Bioscene

Journal of College Biology Teaching

Volume 30(2)   May 2004

Bioscene

Journal of College Biology Teaching

Volume 30(2) **May 2004**

ISSN 1539-2422

A Peer-Reviewed Journal of the

Association of College and University Biology Educators

An archive of all publications of the Association of College and University Biology Educators (ACUBE) can be found at http://acube.org or at http://bioscene.org

Bioscene is published in March, May, August and December. Please submit manuscripts by July. 1, 2004 for consideration in the next issue.

Cover image: Photograph of asters with bees in Colorado courtesy of Ethel Stanley.

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July 1, 2004 for the August 2004 Issue

November 1, 2004 for the December 2004 Issue

Evolution Kills: A Web Resource for Instructors of Evolutionary Biology

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Abstract: We have developed a laboratory course that demonstrates how evolution can be taught as a participatory, investigative science at the undergraduate college or advanced secondary high school level. The course emphasizes the applied importance of evolution to areas such as medicine and agriculture. Because many instructors face budgetary or other constraints, we have developed labs that can be run with minimal resources and a wide range of possible materials. To provide access to these materials, we have created a website aimed at instructors of evolutionary biology (http://www.evolutionkills.org OR http://www.faculty.virginia.edu/evolutionlabs). Included on the website are detailed descriptions of the course materials, a database of other articles describing laboratory and field exercises in evolution, and links to other sources of information pertinent to the teaching of evolution. We believe that this website provides a much needed resource for instructors of evolution and encourages inquiry-based learning approaches to the study of evolutionary biology at the undergraduate level.

Keywords: evolution, laboratory exercises, online exercises

INTRODUCTION

Over the past two decades, evolutionary biology has developed into a vibrant, investigative science with direct relevance to societal issues such as the origins of infectious disease (Antia et al. 2003) and biotechnology (Wilkinson et al. 2003). The emergence of evolutionary biology as a scientific discipline of direct societal relevance is in stark contrast to the continuing efforts to limit the teaching of evolution in high schools, or to question evolutionary ideas as a valid province of science (Antolin and Herbers 2001; Storey 1997). Unfortunately, at many academic institutions, evolution is still largely taught as a theoretical, dialectical discipline that often only discusses broad conceptual landscapes; it is not regularly taught as an experimental, analytical science of applied relevance on par with physiology or molecular biology. This situation often leaves students with the impression that evolutionary biologists are armchair scientists who do not conduct "real" research, rather than with the impression that modern medicine and agriculture, with direct relevance to their lives, are dependent on an understanding of evolutionary principles. For example, future medical professionals, many of whom major in biology as undergraduate students, need to understand that evolution can kill, as when disease-causing bacteria evolve antibiotic resistance.

To help rectify this situation, we have developed a laboratory course that serves as a model for illustrating how evolution can be taught as an experimental and investigative science at the undergraduate level. In order to encourage the teaching of evolution at a variety of academic institutions, we have developed labs that can be run with minimal resources and a wide range of possible materials. In order to provide access to these materials, we have created a website (http://www.evolutionkills.org OR http://www.faculty.virginia.edu/evolutionlabs) that includes detailed descriptions of the laboratory and recitation exercises used for this course. In addition, we have built a database of other exercises in evolutionary biology that can be used in undergraduate or advanced secondary courses. These additional exercises were gathered from an array of sources, including published books, articles and symposia, online tutorials, educational websites, and course websites from other institutions. In this paper we outline the exercises that were used for the course and the materials that are available on the website (Outline 1).

Outline 1. *Information available on the website*

- I. Course
  - a. Sample Syllabi
    - i. Recitation (with TA comments)
    - ii. Laboratory
  - b. Multi-week Laboratory Exercises
    - i. Antibiotic Resistance in *E.coli*
    - ii. Speciation
      1. *Phytophthora* Isolating Mechanisms
      2. *Microbotryum* Isolating Mechanisms
    - iii. Phylogenetics
      1. Phylogeny of "fasteners"
      2. Phylogeny of biblical passages
      3. Molecular Phylogeny / GenBank Class Project
      4. Suggestions for independent GenBank Projects
  - c. Stand-alone Laboratory Exercises
    - i. Sexual Selection/Mate Choice
    - ii. Genetic Drift – Beans
    - iii. Genetic Drift – POPULUS
    - iv. Selection Demonstration – Woozleogy/Dawkins
    - v. Group Selection – POPULUS
    - vi. Calculating Heritability – Butterfly Eyespots
    - vii. Wagner Trees – Phylogeny Reconstruction
    - viii. PAUP – Phylogeny Exercise
- II. Additional Laboratory Exercises
  - a. Multi-week labs
  - b. Three-hour labs
  - c. One-hour labs
  - d. Field exercises
  - e. Online resources
- III. Published Labs
  - a. Exercises – sorted by category
    - i. Behavioral/evolutionary ecology
    - ii. Population genetics
    - iii. Phylogenetics
    - iv. Selection
  - b. Exercises – alphabetical by author
  - c. Complete laboratory manuals (with reviews)

A COURSE EXAMPLE

We have taught Experimental and Investigative Evolution at the University of Virginia for the last several years. This course is taught as a lecture with an accompanying hour-long weekly discussion section. In addition, a separate laboratory course is available for roughly 20 students to take concurrently or after they have taken the lecture portion of the course. The course is structured around a central theme of the evolution of disease. By focusing on disease evolution, the course emphasizes the relevance of evolutionary processes to everyday life, thereby disabusing students of the preconception that the study of evolution is a purely theoretical endeavor.

The laboratory class is divided into four learning units: microevolution, speciation, reconstructing evolutionary history, and analyzing genetic change. Within each unit of the laboratory course, students complete a prescribed group exercise, and then individual students or small groups of students propose and test hypotheses that build on the first exercise. Each unit concludes with student presentations of these independent projects.

Student response to the laboratory course has been very positive, and the course scores are above department averages. In general, students enjoyed the independent, thought-provoking nature of the research projects. Suggestions for improvement include expanding the scope of the course and making the phylogenetics section more exciting. We have included a summary of course evaluations from a recent semester (see Outline 2).

Outline 2. Course evaluations -- *Online course evaluations for Evolutionary Biology Laboratory (Biol 403) at the University of Virginia for the spring semester of 2004 are summarized below. We include student responses to questions regarding the effectiveness and structure of the course. Numeric responses range from 1 (excellent) to 5 (very poor). Average responses for all biology department courses are also listed.*

QUESTION	Biol 403 Average	Biology Department Average
In terms of helping me learn the material, the course's organization was	1.67	2.04
The quality of assigned reading for this course was	1.67	2.16
In terms of the amount I learned, this course was	1.33	1.84
My overall evaluation of this course was	1.22	2.03

Responses to open ended questions. We have selected responses that pertain to the course structure. Responses complimenting the teaching assistant and two responses to the second question regarding clarity of expectations for a specific assignment were not included.

1. **These are the features of the course that I especially liked:**
   a. "I liked the experiments."
   b. "I liked the discussion-based setting and the workshopping time allowed."
   c. "The course was a great combination of thought-provoking [sic] and informative without being overloaded with assignments."
   d. "We got to do the learning. We were provided with the resources we needed and got to motivate ourselves to pursue projects according to our own interest."
   e. "We had a lot of independence in our projects and got to study what we were interested in."
   f. "The course definitely encourages independent thought. This is probably the closest I've gotten to practicing real science here at UVA."

2. **These are my recommendations for improving the course:**
   a. "Feel like my understanding of evolutionary bio is kind of blotchy . . .I know lots about bacterial resistance, phylogenies and DNA typing, but what else is important to evolutionary bio field? Don't know if this can be practically improved in such a lab course though, because I did like learning things in depth."
   b. "I could have used some more time to organize the phylogenetics..."
   c. "Make phylogenetics portion more excited [sic] or take less time/make less percentage of grade."

Sample syllabi for the laboratory and the recitation portions of the course are available on the "Course" page of the website. These are provided to give instructors an idea of how this class was structured throughout the semester. Additionally, there are sections providing links to "Multi-week Laboratory Exercises" and "Stand-Alone Laboratory Exercises." The multi-week labs were designed to allow students to investigate a broad evolutionary topic in depth over the course of several weeks. Each of these exercises includes detailed instructions for the lab, suggested readings, background material for students, supplies needed, hints for instructors, and relevant, actual data collected by students at University of Virginia (Laboratory Exercise 1).

