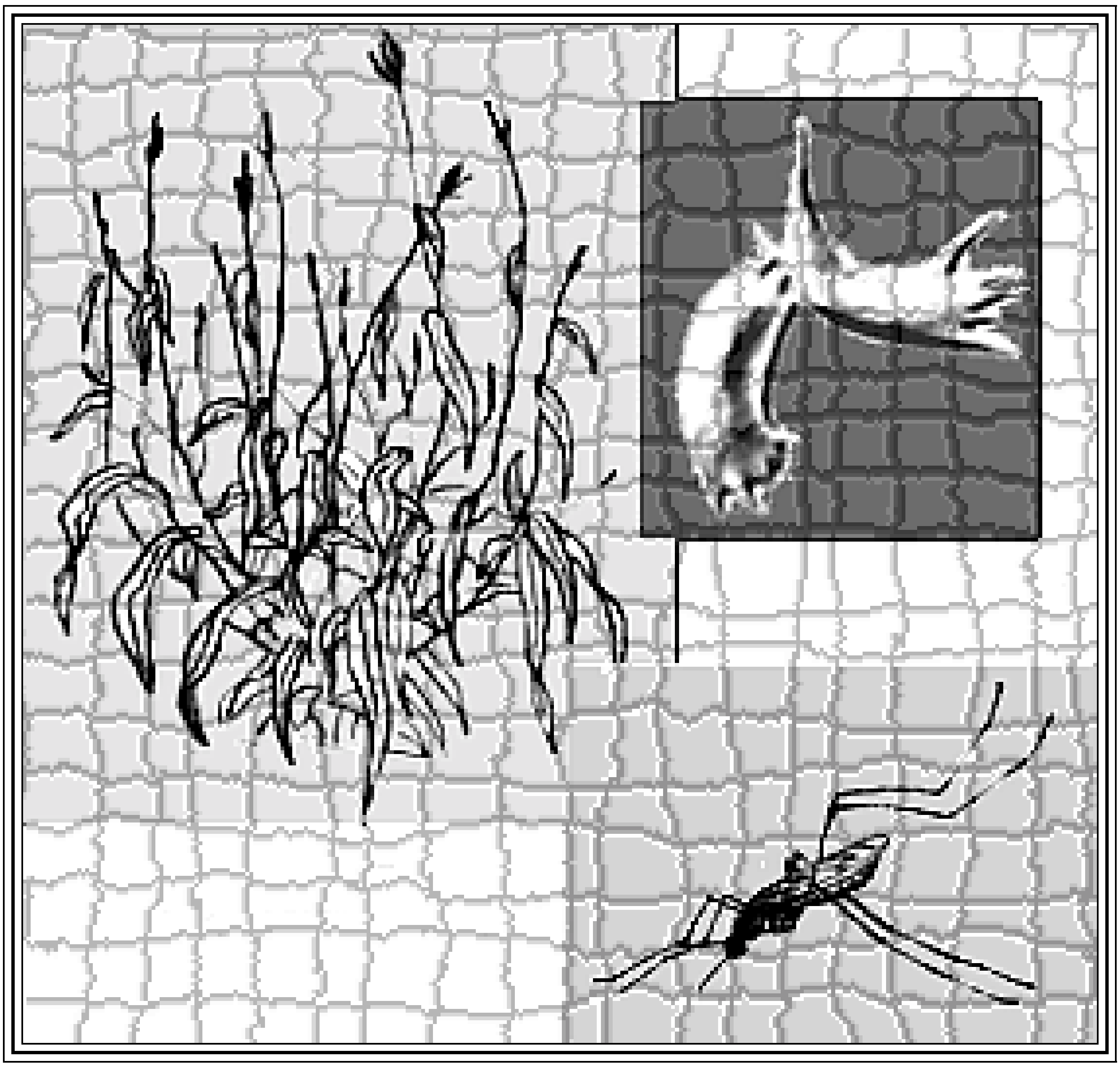
Bioscene

Journal of College Biology Teaching



Volume 24(1) April 1998

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Journal of College Biology Teaching

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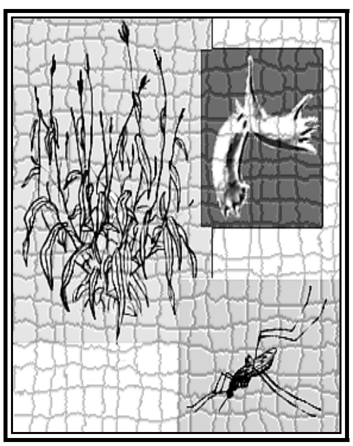

Cover Illustration: This graphic depicts Teosinte, two sickled red blood cells and a mosquito for the case study *Kingdoms Entangled: Mole-cules, Malaria and Maize*. The illustrator is Micah Stanley, a student at Arizona State University.

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Bioscene Journal of College Biology Teaching

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Deadlines for 1998 Submissions

June 30, 1998 for August Issue **October 30, 1998 for December Issue**

Investigative Case Study Approach for Biology Learning

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Abstract: This paper gives background on the investigative case study approach for biology, a variant of problem-based learning (PBL). Like many variants of PBL, this is a method of learning and teaching that gives students opportunities to direct their own learning as they explore the science underlying realistically complex situations. Students work collaboratively to identify issues and frame questions of interest to them, then to identify and manage additional information in answer to their questions. In investigative case-based learning, however, students develop questions that lend themselves to scientific investigation, they develop reasonable investigative approaches relevant to their questions, gather data and information to provide support for their conclusions, and work to persuade others of their findings. In this paper the terms "case study approach" and "case-based learning" are used interchangeably.

Keywords: biology education, case study approach, investigative case-based learning, PBL, teaching strategies

Introduction

Over the last decade there has been a growing realization that, somehow, science teaching and learning must become more effective. Study after study show that students are not able to use the science they have learned to address "real-world" problems (e.g., White, 1988). Worse, a recent NSF report "Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering and Technology" (SME&T) notes that while "America's basic research in science, mathematics and engineering is world-class ... most of its population is virtually illiterate in science" (NSF, 1996. p. iii). While recognizing that many innovations and improvements have been taking place at the undergraduate level, the report notes that these are not yet widespread.

This NSF report recommends that "SME&T faculty: …

C. Build into every course inquiry [i.e., involving the student in asking questions and finding answers (p. 53)], the processes of science, a knowledge of what SME&T practitioners do, and the excitement of cutting edge research.
D. Devise and use pedagogy that develops skills for communications, teamwork, critical thinking and lifelong learning in each student...
F. Start with the student's experience ... and relate the subject matter to things the student already knows. (pp. 65-66, NSF, 1996).

In this paper, we suggest that investigative case-based learning, an approach that encourages student-initiated science investigations as an outgrowth of case analysis, is one way to bring these elements into biology education. For a more complete presentation of the approach, several cases, examples, and scenarios of student learning, see Waterman and Stanley, 1998.

What is Case-Based Learning?

The use of cases is as old as storytelling itself. It is instruction by the use of narratives - stories - about individuals facing decisions or dilemmas. Learners are encouraged to engage with the characters and circumstances; to investigate so as to understand the facts, values, contexts, and decisions in the story; and to connect the meaning of the story to their own lives.

Models of case learning build on this general approach and formalize it in different ways to suit the subject matter and learning goals (Boehrer and Linsky, 1990). Cases are most commonly used to teach decision-making skills to professionals. A well known model for this goal is the Harvard Business School case method (Christensen and Hansen, 1987) in which students receive extensive case histories that they individually analyze before attending a instructor-led, large class discussion. In the business school model, cases are often a culminating activity coming last in the instructional sequence.

A radically different case study model is called problem-based learning or PBL (Barrows and Tamblyn, 1980), which originated for learning medical biology and is being used at increasing numbers of US medical schools.

The goal of the original PBL model is learning of science subject matter, more so than development of medical decision-making skills. PBL strategies are now being used in many other settings in which science is learned, and the original medical model has many variations. Because the investigative case study approach builds on the original medical model, we present that model next. The version of medical PBL described here is the way the original model has been implemented at Harvard Medical School (Wilkerson and Feletti, 1989, Tosteson, et al., 1994).

The Original PBL Model of Case Study

The investigative case study approach to be discussed later in this paper is a variant of the original medical PBL model described by Barrows and Tamblyn (1980) and uses much of its basic framework. In the original PBL model, a group of students works together to read, analyze and understand a case which is a story about patients, their social contexts, and medical practitioners. In the original PBL model the case comes first in the instructional sequence, before or concurrently with lectures and labs. This placement is important because the case is being used to help students structure their learning of a new topic area.

An essential feature of the original PBL approach is that cases are analyzed by small groups of students working collaboratively. Students usually meet two to three times to work on any given case. Students read part of the case out loud, then discuss the elements presented thus far in the case. They draw upon what they already know, list their outstanding questions, and develop a learning agenda -- a set of issues they agree to pursue individually before their next meeting. In case discussion, then, students are actively engaged and working together to brainstorm issues, communicate what they know, and develop their plans for learning. In the original PBL model, the instructor plays a more facilitative role during case discussion, instead of a didactic or directive role.

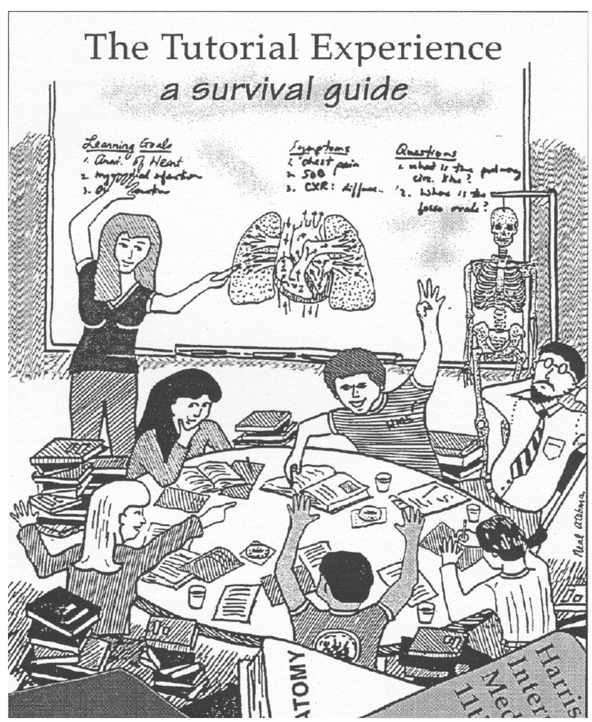
The PBL cases as originally used serve as realistic contexts that define a problem space and help students organize their learning of a body of known information. As students identify what they already know and need to know in order to understand the case, their learning becomes self-directed within the context of the case. Since learning occurs around a particular realistic problem, there is greater likelihood that the learned material will be better retained and more easily applied to similar situations (Brown et al., 1989, Schmidt, 1983).

Classically, the case is first presented to medical students without guiding questions or statements of objectives. They may receive instructor-developed objectives after the first meeting or two. The delay in giving instructor-made questions is intended to ensure student-centered learning. Since the questions the students are pursuing are their own, they are more highly motivated to answer them than they are instructor- or text-posed questions.

The original PBL model addresses several of the elements identified in the NSF report. Students are using collaborative teamwork, they are starting with what they already know, and they are developing skills of communication and lifelong learning. The problems they are working on are complex and, like real problems, require learners to draw upon information from several disciplines. The multidisciplinary nature of the cases provides openings and opportunities for faculty to work together across disciplines as well.

As mentioned above, PBL strategies are being used for learning science outside of medical schools. The basic elements of the model are usually retained, with variation existing in such features as the amount of instructor directedness, the expected amount of collaboration among students, the degree to which the problem is focused or open-ended, when and if instructor-set learning goals are revealed, and the timing of the case in the curriculum. PBL as practiced in some of these settings can encourage inquiry (see for example, Bergland and Klyczek, 1996).

There are many strengths to the original PBL model that are retained in the investigative case study approach. For undergraduate and graduate science learning, however, we found the original PBL model to be lacking an important feature: as generally practiced at medical schools, PBL does not encourage students to initiate and undertake scientific investigations.



Who is the teacher here? Image by Neal Atebara. Copyright 1987.

A New Use of Cases: Contexts for Developing Scientific Investigations

"One of the greatest challenges in biology is to frame appropriate and productive questions that can be pursued by the technology at hand. You have probably had a great deal of experience in solving pre-posed problems, such as those found at the end of textbook chapters. However, if you were asked to go into a lab or out in a field and pose a research questions, you will find that this is often difficult to do without some practice." The BioQUEST Library IV: A Note to the Student, 1996.

The investigative case study approach promotes research-like environments for learning biology. While the problem space is still defined by the case, students are not asked only to learn new material as in medical PBL. Students are asked to pose a researchable question about the biological phenomena. They must also develop accountable approaches to investigate these phenomena and then carry them out. Finally, they present conclusions to the class that provide a reasonable answer to this question.

