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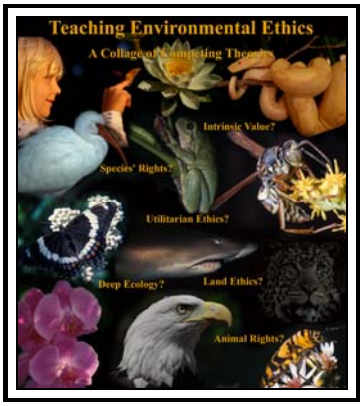

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Laboratory Exercises

Articles

News & Views

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Bioscene: Journal of College Biology Teaching

Guidelines for Submissions

I. Submissions to *Bioscene*

Bioscene: Journal of College Biology Teaching is a refereed quarterly publication of the Association of College and University Biology Educators (ACUBE). Submissions should reflect the interests of the membership of ACUBE. Appropriate submissions include:

- Articles: Laboratory and field studies that work, course and curriculum development, innovative and workable teaching strategies that include some type of evaluation of the approaches, and approaches to teaching some of the ethical, cultural, and historical impacts of biology.
- Reviews: Web site, software, and book reviews
- Information: Technological advice, professional school advice, and funding sources
- Letters to the Editor: Letters should deal with pedagogical issues facing college and university biology educators

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II. Preparation of Articles

Submissions can vary in length, but articles should be between 1500 and 4000 words in length. This includes references, but excludes figures. Authors must number all pages and lines of the document in sequence. This includes the abstract, but not figure or table legends. Concision, clarity, and originality are desirable. A complete submission will consist of the following:

A. Cover letter: All submissions should come with a cover letter (cover letter could simply be an email with accompanying attachments) indicating that the manuscript is being submitted exclusively to *Bioscene* and why it is appropriate for this journal. Authors may also offer graphics from the article as possible cover art.

B. Cover Sheet: Submissions should include a cover sheet that includes the title of the article, the number of words in the manuscript, the corresponding author's name, and all co-authors. Each author's name should be accompanied by complete postal and email addresses, as well as telephone and FAX numbers. Even with hardcopy submissions, email will be the primary method of communication with the editor of *Bioscene*.

C. Abstract: The first page of the manuscript should contain the title of the manuscript, the names of the authors and institutional addresses, a brief abstract (200 words or less) or important points in the manuscript, and keywords in that order.

D. Manuscript Text: The introduction to the manuscript begins on the second page. No subheading is needed for this section. This supply sufficient background for readers to appreciate the work without referring to previously published references dealing with the subject. Citations should be reports of credible scientific or pedagogical research.

The body follows the introduction. It is recommended that it be broken into sections with appropriate subheadings including Materials and Methods, Results, and Discussion. Some flexibility is permitted here depending upon the type of article being submitted.

Acknowledgment of any financial support or personal contributions should be made at the end of the body in an Acknowledgement section, with financial acknowledgements preceding personal acknowledgements. Disclaimers and endorsements (government, corporate, etc.) will be deleted by the editor.

A variety of writing styles can be used depending upon the type of article. Active voice is encouraged whenever possible. Past tense is recommended for descriptions of events that occurred in the past such as methods, observations, and data collection. Present tense can be used for your conclusions and accepted facts. Because *Bioscene* has readers from a variety of biological specialties, authors should avoid extremely technical language and define all specialized terms. Also, gimmicks such as capitalization, underlining, italics, or boldface are discouraged. All weights and measures should be recorded in the SI (metric) system.

In- text citations should be done in the following manner:

"…rates varied when fruit flies were reared on media of sugar, tomatoes, and grapes" (Jaenike, 1986).

or

" Ulack (1978) presents alternative conceptual schemes for observations made…"

E. References: References cited within the text should be included alphabetically by the author's last name at the end of the manuscript text with an appropriate subheading All listed references must be cited in the text and come

from published materials in the literature or the Internet. The following examples indicate *Bioscene*'s style format for articles, books, book chapters, and web sites:

Articles-
Single author:
DEBURH, L.E. 1991. Using *Lemna* to study geometric population growth. *American Biology Teacher* 53(4): 229-32.
Multi-authored:
GREEN, H., GOLDBERG, B., SHWARTZ, M., AND D. BROWN. 1968. The synthesis of collagen during the development of *Xenopus laevis*. *Dev. Biol*. 18: 391-400.

Books-
BOSSEL, H. 1994. *Modeling and Simulation*. A.K. Peters, London. 504p.

Book chapters-
GLASE, J.C. AND M. ZIMMERMAN. 1991. Population ecology: experiments with Protistans. In Beiwenger, J.M. 1993. *Experiments to Teach Ecology*. Ecological Society of America, Washington, D.C. 170p.

Web sites-
MCKELVEY, S. 1995. Malthusian Growth Model. Accessed from
http://www.stolaf.edu/people/mckelvey/envision.dir/malthus.html on 25 Nov 2005.

Note that for references with more than five authors, note the first five authors followed by *et al*.

F. Tables
Tables should be submitted as individual electronic files. Placement of tables should be indicated within the body of the manuscript. All tables should be accompanied by a descriptive legend using the following format:

Table 1. A comparison of student pre-test and post-test scores in a non-majors' biology class.

G. Figures
Figures should be submitted as individual electronic files, either TIFF or BMP. Placement of figures should be indicated within the body of the manuscript. Figures include both graphs and images. All figures should be accompanied by a descriptive legend using the following format:

Figure. 1. Polytene chromosomes of *Drosophila melanogaster*.

III. Letters to the Editor

Letters should be brief (400 words or less) and direct. Letters may be edited for length, clarity, and style. Authors must include institution address, contact phone number, and a signature.

IV. Other Submissions
Reviews and informational submissions may be edited for clarity, length, general interest, and timeliness. Guidelines for citations and references are the same for articles described above.

V. Manuscript Submissions

Article manuscripts may be sent to the current editor either electronically or by hard copy, accompanied by a disc copy. Electronic submissions are preferable. All authors will receive confirmation of the submission within three weeks. Manuscripts should be submitted either as a Microsoft Word or RTF (Rich Text File) to facilitate distribution of the manuscript to reviewers and for revisions. A single-email is required to submit electronically, as the review process is not blind unless requested by an author. If the article has a number of high resolution graphics, separate emails or separate discs mailed to the editor may be required.

If hard copy is sent it must be accompanied by a disc containing the complete submission. Three copies of the manuscript, as well as the original, should be submitted. Standard paper should be used with lines of sections of the manuscripts numbered and enough margin to permit reviewer comments. Two self-addressed stamped envelopes must be included if the authors wish to receive reviews and responses by methods other than email.

VI. Editorial Review and Acceptance

Manuscripts will be sent out for review, once the author has either joined ACUBE or agreed to page charges. Charges will be the membership fee at the time of submission per page. Once the authors' membership or page charge status has been cleared, the manuscripts will be sent to two anonymous reviewers as coordinated through the Editorial Board. Reviewers will examine the submission for:

- **Suitability:** The manuscript relates to teaching biology at the college and university level.
- **Coherence:** The manuscript is well-written with a minimum of typographical errors, spelling and grammatical errors, with the information presented in an organized and thoughtful manner.
- **Novelty:** The manuscript presents new information of interest for college and university biology educators or examines well-known aspects of biology and biology education, such as model organisms or experimental protocols, in a new way.

Once the article has been reviewed, the corresponding author will receive a notification of whether the article has been accepted for publication in *Bioscene*. All notices will be accompanied by suggestions and comments from the reviewers. Acknowledgement of the reviewers' comments and suggestions must be made for resubmission and acceptance. Upon acceptance, the article will appear in *Bioscene* and will be posted on the ACUBE website. The review process can take 4-5 months. Upon final acceptance, the article will appear in *Bioscene* and will be posted on the ACUBE website within six months of publication. Depending upon volume, time from acceptance to publication may take up to a year.

VII. Editorial Policy and Copyright

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Environmental Studies and Utilitarian Ethics

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Abstract: Environmental ethicists have focused much attention on the limits of utilitarianism and have generally defined "environmental ethics" in a manner that treats utilitarian environmental ethics as an oxymoron. This is unfortunate because utilitarian ethics can support strong environmental policies, and environmental ethicists have not yet produced a contemporary environmental ethic with such broad appeal. I believe educators should define environmental ethics more broadly and teach utilitarian ethics in a non-pejorative fashion so that graduates of environmental studies and policy programs understand the merits of utilitarian arguments and can comfortably participate in the policymaking arena, where utilitarian ethics continue to play a dominant role.

Keywords: Environmental Education, Environmental Studies, Environmental Ethics, Utilitarianism, Utilitarian Ethics

Introduction

The current generation of college students is expected to witness a dramatic decline in biodiversity, the continued depletion of marine fisheries, water shortages, extensive eutrophication of freshwater and marine ecosystems, a dramatic decline in tropical forest cover, and significant climatic warming (Jenkins 2003, Pauly et al. 2002, Jackson et al. 2001, Tilman et al. 2001, Adedire 2002, Karl & Trenberth 2003). The ethical implications of these anthropogenic ecological changes are clearly evident and have generated a tremendous interest in environmental ethics - a subject that has justifiably entered the environmental biology classroom.

The teaching of environmental ethics in environmental science courses has been heavily influenced by recent philosophical debates and many educators have followed environmental ethicists in rejecting the ethics of utilitarianism. Environmental science textbooks commonly exemplify this trend by associating utilitarianism with discredited "worldviews."

Despite the deprecatory treatment by environmental ethicists, utilitarianism continues to be widely accepted by professionals in other fields and utilitarian ethics still dominate the public policy arena. The derisive treatment of utilitarian ethics in environmental science courses may, consequently, have unfortunate consequences. Many graduates of environmental science courses are likely to be called upon to implement and defend policies they are ill prepared to understand or fully accept without a basic appreciation for the merits of utilitarian ethics. Environmental science graduates may also find themselves isolated from economists and other professionals if they fail to develop an appreciation for the limitations of competing theories and develop an antipathy for utilitarian ethics. To prepare graduates of environmental science courses for participation in the policy process, it is important that environmental biologists teach the strengths, as well as the weaknesses, of utilitarian ethics in a non-pejorative fashion, and the limitations, as well as the strengths, of competing theories.

