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Learning Programs for Biology Education

Life in Aquatic Environments: Exploring Vernal Pools
Study Guide

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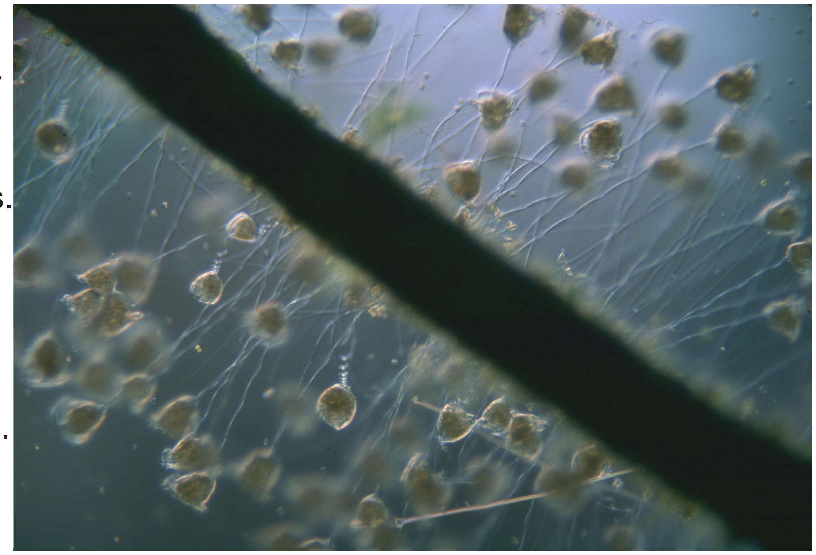
Supplement to Video Program

Vernal Pools are temporary wetlands that fill during rainy months, but dry up later in the year. The organisms that thrive in these *Spring Pools* are adapted for short life cycles, and many have the ability to survive the dry period.

Protozoans

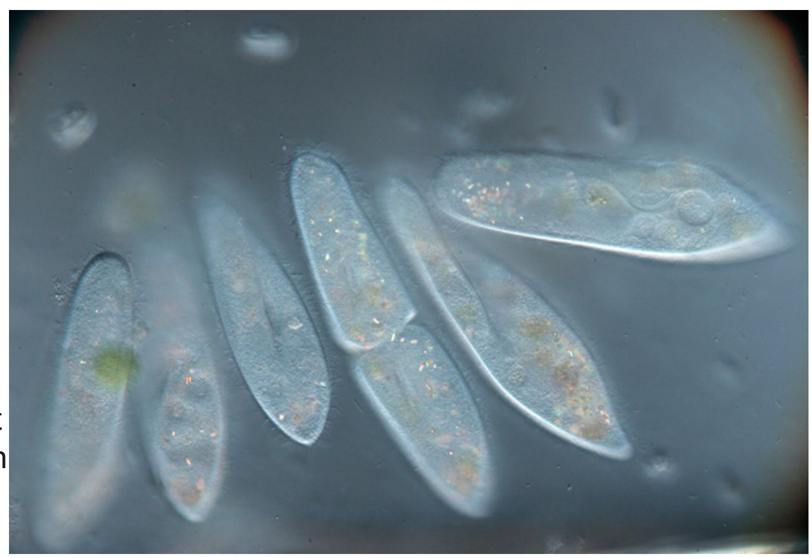
Protozoans, like single-celled algae, consist of a single, complex cell. Many biologists separate protozoans from algae based on the way they move. If the organism can move itself from place to place, it's called a protozoan. If it carries out photosynthesis and cannot move, it's called an alga. Both protozoans and algae are like the cells of plants and animals: their DNA is surrounded by a double membrane, a protective envelope known as a nucleus. Each cell contains a variety of tiny organelles, such as mitochondria, which extract energy from food molecules. This energy drives all the life processes in the cell.

Protozoans that live in vernal pools (and other fresh water habitats) have contractile vacuoles that rid the cell of the excess water that passes through the cell membrane by osmosis. They have digestive organelles, and many engulf and digest other organisms. They have microtubules – the tiny protein tubes that move things around within cells. Most reproduce by asexual division, but many also have a sexual process.



Vorticella

Bacteria, by contrast, are much simpler cells. Their DNA is concentrated in a single, long, molecule, containing a few thousand genes. But this DNA is loose in the cell, not contained by a nuclear membrane. They have none of the organelles seen in protozoans and algae.



