Curriculum developed at the Stroud Water Research Center by William Anderson of Unionville High School, supported by a grant from the National Science Foundation's Research Experience for Teachers program. For non-commercial use only.

Instructional Unit: Life in a Pond (or Stream)

Level: grades 6-12

Content Focus: Ecology, Experimental Design, Microbiology, Lab Skills

Background: Almost all students have access to some form of aquatic habitat. Ideally it may be by their school, in their neighborhood, or at a local park. Water samples may be taken with any suitable closed container and brought to school. For students without reasonable access to a water sample the instructor may be able to bring in extras, students may share, or there may be an algae encrusted fish tank in the classroom (we keep one especially for this purpose-the fluorescent light is on 24 h). We have had spectacular results with water samples from a local golf course, both riparian streams that run through the property and stagnant "water hazards," which are typically covered with algal mats. Collaboration with the greens superintendent is a good way of establishing a working relationship with the community. Our local golf course is required to do community outreach for International Audubon certification, which it has been awarded, and they love field collection visits from students (scheduled, of course). Once the laboratory classroom is filled with plastic milk bottles, Tupperware containers, and buckets of smelly slimy water it's time to go to work.

Data Book Set Up: Depending on the academic level of the students various protocols may be used for keeping a data book. These may range from a marble cover "copy book" with sewn in pages to commercially available books with built in carbon paper. Minimum requirements should include a purpose and date on each page. At The Science Research Competition the use of both data books and field collection logs (on waterproof paper) is taken very seriously and experimenters may be required to reconstruct an experimental collection from previous months or even years. Sample protocols are found in appendix I.

Initial Values: Because water samples may be analyzed and studied over time, initial values should be taken within 24 h of sample collection. Tests are usually performed with LaMotte test kits, but there are many other sources. A good teaching strategy is for students to practice testing samples of known concentration that the teacher has prepared in advance. Measuring dissolved oxygen (DO) accurately is very difficult but students should attempt it anyway. Ultimately they may focus on relative change in DO over time as the sample ages and biological activity takes place. Depending on availability of test kits the following measurements should be attempted for each sample:

- Phosphates
- Nitrates
- Dissolved oxygen
- Ammonium
- Turbidity
- pH
- Hardness

Macroscopic Inventory to 40X: In this activity students will look for macroscopic organisms that they may have collected. It is unlikely that they have collected any vertebrates, but invertebrates and plant materials (especially insects, flatworms, duckweed, *Anachris* sp., etc.) may be found. Depending on the level of the student identification may be very general “a flatworm” will suffice for a middle school student or very specific “*Planaria dugesia*,” would be expected of an AP Biology student. From a practical standpoint the lab protocol is extremely simple: pour the entire sample through a series of increasingly small sieves. This can include something as simple as a kitchen colander and a piece of window screen. Because each sample will be considered separately it is important that sifting devices are washed thoroughly between samples. It is also important that student wash hands thoroughly every time they handle their samples. Examination of sifted samples should be accomplished with dissecting microscopes (40X magnification) or even hand lenses.

Microscopic Inventory to 400X: This is the classic science class activity, the microscopic examination of pond water. Most students are quite good at locating living organisms in a productive sample of pond water. The harder part is the identification. Depending on the ability of the student and the classroom resources available in terms of field guides, a general identification “ciliate” or “filamentous green algae” may be all that is possible. It is important to document the contents of the sample because this will become a longitudinal project, which may be done by having the students make laboratory sketches of their organisms. Although it sounds difficult we have had spectacular results taking digital images by simply holding the lens of a digital camera up to the eyepiece of a dissecting microscope. This has even worked with cell phone cameras.

Food Web Construction: In this exercise students should start to determine the ecological connections among and between the organisms that they have discovered in their samples. Depending on the richness and diversity of their sample they may or may not have enough variety to justify considering their sample “an ecosystem.” In that case a class pond (stream) ecosystem can be constructed on a large piece of poster paper. Make sure that arrow indicating energy flow are present and that the directional component is correct (from consumed to consumer). Although not technically part of a food web students should indicate the results of chemical tests on the poster. Unless desired as an independent variable sample bottles should be stored where they receive some sunlight or artificial light. Even if it occurs as a one-celled algal organism every food web must have photosynthetic organisms.