It must be appreciated that the training given most biologists seldom includes rigorous courses in philosophy. Consequently, environmental science instructors are likely to lack knowledge of, or an appreciation for, the relative merits of competing theories. I hope my treatment of this subject serves, in part, to address this issue by exposing biology instructors to several important philosophical debates, and by raising awareness of the unsettled nature of environmental ethics.

The Changing Status of Utilitarianism in Environmental Ethics

Utilitarianism, in its most traditional form, is both a theory of the good and a theory of the right. It holds that the greatest good is happiness and freedom from pain and suffering. Acts that promote the greatest good (i.e., have the greatest utility) are morally right. Acts that reduce overall happiness and/or promote pain are morally wrong.

Some advocates of utilitarianism have redefined the greatest good to be the satisfaction of personal desires or preferences. Preference utilitarianism is, of course, integrally associated with a host of contemporary economic theories, which commonly hold or assume that individuals are best served when they are able to pursue and satisfy their preferences within a free market.

No one familiar with the environmental movement in the United States can doubt or deny the important role utilitarianism has played as a justification for protecting wilderness, ecosystems, and species. Modern environmental ethicists have, however, criticized utilitarianism on various grounds and have distanced themselves and the field of environmental ethics from traditional theories of morality, including utilitarian ethics, by rejecting anthropocentrism, denying the importance of sentience, embracing intrinsic value theories, and affirming holistic ethics.

In the 1970s, several environmental ethicists and animal rights proponents challenged the inferior moral standing of other species and anthropocentrism (i.e., "speciesism" and "human chauvinism"). They persuasively argued that value and morality cannot be reduced to matters of interest or concern to human beings alone, and that there are no justifiable reasons for excluding the interests of other species from moral consideration (Singer 1975, Fox 1978, Regan 1979, Routley & Routley 1979). Anthropocentrism was also attacked and rejected for failing to recognize the intrinsic value of non-human life forms and for justifying many of the environmentally destructive practices environmentalists oppose (e.g., Naess 1973, Devall & Sessions 1985).

The rejection of anthropocentrism did not necessitate a refutation of utilitarian ethics. However, a non-anthropocentric utilitarian approach to environmental ethics only broadens the set of morally relevant organisms to include, in addition to humans, elephants, cetaceans, great apes, and a handful of other sentient organisms. Utilitarianism has, therefore, been roundly criticized by those ethicists that reject sentientism and believe a legitimate environmental ethic must go further and assign moral standing to such insentient entities as plants, species and/or ecosystems. (e.g., Goodpaster 1978, Callicott 1980, Sagoff 1984).

Intrinsic value or inherent worth is what makes trees, species, and ecosystems the subjects of direct moral concern in the minds of many environmental ethicists, so its importance to the field can hardly be overstated. Because utilitarians recognize only the intrinsic value of pleasure or desire satisfaction, the commitment to intrinsic value in environmental ethics has also driven a rather deep wedge between environmental ethics and the ethics of utilitarianism.

In addition to rejecting anthropocentrism, sentientism, and utilitarian limits on intrinsic value, a number of environmental ethicists argue that an adequate environmental ethic must be holistic, as opposed to individualistic, and make ecosystems and species the subjects of direct moral concern. Such "holists" do not deny that we have duties to individuals, but they contend that our duty to preserve wild places, species, biotic communities, and ecosystems can trump the interests or rights of individuals. Following in the footsteps of Aldo Leopold, Callicott (1980) claims, in particular, that the *summum bonum* (i.e., greatest good) is the "land" and that an environmental ethic must provide environmentalists and conservationists with grounds for managing exotic, over-abundant, and problematic species - even when this involves killing, and otherwise harming, individuals.

While one can imagine a non-anthropocentric utilitarian environmental ethic, there can be no such thing as a holistic utilitarian environmental ethic. Utilitarianism is necessarily individualistic because only individuals can experience pleasure and pain or satisfy their interests. Environmental and utilitarian ethics have, therefore, become antithetical in proportion to the degree to which environmental ethics has embraced holism.

In Defense of a Utilitarian Environmental Ethic

Human beings and other sentient organisms depend on the ecological services natural environments and wild organisms provide. Natural systems and wild organisms regulate climate and biogeochemical cycles, are an important source of food, produce and protect fertile soils, pollinate crops, produce pharmacologically active compounds, control pests, and increasingly serve as a source of unique genetic material. The estimated economic value of all these and other ecological services easily exceeds the world's economic output (Myers 1996, Costanza et al. 1997) and, because many natural services and products are non-substitutable, the instrumental value of wild organisms and natural areas is, for all practical purposes, infinite. Given the dependence of all sentient life on the ecological services natural environments and wild organisms provide, an ecologically-informed utilitarian ethic must, in some sense, be an environmental ethic. To be taken seriously, however, proponents of utilitarianism must respond to a handful of claims environmental ethicists have made regarding the nature of utilitarian ethics. In particular, proponents of utilitarianism must address claims that utilitarian ethics:

- Are inherently anthropocentric and/or sentientist,

- Ignore the rights and/or intrinsic value of other species and biological entities, and
- Justify environmentally destructive policies by making sentient individuals, rather than species and ecosystems, the locus of moral concern.

The claim that utilitarian ethics are anthropocentric constitutes a valid criticism of the way utilitarian ethics have generally been applied, but a utilitarian ethic that recognizes the pain and suffering of *all* sentient organisms does not arbitrarily favor humankind. Utilitarians were, in fact, ahead of their time in recognizing the moral standing of other animals (Bentham 1823), and have denounced anthropocentrism (i.e., "speciesism") (Singer 1974, 1975).

It is certainly true that utilitarian ethics ignore the rights and intrinsic value some ethicists believe insentient life forms possess, but this might well be considered a virtue of utilitarianism rather than a liability. Utilitarians can, of course, recognize legal rights and value species, ecosystems, etc., intrinsically - in the sense of valuing these entities for what they are and "as is." Ethicists that wish to go further and appeal to "natural rights" or "intrinsic value" in order to establish the moral standing of insentient entities have the burden of proving that such rights and/or values actually exist, are identifiable, and are of a very special kind. Insentient entities must be shown, that is, to have the same kind of rights and/or value that other entities with moral standing have (e.g., human beings). Demonstrating the existence of such rights and/or value has proven to be a difficult problem for environmental ethicists and they have largely failed to convince policymakers that trees, microorganisms, and communities have rights, or the kind of value that makes them legitimate objects of direct moral concern. Furthermore, no proof of such rights and/or value seems possible.

The assertion that utilitarianism can justify policies that environmentalists disapprove of has been made by ethicists claiming, in particular, that a utilitarian interest in individual welfare conflicts with an environmental interest in species and ecosystems. Callicott (1980), for example, argues that the holistic ethic he endorses is superior to the sentientist ethics of utilitarianism because the practitioners of the latter ethic would be prohibited from culling deer to protect sensitive ecosystems. A utilitarian environmental ethic would not, however, prohibit culling when the intended purpose is to promote the aggregate welfare of the population in question and/or to protect the ecosystem upon which the welfare of sentient beings depends. Wildlife managers would only be required to minimize suffering by employing the most humane methods at their disposal. The land ethic Callicott favors places no such demands on wildlife managers, but it is difficult to see how this difference might be construed as commendable.

The above-mentioned claim takes many other forms and it is also argued, for example, that those interested in the pain and suffering of individuals would have to abstain from hunting, condemn "merciless" predators, guard the lives of wild animals, and liberate domesticated animals (Callicott 1980, Sagoff 1984). Such claims ignore the instrumental value of healthy environments, however, and can only be derived from a superficial characterization of utilitarian ethics (This point is convincingly made by Varner, 1995). Critics of utilitarian ethics are not confined to the ranks of environmental ethicists and some educators may object to teaching utilitarianism on the grounds that it is flawed in ways that have little or nothing to do with environmental issues. A thoroughgoing defense of utilitarian ethics is beyond the scope of this paper, but it should be pointed out to the critics of utilitarianism that utilitarian ethics continue to be applied to a diverse array of 21st Century problems, including ethical problems encountered in public education, medicine, bioengineering, law, and economics. In all of these fields, utilitarianism has its proponents and utilitarian arguments are common.

Contemporary Environmental Ethics as a Problematic Alternative to Utilitarianism

Environmental ethicists have encouraged a vigorous and healthy debate regarding the attributes of a satisfactory environmental ethic, but no consensus has been reached concerning the specific nature of such an ethic and no single theory is widely accepted, even within the discipline.

Educators should recognize that environmental ethicists encounter both practical and philosophical problems when they attempt to make insentient beings the subjects of direct moral concern. As a practical matter, it is difficult to demonstrate that the moral standing of trees, insects, and bacteria can be established in time to prevent a significant worsening of the current environmental crises, given that the vast majority of Americans hold views that have been shaped by Christian theology and the

anthropocentric ethics of Locke, Mill, Kant, and Descartes. As a philosophical matter, it is hard to argue that the interests of humans are no more important or of no greater moral concern than the similar interests of a tree or bacterium, but when moral standing comes in different colors or degrees, its meaning becomes vacuous and problematic. Does it mean anything to say, for example, that a tree has moral standing if it can justifiably be cut down to eliminate a threat to human life or to provide a family with firewood?

The only way to prevent a hierarchy of moral standing from developing and trivializing what it means to have standing is to treat the interests of all organisms, including human pathogens, equally. No ethicist is prepared to treat the "interests" all organisms have in living, etc., equally, and environmental ethicists have been forced to acknowledge that certain human interests must outweigh the interests of other life forms, including their interest in survival (e.g., Callicott 2003, Eckersley 1998).

