Investigating microbial ecosystems using a Winogradsky Column
Teacher Instructions

Introduction

Winogradsky Columns are named after Sergei Winogradsky, a Russian microbiologist who used the columns throughout his career to study microbial ecology. In the classroom, Winogradsky Columns are incredibly simple tools with which students can explore a variety of topics. Topics such as succession, nutrient cycling, and microbiology are a few of the topics that could be covered.

This is the second year I have implemented the use of Winogradsky Columns with my 9th grade students. We set-up our columns in the first month of school, during our study of ecology. Having their own ecosystem in the classroom piques their interest and provides the opportunity to "practice" some of the concepts we are investigating. As the semester progresses, referring to and observing the columns serves as an introduction to key processes as cellular respiration and photosynthesis. Finally, the use of columns can be adapted to create a more inquiry based activity in which students can investigate how light, pH, or temperature affect microbial ecosystems or they might compare the microbial populations in freshwater and marine ecosystems.

What is the Winogradsky Column? The Winogradsky Column is a clear, thin plastic or glass column filled with saturated soil. The soil has been enriched with carbon, carbonate and sulfate sources. The column is set-up so that an anaerobic lower area and aerobic upper area develops. Microbial populations develop in a manner that is related to the concentration gradients of oxygen, sulfur, nutrients, and light. The result of the microbial activity is a multicolored column of mud!

Materials

a. Students are responsible for the materials to be placed in their columns. (Refer to Student Instruction page.) It may, however, be helpful to have calcium carbonate, calcium sulfate and sodium sulfate sources available.

b. In addition, the materials listed below should be available in the classroom.
    - Extra newspapers to cover lab tables.
    - Balances or scales to weigh materials.
    - 40 watt lights, fluorescent lights or window space.
    - Dowels or other tools to pack the mud in the columns (so as to remove trapped air).
    - Spoons and extra containers for mixing.

Procedure

The procedure I used this year with my students is described on the Student Instruction sheet. In examining some of the resources available, I often found ambiguous or at times even conflicting advice. My solution was to contact Dr. William Picking, University of Kansas. Relying on his advice resulted in successful columns. Below are some of the key points in constructing successful Winogradsky columns.

- The circumference of the column is critical. The smaller and taller the better. As much surface area as possible should be exposed to light. This is where students will be able to observe the various colored bacteria. Our two most productive columns were made in glass graduated cylinders.
- Start with mud that is saturated and anaerobic. Pond, river and lake mud is good.
- Have students pack the mud throughout the construction process. Remove as much trapped air as possible.
- Don't use raw eggs.
- Get rid of excess water. If a layer of water persists on the top of the column have students carefully remove it.
- Many of my students underestimated how much mud and water it would take to pack a column so some pre-lab advice might be in order here.

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Objectives

- Become familiar with nutrient cycles.
- Learn about the role of microbes in ecosystems.
- Gain an understanding of succession.
- Identify key processes that make life possible.

Pre-lab Work.

A. Record helpful (that means "in your own words") explanations of each of the processes listed below. These processes are critical to life and hence ones which you need to understand in order to appreciate the complexity and beauty of living world. These questions will be a bit difficult for you to answer at this point but you must give it a go.

1. **Cell respiration** is a characteristic of all organisms. What does this process accomplish? Give three examples of organisms that use **aerobic** cell respiration and two that use **anaerobic** cell respiration. Be able to distinguish between aerobic respiration and anaerobic respiration.

2. **Metabolism** is also characteristic of all organisms. What is metabolism?

3. **Photosynthesis** makes the world work. Why would life for all be a few microbe species come to a halt if somehow the process of photosynthesis came to a halt?

4. What does photosynthesis have in common with **chemosynthesis**? How do the two processes differ?

5. What are **microorganisms**? What role do microorganisms play in the muddy bottom of ponds and lakes?

6. Learn about the microbiologist Sergei Winogradsky. All university faulty members have information about their research (and sometimes a bit of personal information) on their university's web page. You are the university editor charged with writing a two-paragraph entry for the web page that features Sergei's research.

B. Explore the web site listed below to learn the specifics about what a Winogradsky column is and what we might be able to learn from it. If you don't care for this web site, find one to your liking and record the site you used. In any event, do something to demonstrate that you read about these columns and have learned something.

www.biology.ed.ac.uk/research/groups/jdeacon/microbes/winograd.htm

Planning and Setting-up your group's Winogradsky Column

1. Each person in your group must bring their assigned materials on the proper date.
   Record date here: ________________

2. When considering the amount to bring, think about the size of the container you will be using!

Material	Person responsible
Clear cylinder: 15-25 cm tall, 4-8cm in diameter. Can be glass or plastic. Really should be as thin as possible. (For example a flower vase. Tennis cans are OK but as about as thick as will work.)	
Soil: pond mud, river sediment, garden, woodland or field.	
Water: from pond, stream, birdbath or aquarium. If possible, "match" the water with the mud source.	
Carbonate source: Calcium carbonate, chalk, limestone, ground egg shells, or baking soda (added at about 1-2% of soil weight).	
Organic carbon source (*cellulose*): shredded newspaper, fine sawdust, or shredded leaves	
Sulfate source : calcium sulfate, magnesium sulfate, or boiled egg yolk (added at about 1-2% of soil weight).	

Procedure

Note: analytical balances are available for you to weigh your "ingredients".

1. Prepare the soil by sifting it to remove any stones, twigs, or lumps. Stir the soil/mud to get a uniform consistency. Use some of your water to make a slurry.

2. Place a 2-3 cm layer of the mud mixture in the column, add the source of cellulose, and stir and pack (use a dowel or stick). Pack the mud so as to remove trapped air. Also, don't be skimpy with the cellulose.

3. Now stir in the other ingredients to the remaining mud mixture and add more cellulose if you like. Add this final mixture to the column, 2-3 cm at a time, with gentle tamping to force out trapped air. Remove as much air as possible! Continue this process until the tower of mud is about 3-4 cm from the top of the column.

4. The last layer should be 1 cm of water. This should leave approximately 2 cm of air between the water and the covering of the column. This layer will be removed later.

5. Cover the opening with plastic film and secure with a rubber band. Put the class period and group name on the bottom of the column.

6. Place the column under any one of the lights or near a window. If you use an artificial light adjust the light so that it is shining on the upper portion of the column if possible. Don't place the column where it may overheat.

7. Wash your hands!

Discussion and Observations

Over the next few weeks and months you will need to record observations of the changes in the column. You should also plan on making several labeled drawings of the column. Finally be prepared to answer questions regarding the processes occurring in our microbial ecosystems.