In all three multi-week labs, students first complete an instructor-led exercise, and then design and complete independent or group projects using the materials and/or information acquired in the first portion of the exercise. For example, in the phylogenetics unit, several short exercises are presented, followed by a longer exercise. The students are first instructed on how to construct a phylogenetic tree using pseudo-organisms, in this case "fasteners" such as different types of nails and screws or different models of paperclips, although real organisms could also be used (several are suggested). After identifying pertinent "traits" of the fasteners, the students construct a simple tree. The next exercise involves developing a "phylogeny" of the biblical passage "And God said, 'Let there be light:' and there was light." Students are given different versions of the passage that originate from different versions of the Bible and are asked to construct a tree that they think represents the chronological evolution of the phrase. The biblical phylogeny in particular demonstrates how the tools of evolutionary biology can be used in academic endeavors outside of biology and can lead to discussions about the differences between cultural and biological evolution.

After these two short exercises, the students are introduced to GenBank, a collection of publicly available DNA sequences. Students learn how to find DNA sequences using GenBank and then how to construct trees using PAUP and MacClade computer programs. The specific group exercise involves a medical mystery, in which the students determine whether staff at a French hospital infected a patient with HIV. The students compare the HIV sequences from two nurses with the sequence from the patient and with the HIV sequences in the population at large. After the students complete this portion of the unit, they are ready to use GenBank and their acquired skills to investigate other biological questions.

Students then propose a project using the sequences available on GenBank and complete independent or small group projects. These projects can include topics as diverse as which humans colonized New Guinea and Australia or whether the phylogeny of parasites such as *Cryptosporidium* spp. follows the phylogenies of their hosts. The unit concludes with presentations of the GenBank projects. These phylogenetic activities demonstrate how easily available materials can be used to construct effective experimental classroom activities for students. The different exercises described could each be taught independently or, as we have done, as part of a larger section on phylogenetics.

STAND-ALONE EXERCISES

Outlines of "Stand-alone Laboratory Exercises" are also provided on the website. These shorter labs are designed to accompany recitation or discussion sections. Like the longer labs, these exercises allow students to test hypotheses and engage in active problem solving. For example, one short exercise focuses on mate choice and sexual selection in humans. Students propose hypotheses about mate choice in humans and then use singles ads or wedding announcements to test their hypotheses. Projects can address topics such as age differences between mates and how this relates to female reproductive potential, or which qualities, physical or economic, men and women emphasize in their ads. Also included in this section are several exercises using the computer program POPULUS by Don Alstad at the University of Minnesota. This program can be used to demonstrate many concepts in evolutionary biology, from the basics like genetic drift, to more complex topics such as interdemic group selection.

We recognize that cost is one of the limiting factors when instructors are designing courses. All of the exercises described above can be completed with minimal resources; in most cases, the only requirements are computers with Internet access. POPULUS is free for download, and PAUP and MacClade software can be purchased for relatively low cost. If funds are unavailable for software purchase, there are freeware phylogenetic programs, including PHYLIP that can be used instead. Some of the other exercises, such as the *E. coli* antibiotic resistance lab and the speciation labs using *Microbotryum* and *Phytopthora*, require standard culturing tools and incubators, but none require unusual or expensive equipment.

OTHER RESOURCES

There are many well-designed laboratory exercises that encourage students to test hypotheses and design experiments in evolutionary biology. However, there is no single source that has compiled these exercises. Many of the exercises that test evolutionary concepts are located in specialty-journals or general biology education journals that are not specifically focused on evolution. Therefore, in order to facilitate implementation of laboratory-centered evolution courses, we have assembled an extensive online list of published laboratory exercises that focus

Laboratory Exercise 1: Antibiotic resistance in E.coli – Sample Results*. Class data from the University of Virginia, Spring 2000.*

In this lab exercise, students collected *E. coli* from swabs of themselves and then tested the cultured strains for antibiotic resistance. Figures 1 and 2 show *E. coli* colonies that were grown on eosin-methylene blue agar plates in the classroom. The results show that a quarter of the class harbored antibiotic resistant *E. coli*. This exercise can be used to launch a discussion of how disease-causing organisms can evolve resistance to common antibiotics. Students can then propose independent projects that use the cultured strains to test specific hypotheses about resistance. For example, experiments that investigate competition between resistant and non-resistant strains can be conducted to determine whether there is a cost to antibiotic resistance. Complete instructions for the lab are available on the website (http://www.faculty.virginia.edu/evolutionlabs/Antibiotic_Lab_Web_Page.html)

Figure 1 E. coli *colonies grown on eosin-methylene blue (EMB) agar*

Figure 2. *Growing* E. coli *on eosin-methylene blue (EMB) agar in the classroom*

ANTIBIOTICS TESTED

1 Ampicillin (Amp)
2. Chloramphenicol (Chl)
3. Kanamycin (Kan)
4. Rifampicin (Rif)
5. Streptomycin (Strep)
6. Tetracycline (Tet)

Class size of 15
Total number of lines grown = 262
- 12 people with no resistance to any antibiotics (total 216 lines with no resistance)
- 3 people with resistance
  - *person A*
    - 17 lines resistant to Amp, Strep, and Kan
    - 1 line resistant to Kan only
  - *person B*
    - 1 line resistant to Amp, Chl, Kan, and Strep
    - 16 lines resistant to Amp and Strep
  - *person C*
    - 11 lines resistant to Tet

on evolutionary biology (http://www.faculty. virginia.edu/evolutionlabs/published_exercises.html). These articles were gathered from general biology education journals such as *American Biology Teacher* and *Bioscene*, from specialty education journals such as *The Plant Health Instructor* and *Journal of Natural*

Resources and Life Sciences Education, and from workshops presented at symposia, such as the Wilson Society and Ecological Society of America. Lab exercises that are part of course websites from other academic institutions are also listed. An additional database of online resources is presented; these resources include professional educational websites, professional organizations focused on evolution and/or biological education, tutorials in evolutionary topics, and modeling software for evolution.

Published activities have been categorized according to broad evolutionary topics, including: behavioral/evolutionary ecology, population genetics, phylogenetics, and speciation. Many of the labs would fit into multiple categories, but all have evolutionary questions at the center of their investigations. At present, we list thirty-nine separate articles describing laboratory exercises. When possible, links to PDF files or to online access of articles are provided. Roughly 75% of articles listed have such links, which provide instant access to these resources. We have provided the bibliographic information for nine complete laboratory manuals that have broadly defined evolutionary themes. Unfortunately, many of these manuals are out of print, and others are difficult to find. When possible, informal reviews by one of the authors (JRV) are listed. The reviews attempt to identify which activities in the manuals are likely to be useful for designing evolution lab exercises, although we have not specifically tested the activities in the manuals.

Finally, in the "Additional Labs" section of our course website, we have included links to other, less formal, laboratory exercises, the majority of which are located on course websites for evolution classes at other universities. Because these course links change frequently, when possible, and with permission from the course instructors, we have provided a permanent link to the information on our website. Frequently, however, we were unable to contact the author of the course material. In these cases, we have simply provided a link to the original source of the material, which may or may not be permanent.

These additional labs are divided into sections according to length/type of exercise (Multi-week labs, three-hour labs, one-hour labs, and field exercises). Within each sub-heading, activities are listed according to what type of materials the lab uses: labs using organisms, labs using models, and labs using data that are provided. Finally, some of the published articles describing exercises that fit into these categories are also listed. Hence, there is some redundancy between the Additional Labs section and the Published Labs section, but this redundancy is intended to aid instructors by providing more information about the scope of activities available.

Also included on this web page is a section listing "Online Resources." The online resources are provided to give instructors ideas of other of places to look for teaching suggestions and background information. The online resources are divided into the categories of educational websites, models/simulations, online tutorials/activities, and pages of links.

We have also included comments from teaching assistants that taught the recitation/short exercise portion of the course. These comments, with minimal editorializing, are posted alongside the recitation syllabus and should be helpful to instructors planning to use the activities.

CONCLUSION

Evolution needs to be taught as an investigative discipline that forms the essential core of biology education. Biology students at all levels should learn the basic tools of evolutionary biology. We have created a course and accompanying website to encourage this broad educational goal. Because of the number and variety of exercises listed, this website should be a valuable resource for instructors of evolutionary biology at all institutions regardless of the scope of their specific courses or their budgets.

ACKNOWLEDGEMENTS

We would like to thank Findley Ransler for checking links and the rest of the Antonovics/Taylor lab for helpful suggestions on the design of the website. Two anonymous reviewers provided suggestions on an earlier draft of this manuscript. Audience members at the 2003 meeting of Association of College and University Biology Educators also provided useful suggestions for improving the website. Doug Taylor was the instructor and Steve Keller was the teaching assistant for Biol 403 - Spring 2004. Funding for this project was provided by a NSF Course and Curriculum Development grant (DEB9996449).

