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# Bioscene: Journal of College Biology Teaching

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# Using the Concept Map Technique in Teaching Introductory Cell Biology to College Freshmen

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***Abstract:*** In our study, we focused on the conceptual understanding of the concepts and processes presented in the first lectures of an introductory course in cellular biology for biology majors. The study topic we considered was, "the structure of DNA and the functions of nucleotides". One hundred and eighteen students were asked to prepare concept maps from a list of twenty given concepts. Analysis of these maps has shown a compartmentalization into two major groups of concepts. The most frequent concepts were from the genetic aspect, while frequencies of concepts from the energetic aspect were comparatively low. Many students did not recognize that molecules like ATP or GTP are simply nucleotides. Other interesting misconceptions concerned the concepts of nucleic acids, purines and pyrimidines. One of the advantages of using the concept map technique was that it encouraged the instructor to start using maps as a graphic instructional tool, summarizing his lectures. In addition, the need to select twenty concepts and arrange them in a map forced him to go over his lectures and reconsider whether or not these concepts should have been selected for instruction.
***Key words:*** conceptions, concept map, undergraduate, genetic material, energy balance, cell biology,

**INTRODUCTION**

This paper describes a case study that aims to explore students' understanding of concepts and processes in an introductory cell biology course, at the Life Sciences Department, Tel-Aviv University. We started this study due to two main reasons.

One reason was students' statements, such as: "…This course [introductory cell biology], sometimes feels like a shower of new concepts threatening to drown me out. It seems that I have a thousand new words in my head and I can't draw the whole picture", or "There are many different words alike: amino acid, nucleic acid, nucleotides, nucleosides… and I can't arrange them in my mind…" Since all of the course lectures were videotaped, we carefully observed the first six lectures of the course. What was immediately apparent from the videotapes was the large number of concepts (sometimes over 50) that the instructor mentioned in each lesson. Moreover, most of these concepts are on the molecular level, and to many students, who did not study either advanced biology (40% of freshmen) or chemistry (56% of freshmen) in high school, these concepts are completely new.

The second reason for this study was the course instructor's wish to explore students' understanding of concepts and processes, since in previous years students tended to describe this course as challenging and interesting, but very difficult in terms of subject matter. This instructor later became an active partner (third author) in our research. It is also worth mentioning that the "cell biology" course is one of the corner stones for life sciences majors in their first year of their undergraduate studies.

We believe that students' experience in the first year of their studies is a very important element in their decision to stay or leave their field of study. Tobias (1990) claims that introductory science courses are responsible for driving away many students who started off majoring in sciences programs. One of the negative features of these courses, Tobias mentioned, is that they do not pay enough attention to students' conceptual understanding. Trowbridge and Wandersee (1996) stressed that in introductory science courses it is especially important for instructors to be aware of students' understanding, since these courses bring into play "large conceptual frameworks" (Trowbridge & Wandersee, 1996, p.54).

Thus we decided to focus on the first lectures of the introductory cell biology course and to try to reveal students' conceptual understanding. The subject we focused on was, "the structure of DNA and the functions of nucleotides." We chose this subject, since understanding the molecular structure of DNA is an important goal in teaching biology, especially in our era (Wilcoxson, et al., 1999), which includes the human genome project and gene therapy. However, molecular biology, with its heavy emphasis on minute details and abstract concepts, is considered to be an intellectual challenge that many sophomores are not developmentally ready to engage (Malacinski & Zell, 1996).

In the last two decades there has been much interest in investigating students' conceptions concerning DNA (Bahar, et al., 1999; Garton, 1992; Hallden, 1988; Johnstone & Mahmoud, 1980; Marbach-Ad, 2001). Most of these studies focused on students' understanding of the functions of DNA as the genetic material (Bahar et al., 1999; Fisher, 1983; Kindfield, 1994; Lewis, 1996; Malacinski & Zell, 1996; Marbach-Ad, 2001; McInerney, 1996), and more specifically understanding the concepts of DNA, RNA, gene, chromosome (Lewis & Wood-Robinson, 2000), and protein, and the processes of DNA replication, transcription and translation. Studies of various age groups, ranging from high school students (15-17 years) to university professors of genetics examined their understanding of basic molecular biology processes (Hildebrand, 1986 and 1991; Kindfield 1992). The research compared novices and experts concerning their conceptions and ways of dealing with genetic problem solving. Kindfield states that "some of the most crucial processes are consistently cited as the most difficult components of biology to learn." Similarly, Fisher (1983) reported that college students in an upper-division introductory genetics course for science majors had difficulty identifying the products of translation given the following multiple choice options: a) amino acids, b) transfer RNA, c) activating enzymes and d) messenger RNA. Many (45%) failed to identify the correct molecules as "c) activating enzymes".

In contrast to the rich literature about the functions of DNA, students' conceptions concerning the functions and the structure of the nucleotides (DNA's building blocks) have been rather neglected, even though they take a central part in cellular processes. The nucleotides are involved in both the genetic aspect of the living cell, as well as in its energetic aspect (e.g., ATP, GTP) - playing a major role in regulating cell reactions.

The desire to explore students' understanding of a certain subject or concept is shared by psychologists (e.g., David Ausubel), science educators (e.g., Joseph Novak) and philosophers (e.g., Bob Gowin). Novak and Gowin developed the concept map technique as a way of capturing participants' understanding of the portal concept (Novak & Gowin, 1984). Concept mapping is a technique for externalizing concepts and propositions that express the relationships between concepts. This method was originally used as a way of "determining how changes in conceptual understanding were occurring in the students" (Novak, 1990, p. 937).

Maps have a long and noble intellectual history. Concept maps were originally intended as graphic organizers to be constructed by the specialist - not by the learner -and they consisted of boxed concepts connected by unlabeled lines, so the exact nature of the relationship between them remained unspecified for the learner (Trowbridge & Wandersee, 1998).

There is a great variety of graphic organizers, including flowchart, roundhouse diagram, and vee diagram used in teaching today (Trowbridge & Wandersee, 1998), as a diagnostic tool, as an instructional tool and for assessment and evaluation. Recently, Bahar et al. (1999, p.134), for example, used a word-association test to map the cognitive structure of areas of elementary genetics in first-year biology students. The underlying assumption in a word-association test is that the order of the response and retrieval from long-term memory reflects at least a significant part of the structure within and between concepts (Shavelson, 1972). The results of Bahar et al.'s study showed that the students generated many ideas related to ten key words, but they did not see the overall picture as a network of related ideas.

In our study we decided to use the concept map technique, but not in the classic way characterized by Novak and Gowin (1984). Thus, students were not initially trained to draw maps due to the time limitations imposed by the course. Instead, we explained the basic principles of concept maps, showed examples of concept maps in various topics (Novak & Gowin, 1984), stressed the importance of drawing as many lines as possible between the twenty concepts with which the participants were presented, and of writing a proposition for each line.

## METHODS

### *Course description*

The introductory cell biology course for freshmen at Tel-Aviv University is a four-credit, one semester class (28 lectures - two hours, twice a week). Three instructors from the department of cell research and immunology teach the course in rotation, each of them specializing in specific topics. The instructors cooperate and build the curriculum as a successive unit. The course rationale is to teach the central cellular processes from both a functional and a structural viewpoint, emphasizing basic cellular mechanisms, while paying relatively less attention to cell morphology. The six first lectures serve as an introductory chapter to the course, providing a systematic overview of the macromolecules (carbohydrates, phospholipids, nucleic acids, and proteins) that build the cell and are involved in the life cycle processes. The instructor emphasizes similarities in macromolecular structures by presenting each one of them, except phospholipids, as a polymer chain, consisting of monomer building blocks.

After these first six lectures, when the students are aware of the basic components of the cell, the next chapter (six lectures) begins with processes that take place in the nucleus (e.g., DNA replication, transcription, chromatin division). Another chapter (six lectures) deals with specific topics such as protein transport, the cytoskeleton and the process of endocytosis. The next three lectures deal with specific organelles, such as endoplasmic reticulum, lysosome and mitochondrion. The final three lectures are dedicated to generic aspects, such as differentiation, cancer, viruses and cell cycle regulation.

The recommended textbooks are: *Molecular Biology of the Cell* (Alberts, et al., 2002) and *Essential Cell Biology* (Alberts, et al., 1998). It is suggested that students read 2-3 pages from the textbooks for each lecture. The reading is optional, and the specific subjects that are covered in the reading task are not discussed in class, but account for 10% of the final exam score. Since the lectures are in Hebrew and the textbooks are in English, students learn primarily from their lecture notes, instructors' videotapes, and Power Point presentations. The Power Point presentations used by the instructors in class present artwork from the textbook, in order, to increase students' familiarity with the textbooks and, to bridge between the Hebrew lectures and the English textbooks. Thus, the graphics are presented in English, while the lectures are in Hebrew. The instructors' Power Point presentations are made available to students.

Eleven discussion sessions accompany the lectures and are conducted by teaching assistants (TA). They are designed to allow students to practice and expand their knowledge. Though sessions are optional, most students attend them.

***Overview of the present study***

The study was conducted in the spring of 2002. Over four hundred biology majors (463) were enrolled in this class and were arbitrarily divided into two classes of approximately 230 students each. These classes were taught in a traditional lecture format. The two class sessions that this study focused on were dedicated to DNA and RNA as polymers, as well as to their corresponding monomers, the nucleotides. The instructor emphasized the structure of nucleotides and their dual role as mediators of genetic information while also constituting the "currency" of energy in the cell.

During the following discussion session, a group of students (approximately 150), which were selected arbitrarily, were asked to prepare concept maps referring to twenty concepts: DNA, RNA, nucleic acids, nucleotides, ATP, dATP, ADP, GTP, ribose, deoxy ribose, sugar, phosphate, nitrogen bases, purines, pyrimidines, protein, amino acids, energy balance, monomer, and polymer.

We introduced the main features and principles of concept mapping. In addition, we exposed the students to two concept maps, taken from Novak and Gowin's classic book "*Learning How to Learn*" (1984, p.18). These two concept maps included the same concepts but constituted different structures. By introducing these maps we intended to convey that from the same concepts a number of different maps could be constructed, all of them correct as long as they represented the correct relationships among concepts. In addition, we asked the students to try drawing as many lines as they could between the twenty given concepts, and to make sure they wrote a proposition for each line.

***Concept-map analysis***

One hundred and eighteen concept maps were collected and analyzed both qualitatively and quantitatively. First, we examined the frequency of each of the twenty concepts in the concept maps. Then we analyzed all the propositions regarding each concept. This research did not consider whether the propositions were correct or incorrect; our main purpose was to find out if there were propositions that were shared by many students, thus reflecting alternative conceptions.

In order to analyze and characterize students' propositions, we condensed all propositions concerning each concept, or group of concepts, in separate tables. Identical or similar propositions were combined, yielding subcategories. Then, subcategories with similar ideas were combined to form major categories of "conceptions." Finally, we were able to characterize a few major categories for each concept and the frequency for each category was calculated in order to trace common conceptions.

Two other aspects examined were the structure and the scientific accuracy of the concept maps. In order to evaluate propositions, we referred to two sources: definitions from the scientific literature (Alberts, et al., 2002 & Suzuki, et al., 1999), and a map, which was constructed by Prof. Gershoni (one of the course instructors) and his TA (Figure 1).

In order to validate the categorization of the propositions, a sample of the students' maps was given to a researcher in science education, who was not connected to this study, and to a high school biology teacher. Each analysed and defined categories of propositions independently, and their categories were similar to ours.

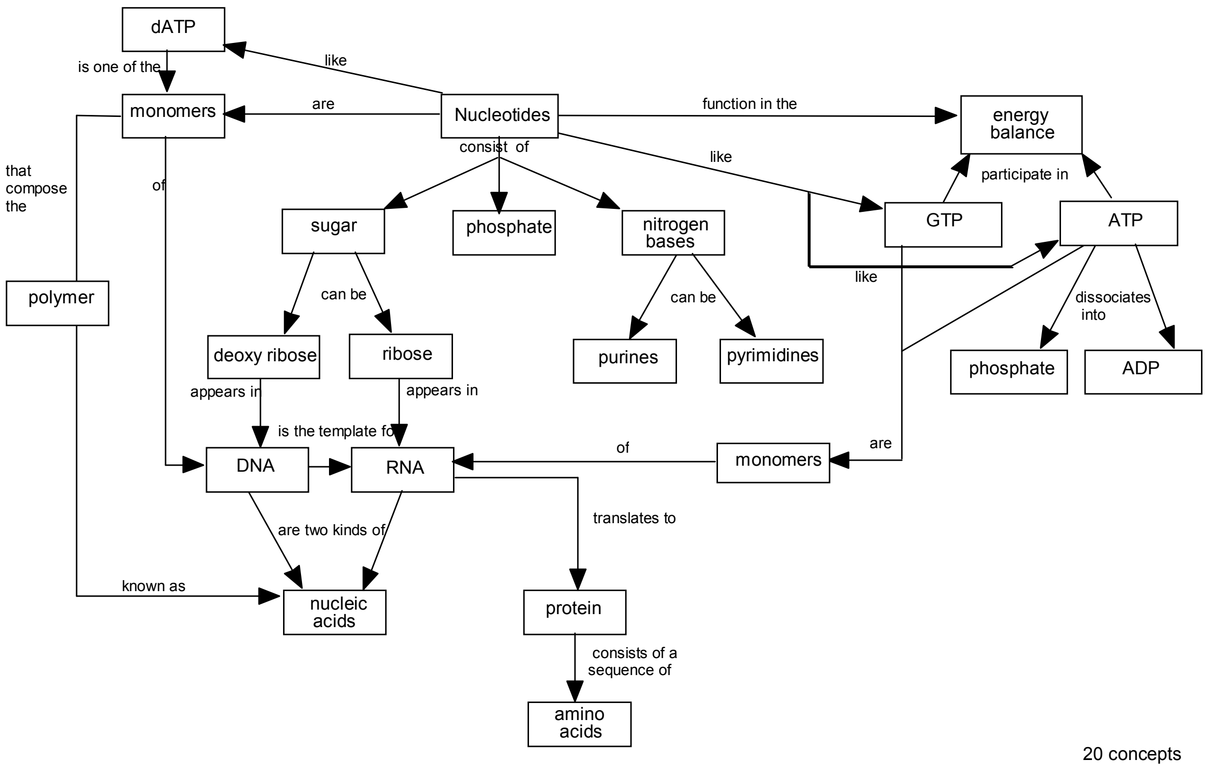


***Figure 1***. *The map that the course instructor and his TA constructed from the twenty concepts*

**RESULTS**

*Concepts and propositions in the concept maps*

While analyzing students' concept maps, we first examined frequencies of each concept in students' maps and distinguished between valid and false propositions, concerning each concept (Table 1).

In Table 1 the concepts were arranged in descending order, based on their frequencies. Inspection of this table shows a compartmentalization into two groups of concepts. The most frequent concepts were: DNA (98%), nucleotides (94%), RNA (92%) and protein (92%). These concepts are key concepts, from the **genetic aspect**, and the relations among them are known as the "central dogma" (Crick, 1966). The frequencies of the concepts that are central from the **energetic aspect** of the nucleotides: ATP, ADP, GTP and energy balance, on the other hand, were comparatively low in frequency (78%, 72%, 63% and 63% respectively), with the concepts ATP and ADP being more common than the concepts GTP and energy balance. Another noteworthy finding was that dATP, a monomer specific to DNA, was the concept with the lowest frequency (39%) in the students' maps.

Table 1 also summarizes the distribution of students' propositions for each concept. We distinguished among students who had only valid propositions, only false propositions, or a combination of valid and false propositions concerning each concept. Inspection of the data shows, that although high frequency of a concept may indicate that the students are familiar with this concept, it does not guarantee that a given student appropriately understands the meaning of this concept and its relationships to other concepts. For example, the concepts of DNA and RNA, which were mentioned by over 90% of the students, appeared with valid connections only in about half of the maps (DNA- 51%, RNA- 57%).

***Students' conceptions as reflected in maps***

We focused on conceptions that were shared by a considerable number of students, i.e., more than 10% of them. One of the most interesting findings concerned the **nucleotides.** The most common proposition in the category of **nucleotide functions** was "Nucleotides are the building blocks of DNA and RNA" (82% of the students referred to this function), while only about a third of the students (28%) referred to the function "Nucleotides participate in the regulation of the energy balance". It is important to emphasize that these two propositions together represent the two major functions of nucleotides taught in lectures; the so-called genetic and energetic functions (the role of nucleotides as co-factors, such as NADH) are taught in subsequent lectures. Surprisingly, only 18% of the students mentioned **both** functions.

