

Lichens and Pollution

Grade Level	7 th -10 th
Subject Areas	Biology, Ecology, Experimental Design, Plants, Scientific Method
Skills	This activity will use observation, comparison, data analysis, scientific method, critical thinking, and math skills to determine how lichens can be a sensitive measure of pollution in the environment.
Duration	The activity will take one 45 minute period for background lecture and to brainstorm pollutants to be used in the laboratory., a second 45 minute period to set up and run the experiment, take measurements and observations and a third period to discuss and compare the results as a group. An additional period can be used if time and resources permit for a field trip to observe and collect lichens in the local ecosystem from more polluted areas (near highways) and pristine locations (mountain valleys). If this is not possible, lichens can be collected by the instructors or by student volunteers.
Setting	Classroom setting with typical biological laboratory and lecture room with white board. Field trip to various locations for collecting and observing lichens if resources and time permits.
Vocabulary	Lichen, fungi, algae, cyanobacteria, organic acid, photosynthesis, symbiosis, pollutants, ecosystem
Standards Addressed	MT Content standards 1, 2, 3 and 6
Objectives	Students will: <ul style="list-style-type: none">● Understand that lichens are excellent examples of symbiosis between fungi and either algae or cyanobacteria● Understand the habitat for lichens and learn about the variety found in nature and especially in the students local community● Identify the role fungi in the symbiotic relationship: as the source of nutrients by dissolving rocks with organic acids● Identify the role algae or cyanobacteria in the symbiotic relationship: as the source of organic carbon by fixing CO₂ through photosynthesis● Understand that many lichens are highly sensitive to pollutants and they can and are being used to monitor pollution● Understand the advantages of using lichens to monitor air quality especially in many locations where expensive equipment is not practical● Become familiar with the source of pollution in the students local environment and whether the air quality is meeting EPA requirements and the consequences of air pollution● Observe the effect of pollutants from sources such as automobiles and

industrial products on lichens collected as a group from the local environment

Materials

- Lichens
- 20 ml Serum Bottles
- Serum Bottle caps and rings
- Bottle sealer
- A variety of Pollutants that the students brainstorm

Background

The students need background on a variety of topics for this lesson to be most effective. First the students should have some background on microbiology specifically what a microorganism is, the differences between the domains of life (bacteria and archaea prokaryote vs. eukaryote), what are fungi and algae. The student should also know the difference between algae and cyanobacteria and the concepts of photosynthesis and generation of energy from light in the form of glucose and ATP. The student should know that algae need more than light for survival (nutrients and water) and the fungi are the source of the nutrients which come from acids and the dissolving of rocks and other materials. The concept of weathering and the importance of biological life (especially microorganisms) could be introduced when discussing lichens also. Finally, the students should know that the algae are the source of glucose and energy for themselves and the fungi.

The resources below are excellent sources of information on lichens and air quality. The resources also give stressed vs. un-stressed lichen pictures (Figure 1).



Figure 1. Example of lichen from low stressed and high stressed environments. From <http://www.fs.fed.us/r6/aq/lichen/morpholo.htm>

One should stress to the students that the US forest service is already monitoring and using lichens for air quality data (see resources).

The students should also have a grasp on the types of pollutants such as heavy metals, sulfur dioxide, pesticides, DDT, particulates etc. One could also stress that in some locations such as Yellowstone, the pollutants are

natural.

This paragraph from the Colorado state resource below is an excellent way to tie in standard 6 with the other standards and should be emphasized before the experiment also.

