

FIELD TRIP

Microorganisms

Theme

Microorganisms play a vital role in the high desert ecosystem. They are everywhere!

Utah State Science Core Curriculum Topic

Standard Five: Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.

Objective One: Observe and summarize information about microorganisms.

Objective Two: Demonstrate the skills needed to plan and conduct an experiment to determine a microorganism's requirements in a specific environment.

Objective Three: Identify positive and negative effects of microorganisms and how science has developed positive uses for some microorganisms and overcome the negative effects of others.

Field Trip Location

Accessible pothole locations include Sand Flats Recreation Area east of Moab and

Pothole Point in the Needles District of Canyonlands. Potholes are ephemeral and dynamic, so don't count on a full pothole unless you've visited it very recently. Activity in potholes is greater when the water is warmer, from late spring through fall. Lichens are found almost everywhere there is rock; you'll need south-facing and north-facing rock slopes for the investigation. Cryptobiotic soil is extensive in southeastern Utah; a place with crypto islands in slickrock is most easily examined without damaging the soil.

Times

Pre trip is 30 minutes

Field trip lessons are each one hour

Post trip is 45 minutes

Science Language Students Should Use

Algae, fungi, microorganism, decomposer, single-celled, organism, bacteria, protozoan, producer, hypothesis, experiment, investigation, variable, control, culture

Background

Microorganisms are everywhere and play many important roles in the high desert ecosystem. Some microorganisms are plants or animals, but some belong to the other three kingdoms of living things. Some sixth-grade students may be familiar with the kingdoms and may ask about them, so here's an update or review.

- 1) *Monera* consists of bacteria, including cyanobacteria. Monerans are small, simple, single cells, and sometimes form chains or mats. Some absorb food; some are photosynthetic.
- 2) *Protista* includes protozoans and algae of various types. These are large, complex, single

cells, sometimes forming chains or colonies. They get their nutrition in a variety of ways.

3) *Fungi* are molds and mushrooms. These have a multicellular filamentous form with specialized complex cells. They absorb food.

4) *Plantae* are plants, including mosses, ferns, woody plants, and non-woody plants. These are multicellular forms with specialized complex cells; they photosynthesize. 5) *Animalia*

includes everything from sponges and worms to mammals. Animals are multicellular forms with specialized complex cells. They ingest food.

Viruses aren't included in the kingdoms because

they are on the borderline between living and non-living things. They are noncellular parasites that cannot live or reproduce outside of a living organism.

Probably, the most fragile component of this arid region is cryptobiotic soil crust. The crust is a community of microorganisms, including cyanobacteria and a variable mix of lichens, fungi, and mosses. This network of organisms plays a vital role in erosion control, nitrogen fixing, and moisture absorption. One footprint can destroy years or even decades of this soil's growth, and new growth often has a different mix of organisms than that of the previous crust.

Rock lichen is composed of another community of microorganisms, namely fungi, with algae, cyanobacteria, or both. That's two or three kingdoms intermeshed. Fungus forms the tough outer layers of lichen, while algal (and/or cyanobacterial) cells enmeshed in fungal threads compose the inner layers. The lichen structure is more elaborate and durable than either fungi or algae alone. Dry lichens have the ability to absorb more than their own weight of water. They can carry on food production at any temperature above 32°F. Temporary water, such as dew, can be taken almost directly into the algal cells of the lichen; the water does not need to go through roots and stems as it does in vascular plants.

Desert potholes provide homes to a fascinating

array of small organisms and microorganisms. Pothole dwellers have unique adaptations, enabling them to survive in this feast or famine environment. Most of these organisms have shortened life cycles, reducing the length of time they are dependent on water, and thus allowing them to live in shallow, short-lived pools. The life cycles of clam shrimp and fairy shrimp are 5-10 days. The life cycle of a tadpole shrimp is 12-14 days. Tadpole shrimp, as a result, require deeper potholes in order to survive.

A pothole's size determines its diversity and species make-up. Microorganisms, such as single-celled algae and protozoans, inhabit shallower pools. Slightly deeper pools might have tiny worm-like larvae of midges wriggling around their bottoms. The deepest and largest pools might contain a variety of tiny crustaceans and insects: fairy shrimp, clam shrimp, tadpole shrimp, water striders, back swimmers, water boatmen, and whirligig beetles.