***Table 1***. *Percentage of students mentioning concepts and the percentage distribution of propositions of those mentioning the concepts.*

| The concept | Percentage of students mentioning concept* | Propositions (relationships between concepts) | | |
|---|---|---|---|---|
| | | All valid | Some valid and some false | All false |
| DNA | 98 | 51 | 46 | 3 |
| Nucleotides | 94 | 45 | 43 | 12 |
| RNA | 92 | 57 | 40 | 3 |
| Protein | 92 | 82 | 13 | 5 |
| Amino acids | 86 | 60 | 27 | 13 |
| Polymer | 85 | 86 | 12 | 2 |
| Monomer | 82 | 76 | 21 | 3 |
| Phosphate | 82 | 71 | 13 | 16 |
| Purines | 81 | 45 | 7 | 48 |
| Pyrimidines | 81 | 45 | 7 | 48 |
| Sugar | 80 | 75 | 17 | 8 |
| ATP | 78 | 63 | 33 | 4 |
| Deoxy ribose | 78 | 77 | 9 | 14 |
| Nitrogen bases | 76 | 72 | 6 | 22 |
| Ribose | 75 | 81 | 10 | 9 |
| Nucleic acids | 73 | 42 | 21 | 37 |
| ADP | 72 | 77 | 16 | 7 |
| Energy balance | 63 | 67 | 29 | 4 |
| GTP | 63 | 62 | 22 | 16 |
| dATP | 39 | 28 | 11 | 61 |

* The total number of students who constructed concept maps = 118

Another group of interesting propositions related to the **energetic aspect**. We discovered that less than half of the students (42%) connected both ATP, ADP and GTP with “energy balance”, and 24% connected **only** the ATP with “energy balance”, i.e., they did not mark any connection between GTP or ADP and “energy balance”. A false proposition made by a considerable percentage of students (12%) was that “dATP participates in the regulation of the energy balance.” It seems that some students over-generalized and extrapolated from ATP’s function to dATP.

Other interesting misconceptions were regarding **DNA structure**. For example, concerning the concept **nucleic acids,** 14% of the students incorrectly wrote, “Nucleic acids are a type of nucleotides.” On the same issue, it was interesting to see that while 12% of the students mentioned the valid proposition, ”Nucleic acids are polymers,” 15% exposed a misconception by writing “Nucleic acids are monomers,”

Regarding the concepts of **purines** and **pyrimidines**, we learned that while 23% of the students mentioned that “Purines and pyrimidines are kinds of nitrogen bases” (valid), almost twice as many (38%) mentioned that “Purines and pyrimidines are types of nucleotides” (misconception).

***Structure and scientific accuracy of the concept maps***

In analyzing each concept map, we discovered that, even though the students were not trained to build classic concepts maps, three major types of maps were found:

1. **Branched** concept maps, which included many cross-links (e.g., Figures 2 and 3).
2. **Fragmented** concept maps, which were divided into separate fragments, or more precisely, into discrete sub-maps (e.g., Figure 4).
3. **Linear** concept maps (like flow charts), based on single connections between concepts (e.g., Figure 5).

Table 2 summarizes the frequencies of students’ maps in terms of their structure and their scientific accuracy. Most of the students’ concept maps were branched (83%), a considerable percentage of maps were fragmented (14%), and only some maps were linear (3%). Interestingly, half of the fragmented maps (50% of the original 14%) reflected a compartmentalization between the genetic and the energetic aspects of the nucleotides’ functions.

It is worth mentioning that even though 83% of the maps included most of the concepts and were branched, inspection of the propositions indicates that most of them (80%) were only partially correct (e.g., Figure 2). Moreover, only 17% of the maps were considered absolutely correct (e.g., Figure 3).

***Table** 2. Distribution of concept maps by structure and scientific accuracy*

| Category | Types | Percentage |
|---|---|---|
| Structure | Branched maps | 83 |
| | Fragmented maps | 14 |
| | Linear maps | 3 |
| Scientific accuracy | Absolutely correct | 17 |
| | Partially correct | 80 |
| | Absolutely incorrect | 3 |

*The total number of students who constructed concept maps=118

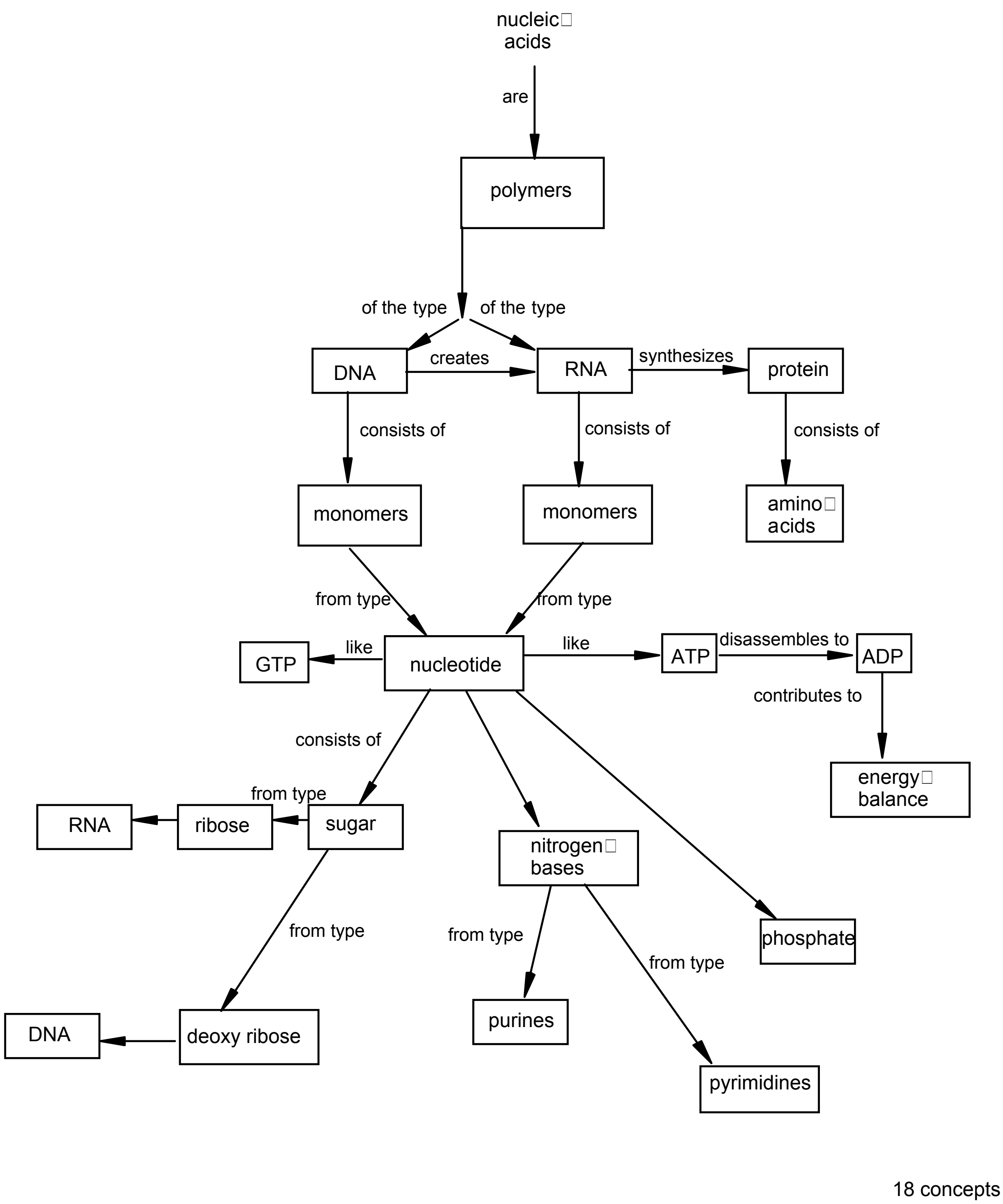


***Figure 2**. A branched concept map with only some of the propositions covered.*

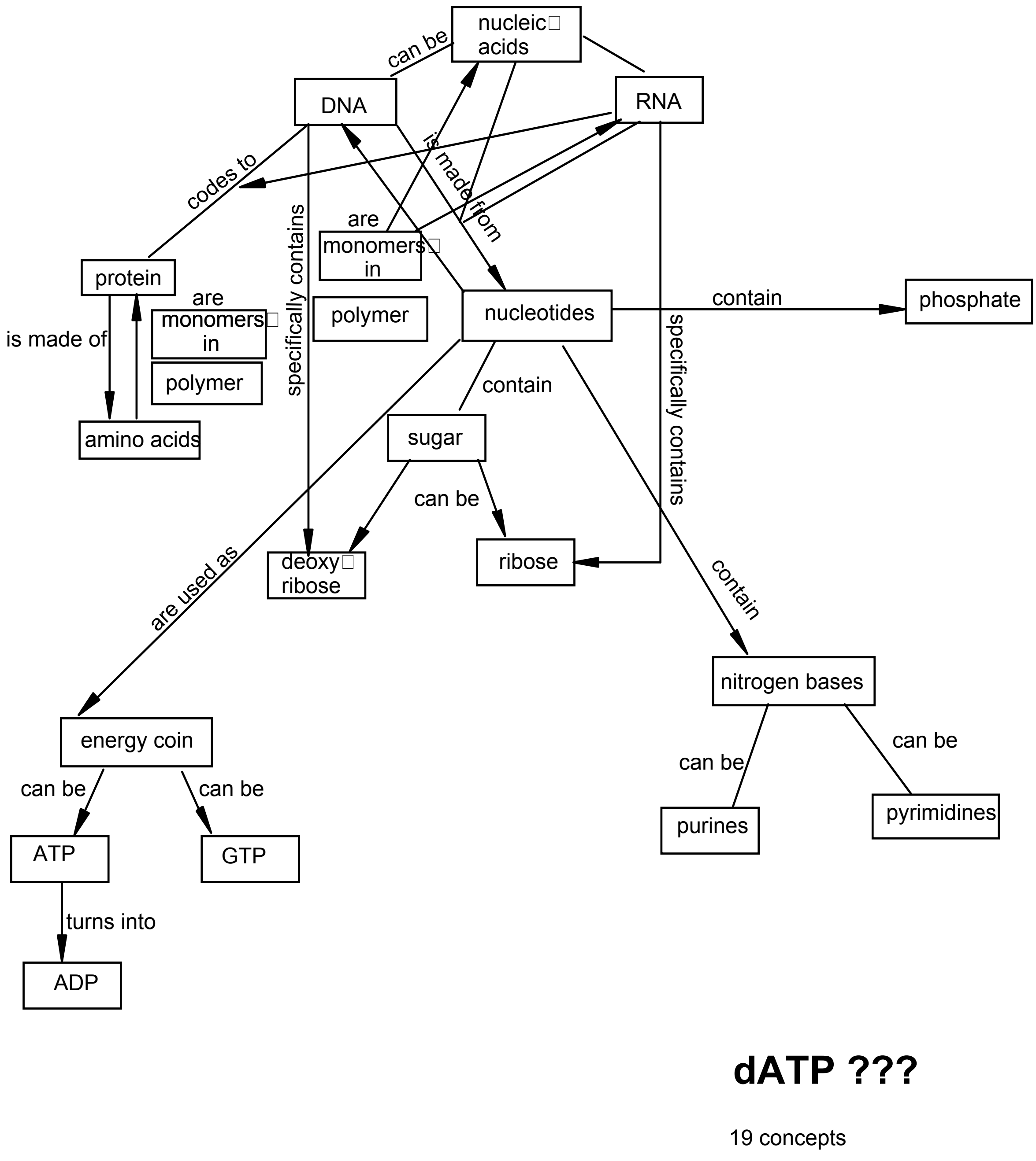


***Figure 3***. *A branched concept map with all propositions correct Note: This concept map, in which all the propositions are correct, is unique*

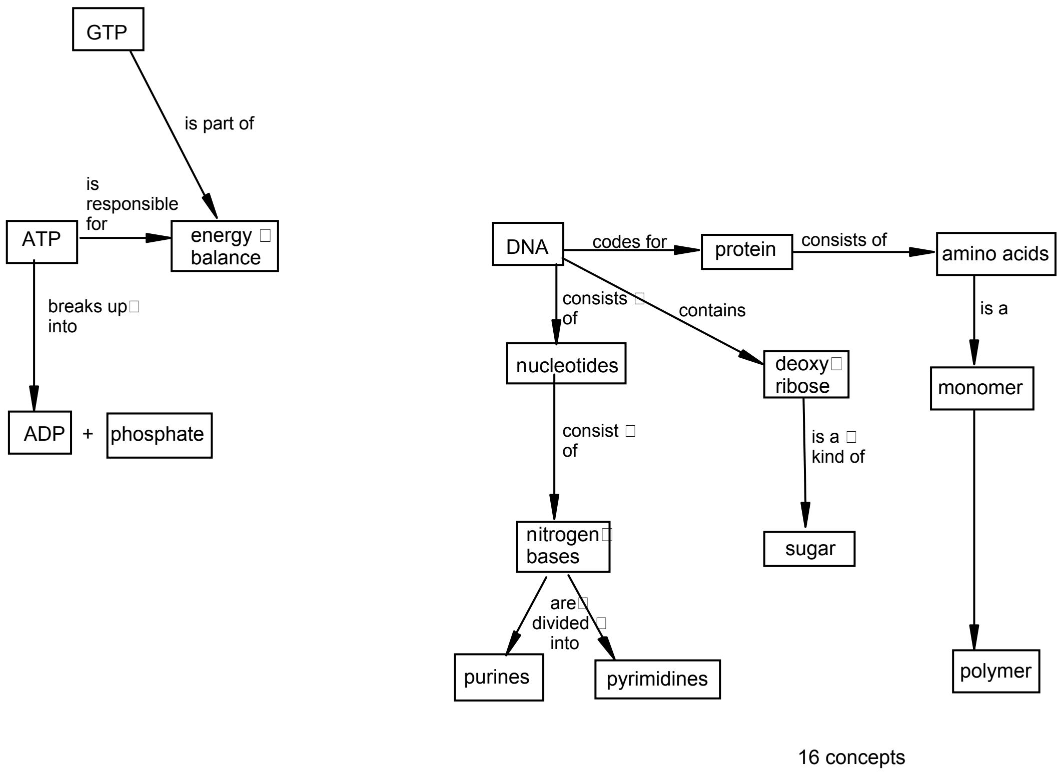


***Figure 4**. A fragmented concept map. Note: This concept map represents a common compartmentalization that students made between the genetic and the energetic aspects.*

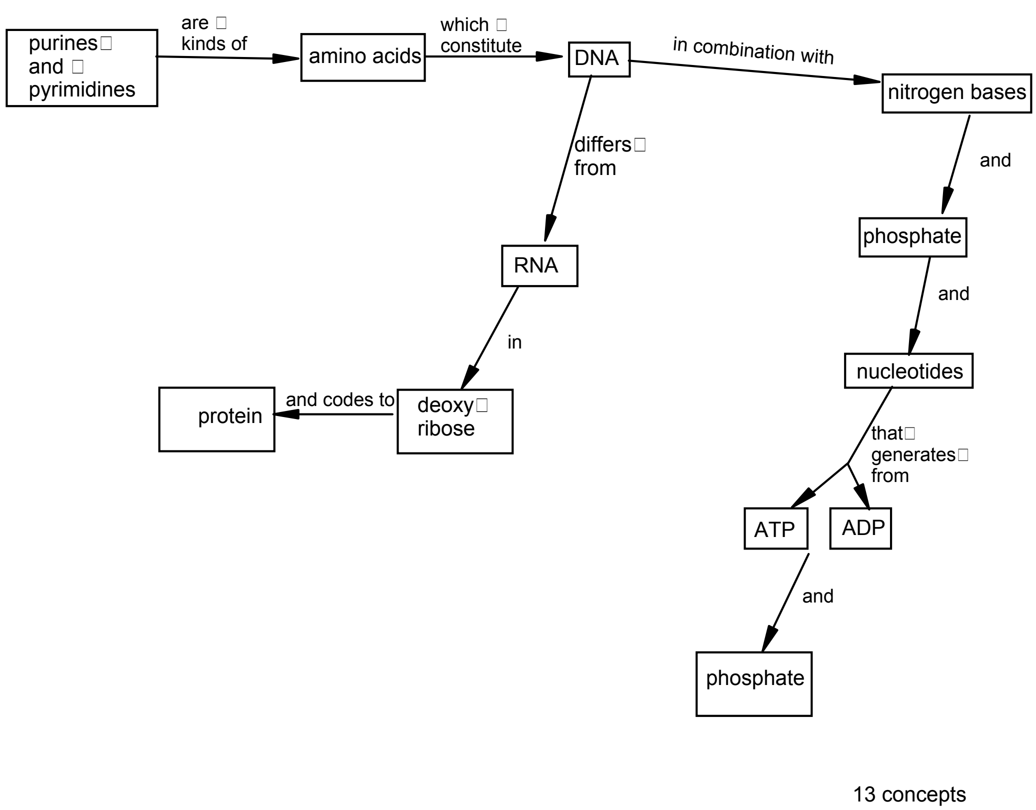


***Figure 5**. A linear concept map with almost all propositions incorrect*

## DISCUSSION

The aim of this study was to explore freshmen's conceptions in an introductory cell biology course, using concept map technique as a course embedded assessment tool. One of our most interesting findings in this study was students' compartmentalization between the genetic and the energetic aspects of the living cell, despite the instructor's effort to connect between them in-class. This lack of compartmentalization was especially marked in regard to the functions of nucleotides, and was observed in students' propositions as well as in the structure of a considerable number of students' maps. It seems that many students are more familiar with the genetic function of nucleotides than with the energetic one. In addition, many students did not recognize that molecules like ATP or GTP are simply nucleotides. For example, one of the students in the course said, "I learned that one of the nucleotides in the DNA is 'adenosine triphosphate' [a misconception], and I learned that ATP is an energy carrier, but it never occurred to me that it is the same molecule!"