Cases written for investigative learning in biology are deliberately open-ended. They don't provide all the details; rather, they sketch a situation and provide a rich space for generating researchable questions. The cases do not necessarily point the learner toward a specific problem, but rather open a context with many potential problems that students can define. This is a significant departure from the way cases are constructed for most PBL variants.

The investigative case-based approach encourages problem posing, investigation and persuasion. By using PBL strategies in this way, biology instructors can better serve a significant objective of science education: to teach science so that learners have an applicable and flexible knowledge of science content, as well as skill in investigation.

Instruction with cases can be organized in many ways, from pairs looking at minicases in a large lecture, to small groups studying a case for an extended period, to brief case discussions before and after laboratory experiences. Ideally, cases, lectures, labs and other instructional approaches would be well integrated within a course. One of the most important elements of the investigative case-based approach (retained from the origins] PBL model), however, is that it include collaborative discussion of the case issues. In that way, students can identify what they already know and what they need to find out in order to understand the case and pose a problem to investigate. For additional information on collaborative learning see Bruffee (1993)

What Are Some Ways of Proceeding with Investigative Case Learning in the Classroom?

At the 1996 BioQUEST Summer Faculty Workshop a group of biology faculty worked on case-based learning, wrote cases and thought about teaching biology with cases. One product of that group was an analysis of how the case study approach fits with the open-ended, investigative 3P's teaching philosophy of BioQUEST: Problem posing, Problem solving and Peer persuasion. You may wish to use this framework, shown in the box below, as a way to think about what you might ask students to do as they work with cases.

BioQUEST, Cases and the 3Ps: Collaborative, Open-Ended, Investigation (Weinland,L., J. Fischer, K. Grimnes, P. Woodruff, K. Klyczek, M. Howse and M. Waterman, 1996)

Problem-Posing

- Recognizing potential issues
- Brainstorming connections & to define problem space
- Identifying material to be learned
- Posing specific questions
- Defining and specifying focus
- Defining problems further by peer consultation

Problem-Solving

- Obtaining additional references/sources
- Managing information
- Defining problem further (share views/info.)
- Designing and conducting investigations
  - With simulation software for
    - Modeling
    - Representing information
  - With field/laboratory methods
  - With new resources (further references, interviews, etc.)

Peer Persuasion

- Presenting conclusions of investigations
- Developing scientific analyses or reports to persuade peers
- Conducting debate/opposite views or outcomes
- Producing other materials that show understanding of the conclusions.

Working Through an Example Using This Framework

In the box entitled *Fleaing Louisiana*, is a short biology case. The first paragraph will be used to work through the framework shown above. In case-based learning, the first thing to do is to see what the case is about. Read it through to get a sense of the story and issues.

One surprisingly productive case-learning method is to have one student read the case out loud while the others in the group read along silently. This sounds silly perhaps, but it gets everyone "on the same page" and students say it helps them get started. Have a good dictionary and reference books available for students to look things up quickly.

How to begin?

Individuals approach learning with cases in very different ways. You may wish to consider having students do one or more of the following after reading a case:

• Recognize potential issues. Go back and read the case again, this time noting words or phrases that seem to be important to understanding what the case is about. If students have a hard copy, they may underline these phrases. They are looking for learning issues that they might explore further. They might jot down ideas and questions about these phrases. If students are working in a group, this approach might be done as a group discussion, with one person keeping a list of issues (maybe on the chalkboard) as they are raised.

Here's an example of some of the kinds of issues raised in one paragraph of ***Fleaing Louisiana*** (items that are underlined):

> Moses Anders hung up the phone after talking with Ella Cardinale-Jones about her troubles. She had ticks on the dog, roaches in the house and hungry mosquitoes chewing up her kids. "Now Mr. Anders, I'm used to seeing some bugs around -- this *is* Louisiana. But it seems no matter what I do there are more and more of them. How can I get rid of them? I don't feel like my children are safe." Ms. Cardinale-Jones was the 19th caller about these insects this month, and it was only January 7th.

• Brainstorm for connections. By connections we mean connections between the specifics of the case and potential learning issues or potential biology problems to investigate. There are several ways to do this. One way is to think about the case as a whole and see if there are underlying themes. Ask the question: "What is this case about, in general?" Global warming, insect borne diseases and careers in biology are some themes many people identify for "Fleaing Louisiana." Posing specific questions as well as generalizing from those questions to larger learning issues are two other ways to find connections between the case and biology, as illustrated next.

FLEAING LOUISIANA

Case author: Margaret Waterman, 1996. This case may be reproduced and used for educational purposes, with proper reference and copyright notice included.

Moses Anders hung up the phone after talking with Ella Cardinale-Jones about her troubles. She had ticks on the dog, roaches in the house and hungry mosquitoes chewing up her kids. "Now Mr. Anders, I'm used to seeing some bugs around -- this is Louisiana. But it seems no matter what I do there are more and more of them. How can I get rid of them? I don't feel like my children are safe." Ms. Cardinale-Jones was the 19th caller about these insects* this month, and it was only January 7th.

Moses Anders is an intern with the Louisiana Cooperative Extension Service while he finishes his BS in biology. Moses dug out the last of the old tick, flea, and roach pamphlets in the files to send a copy to Ms. Cardinale-Jones. It said that these insects shouldn't be significant problems until late spring, it didn't mention mosquitoes, and the pamphlet did not really answer Ms. Cardinale-Jones questions.

He talked about this situation with his internship mentor Fran Collins, an agent who has been with the Service for several years. "Yeah," she said, "it's been really busy this winter. In fact, it's been this way all the time for a couple of years now." She agreed with Moses that the pamphlet needed to be updated and that he could take on the project, once he'd given her a work plan and time line.

Moses and Judy Yee, an intern in the public health office, traded stories over lunch at one of the city's crowded outdoor cafes. She told him that the first case of Lyme disease in the area had recently been reported, and he told her about his new project. Their talk turned to the weather as they made their way back to work.

*The author is well aware that ticks are not insects but arachnids, but because many Extension Services and even Entomology Departments include these in their pest lists along with insects and the general public thinks of them as all being "bugs" or insects, we have treated them in a similar manner. Certainly, you can point out the difference to your class if they do not do so to you before you get around to it.

• Pose specific questions. Another way to generate ideas and connections is to be clear about what is known so far, and then to see what questions arise.

What we know now: It's January in Louisiana. There are lots of insects, perhaps more than usual, and people with safety concerns are calling Moses Anders about this.

Using the first paragraph again as an example, here are some questions raised by learners who have worked with this case:

- ✓ Why are there lots of insects in January? What affects the number of insects at any given time of year? Are there really more than usual? What is the usual pattern?
- ✓ Why is Ms. Cardinale-Jones concerned for the safety of her children? What diseases do ticks, roaches and mosquitos carry? Are there other reasons besides disease to be concerned about these insects?
- ✓ What can Ms. Cardinale-Jones do to control the insects? What advice should Moses give her? What is the biology of ticks? Roaches? Mosquitoes?
- ✓ Why are people calling Moses Anders about this? What do they think he knows or can do for them? What sorts of jobs deal with these issues?

By generalizing on the questions raised, students can identify potential learning issues. For any one of these issues, they may generate further questions to structure their learning.

Potential learning issues: Insect populations and the factors that affect them. Problems posed to humans by insects. Insect control measures. Unusual insect occurrences in winter. The job held by Moses that would lead people to call him.

Brainstorming can lead to a long list of questions, and there is not time to pursue them all. Have groups spend time identifying a few key questions of interest. Students are usually careful to use the contextual clues provided by the course title, syllabus topics, etc., as ways to help them narrow the list of potential topics. But you never know, a student may become very interested in a good question that is only tangential to the case. If the goal is to learn to pose questions, solve problems, and argue convincingly, some instructors might decide any topic related to the case is fair game.

The questions raised by the brainstorming can lead to different sorts of learning activities. Remember that the goal with investigative case-based learning is to develop problems of interest to students, that can be investigated using the tools of science. Below is an analysis of some of the different types of learning that might follow from some of the questions on the brainstorming list.

• Define problems further by sharing views and concerns: As learners define problems and frame specific questions to investigate, it will be important for them to consult with others: most likely members of the group or other classmates. Talking about ideas and plans with others is an important step in refining problems, and can lead to different perspectives that might help shape good research problems. You might want to save some class time for this kind of activity, or students could do it on-line, or out of class. Encourage learners to continue this practice of sharing their ideas, plans and concerns with others as they gather evidence in answer to the problem and as they prepare to present conclusions. Such conversation and collaboration is a hallmark of the work of scientists.

Learning Activity	Questions
Further brainstorming	"Why is Ms. Cardinale-Jones concerned for the safety of her children?" or "What affects the number of insects at any given time of year?" or "What sorts of jobs deal with these issues?"
Searching out basic facts.	"What diseases do the insects carry?" or "What is the biology of ticks?" or "What advice should Moses give her?" These questions in and of themselves do not pose a scientific research problem, but learning more about these may lead to other questions that are scientific.
Decision making.	"What advice should Moses give her?" Students will need to understand the issues, and evaluate the consequences of the options before they can answer this question. Group discussion and negotiation of diverse viewpoints will also be involved.
Finding information, analyzing it and finding patterns.	"What is the usual pattern of insects in Louisiana?" and "Is it different this year?" These questions might lead students to the Internet or elsewhere to get insect sampling data for analysis.
Scientific investigations	"What affects the number of insects at any given time of year?" could be refined to focus on climatic variables. These could then be investigated by modeling (with Biota or EDM), by actually collecting weather and insect population data, by using data sets collected by others, or by finding published information on the topic.

We've Got a Question, Now What?

Once the students clearly define a problem they wish to investigate, you might consider proposing that they do any of the following:

> "Research is not complete, no matter how many experiments have been conducted, no matter how many puzzles have been solved, until peers outside of a research team are persuaded of the utility of the answers. Persuasion is a social process and an essential one for you to experience in order to understand the nature of scientific theories and paradigm shifts. Communication in the science community is an active process full of controversy and debate. The productive side of science involves open criticism of the methods and conclusions made by a research group. This controversy and debate is important to the creation and acceptance of new scientific knowledge."
>
> (*The BioQUEST Library IV*: A Note to the Student, Soderberg, 1996)

• Obtain additional references/resources No matter what type of question learners pose, it is likely they will seek and use additional resources to help them support and research a reasonable answer. Resources may include textbooks; other library materials; results of computer simulations; results of lab or field research; articles from professional journals or popular press, data sets, maps, emails, websites or other electronically based resources; pamphlets from organizations; interviews with experts; information from museum exhibits, etc. Encourage students to be creative in seeking information.

Suppose, for example, the students chose to study the question: What affects the number of ticks or mosquitoes in Louisiana at any given time of year? They could consult entomology books to learn the basic biology of the chosen insect, or they could locate tick or mosquito sites on the World Wide Web. Such sites might include annual data on mosquito prevalence collected by the CDC, or it might include a scientist describing his/her research on global warming and insect populations. They could search the professional literature for likely articles. They might contact a Lyme disease support group to see how to find information on tick prevalence. They could see if the cooperative extension service had contacts with scientists who regularly sample insect populations or who work on insect control. A different sort of resource students could seek might be computer simulation software that could potentially be used for modeling studies.

• Design and conduct scientific investigations: These might use appropriate laboratory or field methods or perhaps computers with relevant software modules, spreadsheets, graphics, etc.. One important mode in which scientists operate is the synthesis of pieces of existing information into a new theoretical framework (work which may be accompanied by modeling, as was done by Watson and Crick). Students might locate datasets, conduct interviews, and gather ideas from their reading and library research. What makes this kind of work scientific is the use of these bits of information to form a new, justifiable and testable point of view.

For our example, the students might decide to use insect trapping methods to assess insect population size and dynamics over a several month period. (They might even propose it as a multiyear project, to be carried on by future students.) Or they might decide to use software like BioQUEST's *Biota or Environmental Decision Making* to investigate and model the effect on insect populations of changing climactic variables. Their instructor might have laboratory experiences coordinated with this case, so that, for example, students learn concepts of population dynamics using models and simulations. Then the students could tailor these skills to their specific question.

How to End? (Peer Persuasion)

` When learners are ready to present their own conclusions, consider asking them to do one or more of the following:

• Develop scientific analyses and reports to persuade others of the ideas. Any of the formats that scientists use to describe their work might be appropriate here. These might include: a report written in the format of an appropriate journal, a poster such as might be presented at a professional meeting, an article about the work for the popular press, or a report such as scientists in an organization might write to administrators. Such reports or posters would provide an evidence-backed position on the question.

For our example, students studying insect patterns might include data tables, photographs of insect-laden traps at various times of the year, or relevant printouts from the simulation programs in their reports.

• Produce materials that support understanding of the conclusions you are making. The possibilities for these materials are vast: posters, poetry, plays, videos, booklets, pamphlets, consulting reports (if you are role playing), artwork, designs for new technology, scientific publications, newspaper stories, a new case study, etc.

