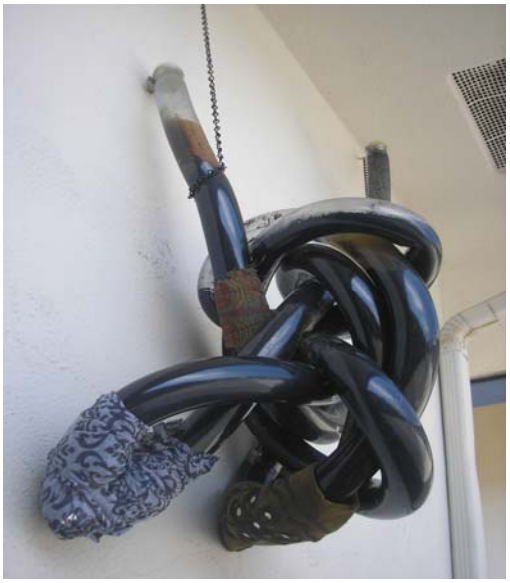
LESSON PLAN The Microbial Knot

Full Title: Urban Succession Microbiology Lesson - The Microbial Knot

Grades: K-12
Medium: sculpture
Author/Teacher/School: artist **Jason Rogalski,** Julian Charter School, with **David Lipson**, a professor of microbiology at SDSU.
Class time required: various over two month period
Sample sketches or products:



OVERVIEW: The Microbial Knot creates a complete ecosystem in which elements and waste products are recycled and can be observed.

OBJECTIVES: The Microbial knot is filled with mud and sea water and since there are more microbes (about ten billion) in one cubic inch of this sculpture than there are humans on the planet, it becomes the perfect place to observe a complete ecosystem. The mud is fed and oxygen removed. Together, the sulfate-reducing bacteria and the purple and green bacteria make a living sculpture which is part of the Urban Succession Project. Urban Succession is a collaboration of artists and scientists who are designing organically shaped sculptural homes for urban organisms.

MATERIALS:

- One five gallon bucket of mud
- 20 feet of transparent plumbing tubing (1 5/8" OD, 1 ¼" ID works good)
- 2 large corks (rubber preferred)

- 2 hose clamps
- a large funnel
- a shovel
- a shoe box of shredded paper
- 2 tablespoons of Epson salt
- a table spoon of concentrated plant food
- 3 different strips of beautiful fabric
- cellulose (energy source)
- sulfate (electron acceptor for anaerobic respiration)
- other mineral nutrients required for growth (ammonium and phosphate)

TEACHER PREPARATION: Introduce concept of microbiological organisms: Bacteria, fungus, protozoa & virus. Use this free online film: Biology: The Science of Life: The Microscopic World

PROCEDURE:

- Preparation Activity Discussion points: Microscopic life is everywhere; size differences, complexity and that virus don't meet all the characteristics of life. Teach students about symbols & metaphor. Ask them what metaphors pop out for them within the virus reproduction cycle. Challenge them to develop a unique set of symbols & metaphors that illustrate the virus reproductive cycle in a fun way. Use copy paper & colored pencils. Each cartoon will be different. Display them all.

- Description: The Microbial knot is clear rubber tubing filled with mud and sea water. This dark soil, teeming with thousands of microbial species, is fed cellulose (energy source), sulfate (electron acceptor for anaerobic respiration), and other mineral nutrients required for growth (ammonium and phosphate). These nutrients drive the selection of species that are being cultivated inside the woven sculpture. Sulfate-reducing bacteria and photosynthetic purple and green sulfur bacteria are the main groups that you can observe using a microscope. But as they multiply, we can see vibrant colors emerge like greens and purples with the naked eye. These are anaerobic organisms, which means that they don't breathe oxygen. To rid the sculpture of oxygen, nitrogen gas is pumped through the salt water. The purple and green sulfur bacteria (like *Chromatium* and *Chlorobium*) use light to grow, except they use sulfide as an electron source for photosynthesis rather than water. The sulfate-reducing bacteria (like *Desulfovibrio*) will break down the cellulose using sulfate instead of oxygen. These organisms exhale hydrogen sulfide. If you sniff the mud you can smell it. Together, the sulfate-reducing bacteria and the purple and green bacteria make a complete ecosystem in which elements and waste products are recycled.