Concerning the energetic aspect, we also discovered that students were more familiar with the concepts ATP and ADP than with the concepts GTP and "energy balance." This might be due to the fact that in high school, teachers extensively mention the ATP molecule as the energy storage compound within cells, while they tend to ignore the other nucleotides involved in energy transformation: UTP, GTP, TTP, and CTP (Storey, 1992). In addition, dATP was the most infrequent concept in students' maps, and when it was mentioned, students usually tended to believe that dATP participates in regulation of the energy balance (a misconception). In his lectures, the instructor emphasized that even though one might think that a "small letter" like "d" does not make much difference, there are major structural and functional differences between ATP and dATP.

Other interesting misconceptions concerned the concept of nucleic acids ("Nucleic acids are a type of nucleotides") and concerned the concepts of purines and pyrimidines ("Purines and pyrimidines are nucleotides").

It is worth mentioning that students' misunderstandings also manifested themselves in the analyses of the scientific accuracy of the maps. Even though most of the maps were branched and incorporated cross-links, they often included a large number of false propositions.

We believe that the major reasons for these errors are the burden of new, abstract, and complex concepts and the partial overlapping between definitions of concepts. Marbach-Ad (2001) pointed out that there is a tendency for confusion among concepts with partially overlapping definitions and among concepts that have similar names. Thus, concepts like nucleotides and nucleic acids may be remembered as synonyms. Concerning the cognitive burden of concepts, Johnstone and El-Banna (1988) claimed that, on the one hand, we have a limited ability to store and process information, and on the other hand, we are required to deal with an outsized amount of new information, in order to learn several subjects and solve problems simultaneously.

In light of these findings, we would like to offer some suggestions. First, we recommend paying attention to the hierarchical structure of the topic. For example, the hierarchy among the concepts of nucleic acids, nucleotides, purines and pyrimidines should be stressed. Second, it is vital to stress the dual role of the nucleotides in the cell as monomers of the genetic material as well as their important role in regulation of the energy balance. Finally, we suggest using concepts, such as DNA, RNA and protein, which students are more familiar with, as a platform that can subsequently be extended by branching out to other less familiar concepts like nucleic acids and nucleotides. We might suggest using visual aid, like concept maps, in order to clarify the hierarchical position of each concept and its inter-relations with other concepts.

## SUMMARY

We believe that using the concept map as a tool for externalizing students' conceptions was very efficient. It did not take much time for the students to construct their concepts maps, and this enabled the instructor to gain an impression of students' understanding from his lectures. As a consequence, the instructor dealt with these issues during the course sessions. The instructor summarized the advantages of the use of concepts map in his classes on three different levels:

a) Students' concept maps may pinpoint the misunderstandings that would have been difficult to discover through multiple-choice exams. Most of these students' misunderstandings had not been experienced by the instructor in previous classes.
b) The request to select 20 concepts and arrange them in a map forced the instructor to go over his lectures and reexamine the necessity of each concept. "…I invest a lot of time in planning my lectures and I was pretty confident of my way of teaching. Talking with you [the second author] and especially having to arrange all the concepts in a map, forced me to reconsider which concepts are really important to the students. It added another dimension that I did not think of before…"
c) Exposure to the concept map technique encouraged the instructor to also start using maps as a graphic, instructional tool for summarizing his lectures, and to relate between new concepts and concepts he mentioned in the last session. "As a consequence of the exposure

to the map technique, I started to build maps and added them to my Power Point presentations as an instruction tool for summarizing specific topics."

d) Next year, as the next step of this study**,** we plan to assimilate the concept map both as an instruction tool, as well as an assessment tool in the final exam.

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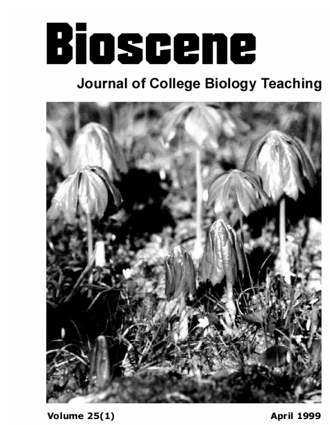


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# Dyes, Fibers, and Paper: A Botany Lab Exercise For Non-Biology Majors

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***Abstract***: This laboratory exercise affords students a hands-on experience learning about traditional dyes, fiber strength, and paper making. It is economical, simple to prepare, provides satisfactory results, and is student friendly. Dyes were extracted from plant leaves, stems, roots, and fruits. Hard-boiled eggs were place in the dyes for 15 minutes to determine what color each dye would produce. Colors of the eggs differed from the colors of the dye solutions. Fibers were procured from different materials (cotton, jute, hemp, etc.). Filaments were removed from the twine and a stress test was used to determine the strength:weight for each fiber type. Twine from each fiber type was used to make rope using the rope maker from the Boy Scout's Pioneering merit badge pamphlet (1993). Paper was made from recycled fibers suspended in water. A homemade deckle was used to collect and press the fibers to make a sheet of paper. Students found the exercise interesting and stimulating.

***Keywords***: Dyes, fibers, non-majors, papermaking, rope making, textiles

## INTRODUCTION

Most colleges and universities require non-science students to take a science class to fulfill graduation requirements. Often these students take a science class that is specifically designed for non-science majors. This laboratory exercise was designed as part of a plant biology course for this type of student. The course covers the major plant groups, plant structures and functions, and human uses of plants. The theme of the lab exercise is the investigation of how textiles and paper can be made and processed. The exercise is separated into three sections. The first section describes the production of plant dyes and the dying procedure; the second section describes how to make rope and test the strength of the utilized twine; and the third section describes how to make paper. To perform all three activities requires approximately two hours.

All materials for this exercise can be purchased in local hardware stores and supermarkets. Instructors do not need a detailed knowledge-base for each topic to ensure a quality exercise for the students. A rope maker can be purchased or constructed with a table saw (Boy Scouts, 1993). Materials and equipment for the exercise are relatively inexpensive and many are reusable.

## METHODS AND MATERIALS

### Dyes

Fresh or preserved plant materials, including roots, stems, leaves, fruits, and flowers, can be boiled in water to produce a variety of natural dyes. These dyes can then be used to color hardboiled eggs, skeins of wool, or pieces of cloth. Dying cloth is a more complicated and time-consuming procedure; therefore, eggs were used in this lab to simplify and expedite the dying process. Required materials for the egg dying procedure include the following: a hotplate or stove, oven mitts, slotted spoons, sauce pans, eggs, egg stands, crayons, paper towels, dye plants (see Table 1), a food strainer, knife, and cheesecloth.

*Table 1. The following easily obtainable plant sources may be used to make plant-based dyes for staining eggs or cloth.*

| COLOR | DYE MATERIALS USED |
|---|---|
| Blue | Canned blueberries or red cabbage leaves |
| Brown | One cup hot water plus 1 tablespoon instant coffee and 1/2 teaspoon vinegar |
| Green | Liquid chlorophyll (purchased at a pet store or drug store.), spinach leaves, or yellow delicious apple peels |
| Lavender | Grape juice or violet blue dye (see below) plus 2 teaspoons lemon juice |
| Orange | Yellow onion skins |
| Pink | Cranberries or beet root |
| Red-brown | Red onion skins |
| Violet blue | Violet flowers |
| Yellow | Orange or lemon peels, carrot tops, celery seed, or one cup hot water plus 1 1/2 teaspoons turmeric or ground cumin and 1/2 teaspoon vinegar |

To extract the colors from the plant material, chop or mash the plant tissue into small pieces and place into a 1000 ml beaker and loosely pack the material. Add enough water to bring the beaker contents up to 750 mls. Boil the dye plants until the water turns the desired color, allow the dye to cool, and then filter the dye through a piece of cheesecloth placed in a food strainer to remove any plant pieces. For light dyes, only 15-30 minutes of boiling is required; for darker dyes 1-2 hours may be necessary. Plants can also be allowed to steep overnight. The less water used to extract the dye from the plant dye source, the darker the resulting dye (Casselman, 1980; Kramer, 1972; Thomas, 1980). Dyes can be made ahead of time and stored in the refrigerator or freezer. Place eggs in dye for approximately 10 minutes depending on the shade desired.

Hard boil eggs and allow them to cool. Hardboiled eggs are used to avoid messy breakage of raw eggs. Eggs can be decorated with white or colored wax crayons before dying or between dyes if eggs are placed in more than one color. The dye will not stain the area colored with the crayon. Place an egg gently into a container of room temperature plant dye (use a large slotted spoon to lower the egg into the dye). Let the egg sit in the dye for at least 15 minutes. When the egg is ready, use a slotted spoon to remove it from the dye, blot it dry with a paper towel, and place it in a stand to finish drying. The caps from plastic soda bottles can be used as individual egg stands. Alternately, the egg may be placed in a second dye before drying. It is best to first dye the egg with a light dye, then with a darker dye. The longer the egg (or piece of cloth) is left in the dye, the darker the color produced. Eggs or cloth may also be boiled in the dye for 1-2 hours in order to produce a darker color. Since the eggs may have been sitting out for a period of time before the dying process is complete, ***do not eat the eggs***.

**Fibers**

Required materials for rope making and the string stress test include the following materials: a rope maker or materials for constructing one (plywood, medium gauge metal rods, band saw), balls of string made from assorted fibers (cotton, jute, hemp, etc.), scissors, a balance, a meter stick, 2 ring stands with a crossbar, a weight hook (to hang from the string and put weights on), 1 kg weights, newspaper (to cushion the weights that fall), and a C-clamp (to hold down the rope maker to a tabletop).

Follow directions as per the *Pioneering* merit badge pamphlet to assemble a rope making device (Boy Scout Merit Badge Pamphlet Series, 1993). Merit badge pamphlets are available for $US 3.15 from www.scouting.org. Three pieces of string are tied to the rope maker and the handle is turned, causing the string to twist together to make a rope. At least three people are needed to make rope using the device, and getting the proper tension on the string requires a little practice.

To test the strength of the fibers used to make the rope above, first cut a 3 foot (1 m) piece of string. Use a balance to weigh the string in grams. Tie one end of the string to the middle of a crossbar clamped across the tops of two ring stands and one end to a weight hook. Place padding below the weight hook to cushion the weights that fall when the string breaks. Slowly add weights to the weight hook, increasing the weight by 1 kg increments. After the string breaks determine how much weight the string held before it broke. Record the string length, string weight, and total weight the string held. Divide the weight of the string by the weight supported by the string to determine the strength weight ratio and compare the ratios for different types of fibers.

**Paper Making**

Required supplies for paper making include the following: shredded colored paper cut or torn into 2 inch pieces and soaked overnight in a dishpan of water, a blender, a pitcher, glitter, bits of paper, plant material to add to the paper slurry, a big plastic tub, a deckle (2 picture frames, window screen, staples and staple gun or a hammer and tacks), a sponge or wooden block, towels, dishpan, a piece of plywood, bricks, and white paper.

Fill a dishpan half full with warm water. Add pieces of cut or torn paper. You can use newspaper, construction paper, recycled office paper, or very small pieces of material. Allow the paper to soak at least 1 hour. Soaked paper can be frozen for later use. Fill a blender half full with water. Add one or two handfuls of soaked paper. Blend on high for several minutes to form a smooth mixture. If necessary, add more water. Place the deckle horizontally in a plastic tub with at least three inches of water. The deckle can be made from two 8 × 10 wooden picture frames. Remove the glass and back from each frame and staple or tack fine window screen to the back of one frame, covering the frame opening. Hold the frame with the screen face down in the water with the back of the other frame held tightly against the screen side. Add the paper mixture to the deckle. The sides of the picture frame will keep the mixture over the screen. Hold the deckle so it is partially submerged in the water and shake it gently to disperse the paper mixture evenly over the screen. To make paper more decorative and personalized add leaves, petals, glitter, etc. to the paper mixture and swirl to mix. Slowly lift the deckle from the water. Hold the deckle at a slight angle to allow the excess water to drain. Use a small wooden block or sponge to press some of the water out of the newly formed piece of paper. Remove the top frame from the deckle and flip the bottom frame with the paper onto a piece of white paper on a towel. Remove the frame from the wet paper and place another piece of white paper and towel on top of the paper. Blot the paper to remove as much excess water as possible. Remove the towels and transfer the wet paper to a thick stack of newspapers. Layer the newly made paper and newspapers, then place a large piece of plywood on the stack and a brick or heavy weight on top to squeeze out excess moisture. Remove the newspaper after 24 hours and allow the pieces of paper to dry fully. The paper will be fairly thick, but can be used to make a cover for a notebook, a box, or as backing for thinner paper (Dawson, 1992; Grummer, 1990, Ramsay, 1999). Since the new paper is thick, it may warp as it dries; a steam iron can be used to smooth the paper.

**DISCUSSION**

We found this lab to be very successful. The lab proceeded smoothly if students were divided into the following three activity groups: dyes, fibers, and paper. Students completed one activity and then rotated to the next activity until all three were complete (see proposed lab handout).

There is a minimal investment in supplies and materials for developing this lab exercise, and many of the materials can be reused. The deckle and rope maker can be used for many years, and unused soaked paper can be frozen. The dyes can be stored in the refrigerator or freezer for long periods of time.

To help students summarize their dye experiment a chart can be made comparing the dye plant used with the color of the resulting dye and the color of the egg after it was placed in the dye. Some students may wish to use one dye color and leave their eggs in for varying amounts of time and compare the results.

When students make their rope have them indicate the fibers they used, then test the strength of the fibers and answer the following questions. What was the length of the string used? What was the weight of the string? How much weight did the string hold? What was the length:weight supported ratio? What was the weight of the string:weight supported ratio? What can the ratios above tell us about the strength of the string? When would it be better to use a synthetic rope? A natural rope? From what plant sources do different fibers such as hemp, jute, and manila come? Where do synthetic fibers come from? Do manufacturers ever mix natural and synthetic fibers?

After students make their paper ask them if they used any add-in materials to decorate the paper and what effect it had on their finished paper. What color(s) of pulp did they use? Did the colors of the pulp blend in to form one new color or does each color stand out? What is the overall consistency of their paper compared to notebook paper? How can this consistency be changed?

Students enjoyed performing this laboratory and learning about dyes, fibers, and paper. They were excited to make something (paper, colored eggs, rope) that they could take home. Art students especially appreciated papermaking. Students enjoyed decorating their paper by embedding glitter, leaves, or colored paper in their pieces of paper. This laboratory exercise could be employed in a biology or botany for non-majors course or in an ethnobotany course.

**PROPOSED LAB HANDOUT**

## WORLD OF PLANTS LAB EXERCISE: DYES, FIBERS, AND PAPER

**Exercise A. Natural Plant Dyes**
Dye one egg, set it in the tray to dry, then fill in the information sheet by the tray. Before you leave lab today, fill in the chart below with information about the types of natural plant dyes you saw in lab and the color each produced.

| Type of Dye | Color of Dye | Color of Dyed Egg |
|---|---|---|
| Coffee Seeds | | |
| Yellow Onion Skins | | |
| Blueberries | | |
| Red Onion Skins | | |
| Spinach Leaves | | |
| Beet Root Juice | | |

**Exercise B. Paper Making (Dr. Meekins)**
Use the paper pulp and add-in materials available to make a piece of paper. Leave the paper in lab to be pressed and dried. Make sure to fill in the information sheet by the paper press and label your sheet of paper.

What color(s) of pulp did you use? ________________________________________

What add-ins, if any, did you add to the pulp? _______________________________

**Exercise C. Rope Making and Testing Fiber Strength**
Make a piece of rope from the string provided. Fill in the information sheet by the rope making device to indicate the type of rope you made, then test the strength of the fibers in your rope and answer the questions below.

What fiber did you use to make your piece of rope? _______________________________________

What was the length of your string? ________________________________ meters

What was the weight of your string? ________________________________ grams

How much weight did your string hold? ___________________________kilograms


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# Using Independent Research Projects to Foster Learning in the Comparative Vertebrate Anatomy Laboratory

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***Abstract:*** This paper presents a teaching methodology involving an independent research project component for use in undergraduate Comparative Vertebrate Anatomy laboratory courses. The proposed project introduces cooperative, active learning in a research context in a Comparative Vertebrate Anatomy course. This project involves pairs or groups of three students testing a hypothesis concerning variation of an anatomical feature among vertebrates and an oral or poster presentation that reports the results. The project requires both examination of anatomical descriptions in scientific literature and direct anatomical investigation of vertebrate specimens available in the laboratory. This project component has been used successfully at two schools, where it increased student enthusiasm for the discipline, increased student interpretive skills, and better placed the course material within the context of science. Both faculty and student perceptions of the successes and difficulties of such a project are presented.