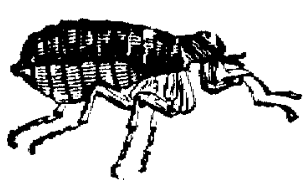
For Fleaing Louisiana, learners might produce a new pamphlet that includes the information about yearly fluctuation in insect populations, a scientifically based public talk of the kind extension agents offer, or a set of insect control guidelines. Any of these could be used to incorporate findings from student scientific investigations of the questions.

• Initiate debate on views or outcomes This could be several things. It could be that a poster session is set up, with a discussion (led by a commentator?) on the views and outcomes presented. Or, it could be an actual debate. For "Fleaing Louisiana," a debate on global warming might be something teams of students might choose to prepare. Or it could be a format that brings in perspectives in addition to the scientific. For example, in the case of global warming it could be a heated exchange of letters to the editor in a newspaper (such as happened in my town this year) or a fictional email exchange between opponents and proponents of global warming. The perspective of an anti-global warming member of Congress could be represented for other students to respond to, as a persuasive exercise.

Conclusion

While no one method or educational approach is a panacea for science education, investigative case-based learning offers promise as one more tool in the biology instructor's toolbox. The investigative case study approach addresses several of the elements identified in the NSF report. Students work collaboratively. They begin their learning with questions stemming from or based on what they already know. As they work in teams and as they present their findings they develop communication skills and the information management skills needed for lifelong learning. Most importantly, students develop and use skills of scientific inquiry as they develop, conduct and present their own investigations.

Interest in case-based approaches is rapidly growing in biology education: our Internet searches have turned up numerous examples of people using narratives to structure student learning. Few of these are designed to be truly investigative, but many would lend themselves to that pedagogy. See, for example the project called "Hello Dolly" and several items in the *Handbook of Engaged Learning Projects* (Fermi National Lab, online, Fraccaro, W. et al., online and Peretz, S., online). Resources for connecting with others using cases are listed in the box to the right.



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Connecting via Internet to others using cases and PBL:

- *See also the Fermi Lab references in Literature Cited.*
- The University of Delaware is using cases and other forms of problems for an institution-wide reform of science learning and teaching. [http://www.udel.edu/pbl/]
- Clyde Herreid has been working with faculty at the University of Buffalo on case-based science learning for several years. This is a well-organized web site, with links to many other projects and faculty working with cases in several disciplines. [http://ublib.buffalo.edu/libraries/projects/cases/case.html]
- At the University of Oregon a group has been developing "workshop" biology for the past few years and uses some case material, especially for the "issues" activities. [http://biology.uoregon.edu/Biology_WWW/Workshop_Biol/Activities/format.html]
- At Niagara University, a project on cases for human anatomy and physiology is underway. They have a few cases on line, and some highly structured questions that accompany them. [http://www.niagara.edu/~bcliff/]
- The BioQUEST Curriculum Consortium has been working on the problem of connecting cases to open-ended student investigations. A multipart case "Kingdom's Entangled: Molecules, Malaria, and Maize" is designed to help students and faculty raise researchable questions. The case is supported by the BioQUEST library of investigative software. For the complete case, see also Waterman and Stanley, 1998. [http://bioquest.org]
- Mark Bergland has developed Case It (also part of BioQUEST Library), a DNA electrophoresis simulation with cases to be solved. [http://www.uwrf.edu/ ~mb02/welcome.html]

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A Simple Experimental Model to Isolate Antigenic Epitopes Recognized by Antibodies

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Abstract: This report describes a hands-on experimental protocol for students to understand how by limited proteolytic digestion they can dissect a large antigenic protein into small pieces, and then using standard immuno-biochemical techniques can identify the pieces or the peptides that serve as the epitopes in antigen-antibody reactions. The project described is suitable for demonstration in laboratories that teach immunochemistry.

Keywords: Antigen, Epitopes, Haptens, Proteolytic enzymes, SDS-PAGE, Enzyme-linked Immunosorbent Assay (ELISA)

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Introduction

Antibodies, as a group, are well-characterized proteins that are the hallmarks of the vertebrate immune system. Understanding the biochemical basis of antigen recognition by antibody or other immunological entities such as T-cell receptors is fundamentally important; it complements and extends the concept usually acquired in connection with the study of enzyme-substrate interactions. Furthermore, for beginning students of biochemistry, it is worthwhile to know that an antigen, particularly a protein, may have only a few distinct regions with which the antibody can combine. These regions called epitopes, which occupy the cleft in the binding site of the antibody, maximally consist of about six or seven amino acids, and are considered immunodominant by virtue of their ability to evoke an antibody response. Thus, the immunogenicity of a protein molecule depends on the quantity and diversity of these immunodominant epitopes, which are essentially short peptide segments or domains in the protein. Isolation and identification of such peptide epitopes from a complex protein are useful in the design of safe and effective vaccines. In this report, we describe a simple project that allows students to acquire and appreciate the basic concept of antigenic epitopes (generation of peptides) and the role of proteolytic enzymes in antigen processing..

These experiments require standard equipment available in colleges or universities with programs in biochemistry or immunology, and include a fraction collector, a spectrophotometer or a UV monitor such as ISCO UA-5 absorbance detector, microtiter ELISA plates, micropipettes, an incubator, a microplate reader and an electrophoresis apparatus. In addition, it is necessary to have both anti-hapten and anti-carrier protein antibody reagents. Usually these reagents can be obtained from commercial sources (e.g. Sigma Chemical) for a cost of about $100-200, or from colleagues at National Institutes of Health or other research institutions; but they can also be prepared beforehand by immunizing animals, such as New Zealand white rabbits. To produce these antisera in-house takes about two months. Raising and identifying such antibodies could be the project of an immunology lab. To do this, the hapten is conjugated with a protein that is different from the carrier protein to be studied. Immunization is performed a few times with the conjugate, such as phthalate-bovine serum albumin used here, before bleeding the rabbits for antisera. To obtain antisera to the carrier protein under study, the unconjugated carrier protein, such as keyhole limpet hemocyanin (KLH), can be used to immunize a different group of rabbits. The antisera from the latter will only recognize the carrier protein not the hapten.

These experiments can be performed in five three hours sessions. Briefly, the project entails the following experimental steps: (1) preparation of a hapten-protein conjugate, (2) overnight digestion of the conjugate with trypsin, (3) sodium-dodecyl sulfate-polyacrylamide (SDS-PAGE)-gel electrophoresis of the protein conjugate before and after digestion with the proteolytic enzyme trypsin, (4) gel-filtration of the digest and collection of the fractions that absorb at 280 nm, and (5) enzyme-linked immunosorbent assay (ELISA) of the peak fractions. For simplicity, no reverse-phase high performance liquid chromatography or high voltage paper electrophoresis for peptide mapping is included in the project. In our laboratory, students usually work in pairs, with each partner sharing responsibilities for a section of the project, and then exchanging and compiling the data. Occasionally, an individual student may work on a semester-long project and receive research credit for it.

Experimental

Reagents and materials required for experiment 1 (preparation of phthalate-KLH conjugate):

(1) Hapten: 4-amino-phthalate (from Pfaltz &Bauer, Inc., Waterbury, CT, USA)
(2) Protein for conjugation: Keyhole limpet hemocyanin or KLH (from Calbiochem., La Jolla, CA, USA)
(3) Borate buffer pH 8.0; sodium nitrite; hydrochloric acid; sodium hydroxide, starch-iodide paper
(4) Magnetic stirrer, dialysis bag and glassware

Protocol for making a hapten-protein conjugate (experiment 1): (1) Prepare an amino-phthalate solution by adding 0.8 ml 1 N HCl to a solution of 0.135 M 4-amino-phthalic acid (27mg/0.3 ml 0.5 N NaOH); cool in an ice bath for about 20 min. (2) Add 0.15 ml of 1 M sodium nitrite to amino-phthalate while stirring rapidly for 20 min. Place a drop on the starch-iodide paper to check, if it turns dark blue. If not, add more sodium nitrite. This produces the diazonium salt. (3) Mix this product very slowly with an ice-cold solution of keyhole limpet hemocyanin (KLH) in 2.5 ml borate buffer pH 8.5 (10 mg/ml). Adjust pH to 9.5 with 0.1 N sodium hydroxide. (4) After 2 hour in ice bath, dialyze the reaction mixture against 0.05 M ammonium bicarbonate buffer pH 8.0 for 24-48 hours. To remove all unbound amino-phthalate, it is necessary to change the buffer a few times during dialysis. Note the volume after dialysis. The ammonium bicarbonate buffer is good for concentrating or freeze-drying of the conjugate without accumulation of salts. The conjugate formed is colored and has an absorbance around 420 nm. This may be used to determine the hapten to protein ratio.

Reagents and materials for experiment 2 (Digestion with trypsin and electrophoresis) :

(1) Trypsin (10,000 units /mg)
(2) Soybean trypsin inhibitor
(3) 30% Acrylamide/8% Bis-acrylamide solution in distilled water
(4) 1.5 M TRIS-Cl buffer pH 8.8 containing 0.4% SDS
(5) 0.5 M TRIS-Cl buffer pH 6.8 containing 0.4% SDS
(6) 2x SDS sample buffer (2.5 ml of TRIS-Cl /SDS buffer pH 6.8, 2 ml glycerol, 0.2 ml 2-mercatoethanol, ~1 mg bromophenol blue in 10 ml H_2O)
(7) 10% ammonium persulfate (freshly prepared)
(8) TEMED (N,N,N’,N’-tetramethylethylene diamine)
(9) Electrophoresis apparatus (Bio-Rad® mini-PROTEAN II®)
(10) Teflon combs
(11) 25-ml Erlenmeyer sidearm flask
(12) Power supply

Protocol for proteolytic digestion of the hapten-protein conjugate: (1) Add and mix solid trypsin (3 mg) to 10mg of hapten-protein dialyzed conjugate solution in 4.0 ml of 0.05 M ammonium carbonate pH 8.0) and digest at 25^{o}C for 15 hours. Digestion for at least 15 hours appears to be better than digesting for shorter periods. Figure 1 depicts a sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) profile of such digestion of KLH-phthalate with trypsin for various time periods. (2) Add 0.640 ml soybean trypsin inhibitor (2 mg/ml) at the end of digestion.

Protocol for making SDS-PAGE[1] using a 15% polyacrylamide separating gel with a 5% stacking gel: (1) Mix 7.5 ml of acrylamide/bis-acrylamide solution in a 25-ml sidearm flask with 3.75 ml of Tris-Cl buffer pH 8.8 and 3.75 ml distilled deionized water. Degas under vacuum for 5 min. (2) Add and gently mix 50 µl of 10% ammonium persulfate and 10 µl TEMED, and pour immediately into the glass plate sandwich assembled using two glass plates separated with 0.75 mm Teflon spacers. (3) Overlay with H_2O, and allow the gel to polymerize for 1 hour at room temperature or overnight at 4^{o}C, (4) Remove H_2O layer, wash with TRIS-Cl buffer pH 8.8, insert the Teflon comb. (5) Prepare a 5% stacking gel by mixing 0.65 ml of 30% acrylamide/0.8% bis-acrylamide, 1.25 ml of TRIS-Cl buffer pH 6.8 and 3.05 ml H_2O. Degas for 5 min under vacuum, then add and mix 25 µl of 10% ammonium persulfate and 5 µl of TEMED. (6) Using a syringe layer the solution over the separating gel and the Teflon comb insert. The stacking gel polymerizes in 30-45 min. (7) Mix equal volume of the protein sample and 2x SDS/sample buffer, boil 5 min at 100^{o}C. Remove the comb carefully, fill the wells with SDS/electrophoresis buffer (3g TRIS, 14.4 g glycine, and 1g SDS in a total volume of 1 liter) and then load 10-20 l of the protein in sample buffer. (8) Fill both upper and lower chambers of the electrophoresis unit with SDS/electrophoresis buffer, connect to the power supply and run at 10-15 mA per 0.75 mm of slab gel. Total run time is 1-1.5 hour or when the bromophenol blue dye front is 0.5 cm from the bottom of the gel. (9) Upon completion, carefully disassemble the gel and stain with Coomassie Brilliant Blue solution (50% methanol, 0.05% Coomassie Brilliant Blue R-250, 10% acetic acid, 40% water) for

30 min to 1 hour, and destain in a solution containing 5ml methanol, 7ml acetic acid, 88% ml H_2O.

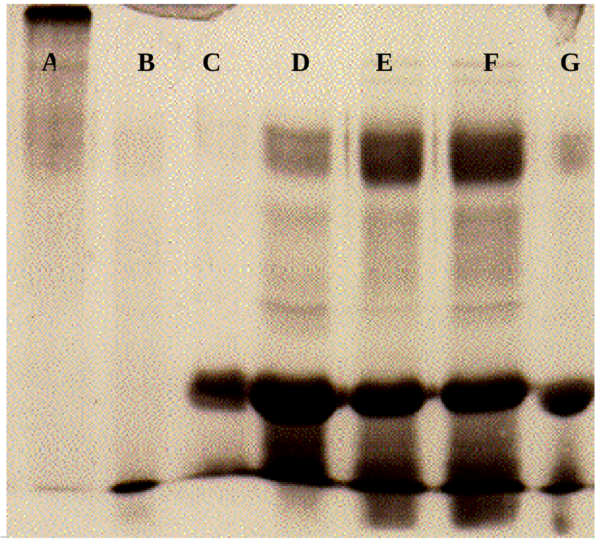

FIGURE 1. SDS-PAGE analysis of KLH-phthalate before and after digestion with trypsin for various time periods. Lane A. undigested KLH-phthalate; Lane B. SDS-PAGE buffer; Lane C. trypsin only after 1.5 hours; Lane D. KLH-phthalate after digestion with trypsin for 1.5 hours; Lane E. KLH-phthalate after digestion with trypsin for 3 hours; Lane F. KLH-phthalate after digestion with trypsin for 15 hours; Lane G. trypsin only after incubation at 25^{o}C for 15 hours.