A pothole is a unique habitat that is very easily disturbed. Pothole organisms are sensitive to sudden water chemistry changes (brought on by sunscreen, for example), temperature changes, sediment input, being squashed, and being splashed out onto dry land.

Seedling in cryptobiotic soil crust



PRE-TRIP ACTIVITY

Mystery Photographs

Objectives

Students will be able to:

- Define the term microorganism.
- Name at least two kinds of microorganisms and their functions.

Materials

Six copies of a numbered set of photographs of microorganisms (from Kuhn, 1988: 30-33; Nardo, 1991: 39, 60, 63; Ricciuti, 1994: 11, 47); seven copies of *Mystery Photographs Description Sheet*; optional: books with color photographs of microorganisms.

PROCEDURE

1) Ask students to define the term *microorganism*. Probe them for how much they know about microorganisms. Be sure they know the basic definition of a microorganism: An individual organism that cannot be seen without the aid of a microscope.

2) Break students into six groups. Have each group number a sheet of paper from one to thirteen. Each group will get a set of numbered photographs of microorganisms taken through microscopes. They will also get a sheet with a description of the organisms in the photographs. However, the descriptions are not in the same order as the numbered photos. Their job, as a group, is to match the descriptions to the photographs. Tell students to read the descriptions closely for clues and to

write each organism's name next to its photo number. Model one example on the board; illustrate that the first one that they figure out will probably not go on the first line on their paper. Circulate among the groups as they work. If available, hand out books with color photographs of microorganisms to groups that finish early.

3) Reconvene the students as a whole group. Go over the answers, re-reading and discussing just the descriptions that students found difficult to match.

4) Preview the field trip, telling students that they will be looking at a couple of different, small communities of organisms, using hand lenses and microscopes to get close-up looks, and completing some scientific experiments. Review the items that students need to bring to school on the day of their field trip.

Studying microorganisms through a microscope



MYSTERY PHOTOGRAPHS DESCRIPTION SHEET

Because the foot-shaped **paramecium** is transparent, you can see its dark nucleus. The paramecium filters smaller protozoans and bacteria from the water to eat.

Spyrogyra are algae that form floating green masses on ponds. Their spiraling green bands of chloroplasts are the sites where photosynthesis takes place.

Desmids are one-celled green algae that can look like stars, balls, rods, ovals, or figure eights. In great numbers, they may tint the water green.

Shrimp and lobsters have a microscopic relative called a **water flea**, a roundish animal with a small head and feathery antennae. The antennae allow the water flea to swim jerkily through pond or pothole water.

Hydras are almost-microscopic animals that look like squids or octopuses. Their tentacles have stinging cells to paralyze prey such as water fleas.

An armored amoeba called a **foraminiferan** makes a multi-chambered shell that drops to the sea bottom after it dies. Where these animals are abundant their shells form chalky limestone layers. The pyramids of Egypt are made of cut blocks of limestone made up of these foraminiferan shells.

The hairy **pneumonia bacteria** pictured here is starting to divide in half.

Proteus mirabilis bacteria is normally present in your intestines, where it feeds on nutrients. It looks like a hairy hotdog.

Yeasts are a type of microscopic fungus. Some of them are used for making bread and pizza dough. Magnified 40,000 times, this one looks a bit like a pizza itself.

Fungi and bacteria are decomposers at work on some dead plant roots in this microscopic view. Look for something that looks like plant roots.

This could be an enlarged view of the leftovers from your last visit to the dentist. (Haven't been lately? Then they're probably still in your mouth!) These **bacteria in dental plaque** are shaped like short and long worms.

The threads holding these sand grains together are actually sheaths of **cyanobacteria**, the main organism in cryptobiotic soil crusts.

Amoebas are one-celled protozoans that move by changing shape and pushing out pseudopods (false feet) in whatever direction they want to go.

STATION ONE

Life in a Pothole

Objectives

Students will be able to:

- Identify at least three species of animals in a pothole.
- Explain at least one reason why diversity is beneficial to a pothole ecosystem.

Materials

Dip nets; trays; hand lenses; microscope and slides; Pond Life (Reid 1967); *Pothole Organisms* identification sheets; *Life in a Pothole Data Sheet*; clipboard; calculators.

