method used by most higher animals), and by phagocytosis (intracellular digestion, the method used by single celled life-forms such as Amoeba and Paramecium).

3. Structures



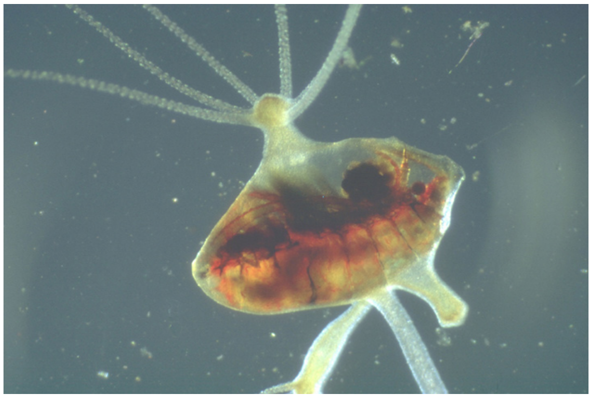
Hydra has a net-like nervous system that allows it to respond to stimuli. The mouth is extremely elastic, able to stretch around prey animals larger than the hydra itself. Surrounding the mouth are tentacles covered with knots of stinging cells that fire on contact with a prey animal. *Hydra* attaches to objects in the water by means of a basal disc, but how the attachment is actually achieved is not fully understood, but thought to involve both suction and an adhesive.

4. Feeding Demonstration



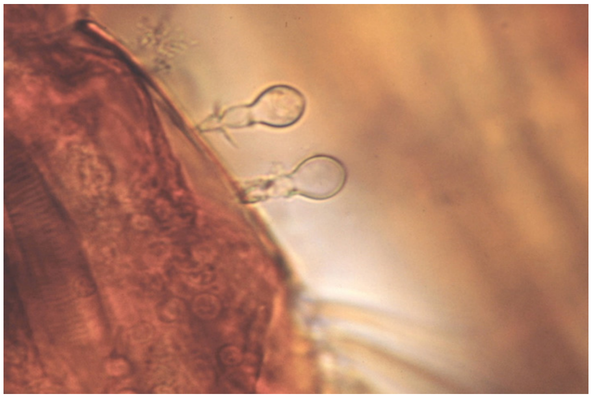
We added a large red copepod to a chamber containing several hydras to see if engulfing such a large prey animal was possible.

5. Copepod Engested



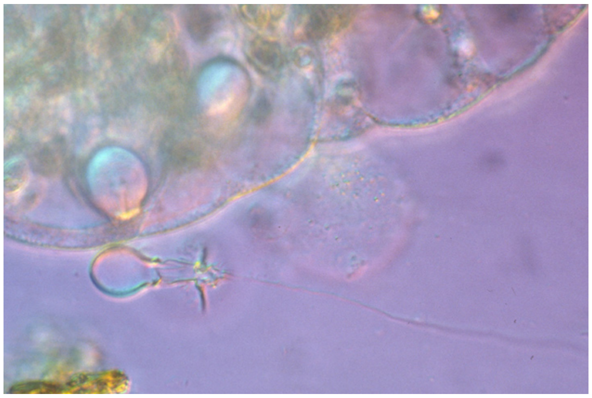
It ate the whole thing.
Twelve hours later the well-cleaned exoskeleton of the copepod was regurgitated.

6. Nematocysts darts



Harpoon-like nematocysts with adhesive threads paralyzed and held the prey for swallowing.

7. Nematocysts fired



The encapsulated stinging cells are shown along with one that has fired. Stinging cells (nematocysts) have trigger hairs that cause them to fire upon contact with appropriate prey animals.

8. Capturing a Daphnia

This huge meal was swallowed sideways.

9. Swallowing a mosquito larva

Hydras are versatile predators, able to feed on small insect larvae, worms, and micro-crustaceans such as waterfleas and copepods.