Reagents and materials for experiment 3 (Gel filtration on Sephadex®):

(1) 5 grams Sephadex G-25 or G-50 in 100ml borate buffer pH 8.0 and make a slurry
(2) Glass column (0.9 x 40 cm) to be packed with Sephadex G-25
(3) UV monitor or spectrophotometer
(4) Test tubes (0.75 cm x 12 cm)
(5) Fraction collector

Protocol for gel-filtration to separate protein fragments based on molecular sizes: (1) Pack a glass column with Sephadex® G-25 or G-50. This is done first by filling the glass column half way with 0.05 M ammonium bicarbonate buffer pH 8.0, and then pouring the slurry of Sephadex in the same buffer with the help of a funnel. As Sephadex® gradually settles at the bottom of the column, open the valve to increase the flow. Keep adding until the slurry of Sephadex settles to the desired height in the column. (2) Wash the column with 0.1 M ammonium bicarbonate. (3) Apply some of the digested conjugate (4.0 ml) to top of the column and elute with 0.1 M ammonium bicarbonate buffer pH 8.0. (4) Collect 1-2 ml fractions, and measure optical densities at 220, 280 and 420 nm. (5) Plot absorbance data vs. fraction number, and then save or freeze-dry the fractions for ELISA. A typical gel filtration profile is shown in Figure 2 below.

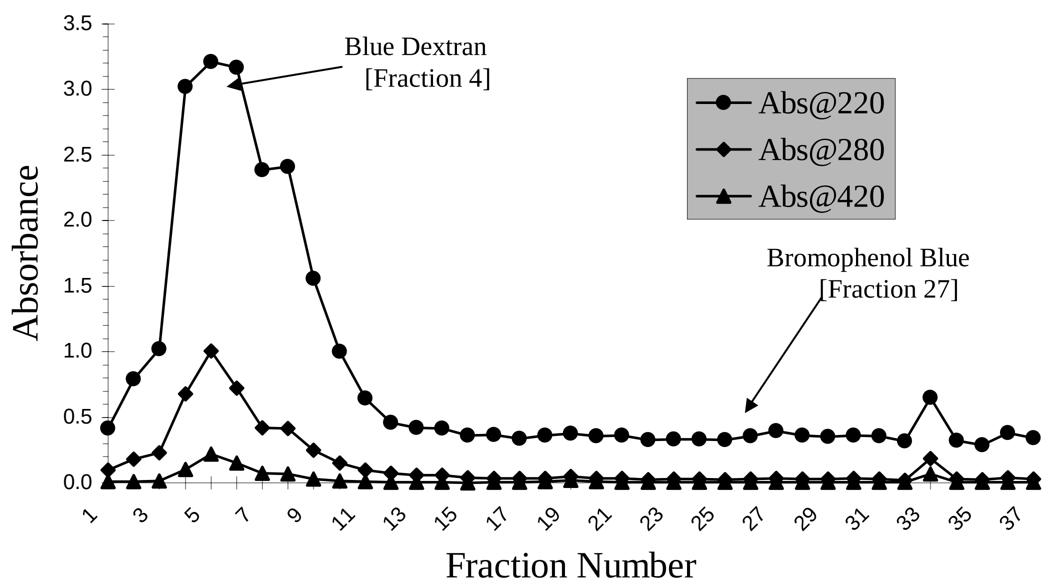

FIGURE 2. Gel filtration profile of a trypsin digest of phthalate-KLH on Sephadex G-25. One ml of the digest of KLH-phthalate was applied on a column of Sephadex G-25 as described, and then eluted with 0.1 M ammonium bicarbonate pH 8.0. Fractions (~1.5 ml) were collected and their optical densities were measured in a spectrophotometer at 220, 280 and 420 nm. The Peak I, peak II, and peak III fractions corresponded to tubes 4-6, 7-9,and tube 33, respectively. Before use we ran 0.5 ml blue dextran 2000 in the same buffer to determine the void volume. We also ran 0.5 ml of bromophenol blue (m.w. 691) in order to ascertain its elution position which may be similar to that of small peptides.

Reagents and materials for experiment 4 (ELISA on different fractions after gel filtration):

(1) 96-well ELISA plates
(2) Anti-phthalate and anti-KLH antibodies[2] (prepared before instruction began)
(3) Goat anti-rabbit Ig -Horseradish peroxidase (commercially available)
(4) O-phenylenediamine (OPD) solution prepared as follows: 4 mg OPD in 10 ml of 0.1 M sodium citrate buffer pH 5.0 plus 10 µl of 30% hydrogen peroxide
(5) ELISA reader for measurement of optical density at 490 nm.
(6) 1% bovine serum albumin (BSA) or gelatin in phosphate buffered saline pH 7.4

Protocol for identification of different fractions of the digest from gel filtration by immunoassay: (1) Apply in triplicate 50 µl of the pooled peak fractions from the gel filtration to wells of two polyvinyl ELISA plates, incubate for 2 hours at 37^{o}C, flush with phosphate buffered saline (PBS) pH 7.4, and block overnight with 100 µl of 1% BSA or gelatin solution. (2) Flush and add anti-phthalate antiserum to the wells of one plate and anti-KLH antiserum to the other plate. (3) Incubation overnight at 4^{o}C, then wash the plates several times with PBS, and add 50 l OPD solution. (4) After 5 minutes add 50 l of 10% sulfuric acid or 1% sodium azide solution. (5) Read optical density at 490 nm in an ELISA reader. Results are shown in Figure 3.

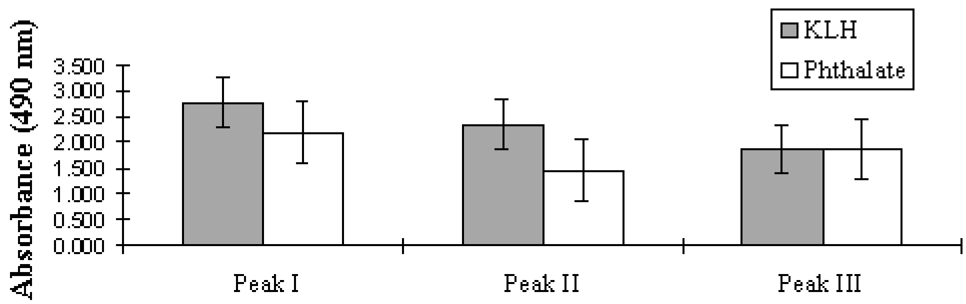

FIGURE 3*. Enzyme-linked immunosorbent assay (ELISA) on peak fractions from gel filtration. All three fractions were tested for their ability to bind to anti-KLH and anti-phthalate coated ELISA plates. The pool of non-peak fraction (tube # 15-17) served as the control. Note that peak III was the smallest fraction from the tryptic digest of KLH-phthalate and it eluted near bromophenol blue (used as an indicator) in the gel filtration experiment. This ELISA result indicates that the peak III fraction contained determinants or epitopes that recognized both anti-KLH and anti-phthalate.*

Discussion

When a hapten (small organic compound) is conjugated with a large carrier protein, it becomes immunogenic and is capable of evoking antibody response if injected into a mouse or a rabbit. The antibody from such immunization is actually a mixture of antibodies (polyclonal), some of which recognize the hapten, some recognize the hapten-protein linkage, and still others recognize various epitopes on the carrier protein. Since the results of the immunoassay (shown in Figure 3) illustrate that the peptides in peak III bind with both anti-phthalate and anti-KLH antibodies, it seems likely that they are heterogeneous and contain epitopes from both KLH itself and from the phthalate-KLH linkage areas. It may be pointed out that specific peptides in peak III can be further resolved by affinity columns like anti-phthalate-Sepharose® columns.

Gel filtration is a standard technique for separation of proteins or protein fragments from a mixture based on their molecular sizes. Usually Sephadex® G-75 gives better resolution than Sephadex G-50 or G-25. However, in a class room situation or for demonstration purposes, Sephadex® G-25 is faster and still serves the purpose well. Isolation of small peptides on such columns can also be achieved with relative ease as we have shown here. The spectro-photometric measurement was carried out at three wavelengths, viz., 220, 280 and 420 nm. These wavelengths correspond to absorbance of peptides, proteins and azo compounds respectively, and provide relative amounts of these components during separation by gel filtration. Both blue dextran and bromophenol blue are easily identified by their characteristic color and because of their molecular sizes they exhibit elution patterns similar to that of the resulting peptides. Blue Dextran indicates the approximate elution volume corresponding to the large peptides while bromophenol blue corresponds to the elution of small epitopic peptides.

Furthermore, the application of ELISA technique permits characterization of these isolated peptides as epitopes since the latter combine with appropriate antibodies. The standard SDS-PAGE analysis of the tryptic digest is a way to introduce the technique. However, this is not applicable for identifying epitopic peptides, as they run past the bromophenol blue dye front during electrophoresis. Electrophoretic separation of peptides requires a different gel[3] (Tris/tricine) and buffer system. The standard SDS-PAGE experiment is therefore optional for this project.

The experiments clearly illustrate that the epitopes recognized by antibodies can be generated from a complex protein by a limited proteolytic cleavage. Conjugating protein with an identifiable hapten facilitates the tracking of epitopic peptides during isolation and immunoassay. It may be added further that the phenomenon of antigen processing that occurs *in vivo* for T-cell recruitment and activation is somewhat similar to what has been demonstrated here *in vitro*. While we are aware that the methods used here are primarily biochemical, and are not necessarily inexpensive; projects like this would certainly help students to understand biochemical methodologies used in addressing questions relating to the immunological processes.

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1997 Annual Meeting *-- Marc Roy (Executive Secretary), Karen Klyczek (ACUBE President, 1998), John Jungck (Bioscene Editor, 1988-1997), and Buzz Hoagland (1999 Program Chair/VP-Elect).*

Association of College and University Biology Educators
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The title, author, and a brief description of the exercise must be submitted by **October 2, 1998** to the program director. Each presenter should bring 50 copies of the exercise to distribute. A table will be set up in Room 206 of Richardson Science Center for these copies. A disk copy of the exercise in a standard word processing format or text file would be appreciated as well. These exercises will be entered into an ACUBE file that can be accessed electronically. The steering committee wishes to rebuild the field/laboratory exercises archive to maintain for distribution.

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The title, author(s), and a short abstract of the poster content must be submitted to the program director by **October 2, 1998**. This information will appear in the final program and be published in the *Bioscene* after the meeting. Posters will remain on display for the entire meeting in the main entranceway (Richardson 'Street') of Richardson Science Center. Poster stands will be provided. Ask at registration desk

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Teaching Cell Biology: Changing the Paradigm

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Abstract: The paper presents a brief summary of methods of presenting laboratory information. It suggests that approaching lab problems in a way science is actually done requires a combination of methods structured into a problem-oriented learning experience. This begins with the instructor and/or students identifying problems, and the students working together in groups to solve the problem. Information pertinent to the problem is gathered from the web, visiting scientists, and the instructor. All projects are published on the web with each student having a home page. The specific example of a problem presented is the relationship of a glyoxysome to the chloroplast and the steps involved in solving it.

Keywords: cell biology, chloroplast, glyoxysome, imaging, microscopy, problem-oriented learning, world-wide-web.

Traditional science laboratories have served many pedagogic functions. Some are used for re-enforcing materials covered in lecture or the text. They are simply adjunct resources for the presentation of additional facts. The lab is typically content oriented and is known familiarly as a "cookbook" procedure. The labs are time and place dependent, but cost efficient and effective for their purpose. They are also useful for large enrollment classes since they require little or no alteration between multiple sections of lab. Nearly everyone who has had a "classical" botany or zoology lab or unfortunately, most general biology labs, has experienced this approach.

Alternatively, laboratories can be inquiry based, research based or problem-oriented. Inquiry labs attempt to balance content with concept and are more open-ended. The student is directed to ask a series of questions or is given a series of questions to answer. The answers and/or outcomes are unknown to the student, but known to the instructor. Good lab design leads the student to the "correct" conclusions generally pre-determined by the instructor. This lab approach remains time and place dependent but attempts to engage the student in a more personal approach. Early attempts at computer assisted instruction were based on reducing the time and place dependency of this model, with the added advantage of individual processing by the student. A highly effective model of inquiry based learning was the BSCS program of the 1960's. The literature abounds with computer modeling and simulations.