PROCEDURE

1) Give a 5- to 10-minute pothole introduction to two pothole groups. Avoid making it any longer; much can be covered during observation time. Topics to cover during the station should include: (1) *habitat limitations* in pothole communities, such as drying up, temperature extremes, and water chemistry variations; (2) *adaptations*, especially short life cycles and how organisms survive dry periods; (3) *types of organisms* students may see, including insects (especially larvae), which mostly spread by adults laying eggs in pools, and crustaceans (related to shrimp and lobsters), which mostly survive as eggs in sand/mud during dry periods. You may also discuss micro versus macro organisms; (4) *pothole formation process*, or simply mention that these depressions are rare in the world, but common in the Navajo Sandstone. **Stress the expectations** of students while they are observing the potholes (i.e. where they may stand, not getting into potholes, and how to catch and release organisms).

2) Separate into two groups, and go to two different potholes. Help students while they

observe and catch pothole organisms. Caught organisms should be placed in a tray for closer observation with hand lenses. Try to catch a smaller organism, and mount it on a slide under the microscope. Once students look, they often become interested in the smaller organisms. Encourage students to use identification sheets. Review main organisms so students learn their names.

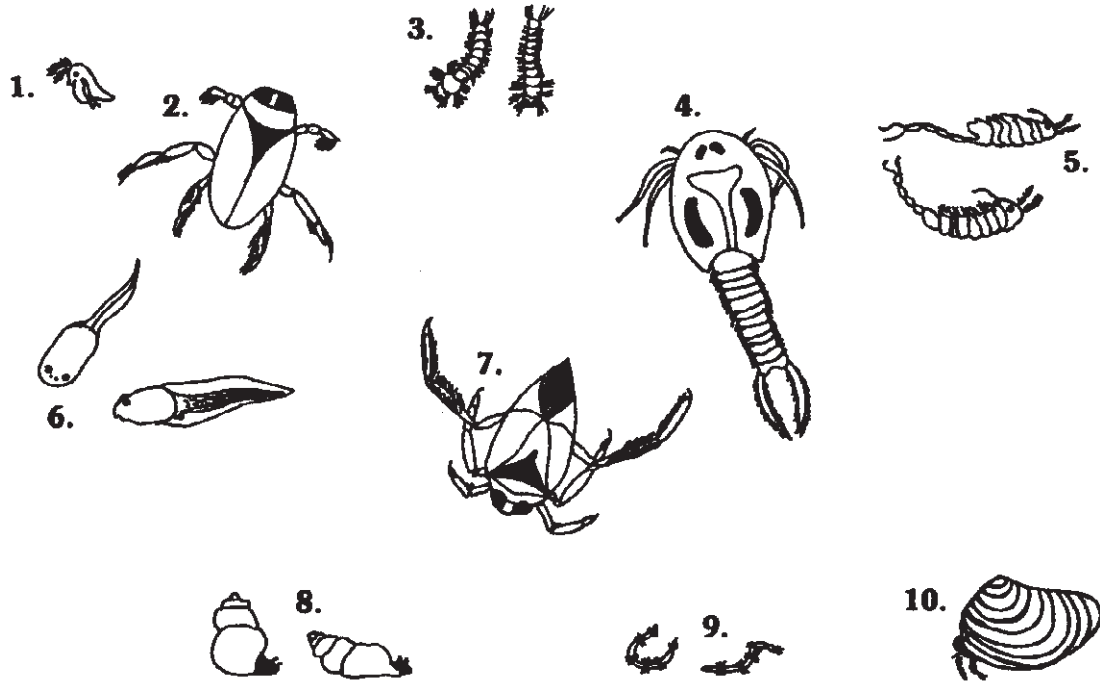
3) This step takes 10-15 minutes. Gather students, and discuss *diversity*, first in a general sense and then in a biological one. Tell students that biological diversity is usually measured by the number of species present. Have students name the species found in the pothole they just viewed, and list them on a laminated sheet. Explain that students will be using a *diversity index* to determine how rich the pothole is. To calculate the index, they will need to estimate the total number of individuals of each species. Explain how they might do that in the pothole, and give them a few minutes to come up with estimates. Show students the diversity index formula, and hand calculators to two volunteer students as you go through its calculation with the entire group. Discuss how the index might be used to compare the diversity of different potholes.

4) If the potholes are diverse, just save about 5 minutes to observe the second pothole and make a qualitative comparison with the first. (In this case, have the dip nets put away for the second pothole.) If the potholes are not diverse, have the two groups split the time more evenly between potholes, and calculate diversity indexes for both. (Collect a sample of pothole water for post-trip activity.)

