Developing collaborative lab experiments across disciplines through the identification of bacteria

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Outline of today’s session

• Development of our collaborative lab activity

• Review the background that students learn before being given the assignment.

• Work through the lab experiment

• Discussion:
  – Student impressions of the lab.
  – What you liked / think can be improved.
  – How you can begin to design a collaborative lesson.
  – Tips on writing an teaching grant.

Acknowledgements

Joanna Huxster, Ph.D. Sarah Moss, MS ‘15 Emily Bilyk, BS ‘16

Association for Biology Laboratory Education
Roberta Williams Laboratory Teaching Initiative Grant Recipient - 2014

SJU offers four non-science major, lab-based courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Bio 165: Exploring the Living World</th>
<th>Env Sci 106: Exploring the Earth</th>
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<tr>
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<td>- Cells</td>
<td>- Global Climate Change</td>
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<td>- Evolution &amp; Ecology</td>
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<td>- Evolution &amp; Biodiversity</td>
<td>- Natural Resources (air, water, soil)</td>
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<td>- Physiology</td>
<td>- Sustainability</td>
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<td>- Ecology</td>
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Phy 115: Investigations in Astronomy

Chem 115: Chemistry in Daily Life

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Our basis for collaboration:

**having students knowledgeable in one topic teach others**

"Tell me, I’ll forget
Show me, I’ll remember
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Collaboration in a non-science majors laboratory: **Winogradsky Column**

**Observation → Question**

What causes the change?

**Procedure:**

Test for the presence of bacteria.

Identify what bacteria are present:

**Non-majors:** Identify the pigments.

**Majors:** Sequence the DNA

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Grouping: Having **majors work with non-majors**

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Grouping: Having **majors work with non-majors**
1. define the term collaboration as it applies to the nature of science;

2. state two different techniques of identifying microorganisms;

Ramirez et al. 2015
Journal Microbiology & Biology Education

Students taking ENV 106: Learn about water quality and how to detect the presence of organisms in water.

BIO 165: Learn how to identify and classify organisms.

What happens when the two are put together?

Is there any bacteria present in the water? If so, what?

Bacteria Identification can be colorful!
One skill we enforce in our classes is the use of a dichotomous key.

1a. Gram-positive cells
1b. Gram-negative cells
2a. Rod-shaped cells
2b. Non-rod-shaped cells
3a. Can tolerate oxygen
3b. Cannot tolerate oxygen
4a. Ferments lactose
4b. Cannot ferment lactose
5a. Can use citric acid as a sole carbon source
5b. Cannot use citric acid alone
6a. Produces hydrogen sulfide gas
6b. Does not produce hydrogen sulfide gas
7a. Produces acetoin
7b. Does not produce acetoin
8a. Produces gas from glucose
8b. Does not produce gas from glucose

What ENV science students learn before being assigned the activity.

“it is an old maxim of mine that when you have excluded the impossible, whatever remains, however improbable, must be the truth.”

-Sherlock Holmes

The Adventures of Sherlock Holmes
**Basics of bacterial growth in the laboratory**

Bacteria are microorganisms that can be grown in a wide variety of ways:

- They can be grown in liquid suspension.
- They can be grown on semi-solid plates (nutrient agar plates).

The agar contains nutrients for the bacteria to grow and reproduce. When a bacterial cell lands on the agar and begins to replicate, it produces a colony visible to the eye.

Different bacteria produce different types of colonies (color, size, shape).

When the liquid is turbid, there is > 10^7 bacteria present!

**Detection of bacteria in water**

The presence of microorganisms, particularly disease causing bacteria, in water samples is often difficult to detect, due to the low concentration of these cells in such environments.

It is also hard to look for every type of microorganism! So, in testing water quality, we look for the presence of an indicator organism - Example: *Escherichia coli*.

*E. coli* is a fecal coliform bacteria – it can ferment lactose and grow at 42°C.

We can use a **membrane-filtration device** and “catch” any bacteria onto a membrane.

The membrane is then placed on semi-solid agar with nutrients to allow the bacteria to grow into colonies.

Report any **BLUE colonies**.