Research labs take the inquiry one step further and ask questions that do not have pre-determined answers. This model engages students in "real science" where the outcome is unknown, at least in all of its details. Learning is highly individual and usually requires the development of sophisticated laboratory skills. It also requires more instructor time and expertise. Consequently, projects usually reflect the research interest of the instructor and the facilities of the institution. This is an expensive approach to lab. It requires considerable time and materials and is based on the older apprentice model of education. It is usually reserved for the best of the majors and is rarely used in lower division courses with large numbers of students. It is difficult to schedule (protocols don't always fit neatly into one or two hour blocks), and is highly dependent on place. Often, research projects require a significant investment in facilities and support staff and most projects are done within the facilities of the faculty supervisor.

The latest vogue in science education is problem-oriented learning. This is a modification of a research plan and involves new problems for the student, but not necessarily for the instructor. Labs are learner focused, cooperative team efforts, with a high level of "ownership." All knowledge is contextual and students learn only what they need to solve a problem. Case studies are often employed for starting points and the outcome is flexible but usually able to be controlled. The instructor's role is to choose appropriate case studies and attempt to steer the process in a particular direction (often to ensure content coverage). This approach to lab requires extensive library holdings and often-sophisticated facilities. It is also more demanding of instructor time in the role of facilitator.

So, which is best. For us, the answer is a combination of all of the above with a focus on how real problems are solved in science. None of the strategies mentioned above are appropriate to the way science is actually done. Each approach highlights only one aspect of solving a problem. For most laboratory scientists, the process of solving a problem is likely to begin with the recognition of an interesting question or topic. Sometimes this can be assigned by others, but more likely, it is a phenomenon that grabs our attention and one for which we don't have adequate easy answers.

Once the problem is formulated, the next step is invariably checking the literature. The equivalent today would be to run it through a search engine on your browser. One need to know what has been reported before one can ask intelligent questions. Next, or perhaps simultaneously, the problem is discussed with local or regional experts. Having gained enough knowledge from the literature about the topic, we feel easier about approaching our peers. If the experts don't have a satisfactory solution, our interests may get piqued even more and then the fun begins. We decide to find a solution through experimentation. There is a problem or question that no one seems to have an acceptable answer. We first design a protocol based on our experience and skill and often expand those skills as it becomes necessary. Take, for example, a problem dealing with genetic variability. It could easily lead us to learn new techniques of molecular biology (PCR, restriction mapping, sequencing), while leading us away from the familiar and comfortable (microscopy, histology, karyotypes). We discover that while every technique has merit to someone, only a few will be relevant to a given problem. And some are more relevant than others. If we are going to answer a problem, we learn the techniques that are required. Alternatively, one learns a technique and then never asks questions that can not be answered with that technique.

The typical cell biology lab teaches techniques. Some will be used at a later date, most will not. Even twenty years ago, questions of genetic code would have been quite limited by the techniques available for RNA/DNA studies, when compared to modern procedures. Who would have thought those fluorescent probes would be as readily available as they are today? It should not surprise us that many of the hot techniques of today will be rather passe twenty years from now. In my day, we used a lot of colored pencils and drew every structure visible in the light microscope. Today, we are making digital videos of the movement of SNRPs within a nucleus, and publishing it on the Internet.

Consequently, it is time to evaluate, once again, our laboratory approach to cell biology. Instead of a traditional syllabus of 12-14 weeks with each week devoted to a different technique, the focus of the lab should be a project aimed at the solution of a problem. Rather than begin the sequence with "How to use a microscope," we should lay out a number of case studies, appropriate problems, or better still, use the first weeks to focus on teaching our students how to spot a significant problem that can be addressed. This is best done by utilizing group projects that require constant interaction and focus. Each group must be able to state the problem with sufficient clarity that all members of the group understand what is being asked and find their role within the solution.

In my course, we have done away with lectures, canned labs, written exams and even the textbook. This may sound like the instructor has it pretty easy, but it is not so. Working with up to 15 students in groups of 3 or 4, we meet once a week for a three hour session. In the early part of the semester, the group focuses on basic techniques of cell imaging (the focus of the course), and more importantly on the identification of appropriate problems. All of the students have completed a basic course in cell and molecular biology, so they are familiar with the terms and concepts of modern cell biology. They are asked to use their old texts, the library, the Internet or any source they can imagine and to return by the second week with some spark of a topic in cell imaging that excites them. Each student presents her/his "idea" to the entire group and the group critiques each idea. The main role of the instructor is to elicit the ideas, help to refine them and keep them on track. It is also important that the problems are stated in terms that are approachable in the limited time of a semester and with the equipment and facilities at hand. For example, a student may wish to complete the genome sequence for Arabidopsis. With coaching and discussion, that may be whittled to using FISH to study the location and regulation of a single gene. That gene should be one for which there is a commercial source of an appropriate oligonucleotide for the hybridization.

At this point, students begin to group themselves around the basic ideas and some are accepted as appropriate while others are left open for further work. Then the groups must decide what is it that they need to know before proceeding. In our example above, the students would have to determine what FISH is (fluorescent *in situ* hybridization) and how it applies to visualizing the action of a gene. There is no better way to determine this then using the web. Simple searches of "genome and localization" will yield a host of appropriate papers and abstracts, some of which will refer to visualizing the process. Then, the students ask for a review of FISH. If it is appropriate the instructor may choose to give a 20 minute or 3 hour lecture, or better, ask an expert to give a seminar to the group, or visit a laboratory where it is being performed. In other circumstances the students will do a review of the procedure and report it to the group. The important part is that FISH is introduced as a means of solving a question and not as an isolated technique. If they do not need to use FISH, it may never be covered in the course. The protocols are selected on the basis of the stated problems and often come from on-line sources (c.f. http://www.gac.edu/ cellab/).

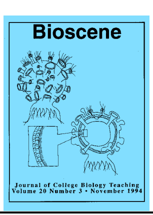
Since this is a course on advanced cell imaging techniques, there are some basics. All aspects of microscopy are covered to some extent, usually by careful selection of the projects. Standard light, dark field and phase microscopy, photomicrography, and fluorescence are covered. If appropriate, TEM, SEM and AFM might be covered, at least in principle. All students are introduced to digital and analog techniques of image recording, including the use of scanners, darkroom techniques and file formats. All projects must utilize some form of image processing and analysis. The specifics are left to the students, but in our experience, *Adobe Photoshop*® and/or *Corel Photopaint*® work well for most image manipulations. These are PC based programs, but students opt for similar programs for Macintosh or even UNIX based programs. *Metamorph*® is used for advanced work (including 3D deconvolution) although *NIH Image*® and/or *Sigma Scan*® are also employed. Digital video and morphing are introduced and 3D reconstruction is accomplished with *Spyglass Slicer*® (now *NOeSYS*®). All projects are eventually published on the web and each student creates a home page. There are now so many programs for this that the students invariably lead the way. As a start they are introduced to the UNIX system on campus and learn to FTP and Pico edit from the start.

Now for the best part. Most of the images needed are available on the web. It is not necessary for a student to know how to do FISH if the images they need can be obtained from elsewhere. They should understand what the procedure is, but do not need to be skilled at performance of a protocol. For undergraduate projects, there is an almost unlimited resource of images available on the net. Normally, our projects are focused on protocols that can be performed by students, but they know from the start that it is the analysis that is important. For example, one of last year's projects involved the reconstruction of a chloroplast. The project centered on the relationship of a glyoxysome to the chloroplast when it was noted that published images were always 2D TEMs. Without realizing what a formidable task lay ahead, the students chose to obtain serial sections of a chloroplast, digitize the images, stack them and reconstruct a rotatable image (hopefully in relation to microbodies in the cytoplasm). This was not a trivial undertaking, since cutting serial sections requires quite a lot of skill. Fortified with the enthusiasm of ignorance but excited about the ultimate image the students forged ahead. What they found was a citation that gave a series of 2D images of a sectioned plant cell. When photocopied and faxed images proved too blurry, they contacted the author by email, explained their project and obtained a set of original photomicrographs (by snail mail). The author was not up to the task of creating the digital images and was surprised by the students' request for images that they could receive by FTP. The project was completed with the supplied images, even though the students, as a back-up, had fixed and embedded plant materials and learned to use a TEM. The images merely saved them many hours of sectioning and allowed them to put their time into the 3D reconstruction. As for the relation to the glyoxysome, the students learned that it was not as easy a solution as they had originally thought. They have a new respect for the published work of others.

The basic procedure is:

- Find a topic that excites the student curiosity
- Search the literature (web browsers, search engines) and refine the problem
- Obtain published images (FTP or download from the net)
- Digitize and enhance images (threshold, erase unwanted material)
- Image Analysis (counts, area, cross-section diameter, etc.)
- Morph or 3D reconstruction
- Plan and execute presentation on home page or as *Authorware*® presentation.

Our focus is on an image as data. It matters how the image was obtained, but the real work begins with the image. The production of a visual answer to a problem of interest to the student leads to retention of more content than one would imagine. The students become creative with their work and are justly proud of their accomplishment. Equally important, they learn to work with a team toward a set deadline (upon which their entire grade depends). They do not waste time going over cookbook protocols and techniques they may never use. Finally, they come to realize that they can either master any technique if there is a need for it or find someone who is a master to cooperate.



BIOSCENE Contributors

Do you have a manuscript, announcement, book review, labs/field studies that work, course development materials, technological advice, software reviews, curricular innovation, letter to the editor, undergraduate research opportunity to share? Please note that the deadline for the August issue is June 30, 1998. The deadline for the December issue is October 30, 1998..

The History of Rockhurst College

ACUBE 1998 Meeting Site

The Spirit behind Rockhurst College was born in 1521, when a Spanish soldier took a cannonball in the leg at Pomplona. That soldier, later to be known as St. Ignatius of Loyola, used his recovery period to develop his spirituality and approach to life. The new spirituality led to the formation of the Society of Jesus. The subsequent Jesuit tradition of service to others through a liberal education has been renowned worldwide for more than 450 years.

The Ignatian spirit was expressed in Kansas City in 1910 with the founding of Rockhurst College and High School. A charter from the state of Missouri empowered "Rockhurst University" to offer degrees. The construction of Sedgwick Hall in 1914 allowed the opening of high school classes in 1914; college classes began in 1917. Small in numbers but infused with the Jesuit spirit, the first Rockhurst College students were all taught by the Rev. Alphonse Schwitalla, S.J. Just as the Jesuit order grew from the calling of one man into a worldwide force, so Rockhurst has grown from the dream of a small, hardy crew of priests, into an institution with national reach.

A commitment to academic excellence and community service has marked Rockhurst's path. Today the College serves approximately 3,000 students at the main campus in Kansas City's cultural district and at the Ignatius Center of Rockhurst College/Saint Louis University, located in suburban Kansas City. Both undergraduate and graduate degree programs feature the lifelong liberal arts learning approach that is a hallmark of Jesuit education. Through a subsidiary, Rockhurst College Continuing Education Center, Rockhurst is also the nation's largest nonprofit provider of adult continuing education.

Currently, Biology is the second largest major at Rockhurst with 128 students in their junior or senior years. About 2/3 of them are looking towards graduate work in Occupational Therapy Education or Physical Therapy Education. Another 15-18 are pursuing pre-professional degrees in pre-medicine, pre-dentistry, pre-optometry, or pre-veterinary medicine. About 8-10 are planning to do graduate work in biology.

During academic year 1997-1998 there were 8 full-time faculty slots including a morphologist, a microbiologist, a geneticist/entomologist, an invertebrate zoologist, a botanist, a person for anatomy and physiology, and an environmental physiologist, (The eighth slot this year was covered by two part-time instructors). This fall we have a new microbiologist, replacing Ed Kos who retired, and a new molecular biology slot. With the addition of about 27 adjunct hours we are able to cover most of the standard spectrum of biology curricula, though we lack any courses in the "ologies" (ornithology, mammalogy etc.) We do sometimes provide these courses as reading courses or for small senior groups on demand.

August 1998 will see us entering our third full year in our new Richardson Science Center, which for the most part is electronically state of the art for teaching and consists of 12 laboratories, four computer labs, three classrooms each of which will seat over 60 students, and three seminar rooms. Come to Rockhurst and see the new facilities and join us for what we hope will be a very exciting 42nd annual meeting of the Association of College and University Biology Educators (formerly AMCBT).

ACUBE 42nd Annual Meeting

Rockhurst College
Kansas City, Missouri
October 15-17, 1998

Preliminary Program

Are We Preparing Global Citizens: Aware, Active, and Accountable?