Tadpole shrimp



POTHOLE ORGANISMS



AUDREY GRAHAM

1. Water Flea
2. Water Boatman
3. Mosquito Larvae
4. Tadpole Shrimp
5. Fairy Shrimp
6. Red-spotted toad tadpoles
7. Backswimmer
8. Snails
9. Gnat larvae
10. Clam Shrimp

See also Williams 2000, 172-173.

Life in a Pothole

Species Name	Number of Individuals
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#1

#2

#3

#4

#5

#6

#7

#8

#9

#10

Total number of Species =

Total number of Individuals =

Diversity = Total number of species / Square root of total number of individuals =

STATION #2

Lichens Up Close

Objectives

Students will be able to:

- Identify rock lichens and name two lichen components.
- Name one role of lichens in the high desert ecosystem.
- Explain the basic steps of the scientific process.

Materials

Hand lenses; name tags (*algae; fungus; water and minerals; sunlight; oxygen; carbon dioxide; photosynthesis*); pictures of lichens (e.g. Sharnoff, 1997, 58-71; Corbridge and Weber 1998); microscope and slides; quarter sheets of blank paper for observations; copies of *Science Investigation Form* and *Data Collection Sheet: Do Lichens Like Sun or Shade?* (back to back); cardboard plot frames; pencils; clipboards; measuring tapes; compass.

Note

If possible, prepare a lichen slide for the microscope before the station begins.

PROCEDURE

1) Start by briefly pointing out both lichens and mosses on nearby rocks. Make sure that the students can distinguish between them. Then have students sit in a group. Tell them that a lichen is made up of two organisms, and ask if they know or can guess what these are. If a student answers *fungus* or *algae*, have her stand up and put on the corresponding nametag. Prompt as needed. Then, ask students to name something that plants need. As they answer, hand out corresponding name tags, and explain that the fungus attaches to the rock and brings in most of the water and minerals. Have the person with the *water and minerals* nametag stand next to the fungus. Have the people with the *carbon dioxide* and *sunlight* nametags stand around the *algae*. Explain that algae is the only organism of the two that can photosynthesize (make food from these ingredients). Because algae gives off oxygen during photosynthesis, have the person with the *oxygen* nametag point away from *algae*. Give the *photosynthesis* tag to the last student, or have *algae* hold it. Re-emphasize that the algae makes most of the lichen's food. Mention, however, that fungus attaches to rock, bringing in much of the water and minerals necessary for making food. An amusing review, that students will remember, goes something like this: "Allen Algae and Frieda Fungus took a lichen to each other. After they married, Allen did the cooking, and Frieda built the house. But, I hear that their marriage is on

the rocks."

2) (Note: You may choose to reverse the order of 2 and 3.) Tell students that they will be using hand lenses and microscopes to examine the area's lichen. Ask each student to write down two observations he/she makes with the hand lenses and two observations he/she makes with the microscope. Give boundaries, and hand out hand lenses. Have half the group start with the microscopes and half with the hand lenses. Afterwards, have students sit back down and take turns reading at least one observation each.

3) Show students lichen photos, as you talk about lichens. Review why they are important:

- They grow all over world and may be important, like trees, in the carbon dioxide-oxygen balance in the air we breathe.
- They are important as air pollution indicators.
- They sometimes help archaeologists in dating ruins. (Discuss how lichens grow and their rates of growth.)
- Some hummingbirds make nests with them.
- In other parts of the world, reindeer and monkeys eat them. Traditionally, some northern Native Americans ate them when other food supplies were low.
- Some are used as dyes.

4) Save about 35 minutes for the second part of this station, a scientific investigation concerning lichen growth in this area. Pass out clipboards, pencils, and back-to-back copies of the *Science Investigation Form* and *Data Collection Sheet: Do Lichens Like Sun or Shade*. Instruct students to work in pairs. Go over the steps of a scientific investigation, as needed. Have students write in the question: "Do more lichens grow on north-facing rocks or on south-facing rocks?" For their prediction/hypothesis, students should write whether they think there will be more, less, or the same amount growing on the north-facing rocks. Explain that *procedure* means the way in which they will conduct their experiment. Explain some factors of good procedure, including random selection of plots on their chosen rock faces and no altering of data to fit what they have predicted. Demonstrate a way of randomly selecting plots. Go over the data collection sheet. Take time to explain aspect,

and review compass directions. Demonstrate how to measure smallest and largest lichens and how to estimate percentages of cover by lichens. (Explain that the data sheet asks for more information than is needed to answer our particular question, but scientists often collect extra data because it can eventually lead to more interesting questions and hypotheses.) Have students fill out the procedural steps they will use.