10. Asexual reproduction by budding

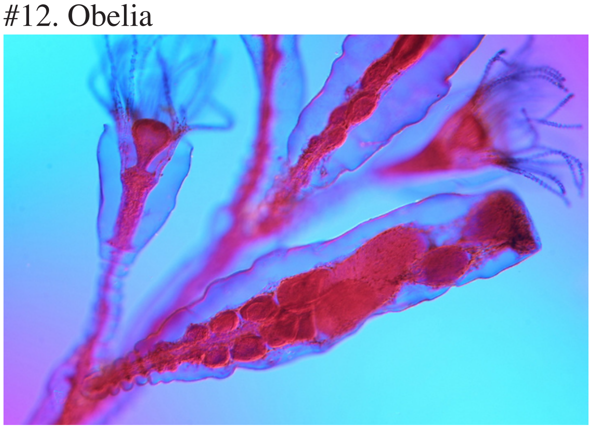
Hydra buds off new individuals from its lower body wall. The digestive cavities remain open and connected with the parent's digestive cavity until the new individuals are ready to break free and begin their independent lives.

11. Green hydras (Chlorohydra)

The green color is due to hundreds of algae cells living in the hydra's tissue.

What benefits might each partner get from their symbiotic relationship?

#12. Obelia



Marine docks are often covered by a furry growth of Obelia, a colonial hydroid made up of hydra-like feeding polyps and reproductive polyps that produce free swimming medusae, the sexual stage that disperses Obelia along the coast line.

Study *Hydra* at School

One of the best methods for finding *Hydra* is to collect water plants from a permanent pond in a clean glass jar. Keep the jar near a window, but out of direct sunlight. Hydras often leave their aquatic jungle and attach to the glass where there are easily seen when the jar is lit from behind. (Green hydras will collect on the side of the jar facing the window.) Once located, hydras are easily removed with an eye dropper and placed in a petri dish or other container suitable for observing these fascinating animals. While at the pond, use a nylon stocking/coat hanger net to capture water fleas and copepods. Offer them to an extended *Hydra* and observe its feeding behavior.

Photographs by Bruce J. Russell
Illustrated Organisms by Leslie Russell
For more observations and life cycle information on *Hydra*
Preview the program **The Biology of Cnidarians**
and download the Teaching Guide at www.eBioMEDIA.com