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Cooperative and Active Learning in Undergraduate Biological Laboratories at FIU-- Implications to TA Teaching and Training

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Abstract: There were several changes in the laboratory teaching program in the Biological Sciences at Florida International University (FIU) between 1993-1994. The underlying goal was the improvement of the amount of material learned and retained by the student, but these changes showed little positive improvement. It was deemed necessary for FIU to incorporate a completely different, well-researched approach. At the time of these implemented changes, it became apparent that Teaching Assistant (TA) training and development necessitated a restructuring that would involve the instructor on a more cognitive and interactive level with the students. Therefore, the goal for FIU was to prepare the TAs with a general pedagogical construct that would require a higher level of instructional and collaborative training in order to help improve student learning and retention of materials presented in the laboratory teaching program. The five basic constructs of cooperative learning were employed and the results proved to be of significant benefit to both the TAs and the students in their classes.

Key words: cooperative learning, active learning, positive interdependence, individual accountability, face-to-face promotive interaction, collaborative skills, group processing laboratory instruction, biology

INTRODUCTION

Cooperative Learning (CL), a pedagogy that has been used extensively in various settings in higher education, has demonstrated its value in learning and retention (Angelo and Cross, 1993; Astin, 1993; Cooper et al.; 1990; Goodsell et al., 1992; Johnson et al, 1991; McKeachie, 1986). CL is instruction that involves students working in teams to accomplish a common goal (Johnson et al., 1991). The CL method was utilized by FIU in training TAs in order to help improve student learning and retention.

The Basic Elements of Cooperative Learning

Cooperative Learning is more than group work or group assignments. There are five basic constructs that are important foundational elements to consider when developing this pedagogy (Felder and Brent, 1994; Cooper, 1990). The first basic element of cooperative learning is positive interdependence. This occurs when there are mutual goals, joint rewards, shared resources, and assigned roles. The second basic element of cooperative learning is face-to-face promotive interaction among students. This interaction exists when group members communicate their ideas to one another in order to learn and accomplish a task (Johnson et. al., 1991). The third basic element of cooperative learning is individual and group accountability. Two levels of accountability must be structured into cooperative lessons. The group must be accountable for achieving its goals—this accountability is accomplished by having a small fraction (5-10%) of the overall average based upon group performance. Each member is accountable for his or her share of the work. Individual accountability is more important in the assessment of grades and is responsible for the remaining percentage of students' grades after any "group" grade has been factored in (usually 90-95%). Usually, there is only a group portion to students' grades as a bonus. For example, if all members of a group get an "A" on a quiz, all members of that group get five bonus points added to their quiz grade as a reward for functioning well as a group. The fourth element of cooperative learning is interpersonal and small group skills. Groups cannot function properly if students do not use the required leadership, decision-making, trust building, communication, and conflict-management skills. The fifth basic element of cooperative learning is group processing. Group processing exists when group members analyze their performance in achieving goals and maintain effective cooperative relationships.

The Importance of Groups and Roles

Group functioning is an essential and natural element of the college laboratory experience. Cooperative Learning maximizes group learning benefits by ensuring that students function in a face-to-face promotive environment to achieve certain goals. Although no system is foolproof, the groups formed use principles deemed apt in decreasing the chances of negative group interactions. The main principle is to ensure a diversity of backgrounds in the group, be it cultural, ethnic, academic, or breadth of experience (Johnson et. al., 1991).

It is helpful to have students initially fill out 3x5 cards with some basic background information including name, age, sex, major (if applicable), year in college, ethnic origin, and their personal strengths so the instructor can determine group constituency in the following meeting. There should never be only one female in a group, all females, or no females. Studies have shown that women's ideas and contributions are often devalued or discounted in mixed gender teams, and the women take passive roles in group interactions, to their detriment (Felder et al., 1994; Heller and Hollabaugh, 1992). The same rule applies to minority students (Felder et al., 1994; Heller and Hollabaugh, 1992).

Groups should be designed to be as heterogeneous as possible without placing one female or one minority student in a group. Students should not be grouped with their friends because past experience has shown that prior friendships detract from overall positive interaction. Once groups are assigned, the other critical step is to define and assign roles. It is also helpful to change roles periodically to help keep all students actively engaged.

TA Training Prior to the Implementation of CL

Prior to the implementation of cooperative learning at FIU, the training of teaching assistants involved weekly lab meetings. During those meetings, the TA coordinator would go over key issues regarding what was planned for teaching that week. Teaching assistants with no prior teaching experience had an opportunity to ask questions during that time. These questions focused on the material to be covered rather than on how to teach that material; this was due to the fact that most new teaching assistants have little confidence in their laboratory teaching ability.

Implementation of CL into TA Training

In 1995 CL and Active Learning (AL) techniques were incorporated in the laboratory instruction curriculum of the Biology department at Florida International University by a few volunteer TAs (Angelo and Cross, 1993). Initially, only some CL exercises were intermixed with traditional lecture format. Students responded positively to the TAs who were providing a change of pace from teaching their labs through lecture alone to actively involving their students through the use of CL. Students enjoyed labs more and began to see a connection between their labs and the lecture course. Therefore, it became apparent that the department could no longer justify standing in front of the TAs and lecturing about teaching, safety, or anything else in the traditional paradigm if students preferred and learned more in an interactive and cooperative environment.

In 1996 the department began using CL and AL techniques in the actual training of TAs. For the first time at FIU, all TAs were required to attend a two day training workshop. During this workshop, the TAs were taught about teaching techniques such as active and cooperative learning. The TAs were taught the techniques of CL by experiencing CL themselves. For example, the TAs filled out 3X5 note cards, which were used to place them into CL groups. They were assigned group roles and completed tasks just as they would have their students do. The results of the entire process were extremely helpful for all involved. The training helped the TAs understand how they were expected to conduct their labs as well as created a support system for the new TAs.

TAs were taught how to assess individuals and groups by making and administrating quizzes and practicing questioning before being allowed to move to the next task, checking assigned work. In their training, TAs practiced doing "one-minute-papers" after the completion of each task or section. The point was to examine the use of group processing to maintain the skills necessary to keep the group functioning properly. The "one-minute-papers" allow students to express their feelings about what they learned, including the "muddiest point," and to comment about the functioning of their group.

Incorporating CL into Teaching Biology Labs

At FIU four roles are defined that have been helpful in teaching in biological laboratories. Other types of laboratories may want to define their own according to context. The "Recorder-Checker" is responsible for ensuring that the data from all experiments performed in lab are recorded, that any drawings, sketches, graphs and/or tables are made and that the questions in the lab manual pertaining to that week's lab are answered. The "Protocol Manager" ensures that everyone is following the tasks step-by-step, and that everyone in the group can relate what they are learning to the questions in the lab manual and to those given by the instructor. The "Maintenance Manager" ensures that the supplies and equipment needed for the lab are in place to perform the tasks, the group is practicing good lab hygiene, and the group is functioning in a cooperative manner. The "Encourager" motivates the group to begin, continue, and finish each task, ensures that the group can relate the procedures of the tasks to the objectives of the lab, assists the group with seeing the "big picture" (tying previous lab concepts to the present), and determines that the group has performed all tasks completely and correctly.

Assigning roles is especially important from a standpoint of student empowerment in a laboratory classroom. For both science and non-science majors, the first college laboratory experience can be overwhelming and discouraging. There are procedures to follow, microscopes to set up, chemicals to mix, samples to prepare, and many other tasks to perform, while continuously answering questions. In a two-person interaction, communication about respective responsibilities is fairly simple (i.e. You do this and I will do that). In a group of three or four, however, the dynamics change and having more people to do the work only increases the stress level due to the additional task of organizing the responsibilities of several people. Defining and assigning the four roles from day one minimizes this stress and allows even otherwise reticent students to take ownership in accomplishing tasks at hand.

Although roles can be very useful, there are several pitfalls to avoid. The first is that students may focus on their roles too much and forget that the goal is for everyone to get an overall understanding of what is happening in the lab. It is important to stress to students that having assigned roles does not mean they have no responsibilities beyond their own roles. It is in students' interest to ensure that the duties of each student's role are being carried out, because, in doing so, they increase their own potential (Johnson et. al., 1991). Notice that the duties assigned to each task begin with "ensuring." In other words, students must ensure that the duties assigned to their roles are performed; they do not necessarily need to have to do the tasks themselves. Students are told that it is every group member's responsibility to make sure that all members of the group keep up with the material and perform their tasks and roles. Students need to be reminded that they are interdependent and will benefit from helping each other. Certain roles require more work; therefore, it may be necessary, or desirable, to ask another individual for help. As with all aspects of the laboratory environment, students need to be carefully monitored and guided, especially at first, as they learn to work cooperatively.