5) Give students boundaries, and have them investigate as many plots as possible on one slope. When their time is half over, have them switch to the opposite-facing slope.

6) Gather students, and discuss their results. If the students haven't already figured this out, more lichens, and more types, grow on north aspects. Their conclusion might be related to *why* there are more lichens on north-facing slopes (i.e. lichens seem to thrive in moister, cooler locations). Tell students they have just completed a scientific experiment using all the elements of the scientific method. Are there other questions about lichens they could ask? Reemphasize the important roles of lichens.

EXTENSION

Have students “advertise” in a newspaper article the use of lichens in a new household product or a technological breakthrough. The advertisements must include basic lichen information and their important role in an ecosystem.

Studying lichens



Lichens up close

Scientists' Names: _____ Date: _____

QUESTION

PREDICTION OR HYPOTHESIS

PROCEDURE

List step by step.

RESULTS

What actually happened?

CONCLUSIONS

What did we learn or what do our results mean?

DATA COLLECTION SHEET

Do More Lichens Grow on North-Facing Slopes or South-Facing Slopes?

Plot#1

Aspect: _____

of Colors: _____

Smallest: _____

Largest: _____

% of Coverage: _____

Plot#2

Aspect: _____

of Colors: _____

Smallest: _____

Largest: _____

% of Coverage: _____

Plot#3

Aspect: _____

of Colors: _____

Smallest: _____

Largest: _____

% of Coverage: _____

Plot#4

Aspect: _____

of Colors: _____

Smallest: _____

Largest: _____

% of Coverage: _____

Plot#5

Aspect: _____

of Colors: _____

Smallest: _____

Largest: _____

Plot#6

Aspect: _____

of Colors: _____

Smallest: _____

Largest: _____

Cryptos Up Close

To be used in place of station #1 if potholes have dried up or are too muddy for observation; one hour.

Objectives

The students will be able to:

- Identify cryptobiotic soil.
- Name at least two functions or roles of cryptobiotic soil in the high desert ecosystem.
- Explain the basic steps of the scientific process.
- Measure and record cryptobiotic soil crust data.

Materials

Disturbed chunks of cryptobiotic crust for examining; microphotographs of cyanobacterial sheaths; hand lenses; microscope and slides; bottle of water; eye droppers; copies of *Science Investigation Form* and *Cryptobiotic Soil Data Collection Sheet* (back to back); rulers; pencils; clipboards; calculators; optional: polysaccharide sheath model.

Note

If possible, prepare a microscope slide showing cyanobacterial sheaths before the station begins.

PROCEDURE

1) Have students sit within a few feet of cryptobiotic soil. Tell them that they will look closely at the cryptos in a few minutes, but to first see if they can identify any variation in the cryptos from where they are sitting. Tell them that cryptobiotic soil crust is a community of organisms and there are slightly different organisms in the community from place to place. Explain, however, that all of the soil crust contains cyanobacteria sheaths. Use the polysaccharide sheath model and/or your fingers coming out of the end of a pulled-down long sleeve to demonstrate how the filaments come out of a sheath when the soil is moist. Show them real sheaths in a chunk of cryptos reserved for this purpose. These sheaths are what allow the crust to play such an important role in holding the soil together. Show them microphotographs of the sheaths.

2) Ask students to take turns looking through the microscope at a slide showing the sheaths, and when they're not at the microscope, to get on their bellies with hand lenses to look at live cryptos. Give boundaries and warnings about not crushing living cryptos. After a few minutes, gather the group, and briefly discuss some observations. Tell them about the other organisms that are part of cryptobiotic soil, particularly mosses and lichens.

3) Have students put water (using eyedroppers) on some mosses in the soil crusts. Watch, and

note the changes. The mosses swell up, absorbing moisture, and turn bright green.

4) Tell students that there is another function of cryptobiotic soil that is impossible to see. Ask if any students have seen their parents add compost or fertilizer to plants. Explain that, like fertilizer, the lichens in cryptobiotic soil add nitrogen to the soil. Only a few kinds of plants add nitrogen (e.g. beans, alfalfa, cryptobiotic crusts), but nitrogen is essential for other plants to grow. Review the cryptos functions as a soil stabilizer and water absorber.