***Key words*:** Vertebrate anatomy, active learning, cooperative learning, problem-solving, inquiry, research, hypothesis testing

## INTRODUCTION

The emphasis in undergraduate science education has shifted to active learning, cooperative learning, and problem solving (National Science Foundation, 1996; National Research Council, 2000; Carin and Bass, 2001; Miller et al., 2002). Ways to integrate these learning strategies into collegiate laboratories are fairly obvious in the more explicitly experimental branches of biology. However, laboratories in disciplines such as anatomy traditionally focus on the memorization of names of structures, relationships among structures, and acquisition of dissection skills. This traditional emphasis makes ways to involve student inquiry less intuitively obvious.

Courses in comparative vertebrate anatomy are often difficult to teach because the material requires that students learn complex terminology that is used in a variety of contexts (e.g., phylogenetic, functional, developmental). These contextual perspectives are critical if students are to understand vertebrate anatomy as a science and not simply a litany of names. The extensive anatomical terminology in anatomy courses, typically leads students to view comparative anatomy as a biological field that is so well known that it is “beyond” active research inquiry.

Suggestions have been proposed for increasing the problem-solving and deductive reasoning involved in human and comparative anatomy laboratories by using investigative exercises (Chang, 2000; Koprowski and Perigo, 2000), clinical case studies (Cliff and Curtin, 2000; Peplow, 1998), brainstorming (Geuna and Giacobini-Robecchi, 2002), and model building (Shigeoka et al., 2000). These strategies are useful in providing both a context for the knowledge attained in the course and developing problem-solving skills. However, in addition to helping students learn the material, we were interested in linking laboratory activities directly to the research experiences that sustain the discipline and provide students with a sense of personal ownership that has been shown to increase retention of content (Clark et al., 2000). Contrary to student perceptions, comparative vertebrate anatomy is a field of active research in which students can verify or nullify hypotheses through direct observations.

This paper presents a teaching methodology involving an independent research project component for use in undergraduate Comparative Vertebrate Anatomy laboratory courses. This project component has been used successfully at two schools, Emory and Henry College and Regis University. Faculty and student perceptions of the successes and difficulties of project are presented. Two of the authors are faculty members (M.J.G. and C.F.); whereas, the third is a student who has completed the course (D.J.L.).

## INDEPENDENT PROJECT METHODOLOGY

### Overview

Groups of two or three students test a hypothesis concerning the variation in an anatomical feature of vertebrates and give an oral or poster presentation of their results. Allowing students to work in pairs or groups provides students with a collaborative learning experience and reduces the workload of this demanding project on each student. This project is not just a literature review, but it requires both examination of anatomical descriptions in scientific literature and direct anatomical investigation of vertebrate specimens available in the laboratory.

### Selecting and Refining a Hypothesis

Early in the semester students begin their project by selecting an anatomical structure in which they have some interest. Students may choose any structure that is feasible to study within the limits of the facilities and specimens available. They should attempt to choose a structure that is not explored in significant detail in lecture or laboratory. In discussing topics with students, telling them to pay some attention to function (or at least function as inferred from anatomical structure) likely will be helpful to them in making their choice. The functional connection is especially important for structures such as muscles for which function can be clearly inferred from structure.

Once students select their structures, they propose a functional or evolutionary hypothesis to test. The hypothesis or question must be based on the students' knowledge of vertebrate relationships and anatomy, which will be somewhat limited early in the course. The instructor should help students develop concise and relevant hypotheses that can be tested with the specimens available for student examination. A proposed hypothesis could suggest that a structure will vary based solely upon function, based solely upon ancestry, or based upon some combination of the two. Hypotheses concerning development of structures usually are not reasonable given the specimens typically available. Students are encouraged to develop a more general hypothesis at the start that can be refined based upon some preliminary examination of specimens. (See Table 1.)

As in any scientific study, students need to begin by looking into what exists in the published literature. Literature review should begin early in the semester before specimens in the laboratory are available for dissection. To introduce students to the primary literature, start them with the lecture textbook and laboratory manual. If the structures being studied by the students are not covered, they should read about functionally or physically associated structures. After reading what is available in course materials, students should continue their literature search in the library. Instructors can facilitate this process by placing some relevant works on reserve. It is important to inform students that, unlike in some areas of biology that employ rapidly changing techniques, the publication date is not as serious a concern in anatomy. Gross descriptions of anatomy from the 1800s and early 1900s will likely still be useful and relevant. However, it is helpful to warn students that some older sources give different names to structures based on past naming conventions or older hypotheses of homology. We expect students will get their data concerning human anatomy from the literature since we did not have access to a cadaver lab at either of our schools, and fortunately the literature on human anatomy is extensive. Reading the scientific literature should help students refine their hypotheses. Requiring students to submit a preliminary hypothesis with an annotated bibliography early in the semester permits the instructor to make suggestions, which will be useful to the students and helps them to stay on schedule with their research.

In general, functional hypotheses will require students to do some research on the function or physiology of the organisms or structure to be studied. For example, a study exploring the hypothesis that the liver will be more complexly lobed in endothermic organisms requires that students know about and can categorize the thermal physiology of all the specimens examined. Students need to know that birds and mammals are endothermic, and that birds usually have higher metabolic rates and body temperatures than mammals. In addition, they should know that turtles, lizards, snakes, and crocodylians typically have a higher metabolic rate and maintain a higher body temperature than amphibians.

### Initial Explorations

A benefit of independent projects is that it makes it obvious to students that science is a dynamic endeavor based on data. Students need to be encouraged to examine specimens as early as reasonably possible to further refine their hypotheses and determine if they are testable based on the gross anatomical data they can reasonably collect. It is often difficult to convince students to simply begin by examining the structural aspects of their specimens. Because most biology students in our classes were more familiar with experimental biology, they were more comfortable beginning examination of all aspects of their specimens at once similar to running a series of planned experiments. We found that it was important to explain to students that the initial series of examinations is required for the same reason that molecular biologists perform trial runs, to refine the methods and ensure that the study is feasible. In an anatomical study the initial examination ensures that structures are visible, variable, and possible to examine given the methods available.

***Table 1.*** Initial student hypotheses and the refined hypotheses developed after examination of specimens and the primary literature.

| INITIAL HYPOTHESIS | REFINED HYPOTHESIS |
|---|---|
| More active vertebrates will have more extensive coronary blood vessels . | Endothermic vertebrates, which typically have more active lifestyles, will have more extensive coronary vasculature and thus rely less upon oxygen from blood in the heart lumen than ectothermic vertebrates. |
| Tetrapod vertebrates that use their forelimbs for manipulation of objects will have more complex muscles in the forelimb. | Tetrapod vertebrates that typically move their manus with greater precision will have a more complexly divided forelimb musculature and these muscles will have longer tendons connecting to insertion points on the manus. |
| The ligaments supporting the liver in vertebrates will be most similar in closely related vertebrates regardless of how the vertebrates move. | Similarity in the position, number, and extent of hepatic ligaments in vertebrates will be similar among more closely related vertebrates and will not correlate with the type of locomotion utilized by the animal. |

Students also need to determine which specimens they should examine. The best answer to the question "How many do I need to examine?" is "as many as you possibly can." However, comparison of the anatomical structures of some organisms will be more important in addressing the hypothesis and those organisms absolutely need to be examined. If the student's hypothesis concerns the correlation of a type of structure with a specific function, then the implication is that the similarity is due to function NOT due to ancestry. Therefore, finding two or more members of a closely related group that have differing functions for the same structure will be important data to use for supporting or rejecting the hypothesis. Conversely, if the student hypothesis concerns the correlation of a type of structure with ancestry, not with function, examining a range of organisms with different degrees of relatedness and different functions would be needed for supporting or rejecting the hypothesis.

**Gathering Data**

The gathering of data takes a significant amount of time. This may require students to have access to the laboratories outside of the class period. Students need to examine as many species and individuals as possible. To support or reject a hypothesis about anatomical evolution requires examination of a large number of animals. It is a good idea to remind students that anatomical structures often vary within species. Looking at a single cat does not necessarily provide a good base of knowledge concerning the anatomy of this species. We required student to keep a lab notebook for recording data, which was to include sketches and prose descriptions. Students were told to specifically do the following:

1) Describe the features of your structure that are relevant to the hypothesis being tested. It is not uncommon for students to have to re-examine specimens after looking at other specimens. Anatomists' perspectives often change after observing how something varies.
2) Measure each specimen's size using standard anatomical measuring techniques
3) Identify each specimen's sex and its reproductive condition--sexual maturity or what stage of sexual activity it is at (e.g., pre-spawning female with ovary full of ova).
4) Indicate the anatomical preparation and preservation of each specimen (e.g., double injected and preserved in Carosafe™).
5) Indicate any individual peculiarities of each specimen such as any damage or inferred pathology.

Students need to be cautioned that in dissecting specimens they must do as little damage as possible. If students need to dissect a bilateral structure, they should be instructed to dissect only one side leaving the other intact. For reasons of economy and responsible use of specimens, we required each specimen be examined by all the students who needed to study the various anatomical features and required. Students were required to discuss any removal or destructive dissection with the instructor before proceeding.

**Drawing Conclusions**

Students will need to interpret their many observations to address their hypotheses and to generally understand what they have observed. We suggested the following to students.

1. Arrange rough drawings, descriptions, or summaries of the organs or structures of various organisms in a table with organisms grouped taxonomically.
2. Arrange rough drawings or very short descriptions of the variable organ or structure along the top of the phylogenetic tree provided in class.
3. Arrange rough drawings, descriptions, or summaries of the organs or structures of various organisms in a table with organisms grouped on the basis of pertinent qualities mentioned in your hypothesis (physiology, diet, function, etc.).
4. Consider what anatomical form would be intermediate between the anatomical forms you saw in the species you examined. Would these intermediates be functional?
5. Consider how each type of organ or structure could have developed.
6. Consider the natural history/ecology of the organisms examined and how that natural history would affect the functioning of their organ or structure.
7. Remember that the flexibility, texture, and especially the color of structures can be altered by the method of preservation and injection used.

Students can then use their data to support or reject their hypotheses. Students should be reminded that a single conflicting datum may be enough to reject a hypothesis.

**Presenting Results**

Students should present their results in some format to the class. This allows students to see what other students have learned and motivates students to synthesize what they have learned. We have used both scientific poster sessions and oral presentations involving visual aids. In both cases students are expected to answer questions about their research. The requirement that two (or more) students work together gathering data and producing a final presentation fosters the development of group skills and reduces the pressures of the presentation. Opening the final presentation session to the academic and outside community also gives the students a chance to demonstrate their work and knowledge. A digital camera is particularly useful, but not absolutely necessary, in allowing students to clearly show the structures they studied without spending a large amount of time preparing illustrations.

## PROJECT BENEFITS

### Direct Project Benefits

A direct benefit of this type of project is that students come to understand an anatomical system in significant detail. The volume of material that is typically covered in a Comparative Vertebrate Anatomy course often results in students not developing a comprehensive understanding of individual anatomical structures. This project provides students with an appreciation and some understanding of the overall complexity of vertebrate anatomy. Occasionally, students even identified errors or omissions in dissection guides. Independent-inquiry based projects clearly provide students with a sense of ownership of the material (Davis, 2002). An additional benefit is the level of pride that the students take in their primary knowledge of “their” structure; this has been shown to increase student retention of material (Clark et al., 2000; Rao and DiCarlo, 2001).

The project requires students to utilize anatomical skills in dissection and examination of specimens. Repeated manipulation and examination of specimens result in students becoming more efficient at and comfortable with dealing with vertebrate tissues and organs. At the start of the project, students usually have difficulty seeing variation in or even finding “their” structures. However, by the end they are comfortable with both dissection and recognizing the types of variation that are anatomically “significant.”

### Indirect Project Benefits

One of the most satisfying benefits of the project is the students’ realization that anatomical inquiry is a scientific activity, based on observation that can support or reject hypotheses. Students also quickly realize that dissection manuals are not the ultimate authorities and that there is much that is not known about the anatomy of vertebrates. By conducting their research projects in areas of interest, students also became aware that vertebrate anatomy is relevant outside of the classroom. For example, students interested in pursuing graduate work in physical therapy chose studies of muscle or ligament variation.

As with most independent projects, students developed an increased understanding of how scientific inquiry proceeds. However, a particular benefit to this approach in a comparative anatomy course is the students’ increased comfort with anatomical terminology. This clearly helped the students to be more comfortable than with the more traditionally taught comparative vertebrate anatomy material. The projects also provide an understanding of why fields like comparative vertebrate anatomy need to have such a complex terminology. The students needed precise terms to convey their results to each other. Interestingly, for some students studying musculature extended their learning beyond the classroom and into their daily lives. This was evident when several went to the grocery store to purchase additional specimens for their project.

**Project Concerns**

One significant concern, about instituting an independent project component to the comparative vertebrate anatomy laboratory, was that it reduced the amount of specific content that can be covered. Like Chang (2000) we had to reduce the laboratory coverage to incorporate inquiry activity into the course. We chose to decrease the time spent on posterior musculature, focusing on the anterior musculature, and/or peripheral neuroanatomy, focusing on the central nervous system and cranial nerves. The fact that the anatomy of these areas in mammals was already covered in greater detail in other courses offered at our schools (Anatomical Kinesiology and Neuroscience) made the reduction of lab coverage most reasonable. The lecture components of these courses still covered these anatomical areas. We recommend that consideration of the anatomical components of other courses in the science curriculum and assessment of the laboratory time to be saved guide the selection of material to be excluded.

Another significant concern is the workload involved in an independent project. Independent projects require a significant time investment on the part of students and the instructor. This does not differ from independent projects instituted in other areas of biology. However, the types of observations necessary in an anatomical study usually require more time than typically is available in one or two laboratory periods set aside for the project. An anatomical project unlike projects in some other biological areas is not based on experiments of predictable duration, and requires repeated examination of specimens to check and double check observations. It was occasionally difficult to effectively convey to the students the need to start early and that anatomical data require checking and re-checking. When including a project like this, the course needs to be adjusted so that the amount of work required is not unreasonable. A comparative vertebrate anatomy independent project also requires the scheduling of additional available time to permit students safe access to laboratories and specimens outside of class time.

Instructors need to provide specimens of other species in addition to the dogfish sharks (*Squalus acanthias*), mudpuppies, and cats. These traditional specimens are not sufficient for most students' projects. Some examples of specimens found to be of value include freshwater dogfish (*Amia calva*), perch, turtles, American chameleons, snakes, pigeons, chickens, rats, rabbits, and minks. If the school is located in a rural area, students can be encouraged to bring in road kill, provided that the instructor has obtained and distributed copies of the proper permits, students use gloves when handling animals, and there is refrigeration for the specimens. Fetal pigs are not as highly recommended because of their earlier stage of development, which is less directly comparable to adult specimens. Students initially complained that they had no "talent" in making sketches of their observations. However, it is always valuable to have students sketch some part of the structure. Sketching anatomical structures forces close observation by students and encourages kinesthetic learning as hand movements in drawing are used to approximate the observed shape of the structure.

**Assessment**

Evaluation of the independent research project was informal and lacked statistically comparable quantitative measures. However, student feedback was gathered in an anonymous, open-ended, written course-evaluation questions administered at both schools at the end of the course and through informal discussion with individual students. In the course evaluations, 73.8% of students (31 of 42) indicated that the project was valuable and should be continued, 9.5% (4 of 42) indicated that the independent project was valuable but recommended that it not be continued because it required "too much" work, 7.1% (3 of 42) suggested that the project be discontinued with little elaboration, and 11.9% (5 of 42) gave no opinion on the project leaving the survey item blank. A large majority (83.3%) of students considered the independent project to have been a valuable experience that contributed to their knowledge and appreciation of the discipline of vertebrate anatomy. The most frequently cited student concerns were centered on the amount of work required to complete the independent project. Most students who recommended discontinuing the independent projects recognized their value but were concerned about work load (9.5%). Comments included: "The hands-on learning was great in the projects but too much time was spent outside lab time[;]" "The independent project was fun and I learned a lot but I spent way too much time on it[;]" and "The project provided excellent 'hands-on' approach to anatomy, but the project took a lot of time. Don't do it next time." Some students recommended discontinuing the independent project (7.1%) without elaboration. Comments included: "Get rid of it" and "Don't do independent projects." The brevity of these responses does not allow further analysis. It should also be noted that the typical comparative anatomy course without an independent project also elicits comments about heavy work load and the benefits of the independent project were notable and recognized by most students.