“Lichens were recognized as potential indicators of air pollution as early as the 1860's in Britain and Europe (Hawksworth and Rose 1976). Since then, lichens have played prominent roles in air pollution studies throughout the world because of their sensitivity to different gaseous pollutants, particularly sulfur dioxide. They have also been found to act as accumulators of elements, such as trace metals, sulfur, and radioactive elements (Stolte et al. 1993, Ahmadjian 1993). During the period 1973-1988, approximately 1500 papers were published on the effects of air pollution on lichens (Richardson 1988, in Ahmadjian 1993), and many general reviews of lichens and air pollution have been compiled (Ahmadjian 1993). “

Procedure

1. Before the lesson background material must be given to the students with focus on lichen ecology, lichen symbiosis, pollution (especially as it relates to the local environment), and lichens as an indicator of air quality. Have the students brainstorm a variety of pollutants that can be tested in the classroom. Some ideas include smoke (from matches), auto exhaust (can collect in a 160 ml serum bottle from tail pipe – cap and seal immediately), cigarette smoke (let your principal know beforehand), nail polish remover, natural gas, 100% CO₂, sulfur dioxide, ammonia fumes, etc.
2. If time and resources permit, arrange a field trip to lichen hunt. The field trip can range from one hour if just searching around the school to a whole day if searching at various places in the community. This would be a great time to identify if lichens of the same species are affected differently depending on where they are located. Lichens near the highway may be quite a bit different than those in the mountains or in Yellowstone Park. They may vary within areas of the park also from natural and volcanic pollutants.
3. Come up with a few problem questions together as a group. For instance, they may come up with “Will the lichens change color when exposed to pollutants?” and “Which pollutant will have the greatest effects?” and “Which lichen is the best for pollutants in the Gallatin Valley?”
4. Divide students into groups of 2-4 and have each group do 1-2 different pollutants with the same lichen and a 1-2 control bottles. Try to measure the same amount of lichen for each 20 ml serum bottle.
5. Add the pollutant sparingly. Students tend to add way too much (drench the lichen in hairspray for instance). Cigarette and match smoke can be added by tipping the bottles upside down. Add 1-3 drops of water to each serum bottle to keep slightly moist.
6. Add rubber serum bottle cap and ring immediately and cap. The rubber septum is impermeable to even hydrogen.
6. Cap the control bottles
7. Place near light source
8. Observe daily over a one week period

9. Write observations and measurements
10. After the experiment write the results on the whiteboard for the serum bottles and lichens found in the field. Come up with conclusions as a group.

Assessment

To evaluate learning, results and conclusions should be discussed at the end of the experiment. The students should have an understanding of what a lichen is and the concept of symbiosis. The students can be asked questions regarding lichens and how they can be used to monitor air quality. One could ask about other symbiotic relationships also. The students should also have a better understanding of pollutants and how they harm the environment and how far they can travel. They should be questioned on what types of pollutants are common in their community and if they are now more aware of the issues facing their community and natural environments such as Yellowstone. The students could also be asked whether lichens are being used to monitor pollution and the practicality of using them in remote locations where expensive monitoring equipment is not practical. The instructor can also ask questions on what they can do to help improve air quality.

Extension

A good extension would be for the students to learn how pollutants effect the human body.

As part of a unit, the students should learn about photosynthesis and autotrophy (carbon fixation). They should learn how glucose is made from CO₂, water and light energy to build plants. An idea of an experiment would be to grow algae with and without nutrients so the students gain an appreciation for the need of minerals.

A final activity would tie in weathering of rocks by lichens. One idea would be to observe weathering on rocks that are sterilized and have the lichens removed vs. rocks with active lichens in a moist environment. The results may be small but could be observable with a dissecting scope over a couple month period. The students could then extrapolate that to millions of years and understand how whole mountain ranges can disappear. This would need to be tied into other weathering events such as wind, rain, and freeze-thaw.

Resources

<http://www.lichen.com/>

http://www.colostate.edu/Depts/Entomology/courses/en570/papers_1996/simonson.html - Review of lichens as pollutant indicator in colorado

<http://www.fs.fed.us/r6/aq/lichen/images.htm> - lichen species database with sensitivity information to various pollutants

<http://gis.nacse.org/lichenair/?page=lessons> – US Forest service air quality database

<http://www.fs.fed.us/r6/aq/lichen/> Air Quality Biomonitoring Program on National Forests of Northwest Oregon and Southwest Washington

<http://www.fs.fed.us/r6/aq/lichen/morpholo.htm> - Lots of images on un-stressed and stressed lichens