The commitment to holistic entities in environmental ethics (e.g., species and ecosystems) also introduces what appear to be intractable practical and philosophical problems. Although holists acknowledge that we have duties to humans that can trump our duties to species and communities, the implications of a holistic approach to ethics cannot be escaped. All holistic ethics place the good of the whole (i.e., community, state, etc.) ahead of the welfare of individuals. In this respect, they resemble classically fascist doctrines that emerged in the mid-20th Century. Not surprisingly, environmental holism has in fact been dubbed "environmental fascism" (Regan, 1983).

Holistic ethics represent a radical departure from the normative ethics of human rights and concern for the welfare of individuals, and convincing the public that such a radical departure is ethically mandated presents enormous practical difficulties. There are also no holistic principles or rules for establishing the relative worth of different ecosystems is committed to an ethical position the validity of which cannot be objectively demonstrated. Unless all parties are willing to accept that such value exists, as a matter of faith or intuition, staunch advocates of intrinsic value theories can only presume to hold a superior moral position. Furthermore, even if it is agreed that species, etc. possess some form of intrinsic value, it must be demonstrated that such value is morally relevant or should be preserved. As noted previously, this has proven to be difficult.

Assuming insentient organisms, species, etc. are intrinsically valuable, there is still no logical way to define the nature of intrinsic value so that the concept is not eviscerated, at least as a practical matter, by the development of a hierarchical value system. Assuming all organisms have intrinsic value, the eradication of pathogenic organisms can only be condoned if certain human interests and values are placed ahead of the "interests" and intrinsic value of other species. As Regan (1992) has pointed out, such a hierarchical concept of intrinsic value is indistinguishable from the concept of instrumental value. Any hierarchical value system is also necessarily anthropocentric because humans must, by

species or ecosystems, but to argue that a one-acre pond on "the back 40" is as morally important as a similarly-sized hot spring in Yellowstone would strike most Americans as absurd. To argue otherwise reintroduces a host of problems that are encountered when moral standing comes in differing degrees or is only recognized under certain conditions.

Any ethic that emphasizes the "interests" of species, communities and ecosystems may also rest on a shaky foundation because these are incorporeal entities (i.e., they are scientific abstractions). Such entities have no natural or clearly defined boundaries in time or space, and terms like *species*, *community*, and *ecosystem* are difficult, if not impossible, to precisely define.

Even if it is agreed that species, communities and ecosystems exist in some real sense, it is entirely unclear what "interests," if any, they might possibly have. It is also unclear how the extinction of a species can be regarded as unethical when the killing of individuals is not, without appealing to human values and utility. The loss of a species represents the loss of a unique assemblage of genes, but this is also what is lost when individuals and populations are destroyed. The difference is one of scale.

The value of species to communities and ecosystems is certainly greater than the value of individuals, but appealing to the ecological importance of individual species is problematic. Not all species are likely to play a crucial role in the functioning of ecosystems and some species may be ecologically interchangeable. Even when a particular species plays a vital role in a community or ecosystem, it is impossible to say that its removal is good or bad without appealing to human values and/or ascribing to questionable beliefs concerning the nature of biological communities and ecosystems.

The recognition of intrinsic value in environmental ethics creates further difficulties. An environmental ethic based on the intrinsic value of insentient organisms, species, communities and/or

default, construct the hierarchy of intrinsic value or the rules allowing for dissimilar treatment.

Not all environmental ethicists believe that a valid environmental ethic must be non-anthropocentric, holistic, or embrace the concept of intrinsic value. These are dominant themes in environmental ethics, however, and the lack of consensus only highlights the fact that there is no widely-accepted alternative to a utilitarian environmental ethic.

Conclusions

The environmental challenges today's students will face are truly daunting, and a strong environmental ethic, capable of discouraging destructive environmental policies, is desperately needed. Unfortunately, environmental ethicists have not yet produced a widely-accepted "environmental ethic" policymakers can fruitfully apply to the variety of "real world" problems they face, and it is still unclear what the attributes of such an ethic should be.

The majority of environmental ethicists appear to believe that a *true* environmental ethic is one that makes other organisms and/or holistic entities, like species and ecosystems, subjects of direct moral concern. This definition has helped to establish and define the scope of environmental ethics as an academic discipline, but it is too narrow to serve the present and future needs of environmental advocates and policymakers. It is also alienating, and environmental biology programs that are dominated by such a view not only risk producing graduates that are ill-prepared to participate in public policy debates, they risk losing potential students and collaborators with an interest in law, economics, civil engineering, etc. As Soule and Press (1998) have pointed out, mainstream neoclassical economists, for example, are rare in environmental studies programs, and this is probably because they find their views and those of their peers and professors ideologically incompatible.

Environmental ethics should not be shaped by practical concerns alone, but arguments that appeal to the moral standing of trees, species and ecosystems have not proven themselves to be logically superior to their more traditional alternatives, and should not be taught as such.

Many environmental ethicists and educators unjustly equate anthropocentric ethics and utilitarianism, in particular, with destructive environmental policies and methods of valuation that lead to environmental degradation. This is extremely unfortunate because traditional utilitarian and rights-based ethics can be used to reject the very practices they are often blamed for endorsing, and resonate with most Americans. When anthropocentric arguments are used to defend destructive and unsustainable environmental policies, the benefits to humans are nearly always exaggerated and/or the costs of environmental degradation to present and future human beings are underestimated. This being the case, such policies can usually be shown to be unethical from a utilitarian perspective.

In many environmental studies and policy classrooms, utilitarian ethics are unquestionably discussed in a fair and unbiased manner, but the tendency to associate utilitarianism with environmental problems and "environmental ethics" with their solutions is too often readily apparent. In one otherwise well-written environmental studies textbook, for example, the "western worldview" is described as "human-centered and utilitarian. It mirrors the beliefs inherent in the 18th Century frontier attitude" and is associated with "a desire to conquer and exploit nature as quickly as possible." The same textbook goes on to describe the principles of deep ecology in panegyric terms. "Deep ecology stresses harmony with nature," and a "respect for life" (Raven & Berg 2004). Another popular text claims that the "ecocentric environmental worldview is the environmental wisdom worldview" and differs from the "planetary management worldview" in holding that some forms of economic growth are environmentally harmful and should not be encouraged; inaccurately implying that ecologically enlightened homocentric views fail to recognize this fact (Miller, 2003).

The field of environmental ethics is fecund, exciting, and unquestionably important, but it is also nascent, fluid, experimental, and apparently incapable of providing near-term solutions to the ethical dilemmas attendant to modern environmental problems. Its failure, as a practical discipline, is an admitted source of concern to many environmental ethicists and the direction the field has taken over the last 30 years is now being extensively reevaluated from within. Our academic institutions need to recognize that this process will take time and that a genuine environmental ethic should and must be defined, for now, in broad enough terms to include utilitarianism.

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Guided Inquiry and Social Collaboration in an Online Classroom

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Abstract: The topic of inquiry is explored in an online freshman level introductory biology course for non-majors. The research took place in a distance learning program at a small community college in the Southeast. Students in the course were required to complete an extended guided inquiry in their homes and to communicate about their work by way of the class discussion board. Extensive social collaboration among the members of the class is documented. The students' work is analyzed qualitatively in terms of their research questions, hypotheses and process skills. A consideration of how the students evaluated the scientific validity of their own work is included.

Keywords: Online biology instruction, web-based teaching, inquiry, distance learning

Introduction

As a pedagogical practice *inquiry science* first came to prominence in American schools in the 1960s. The concept of teaching science by way of experimentation was certainly not a new one. Yet, the overall philosophy behind inquiry-based science instruction began to be systematically paid attention to in a way that was unrivaled at the time (Shymansky, Hedges & Woodworth, 1990; NRC, 2000). The philosophy is quite simple. Students will have a deeper understanding of how science works and how scientists do their jobs if they engage in some of the same *process skills* as professional scientists (Roth, 1995; Enger & Yager, 1998; Martin, Jean-Sigur & Schmidt, 2005). This, it has been widely argued, will foster a deeper level of scientific literacy at all levels of education (AAAS, 1993; NRC, 1996; NRC 2000; Sibert & McInthos, 2001). For example, students may be better equipped to evaluate scientific claims that come to them through the popular media if they have had actual experiences with scientific inquiry. In other words, they may become a more critical consumer of scientific information.

Inquiry based science instruction encompasses a wide range of levels. The experiences that most closely match the work of an actual scientist are known as *open inquiry* (Roth, 1995; NRC, 2000). There are those that argue that "it isn't inquiry" unless it is entirely, or nearly entirely, student directed. Proponents of such open inquiry believe that, in order for a student to fully experience the process of doing science, they must decide their own questions, methods, procedures, etc. This form of inquiry is certainly worthwhile and valuable. Yet, other forms of inquiry exist as well. Certainly even the staunchest of inquiry purists are not naive enough to believe that scientists always direct their own thinking. Many well paid, well respected professional scientists are often told by the people who sign their paychecks what they should research, and often how and when.

A lot of labels have been offered in the literature to describe those forms of inquiry that are not entirely open. In many cases, for example, a teacher may provide a research question to his students. Also, a set of materials may be provided and the question or direction of the research left to the discretion of students. Bell, Smetana & Binns (2005) have recently suggested that the widely used term *structured inquiry* should be reserved for situations in which students are provided with both a question and a method, while *guided inquiry* should be applied to those situations in which only a research question is supplied. Other writers use these same terms, as well as many additional ones, in slightly different ways.