The instructors clearly noted an increase in student enthusiasm for the course material and a reduction in complaints about the complex terminology of anatomy. This was particularly noticeable in students who were doing poorly in either the lecture, or on lab exams that required memorization of structures. The instructors were also satisfied that students were able to recognize vertebrate anatomy as a field, like other fields in biology, that is based on testing assumptions using empirical evidence.

**CONCLUSIONS**

An independent research component implemented in upper-division undergraduate Comparative Vertebrate Anatomy laboratory courses at Emory and Henry College and Regis University was successful at actively engaging students in the field of comparative vertebrate anatomy as a science. Although implementing such a project does require time, organization, and additional work on then part of the faculty and students, the benefits of such a project are worth the effort. The project engaged students as research scientists utilizing their interpretive skills as well as their technical anatomical skills. In addition, the project served to help inform many students, faculty, and administrators of the scientific nature of comparative anatomy and its legitimacy as a research area. We hope that others will implement similar research-based projects in comparative vertebrate anatomy courses to ensure that anatomical disciplines do not get "left behind" as science education increases in its emphasis on active learning, cooperative learning, and problem solving (National Science Foundation, 1996; National Research Council, 2000).

**ACKNOWLEDGEMENTS**

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# Inducing Mutations in *Paramecium*: An Inquiry-Based Approach

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***Abstract***- A major challenge in teaching any college level general genetics course including a laboratory component is having the students actively understand the research part of an experiment as well as develop the necessary laboratory skills. This laboratory experience furthers the students' knowledge of genetics while improving their laboratory skills. It provides the students with experience in the design and implementation of their own experiments. This inquiry-based approach will provide them an opportunity for a deeper appreciation of how scientists perform their investigations. The students were given four weeks to induce mutations into *Paramecium* that will alter their physical and/or behavioral traits.

**Keywords:** Undergraduate, *Paramecium*, mutation, genetics, inquiry-based

## INTRODUCTION

A major challenge in teaching any college level general genetics course including a laboratory component is having the students actively understand the research part of an experiment as well as developing the necessary laboratory skills. Most laboratory exercises published for undergraduate genetics courses fall into the traditional cookbook approach and do not provide the students the opportunity to design their own experiments. The goals of this laboratory experience were to: further the students' knowledge in the field of genetics while improving their laboratory skills; provide the students experience in the design and implementation of their experiments; provide the students experience in literature searches; and provide the students the experience of presenting their results from their experiments in a symposium format. The National Science Education Standards state that students "must actively participate in scientific investigations, and they must actually see the cognitive and manipulative skills associated with the formulation of scientific explanations" (National Academy of Sciences, 1995). This inquiry-based approach is designed to give them a deeper appreciation of how scientists conduct their investigations. The students were provided with four weeks to induce mutation into *Paramecium* that would alter physical and/or behavioral traits.

Since the extensive and classic work by Jennings (1906), *Paramecium* (Figure 1) has been one of the favorites for the study of behavior in unicellular organisms and has been used in many studies that are important for understanding the physiological mechanisms of behavior (Van Houten, 1992). This organism has been shown to have relevance to investigations of cellular processes and signal transduction pathways in higher organisms. *Paramecium* is an excellent model for studying the diverse aspects of behavior including chemical sensation and response, detection of chemical gradients, changes in cellular membrane potential, and responses to stimuli (Kung et al., 1975; Kung & Saimi, 1982). *Paramecium* incorporates the complexity of many larger life forms in a compact package. It possesses motility, electrical activity akin to nerve cells, and cellular signaling pathways similar to those found in humans. *Paramecium* has been likened to "swimming neurons" (Hinrichsen & Schultz, 1988). They have been used as a primitive system to study taste and olfaction, galvinotaxis, and vertigo, to name a few. One particular advantage of studying this organism is its swimming behavior- swim speed and turning frequency, which are easily recorded and are well documented in the literature for both wildtype and known mutants. Moreover, *Paramecium* is responsive to a wide range of environmental stimuli, including chemicals (taste/smell), light, touch, osmolarity, gravity, and electrical fields (Hinrichsen & Schultz, 1988; Machemer, 1988; VanHouten & Preston, 1987).

***Figure 1.*** *Cell of wildtype* Paramecium*. Photo by John Wayne Johnston*

Paramecia, like other ciliates, have both a germline and a somatic nucleus. The germline micronucleus is diploid, and intervenes in sexual processes (Fujishima, 1988). The somatic macronucleus is polyploid and is the seat of all transcription. Because of the elimination of repeated sequences, the macronuclear genome of *Paramecium* is very "compact"; it is estimated that its coding region is over 70% compared to 1% found in the human genome (Genscope). The introns are small (from 18 to 35 bases) and the intergenic regions generally less than 50~100 bases (Figure 2). Because of this, mutations are very likely to affect genes and therefore produce a measurable phenotype.

*Paramecium* is an ideal classroom organism because it is easily cultured, can reproduce readily, is accessible to microscopic study, inexpensive and readily available, (as are all the materials necessary for the following exercise). Additionally, studies of *Paramecium* raise no ethical issues inherent in many animal studies. This organism is an excellent model to incorporate scientific inquiry based activities into the classroom. Today it is important for educators to provide their students with the opportunity to experience good basic science, which includes questioning, experimentation, observations, data collection, analysis and finally drawing conclusions based upon their findings. This *Paramecium* based activity represents how scientific inquiry can be built into the classroom curriculum and be in compliance with the National Science Standards as seen in Table 1.

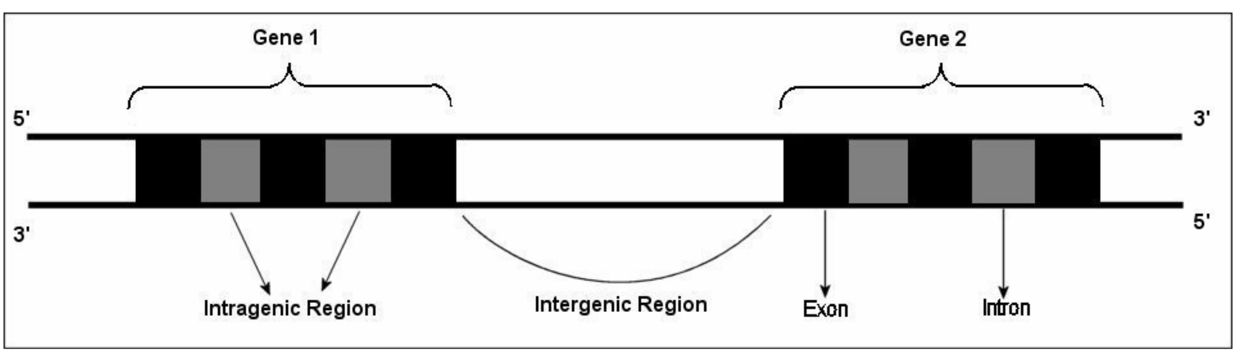



***Figure 2.*** *The schematic of DNA sequence shows two genes. Note the intragenic regions known as introns. Introns are non-coding DNA segments, which are removed after transcription to produce a functional messenger RNA. Also included in the figure are exons and intergenic regions between the genes.* Paramecium tetraurelia *has very few intragenic and intergenic regions. Image created by Olivia Cauthorn.*

***Table 1.*** *National Science Standards, (National Academy of Sciences, 1995)*

| TEACHING STANDARD | FOCUS OF STANDARD | DOMAINS OF INCLUSION |
|---|---|---|
| Standard A | Teachers of science plan an inquiry-based science program for their students | In doing this, teachers select teaching and assessment strategies that support the development of student understanding and nurture a community of learners |
| *Standard B* | Teachers of science guide and facilitate learning. | In doing this, teachers<br>✓ focus and support inquiries while interacting with students<br>✓ orchestrate discourse among students about scientific ideas<br>✓ challenge students to accept and share responsibility for their learning<br>✓ recognize and respond to student diversity and encourage all students to participate fully in scientific learning<br>✓ encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterizes science |
| Standard D | Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. | In doing this, teachers<br>✓ structure the time available so that students are able to engage in extended investigations<br>✓ identify and use resources outside the school |
| Standard E | Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning | In doing this, teachers<br>✓ display and demand respect for the diverse ideas, skills, and experiences of students<br>✓ nurture collaboration among students<br>✓ structure and facilitate ongoing and informal discussions based on the shared understanding of rules of scientific discourse |

## METHODS AND MATERIALS

The students were supplied with a bacterial culture of *Klebsiella pneumonea*, regular wheat media, and a stock of *Paramecium tetraurelia.* The student teams (2-3 students) were responsible for maintaining a stock solution of *Paramecium tetraurelia* wildtype cells. *Paramecia* were grown in wheat media that had been inoculated with bacteria. The bacteria, *Klebsiella pneumonea*, were grown overnight at 37$^o$ C in 50 mL wheat medium; the following day, the inoculated wheat medium was allowed to cool to room temperature, and 500 ul of Paramecium was added to the inoculated medium. Following the overnight incubation, the wheat medium was cloudy in appearance due to the bacterial growth. As the cell population increased over time, the cloudiness of the wheat medium culture decreased due to the cells feeding on the bacterial within the culture. A new stock cell culture would have to be started every 8-10 days. This involved inoculating 50 mL of wheat medium with *Klebsiella pneumonea*, growing the culture overnight at 37$^o$C, allowing the flask to cool to room temperature and then transferring 500 µl of cells from the previous stock culture into the freshly inoculated wheat medium. In addition the students were instructed on how to video tape and calculate their cells swim speeds and turning frequencies. They were also provided with stage micrometers as a means to measure the size of the cells. Stage micrometers are available through any biological supply catalog.

## OUTLINE OF THE LABORATORY SCHEDULE

This activity was implemented over a four-week part of the semester that used a weekly 3-hour laboratory period. All the students were familiar with working with *Paramecium* in the lab because their two previous laboratory activities involved these cells. In addition, the students received the necessary information about these cells from both their laboratory notebook (Elwess & Latourelle, 2003) and lecture notes. These sources included two well-documented facts about *Paramecium tetraurelia*, its average swim speed is 1.0 mm per second, and it is typically 120-140 μM in length.

We presented the students with the challenge of inducing measurable phenotypically sustained changes in *Paramecium tetraurelia* one week in advance of the start of their projects (Figure 3). Students were advised, that once they had evidence that they had achieved phenotypic changes, their cells were to be placed back into the regular wheat medium for at least two to three days. This would ensure the change would be carried over many generations since Paramecium populations double every 70 minutes under ideal conditions (Kippert, 1996). However with the transfer of 500 ul of experimental cells back into 50 mL of regular wheat medium, the authors recognize that a small amount of mutagen might be transferred. A future inclusion for this laboratory experience will include a washing step prior to transfer. This would involve concentrating the cells by centrifugation (350 x g) for 1 minute in 15 mL conical tubes. The cell pellet would be collected and suspended in 50 mL of regular wheat medium that had not been inoculated. Then 500 ul of culture would be placed into a 50 mL of inoculated wheat medium. This would reduce or eliminate the transfer of the mutagen. It was important for the students to recognize the difference between a mutagen versus the action of an agent simply causing a physiological effect on behavior.

The students were informed of materials available to them in the lab, and told they could bring in products (with instructor's approval). They were asked to consider what possible agents in the cells' natural environment could cause mutations, and suggest some ideas including such as farm runoff, fertilizers, and ultraviolet light exposure. Each team of students was required to submit an experimental design matrix to the instructors before starting their preliminary investigation (Figure 4). The students were provided time in the departmental computer laboratory to research primary literature using databases such as PubMed. The students also started the necessary cell cultures that they would need to perform their initial investigations. The cultures usually took 4-6 days to be at their optimal growth in terms of number of cells.

### *Week 1*

Upon approval of their experimental design, teams set up their initial experiments. A primary objective was to determine the concentration range and time of exposure for their chosen mutagens. They determined a workable concentration range as well as exposure time through simple trial and error as well as obtaining information from the primary literature. Monitoring of the cells demanded frequent laboratory visits for microscopic observations. This served to reinforce the students' understanding and preparation of solutions, dilutions, and concentrations. Experiments included exposing the cells to Miracle-Gro®, UV light, Vitamin A, cupric sulfate, microwave radiation, sodium azide, sterobol, and caffeine. At the end of this week the teams were to submit a revised matrix based on their preliminary results, which had a more defined approach with a better-stated hypothesis.

### *Weeks 2-3*

During this time the students focused on refining their concentrations and/or length of exposure for their chosen approach. There was a computer laboratory across the hall from the genetics laboratory where the students could research their approach and/or journal articles related to their experiments.

### *Week 4*

The students used this time to document and analyze their results. This included videotaping the experimental cells to quantify or qualify their swimming behaviors compared to wild-type cells and/or taking pictures of their cells to determine differences in cell structure and/or physiology. The students used the computer lab for data analyses.

### *End of the Semester*

At the end of the semester each team gave a 12-15 minute oral presentation in a symposium format. This involved each team bringing the results of their research to their peers in a more formal manner than simple classroom discussion. Their presentations included their experiment design, background information from literature reviews on their approach, results, conclusions, and finally suggestions for follow-up experiments.

## RESULTS

The students obtained a wide variety of results with this laboratory experience. Fifteen (55.55%) of the 27 student teams had quantitative success in inducing mutations in their cells. Six teams *appeared* to have some type of mutation but could not produce the data to support this finding. This in itself was an importance lesson for them, that in scientific experimentation data are needed to form conclusions. Six teams generated data indicating that they did not induce any physical or behavioral mutations. This helped enforce the concept that negative results are an important part of scientific investigation.

## Inducing Mutation
**(Design Matrix Required)**

**Introduction:**
Paramecium is an excellent model for studying the diverse aspects of behavior including chemical sensation and response, detection of chemical gradients, changes in cellular membrane potential and responses to stimuli. As a unicellular organism, *Paramecium* incorporates the complexity of many larger life forms in a compact package. It possesses motility, electrical activity akin to nerve cells, and cellular signaling pathways similar to those found in humans. Paramecia have been likened to "swimming neurons". The genome of *Paramecium* is very "compact": it is estimated that its coding region is over 70% compared to 1% found in the human genome. *Paramecium* is an ideal classroom organism because it is easily cultured, can be grown in large numbers, is accessible to microscopic study, inexpensive and readily available, as are all the materials necessary for the following exercise. Additionally, *Paramecium* raise no ethical issues inherent in animal studies. This is the organism that will be used for this laboratory activity-Inducing Mutations. Mutations are useful in Science because they are an indication of where problems are occurring and what might be causing them.

**Purpose and Objectives:**
Your group will design an experiment(s) to induce a measurable mutation(s) within wildtype cells. You might want to consider what agents might be affecting the quality of these cells natural environment OR what type of mutagen in general can induce a mutation. The goal here is to induce mutations but not kill the cells. Be sure to include controls in your experimental design! Remember that you are going for mutation not just abnormal behavior in response to test conditions in which you have placed your cells. As an example, if you placed your cell sample in wheat media that is much colder than that to which they have been accustomed, the cells will probably respond with "abnormal" behavior. Is this a mutation? Would their response be the same if the temperature of their environment were brought up to normal? If your cells have indeed been mutated, they should display their mutation over time. When the cells are removed from the test conditions, returned to normal wheat media and environmental surroundings, the mutation(s) should still be evident. **Be sure to have your experimental design approved by the instructor prior to initiating the experiment.**

**Initial Materials:**

Wheat grass media
Test tubes
Depression slides
Dissecting microscope
Pasteur pipettes
Wildtype cells (Amount dependent on design)

**Expectations:**
1. Induced mutations within your cell population
2. A completed design method for determining and measuring the mutation and an approximate % of mutated cells within your *Paramecia* population.
3. **In addition to recording your results in your laboratory notebook, you will be giving an oral presentation on your investigation during the week of _______**

***Figure 3.*** *Student directions presented prior to investigation of inducing mutation(s).*

| **Title of the Experiment** | | | | | |
|---|---|---|---|---|---|
| **Hypothesis** | | | | | |
| **Independent Variable** | | | | | |
| **Levels of Independent Variable** | | | | | |
| **Number of Repeated Trials** | | | | | |
| **Dependent Variable** | | | | | |
| **Controlled Factors or Constants (at least 3)** | | | | | |
| **Control or Explanation *or* Why It Is A Controlled Experiment** | | | | | |

***Figure 4.*** *Design matrix used in the general genetics laboratory sections.*

*Paramecium* behavioral mutants are named according to their behavior, for example the *pawn* mutant was named for the chess piece. The *pawn* mutant in *Paramecium* has a defective calcium channel and therefore cannot move backwards just as the chess piece cannot move backwards. Each team that had produced a mutation was allowed to assign a name to its mutant.