Paramecia

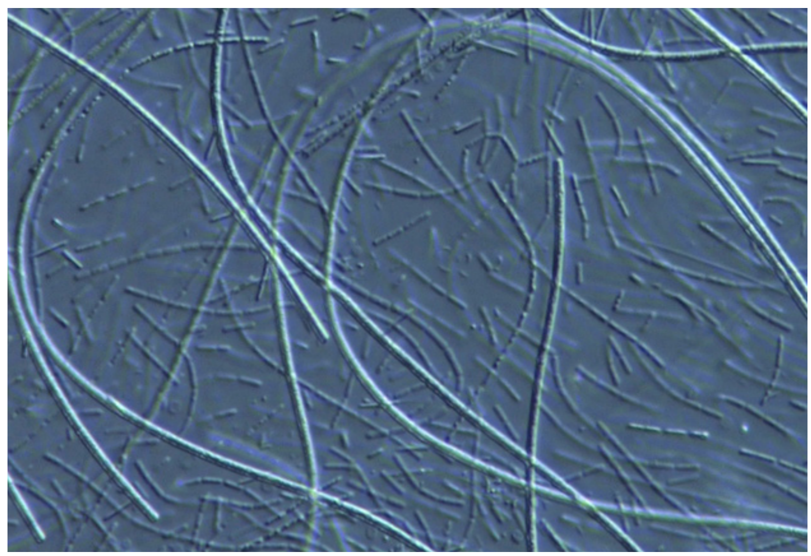
The various groups of protozoans represent widely separated branches on the tree of life. A ciliate and an amoeba are far more distant relatives than are plants and animals. For convenience, fresh water protozoans are usually grouped into three categories: Flagellates—organisms that move by a flagellum, which can be a long single whip, or several whips; Amoebas—organisms that creep along by extend their cell membrane in what is called a pseudopod (false foot); and Ciliates, organisms covered by rows of hair-like cilia.

Two classic protozoans found in vernal pools are shown. The first is Vorticella, a cell on a spring, then Paramecium. Both are bacteria feeders, which start the vernal pool food chain by breaking down last year's detritus. The increase in bacteria allows more protozoans to feed and multiply. The same happens to organisms that feed on the protozoans. The third observation is Nassula, a ciliate that forms cysts that rest in dried mud for years awaiting a rain. Nassula feeds on Oscillatoria, the cyanobacteria shown in the bacteria section. Amoebas, and the flagellate Peranema finish out the single cells shown. The last examples are of colonial organisms including Volv?ox, the relatively large spheres with smaller daughter colonies developing inside. These break out to become the next generation of Volvox.

Some questions for discussion based on the observations:
What are some differences between bacteria and protozoans?
What kinds of movement are seen in various protozoans?
How might protozoans be important to the other life of vernal pools?
What kinds of things do protozoans eat?
How might protozoans locate food?

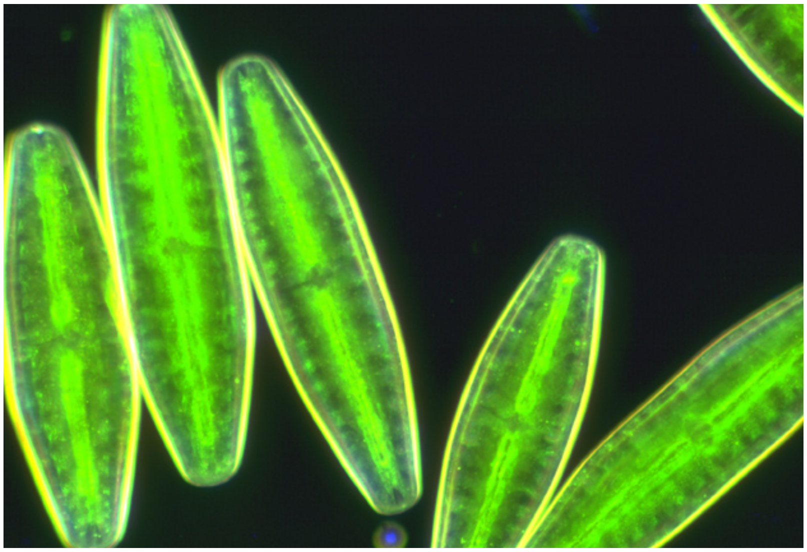
Bacteria

Bacteria breakdown all kinds of dead material and animal waste products, allowing materials that would otherwise remain locked up and unavailable to be recycled. They convert nitrogen in the atmosphere into nitrogen compounds that plants can use. Cyanobacteria produce significant amounts of oxygen. They give us a peek at what early life on Earth was like, and what life might look like on other worlds. In spite of their great importance, very little is known about the specific kinds of bacteria you might find living in a vernal pool. Microbiologists estimate that only about 10% of bacteria have been named and studied.



Some questions for discussion based on the observations:
How many different shapes? Make sketches.
How different are bacteria from each other in size?
How are bacteria distributed—randomly or in clusters?
How do cyanobacteria get energy?
How do bacteria survive the dry phase of a vernal pool?
What roles might bacteria play in the Vernal Pool food web?