In adult science education, there is also an emphasis on inquiry and a call to help college science students develop an understanding of how science works (Sibert & McInthos, 2001). As anyone who is involved in college level science instruction knows, there has also been an explosion in science courses offered by way of distance learning formats, particularly internet-based ones (Collins, 2000;

Kriger, 2001; Skinner & Hoback, 2004). Some involve library and/or internet research. As noted by Bell, et al. (2005) such research clearly does not represent genuine scientific inquiry. Many college textbook publishers have pursued "virtual labs." Sadly, many of the pre-packaged course cartridges and curricula for online biology instruction feature ostentatious computer simulations that offer students practically no opportunity, if any, to experience real science. Recent research has called the effectiveness of many such programs into question when matched against the current reform movements that intend for students to experience real science as part of their overall preparation to become scientifically literate (NRC, 2002; Sibert & McInthos, 2001; Brickman, Ketter & Pereira, 2005). The most terse and noteworthy argument against heavy use of such simulations may have been summed up by La Velle (2002): "*It just isn't real.*"

This paper explores the challenge of inquiry in online biology instruction. The author has been a community college biology instructor for more than 12 years. Several months ago, he designed and delivered his first online biology course for non-majors. The goal was to provide quality instruction that matched a traditional, seat-based course (Lunsford & Bolton, in press). In the current study, pedagogical processes and student outcomes involving a guided inquiry activity that the students completed at home were analyzed. It is hoped that this paper will assist other reform-minded biology teachers who are involved in, or who are considering, biology instruction by way of a web based delivery system.

Methods

Thirteen students enrolled in a freshman level biology course for non-majors comprise the research participant population. The class was offered by a small community college in the southeastern United States. Enrollment at the college typically averages about 2,000 students. The college continues to experience growth in terms of its distance education offerings. At the time of this study, the only science course offered in an online format at the school had been a chemistry class. Students came to campus to complete lab. The freshman level biology class that is the subject of this writing offered lecture and lab in a distance learning format. With the exception of one lab activity (microscopy) completed with an off-campus laboratory mentor, and two summative examinations taken with a test proctor, the entire course was completed online. Topics in the course included nature of science, cell biology, ecology, genetics, evolution, metabolism, chemistry and others typically teachers opt for "lab activities" that exclusively encountered in an introductory college biology course. Students completed a total of 15 laboratory activities. One of the labs, a guided inquiry involving metabolic activities of the common yeast, *Saccharomyces cerevisiae,* is the subject of this paper. Data sources include the class discussion board responses and laboratory reports of all 13 students. Data were analyzed in terms of the social collaboration among the students and teacher as well as the ways in which the students posed research questions, developed hypotheses and made conclusions. All participants provided informed consent.

To initiate the guided inquiry all students were asked to do some background reading in their textbook about metabolism, particularly focusing on cellular respiration in both aerobic and anaerobic situations. As an extension of their reading, they were asked to locate text or internet information about metabolism in the organism commonly known as "baker's yeast" or "brewer's yeast," *S. cerevisiae.* Practically every biology teacher has seen, at one time or another, the classic experimental set-up for collecting carbon dioxide from a yeast culture shown in Figure 1.

Figure 1: A simple apparatus made of a bottle, balloon and tape used to capture carbon dioxide for quantification during the guided inquiry. Photo by Brian Guercio.

The author felt that this simple but easily inquiry that students could set up at home while interacting by way of the class web page. Students were shown an image similar to Figure 1 to initiate the activity and to acquaint them with the set-up to collect carbon dioxide. They were also provided with written starter instructions.

> In this activity, your dependent variable will always be the measured height and/or diameter of the balloon. Decide on possible independent variables (experimental variables or treatments). Possibilities include, but are not limited to, type of food, amount of food, color of culture bottle, temperature of culture, etc.

As part of their grade for the activity, each student was asked to provide a list of at least five potential research questions on the class discussion board. Further, they were asked to respond to at least two of their classmates' postings. Once the research questions and posts were completed, participants were asked to select a question and write a hypothesis. Additional postings by the class and teacher helped students to hone the hypotheses. In turn, potential methods were posted in the same fashion. Finally, students were asked to run at least one experimental trial and briefly summarize the results. Additional class discussion about each student's results was pursued as described above. Discussion board entries accounted for 40% of each student's grade for the lab. Finally, students were asked to write a detailed research report, formatted like a professional research paper, about their inquiry. This report rounded out the remaining 60% of each student's evaluation.

The student's research questions were categorized into three groups based on the work of Scardamalia & Bereiter (1991; 1992) and Roth & Bowen, (1993). While these researchers dealt mostly with middle-school aged students, their system of categorizing science questions asked by students can be valuable at any level of education. In summary, students may ask (1) basic information questions that are most efficiently answered by way of text and/or library research, (2) wonderment questions that feature a level of curiosity beyond what is readily accessible by text-based (or internet-based) research or (3) covariation questions that are most similar to those asked by practicing scientists. Such questions most often link two variables, the manipulated and the measured.

Next, students' hypotheses were evaluated in terms of scientific soundness (i.e. were they specific, testable and empirically based). Finally, all quantifiable activity could form the basis for a guided students' conclusions were evaluated in terms of if and how well they were based on evidence, and whether and how the students dealt with replication and sample size issues in their conclusions.

To illustrate social interactions among the students and teacher (the author), two students were randomly selected from among the group. Their discussion board entries and research papers were utilized as a source of illustrative quotations in the analysis.

Results

Over the course of 14 days, 260 discussion board entries were produced by the participants and the instructor. The instructor tried, whenever possible, to let the students assist one another with development and improvement of their questions, methods, etc. He would often ask guiding questions and/or explicitly tell students to implement the next step in their inquiry process (ex. accept their hypothesis and ask them to propose a method). He made an effort to structure his questions and comments in a way that would, hopefully, assist the participants in evaluation of the work of their peers.

The participants collectively generated 64 potential research questions. Of these, 61 were detailed enough to be categorized by the author as covariation questions. The remaining three were counted as wonderment questions. Randomly selected examples of questions posed by the participants, as well as related discussion board responses are shown in Tables 1 and 2.

With regard to hypotheses the participants stated, two were judged incomplete by the author. Kevin (all names are pseudonyms) failed to explicitly state a hypothesis but gave enough information for the hypothesis to be inferred (see Table 3). The resulting discussion also led to an exploration of the notion of "operational definitions" and "sample size" in the context of their importance in science. In the second case, the student (Ellen) was not detailed enough in her hypothesis to allow the reader to imagine an experimental design. She hypothesized that "since apple juice is used in fermentation and cider, I believe that it will have a faster metabolic rate than other juices when yeast is added." This hypothesis does not specify which "other juices" would be tested or mention a control. Yet, Ellen sought out help from the teacher on this point. Additional class discussions helped this student to modify this hypothesis to produce a clear, testable statement. See Table 4.

Table 1. Anita's Potential Research Questions and Class Discussion

Anita's questions: (note: all names are pseudonyms)

1. Would the metabolic activity rate be different using a powdered sugar than using regular granule sugar?
2. What effects would adding fruit, such as a raisin have on the metabolism?
3. Would the metabolic activity rate be different using purified bottle water versus tap water?
4. Would the metabolic activity rate be different using juice from concentrate versus freshly squeezed juice? (ex: orange juice)
5. Would water temperature affect the metabolic activity rate?

Royce to Anita:
I would try to narrow the fruit down to a certain kind of fruit, because some fruits are high acidity [sic] and others are not and that would make a huge difference in the outcome of your experiment.

Joe to group:
Why not try a set of different fruits?

Lillian to Anita:
I think your #4 was an interesting question. Using concentrate juice vs. fresh squeezed juice. [sic] Would you use concentrated juice without added sugar, or would you use the regular concentrate where the manufactures add sugar?

Anita to Lillian:
Good question Lillian. I think I would use the concentrate where the sugar is added because then both the bottles to compare would have sugar (though maybe different amounts), and the test would better compare fresh versus concentrate rather than dealing with the sugar effect. Does that make sense?

Teacher to Anita:
…another great set of questions from Anita. Please move to step 2; try to select one question and design a hypothesis.

All other hypotheses written by the participants varied widely in quality. However, they were all clearly stated and testable. The two students randomly selected to represent typical examples (Janette and Anita) based their hypotheses from their list of questions (Tables 1 and 2). The discussions of their hypotheses are replicated in Table 5. Table 6 provides a summary of each student's inquiry in terms of the question they pursued, how they dealt with replication and sample size, and how each student summarized the outcome of their inquiry. It should be noted that, despite recommendations from their peers and from the teacher, students engaged in this activity were free to construct their experimental design as they chose.

Table 2. Janette's Potential Research Questions and Class Discusssion

Janette's questions: [sic]

1. In random types of food sources, does time of fermentation (30 minutes versus 2 hours) effect the metabolic activity rate?
2. Will the metabolic activity be effected differently in different temperatures (room temperature, refrigerator, warm oven or freezer)?
3. Does the amount of sugar in a [a commercial gelatin desert] effect the metabolic activity rate differently than sugar free [commercial gelatin desert]?
4. Does the sodium content in salty peanuts versus salt free peanuts effect the metabolic activity rate?
5. Does the color of the container used effect the metabolic activity rate differently than a clear container.

Ellen to Janette:

I think the [gelatin desert] and the peanuts are very creative. Would you have to crush the peanut to maybe get a better test than a whole peanut?
Teacher to Janette:

Any of these would be very interesting. You've come up with some unusual (but neat) questions. Please try to select 1, go to step 2 and come up with a good hypothesis. Thanks.

Table 3. Excerpts of a Discussion between Kevin and the Class about Hypothesis and Operational Definitions.

Kevin's Questions: [sic]

1. Will there be a difference in the metabolic activity rate in regular juice versus sugar free juice?
2. Does light or darkness effect the metabolic activity rate?
3. Will the metabolic activity rate be different depending on the brand of yeast chosen?
4. Does the amount of the food source used versus the amount of yeast used effect the metabolic activity rate?
5. Does temperature effect the rate of metabolic activity?