Procedure: Creating a Microbial Knot: This may be done as a class project, partly or wholly.
Step #1 Bring the bucket, & shovel. Knee high mud boots are ideal, but use what you have. Wear cloths that you can get dirty. Go to your nearest estuary (or a freshwater lake could work) Find a location with the

darkest, silt mud possible. Wade out into the mud and use the shovel to half fill the bucket with fine dark mud. You'll need 2-3 gallons of mud. The more sulfur you smell, the better (this is the "breath" of what you hunt). Keep a couple inch layer of water on top of the mud to keep out the oxygen, as these microscopic organisms are anaerobic.

Step #2 You may want to cap your bucket to avoid spilling & less aeration. Bring it back to the class. Stir in the shredded paper, plant food & salts. These will feed the microbes. This can be done with the class.

Step #3 This step should be done outside. Tie or clamp the hose to something upright like a pole, so that one end of the hose is elevated 2 or 3 feet. Put the large funnel into the hose. Do not cork the exit end of the hose.

Step #4 Next, start slowly pouring the mud into the funnel. Try to avoid any air bubbles in the hose by keeping the funnel full. Carefully watch as the mud moves towards the exit end of the hose. This part tends to be fun. The mud looks alive. It is not alive, but it has more living organisms in it than humans on earth, so it makes you wonder. It seems to want to move. When you've got about 3 feet before the end, stop pouring mud & elevate the exit a foot or so. Allow the last mud to enter. Remove the funnel, and cork both ends.

Step #5 Use a screwdriver to tighten the hose clamps onto the area where the hoses overlap the corks. Really tighten them. The microbes will be inflating the hose like a balloon, so this is important.

Step #6 Tie the hose into a sculptural knot. Tie a few fabrics onto areas of the knot to mask the hose from any light at all. These can be removed & checked later for color change.

Step #7 Hang it in a location that get NO "direct sunlight", but does receive some indirect light. This may require some draping. Too much sunlight tends to over stimulate the microbes, but the Purple and Green Sulfur Bacteria are photosynthetic, and thus require a small amount of indirect light. If you hang this inside the classroom, it will stink loudly. The billions of microscopic organisms all exhale sulfur. You probably don't want this inside your classroom.

Step #8 Have students follow the lesson plan posted on the Urban Succession website and adjust it any way that fits your needs. See our website for photos of us doing each step: http://www.rogalskiart.com/microbial-knot.html

Display your Microbial Knot in indirect sunlight and public view. Instruct students to keep a lab journal. They should include:
Instructions on how the knot was created.
A hypothesis stating what they expect to see happen.
Students should add observations once a week.
Teacher should take weekly photos to document the progression. Copies may be given to students to add

to their journal.
Teacher should discuss student observations each week. Take special note of color changes, smells, and the inflation of the sculpture. All these show the population growth within the sculpture.

Independent Practice**:** Have students work in small groups to culture protozoa. Teacher picks up a small bucket of water from a local lake or pond. Use the attached Microscope orientation sheet. Click Here
They will probably not see any organisms. Discuss binary fission, compared to mitosis. Teams should add 100mL of pond water to a beaker along with a gram of the following: boiled egg yolk, flour, & rice. Name your culture creatively with a tag and cover it. (It will smell) Three-five days later, teams should use microscopes to explore their cultures.

Summary: Through discussion, compare what is happening in their pond culture to what is happening in the microbial knot. This can be extended to other areas such as the kitchen sink, the bathroom floor, or any living body. Establish that organisms are everywhere from the bottom of the ocean, to your body.
They are not all bad, and in fact some are vital to your survival.

TEACHER TIPS: This lesson is meant to be used in conjunction with your normal microbiology unit over two weeks. The Microbial Knot should be left up for at least a month to see it fully develop. Side experiments can be developed, such as masking areas from light. Formative assessment could include a quiz given two weeks into the lesson. Each student should correct his or her own quiz as a class. Lab journals could also be collected & displayed. A virus reproduction cartoon could also be produced.

CA CONTENT STANDARDS:

Investigation and Experimentation

The Microbial Knot could work as a class project to address the "Investigation and Experimentation" Science Content Standard at any grade level K-12. Ideally, this would be along with individual students cultivating their own microscopic organisms as described in the Independent Practice step. While it works best for life science, stemming from study of the cell, it can be tweaked to examine nearly any branch of science.

- microscopic organisms are found everywhere.
- types of microscopic organisms: Bacteria, Virus, Protozoa, & Fungi.
- basically how each type reproduces.
- size differences between virus & cells/bacteria.
- that viruses don't meet all the characteristics of life.

BIBLIOGRAPHY/WEBOGRAPHY:

http://www.cosmeo.com/videoTitle.cfm?guidAssetId=90696d2b-2e3e-4923-bef9-32374772a0d3
http://www.youtube.com/watch?v=uFXuxGuT7H8
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