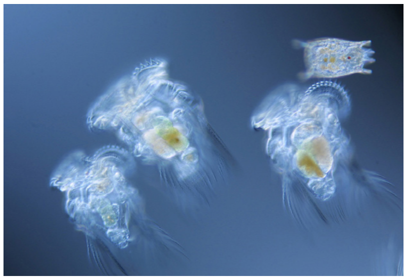
Algae

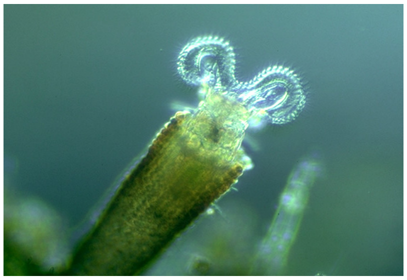


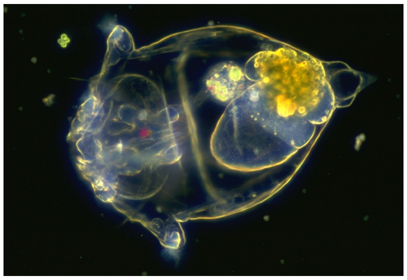
The name Algae covers a diverse assortment of single-celled organisms that photosynthesize. In the evolution of algae, golden yellow diatoms and green algae are as far apart on the evolutionary tree as plants are from animals. Vernal pool microalgae are an important early food source for emerging crustaceans and others. As the pool fills, algae hatch from cysts produced when the pool dried in the previous season. Later, algae feed insect larvae and other organisms as the pool dries.

Some questions for discussion based on the observations:
Are all algae cells green?
What role might the glass house of a diatom play in its survival?
What is the difference between a single cell alga and a colonial alga?
Are there any symbiotic algae?
How do microalgae survive drying?

Rotifers



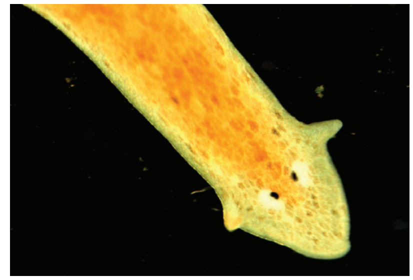


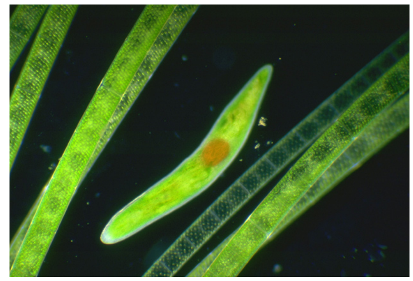


Vernal pools are a rotifer stronghold. Dozens of different rotifer species live in most vernal pools. Some rotifers attach to objects in the water and bring in food by creating powerful currents using their ciliated wheel organs. Others swim through the open water taking in microalgae, bacteria and protozoans. Some are asexual, producing eggs that hatch into another generation of female rotifers. Others mate and produce resistant eggs that can withstand long periods of drying, an essential adaptation for living in vernal pools. Many rotifers survive short periods of drying by going into a state of abiosis. They lose their water and lay dormant until a rain brings life back to the desiccated rotifer.

Some questions for discussion based on the observations:
How many different kinds of rotifers are seen in this observation?
How do rotifers feed? What are they eating?
How do rotifers chew food?
Where is the food digested?
Of what advantage is a tube made of bricks?
What might be the advantage of living in a colony?
How might rotifers be important in vernal pool ecology?

Flatworms





Several kinds of flatworms have made temporary habitats their home. These include a number of predators that use slime to entrap prey such as water fleas and copepods. They then insert their centrally located mouth tube and suck out the prey's organs. One of these small predators supplements its meals with a garden made up of symbiotic algae—the tiny green spheres seen in the high magnification views of the green flatworm.

Some questions for discussion based on the observations:
How do flatworms move?
How do they trap prey?
What kinds of prey do they capture?
Once the prey is captured, how do they feed?
Do vernal pool flatworms have ways of locating food?
Some flatworms contain green algae cells. How might that help or hurt them?

Ostracods (seed shrimp)

Ostracods are crustaceans with two cupped shells that encase the entire body. The shells open slightly, allowing the antennae to whip in food, and move the ostracod through the water. Ostracods eat detritus, going over every bit of organic material, searching for edibles.

A question:
What do Ostracods eat?

Waterfleas

Daphnia, a common waterflea of vernal pools, feeds on microorganisms. Its clear shells, or carapace, allow its internal organs to be easily seen and studied. You can see its swimming antenna attached to the carapace. The observation shows eye, jaws, intestine, and embryonating eggs that will develop into baby Daphnia. Note how the mother expands her carapace to allow her offspring to stretch and flex their muscles. In this asexual form of reproduction called parthenogenesis, all the offspring are females. As the pools start to dry down, males appear in the population. Mating produced eggs embedded in a matrix of tiny air chambers. The female wears these resistant eggs like saddles, releasing them to float to the pool's edge, where they remain until the following wet season. Then, when the pool fills, a new female Daphnia hatches out, and the population builds anew.