An important role for the laboratory instructors using CL is to monitor and evaluate group functioning (Johnson, et. al., 1991). A great tool is associating a "thought" question with each task. Pro-actively, the TAs can pick any group member and ask a higher-order or methodology question and then evaluate each response. In doing so, they determine if the students are cognizant of the information and are functioning as cooperative groups. If instructors desire specifically to evaluate roles, they might ask a group member what has been done or is being done to fulfill his/her role. They might also ask one group member what another group member has done to fulfill her or his specifically assigned role.

The performance of each individual is assessed independently by quizzes and lab practicals, and the results are returned to the individual in order to ascertain who needs more assistance, support, and encouragement in learning. Our goal with CL is to improve the performance of the individual.

Individuals (independently and secretly--from the other members of the group) need to describe which actions of the members are helpful and detrimental. The instructor uses this information to implement strategies and make decisions about which behaviors to continue or change. Assessment of group processing skills is accomplished by having students write their analysis of their group's functioning in a "one-minute-paper" that is filled-out and returned at the end of every laboratory period. The instructor uses this information to decide which functioning skills and behaviors require modification and which are being used adequately.

In order to incorporate these roles into biology laboratories at FIU, TAs needed to be trained to implement these roles themselves. The initial training was carried out during the 2 day training workshop of TAs. During that workshop, TAs were assigned group roles as part of their training providing them with a sense of what implementation those roles would be like for the students. The roles of "Recorder-Checker", "Protocol Manager", "Maintenance Manager", and "Encourager" were discussed previously. Additional training of the TAs was provided during the weekly lab meeting held for individual lab exercises. TAs were required to carry out lab procedures in a group setting similar to what their students would be expected to do.

CONCLUSIONS

The results of using Cooperative Learning in teaching and training in the Biology Department at FIU have been very positive. Responses from instructors indicate that students are more engaged and participatory in the learning process. There has been an increase in the cognitive level of the material communicated, learned, and assessed by the students. Students have shown an increase in their ability to devise and practice scientific experimentation. Critical thinking skills have improved. TAs find that teaching and feedback are more rewarding. The failure rate has dropped and grade averages have improved. TA evaluations have also improved dramatically.

The TA's responses to being trained in a cooperative and active format have been very favorable. They are better prepared to perform CL than if it were simply explained to them. They also fare better at learning and retaining the information that is covered in orientation. Much less repeating of concepts and information throughout the semester is necessary, allowing for more material to be covered in greater detail. A more enthusiastic and well-prepared teaching staff is another positive outcome of TA training with CL and AL. The general feeling among the TAs is that there is much more collaboration, mentoring, and assistance, which makes for a positive attitude in the laboratory.

The implementation of CL into biology laboratories not only enhanced the overall lab experience, but especially helped shy and quiet students or students from minority groups to fit in with the rest of the students in lab. The students became highly invested in their groups and their group roles. For example, many students began to work outside of class in their CL groups. They studied together for lab and lecture exams as well as for other course exams. They valued working together as a team to help each other learn. The students wanted to have their professors incorporate CL into their lecture classes. Students expressed that labs were more fun, that the biological concepts made more sense, and that they worked harder because they not only wanted to learn, but they wanted all of their group members to learn too.

In essence, training the TAs at FIU in CL and AL techniques and then implementing these practices in the laboratory environment helped to accomplish FIU's ultimate goal of improved learning and retention by biological laboratory students. FIU has continued with these practices and continues to see positive learning and retention gains for TAs and students alike. Whereas new TAs benefit greatly from using CL in biological laboratories at FIU, implementing CL has also had an impact on TAs with previous teaching experience. CL has made labs more organized and students more engaged in the material covered. Using CL during students' first college lab experience, allows them to experience science as scientists (working cooperatively), while at the same time making labs more meaningful and enjoyable, which allows students to continue to be successful in future lab experiences.

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The Five-Tool Biology Major

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Abstract: Program-level assessment of the biology curriculum at a small liberal arts college indicates progress in the development of communication skills and content knowledge. The authors propose a mechanism to provide more research opportunities for students, giving them all the tools necessary to do science.

Keywords: Program-level assessment, content knowledge, primary literature, communication skills, undergraduate research

INTRODUCTION

The New York Yankees' Alex Rodriguez is a five-tool player. The 10-year veteran has produced 44 home runs and 22 stolen bases per year, along with career batting and fielding averages of .308 and .977, respectively. Rodriguez also has a strong arm, averaging 360 assists per year from the shortstop position (statistics courtesy of www.baseball-reference.com).

For the record, the five tools of baseball are: 1) hitting for average, 2) hitting for power, 3) running speed, 4) arm strength, and 5) fielding ability. Five-tool players may not lead the league in every statistical category every year, but they are the best all-around players in the game. They routinely produce key hits, timely stolen bases, and spectacular defensive plays.

A good scientist must also develop five critical tools: 1) content knowledge, 2) research skills (laboratory and/or field), 3) an ability to interpret primary literature, 4) writing skills (for grant proposals and manuscripts), and 5) speaking skills (for communicating with peers and the general public).

The interpretation of biological data requires a specific knowledge base. To understand and integrate information from different areas of biological inquiry, students should be familiar with fundamental concepts associated with each area, including cell structure and function, the molecular basis of heredity, biological evolution, and the interdependence of organisms.

Learning science means doing science. To fully understand and appreciate the scientific process, biology students should be engaged in hands-on, investigative activities (McNeil and D'Avanzo, 1997; Glasson and McKenzie, 1998; Lewis *et al*., 2003).

Communicative skills are essential for biologists as they generate data, share their findings, and build on the work of others. Successful communication depends on both the ability to effectively convey information (written and oral) and the ability to interpret and evaluate information presented by peers (Feldman *et al*., 2001). Reading primary literature allows students to enhance their critical thinking skills as they participate in the dissemination of scientific information (Fortner, 1999; Houde, 2000; Smith, 2001).

Davis & Elkins College (D&E) is a private, four-year liberal arts college that stresses small class size and strong faculty-student interaction. The Department of Biology and Environmental Science offers a curriculum designed to promote science as a process of inquiry and to instill within students an appreciation of the underlying unity and diversity of life. To meet the needs of students with diverse career interests, three degree options are offered: Bachelor of Science (B.S.) in Biology, Bachelor of Science in Environmental Science, and Bachelor of Arts (B.A.) in Biology and Environmental Science. The current study represents a program-level assessment of the B.S. in Biology degree. Specific criteria are used to assess development of each of the five scientific tools.

ASSESSMENT METHODS

In addition to math, physics, and chemistry requirements, biology majors at D&E must take five core content courses. *Principles of Biology I* (BIOL 101) introduces first-semester biology majors to cell structure and function, genetics, and developmental biology, while *Principles of Biology II* (BIOL 102) is taken in the second semester and deals primarily with the ecology and evolution of organisms. *Genetics* (BIOL 205) is a survey of prokaryotic and eukaryotic inheritance; *Cell and Molecular Biology* (BIOL 302) investigates metabolism, gene expression, and differentiation of eukaryotic cells; *Evolution* (BIOL 305) emphasizes the evidence, mechanisms, and genetics of organic evolution.

All D&E students are required to take the *College Basic Academic Subjects Examination* (C-BASE; Assessment Resource Center, University of Missouri) prior to graduation. To demonstrate an understanding of basic biological concepts, biology majors are expected to score "medium" or "high" on the *Fundamental Concepts of Life Science* component of the C-BASE.

Biology majors are also expected to demonstrate competency in basic biological research methods associated with laboratory components of the five core content courses. See Figure 1 for an example of a laboratory skills checklist.

Figure 1. *Laboratory Skills Checklist*

BIOL 205 - Genetics

Student ______________________________

Biology majors must demonstrate competency in the following areas:

1. **Basic statistics**
   - Probability _______
   - Chi-square test _______
2. **Laboratory techniques**
   - Slide staining/light microscopy _______
   - Use of micropipette _______
   - Restriction enzyme digestion of DNA _______
   - Gel electrophoresis _______
   - Culture maintenance _______
   - Bacterial transformation _______
3. **Experimental protocols**
   - Testing hypotheses _______
   - Interpreting results _______
4. **Laboratory report**
   - Format _______
   - Content _______
   - References _______
   - Writing style _______

With the exception of BIOL 305, all core courses require written laboratory reports. Figure 2 provides a sample laboratory report format. Biology majors are expected to demonstrate scientific writing skills by scoring between 80 and 100% on all reports required for BIOL 205 and 302.