We have included some figures demonstrating the effects of some mutagens. Figures 5 and 6 represent differences in swim speeds between the control and test cells grown in Miracle Gro® and Caffeine respectively. In both cases the cells were video taped and their swim speeds calculated. In both cases the test cells statistically swam faster than the control cells. One team saw the number of changes in direction/second as the difference between the control and the test cells (Figure 7). The cells were video taped, and the tape was played back frame-by-frame (30 frames per second) so the students could count the number of changes in direction per second. Figure 8 shows the overall structural differences between the test (UV light exposure) and control cells and Figure 9 illustrates the analysis of the generated length data supporting those structural differences.

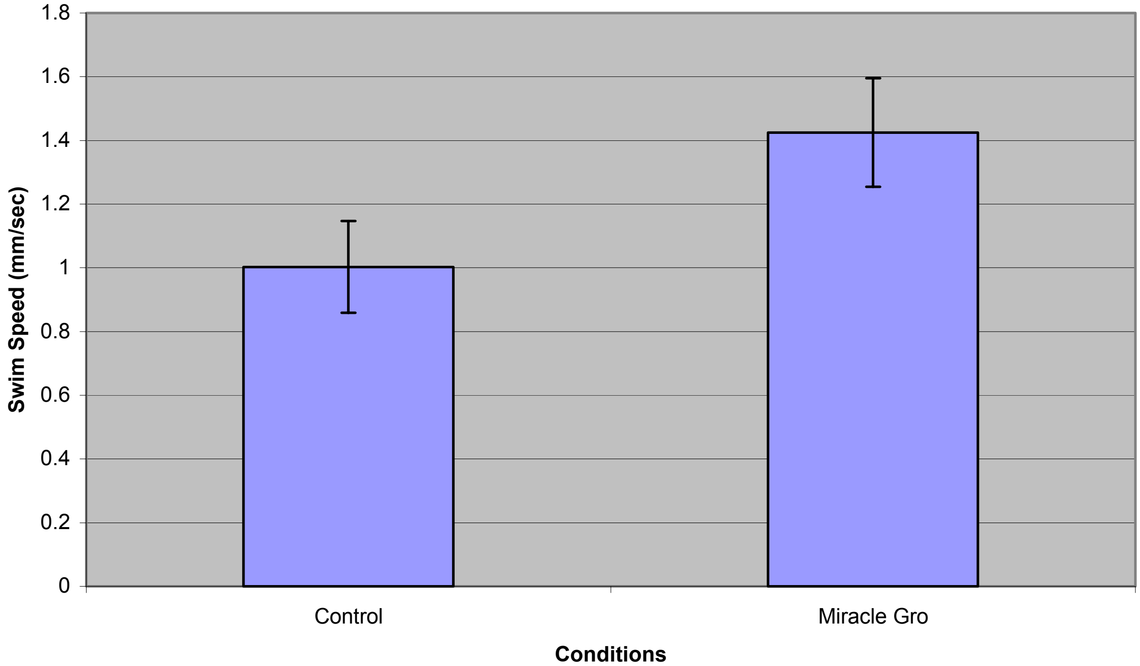



***Figure 5.*** *Comparisons of swim speeds in the control and test cells. Cells were placed in medium containing 0.25% of Miracle-Gro® for 48 hours, then placed back into the regular wheat medium. The control cells (N = 10) swam at a rate of 1.00 mm/sec ± 0.144; whereas, the test cells (N = 10) swam at a rate of 1.42 mm/sec ± 0.17. The students named their cells JJK for Jackie Joyner Kersey, since their cells swam faster than the control.*

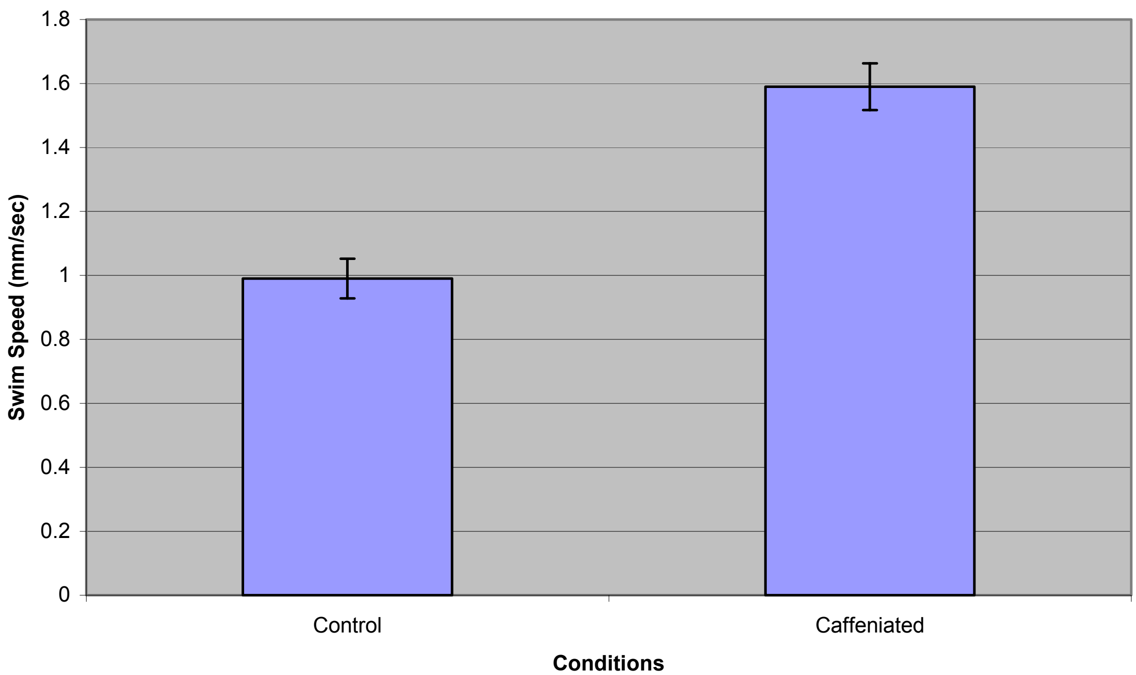



***Figure 6.*** *Comparisons of swim speeds in the control and test cells. Cells were placed in 50 mL of inoculated wheat medium with 50 mg of caffeine for 48 hours, and then placed back into the regular wheat media. The student teamed named their cells Tanked. The control cells (N = 8) swam at a rate of 0.99 mm/sec ± 0.06; whereas, the test cells (N = 8) swam at a rate of 1.59 mm/sec ± 0.07.*

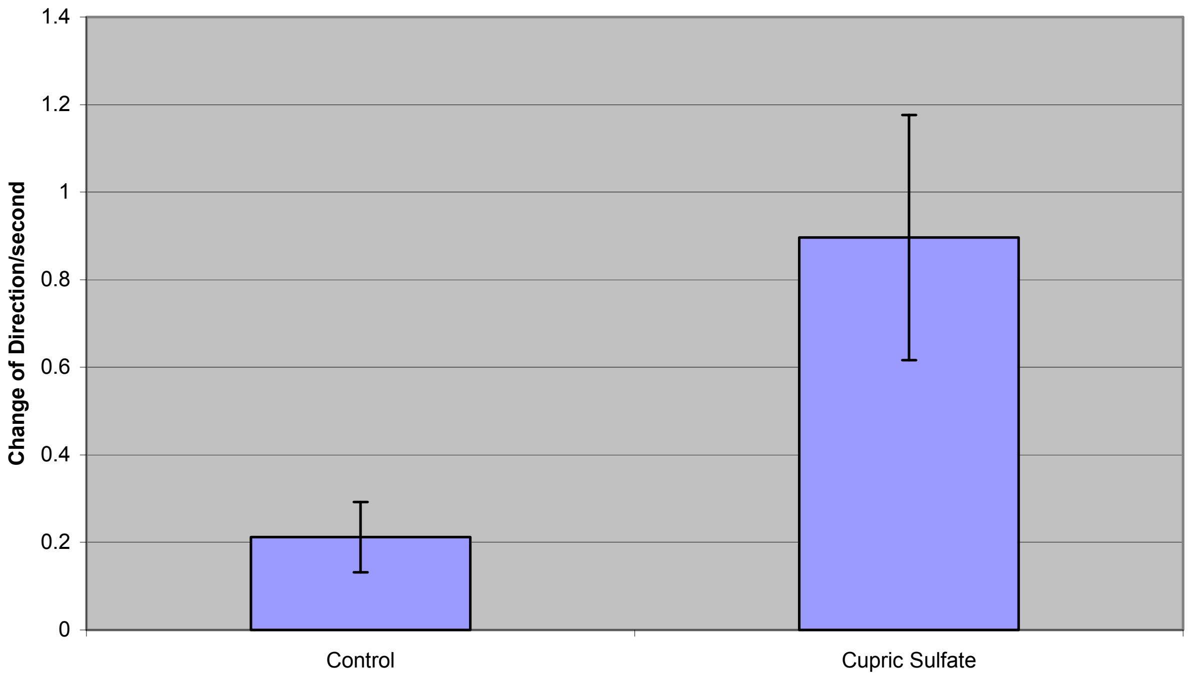
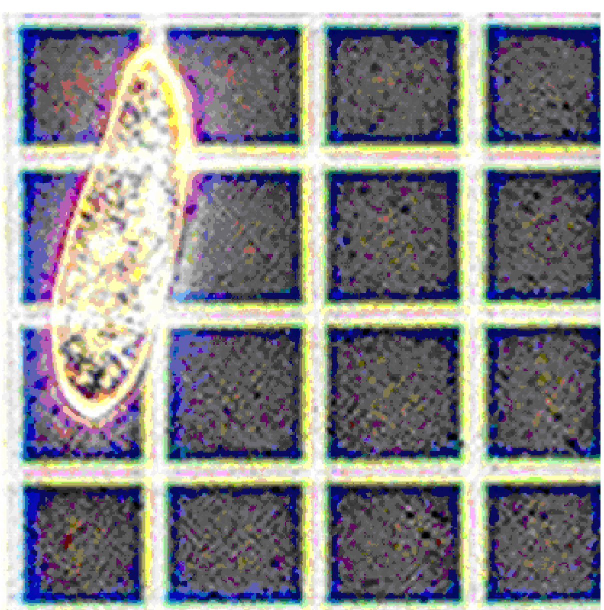
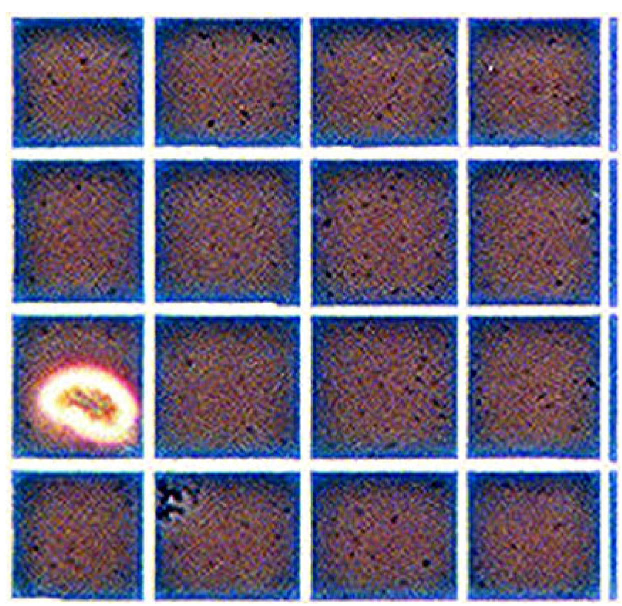



***Figure 7.*** *Comparisons were made for changes in direction between the control and test cells. Test cells were exposed to a medium containing 25 µM cupric sulfate overnight then transferred to regular wheat media. The cells were video taped and the tape played back frame-by-frame (30 frames = one second) to count the number of changes in direction. Five control cells and five exposed cells were measured. The control cells had an average change of direction of 0.212 $\pm$ 0.08 per second; whereas ,the test cells had an average change of 0.896 $\pm$ 0.28. The students named their cells Tune-Up because the swimming behavior reminded them of a car that needed a tune-up.*



**A.**



**B.**

***Figure 8.*** *Side by side comparison of a wildtype cell (A) compared to a cell that has been mutated by a 30-minute exposure to UV light (UV range 280-315 nm) for 4 consecutive days (B). The mutated cells were named Minimecium by the student team.*

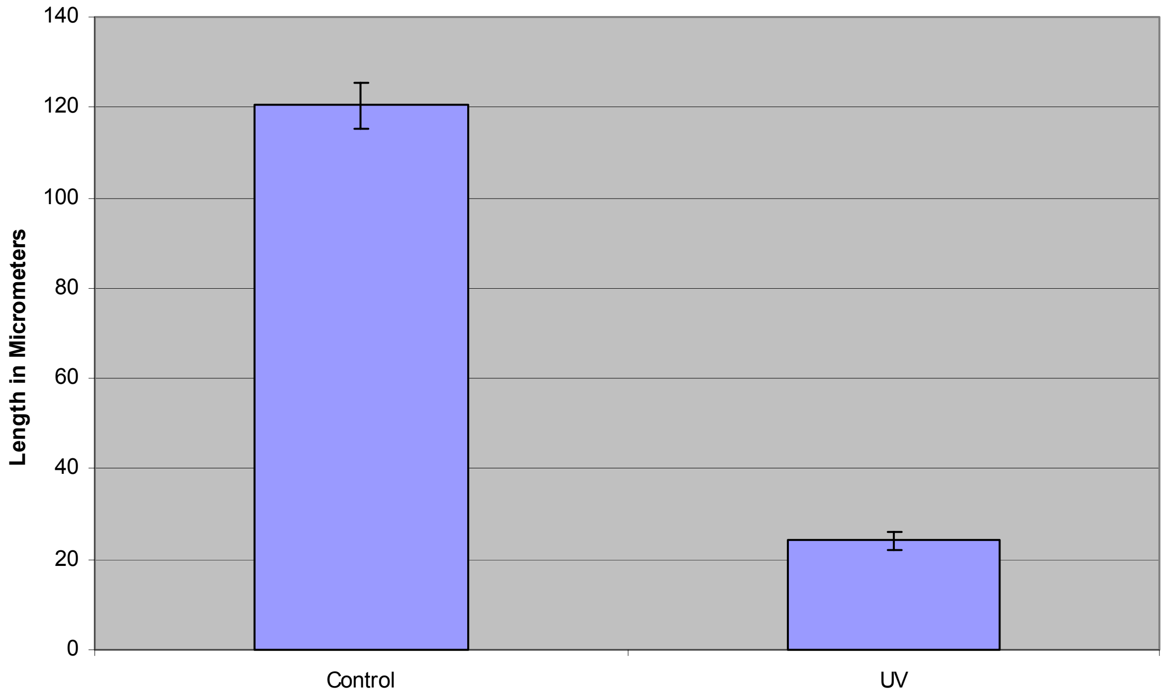



***Figure 9.*** *Comparisons of the length of the cell between the control and test cells. Test cells were exposed to UV light (UV range of 280-315) for 4 consecutive days for 30 minute each day. The cells were photographed on a stage micrometer. Five control cells and five UV exposed cells were measured. The control cells had an average length of 120.4 µm ± 5.18; whereas, the test cells had an average length of 24.2 µm ± 1.92. This team of students named their cells Minimecium.*

## ASSESSMENT OF STUDENTS

The students were assessed on the basis of five different categories: The Design Matrix, they submitted two, the initial matrix, and the revised matrix (10% of activity grade); Literature review on the agent they were using to induce the mutations (10% of activity grade); Effective use of the laboratory equipment and instruments (20% of activity grade); Recording of results in their laboratory notebooks (30% of activity grade); and Formal Presentation of their results (30% of activity grade).

## DISCUSSION

This laboratory experiment provided our junior/senior level general genetics students with a valuable learning experience that gave them the opportunity to enhance their laboratory skills, conduct literature research on their topics, design their own experiments, collect and interpret their data, and prepare an oral presentation. What surprised us the most was the student response to our questionnaire about their research experience.

### *Student Outcomes/Responses*

The students were asked at the end of this experience to respond to the following questions:

1. Approximately how much time outside of your scheduled laboratory time did you invest in this experiment?
2. How do you feel about this particular inquiry based approach to learning as opposed to other more prescribed approaches in other science labs?
3. What were the positive aspects of this 4-week project?
4. What were the negative aspects of this 4-week project?
5. If you had to talk to next year's general genetics class about this experience, what would you tell them?

Figure 10 is a summary of the student group response to question number 1. There was a wide range of time (1-5 hours), the overall average was 2.56 hours ± 1.32.