Bacterial Survey at 1000x: It is highly likely that the pond sample contains live bacteria, especially if it has been several days since collection. Advanced students can be shown how to make and stain (methylene blue) bacteria smears for a preliminary look at diversity of bacterial species. Although it is possible to see stained bacteria at 400x, a microscope equipped with oil immersion (1000x) will yield far better results. Bacteria smears are readily stored and may be archived for comparison later as the samples change over time. Another alternative to making a bacteria smear (which requires a flame) is to make a hanging drop preparation. This is fairly simple, with the advantage that the students get to see bacteria in motion. Don’t forget to wash hands.

Bacterial Isolation: If resources and time permit, the microorganisms in the sample can be streaked on nutrient agar plates for isolation. This is suggested for advanced students or for classes doing a major unit on microbiology and who wish to use the sample as a source of unknown microorganisms. Ultimately isolated colonies would be sub-cultured to determine morphology, Gram stained, and grown on selective media to identify. Wash hands.

Bottle Biology: After several days of intense lab testing, macroscopic and microscopic examination and identification of organisms you may have had enough. If not, consider using the sample as a source for a “Bottle Biology” project. In overview the students convert a plastic soft drink bottle into a semi-permanent “mini-ecosystem” which will be kept, examined and used for the entire year. A sand or gravel substrate is added and the sample placed in the bottle. If the teacher wishes the initial sample may be modified by providing each bottle with some aquatic plants and small snails. Even the most cynical students take the progress of their sample very seriously and often go right to the window sill to examine it as soon as they arrive in class (at least for the first few weeks). Many students request fish for their “bottles” but they are not permitted to have fish until the measured DO of their ecosystem is high enough to support

Longitudinal Data Collection: It is reasonable to collect a complete survey of all parameters initially measured at least three times during the life of the sample. A reasonable time period would be 2 weeks and 6 weeks after collection. Measurements that took several days initially should take far less time since students know the protocol.

Culminating Activity: The Life in a Pond unit presents many opportunities for both formative and summative assessments. These may be as simple as “did you bring in a sample?” to true performance based assessments such as “correctly determine the nitrate concentration of a sample to +/- 2 pm.” Pencil and paper tests may assess knowledge of taxonomy, concepts of energy flow, binomial nomenclature, or pond chemistry. Since data collection and organism documentation have been emphasized they should also be included in assessment (data book audit and lab drawing portfolio). Prior to a summative evaluation in a Biology II elective course in which we spent 8 weeks on this unit, each student was required to contribute one slide to a review slide show (I.e. PowerPoint). The grading rubric appears below.

Lab Practical Exam: It is suggested that classes be exposed to the concept of a lab practical examination. This can be on a small scale for beginning students (read the value for nitrate on the colorimeter) or extensive for upper level students. For AP Biology students our lab practical examinations typically involve 25 stations (a microscope, instrument, specimen, etc.) with 4 questions per station.

Extensions and Spin-offs/ The Science Research Competition (SRC) project:: As a result of interest developed in this unit several students have taken the techniques that they learned and have developed independent research projects for competition. For teachers wishing to differentiate instruction this unit offers ample opportunity for offering students activities that are more difficult or more challenging Development of sustained student interest in a topic validates this as a curricular and cross curricular activity in life sciences.

Life in a Pond Presentation

Student Name: **Class:**

Directions: Each student is responsible for creating one slide for a review slide show of all of the living things (mostly algae) we have been studying since the beginning of the course.

Your slide should contain:

- Latin name of organism
- Phonetic pronunciation (pronounced by you)
- Information about classification (especially division-use Arms and Camp for reference although there ARE newer treatments of this topic)
- Ecological aspects
- A really good photomicrograph-$\mathbf{E}^3$ if you take the digital image yourself from prepared slides

If you have an abundance of information you may use a second slide. There are other topics you COULD include if you wanted to make a comprehensive review; different lab techniques, classroom procedures. There is room for humor in these slides, the others (above) should be academically serious. See me for the green light.

Prepare a "storyboard" of your slide on <u>unlined</u> paper. Solve any composition, electronic, storage, transfer, technical, e-mail issues.