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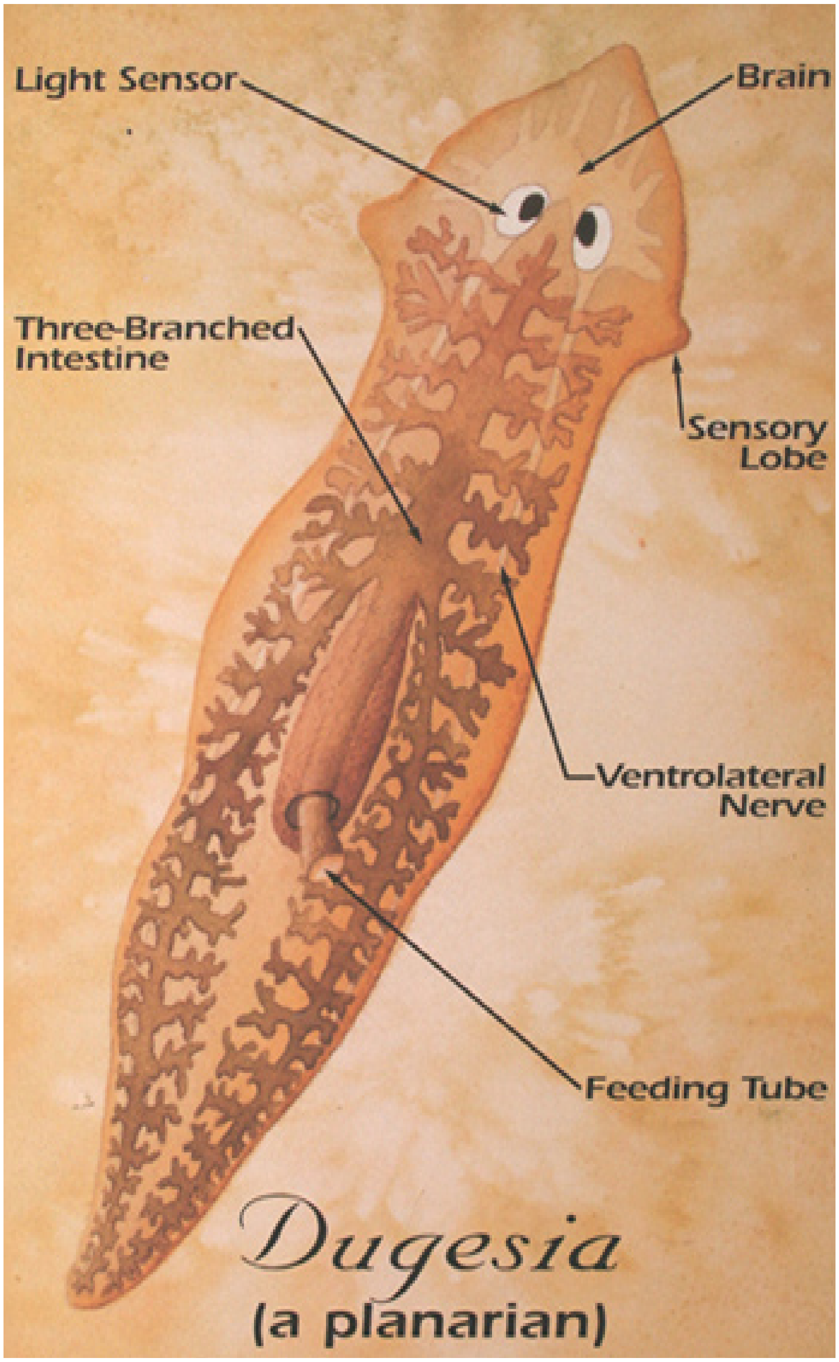
Planaria



Planaria is the common name for flatworms belonging to the genus *Dugesia*. The one most often found is *Dugesia tigrina*, the common brown planarian. Flatworms (phylum Platyhelminthes) are the simplest animals to have three cell layers (Cnidarians such as *Hydra*, have two cell layers). Planarians can be found on the underside of stream rocks and in pond vegetation where they scavenge for food and prey on snail embryos and crippled aquatic insects.

Some of the questions that follow can be answered by studying the recorded observations. Others will require some hands-on experimentation with living planarians.

1. Planaria's head, "Eyes and ears"

These simple eyes (with black sun shades) allow planarians to avoid bright light and the danger of cell-killing ultra violet radiation. The ear-like projections are loaded with smell receptors used for locating food. How might a planarian use its ear-like sensory organs to locate a food source. What are the sensory lobes actually sensing?

2. Mouth and feeding tube

The mouth is the opening through which the feeding tube extends. The feeding tube can be extended up to half the worm's body length. What mechanism could allow materials to flow through the feeding tube into the worm's intestine?

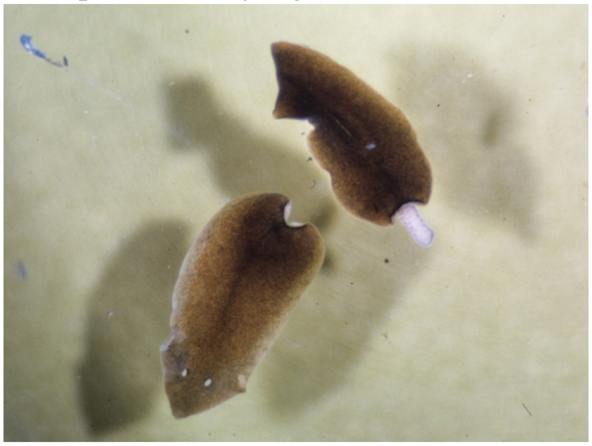
3. Intestine

The three-part intestine has pockets that spread the digested nutrients throughout the worm's body. How does the worm eliminate material that is not digested?