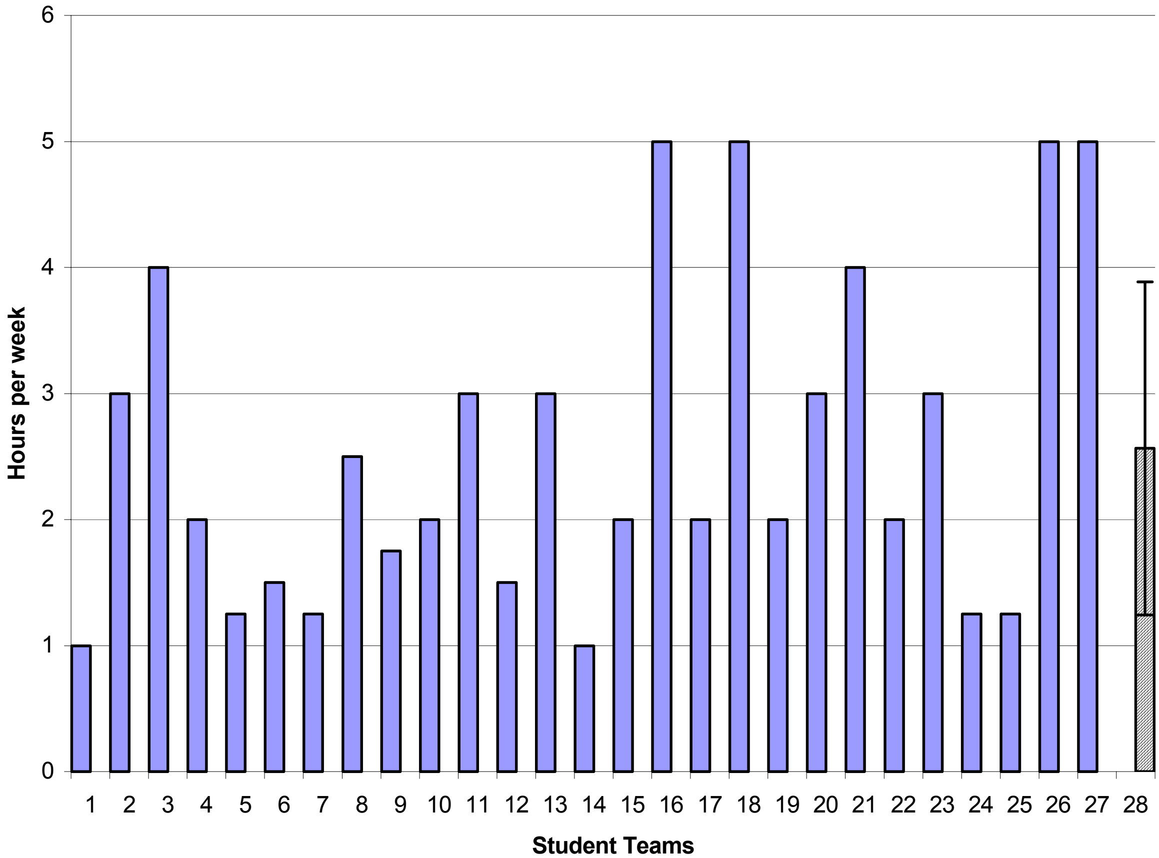



***Figure 10.*** *The individual team responses to the question of how much time outside of the scheduled laboratory time did they spend per week in the lab with this laboratory experience. The overall average (far right column) for all the teams was 2.53 hours/team ± 1.31 hours.*

The students had very positive responses to question 2 above. We have included several of their comments concerning this inquiry-based approach to learning:

> "This format allowed for free-thinking and creativity in a laboratory setting. This was very beneficial in the understanding of the scientific method."

> "This helps you think independently; you are given a chance to do hands-on work using your own ideas."

> "It was very challenging but exciting."

The survey also asked the students to share what they felt were both the positive and negative aspects of this project. The students in general felt that the most positive aspects of this activity were the independence and creative freedom they were given.

> "We had a lot of freedom to choose how to design our experiment."

> "Results were more exciting and rewarding since we were given the freedom to design our own experiments."

The students felt that the extra time they had to invest was the major negative aspect of this activity. One student summed it up well. "The only negative aspect was the amount of time invested. However, with the freedom to design your own experiment comes the responsibility, so I can't complain."

The students expressed their feelings when asked what they would tell next year's genetics class about this inquiry-based laboratory experience. Most of the students gave positive and encouraging responses. Some of these are:

> "It's an excellent experience; just be prepared to dedicate some time."

> "It's one of the best labs you will ever get to do."

> "This type of activity not only helps develop necessary skills to conduct lab procedures, it prepares you for the outside world. The ability

to design, analyze, and learn new techniques is an asset to any institution."

Our students did provide the comment that a good laboratory partner is crucial when working on any type of team effort and/or activity. Creating opportunity for our students to be engaged in active learning based on their own questions and experimental design has been a realized goal. On the way to this goal, students developed skills to enhance the understanding of natural phenomena. They cultivated the art of questioning both themselves and the statements of others. Above all, they formed positive attitudes toward science.

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## *Message from Our President-Elect:*

Dear fellow members of ACUBE,

The next annual meeting is still months away, but I am already looking forward to it and hope the other members of ACUBE are as well! The excellent facilities at Wabash College are most appropriate for the theme "Technology in Biology Education." Please share your teaching ideas by submitting a proposal for a paper, workshop, or poster to the Program Chair, Joyce Cadwallader at jcadwall@smwc.edu.

So much of how I teach has been a direct result of my interaction with the membership of ACUBE. I would like other potential and current members to benefit as much as I have. Bring a colleague to experience the collegial interactions, present a paper, and learn more about our peer-reviewed journal Bioscene. The best way to get our colleagues interested in ACUBE is to have them directly experience what our organization has to offer. I always return home from the annual meeting rejuvenated, with at least one useful idea that I try to use in the classroom or laboratory right away.

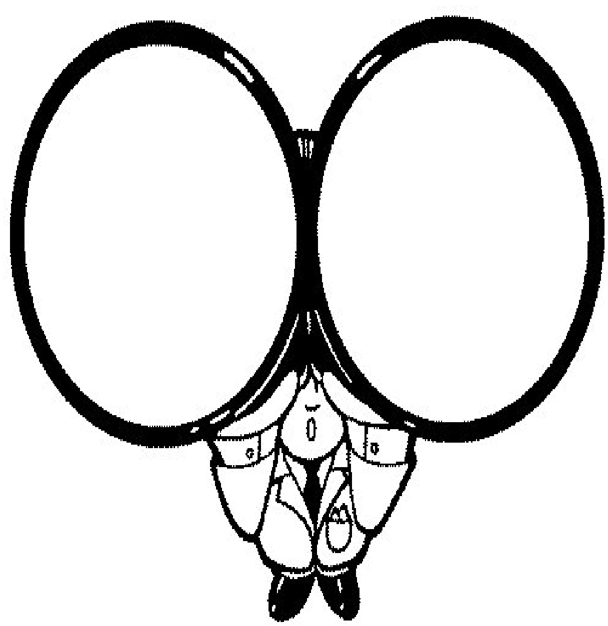
Submit that proposal, and I will see you in October in Crawfordsville, Indiana!

Sincerely,

Lynn Gillie
President-Elect

# Rear View Mirror -- Looking Back

*Edward Kos*
*ACUBE Historian*



**1994**

The 1994 meeting (38th) of the Association of Midwest College Biology Teachers took place at Henderson Community College in Henderson, KY, September 22-24. The theme of the meeting was "Teaching as Scholarship." It opened with a panel on the question, "How is Teaching Scholarship?", which focused on such things as Modeling, Simulations, and Student-Designed Labs. The panel was followed by a series of Workshops including Role Playing and Classroom Theater in Teaching Biology, and Biology in Cyberspace. The various concurrent sessions held after the panel and workshops dealt with ways to develop scholarly laboratory and research endeavors. The banquet speaker was Dr Angelo Capparella, Illinois Normal University, Normal, Illinois whose topic was "Bird Diversity in South America." (A lasting memory was my introduction to southern-style barbeque, vinegar-based rather than tomato-based BBQ. Quite tasty.)

**1984**

The 1984 meeting (28th) of AMCBT was at St. Xavier College (now University) in Chicago, IL, September 27-29. The theme of the meeting was "Brave New World." The opening, keynote speaker was Dr. Joan Straumanis, Academic Dean and Professor of Philosophy, Kenyon College, Gambier, Ohio. Her presentation was titled, "Re-Visioning Science Education." It was followed by questions and audience participation. The sessions on the next two days, centered on topics dealing with introducing the student to research design, data collecting, using computer retrieval systems, developing research equipment by students, preparing manuscripts, and experiments that work. The banquet speaker was Dr. Daphne Fautin, California Academy of Sciences, who spoke on "Coevolution of Sea Anemones and Anemone Fish in Tropical Reefs."

**1974**

The 1974 meeting (18th) was held at Lincoln University, Jefferson City, MO, October 4-5. There was no major theme for the meeting; however, in May of that year the president of AMCBT (Rev. John Ostdiek) sent out a request (see "AMCBT" News) for presentations . He listed nine areas in which changes were occurring. These were troubled times throughout the country, not the least of which seemed to be going on in the area of biological education. What had seemed to forecast a bright future in biological education had dimmed considerably. The president of AMCBT, in the September issue of "AMCBT News," raised some specific concerns: How could biology departments become more effective? How could they become more flexible and versatile, both in curriculum and in imbuing those traits to our students? Most of the sessions were conducted as discussion groups attempting to define the problems and suggest possible solutions, or looking at specific problems including Problems Concerning the Departmental Chair, Attracting Quality Students, Expectations of Incoming Students, and Interdisciplinary Courses. It was a meeting of very concerned members. (Personal note—I didn't attend the meeting being in Thailand at the time. It was the presidency of Richard Milhouse Nixon, the time of Watergate, and the intensifying of the Vietnam conflict. It was a time to be concerned.)

**1964**

The 1964 meeting (8th) of AMCBT was held at the University of Kansas, Lawrence, KS. It was a meeting of considerable significance for such a young organization. It was a Midwestern Regional Conference presented by AMCBT and the Commission on Undergraduate Education in the Biological Sciences (CUEBS). The opening Plenary session had one presentation on the CUEBS program by Victory A. Gruelach Executive Director of CUEBS, and a report on the Berkley and St. Louis Conferences by Willis H. Johnson, CUEBS Commissioner from Wabash College. Following these presentations and lunch, the members broke up into 12 group discussion sessions. Each group discussed a given topic. These were: Courses and Curricula for Prospective Elementary and Secondary School Teachers, Courses and Curricula for Professional Students, Biology in Liberal Education—Large and Small (two sessions), and Courses and Curricula for Biology Majors—Large and Small (two sessions). The results and findings of these sessions were reported back to the entire group, consisting of faculty from both large and small institutions. It is interesting to note that the primary reason for the formation of AMCBT was a topic of national significance. Not all the attendees were members of AMCBT, but some non-members did join. AMCBT held its business meetings, lunches, and dinner speaker session separately from the CUEBS members. The speaker at dinner was Sam Hinton, Curator, The Scripps Institution of Oceanography. The results of this session and other sessions like it, and the work of the CUEBS Commission led to the development of the first revision of the high school biology curriculum; three different versions were eventually produced. In addition CUEBS produced curriculum recommendations for colleges and universities; this was something AMCBT started working on eight years earlier. It was a meeting, which verified AMCBT's primary goals.

**2004**

This brings us to the 2004 meeting (48$^{th}$) of ACUBE to be held at Wabash College, Wabash, Indiana, October 14-16. I most enthusiastically encourage you to attend and bring a friend. The March issue of Bioscene will contain program information as well as a request for you to present at the meeting. In some respects the aura of the time reminds me of the 1974 meeting; there is a growing unease in the educational community, which I sense more and more. There seem to be too many unfunded mandates affecting all levels of education. In the collegiate world there seems to be developing a sense of futility in having a higher education; there don't appear to be many areas in which one can find personal and financial fulfillment with a higher degree. But we are in an election year; my hope is that once it is over things will improve.

# ACUBE

**Web Site**

**http://acube.org**

The Association of College and University Biology Educators (ACUBE), placed the organization's rich archive of materials online for the benefit of members and interested biology educators. Nearly 48 years of the society's publications and resources are currently accessible.

**Featuring the Online ACUBE archives:**

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

**ACUBE Organizational Information:**

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

## Call for Nominations

# Honorary Life Award

The **ACUBE Honorary Life Award** is presented to ACUBE members who have made significant contributions and/or service to ACUBE and the advancement of the society's mission. The award is presented at the annual fall meeting of the society.

If you wish to nominate a member of ACUBE for this award, send a Letter of Nomination citing the accomplishments/contributions of the nominee and a *Curriculum Vita* of the nominee to the chair of the Honorary Life Award committee:

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

# Wabash College

## Site of the 48th Annual Meeting

## Association of College and University Biology Educators

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

## Crawfordsville, Indiana

Located on the banks of Sugar Creek in West Central Indiana, Crawfordsville was organized into a city in 1823. As the seat of Montgomery County, Crawfordsville has served as the financial and trading center for surrounding counties. Because of its cultural strengths, by the end of the 19th Century, it became known as the "Athens of Indiana." In addition to being the home of General Lew Wallace, author of "Ben Hur," Crawfordsville has been the home of numerous other writers. Today, the City has diverse industry sectors including, steel production and processing, agribusiness, printing, education, distribution, optics, metal and plastic fabrication and lighting. With a growing population of over 15,000 diverse residents, Crawfordsville is one of the "Top 100 Best Small Towns in America."

# Call for Presentations

**Association of College and University Biology Educators (ACUBE)**
48th Annual Meeting
Wabash College
Thursday October 14, 2004-Saturday October 16, 2004

## Technology in Biology Education

Computers and equipment play important roles in science today. They have become the tools needed to engage in science, but sometimes it feels like science is determined by the tools. How much time is required to introduce students to these tools? What are some creative and/or productive ways to introduce computers into our classrooms. What other forms of technology contribute to biological education? What are useful ways to evaluate the impact of use of technology in the classroom?

Here are some examples of potential presentation topics: scientific technology, databases, bioinformatics, "gear technology", innovative uses of the web (Powerpoints, bulletin boards, online exams), "drop boxes", student generated posters, on-line posters, personal response systems, simulations, and anything else which relates to technology.

Presentations, posters, and workshops addressing other topics are welcome.

Many of you have so much to contribute to help us all become better teachers. Please consider sharing your ideas and techniques at the 48th Annual Meeting of ACUBE at Wabash College, Crawfordville, IN in 2004. Please email your abstract and mail or FAX a hard copy of the abstract with the completed form by July 1, 2004 to:

Joyce V. Cadwallader, Department of Sciences, Mathematics, and Computer Information Systems
Saint Mary-of-the-Woods College, Saint Mary-of-the-Woods, IN 47876
Phone: (812)535-5155 FAX: (812)535-5228 email: jcadwall@smwc.edu

Proposed Title:______________________________________________

Presentation type (Please Rank): Poster 45 minute Paper 90 minute workshop

Equipment/Facility needed
______ 35 mm slide projector
______ Overhead projector
______ PC computer lab
______ Other (Please explain)
_____ Macintosh computer lab
_____ PC projection system
_____ Macintosh projection system

Name of Presenter______________________________________________

Professional Address______________________________________________

Phone:______________________ email______________________________

Abstract (200-250 words):

# ACUBE 48TH Annual Meeting

October 14-16, 2004

Wabash College
Crawfordsville, IN

# Technology in Biology Education

## Preliminary Program

### *Thursday, October 14th*

| | | |
|---|---|---|
| 2:00 - 5:00 PM | **Pre-Conference Field Trip: Pine Hills** | **Location TBA** |
| 3:00 - 5:00 PM | **Steering Committee Meeting** | **Biology and Chemistry Buidling** (TBA) |
| 6:00 - 8:00 PM | **Registration and Reception**<br>*heavy h'ors d'oerves* | **Biology and Chemistry Building Entry and Room 104** |
| 8:00 - 9:00 PM | **Opening Session**<br><br>**Welcome to ACUBE**:<br>ACUBE President: **Terry Derting**, *Murray State University*<br>**Welcome to Wabash College:**<br>Dean of the College**, Dr. Mauri Ditzler,** *Wabash College*<br>Program Chair: **Joyce V. Cadwallader,** *Saint Mary-of-the-Woods College*<br>Local Arrangements Chair: **Austin Brooks,***.Wabash College*<br><br>**OPENING ADDRESS** (Public Welcome to Attend)<br>**John Kraemer*, Southeast Missouri State University***<br>*Title: TBA* | **Biology and Chemistry Building Room 104** |
| 9:15 - 10:15 PM | **Steering Committee Meeting** | **Biology and Chemistry Building** (TBA) |