To fulfill departmental requirements, biology majors must complete *Current Topics in Biology* (BIOL 340), a course that involves the analysis and discussion of current research articles. The instructor usually selects articles with a common theme. Figure 3 contains instructions for analyzing journal articles; whereas, Figure 4 provides citations of representative articles.

To demonstrate an ability to communicate information related to biological research, biology majors are also required to participate in *Senior Seminar* (BIOL 397). Satisfactory completion of BIOL 397 requires oral presentations of research data. Figure 5 shows the presentation analysis form utilized by the course instructor.

Figure 2. *Lab Report Format*

BIOL 302 – Cell & Molecular Biology

ABSTRACT (8 points)

Briefly summarize the report. Include basic aspects of each section in the summary. Start with an introductory sentence or two to describe the underlying question. In a few sentences, describe the experiments you performed to address the question. What were your results and how do they compare with information you found in the literature?

INTRODUCTION (20 points)

The introduction should consist of general background information. Basic concepts associated with the topic should be covered, but you should <u>not</u> discuss the actual experiments you performed. Reference all material you obtain from outside sources in the body of the text (author, date).

METHODS (8 points)

Write out, in complete sentences, the procedures that you followed to perform each experiment.

RESULTS (12 points)

Write out the result of each individual experiment. Include graphs and/or tables, as well as text, to present your data. Do not interpret data in this section; simply present your findings.

DISCUSSION (40 points)

This is the most important section. In the discussion, you should attempt to interpret the data you have collected. Analyze the result of each experiment individually. How do these results compare to information found in the literature? Does the literature support or contradict your results? Offer potential reasons for conflicting results. Suggest alternative or follow-up procedures to further analyze the question. Reference any information you find to help explain your results.

MISCELLANEOUS (12 points)

Lab reports should be written out in paragraph form (double-spaced). Check spelling and grammar. Each section should have its own heading. You must reference <u>all</u> information you obtain from outside sources and include an alphabetical “literature cited” section at the end of the report. Items in the literature cited section should contain the following information: Author(s). Year of Publication. Title of Article. Title of Journal. Volume: Page Numbers.

RESULTS

The Department of Biology & Environmental Science instituted its current assessment plan in the fall of 2001. The present study tracked the progress of the five biology majors who completed each of the core content courses, the C-BASE, BIOL 340, and BIOL 397 by the spring of 2004.

All five students scored “medium” or “high” on the *Fundamental Concepts of Life Science* component of the C-BASE, demonstrated competency in all core course laboratory skills, scored 80% or higher on all laboratory reports in BIOL 205 and 302, and successfully completed both the Current Topics course and the Senior Seminar.

All five students graduated with the B.S. degree in Biology. Two have taken entry-level jobs in forestry and fire management, two have been accepted into graduate programs in biology, and one will be attending medical school.

Figure 3. *Instructions for Analyzing Journal Articles*

BIOL 340 – Current Topics in Biology

1. **CITATION**
   Include authors' names, year, title of article, name of journal (may be abbreviated), volume of journal, first & last pages of article.

   Example: Perrault S.D., R.R. Barbee, and V.L. Slott. 1988. Importance of glutathione in the acquisition and maintenance of sperm nuclear decondensing activity in maturing hamster oocytes. *Dev Biol* 125: 181-186.

2. **GAP IN KNOWLEDGE**
   What biological question does this research address? What was known & unknown prior to this research? This information is generally found in the Introduction of the paper.

3. **OVERALL HYPOTHESIS**
   A hypothesis, in this case, is a statement of explanation to a question concerning some biological phenomenon. An overall hypothesis may not be clearly stated. You may have to infer what the hypothesis is, based on the procedures being used to address the research question.

4. **PREDICTION**
   An "If…, then…" statement. If the hypothesis stated in step 3 is correct, then we would expect certain predictions to be correct. The experiments conducted should test these predictions and, therefore, lead to support for or against the overall hypothesis.

5. **EXPERIMENTAL APPROACH**
   What, specifically, was measured or determined? Summarize the approach in your own words.

6. **RESULTS**
   What new information was produced? Summarize the results in your own words.

7. **CONCLUSION**
   What do the authors make of the data? Are their conclusions valid? Is there any other possible interpretation? Do the data support the hypotheses? Are there any alternative hypotheses?

8. **NOW WHAT?**
   A good paper may generate more questions than it answers. After reading this paper, what is the next question these authors (or other researchers in this field) should address?

Figure 4. *Representative Articles*

DIET & EXERCISE

Hanninen, O. *et al*. 2000. Antioxidants in vegan diet and rheumatic disorders. *Toxicology* 155: 45-53.

Williams, N.I. *et al*. 2001. Longitudinal changes in reproductive hormones and menstrual cyclicity in cynomolgus monkeys during strenuous exercise training: Abrupt transition to exercise-induced amenorrhea. *Endocrinology* 142: 2381-2389.

ALTERNATIVE MEDICINE

Schwartz, E. *et al*. 2002. Oral administration of freshly expressed juice of *Echinacea purpurea* herbs fail to stimulate the nonspecific immune response in healthy young men: Results of a double-blind, placebo-controlled crossover study. *Journal of Immunotherapy* 25(5): 413-420.

Solomon, P.R. *et al*. 2002. Ginkgo for memory enhancement: A randomized controlled trial. *Journal of the American Medical Association* 288: 835-840.

SEXUAL REPRODUCTION

Mabry, M. and P. Verrell. 2003. All are one and one is all: Sexual uniformity among widely separated populations of the North American seal salamander, *Desmognathus monticola*. *Biological Journal of the Linnean Society* 78: 1-10.

Mack, P.D. *et al*. 2002. Sperm competitive ability and genetic relatedness in *Drosophila melanogaster*: Similarity breeds contempt. *Evolution* 56(9): 1789-1795.

Figure 5. *Presentation Analysis.*

BIOL 397 - Senior Seminar

Student ________________________________

	Poor	Acceptable	Good	Excellent
Content				
Research Question:	1	2	3	4
Overall Hypothesis:	1	2	3	4
Prediction:	1	2	3	4
Methods:	1	2	3	4
Results:	1	2	3	4
Conclusion:	1	2	3	4
Personal Interpretation:	1	2	3	4
Follow-up Studies:	1	2	3	4
Presentation Style				
Eye Contact:	1	2	3	4
Articulation/Volume	1	2	3	4
Movement/Interaction:	1	2	3	4
Fielding Questions:	1	2	3	4
			Score _____	

DISCUSSION

In many cases, outcomes such as course completion and letter grades are insufficient to describe the specific knowledge and skills obtained by college graduates (Brakke and Brown, 2002). A program-level assessment helps ensure that all graduates of a particular department or program will obtain acceptable levels of skill and knowledge (Gilbert and Mason, 2004).

The C-BASE is a criterion-referenced academic achievement examination that evaluates competency in English, mathematics, science, and social studies (www.arc.missouri.edu/collegebase). The test assesses basic knowledge in each of the four subject areas and provides performance rankings of interpretive, strategic, and adaptive reasoning abilities. The *Fundamental Concepts of Life Science* component of the exam assesses knowledge of basic biology, botany, zoology, and ecology. Although the exam is used primarily to evaluate the college's general education curriculum, results of the life science section effectively complement course grades as an assessment of biology majors' basic content knowledge.

Biology majors are introduced to scientific writing during their first semester at D&E. In BIOL 101, students write two laboratory reports, each preceded by a rough draft. The instructor thoroughly critiques the rough drafts to highlight flaws in format, grammar, and content. Writing skills are often undeveloped in freshman students (many are taking English composition simultaneously), and most are unfamiliar with the standard format required for laboratory reports. However, by the time biology majors complete BIOL 102, they are expected to have acquired the necessary skills to produce a thorough, well written laboratory report. In BIOL 205 and 302, they are expected to score at least 80% on every report.

Students are often intimidated by primary literature. They are unfamiliar with the technical jargon and are uncomfortable dealing with figures, tables and statistics (Smith, 2001). In BIOL 340, biology majors utilize a standardized analysis tool (Figure 3) to dissect journal articles, which are given to them one week prior to an in-class discussion. Armed with the results of their analyses, students (and a faculty facilitator) discuss the paper and compare notes. The goal is for students to become comfortable with graphical representations of data and the interpretation of experimental results. Although students are apprehensive initially, they become quite adept at analyzing articles by the end of the semester.