**Bacterial Shapes**

- (a) spheres (coccis)
- (b) rods (bacilli)
- (c) spirals (spirilla)
- (d) curved rods (vibrios)

Video links provide additional information on the activity. What BIO science students learn before being assigned the activity.
Bacteria are classified according to their cell envelopes

The "cell envelope" in bacteria is everything outside and including the cell membrane.

- **Gram Positive**
- **Gram Negative**

The Gram Stain Procedure

Different Bacteria can appear as different colonies on agar plates
What both students learn before being assigned the activity.

Bacteria are everywhere!

Aseptic Technique

What both students learn while working through the assigned activity.
Streak plates can be used to separate strains in a mixed culture.

Carbon Sources: Citrate Utilization

Tests the ability of some bacteria to use citrate as sole carbon source.

Procedure:

Day 1:
- Inoculate citrate agar slant (urea + bromthymol blue)
- Incubate at 37°C overnight

Day 2:
- Observe results

If can use citrate:
- Sodium carbonate generated...
- pH will increase...
- Turn bromthymol blue dark blue

If cannot use citrate:
- Sodium carbonate not generated...
- pH does not increase...
- Bromthymol blue remains green

Lipases: Lipid Hydrolysis

Potential Bacteria in Water Samples

<table>
<thead>
<tr>
<th>Bacterium</th>
<th>Gram-Reaction</th>
<th>Shape</th>
<th>Citrate utilization</th>
<th>Lipid Hydrolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escherichia coli</td>
<td>Negative</td>
<td>Rod</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Enterobacter aerogenes</td>
<td>Negative</td>
<td>Rod</td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>Positive</td>
<td>Coccus</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Bacillus cereus</td>
<td>Positive</td>
<td>Rod</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Bacillus subtilis</td>
<td>Positive</td>
<td>Rod</td>
<td>Negative</td>
<td>Negative</td>
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</table>

- Because Gram-positive bacteria are being used, you **cannot** use the mFC or mENDO agar.
- Use general growth media (Luria-bertani) with dark filter.
Detection of bacteria in water

Use table to determine which test (citrate uptake or lipid hydrolysis) to use.

Biology students showing the Environment students how to perform the Gram-stain
Gram-staining and inoculating egg yolk agar plates

Lab Budget to ensure critical thinking of lab results

4 weeks in one afternoon...

You have a sample of water.

You will filter the water through the membrane and plate onto LB agar (non-selective).

You will then receive your plate after “one week” of incubation
- try to determine how many different types of bacteria you have.
- Pick one of each and re-streak onto a fresh LB agar plate.

You will then receive “your” re-streaked plates.
- Perform the Gram-stain
- Visualize your bacteria
- Decide what tests you want to choose next and inoculate.

You will then receive the results of “your” test.
- Determine what bacteria you have (if you are able to...)

Rich Uncle Pennybags
How to build collaborations?

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Curriculum Mapping of Objectives

Curriculum Mapping of Activities
**Community of Practice**

SJU views outreach and teaching philosophy as part of a larger science education community of practice designed to promote engagement and mutual learning for all participants.

**Logistics and Housekeeping**

- How to get the classes together?
- How many times to get the classes together?
- Where to meet (is room big enough?)
- What about the rest of the curriculum/material we need to get to?

**Meet together and work together online**

**Collaborative Wiki Site**

On an index card, write down a topic/lab technique that you think your class would benefit from using collaboration.

For that topic, does any other class cover a topic related to it?
- What type of students (intro, upper-class, non-majors?)
- If so, do they use the same approach/technique?
- What benefit would your class get from this?
- What benefit would the other class get from this?

How do you address logistic issues?
- Getting together
- How many times
- Where to meet
- Timing
Writing teaching grants

- Same as writing a research grant – just apply it to your class

<table>
<thead>
<tr>
<th>Research</th>
<th>Teaching</th>
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<tbody>
<tr>
<td>Question Posed</td>
<td>What do you want students to learn?</td>
</tr>
<tr>
<td>Sample Data</td>
<td>Sample procedure</td>
</tr>
<tr>
<td>What if experiment doesn’t work</td>
<td>What if the students are having difficulty completing the activity or obtaining the learning objective?</td>
</tr>
<tr>
<td>$ for research equipment</td>
<td>$ for teaching supplies</td>
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- Ask questions while writing (especially to determine what equipment the grant will support).

- Need to be sustainable