

| **Finding the beauty in microbial diversity** |
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| **Grade level** | High school |
| **Standards** | HS-LS2-3. **Construct and revise an explanation based on evidence** for the cycling of matter and flow of energy in aerobic and anaerobic conditions.[ESS2.E Biogeology](http://www.nap.edu/openbook.php?record_id=13165&page=189) The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth’s surface and the life that exists on it. (HS-ESS2-7) |
| **Goals** | List the learning objectives students will meet through this lesson. Use words from Bloom’s Taxonomy to make sure they are measurable objectives! |
| **Brief description** | This is a paired lesson about microbes with two classroom lessons/lab activities following a field trip where samples were collected. |
| **Time** | Day 1: 1 hr 30 minsDay 2: 1 hr 30 minsDay 1 happens ~1-2 weeks after field trip samples were collected; Day 2 happens >1 month after Day 1. |
| **# students** | 20 |
| **Materials** | Day 1: Students’ samples collected from field trip🡪 Extra mud samples for anyone who missed the trip or to make “example” columns for the whole classAgar plates collected from field tripMicroscopesSlides & cover slipsToothpicks ( for colony picking from agar plate)Winogradsky columns (tissue culture flasks)Labels for columns (sharpies)10 mason jars for mixing material & sample (for working in pairs at station to make columns).Stirring rod in case of needing to stirColumn material (assemble beforehand into falcon tubes):–diatomaceous earth–cellulose–salts–yeast extract–fresh water media (mock, made up in lab, or from pond)*\*Detailed recipe is attached to this document*Bags/containers for mixing column material slurry (8 oz jars)Worksheet to record observations over timeCamera (photograph setup)Day 2:MicroscopeGlass slides & cover slipsToothpicksPlastic pipettes or scoops (to sample Winogradsky columns) |
| **\*Location** | Classroom (Developed for John Muir High School) |
| **\*Logistics** | After field trip:Incubate agar plates that were collected on field trip for “Day 1” classroom lesson visit – if <2 weeks, @ 30° C; if > 2 weeks, leave at room temperature.Day 1:Before visiting classroom, create falcon tubes of Winogradsky column materials by measuring out materials following detailed recipe (below, attached).Collect ~6 liters of Fresh Water Media to bring to create columns (create in lab or from pond)Day 2:No prep outside of classroom. |
| **\*Caltech student needed?** | This was developed as part of an MBL-funded Outreach program, for collaboration between Caltech GO-Outdoors and teachers at John Muir High School.2 GO-Outdoors volunteers are suggested per classroom day.Several GO-Outdoors volunteers are suggested to help assemble column material & other logistics before the lessons. |
| **\*Accessibility** | This lesson is based on visual observation, so having pairs to describe visual changes for any students who require vision assistance is suggested.The assembly requires manual dexterity and fine-motor control sufficient to open jars & manipulate/pour contents into beakers & select microbial colonies to make microscope slides, so students will work in pairs and help each other. |
| **Lesson activities**Day 1:**~12:20 pm**: Arrive at classroom (Leader 1 & Leader 2)**12:30 pm:** Personal introduction/hello🡪Leader 2: Set up microscopes & stations🡪Leader 1: introduce lesson / logisticsIntroduction (15 mins): (slide show? )Explain to students that they’ll be incubating their samples they got from the field trip for 1 month! They get to see changes over time, which they will record, and we will come back to see what they find!**12:45 pm:** Break into 2 groups at 2 stations – (1) Microscope/agar plates (2) column assembly**Rotate after 30 minutes (1:15 pm)**Station 1: Microscope/agar plates (Leader 1)10 studentsColonies from agar plates will be selected using toothpicks, place onto slides and cover with coverslipStation 2: Winogradsky Column assembly (Leader 2)10 students, work in pairs (5 pairs):Each pair gets 2 sets of material for columns & 1 set of 2 beakers/jars for stirring things up.Make 1 student’s column, dumping dry (diatomaceous earth etc) ingredients into 1 beaker, wet (soil sample & Fresh Water media) into 2nd beaker – each student shake up to homogenize into a slurry.Students pour into their first column & label.Rinse these beakersRepeat this process for second student in pair.Rinse the beakers, and leave for the next group of students.Leave columns in a set location, so that during clean-up, students can choose their spot where column will incubate for the next month!**1:45 pm:** Wrap-up:-Hand out observation worksheets & instructions for observations over time-Students help clean up-Volunteer & leader pack up**2:00 pm: leave!**Day 2:🡪*make sure to explain here how you’re going to lead this day.**Write questions down that you’ll ask & sequence out the day so that it makes sense for your learning objectives*Outline the structure of this lesson from beginning to end, including an estimate of how much time each segment should take. Include in the outline how this lesson incorporates the 5 E’s (engage, explore, explain, elaborate, and evaluate). You may wish to structure the lesson activities in segments addressing some of the 5 E’s (e.g., a 10-minute engage segment followed by a 30-minute explore segment). Find more information on the 5 E’s on the GO-Outdoors website page <https://go-outdoors.caltech.edu/volunteers/make-lesson-plan>.**Optional extension activities**List activities that can be used to further explore the lesson topic outside of the time dedicated to the lesson. These can be websites, books, or activities students may wish to explore if they are interested in the material covered. Optionally, these can also include further lessons or GO-Outdoors programs that connect to this lesson plan. |
| **\*Instructor support**Handling of Agar plateWinogradsky column details are in a recipe attached below – students will use a simplified recipe in their handout.Here’s what a Winogradsky column is, and how to handle it:Microscope/slide creation infoLinks/details about how microbial culturing works: |
| **\*Common misconceptions about the lesson**Microbes (bacteria, viruses) are always badWe can grow all microbes in the lab easilyA petri dish shows all of the microbes that are in a sampleMicrobes are too small to affect the global environmentThere are a lot of places that microbes can’t liveIf I can’t see microbes then they aren’t there (like clear water or in sand) |
| **\*Opportunities to engage students in planning**If the lesson structure and outreach relationships with the classroom permit, you may wish to actively engage students in the planning or conducting of the lesson. For examples of this process, explore the lesson plans at <https://sciencegals.org/lesson-plans/>.  |
| **\*Handouts**Recipe for Winogradsky Column handoutWorksheet to record observations over time |

Preparing Winogradsky Columns

Finding the beauty in microbial diversity: Agar Plate Observations

| Question | Answer |
| --- | --- |
| Where did the samples come from? Did you notice any life growing there? |  |
| How many colonies are growing on the plate?  |  |
| Describe the colonies growing on your plate.(i.e. color, shape, size, etc) |  |
| How many different types of colonies can you identify? |  |
| What questions do you have about what grew on the plate? |  |

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