Senior biology majors participate in BIOL 397. Presently, students select journal articles of interest to them, use the skills acquired in BIOL 340 to analyze the articles, and present the data (using Microsoft PowerPoint) to their peers. Presentations get progressively better as students become more comfortable with the process.

The greatest weakness of the current assessment plan is the evaluation of research skills. Participating in laboratory exercises may reinforce biological concepts, and students may pick up some valuable skills in the process; however, students must be actively involved in scientific research to fully understand it.

FUTURE DEVELOPMENTS

In 2002, the department received funding to purchase modern equipment for cell and molecular biology labs. The instrumentation has enhanced the curriculum considerably and has allowed several students to undertake independent research projects in areas such as exercise physiology and toxicology. To give students an opportunity to expand their interests in other areas of inquiry, funding was recently obtained to purchase a new walk-in environmental chamber. The chamber will be an asset in all organism-based courses and will significantly increase research opportunities for students. Individuals interested in animal behavior, botany, or ecology will benefit from the new instrumentation by gaining experience in the design and implementation of long-term experimental protocols in a controlled environment.

In the near future, the department will implement and expand experimental systems developed as part of *Research Link 2000* (www.cur.org/reslink2000.html), a project initiated by the National Science Foundation's Council for Undergraduate Research to provide convenient model systems for undergraduate teaching and research. These experimental systems will facilitate the introduction of research-based laboratory activities into the undergraduate curriculum. For example, the parasitic wasp *Nasonia* is much easier to handle than the fruit fly *Drosophila* and exhibits visible mutations and molecular markers useful for teaching genetic principles such as linkage and epistasis. Furthermore, three closely related species of *Nasonia* exhibit behavioral and morphological differences, allowing demonstration of evolutionary principles such as reproductive isolation, speciation, and adaptation. Stable environmental conditions for long-term *Nasonia* projects will optimize experimental results for students in genetics, evolution, and animal behavior courses. To facilitate study of plant biology, a specially derived strain of the tropical fern *Ceratopteris richardii* (C-Fern) will be utilized. Extended observations of the C-Fern sporophyte phase will be carried out under stable environmental conditions, allowing assessment of the long-term impact of temperature, humidity, and photoperiod on plant growth and viability. Additionally, ecology students will be exposed to a unique algal-invertebrate symbiosis through study of the sea anemone *Aiptasia pallida*. This experimental system will be used to demonstrate potential longitudinal effects of variables such as age, size, nutrition, and environmental stress on a symbiotic relationship. By participating in supervised laboratory procedures associated with these courses, students will become familiar with experimental design and data collection techniques. Moreover, they will be able to follow up their course-based laboratory experiences with long-term independent research projects using any of the above *Research Link 2000* model systems. Ultimately, BIOL 397 will become a forum for sharing the results of independent research with other members of the department.

CONCLUSION

Small class size is integral to the personalized undergraduate education offered at D&E. The authors recognize that the interactive learning environment associated with small groups may have contributed to the favorable assessment results.

We will continue to collect annual assessment data to validate the current study. While acknowledging the small sample size utilized for program assessment, we are encouraged by the preliminary results. When the integrated research component of the plan is in place, we are confident that D&E biology graduates will have all five tools necessary to produce key breakthroughs in the laboratory, timely discoveries in the field, and spectacular discussions in the classroom.

ACKNOWLEDGEMENTS

This project was supported by a 2002 Instrumentation Grant and a 2003 Innovation Grant from the West Virginia Experimental Program to Stimulate Competitive Research (EPSCoR). The authors thank Dr. Catherine Gardiner of the University of Northern Colorado for her contribution to the development of assessment instruments.

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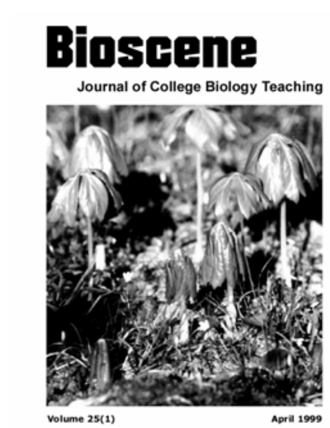

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Wabash College

Site of the 48th Annual Meeting

Association of College and University Biology Educators

Wabash College was founded in 1832 as an independent non-sectarian college for men. For more than 170 years Wabash has been educating young men to "think critically, act responsibly, lead effectively, and live humanely" with a classical liberal arts educational experience. Students may pursue one of twenty-one different majors. The curriculum seeks to allow maximum flexibility as well as to provide the broad base of understanding that is at the core of the liberal arts concept. At Wabash about 25% of the students participate in over 140 study abroad programs. The 850 students come from 34 states and 13 foreign countries. Nearly 21% are students of color. Approximately 90% of the students receive some form of financial aid. The U.S. News and World Report rank Wabash in the top 20% of the 212 National Liberal Arts Colleges. Wabash set two national benchmarks in The National Survey of Student Engagement and ranked in the 90th percentile in three other categories. Wabash ranked first in the level of academic challenge and students' interaction with the faculty. About 75% of Wabash alums attend graduate school within five years of graduation. Thirteen percent of our alums hold Ph.Ds and 12% hold the title of "President" or "Chairman." Only two Ivies have a higher percentage of alumni in Who's Who.

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Registration Fee: **Includes** all meals Friday through-Sat noon, refreshments at breaks, and field trips.

Membership status	by 08/01/2004	after 10/01/04
Regular Member	$ 85	$ 100
Regular member + 2005 dues	$ 115	$ 130
New Member (includes 2005 dues)	$ 115	$ 130
Non-Member	$ 115	$ 130
Non-Participating guest/spouse	$ 55	$ 55
Student (Grad or Undergrad)	$ 55	$ 55
K-12 teacher	$ 55	$ 55
Friday evening dinner only	$ 15	$ 15

TOTAL ENCLOSED (Please make checks payable to ACUBE) ____________

Field Trips: Indicate the trip(s) you plan to attend. Space is limited, register early!

- _______ Pre-meeting field trip to Pine Hills (relic hemlock trees) (Thursday afternoon, October 14)
- ________ Birding trip (Friday morning October 15)
- ________ Crinoid fossil collecting trip (Friday afternoon October 15)

Special needs (food, facilities, etc.):

Please send registration form and payment to: Dr. Austin Brooks
ACUBE Local Arrangements Chair
Department of Biology, Wabash College
Crawfordsville, IN 47933
Voice: 765-361-6350 FAX 765-361-6149 brooksa@wabash.edu

ACUBE 48TH Annual Meeting

October 14-16, 2004

Wabash College
Crawfordsville, IN

Technology in Biology Education

Preliminary Program

Thursday, October 14th		
2:00 - 5:00 PM	**Pre-Conference Field Trip: Pine Hills**	**Location TBA**
3:00 - 5:00 PM	**Steering Committee Meeting**	**Biology and Chemistry Buidling** (TBA)
6:00 - 8:00 PM	**Registration and Reception** *heavy h'ors d'oerves*	**Biology and Chemistry Building Entry and Room 104**
8:00 - 9:00 PM	**Opening Session** **Welcome to ACUBE**: ACUBE President: **Terry Derting**, *Murray State University* **Welcome to Wabash College:** Dean of the College**, Dr. Mauri Ditzler,** *Wabash College* Program Chair: **Joyce V. Cadwallader,** *Saint Mary-of-the-Woods College* Local Arrangements Chair: **Austin Brooks,**.*Wabash College* **OPENING ADDRESS** (Public Welcome to Attend) **John Kraemer,** ***Southeast Missouri State University*** *Title: The Application of Remote Sensing and GIS Technology in Environmental Science Education*	**Biology and Chemistry Building Room 104**
9:15 - 10:15 PM	**Steering Committee Meeting**	**Biology and Chemistry Building** (TBA)
Friday, October 15th		
7:00 AM - 5:00 PM	**Registration table**	**(all locations are in the Biology and Chemistry Building unless otherwise indicated)**