4. Mesostoma's brain

The "brain" is difficult to see in planarians due to their dark pigmentation. A related flatworm, *Mesostoma* shows the brain just beneath the worm's eyespots. In flatworms, the brain is a concentration of nerve cells that coordinate the worm's responses to stimuli. Two nerve trunks lead both forward and back along the length of the worm. Cross connections between the nerve trunks create a ladder-like nervous system.

5. Reproduction by regeneration



Planarians reproduce asexually by simply pinching off in the middle. The tail half regenerates a new head, and the front section a new tail. To study the process, bisect a planarian using an ice cube as an operating table.

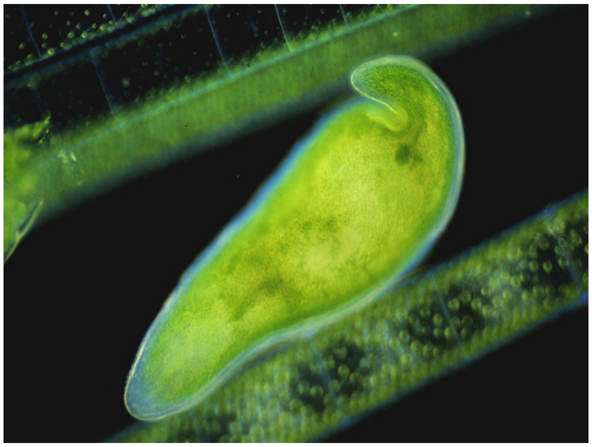
6. Two Headed Planarians

If a small cut is made length wise through the head, a two headed worm will be the result.
How are planarians able to regenerate lost parts, and why can't vertebrate animals do so?

7. *Mesostoma* eats *Daphnia*

Mesostoma has a unique feeding method. It lays out a slime trap that captures Daphnia. Finding one caught in its trap line, it inserts its short feeding tube between the waterflea's shells and sucks out its organs.

8. Green flatworms



Some flatworms culture symbiotic algae in their tissues. The worms waste products are fertilizer for the algae, and the algae return some of the products made by photosynthesis to the worm.

Photographs by Bruce J. Russell
Illustrated Organisms by Leslie Russell
For more observations on Planaria and other free-living flatworms, along with the related parasitic flukes and tapeworms, preview the program **The Biology of Flatworms** and download the Teaching Guide at www.eBioMEDIA.com