Teacher to Kevin:
Please refine your question and state a detailed hypothesis with operational definitions. In other words, leave nothing open to the imagination. For example, when you say "temperature" or "darkness" what does that mean?
Kevin to Teacher:
The variable is actually light. What I have done is take the same color bottles with the same amount of yeast added to each. I have placed one under a constant light, source, one in complete darkness, and one which is exposed to light and darkness.
Ellen to Kevin:

I like the light and darkness effect. One bottle always in the dark at all times, one in light. Say 4 hours a day, 8 hours a day. I am not sure how many bottles you may want to test.
Teacher to class:

Ellen, your comments to Kevin bring up a very important issue or two. One issue is sample size and replication. As we've studied in Unit I, the larger the sample size the better. When it comes to inductive logic and making generalizations, the more samples we have (and the more times we've repeated an experiment) the better and more scientifically sound our arguments become. Of course there is no correct answer to how many bottles. Two is better than one; three is better than two. Also, everyone be sure to think about the issue of control in your future experimental set ups.
Kevin to class:

I thought I'd mention that all of the bottles are in the house so they are always exposed to the same exact temperatures.

Table 4. Ellen's Request for Help with Her Hypothesis and the Resulting Discussion

Ellen's Hypothesis:
Since apple juice is used in fermentation and cider, I believe that it will have a faster metabolic rate than other juices when yeast is added.
Ellen to teacher:
What do you think I could use as a control in this group professor? I don't know what to do.
Teacher to class:
…[based on Ellen's post] here are some questions I'd like **everyone** to consider. Please consider the following. (1) Ellen thinks apple juice + yeast will produce more carbon dioxide (or the same amount more quickly) than will both grape juice + yeast and orange juice + yeast. (2) Obviously, Ellen will compare the grape/yeast and orange/yeast against the apple/yeast. (3) What could she compare the apple/yeast against for a control to be more sure that addition of yeast made the difference?
Lillian to class:
To see if the yeast made any difference to the apple juice she could just do apple juice without any added yeast in one bottle, but because her hypothesis is comparing the apple juice to other juices, then would her control not be the apple juice/yeast mixture and the comparison to the other juices?
Teacher to class:
Good thinking [Lillian]! I would like to see both of these controls. If there is a difference in the apple juice/no yeast and the apple juice/yeast, then I think she could better compare the apple juice with the other juices.

Table 5. Class Discussion of Anita and Janette's hypotheses

Anita's hypothesis:

The bottle with the lemons would produce the most metabolic activity, followed by the one with the raisins and the "plain" one would produce the least activity. My control would be the plain bottle because I would be testing the "food" items against it.

Teacher to Anita:

This sounds good but I'd like to clarify about the control you've proposed. I understand that you'll not add fruit to it but will you add yeast? Please let me know as you describe your method in Step 3. Be very specific about amounts, time, etc in your procedure.

Anita to teacher:

…what I propose is to put yeast, water, sugar, all of equal measures into the containers, but only add raisins to one and lemons to the other.

Teacher to Anita:

Sounds good! I think you can go ahead to step 4, keeping in mind a "time" for the experiment to be declared complete.

Janette's hypothesis:

I believe that the metabolic activity will be different in the different temperatures. I predict that the activity rate will be slowed down to a near stop in the freezer and the activity rate will speed up in the heated oven. The controls will be the size of the containers, the amount of yeast and water in the container and the amount of time exposed to each temperature.

Joe to Janette:

Sounds like a good plan. I'm not sure how well the balloon and plastic bottles will do in the oven.

Teacher to Janette:

Joe's comments may be something to think about. Also, I think your control should be the room temperature environment. Please go ahead with your method, carefully describing what you'll do.

Table 6. Comparison of All Students' (n = 13) Experimental Setup and Conclusions

NAME OF STUDENT	**Research Question: "___ CO_2 production by yeast?"**	**# of replicates (sample size)**	**# of trials**	**Student's Comments on Outcome & Hypothesis**	**Noteworthy student comments or actions if applicable**
Anita	Will adding fruit to sugar water mixture increase	1 per 2 treatments and control	1	"…partially disproved..." [fruit added increased but neither fruit performed better]	"This experiment could be repeated to verify results. I am not certain any gas did escape."
Ellen	Will apple, grape or orange juice influence	1 per 3 treatments & 3 controls	1	"…disproved…"	Says one juice must have had more sugar than predicted
Helen	Will saltine (containing less sugar) or snack crackers (containing more sugar) increase	2 per 2 treatments but had no control	2	"I think this experiment proved…"	Increased amount of food & yeast in second trial.

Table 6 continued.

Janette	Do extreme temperatures effect	1 per 3 treatments & control	2	"…supported my..."	
Jeanne	How does water temperature affect	1 per 2 treatments & control	1	No explicit statement from student about hypothesis	"I observed that the warmer the water temperature the greater the reaction in the yeast fermentation."
Joe	How does light affect	1 per 3 treatments & control	2	"the second trial did support…"	Says balloons in first trial may have been damaged when setting up experiment so thicker ones were used in second trial.
June	How do various temperatures influence	2 per 3 treatments & control	1	"I found that [treatment 1] has the best effect…makes the metabolism rate increase rapidly."	
Kevin	Does light intensity influence	1 per 2 treatments & control	3	"I was not able to verify…because I was unable to successfully conduct the experiment."	The instructor believes that this student used too low a water temperature during the first 2 trials and then confused Celsius/Fahrenheit scales during the third trial and used boiling water.
Lillian	Will table sugar, brown sugar or an artificial sweetener affect	2 per 3 treatments & control	1	"The results of my procedure did not give a clear conclusion."	Student recommended repeating with a longer experimental trial
Mary	Does food coloring, especially dark colors, increase	1 per 1 treatment & control for trial 1; 1 per 4 treatments & control for trial 2	2 but arguably, each was a different experiment.	"my…did not fail."	
Rosa	Will fresh or shelf-life expired yeast influence	1 per 1 treatment & control	3	"…trial supported…Does lead me to believe that…was correct."	"However, outside variables such as room temperature and human error in measurement were not taken into consideration."

Table 6 continued.					
Royce	Will carbonated water cause increased	1 per 2 treatments & control for trial 1; changed control for trial 2	2	"…did not prove…" [first trial] "…have proven…" [second trial]	"[based on advice from the class] I added a control to my [second trial]; adding of a bottle of carbonated water without the yeast to see if it worked strictly off of the CO_2 or if yeast help accelerate the production of CO_2. With the second experiment I also changed the size of the bottles."
Wenona	Does agitation of culture increase	3 per 1 treatment & control	1	"…results did not support…"	"If the cultures had been agitated for a longer period of time, giving the yeast a chance to mix with the sugar source, then I believe that the results would have been a little different. Reproducing the experiment and incorporating a longer agitation time could test this further. "

Discussion

It is clear that use of the discussion board on the class web site can provide substantive dialogue among the class members. This paper reproduces only a few of the 260 discussion board entries from the activity (See Tables 1 – 5). Yet, this small sample demonstrates that the class collaborated heavily about their on going inquiries. They evaluated ideas and made suggestions to one another throughout the process. This notion of "science talk" as it has sometimes been called is regarded as typical in actual scientific practice. Reformists and researchers alike contend that such discussion of problems, results and difficulties encountered during inquiry in classrooms are an integral part of the overall experience of "real science" (Roth, 1995; NRC, 1996; NRC, 2000). Regarding college level biology instruction in distance learning formats specifically, Colling (1997) noted the need for heavy social interaction in order to make the experience successful. So, students who pursue inquiry in online courses have no need to work in a vacuum. With careful planning, social collaboration can be readily fostered in such environments.

There was a high level of covariation questions posed by the participants. Both Scardamalia & Bereiter, (1991; 1992) and Roth & Bowen, (1993) report that these types of questions are rarely generated by science students and that they are much more typical of the sorts of questions asked by practicing scientists. The high incidence of covariation questions from participants in this study may best be explained by the fact that students were given an explicit dependent variable ahead of time and were asked to brainstorm things they could manipulate (independent variables) to change this measured variable. This practice may, of course,

displease open inquiry purists but it seems to be highly appropriate in the context of a guided inquiry. The online discussion board can be as effective as a traditional classroom discussion in allowing teachers and peers to critique wonderment questions and lead students to pose a "cause and effect" covariation question instead.

As noted in the Results, above, only two hypotheses made by the participants were judged as scientifically unsound. In Ellen's case (see Table 4), she simply was not detailed enough to readily allow an experiment to spring directly from the hypothesis. She also asked for help with a control. The teacher and a classmate were able to help Ellen reason through the process to form a more detailed experimental plan. In the case of Kevin (Table 3), the instructor was only able to assume an implied hypothesis from Kevin's limited discussion board postings. In hindsight, this was not a good practice. Kevin had tremendous difficulty with his experiment (See Table 6). He made very few of the required discussion board posts following the one reproduced in Table 3. In an actual classroom situation the teacher may have been able to monitor the implementation of his experiment more closely and help him past the difficulties he had. To alleviate problems such as these in an online setting, teachers may think about requiring more detailed posts about methodology or asking students to submit digital images of their experiment in progress. However, as in Kevin's case, if the student does not participate in these requirements, then they may fall through the cracks. Even in a traditional classroom setting, a teacher cannot force students into full participation during any activity.

As shown in Table 6, there was a wide range of success in how students dealt with the issues of control, replication and evaluation of experimental outcomes. Only one student, Helen, had no control for her inquiry. Students were explicitly taught the concept of experimental control prior to the beginning of the activity and the class dealt with the concept in the discussion board multiple times (see Table 4 for one example). Perhaps explicitly requiring students to describe the control in their experimental proposal could have alleviated this difficulty. Students showed a range of attentiveness to sample size and replication (Table 6). Jeanne, Ellen and Anita were very weak in this area. Not only did their experimental designs fail to include a sample size beyond one, they only did their experiments one time. Rosa had a sample size of one but did perform three trials with a consistent outcome.