Friday, October 15th

7:00 - 8:00 AM	**Buffet Breakfast** (by Interest Group)	**Detchon Center**
7:30 - 10:30 AM	**Field Trip: Birding**	**Location TBA**
9:00 AM - Noon and 2:00 - 5:00 PM	**SUSTAINING MEMBER EXHIBITS** Refreshments provided	**Biology and Chemistry Building**
8:15-9:45 AM	**CONCURRENT WORKSHOP SESSIONS I** 1. **Easy Ways to do Physiology Labs from iWORX/CB Sciences**, Steve Andre, iWORX/CB Sciences 2. **Using Technology with Investigative Case Based Learning** Margaret Waterman, Southeast Missouri State University and Ethel Stanley, BioQUEST, Beloit College 3. **Mastery Teaching and Learning Workshop**, Abour H. Cherif and Karen Murkar, DeVry University 4. **Amphipods as a Model System for Teaching Ecology**, Evolution, and Behavior. Susan E. Lewis, Carroll College	**Biology and Chemistry Building**
9:50-10:20 AM	**POSTER SESSION I** Refreshments provided 1. **Investigative Case Based Learning: The LifeLines OnLine Project** Margaret Waterman, Southeast Missouri State University and Ethel Stanley, BioQUEST, Beloit College 2. **Development of a Blended Online/Traditional Environmental Science Course** Jennifer A Sadowski* and Michael S. Alfieri, Viterbo niversity 3. **Teaching Population Growth Using Cultures of Vinegar Eels, Turbatrix aceti (Nematoda)** Robert L. Wallace, Ripon College 4. **Development of an Upper-level Comparative Bioinformatics Course** Glenna G. Temple, Viterbo University 5. **Tools for Environmental Conservation & Restoration** Peter J. Wilkin, Purdue Univ. North Central	**Biology and Chemistry Building**
10:30 - 11:15 AM	**CONCURRENT PAPER SESSIONS I** 1. **A Single Organism Can Serve Many Educational Purposes** William Brett, Indiana State University 2. **Bridging the Interdisciplinary Divide: A Mathematical Model of Muscle Contraction and Its Uses in Undergraduate Biology and Math Education** Tom Hoogendyk, Biology Department, Northeastern University, and Jennifer Galovich, Mathematics Department, College of Saint Benedict and Saint John's University	**Biology and Chemistry Building**

Friday, October 15th

10:30 - 11:15 AM	**CONCURRENT PAPER SESSIONS I** 3. **Writing, Collaborative Media, and Interactive Online Environments.** Steve Brewer, University of Massachusetts Amherst 4. ***LabWrite*: Educational Technology to Enhance Students' Writing and Learning in Biology Labs** Miriam Ferzli, Michael Carter, and Eric Wiebe, North Carolina State University	**Biology and Chemistry Building**
11:20 - 12:05 AM	**CONCURRENT PAPER SESSIONS II** 1. **The Web Enhanced Course: A Liaison Between the Computer and the Classroom** Hugh B. Cole, Hopkinsville Community College 2. **Human Allometry: Sexual Differences in Growth Rates of Various Body Parts** Buzz Hoagland, Westfield State College 3. **Long-term Impacts on One Semester of Reformed Teaching on Student Learning.** Terry L. Derting, Murray State University	**Biology and Chemistry Building**
12:15 - 1:00 PM	**Luncheon and First Business Meeting** *First and Final Call for Nominations!!* *Out of this World Teaching Idea contributions*	**Detchon Center**
1:00 - 1:45 PM	**Luncheon Program** **John Jungck,** *Beloit College* *Title: Computer Power and Human Learning: Using Technology As If Sudents Matter*	**Detchon Center**
2:00 - 5:00 PM	**Field Trip: Crawfordsville Crinoid Beds**	**Location TBA**
2:00–2:45 PM	**CONCURRENT PAPER SESSIONS III** 1. **The Science of Flight 3.** Lynn Gillie, Todd Egan, and Mary Anne Perks, Elmira College 2. **Round Table Discussion—Recruiting 1st and 2nd year Potential Majors—Strategies** Thomas A. Davis, Loras College 3. **A Survival Guide for Students in the Anatomy and Physiology Course** Neil Baird, Millikin University	**Biology and Chemistry Building**
2:50 - 3:20 PM	**POSTER SESSION II** Refreshments provided 1. **Investigative Case Based Learning: The LifeLines OnLine Project** Margaret Waterman, Southeast Missouri State University and Ethel Stanley, BioQUEST, Beloit College	**Biology and Chemistry Building**

Friday, October 15th

2:50 - 3:20 PM	**POSTER SESSION II** Refreshments provided 2. **Investigative Case Based Learning: The LifeLines OnLine Project** Margaret Waterman, Southeast Missouri State University and Ethel Stanley, BioQUEST, Beloit College 3. **Development of a Blended Online/Traditional Environmental Science Course** Jennifer A Sadowski and Michael S. Alfieri, Viterbo University 4. **Teaching Population Growth Using Cultures of Vinegar Eels, *Turbatrix aceti* (Nematoda)** Robert L. Wallace, Ripon College 5. **Development of an Upper-level Comparative Bioinformatics Course** Glenna G. Temple, Viterbo University 6. **Tools for Environmental Conservation & Restoration** Peter J. Wilkin, Purdue Univ. North Central	**Biology and Chemistry Building**
3:30 - 5:00 PM	**CONCURRENT WORKSHOP SESSIONS II** 1. **Case It! Computer Simulations for the Analysis of Genetic and Infectious Disease—An Update** Mark Bergland and Karen Klyczek, University of Wisconsin, River Falls 2. **Using *LabWrite*: Helping Students Write Better Lab Reports** Michael Carter, Miriam Ferzli, and Eric Wiebe, North Carolina State University 3. **Integrating video camera, digital microscopy into the Biology curriculum and laboratory** Richard E. Wilson, Ken-A-Vision Mfg. Co. Inc	**Biology and Chemistry Building**
5:05 - 5:45 PM	**Web Committee Meeting**	**Biology and Chemistry Building**
6:00 - 7:00 PM	**Social Hour:**	**Detchon Center**
7:00 - 9:00 PM	**Dinner and Second Business Meeting** (two-minute speeches by the candidates prior to dinner; balloting after dinner presentation) **Dinner Presentation** **Cary Mitchell, Purdue University**, *Title: TBA* *Presentation of the 2003 Out of this World Teaching Idea*	**Detchon Center**

Saturday, October 16th

7:30 - 8:45 AM	**Buffet Breakfast** (by Interest Group)	**Detchon Center**
7:45 - 8:45 AM	**Bioscene Editorial Board**	**Biology and Chemistry Building**

Saturday, October 16th

9:00 - 9:45 AM	**CONCURRENT PAPER SESSIONS IV** 1. **Teaching with Ultrastructure—Active Learning with Rotating Teams** Thomas A. Davis, Loras College 2. **Using Technology to Teach an Integrated Mathematics/Biology Course – Preliminary Report** George M. O'Connor and John G. Koelzer, Rockhurst University 3. **Grantsmanship and NSF-Style Student Peer Review In Undergraduate Research Experience** B. G. Blair, G. R. Cline, and William R. Bowen, Jacksonville State University	**Biology and Chemistry Building**
10:00 - 10:45 AM	**CONCURRENT PAPER SESSIONS V** 1. **Interdisciplinary Impact of Evolution** David P. Benson, Marian College 2. **Bioinformatics Instruction: Using Microarray Data Sets to Stimulate Student Learning.** Hugh A. Miller III and Karl H. Joplin, East Tennessee State University 3. **PDAs in the Biology Classroom and Lab: The Future or Fad?** Timothy Mulkey, Indiana State University	**Biology and Chemistry Building**
11:00 AM - 12:15 PM	**Luncheon and Third Business Meeting** **BUSINESS MEETING** Resolutions: *Dick Wilson, Rockhurst University* Executive Secretary Report: *Pres Martin, Hamline University* Bioscene: *Ethel Stanley, Beloit College & Tim Mulkey, Indiana State University* Presidential Address: *Terry Derting, Murray State University* 2004 Meeting: *Margaret Waterman, Southeast Missouri State University*	**Detchon Center**
12:30 - 3:00 PM	**Steering Committee Meeting** Includes newly elected Steering Committee members!	**Biology and Chemistry Building**
12:30 – 4:00 PM	**Post conference: Covered Bridge Festival of Parke County, Indiana -- (Information will be available at meeting for those who wish to participate on their own)**	

Housing Preview

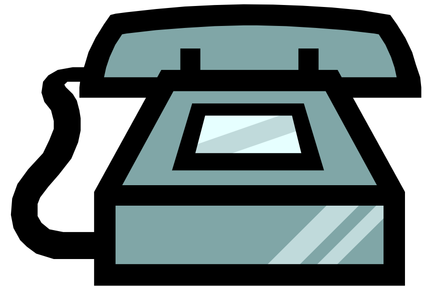
48th Annual ACUBE Fall Meeting

Technology in Biology Education

Wabash College

Crawfordsville, IN

October 14-16, 2004



Lodging: Blocks of rooms have been reserved until September 14, 2004 at the Comfort Inn and Holiday Inn.