Thursday, October 15th

6:00 - 8:00 PM	Registration and Reception	Richardson Entrance
8:00 PM	**Opening Session** Welcome for ACUBE ACUBE President: **Karen Klyczek,** *UW-River Falls* Welcome to Rockhurst College: **Corey Simmonds,** *Acting Dean, College of Arts and Sciences* Program Chair: **Terry Derting**, *Murray State University* Local Arrangements Chair: **Kevin Williams and Dick Wilson**, *Rockhurst College*	Richardson 115
	OPENING ADDRESS (Public Welcome to Attend) ***Long-Term Ecological Research in Tallgrass Prairie: The Role of Basic Research in the Conservation of Grassland Ecosystems,*** Dr. Alan K. Knapp, *Kansas State University and KONZA*	
9:30	Executive Committee Meeting	Richardson 302

Friday, October 16th

7:00 AM - 5:00 PM	Registration table will be open all day Please check your membership; inquire about audiovisual needs; general information.	Richardson Entrance
7:00 - 8:00 AM	Buffet Breakfast (by Interest Group)	Rock Room (Massman Hall)
9:00 - 11:30 AM	Sustaining Member Exhibitors	Richardson 206
8:15 - 12:00 AM	**CONCURRENT WORKSHOP SESSIONS I**	
	1. Differential Centrifugation Using Density Gradient Beads, Harold Wilkinson, *Millikin University*	Richardson 227
	2. Virtual Biology: Design and Implementation of Web-Based Biology Courses, Tim Mulkey, *Indiana State University*	Richardson 205
	3. Interdiciplinary Student Projects for Introductory Science and Mathematics Courses, John Jungck, *Beloit College*; Anita Salem and Dick Wilson, *Rockhurst College,*	Van Ackeren 332
	4. Rediscovering *Chlamydomonas*, Steve S. Daggett, *Avila College* and Donna L. Ritch, *UW - Green Bay*	Richardson 221
	5.	
9:45 - 10:00 AM	**Morning Break (Refreshments)**	Richardson 206
11:30 - 1:15 PM	Luncheon and First Business Meeting	Rockroom (Massman Hall)

Are We Preparing Global Citizens?

Panel:

- Dr. Dean Jerringan, *Ottawa University, Associate Professor of Science Education (formerly 30-year teacher at Shawnee Mission South High School)*
- Mr. Chris Gentile, *Director of Material Engineering and Technical Services; Allied Signal Inc.*
- Mr. Joe Werner, *Urban Ecologist, Kansas City Power and Light Co.*
- Mr. John Strickler, *Executive Director, Kansas Association for Conservation and Environmental Education*
- Mr. Brad Williamson, *Olahe East High School, Monarch Butterfly Project*

1:15 - 2:00 PM	Shareware	Richardson 203/205
1:15 - 2:00 PM	Student/Faculty Posters and Displays	Richardson 'Street'
1:30 - 4:00	**CONCURRENT FIELD TRIPS**	

All trips will leave from Massman Hall parking lot

1. **Powell Gardens** - Large horticultural collection -- and walking tour of landscaped garden and nature trails.
2. **Negro Leagues Baseball Museum/ KC Jazz Museum**
3. **Bayer Laboratories** - Animal research facilities
4. **University of Kansas Museum of Natural History** - Meet with curators of birds and mammals (Larry Martin and Thor Holmes)
5. **Linda Hall Library of Technology and Science** - Rare book collection and tour of arboretum - walking field trip. (Current exhibit will be George L. Leclerc, Comte de Buffon, *Histoire Naturelle*)
6. **Plaza shopping tour** - Particularly for spouses - buses will deliver participants to the Plaza and pick them up for return to hotel or campus - self-guided
7. **Kansas City Zoological Gardens and IMAX Theater** - Buses will deliver participants to the Zoo front door, and pick them up for return to hotel or campus in time for 4:15 sessions or dinner, at the participant's choice - self-guided (unless there are a large number of children, in which case Rockhurst will try to provide two student chaperones).

2:00 - 4:00 PM	**CONCURRENT WORKSHOPS SESSIONS II**	
	1. Virtual Problem-based Learning, Karen Klyczek, *UW-River Falls*	Richardson 203
	2. Developing Teaching Strategies for Case-Based Learning, Margaret Waterman, *SE Missouri State University*, and Ethel Stanley, *Beloit College*	Richardson 125
	3.	
	4.	
	5.	
4:00 - 4:15 PM	**Afternoon Break (Refreshments)**	Richardson 206
4:15 - 5:00 PM	**CONCURRENT PAPER SESSIONS I**	
	1. Linking Biology and Chemistry: A First Look, Buzz Hoagland and Patti Depra, *Westfield State College*	Richardson 125
	2. Training Biological Citizens: Definitions and Content, Tom Davis, *Loras College*	Richardson 315
	3. Enhancing the Science Curriculum of Homeschooled Children Through a Community Outreach Program, Mary Haskins, *Rockhurst College*	Richardson 115
	4. Students With Disabilities: What Is Our Role? Jill Kruper, *Murray State University* and Marty Mitchell, *Edinboro University*	Richardson 306

	5. The Development of Inquiry-Based Outdoor Classrooms, Ed Story and Mike Quillen, *UK-Maysville Community College*	Richardson 302
5:30 - 7:00 PM	Posters, Exhibits, Social	Richardson 206
6:30 PM	**BANQUET**	Rock Room (Massman Hall)
7:30 PM	**BANQUET ADDRESS:** The Anemone is Not an Enemy to the Clownfish, Dr. Daphne G. Fautin, *Professor of Biology, University of Kansas*	Richardson 115
9:00 - 10:15 PM	Curricular Issues Discussion (with cash bar) "Preparing Global Citizens", Tom Davis, *Session Organizer*	Massman Gallery
9:00 PM	Bus available to hotels	Richardson Front Door
9:00 - 12:00 PM	Jazz Pub Crawl - led by Phil Colombo, *Assistant Professor of Chemistry*	
10:15	Second bus will catch up with Crawl if enough discussants are interested	Richardson Front Door
Saturday, October 17th		
8:00 - 9:15 AM	Buffet Breakfast (by Interest Groups; Bioscene editorial board get food and take upstairs to M248)	Rock Room (Massman Hall)
8:00 - 9:15 AM	*Bioscene* Editorial Board, Ethel Stanley and Tim Mulkey, presiding	Massman 248
8:30 - 10:30 AM	***Open Balloting***	Richardson entrance
9:00 - 11:30 AM	Zoological Gardens - Bus available for spouses/children leaves from in front of Richardson Science Center. Pick up is at 11:15 from zoo main gate for return to campus.	
9:00 - 11:30 AM	Sustaining Member Exhibitors	Richardson 206
9:00 - 9:45 AM	**CONCURRENT PAPER SESSIONS II**	
	1. A Multidisciplinary Inquiry-Based Introduction to Science for Pre-service Teachers: Are Teachers Prepared to Teach Science?, Terry Derting and Jimmy Dorris, *Murray State University*	Richardson 302
	2. Science Studio (A science intervention program for middle school girls). Faith Wilson. *St. Teresa's Academy*	Richardson 315
	3. What do your students say about evolution?, Nancy Sanders, *Truman State University*	Richardson 125
	4. Teaching Sexual Differentiation: Beyond the Textbooks, Marc Roy, *Beloit College*	Richardson 306
	5. Collaborative Case-Based Learning for Introductory Biology Students using Molecular Biology Computer Simulations and Internet Conferencing, Mark Bergland, *UW - River Falls*	Richardson 203
9:45 - 10:15 AM	**Morning Break** Posters, Exhibits, Refreshments ***Balloting Closes at 10:30 AM***	Richardson 206
10:15 - 11:00 AM	**CONCURRENT PAPER SESSIONS III**	
	1. Problems of Teaching Large Numbers of Students in General Education Laboratory Classes Involving Many Graduate Student Assistants, Rita Ghosh, *Indiana State University*	Richardson 125
	2. Gas Chromatography in the Non-Major Environmental Science Course, James Edmiston, *Quincy University*	Richardson 302
	3. Labs That Work: A Dinosaur Trachways Exercise, Robert L. Wallace and William S. Brooks, Ripon College	Richardson 315
	4.	
	5.	
11:00 - 12:30 AM	Luncheon with Business Meeting	Rock Room (Massman Hall)

BUSINESS MEETING
Presidential Address: **Karen Klyczek,** *UW - River Falls* and **Charlie Bicak**, *UN-Kearney*
Election Results: **Dick Wilson**, Rockhurst College
Bioscene: **Ethel Stanley**, *Beloit College*, **Tim Mulkey**, *Indiana State University*
Executive Secretary Report: **Marc Roy,** *Beloit College*

12:30 PM **===ADJOUNRNMENT OF REGULAR MEETING===**

12:35 - 1:15 PM Executive Committee Meeting Richardson 302
Includes newly elected Executive Committee members!

If you are interested in presenting a workshop or paper please contact Terry Derting at Terry.derting@murrraystate.edu or 502-762-6327.

ABSTRACTS OF SESSIONS

Concurrent Paper Sessions:

S.I.1. Linking Biology and Chemistry: A First Look. Buzz Hoagland and Patti DePra, *Westfield State College*

During the spring 1988 semester a chemistry faculty and I linked a second semester general chemistry course with a second semester introductory biology course. Sixteen students were co-enrolled in both courses that met for lecture MWF at 8:30 (General Chemistry II) and MWF at 10:30 (Biological Concepts). Students were given a survey designed to determine their understanding of the nature of the link between chemistry and biology at the beginning and the end of the semester. The extent to which each course was modified, the nature of the involvement by each faculty member, and student reactions will be discussed.

S.I.2. Training Biological Citizens: Definitions and Content. Tom Davis, *Loras College*

Participants in this session will discuss first, what is a "good" biological citizen and second, what subject matter should be specifically included to train better biological citizens in a one semester, introductory, non-majors biology course. In the past I have chosen the following six broad topics: a. Cells; b. DNA, Genetics, Heredity; c. Plants; d. Viruses, Prokaryotes, Protoctista and Fungi; e. Evolution; f. Ecology and Environmental Ethics. Third, participants will discuss their ideas on how to best promote active student ownership of this information.

ASSIGNMENT: Participants in this session are asked to prepare and bring to the session their definition of a "good" biological citizen and choose 6 major topics that they would include in a one semester course to train biological citizens.

S.I.3. Enhancing the Science Curriculum of Home-schooled Children Through a Community Outreach Program. Mary Haskins, *Rockhurst College*

Rockhurst College offers biology laboratories for middle and high school students who are home-schooled. Students attend one 2 1/2 hour lab/week on the Rockhurst campus. The self-supporting program provides several benefits to both the homeschool students and the Rockhurst community. These benefits include:

1) augmenting the science education of home-schooled children;
2) enhancing Rockhurst's visibility within the community;
3) enhancing Rockhurst's reputation within the metropolitan area;
3) providing teaching experience and jobs for graduate and undergraduate students who work in the program;
4) and serving as a potential recruitment tool.

S.I.4. Students With Disabilities: What Is Our Role? Jill H. Kruper, *Murray State University* and Marty Mitchell, *Edinboro University*

Have you had students in your classroom with vision or hearing impairments, cancer, or hemophilia? Students such as these have different types of disabilities that need to be addressed when considering how your students will learn. Despite the fact that most biology educators have had students with some type of disability in their classroom, few institutions require their faculty to be formally trained about their role as educators when teaching students with disabilities.

We will present information to bring you up to date on what is required of the student with some type of disability and the teacher when designing lectures, exams, and laboratories. Specifically, we will address how teaching a biology course to students with disabilities can be very challenging as compared to courses in other disciplines. We will also provide helpful suggestions so that you will be better prepared when you realize you are teaching a student who cannot see, or perhaps, hear you.

S.I.5. The Development of Inquiry-based Outdoor Classrooms. Ed Story and Mike Quillen, *UK-Maysville Community College*

The presenters of this proposed session have developed a state award winning Outdoor Education Center at Ward Elementary School in Fleming County, Kentucky. Ward Elementary is located in rural Northern Kentucky.

The development of Outdoor Classrooms as a tool for Inquiry-based education is a viable option for today's schools. The developmental process, beginning at site selection and ending in integrated cross-disciplinary curricula is both involved and rewarding. This session will discuss various processes and pitfalls, and will present a successful sequence from planning through implementation.

The site has been developed with trails, bridges, ponds and a shelter for group instruction. A power-point presentation will guide the participants through the development phase, the curriculum development phase, the teacher and teacher aid in-service and the actual implementation of the outdoor center into the existing school curriculum.

Problems and stumbling blocks will be addressed along with solutions to them so that the center can flourish in the community. Other topics addressed will include: size of site, securing financial support, actual construction, development of activities that can be used, teacher training, teacher aide training and securing the future of the site.

S.II.1. A Multidisciplinary Inquiry-based Intro-duction to Science for Pre-Service Teachers: Are Teachers Prepared to Teach Science? Terry L. Derting and Jimmy Dorris, *Murray State University*

We present a preliminary evaluation of a recently-instituted multidisciplinary science course that was developed initially for pre-service teachers through funding by the Eisenhower Foundation. The course focuses on physics, biology, and geoscience. Survey and evaluation data for two semesters of the course will be presented and compared with similar data for our traditional non-major courses in geosciences and biological sciences. We will discuss whether the course has resulted in improved student attitudes towards science, improved critical thinking skills, and improved understanding of basic scientific concepts and the process of science. We believe that development of a positive attitude, critical thinking skills, and an understanding of science is essential for adequate preparation of teachers in science. We will also discuss the problems encountered with the development and implementation of a multi-disciplinary course.