With regard to evaluation of their hypotheses, based on their data, four of the students (ex: Royce and Helen) inappropriately used words like "proved" and "disproved" when speaking of their hypothesis and experimental outcomes. Lillian's statement that "The results of my procedure did not give a clear conclusion" was probably the most accurate of all. Students seemed too eager to draw definitive, black and white conclusions from their limited work. As noted by Lunsford (2002) interpretation of scientific data is a high-level cognitive skill with which students in a traditional classroom setting often have substantial difficulty. The author was encouraged to read words like "supported" in lieu of "proved" in some students' research reports. Also, it is of note that a few of the students identified problems with their experimental designs and/or noted the need for replication. Comments from Lillian, Rosa, Wenona and Helen (Table 6), for example, suggest that at least some students gained a more clear understanding of how science actually works.

Conclusion

Today the average adult clearly has a distorted view of how scientists do their work and how scientific knowledge is generated or constructed. Major reform recommendations put forth in the 1990s (AAAS, 1993; NRC, 1996) will hopefully change this view in the coming years. With the extension of calls to participate in socially based scientific inquiry for adult learners (Sibert, & McInthos, 2001), more attention has been paid to how college biology courses are delivered. Inquiry is a fun way to learn but it is a hard skill to master. Just as in regular classroom settings, students enrolled in online biology courses should have opportunities to design and carry out experiments and to talk about them critically. Distance learning students have the potential to participate in, and learn from, scientific inquiry like their traditional counterparts. In the absence of advanced equipment found in most biology labs, inquiries generated by online students may not be as sophisticated as those of traditional students. Yet they still can experience real science, even while working in their kitchens. Biology teachers may act as mentors by way of the classroom discussion board in an online setting, just as they do in person in a regular classroom. Again, the outcome may not be as sophisticated; yet, the mentoring is genuine. The results of this research clearly show that rich socially-based participation in scientific inquiry is possible in the modern age of online instruction. Teachers in these situations will experience the same sorts of successes, frustrations and failures as they do in a traditional classroom setting.

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Despotic Ducks

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Abstract: This field experiment is designed to test for despotic behavior in Mallards (*Anas platyrhynchos*), and to examine how ducks distribute themselves relative to their resources. Students present Mallards with food patches differing in profitability in order to examine whether ducks distribute themselves ideal freely or ideal despotically. Students also test whether foragers have equal competitive ability, and look for despotic behavior among individuals. Despotic behavior is when certain individuals monopolize resources and prevent others from gaining access to those resources. This exercise is designed to allow students to be involved in every step of the scientific process.

Keywords: despotism, foraging, ideal free distribution, despotic distribution, ducks.

Introduction

Often it is challenging to find field experiments that can be conducted in a reasonable amount of time, and that will provide useful data for analysis. Yet, students enjoy field experiments; and hypothesis-testing experiments enabling students to collect and analyze data provide students with valuable research experience (Darling 2000). This field exercise provides students with an opportunity to conduct a hypothesis-testing experiment, and analyze their results.

Fretwell and Lucas (1970) and Fretwell (1972) proposed the ideal free distribution (IFD) theory to explain how animals should distribute themselves within an environment containing patches of varying suitability. The ideal free distribution theory applies to situations when there is competition over a resource which is patchily distributed (e.g. food or mates) and the following conditions are met: 1) individuals are 'ideal' in assessing patch quality (i.e. they have complete information about the availability of resources), 2) individuals are 'free' to enter or leave any patch of their choice (there is no resource defense), 3) patch quality decreases with increasing competitor density, 4) all individuals select the most profitable patch while compensating for existing competitors in the patch, and 5) all individuals have the same competitive ability.

If these conditions are met, the IFD theory predicts that the number of individuals per patch will be proportional to the fraction of resources in that patch. The theory also predicts that the intake per individual will be equal across all patches.

According to the IFD theory, if there is a group of twenty-four ducks feeding in a pond that has pieces of bread distributed in two patches, and one patch has twice as many equally-sized pieces of bread as the other patch, you would expect that there would be eight ducks in the poor patch, and sixteen ducks in the rich patch. Furthermore, the IFD predicts that the food intake (number of pieces of bread consumed per duck) will be equal in both the rich and poor patches.

A number of studies have tested the ideal free distribution theory in a variety of species, and have found that animals tend to distribute themselves as predicted (Milinski 1979; Harper 1982; Power 1984; Godin and Keenleyside 1984; Gillis and Kramer 1987; Darling 1989; Baum and Kraft 1998). However, often individuals do not get equal shares of the resources. Often, dominant individuals obtain more than their fair share of the resources (Milinski 1979; Harper 1982; Desrochers 1989; Baum and Kraft 1998; Cresswell 2001). These dominant individuals may act as despots chasing subordinates away from the resources (Milinski 1979; Harper 1982; Desrochers

1989; Baum and Kraft 1998; Cresswell 2001). If some individuals behave despotically, then individuals are no longer 'free' to enter or leave any patch of their choice.

In contrast to the ideal free theory, the ideal despotic distribution assumes that individuals vary in their ability to obtain resources (Fretwell 1972). The best competitors are expected to occupy the most profitable patches and prevent others from gaining access to those resources. Thus, the ideal despotic distribution predicts variation in food intake between individuals (Fretwell 1972).

This field exercise is designed to examine how ducks distribute themselves relative to their resources (ideal freely, or despotically). In this exercise, students will present ducks with bread distributed into two patches (a rich patch and a poor patch, Figure 1). Students will test the prediction that competitors will distribute themselves such that the number of individuals per patch is proportional to the fraction of resources in that patch. Students will also test to see if the assumption of equal competitive abilities among ducks is met, and if despotism occurs in ducks.

Figure. 1. A test for despotic behavior using Mallard ducks.Ducks are fed equal sized pieces of bread in two patches of different profitability.One patch is a "poor" patch, while the other is a "rich" patch with twice the profitability as the poor patch.

Methods

use when conducting this experiment with ducks. Buy several loaves of bread. Cut each bread slice into pieces (use quarters if you don't have many ducks in your area, use eighths if you have a lot of ducks).

Experimental Design and Procedures

In my class, after I have introduced the students to the ideal free distribution theory and the ideal despotic distribution, I engage the students in a discussion about experimental design. Rather than give students the methods, I prefer to encourage the class to think about the issues involved with designing an experiment, and allow them to design their own field experiment. I have outlined questions and issues that the class should discuss below.

Field Location

Before conducting this exercise, the instructor needs to locate an appropriate field location. A local park, pond, stream or wetland area may provide a suitable location. Because ducks often aggregate in rural areas as well as in urban and suburban parks, this experiment works well in a variety of settings.

Mallards (*Anas platyrhynchos*) are a common duck species found in many locations, and work well for this experiment. It is not necessary to have a large population of ducks, but you will need approximately eight ducks. If you do not have a location with a duck population nearby, this exercise can be easily adapted to work with other bird species. For example, you could do this exercise in a park using pigeons as your study species, and using a large seed as your food (such as sunflower seeds or peanuts).

Time of Day

Students should discuss when the experiment will be conducted and how long trials will run. One of the assumptions of the IFD model is that the foragers are hungry. Therefore, students will get the best results if they conduct the experiments early in the morning, when the ducks are hungriest. This is especially true of park populations of birds that are fed, and become quickly satiated.

Food

The class should discuss the food type and quantity to be used. Have students prepare the food to be used ahead of time. Pieces of bread are a good food source to

The class should discuss the experimental design. What patch profitability ratio(s) will be tested? For example students could test a 1:1, 2:1, 3:1 or 4:1 ratio. Continuous input experiments work well (food is continually input into the two sides of the

pond at the appropriate ratios). For instance, the class would test a 2:1 ratio by throwing bread continually into the two sides of the pond: throwing in twice as many pieces of bread in the "rich" side as in the "poor" side. Perhaps students may decide that every twenty seconds they will throw ten pieces of bread in the poor patch, and twenty pieces in the rich patch.

What will the control be? The control should be the initial distribution of the ducks prior to throwing in food. When students first arrive at the study site, before conducting any manipulations, students should observe the distribution of the ducks for a set amount of time (perhaps five or ten minutes). During this control period, students should record the number of ducks on each side of the pond at regular intervals.

How many times will students replicate the experiment? Running replicates of the experiment over several days will enable the class to collect sufficient data to run statistical tests. Once a field location is selected, and the students have decided on an experimental design, they can begin collecting data.

What items and equipment will be needed? Students will need bread, stopwatches, tape measures, flagging, paper, and pens for recording data.

Helpful Hints

This experiment works best if the food does not become completely depleted; therefore it is best to choose a sufficient quantity of food for the population of ducks in your study area. It may take a little experimentation to determine the appropriate quantity of food.

Students should count out the appropriate number of pieces of bread and put them in Ziploc bags so that each time they need to add food, it is already counted out.

The pond should be divided in half. Students should measure the midpoint of the pond and mark it with visual markers that they can see (e.g. small pieces of flagging tape near the edges) so that when they are counting which side of the pond ducks are on, they will know where the midpoint is.

Time periods of five to ten minutes in length work well for the experiment. Time periods longer than this may result in ducks becoming satiated.

At each end of the pond two students could be responsible for throwing in the food. Students could work in pairs; one student could have a stop watch and let the other student know when it is time to throw in the food. Another two students (at each end of the pond) should collect data on number of ducks. Additional students can follow 'target' ducks to collect data on the amount of food consumed on each side of the pond.

If one of the desired outcomes is to conduct statistical analysis, then 8 to 12 replicates of the experiment is preferable.

Data Collection and Analyses

The instructor can lead students through a discussion of what data should be collected to test the predictions of the IFD theory and the ideal despotic distribution. Students should periodically (e.g. every twenty or thirty seconds) record the number of ducks in the pond, in both the rich and poor patch, during both the control and feeding periods.