IMPORTANT: Please note this is the same weekend as the **Parke County Covered Bridge Festival** which draws thousands of visitors on weekends. As you will note, weekend rates can be higher than weekday rates. Rooms are at a premium during this time. **PLEASE BOOK YOUR ROOMS EARLY**.

Comfort Inn Phone: (765) 361-0665 (800) 329-5150 ***Book by: 9/14/04*** 10/14 $ 89.95+tax 10/15 $ 89.95+tax	**Holiday Inn** Phone: 765-362-8700 ***Book by: 8/17/04*** 10/14 $ 69.00+tax 10/15 $122.95+tax
Super 8 Motel Phone: (765) 361-8800 (800) 800-8000 10/14 $ 60.00+tax 10/15 $ 75.00+tax	**Days Inn** Phone: (765) 362-0300 (800) 329-7666 10/14 $ 65.00+tax 10/15 $ 75.00+tax
Ramada Limited Phone: (765) 364-9999 (800) 272-6232 10/14 $ 63.00+tax 10/15 $ 82.00+tax	**General Lew Wallace Inn** Phone: (765) 362-8400 10/14 $ 56.00+tax 10/15 $ 75.00+tax
Trippet Hall (on campus) Phone. (765) 361-6490 10/14 $ 87.00+tax 10/15 $ 87.00+tax	

Call for Nominations
President-Elect & Steering Committee Members

ACUBE members are requested to nominate individuals for the office of President-Elect and two at large positions on the ACUBE Steering Committee. Self-nominations are welcome. If you wish to nominate a member of ACUBE for a position, send a Letter of Nomination to the chair of the Nominations Committee:

Dr. Janet Cooper, Dept. of Biology, Rockhurst University
1100 Rockhurst Road, Kansas City, MO 64110
Voice –(816) 501-4237, E-mail – janet.cooper@rockhurst.edu

ACUBE Governance for 2004

President – Terry Derting, *Murray State University*
President-Elect – Lynn Gillie, *Elmira College*
Immediate Past President – Margaret Waterman, *Southeast Missouri State University*
Executive Secretary – Presley Martin, *Hamline University*
Secretary – Jill Kruper, *Murray State University*
First Vice President (Program Chair) – Joyce Cadwallader, *St. Mary-of-the-Woods College*
Second Vice President (Local Arrangements) – Aus Brooks, *Wabash College*

Board Members

Abour Cherif, *DeVry University*
Janet Cooper, *Rockhurst University*
Neil Grant, *William Patterson University*
Brenda Moore, *Truman State University*
Conrad Toepfer, *Millikin University*
Robert Wallace, *Rippon College*

Standing Committees

Membership – Aus Brooks, *Wabash College*
Constitution- Margaret Waterman, *Southeast Missouri State University*
Nominations – Janet Cooper, *Rockhurst University*
Internet- Margaret Waterman, *Southeast Missouri State University*
Bioscene – Tim Mulkey, *Indiana State University*; Ethel Stanley, *Beloit College*
Awards: Honorary Life Award and Carlock Award – William Brett, *Indiana State University*
Resolutions- Brenda Moore, *Truman State University*
Historian – Edward Kos, *Rockhurst University*

Call for Applications – John Carlock Award

This Award was established to encourage biologists in the early stages of their professional careers to become involved with and excited by the profession of biology teaching. To this end, the Award provides partial support for upper division undergraduate and graduate students in the field of Biology to attend the Fall Meeting of ACUBE.

Guidelines: The applicant must be actively pursuing an undergraduate program or graduate work in Biology. He/she must have the support of an active member of ACUBE. The Award will help defray the cost of attending the Fall meeting of ACUBE. The recipient of the Award will receive a certificate or plaque that will be presented at the annual banquet; and the Executive Secretary will provide the recipient with letters that might be useful in furthering her/his career in teaching. The recipient is expected to submit a brief report on how he/she benefited by attendance at the meeting. This report will be published in Bioscene.
Application: Applications, in the form of a letter, can be submitted anytime during the year. The application letter should include a statement indicating how attendance at the ACUBE meeting will further her/his professional growth and be accompanied by a letter of recommendation from an active member of ACUBE. Send application information or any questions about the Award to:

Dr. William J. Brett, Department of Life Sciences, Indiana State University, Terre Haute, IN 47809
Voice—(812) 237-2392; FAX (812) 237-4480; E-mail—lsbrett@isugw.indstate.edu

If you wish to contribute to the John Carlock Award fund, please send your check to: Dr. Pres Martin, Executive Secretary, ACUBE, Department of Biology, Hamline University, 1536 Hewitt Ave., St. Paul, MN 55104

ACUBE

Association of College and University Biology Educators

NAME: ____ DATE: __________________

TITLE: ____

DEPARTMENT: ____

INSTITUTION: ____

STREET ADDRESS: ____

CITY: ________________________________ STATE: _____________ ZIP CODE: ___________

ADDRESS PREFERRED FOR MAILING: ____

____

CITY: _____________________________ STATE: ____________ ZIP CODE: _______________

WORK PHONE: __________________ FAX NUMBER: ____________________________________

HOME PHONE: __________________ EMAIL ADDRESS: _________________________________

MAJOR INTERESTS	**SUB DISCIPLINES:** (Mark as many as apply)	
( ) 1. Biology	( ) A. Ecology	( ) H. Molecular
( ) 2. Botany	( ) B. Evolution	( ) I. Developmental
( ) 3. Zoology	( ) C. Physiology	( ) J. Cellular
( ) 4. Microbiology	( ) D. Anatomy	( ) K. Genetics
( ) 5. Pre-professional	( ) E. History	( ) L. Ethology
( ) 6. Teacher Education	( ) F. Philosophy	( ) M. Neuroscience
( ) 7. Other _______________	( ) G. Systematics	( ) N. Other ______________

RESOURCE AREAS (Areas of teaching and training): ________________________________

____

RESEARCH AREAS: ____

____

How did you find out about ACUBE? ____

Have you been a member before: _____________ If so, when? _______________________

DUES (Jan-Dec 2004) Regular Membership $30 Student Membership $15 Retired Membership $5

Return to: Association of College and University Biology Educators, Attn: Pres Martin, Executive Secretary, Department of Biology, Hamline University, 1536 Hewitt Avenue, Saint Paul, MN 55104

WHAT THEY MIGHT HAVE SAID

William J. Brett

Most college and university teachers are aware that student class attendance is a growing problem. Some students start their weekends on Thursday night making Friday class attendance considerably less than Monday and Wednesday in M, W, F classes. Instructors have tried various methods to encourage better class attendance. At Indiana State University, some faculty give quizzes on Friday, while others award bonus points for attendance, and others subtract points from the student's total points depending on the number of absences. The University requires student attendance records at three, seven and ten weeks into the semester to notify by letter the "guilty" of their excessive absences. My approach is to provide in the course syllabus a table relating participation in class activities, which relates directly to attendance, to final grades. Recently I have added another reminder of the value of attending class, which I present at the first class session.

CLASS ATTENDANCE

Aristotle said, "He who does not attend class, dost not attend graduation (1)." A relatively low percentage of freshmen finish their senior year. Certainly class attendance plays an important role in this. Newton said, "All objects fall down when dropped (3)." Dropping out of class also drops one's grades. Skipping class usually results in lower tests scores, and low test scores often result in students dropping a class. Fahrenheit is quoted as saying, "An empty chair is colder than an occupied chair (2)." By leaving a chair empty, everyone in the room needs to put out more heat energy in order to compensate for the missing body heat of the empty chair.

1. Aristotle. 347 B.C. Success or failure. Plato's Journal. 47: 27-34.

2. Fahrenheit, G.D. 1702. Temperature emitted by the living body. Radiation Journal. 73:17-24.

3. Newton, I. 1684. Does gravity play a role in dropping grades? Journal of Gravitational Forces. 23:47-63.

The amusing or interesting fact is that if the instructor does not smile while presenting this material, some students will go to the library to find the journals, but other, and usually a larger number, will go to the WEB. The responses will vary from amusement to irritation at the time they wasted on this worthless project, but it does get their attention. A bonus to this endeavor is the presentation of one way to refer to and list citations.