Some questions for discussion based on the observations:
How do waterfleas hold their position in the water to save energy while swimming? (Note how they use their antennae.)
How does Daphnia get food?
What are the advantages of live birth, as opposed to leaving eggs to hatch on their own?
How do males suddenly appear when pool conditions deteriorate, despite the fact that all the waterfleas prior to that point were female?
How does Daphnia tell up from down to maintain its upright orientation in the water? Design an experiment that could show if they are responding to gravity or to light.

Copepods

They are said to be the most abundant crustaceans on the planet, and they are particularly abundant in vernal pools. The red copepods shown in the observation glide along on their backs, filtering the water for microorganisms. Males and females have structures that fit like a lock and key to assure that they are mating with the correct species of copepod. The fertilized eggs develop into larvae called nauplii, which look nothing like an adult copepod. Over the course of twelve larval stages each immature copepod molts into a slightly more mature version, until it reaches its adult copepod shape.

Some questions for discussion based on the observations:
How might the long antennae help a copepod stay suspended in the pool?
What structures produce the copepod's locomotion (forward movement)?
What animals might eat copepods?

Clam Shrimp

Well named, Clam Shrimp not only look like swimming clams, but they exhibit another clam-like behavior. They burrow in the muddy vernal pool bottom where they use their swimming legs to draw in water containing microorganisms and particles of detritus. Clam Shrimp are found almost exclusively in vernal pools. They wouldn't last long in permanent fresh-water habitats, where fish would easily hunt them to extinction. The first scenes in this observation show the newly hatched larva and, a few molt stages later, the beginning of the two shells.

Fairyshrimp

Hatching from eggs buried in the mud, fairyshrimp emerge when rainwater fills their pools. They swim on their backs, filtering the water for microorganisms. Males have elaborate claspers that fit corresponding structures located on the female, thereby assuring mating with the correct species of fairyshrimp. Like clam shrimp, fairyshrimp wouldn't last long in a permanent pond where there were predatory fish. That is why they are only found in vernal pools and other ephemeral waters that dry up each year.

Tadpole Shrimp

Tadpole Shrimp root around in the vernal pool mud, filtering out edibles. The Vernal Pool Tadpole Shrimp is uncommon because vernal pools are uncommon, and it only lives in some of them. Another species of tadpole shrimp is common in rice paddies, where they become a serious pest by uprooting young rice plants.

Together, Clam Shrimp, Fairyshrimp and Tadpole Shrimp (along with brine shrimp) make up a branch of crustaceans known as the Eubranchiopods, or gill-footed crustaceans. They evolved long before fish, and only remain in habitats devoid of fish.

Some questions for discussion based on the observations:
What structures do all three eubranchiopods have in common?
Do each of the three appear to have a different food source?
Why are these creatures found in temporary pools, and usually not in lakes and ponds?

Insects

The first insect shown is a damselfly larva. (The three feather-like gills at the tail end are characteristic of damselfly larvae). Note the widely spaced eyes (good for fixing the exact location of prey) and the extensible mandible tipped with hooked jaws. Early-stage damselfly larvae prey on Daphnia and other free swimmers. Try using the single frame advance of your controller to analyze the strike, each frame is 1/30 of a second. Also note their coat of Vorticella, the stalked protozoan, which was also featured in the Protozoa segment.

Diving beetles fly from pool to pool laying eggs. These hatch into sharp-fanged larvae called water tigers. Small water tigers prey on copepods as seen in the observation, sucking out the copepod's juices. Later-stage larvae prey on insects and tadpoles, some much larger than themselves.

Probably the most abundant insect found in vernal pools is the larva of midges. As this observation shows, they produce a mucus tube, and reach out the end to feed on detritus. Midge larvae will metamorphose into adults that fly and look something like mosquitoes.

The first three water insects shown are all the larval stages of flying insects. Back swimmers live in vernal pools during their entire life cycle. As adults, they hunt the film on the lower side of the water's surface, where waterfleas have become trapped.

Other insects use vernal pools – with their abundant life – as a nursery for their young. Dragonfly larva, mayflies, caddisflies, and many other kinds of midges go through their larval stages in vernal pools. An aquarium net will capture them for inspection, after which they can be returned to the pool.

Some questions for discussion based on the observations:
What makes vernal pools such good habitats for the larval stages of so many kinds of insects?
When would you expect to find the most insects, in Winter or in Spring?
What adaptations for prey capture can you list from the insect observations?

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