5) Explain to students that they are going to do a scientific investigation to answer a question about cryptobiotic soil in this area. Pass out clipboards with the *Science Investigation Form* and *Cryptobiotic Soil Data Collection Sheet* (back to back) and pencils. Students may work in pairs or on their own. Review the steps of the scientific process, as needed. Have them write the question that they will try to answer: "Is the cryptobiotic soil bumpier in one area than in another?" Show them the two areas that they'll be comparing, and have them make and write their prediction/hypothesis. Explain factors of good procedure, including random selection of which bumps they will measure and deciding how the bumps will be measured so that they are all measured in the same way. Demonstrate the random selection and the measuring technique. Go over the data collection sheet. Have them write in the steps of the procedure.

6) Help students get started with their measurements. When half of the data collection time is up, have them switch to the second area even if they haven't measured ten bumps yet. Save some time for them to figure out average bumpiness for each area. (Some will need help with this math.) Gather students, and have them fill out their results section and compare their results. Ask if the results were similar for different data collectors. Were their hypotheses supported by the data? Ask why they think the crust was taller in one area; the answer to this might go in their conclusions section. Discuss factors that might be relevant (i.e. crushing by footsteps, ORVs, bicycles, or even wildlife, drainage patterns, blown sand from a nearby wash or trail suffocating the crust, different types of substrate, steeper slope in one area).

EXTENSION

Have students write a story about a walk through

Cryptos up close

Scientists' Names: _____ Date: _____

QUESTION

PREDICTION OR HYPOTHESIS

PROCEDURE

List step by step.

RESULTS

What actually happened?

CONCLUSIONS

What did we learn or what do our results mean?

CRYPTOBIOTIC SOIL DATA COLLECTION SHEET

Step One

Measure the height of several crypto bumps in two different areas, and record below:

Area One	Area Two
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.
6.	6.
7.	7.
8.	8.
9.	9.
10.	10.

Step Two

Compute average bumpiness for each area.

Average = total measurements in area / number of measurements in area

AVERAGE BUMPINESS IN AREA ONE =

AVERAGE BUMPINESS IN AREA TWO =

POST-TRIP ACTIVITY

Exploring Pothole Microorganisms

a crypto forest from an insect's perspective. This story should include interesting and correct information about high desert cryptobiotic soil.

Objectives

Students will be able to:

- a. Make a slide, and use a microscope properly.
- b. Explain the basic steps of the scientific process.

Materials

Microscopes; microscope slides; eyedroppers; water collected from a pothole; one sheet of paper per group; containers to set out the above items at each station; water and absorbent cloths for cleaning slides; extension cords and power bar as needed.

PROCEDURE

1) Briefly review the field trip. Ask students if they can name the first step of the scientific process. Write *question* on the board, and then write the question: "How many different types of microorganisms can we find in collected pothole water?" Ask for the next two steps of a scientific investigation, and write *hypothesis* and *procedure* on the board. Ask students to wait to make their hypothesis until you give them more information about the procedure (so that they can make a more educated hypothesis).

2) Demonstrate and write on the board (in abbreviated form) the procedural steps students will use in gathering data for this investigation:

- a. Use an eyedropper to put one small drop of pothole water on a microscope slide.

(Demonstrate and stress this drop should be smaller than a dime.)

- b. Look at slide through microscope.

Discuss how to tell if you are looking at a microorganism or just dust. It's very difficult to tell at times. Describe that most small sand or silt grains have rounded edges and sometimes broken edges that look like glass breaks. Tell students to look for movement, cells, hairs, or things that look like photos they've seen of microorganisms. This is also the time to demonstrate and explain how to use the microscope and how to handle it without damaging it. Ask students to show other group members anything they suspect of being a microorganism.

- c. Make a group list of different organisms seen. The list can include the organism's name, if known, and/or a written description or drawing. Each group should have notes good enough to determine if another group's sighting is the same or different than their sightings. Explain that each group's list will be collected for review.

- d. Clean slides. (Describe how.)

3) Now have students make hypotheses. Assign six groups to six microscope stations. Circulate among the groups at the microscopes.

4) After the procedures are completed, bring students back together and compare the lists of findings (results) of the different groups.

Discuss conclusions.

Potholes in the Needles District of Canyonlands National Park



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