### *Friday, October 15th*

| | | |
|---|---|---|
| 7:00 AM - 5:00 PM | **Registration table** | **(all locations are in the Biology and Chemistry Building unless otherwise indicated)** |
| 7:00 - 8:00 AM | **Buffet Breakfast** (by Interest Group) | **Detchon Center** |
| 7:30 - 10:30 AM | **Field Trip: Crawfordsville Crinoid Beds** | **Location TBA** |
| 9:00 AM - Noon and 2:00 - 5:00 PM | **SUSTAINING MEMBER EXHIBITS**<br>Refreshments provided | **Biology and Chemistry Building** |
| 8:15-9:45 AM | **CONCURRENT WORKSHOP SESSIONS I** | **Biology and Chemistry Building** |

| | | |
|---|---|---|
| 9:50-10:20 AM | **POSTER SESSION I**<br>Refreshments provided | **Biology and Chemistry Building** |
| 10:30 - 11:15 AM | **CONCURRENT PAPER SESSIONS I** | **Biology and Chemistry Building** |
| 11:20 - 12:05 AM | **CONCURRENT PAPER SESSIONS II** | **Biology and Chemistry Building** |
| 12:15 - 1:00 PM | **Luncheon and First Business Meeting**<br>*First and Final Call for Nominations!!*<br>*Out of this World Teaching Idea contributions* | **Detchon Center** |
| 1:00 - 1:45 PM | **Luncheon Program**<br>**John Jungck,** *Beloit College*<br>*Title: Computer Power and Human Learning: Using Technology As If Sudents Matter* | **Detchon Center** |
| 2:00 - 5:00 PM | **Field Trip: Birding** | **Location TBA** |
| 2:00–2:45 PM | **CONCURRENT PAPER SESSIONS III** | **Biology and Chemistry Building** |
| 2:50 - 3:20 PM | **POSTER SESSION II**<br>Refreshments provided | **Biology and Chemistry Building** |
| 3:30 - 5:00 PM | **CONCURRENT WORKSHOP SESSIONS II** | **Biology and Chemistry Building** |
| 5:05 - 5:45 PM | **Web Committee Meeting** | **Biology and Chemistry Building** |
| 6:00 - 7:00 PM | **Social Hour:** | **Detchon Center** |
| 7:00 - 9:00 PM | **Dinner and Second Business Meeting**<br>(two-minute speeches by the candidates prior to dinner; balloting after dinner presentation)<br>**Dinner Presentation**<br>**TBA**,<br>*Title: TBA*<br>*Presentation of the 2003 Out of this World Teaching Idea* | **Detchon Center** |

## *Saturday, October 16th*

| | | |
|---|---|---|
| 7:30 - 8:45 AM | **Buffet Breakfast** (by Interest Group) | **Detchon Center** |
| 7:45 - 8:45 AM | **Bioscene Editorial Board** | **Biology and Chemistry Building** |
| 9:00 - 9:45 AM | **CONCURRENT PAPER SESSIONS IV** | **Biology and Chemistry Building** |
| 10:00 - 10:45 AM | **CONCURRENT PAPER SESSIONS V** | **Biology and Chemistry Building** |
| 11:00 AM - 12:15 PM | **Luncheon and Third Business Meeting**<br>**BUSINESS MEETING**<br>Resolutions:<br>*Dick Wilson, Rockhurst University*<br>Executive Secretary Report:<br>*Pres Martin, Hamline University*<br>Bioscene:<br>*Ethel Stanley, Beloit College & Tim Mulkey, Indiana State* | **Detchon Center** |

| | | |
|---|---|---|
| | *University*<br>Presidential Address:<br>*Terry Derting, Murray State University*<br>2004 Meeting:<br>*Margaret Waterman, Southeast Missouri State University* | |
| 12:30 - 3:00 PM | **Steering Committee Meeting**<br>Includes newly elected Steering Committee members! | **Biology and Chemistry Building** |
| 12:30 – 4:00 PM | **Post conference: Covered Bridge Festival of Parke County, Indiana -- (Information will be available at meeting for those who wish to participate on their own)** | |

# Housing Preview

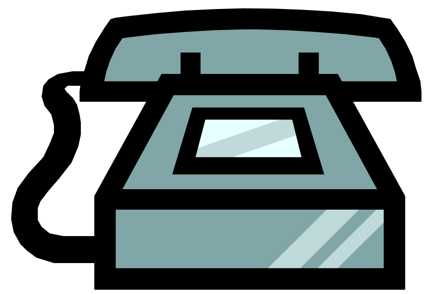
## 48th Annual ACUBE Fall Meeting

***Technology in Biology Education***

**Wabash College**

**Crawfordsville, IN**

October 14-16, 2004



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

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

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

# ACUBE Winter Steering Committee Meeting

**January 31, 2004**

**Place**: Wabash College, Crawfordsville, IN
New Science Building, John C. Rafferty Conference Room
**Present**: Aus Brooks, Joyce Cadwallader, Terry Derting, Lynn Gillie, Pres Martin, Tim Mulkey, Conrad Toepfer, Margaret Waterman
**Absent**: Ethel Stanley, Abour Cherif, Janet Cooper, Neil Grant, Brenda Moore, Robert Wallace
**Time**: 8:30 am

**I. Call to Order**
**II. Approval of Agenda M/S/A**
**III. Approval of Fall Minutes M/S/A**
**IV. Committee Reports**

**Executive Secretary** – Pres Martin
Printed copies of the membership for 2004 ACUBE were handed out along with an expense report for 2003. Income was $10,813 and expenses were $9,785. Nancy Sanders provided all data after the Fall meeting to Pres. Pres explained how Nancy Sanders handled a more efficient method for the finances for the fall meeting. It was proposed that the new method be followed for subsequent meetings. Registration packets at the annual meeting will include a friendly reminder to pay past dues.

**Membership** – Aus Brooks (reporting), Bob Wallace, Conrad Toepfer
A brochure for recruiting new members was produced. The brochure includes the new logo. Further changes will be made on the brochure before they are handed out. Aus would like to promote membership as outlined in the second steering meeting in the fall meeting. He suggests that geographical areas be assigned to the each committee member. People will be given a *Bioscene* CD and possibly back copies of the journal. This will be followed up by email, letter or a phone call. The committee will encourage members to bring one new person for the fall meeting.

Pres has been receiving online applications from international locations. An additional fee for mailing costs of $15.00 for international (outside of North America) applicants was proposed by Margaret Waterman. M/S/A. The committee will also look into having the ability to pay for membership dues on the internet.

**Nominations** – Janet Cooper (chair), Neil Grant
Current Recommendations:
Steering Committee - Marya Czech, Wyatt Hoback, Peter White, Greg Grabowski, and Bobby Lee
President – Bob Wallace, Cynthia Horst, Janet Cooper

**Awards**: Honorary Life and Carlock – Bill Brett; reported by Tim Mulkey
The new wording of the Carlock Award to include 'advanced undergraduates' was approved.
Nominations for the Honorary Life award were discussed and approved.

**Constitution** – Margaret Waterman (reporting), Terry Derting, Malcolm Levin
Constitutional by-laws and Hand Book revisions were distributed. Major changes proposed:
The President term will change from a one-year to a two-year term
Members- at-Large will serve a three-year term
Members of the Steering Committee may be removed from office if they fail to attend Steering Committee meetings for one year or for misusing ACUBE funds or egregious failure to carrying out assigned duties.
Payment of dues is required to receive *Bioscene* issues. Back issues will not be issued.
Keynote speakers at the meeting will receive a complimentary membership and *Bioscene* for the subsequent year.
Responsibilities of the Managing Editor and Technical Manager of the ACUBE web site were specifically stated. Nancy Sanders will serve as the Manager Editor. Tim Mulkey and Margaret Waterman will serve as Technical Managers.
Proposed changes of the Constitution will be published in *Bioscene* and voted on by the membership during the fall meeting. M/S/A

The revised documents will be posted on the ACUBE website.

**Internet** – Margaret Waterman (reporter), Tim Mulkey, Ethel Stanley, Bill Brett, Karen Klyzek, Nancy Sanders

Changes to committee duties are within the updated Constitution and By-Laws.

**Historian** – Ed Kos

It was recommended that the Historian provide a list of past Honorary life awardees, past Presidents and Steering Committee members and past meeting sites. In addition, photographs need to be compiled for the $50^{th}$ anniversary.

It was also proposed that the Historian take photos at annual meetings.

**Resolutions** – Brenda Moore

An addition to the resolutions was proposed about the concept of Intelligent Design being a non-testable and nonscientific explanation for species diversity.

**V. Planning Upcoming Meeting** – Aus Brooks

**Program** - Joyce Cadwallader

See speaker notes.

**Facilities** – Workshop and presentation sessions can all be in the new science building. A PC lab and wireless laptops will be available. Detchon has 24 Macintoshs available. A third PC lab is available in the library. Registration and Thursday evening reception will also be in the science building. There are also wet labs available for sessions. The poster sessions can be in the main hallway.

**Logistics** – Transportation to and from motels can be available, if needed.

**Food** - Campus food services is good but expensive. Aus recommends using them only for the main banquet. The rest of the meals can be covered by outside vendors.

**Transportation**

**Housing --** Days Inn, Ramada and Super 8 are providing a special rate of $75 . The Comfort Inn will block rooms at $89.95. The rate after September 15 is $115. The Holiday Inn will block 20 rooms at a rate of $122.55. There are 18 rooms on campus for $89.

**Speakers** – John Jungck has confirmed his participation at the meeting. Tim Mulkey stated that the NASA Institute for Advanced Concepts (NIAC) is another possibility for the Friday talk. He will make the contacts to arrange this.

Thursday night speaker possibilities – GIS person. Terry Derting and Aus Brooks will work on this.

**Field trips** – The Crawfordsville crinoid beds will be used as a field trip for Friday afternoon. The walking tour at Pine Hills will be Thursday afternoon. On Friday morning, a math faculty person will take people birding in the area.

**Advertising** -Aus Brooks

Halfpage advertisement in *BioScience* will be due March 15 at AIBS. Ethel Stanley will be asked if she wants to do this. Aus will work on an advertisement to put in *Bioscene*.

Aus will work on web information such as meeting announcement, call for abstracts, travel information-campus and city maps, lodging information, institutional description and exhibitor information.

An e-mail advertising a call for abstracts for the fall meeting was approved.

**Registration Form --** Aus will finalize the registration form.

**Exhibitors** -- Exhibitors will be covered by local arrangements. Possibilities include SmartBoards (Terry Derting), GIS, Garmin, ESRI (Terry Derting), Vernier (Terry Derting), iWorks (Lynn Gillie), Seiler (Joyce Cadwallader), Modern Biology (Aus Brooks), HP Tablets (Margaret Waterman), Benjamin-Cummins, McGraw-Hill (Tom Davis), Pfizer (Joyce Cadwallader), iOmega (Lynn Gillie), BlackBoard (Aus Brooks), PRS (Terry Derting).

Door prizes could also be given away.

**Meeting and registration costs** -- Registration fee will be $85. An early bird date for registration will be August 1. After that date the fee increases to $100 (this includes on-site registration).

K-12 teachers will be charged the same rate as regular members.

Undergraduates and graduate students will be charged $55/65 respectively.

**T-shirt**s -- Nancy Sanders volunteered to get individual orders for the T-shirts. Terry Derting will check on this. T-shirt orders can be included on the registration form. Student workers could have different colored T-shirts so that they could be easily identified during the meeting.

**VI. New Business**

Invitation to the 2004 AIBS Council Meeting – Terry Derting
No one will be participating in the Council Meeting on Invasive Species
Request for support for AIBS Public Policy Office – Terry Derting
The committee proposed to not provide monetary funds to support the AIBS Public Policy Office
New member information packet – Lynn Gillie
New members should be sent a welcoming letter, ACUBE CD, old copy(s) of *Bioscene*, list of ACUBE governance, constitution and by-laws, a solicitation to serve on standing committees, and a call to submit papers. The membership committee will create these packets. Pres Martin will be responsible for sending the packets to new members.

**VII. Other Business**

***Bioscene* report** – Tim Mulkey (reporting), Ethel Stanley, Karyn Turla, Jill Kruper
The latest edition of *Bioscene* should come out in March. A notice about page charges for non-members will be posted. The committee proposed to add a $20 page charges for *Bioscene* papers. The charges will be waived for ACUBE members. This revision will be posted in the Instructions to Contributors in *Bioscene*.

Tim has been asked about doing book/equipment/resources reviews. It was recommended that a member will be asked to do such reviews in the future.

**2005 Meeting** – Cape Giradeau, Missouri

i. Select Program Chair
   Proposed Program Chair (First Vice President) – Jill Kruper
ii. Meeting Dates
   October 13-15
iii. Theme – Lynn Gillie
   An interdisciplinary theme was proposed -
   "Biology: Entangled in the Web of Knowledge"

**Future Meetings**

i. 2006 Margaret Waterman will contact Anne Larson to see if having the meeting at U. of Illinois in Springfield is a possibility.
ii. 2007 Carroll College, Waukesha, WI- yet to be confirmed
   $50^{th}$ Anniversary
   It would be nice to have videos of people sharing memories, lists of Life Members, past Presidents. We need to see if original schools involved would like to be included. We could brainstorm where ACUBE will be in 50 years. It would be good to show how the organization has grown from Chair's meetings, to including community colleges, to becoming a national organization. Sister Yackey and Anne had volunteered to help with this at the fall meeting.

Meeting adjourned at 3:30 pm

Respectfully submitted January 31, 2004
Jill Kruper, Secretary

## ACUBE Governance for 2004

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

**Board Members**

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

**Standing Committees**

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

# Call for Nominations

## President-Elect & Steering Committee Members

ACUBE members are requested to nominate individuals for the office of President-Elect and two at large positions on the ACUBE Steering Committee. Self-nominations are welcome.

If you wish to nominate a member of ACUBE for a position, send a Letter of Nomination to the chair of the Nominations Committee:

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

# ACUBE

## Association of College and University Biology Educators

NAME: ______________________________ DATE: ______________

TITLE: ______________________________________________

DEPARTMENT: _________________________________________

INSTITUTION: _________________________________________

STREET ADDRESS: _____________________________________

CITY: ______________________ STATE: __________ ZIP CODE: _________

ADDRESS PREFERRED FOR MAILING: ______________________________

______________________________________________________

CITY: ______________________ STATE: __________ ZIP CODE: _________

WORK PHONE: ______________ FAX NUMBER: ____________________

HOME PHONE: ______________ EMAIL ADDRESS: _________________

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

RESOURCE AREAS (Areas of teaching and training): ______________________

______________________________________________________

RESEARCH AREAS: ____________________________________

______________________________________________________

How did you find out about ACUBE? ____________________________

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

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

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

# Call for Presentations

**Association of College and University Biology Educators (ACUBE)**
48th Annual Meeting
Wabash College
Thursday October 14, 2004-Saturday October 16, 2004

## Technology in Biology Education

Computers and equipment play important roles in science today. They have become the tools needed to engage in science, but sometimes it feels like science is determined by the tools. How much time is required to introduce students to these tools? What are some creative and/or productive ways to introduce computers into our classrooms. What other forms of technology contribute to biological education? What are useful ways to evaluate the impact of use of technology in the classroom?

Here are some examples of potential presentation topics: scientific technology, databases, bioinformatics, "gear technology", innovative uses of the web (Powerpoints, bulletin boards, online exams), "drop boxes", student generated posters, on-line posters, personal response systems, simulations, and anything else which relates to technology.

Presentations, posters, and workshops addressing other topics are welcome.

Many of you have so much to contribute to help us all become better teachers. Please consider sharing your ideas and techniques at the 48th Annual Meeting of ACUBE at Wabash College, Crawfordville, IN in 2004. Please email your abstract and mail or FAX a hard copy of the abstract with the completed form by July 1, 2004 to:

Joyce V. Cadwallader, Department of Sciences, Mathematics, and Computer Information Systems
Saint Mary-of-the-Woods College, Saint Mary-of-the-Woods, IN 47876
Phone: (812)535-5155 FAX: (812)535-5228 email: jcadwall@smwc.edu

Proposed Title:______________________________________________________________

Presentation type (Please Rank): Poster 45 minute Paper 90 minute workshop

Equipment/Facility needed
______ 35 mm slide projector
______ Overhead projector
______ PC computer lab
______ Other (Please explain)
_____ Macintosh computer lab
_____ PC projection system
_____ Macintosh projection system

Name of Presenter______________________________________________________

Professional Address___________________________________________________

Phone:______________________ email_______________________________________

Abstract (200-250 words):

# BioQUEST

**The BioQUEST Curriculum Consortium is an open community of bioscience educators and researchers interested in undergraduate science curricular reform. The projects of the Consortium are designed to help teachers develop tools and resources to provide their students with opportunities to solve complex, research-like problems in the classroom.**

**We invite you to become involved in BioQUEST - attend a workshop, collaborate on a project, or explore a computer simulation!**

BioQUEST Curriculum Consortium

2004 Summer Workshop

SYSTEMS BIOLOGY EDUCATION

Saturday, June 12
through
Sunday, June 20

BELOIT COLLEGE

Modeling in Bioinformatics

Eugene

October 21 - 24, 2004

Lane Community College

Mammalian Bioinformatics

The Jackson Laboratory

Bar Harbor, Maine

November 3 - 6, 2004

**BioQUEST Curriculum Consortium**
**Beloit College**
**700 College Street**
**Beloit, WI 53511**

For more information on these and other BioQUEST Projects:
Email: bioquest@beloit.edu
Phone: 608-363-2743
bioquest.org