S.II.2. SCIENCE STUDIO (A science intervention program for middle school girls). Faith Wilson, *St. Teresa's Academy*

The academic literature still clearly shows that young women shy away from scientific and technical activity despite the importance of these areas in modern society and their future employability. Studies also indicate that young women lose self-esteem beginning with early middle school. Evidence continues to suggest that a single-sex setting can have a positive impact on the above factors. The literature indicates that without further research on the single-sex classroom in a coeducational world we will not know the following: (1) Which techniques, if any, are particularly successful? (2) Is there an age, development stage, or point in a course sequence at which it is especially useful to pursue a single-sex alternative? (3) What strategies are helpful and at what stage is it useful to ease the transition back to the coeducational environment? The long-term rationale for Science Studio is to uncover possible answers to these questions and to impact the overall systemic issue of women in science.

The core Science Studio is a five-day, summer camp held for each of six science modules. During this experiential camp, and subsequent follow-up activities, young women will explore many scientific principals that form the foundation for understanding how the world around them works. Experienced faculty will be co-teaching with St. Teresa's alumnae still in college, majoring in science, and current honor students from the Academy. The honor students will act as role models and mentors.

This single-sex, educational experience will also contain a number of messages about the history and capability of women in science. This, combined with the presence of strong role models, including guest lecturers from the corporate world, will help to counteract the gender bias messages from other sources.

S.II.3. What Do Your Students Say About Evolution? Nancy Sanders, *Truman State University*

What do your students say about evolution? Do you know, or do you think you know? What preconceived ideas do they have about evolution when they walk into your classroom? How do your views shape their views, or do they? I will share with you some of the responses my students give to the question "What do you think/know about evolution?" that I generally ask during the first week of class in my introductory biology classes for majors. I will then share my perspectives on how to address their question and concerns, and I will invite you to share yours!

S.II.4. Teaching Sexual Differentiation: Beyond the Textbooks. Marc Roy, *Beloit College*

Most introductory and many advanced biology textbooks describe mammalian sexual differentiation as a process regulated, in males, by the Y chromosome and the actions of androgenic hormones. Typically, female differentiation is described as being the result of the absence of these factors. In essence, the female phenotype is described as the default form. In this presentation I will show how this model is out-of-date with current research findings and how sexual differentiation in both males and females is due to a complex interaction of biological factors. Discussion will focus on how we can incorporate this changing paradigm into our courses.

S. II.5 Collaborative Case-based Learning for Introductory Biology Students Using Molecular Biology Computer Simulations and Internet Conferencing. Mark Bergland, *UW-River Falls*

This presentation updates *Case It!*, an NSF-sponsored project to engage introductory biology students in critical thinking and problem-solving by making topics in molecular biology more interesting and relevant. Open-ended computer simulations integrated with Internet conferencing will facilitate collaborative case-based learning among teams of students at a variety of educational institutions across the nation and the world.

S.III.1 Problems of Teaching Large Numbers of Students in General Education Laboratory Classes Involving Many Graduate Student Assistants. Rita Ghosh, *Indiana State University*

Keeping students alert and attentive is one of the most challenging tasks in General Ed. Lab. classes. These students are not interested in science. They come ill-prepared and cannot relate to diverse areas of science. These topics do not touch their daily life. It is no wonder that science laboratory seems even more daunting to a large majority of the Gen. Ed. students who enroll because it is a requirement. Then there are students who do have good backgrounds, and for them these courses are too easy to warrant attention. The problem is accentuated by the fact that these Gen. Ed. Science Labs require participation of Graduate Teaching Assistants, who come with varying degrees of background, ability and expertise. Thus they could greatly affect Gen. Ed. students' interest and involvement, if they are not properly trained.

Therefore, it is important for science teachers, strategists and policy makers to devise ways to improve our science education and make it meaningful. To help initiate a dialogue in this important area, I would focus on areas that are pertinent to this discussion.

(1) How to improve laboratories and make presentations interesting, yet focused.
(2) How to challenge students to think and come up with simple answers, or motivate them to design simple experiments which they can do at home. We should point out to the students that many things they are enjoying in life are fruits of scientific endeavor.
(3) Try to include topics and experiments that the students can relate to in their daily life.
(4) How to overcome many of the cultural hindrances and accept scientific reasoning. It is important not only to appreciate science but to be receptive of diverse thoughts and reasoning.
(5) How best to train graduate teaching assistants so that they all acquire a good teaching method, communication skill, and attitude. The objective is to insure a degree of uniformity in all sections of the same lab.

S.III.2 Gas Chromatography in the Non-Major Environmental Course. James Edmiston, *Quincy University*

Detection and measurement of environmental toxins found in field samples with gas chromatography techniques provides the non-science major an opportunity to make connections between fieldwork and quantitative lab analysis. GC techniques, using smaller-scale instruments designed for field analysis, are used in non-major environmental science courses. Specific exercises for the quantitative and qualitative analysis of trihalomethanes in water supplies will be provided.

S.III.3 Labs That Work: A Dinosaur Trackways Exercise, or A Test of Alexander's (1976) Model Estimating The Velocity of Bipedal Dinosaurs (a.k.a. students) From the Footprints They Leave in Trackways. Robert L. Wallace and William S. Brooks, *Ripon College*

In an experimental course on the biology of dinosaurs (Dinosaurs: The Course), we had our students test Alexander's (1976) model that the velocity of a bipedal dinosaur is a function of stride length and hip height:

thus, V - 0.7826 (S^+1.67) (H^-1.17);
where, S - stride length in meters and H = hip height in meters.

To do this our students measured their Foot length (F) and Leg length at the hip (H) and examined that data to test Alexander's assumption that 4F is a good approximation of H, at least for humans. The students then became dinosaurs and made trackways on rolls of newsprint of at least 20 meters long. Dinosaur velocity along the trackway (V) was independently determined, and from that data and data extracted from the trackway (S) the students tested Alexander's model. This lab exercise worked well and probably has many applications from high school through college. Besides a special class such as ours, other that might make use of this include courses in general biology for major or non-majors, biostatistics, human and vertebrate anatomy, and paleontology. However, based on experience, we recommend that the trackway be made in a warm hallway rather than a large, poorly heated gymnasium.

Concurrent Workshop Sessions

WS.I.1 Differential Centrifugation Using Density Gradient Beads. Harold Wilkinson, *Millikan University*

Abstract not yet available

WS.I.2 Virtual Biology: Design and Implementation of Web-Based Biology Courses, Tim Mulkey, *Indiana State University*

Today, the traditional classroom is expanding into the home and workplace. Place- and time-bound students are taking courses via the Internet at locations and times which better suit their schedule and lifestyle. This change in instructional delivery impacts the content, scope, and effectiveness of instructional materials. These virtual classrooms can reach larger student populations with a diverse range of backgrounds, interests, and needs. New challenges are presented to faculty charged with the design of instructional materials for the virtual classroom.

This hands-on workshop will provide participants with an overview of the tools available for web course design and implementation. During this session, participants will use selected tools to begin the design of a web-based course. Participants are encouraged to bring on a PC-format disk the syllabus and other materials that they currently use in a course; this will allow the participant to convert these materials into a format useful in a virtual classroom. [Note: no previous experience with HTML or web design is required. Resource materials will be provided to allow participants to continue development of their virtual courseware after the workshop.]

WS.I.3 Interdisciplinary Student Projects for Introductory Science and Mathematics Courses. John Jungck, *Beloit College;* Anita Salem and Dick Wilson, *Rockhurst College*

One of the most important attributes of undergraduate programs that attract and sustain students in science is a thriving community of students and faculty. Such natural science communities help make learning personally meaningful to students and faculty, allowing them to think about connections to other fields of inquiry. The focus of this workshop will be on the ways in which institutions can cultivate an interdisciplinary, research-rich environment. The workshop will be structured around two projects in population genetics: *A Mathematical Model for Weak Selection of Alleles* and *A Mathematical Model for Selection at a Locus with 3 Alleles.* These two projects are part of a collection of interdisciplinary projects created as part of an NSF grant (DUE-9653093) awarded to Rockhurst College. Included in the workshop will be presentations and discussions on the rationale and motivation for including interdisciplinary projects in mathematics and science courses.

Participants will be encouraged to experiment with difference implementation methods and evaluate the suitability of including interdisciplinary projects in their courses.

WS.I.4 Rediscovering *Chlamydomonas.* Stephen S. Daggett, *Avila College* and Donna L. Ritch, *UW-Green Bay*

Chlamydomonas reinhardtii is a eukaryotic unicellular, green alga. It is found in freshwater and moist soil environments. *Chlamydomonas* sp. are biflagellated and undergo a haplontic life cycle characteristic of many algal protists. *Chlamydomonas* has been used extensively as a research system in cell biology and genetics. It can also be readily incorporated into an undergraduate teaching curriculum. There are several exercises that undergraduates can successfully carry out using *Chlamydomonas* at each level of study. We will demonstrate this by carrying out two protocols. One protocol will involve matings between *Chlamydomonas* cells of opposite mating type and the other will explore *Chlamydomonas* phototaxis. Students find each of these protocols to be both educational and exciting.

WS.II.1. Virtual Problem-Based Learning. Karen Klyczek, *UW-River Falls*

This workshop will demonstrate the use of various types of collaborative problem-based learning (PBL) groups in biology classes. The "virtual" in the title refers in part to using Internet conferencing for intragroup and intergroup collaboration, but also to the use of a more open-ended style of problem than is seen in typical clinical case studies. A summary of results obtained with the PBL strategies in Virology and Immunology classes will be presented, after which participants will have an opportunity to try a couple of different internet communication programs to solve sample problems and to design their own problem scenarios.

WS.II.2 Developing Teaching Strategies For Case-Based Learning. Margaret Waterman, *SE Missouri State University* and Ethel Stanley, *Beloit College*

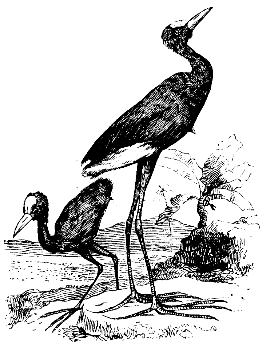
Helping students to become life-long learners who are able to connect biology to their lives is an important goal of science education. One strategy for accomplishing this goal is case-based learning. Learners pursue their own questions, identify and use a wide variety of resources, and present their reasoning and possible solutions.

Join us as we rather interactively consider three cases about students who are engaged in case-based learning using "Kingdoms Entangled: Molecules, Maize, and Malaria" in quite different ways. We will focus on effective teaching strategies for your classroom as well as ours! We will provide a copy of the multi-part biology case "Kingdoms Entangled: Molecules, Maize, and Malaria," and resource information for each participant as well.

Registration at the 1997 Annual Meeting*. Tom Davis, Ray Reed, Nancy Sanders, and Ethel Stanley.*

THE JOHN CARLOCK AWARD

John Carlock was an important member of ACUBE (formerly AMCBT) during its formative years. He helped set the tenor for the general philosophy of the organization, a firm and continuous dedication to excellence in teaching. He designed many teaching techniques and tools and always demonstrated a desire to share these with his colleagues. 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 teaching. To this end, the Award provides partial support for graduate students in the field of Biology to attend the Fall Meeting of ACUBE.



Guidelines:

The applicant must be actively pursuing 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.

Application:

Applications, in the form of a letter, can be submitted to the Executive Secretary anytime during the year, but must be received a minimum of two months prior to the Fall meeting. 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 a member of ACUBE. The recipient must provide a summary of her/his experiences at the meeting to the Editor of Bioscene within a month of attendance at the meeting.

An awards committee consisting of two members, at least one a member of the Steering Committee, will receive the applications from the Executive Secretary and after consideration inform the President of ACUBE of their selection(s). The president will notify the individual(s) selected, at least one month prior to the Fall meeting, and inform her/him of the monetary aspects of the Award.

HONORARY LIFE MEMBERSHIP COMMITTEE (HLMC)

The duty of this committee is to act as the organization's representative in the recognition of those individuals who have made significant contributions to the association. It should be constituted by the President and should consist of three members of ACUBE with at least one an Honorary Life Member. There is no obligation to annually recognize someone as an Honorary Life Member.

1. The chair shall prepare a list of past Honorary Life Members and a copy of the written citation that accompanied the last presentation and include this with a solicitation for nominations to Honorary Life Membership in the appropriate issues of *Bioscene*. The call should include the criteria for such nomination and directions for submission of the nomination.

2. Upon receipt of nominations and appropriate documentation, the chair will transmit the Nominations to the HLMC for consideration.

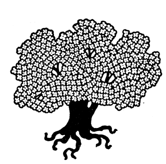
3. After due deliberation, the HLMC will forward its recommendation to the Executive Secretary for consideration by the Steering Committee prior to the next Steering Committee meeting.