Students should also record the number of food items consumed on each side of the pond for individual ducks. It probably will not be possible for students to record food intake for every duck. Therefore have different students randomly select several 'target ducks' to follow throughout each trial. For each target duck, students will want to follow the duck and record how many bread pieces that duck eats in the poor patch, and how many pieces it eats in the rich patch. Students should also record observations about despotic behavior. Are the target ducks chasing other ducks from the food? Or, are they being chased from the food?

Results and Discussion

This laboratory gives students an opportunity to statistically analyze data. I have conducted this lab in my class after students have been introduced to statistical analyses. The instructor can lead the students through a discussion of what results are expected.

Graphing the data will let students visualize whether the ducks distribute themselves according to the predictions of the IFD theory. Students can graph the results to observe if:

1) Ducks are distributed equally on both sides of the pond during the control period as expected.

2) The number of individuals per patch is proportional to the fraction of resources in that patch during the feeding period.

To address these two predictions, students can plot the mean number of ducks on each side of the pond for the control and the feeding periods respectively (see Figures 2 and 3).

Figure. 2. The mean number of ducks recorded in each patch of the pond (the left and right patches) during the control period of the experiment. Because no food is added to either side of the pond during the control period, it is expected that there should be approximately equal numbers of ducks on both sides of the pond

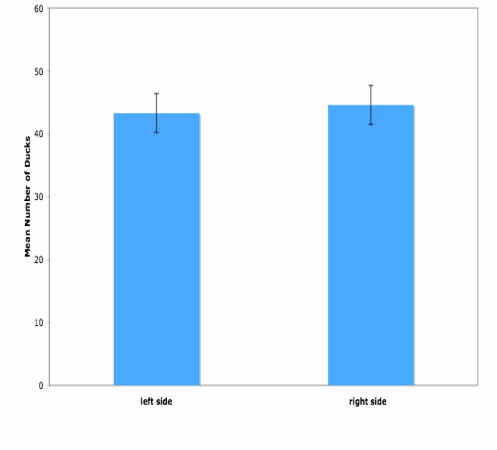
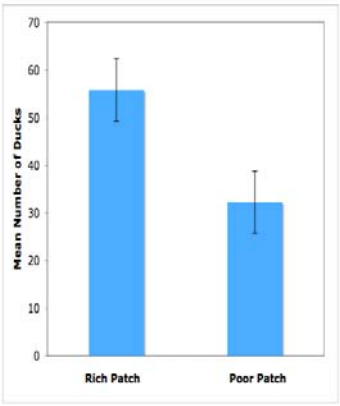


Figure. 3. The mean number of ducks recordedin each patch of the pond (the rich and poor patch) during the feeding period of the experiment. The rich patch contained twice as much bread as the poor patch. If the ducks behaved ideal freely, the expectation is that there would be twice as many ducks in the rich patch as in the poor patch.

number by performing a chi-square test.

3) The food intake per individual is equal across patches. To test this expectation, students can calculate the mean (mean ± SE)



Students can also graph the food intake per duck to examine if all of the "target" ducks have approximately equal competitive abilities or whether some ducks consume more food than others.

Students can statistically analyze the data to determine whether:

1) There were equal numbers of ducks on both sides of the pond during the control period as expected. To test this expectation, students can calculate the mean (mean ± SE) number of ducks on each side of the pond during the control period and compare the means statistically by performing appropriate statistical tests (e.g. t-tests or Mann-Whitney U tests).

2) The number of individuals per patch is proportional to the fraction of resources in that patch. To test this expectation, students can calculate the mean (mean ± SE) number of ducks on each side of the pond during the experimental period. The mean number of ducks can be compared to the expected

number of food items consumed on each side of the pond during the feeding period. The means can be compared statistically by performing appropriate statistical tests (e.g. t-tests or Mann-Whitney U tests).

4) The average food intake is equal among all ducks. To test this expectation, students can calculate the mean (mean± SE) total number of food items consumed (on both sides of the pond) during feeding periods by a given duck. The means for different ducks can be compared statistically by performing appropriate statistical tests (e.g. ANOVA or Kruskal-Wallis test to compare means).

Questions students can address include: Did the ducks distribute themselves according to the predictions of the IFD theory? If the ducks did not distribute themselves according to the IFD theory, why not? Were the assumptions of the IFD theory met? Were all ducks equal in their competitive ability, or were some ducks superior competitors? Were some ducks despotic, taking more than their fair share of the resources and keeping others away from the resources?

Students can present their results in written laboratory reports (in scientific format) and/or orally present their results. For lower division courses, students could write a shorter report by answering a series of questions provided by the instructor.

In conclusion, this field exercise provides students with an opportunity to be involved with designing and conducting an experiment, and analyzing and summarizing their results. Often it is challenging for instructors to find field laboratory experiments that involve testing a hypothesis. This exercise provides a hypothesis-testing field experiment that is fun to do and gives interesting results.

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Learning About Cells as Dynamic Entities: An Inquiry-Driven Cell Culture Project

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Abstract: Using cultured fibroblast cells, undergraduate students explore cell division and the responses of cultured cells to a variety of environmental changes. The students learn new research techniques and carry out a self-designed experiment. Through this project, students enhance their creative approach to scientific inquiry, learn time-management and group interaction skills, and communicate their ideas and results in written and oral form. A Likert scale pre/post assessment was administered for three semesters to determine changes in student attitudes.

Keywords: cell biology, cell culture, laboratory project, independent learning, inquiry-based project, fibroblast cells

Introduction

Helping students to understand and visualize function at the level of cells and molecules can be quite challenging. After all, students cannot see or touch a single cell without the aide of technology, nor can they open one up and look inside. As with many biological functions, we are restricted to what we can observe indirectly about cell function to help us understand these essential units of life. In our attempts to help students make the mental leap into the microscopic world of cell function, we have begun to use cultured cells during a sophomore level Cell and Molecular Biology (CMB) course. This paper outlines our approaches and techniques in using cell culture as a teaching tool in the hopes that others may also find it beneficial to their students. Similar approaches have been used in a summer biotechnology program (Lewis *et al.*, 2002) and in teaching apoptosis to advanced students (DiBartolomeis and Moné, 2003). Ledbetter and Lippert (2002) also report using cultured cells in a short-term laboratory project investigating membrane transport.

This laboratory exercise has been used at a liberal arts college with class sizes averaging about 24 students with approximately 12 students per laboratory section, but is appropriate for larger settings as well. As sophomores, most of the roughly 120 students who took part in the project in the last three years are not yet experienced with independent, critical thinking skills in a laboratory setting. They have taken a one semester introductory biology course, at least one semester of general chemistry, and sometimes have completed Genetics. In the sophomore level CMB course, we had two major concerns. First, when the course was initially designed, laboratory time was used primarily as a way to introduce techniques and classroom time emphasized content knowledge. With new instructors in the last several years, the course emphasis has been placed on helping students further their critical thinking skills through problem-solving, discussion, speculation about relationships, and reasoning. The laboratory portion of the course was lagging behind in those changes, still using primarily "cookbook" style labs. Second, students seemed to find CMB to be particularly difficult, apparently because it, along with Genetics, was the first course they encountered that required them to integrate mathematics, chemistry and biology. They also needed to use their imagination as they speculated about dynamic cells and molecules that are too small for them see. The laboratory portion of the course needed to be redesigned to help develop scientific thinking skills and to help students grasp the dynamic nature of living cells.

The specific goal of the project described here was to provide more opportunity for critical analysis, creativity, and independent thought during the CMB laboratory through the use of student-designed experiments with cultured cells. For overviews of reasoning behind the need to involve students in active, inquiry-based science projects as undergraduates, see National Research Council, 2003 and Rothman and Narum, 1999. In addition, we wanted to help students understand that cells are dynamic entities by working with living cells and to develop meticulous laboratory habits through the use of sterile technique and repeated

measures. The focus of the project was on the process of doing science in addition to learning content and techniques. Student research teams (see Wright and Boggs, 2002 for another approach to team learning in cell biology) were asked to come up with their own question, design experiments to answer their question, and then report their results to peers and faculty either as a scientific poster or paper. The only given was the mouse fibroblast cell culture model system.

We asked the following questions during the laboratory modification: Is it feasible to permit undergraduate students with no previous experience using cell cultures the opportunity to design and carry out their own cell culture experiments as part of a sophomore level core course in biology? Does the open-endedness of an inquiry-based cell culture laboratory put more responsibility on students to think about what they are doing and thus foster greater autonomy and better learning? In addition we asked: Do students have a better concept of cells as dynamic entities after working with cultured cells for several weeks? We will discuss the feasibility through an analysis of the time and costs involved. Data on attitudes and concepts of cell function were gathered through student surveys administered early and late in the semester as well as through our personal observations (see Angelo and Cross, 1993).

Methods

Overview

The cell culture project is incorporated into the semester beginning sometime between the fourth and eighth weeks of the thirteen week term. At that point, the students have discussed basic cell function, organelles, and the structure and synthesis of the major macromolecules. We are usually beginning to study membrane structure and function at this point in the term and have not yet gotten to the details of cellular respiration or to molecular processing and transport within cells. Working in groups of two to four students, the research groups are taught sterile technique, cell splitting, and counting (for instructional details, please e-mail the author). The groups are then asked to care for and observe their cells for about a week, during which time they should be discussing various options for research questions. Each group must present a short research proposal to the professor that includes a hypothesis, the reasoning behind that hypothesis, an overview of the data collection plans, a predicted outcome, and a list of needed supplies beyond those available to all members of the class. The students are then given three weeks to complete their project. Results are presented either in the form of a laboratory report or a poster.