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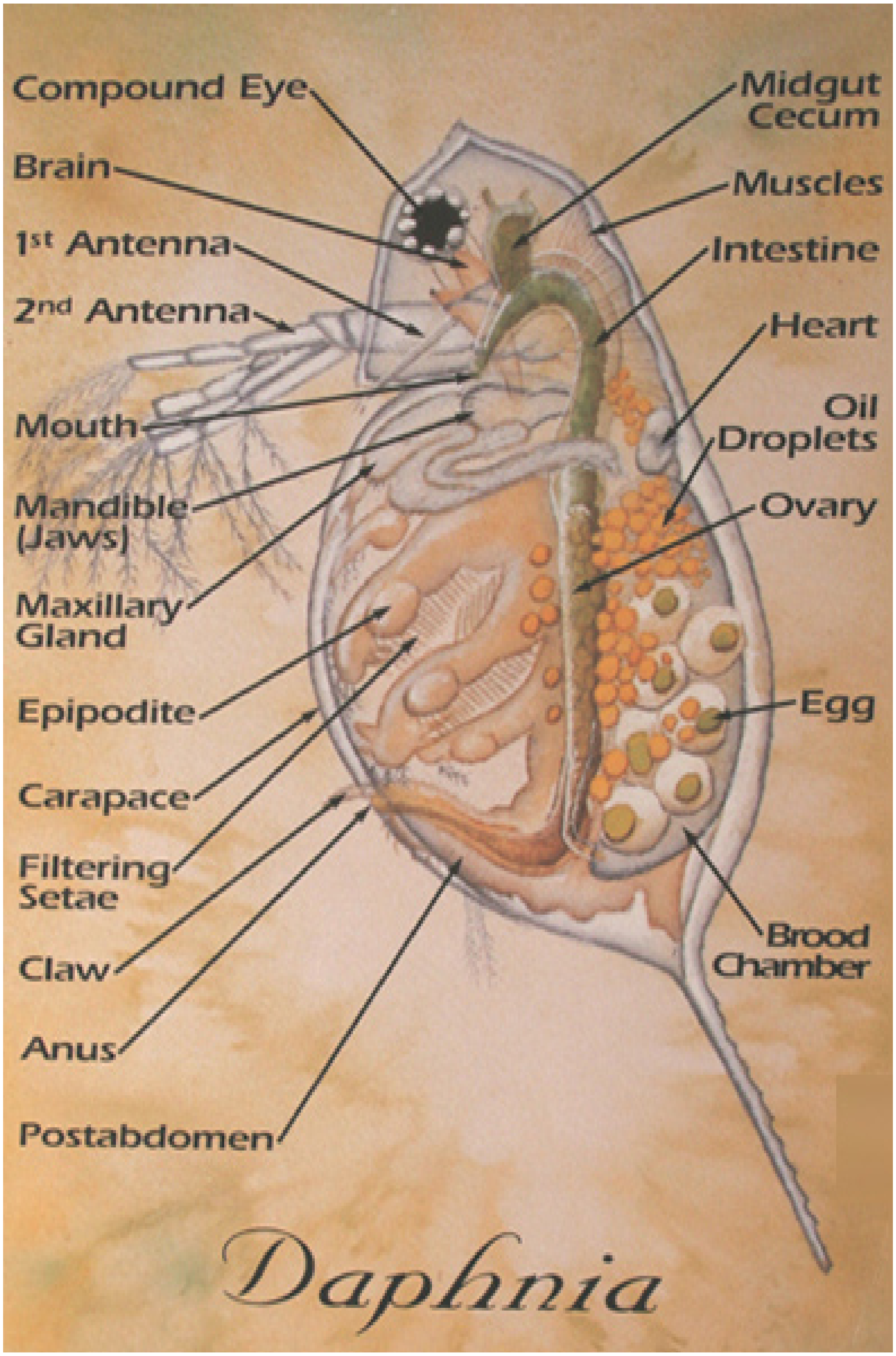
Daphnia



Daphnia (phylum Arthropoda, class Crustacea) belongs to a branch of crustaceans known as cladocerans. Different species of *Daphnia* occupy ecological niches ranging from detritus feeding on the bottom, to suspension feeders living in the open water plankton community.

Some of the suggested questions below can be investigated using the video observations, but for others, studying living *Daphnia* is the way to go. *Daphnia* is easily collected from local lakes and ponds using a nylon stocking/coat hanger net pulled through the water on a line, or attached to a long pole.

1. Swimming *Daphnia pulex*

The long, branched antennae are used in planktonic species to hold position in the open water. The antennae are trimmed with feather-like setae offering a better grip on the water.

The four sets of swimming legs have two functions, neither of which is primarily swimming. They set up currents that bring in suspended food items, and the swimming legs have pads that serve as gills for oxygen uptake.

2. Carapace

The shell-like outer covering in most *Daphnia* species is reinforced with ribs forming a pattern that resembles chicken wire.

With its rigid carapace, how does a *Daphnia* grow?

3. Intestine and heart

As in other animals, the intestine is where food is digested and where the digested products are absorbed into the circulatory fluid. The abdomen can be extended beyond the carapace for eliminating feces. How might the color change seen in the intestine be explained?

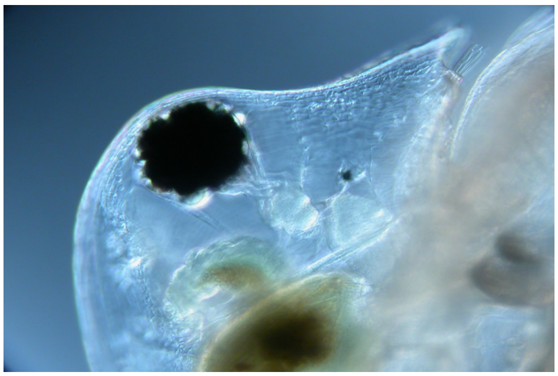
Look for a clear sac just above the brood pouch, the heart. Daphnia's heart has slit-valves at each end, pushes the clear blood around the body.