4. The Steering Committee shall consider the recommendation at the Fall planning meeting and if accepted direct the Executive Secretary to obtain the appropriate memento to accompany the citation presented to the honoree at the subsequent banquet at the Annual Meeting.

5. The chair of the HLMC will prepare the written citation to accompany the presentation and arrange for the presentation to be made to the honoree.

6. The chair, and/or other members of the HLMC, shall prepare an article featuring the honoree for placement in Bioscene.

7. The Executive Secretary of ACUBE shall inform the recipient's home institute of the honor.



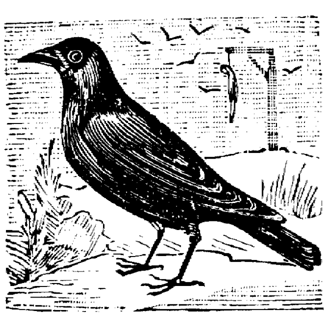
CONSERVATION IN THE 1930s --
A Nickel an Egg, A Dime a Head

William Brett
Indiana State University
Department of Life Sciences
Terre Haute, IN 47809

Sometime about 1937, the State of Illinois decided it should do something to reduce the loss of farmers' corn due to crows. To this end they placed a bounty of 5 cents an egg and 10 cents a head, a head being one that had black feathers on it, not just pin feathers or fuzz; without black feathers it counted as an egg or at least you only got paid 5 cents for it. To the three Bs, Bob Loft, Bob Rassmuson, and Bill Brett, this was something like the announcement of gold being found in California during 1849.

The crows didn't start laying their eggs until late April or early May, but we scouted their nests prior to their laying. We also knew that crows laid 5-6 eggs and therefore locating a nest with less than 5 eggs meant leaving it for a another day or two and then returning to harvest a full crop of eggs. If the nest contained young crows without black feathers, we would leave them there and come back later when they were worth ten cents apiece. As you can see we were not only decent biologists but also good economists. Starting out on an egg hunting expedition, we would choose the order in which we would climb the nest-bearing trees. No matter the type of tree, shagbark hickory the exception, or height of the nest when it was your turn you climbed to the nest. Climbing required both hands and feet which was okay going up but somewhat of a problem coming down with the eggs. After trying several techniques, including lowering the eggs in a cloth by way of a piece of twine, placing them in ones pocket, or placing them in ones cap and then placing the cap on your head, all of which sometimes resulted in broken eggs, we decided on placing the eggs in our handkerchief and then placing the ends of the handkerchief in our mouth. One couldn't talk on the way down, but it did free our hands and feet and succeeded in getting most of the eggs safely to the ground. We learned in our first one or two trips how to tell a crow's nest from a squirrel's nest. The crow's nest was mainly sticks; whereas, the squirrel's contained a great deal of leaves.

I recall one trip in which another boy, Ditto Meyers, his real name was Robert, wanted to go along. After getting him to promise to bring cookies from home we let him join us. When his turn came up, we selected a squirrel's nest for him. He had some doubts about it being a productive crow's nest, but we all solemnly assured him it was. He dutifully climbed up to the nest and just as he was about to place his hand in the nest to obtain the eggs, the squirrel jumped out ran down his arm across his back and jumped to another branch. We all admired Ditto's ability to hang on to the branch under such obvious surprise, but our admiration grew greatly when we observed the speed with which he descended to the ground. It reminded one of how a fireman slides down the pole at the sound of the fire alarm, but the fireman doesn't have a lot of branches to hinder him on the way down. For some reason, Ditto chose not to go crow egg hunting with us again. On a good day we could collect 20 to 40 eggs which brought a total of one to two dollars.

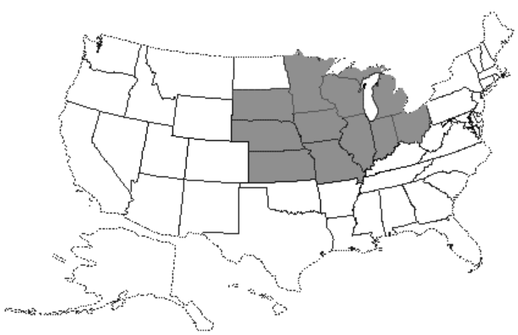


The eggs were turned into Gail Downing, who owned the paint-wallpaper store and was the local mortician. He would count the eggs, give us our money, and then take the eggs to the back of the store and throw them into a metal container that was supposed to break the eggs. Well, it was supposed to break the eggs, but as we noticed some of them survived the drop. Knowing this, and using proper timing and caution, we would return and collect the unbroken eggs. We also collected the bounty money twice on the same eggs. Not believing we were doing anything really illegal, but at the same time not bragging about our accomplishment, we sometimes extended our back of the store egg hunting to eggs brought in by boys other than ourselves. We tried the same procedure with crows' heads and this is where we made our mistake. A couple of the heads had maggots in them and Gail knew that fresh heads didn't carry maggots. After that he disposed of the eggs and heads in another, secretive manner. He didn't chew us out too much for our attempted larceny; in fact I think he secretly admired our enterprising methods. Although the bounty money seemed like easy money to us, measured in time and effort we really earned our pay. We usually went egg hunting on Saturday, leaving at about 8:00am and returning about 5:00 or 6:00pm. During this time we would walk a minimum of ten miles and climb 30 to 40 trees. Climbing trees is not the easiest activity on ones clothes. There were also hazards in crossing barbwire fences, walking across pastureland that sometimes contained a bull, falling out of trees, and getting torn up by blackberry bushes. I recall one particular incident in which I walked into a strand of barbwire a farmer had strung about head high between two trees. One barb caught me on my right cheek just below my eye. Luckily I jerked my head in such a manner that the barb was drawn down my cheek rather than into my eye. It laid open a gash about 2 inches long which my pals assured me was just a small scratch. After continuing with our hunt for another two hours, I arrived home and presented my blood stained face to my mother. Either my mother hid her concern real good or she was so used to me coming home with blood on various parts of my anatomy, that she didn't indicate any particular shock but just took me to the bathroom, washed my face, sterilized the cut with alcohol, and then used what she called "butterfly" strips of tape to pull the wound together. The scar that resulted was much less than I have seen as a result of a doctor suturing a wound of this type.

The bounty on eggs only lasted about two or three years and then the State rescinded it. They determined that it was not having that much affect on the numbers of crows or their affect on the corn crop. I suspect it was due more to natural selection. The crows that built their nests on the highest and thinnest branches had a better chance of producing offspring and following Lysenkoism theory, their offspring also built their nests in places difficult for egg hunters to reach. At least that is what it seemed to us; the nests got harder and harder to reach as we got somewhat older and a good deal heavier, not to mention more cautious or smarter.

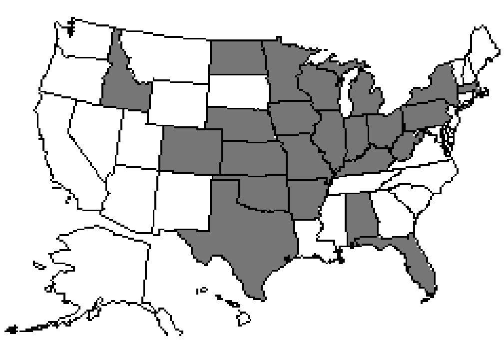
Egg hunting also provided me with one of my favorite pets, a red tail hawk, but that's another story.

MY, HOW WE ARE GROWING!



AMCBT THEN --

At the first meeting in 1957, there were 44 members representing 11 states.



ACUBE NOW --

As of April 1998, there are 314 members representing 24 states.

Note: Help ACUBE as well as your colleagues by letting them know of the benefits of ***your*** organization.

Bioscene: A Brief History

In 1974, the Steering Committee created the *Midwest Bioscene* "as a more viable instrument than AMCBT News or the Proceedings." AMCBT members now had a forum for sharing teaching ideas as well as techniques for field and laboratory study throughout the year. Each issue also provided current news, events of interest, available positions, and member views. The development of this publication over the past 24 years has been remarkable. The individual efforts of those who have served as editors during these formative years are recognized here.

In addition to his strong leadership role on the steering committee, **John Carlock** (Illinois State University) served as the first editor. These first few years were somewhat of a struggle. In "Yes, Virginia, there is a *Midwest Bioscene*..." he advised the members that this publication could only reflect their interests if they made contributions or provided responses. The eventual success of the *Midwest Bioscene* is largely due to his "energy, enthusiasm, interest, and innovation." (Walker 1978)

In 1978, **Nancy E. Walker** (Rockhurst College) began a five year term as editor. She strongly supported the view that the "*Midwest Bioscene* exists to facilitate communication among the members of the AMCBT." Although these issues retained newsletter attributes, she sought out longer articles from the membership and the number of graphics increased.

William Doemel (Wabash College) became interim editor in January of 1983 and began by urging members to "spend a creative evening by a warm fire and write an article for the next issue of the *Midwest Bioscene*." Over the next five years, he redesigned the publication. Cover art became a part of each issue. Ed Kos (1988) wrote "All of us owe Bill a great deal for the hard work he did in changing the format of *Bioscene* as well as greatly improving its content."

In 1988, **John R. Jungck** (Beloit College) accepted the position of editor. A number of innovations quickly followed. An editorial board was formed to assist in the development of a peer review process for submissions. Electronic publishing software enhanced both the text layout and graphics. Articles were sought at a national level as well as through the membership. In 1991, the name of the rapidly developing publication was changed to *Bioscene: Journal of College Biology Teaching*. In 1995, Bioscene was added to ERIC database for education searches. During the 1995-96 academic year, an archive of past proceedings, newsletters, and the *Bioscene* became available via the web. It was one of the earliest organizational publications accessible on the web and, as a result, *Bioscene* acquired a global readership.

The *Bioscene* continues to reflect the convictions of its past editors. Consider once again John Carlock's early advice for success, Nancy E. Walker's facilitated communication, William Doemel's invitation for more articles by members, and John R. Jungck's focus on extended community. What do you think this publication should do?

Bioscene Milestones and Editors

1974-1978 - John Carlock, *Illinois State University*

- 4(1) "created by your Steering Committee as a more viable instrument than AMCBT News or the Proceedings"
- "Yes, Virginia, there is a *Midwest Bioscene*..." response to the notorious "non-issue" published to remind organization that the editor does need something to edit..."AMCBT can respond to your interests and ideas only if you respond to the needs of the organization"
- Nancy Walker in 4(2) recognizes "John Carlock's energy, enthusiasm, interest, and innovation"

1978-1983 - Nancy E. Walker, *Rockhurst College*

- "*Midwest Bioscene* exists to facilitate communication among the members of the AMCBT"
- Accordingly these issues retain newsletter attributes, but additional articles are sought out.

1983-1987 -- William Doemel, *Wabash College*

- Accepts interim editor status in 9(1) Jan 1983 "This issue is the beginning of an experiment."
- Urges members "Why don't you spend a creative evening by a warm fire and write an article for the next issue of the *Midwest Bioscene*?"
- Ed Kos 14(1) "All of us owe Bill a great deal for the hard work he did in changing the format of *Bioscene* as well as greatly improving its content."

1988-1997 -- John R. Jungck, *Beloit College*

- Ed Kos 14(1) extends welcome to John as "a member of many years (since 1967), presenter of many computer programs at Annual Meetings, and also a former editor of *The American Biology Teacher*."
- Formalized editorial board immediately
- Enhanced text layout and graphics
- Other developments:
  - 1991 -- Name changed to emphasize journal -- **Bioscene Journal of College Biology Teaching**
  - 1991 -- Instituted peer review
  - 1995 -- Bioscene added to ERIC database for education searches
  - 1995 -- Archive of Proceedings/Newsletter/and Bioscene available via the web

1998 -- Ethel Stanley, *Beloit College* and **Timothy Mulkey, *Indiana State University***

ACUBE

Association of College and University Biology Educators

Formerly the Association of Midwest College Biology Teachers (AMCBT)

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): ______________________________

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RESEARCH AREAS: ______________________________

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How did you find out about ACUBE? ______________________________

Have you been a member before: __________ If so, when? ____________________

Regular Membership $25.00 Student Membership $15.00 Retired Membership $5.00

Return to: Association of College and University Biology Educators, Attn: Marc Roy, Executive Secretary, Department of Biology, Beloit College, 700 College Street, Beloit, WI 53511-5595

Welcome to

ACUBE On-The Web

URL: http://acube.org

The Association of College and University Biology Educators (ACUBE; formerly the Association of Midwestern College Biology Teachers) has placed its rich archive of materials online for the benefit of its membership. This archive includes 42 years of society publications and resources.

Featuring the online ACUBE archives for:

Bioscene: Journal of College Biology Teaching (1975-present)
AMCBT Newsletter (1964-1974)
AMCBT Proceedings (1957-1972)

Other useful ACUBE information includes:

ACUBE Executive Committee
Editorial Board of Bioscene
ACUBE Annual Meeting Information
Meeting Abstract Submission Form
Searchable Membership Database
Online Membership Application
ACUBE Listserve Information
Scientific Meetings of Interest to Membership
Position Announcements
ACUBE in the News
Sustaining Member Links