Does water temperature affect heart rate? To study heart rate, *Daphnia* can be placed in a small plastic bag with just enough water so that the organism is trapped between the plastic sheets. The bag can then be placed in a petri dish of water of known temperature. Viewed with a stereo microscope, or by using the lowest power objective of a laboratory microscope, the heart rate can be counted at various temperatures.

4. Oil droplets

Daphnia converts digested nutrients into oils. These fats are daphnia's energy reserve and can be transferred to the developing offspring.

5. Compound eye



Individual light sensors are arranged in a ring with optic nerves leading to the brain. Muscles control eye movement. What is the eye used for? If you collect *Daphnia pulex* or other planktonic species of daphnia, try some experiments with light direction, including lighting the subjects from below.

6. Mouth and jaws

This photo, taken from the ventral, or bottom side shows the jaws. Jaws have hardened "teeth" used for grinding up microorganisms brought in by the animal's feeding current.

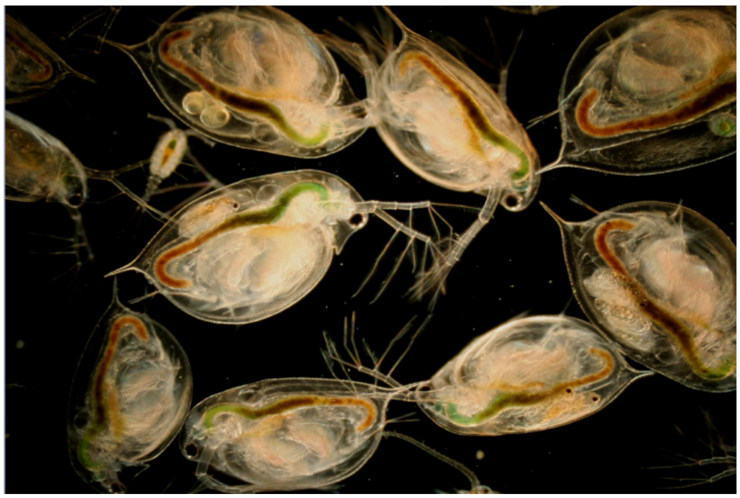
7. Brood pouch with eggs

The eggs develop into embryos that grow into baby daphnia. This female has a particularly large clutch of eggs. Fertilization is not required for development of these eggs. Therefore, all will become females. This asexual process is known as parthenogenesis.

8. Embryos

This female has four embryos about half way through their embryological development, a process that takes from one to two weeks in *Daphnia pulex*. What environmental factors might affect development time?

9. Pregnant mothers



Synchronous development and birthing of babies is common in *Daphnia* populations. One day you might collect a lot of pregnant females and the next – swarms of baby daphnia.

10. Male *Daphnia*

Seasonally, males show up in a population of *Daphnia*. Males differ from females by lacking a brood pouch and by having longer first antennae, the appendages seen on each side of the eye in photo #10. Also, males have hooks used to hold females during copulation.

11. Resistant eggs

Following mating, females develop the saddle-like floating eggs that can survive freezing and drying. These overwintering eggs will hatch when conditions again become favorable. The newly hatched individuals are all female and will repopulate the pond through asexual reproduction.

12. *Daphnia magna*

Living an entirely different kind of life than planktonic *D.pulex*, this large waterflea hangs on objects by its swimming antenna, or sits on the bottom filtering the water for food.

Photographs by Bruce J. Russell
Illustrated Organisms by Leslie Russell
For more observations on *Daphnia* and its relatives preview the program **Branches on the Tree of Life: Arthropods** and download the Teaching Guide at www.eBioMEDIA.com

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