Student Projects

As they consider their individual projects, most student groups discuss various ideas with the professors beforehand. We try to point out if a project is too ambitious or costly to carry out within the constraints of the class, if the students have a serious lack of control in the proposed experiment, or if the students have not considered how they will collect and analyze the data to draw reasonable conclusions. The greatest challenge is overly ambitious ideas, but we remind students that they have only three weeks to complete the project and that this is just one of the classes they are taking. Students also often need reminders that anything added to the medium must be sterile. By one week after the initial instructional laboratory session, each student group must turn in a short written proposal documenting their plans. That proposal includes a hypothesis and the reasoning behind that hypothesis, a list of any supplies needed including the source and cost, a summary of the research techniques including the number of flasks or wells to be repeated for each point in the dataset, what data will be gathered (visual observations, cell counts, viable cell counts, or some other variable), and predicted results, preferably in graphic form. The laboratory assistant helps the students in looking up items in biological and chemical supply catalogs and orders the things they have requested upon approval by the instructor.

During the three weeks of the project, no other formal laboratory sessions are held. Students frequently ask for assistance in determining if their cell cultures have become contaminated, in making and sterilizing things they wish to add to the medium, in determining how to use the 24 well plates, etc. Occasionally, a student group contaminates their cultures. The instructor splits a backup set of cells every few days to have a new stock available in those cases. The instructors and laboratory assistant also monitor how well the students are doing at keeping the work areas clean and whether more disposable supplies are needed. Our greatest challenges have been students failing to clean and put away the hemocytometers and students

trying to keep **all** of their cells when splitting rather than just keeping a few flasks for use (ending up with as many as 20 flasks in the incubator).

Assessment

One concern students often have is "How will I be graded?" We try to be clear with our students that we are grading them on a variety of factors, but whether they get the "right" answer from their experiment is not one of them. We do assess our students' group interaction, cooperation, and effort through a combination of our own observation and student surveys given later in the term. We also grade them on their experimental design and techniques, looking for an answerable but creative question, good controls, repetition, and a logical approach to data analysis. Finally, we grade them on their ability to present the results and to see how the results of their small experiment would modify how they approached the same question again and would generalize to broader issues in cell biology. See Walvoord and Anderson, 1998 and Allen and Tanner, 2006 for discussions of the development of grading rubrics. The grading rubrics used for poster and laboratory report presentations are included in Appendix A.

In addition, we wanted to assess whether the cell culture project was achieving the goals we had for it as laid out in the introduction. We administered an eleven question Likert scale survey to the students before and after the project (Appendix B) during three semesters. We conducted one tailed Mann-Whitney U tests (Avery, 2007) on before and after Likert data. These data give an indication of student opinions about their learning and confidence.

Supplies

Table 1 lists the major supplies used for the cell culture project, including vendors, catalog numbers, and cost estimates. The total cost of running the cell culture project for about 24 students in one semester is approximately $1500. Other items used that are assumed to be readily available in the laboratory are a funnel and flask for the disposal of liquid wastes, microscopes for counting cells using the hemocytometer, a 37˚ degree incubator with 5% oxygen and 95% carbon dioxide, micropipetors and tips, test tube and microfuge tube racks, an inverted microscope for viewing the cells in their flasks, sodium chloride, sodium phosphate, sodium bicarbonate, potassium chloride, potassium phosphate, distilled water, balances, stir bars, flasks, a pH probe, an autoclave, and sterile media bottles. Details for making the solutions are available from the authors.

Table 1. Supplies needed for the cell culture laboratory.

Product	**Use**	**Size**	**Vendor**	**Cost estimate**
Disposable lab coats	Worn whenever working with cells and left in the lab	Various; 30/box	VWR (80076-732)	$154
Gloves	Worn whenever working with cells or chemicals	Various	Dash; 100/box	$4
Cidecon	Disinfection of lab surfaces	1 gallon	Fisher (04-355-64)	$30
Nonsterile gauze sponge	To line a funnel for a liquid waste disposal flask	4000/box	Fisher (22-415-496)	$71
McCoy's medium	For growing cells	1 liter (10X concentration)	Sigma (M4892)	$30
Newborn calf serum	Added to the medium	100 ml	Sigma (T8154)	$16
Pen/Strep solution	Added to the medium and trypsin to kill bacteria	Stabilized; 10,000 units Penicillin; 10mg Streptomycin); 6 x 100 ml	VWR (45000-652)	$67
Trypsin	To loosen cells from the flask	10 g	Sigma (T4799)	$53
EDTA	Added to the trypsin	Tetrasodium salt; 100 g	Sigma (ED4S)	$26
Culture flasks	Cell growth	25 ml and 50 ml; 100 per case	Fischer (08-772-1E and 10-126-9)	$135
24 well plates	Cell growth	100/case	ISC Bio (T-3026-1)	$79
Conical tubes	Alloquots of solutions for student use	15 ml (700/case) and 50 ml (500 per case)	ISC Bio (C-3317-2W and C-3317-3)	$89
Glass pipets (sterile)	Measurement of solutions	1 ml (500/pkg), 5 ml (250/pkg), 10 ml (200/pkg)	ISC Bio (P2830-1, P2830-5, P2830-10)	$53, $42, $37
Microfuge tubes	Alloquots of trypan blue and cells solutions	500/pkg	ISC Bio (C-3269-1)	$9
Hemacytometer	Cell counting	1 slide with coverslip	VWR (48300-476)	$82
Hemacytometer cover slips	Cell counting	12/pkg	VWR (15170-321)	$29
Trypan blue	Determining cell viability	100 ml	Sigma (T8154)	$11

Results

Student projects

Students have tried a variety of projects since the inception of the cell culture labs. Examples include variations in the amount of time cells are exposed to trypsin, variations in the temperature of the trypsin, various dilutions of the medium with PBS, and variations in incubation temperature. The latter can be quite challenging since we have only one incubator which is kept at 37˚C. To try other temperatures, students must also consider gas concentrations, thus realizing that they are manipulating more than one variable. Other students have tried exposing cells to ultraviolet light of various intensities and durations. Many students like to try adding something to the medium. Examples include additional glucose, chemicals known to solubulize membranes, proteinases, salts, and viruses. One group even tried incubating the cells in various dilutions of Gatorade™. With these projects, most student groups confront several experimental design challenges. These include framing a simple, clear question, the use of proper controls, determining a method for data gathering that will be consistent for all group members, determining how to analyze data in such a way that it will answer the question asked, and considering how to manage their time to gather truly reliable results.

Assessment of student attitudes and learning

Although the results were all statistically significant, it was somewhat difficult to measure changes in student perception about confidence and learning through the attitude survey we administered because the students showed great confidence in themselves and their knowledge even before they began the project. That confidence and knowledge is not particularly consistent with our informal observations based on classroom discussions, test results, and discussions with the students during office hours. Transylvania students, however, were often some of the best students in their high school classes, so they tend to enter college with a rather high level of self-esteem.

The combined results from the attitude surveys given in the winter and fall terms of 2005 and the winter term of 2007 to 58 students are shown in Table 2. P values from one-tailed Mann-Whitney U tests on before and after Likert data are shown in the last column. The exact questions asked are shown in Appendix B. The results indicate that despite mild anxiety to begin with, most students were glad they had the opportunity to work with the cell cultures (Question 11). They also show that they felt like they were involved in the scientific process (Question 8) and that the project helped them understand the interactions of cells (Question 3). They also indicate that students felt more confident in their experimental design abilities (Questions 4 and 10) and that they felt like they had developed skills through repetition (Question 5). Finally, the results indicate that students felt that the lab project helped them understand concepts and relationships presented throughout the course (Questions 2 and 9).

Table 2. Average Likert scale scores from the student survey (n=58).

Question	Pre-lab survey	Post-lab Survey	Difference	P
1. Visual image	4.28	4.69	0.41	.0037
2. Concept understanding	3.91	4.25	0.34	.0123
3. Cell interaction	3.81	4.46	0.65	.0000
4. Experimental design	3.53	4.12	0.58	.0002
5. Repetition	3.57	4.25	0.69	.0004
6. Time and groups	4.24	4.59	0.35	.0038
7. Decision making	3.88	4.27	0.39	.0123
8. Real science	3.67	4.56	0.89	.0000
9. Relationships	3.78	4.39	0.61	.0000
10. Outlook on independence	3.57	4.19	0.63	.0010
11. Anxiety/Gladness	3.90	4.19	0.30	.0413

The students ranked themselves amazingly high on time management and group interaction skills before beginning the project (Question 6), something the professors would have ranked quite low. Despite the high starting perception, students felt that their skills improved during the project. The professors noted many groups struggling with time management, work allocation, and responsibility during the project. With this and the many other

group projects that are included throughout a Transylvania education, informal observation of the faculty would indicate a large improvement in these skills throughout their college experience. Given the many mistakes that the groups made and learned from, it is pleasing to note that student confidence in their decision making ability rose significantly during the project (Question 7). In fact, this project showed many students that they had overestimated their initial abilities.

Question 1 addressed one of our central goals for this project, helping students understand cells as dynamic entities. In addition to the survey results, informal observations of the professors are consistent with an improvement in this aspect cell biology. In the discussions students had with us while studying for exams and while discussing their projects, we noticed more students considering cells as changing, dynamic entities than before we began the project. In responses to open-ended questions accompanying the survey given after the project, students often indicated that they had learned a great deal about time management, independent learning, and group interaction skills. The following is one student's analysis of the experience.

> *I enjoyed this lab. It allowed us to apply the knowledge we have gained about the nature of cells to design our own experiment. This knowledge gave us better understanding of what occurred in our experiment. This lab made us think about what we were doing and understand it. We weren't given a road map. Typically in labs we get step-by-step instructions of procedures so it's easy to thoughtlessly follow directions. With this lab, the instructions were our own; therefore, we had to understand why and how every step was to be taken. We learned responsibility in this lab. We learned to rely on each other. We visited the lab every day and 99% of the time, it was all three of us, each with a different task to complete. We alternated each time so everyone got to learn new lab skills and hands on experience. Work in the hood made us consider every potential source of contamination and take extreme care in avoiding it. Everything we did was carefully monitored and done with precision, so as to avoid mistakes and contamination. We had to absolutely focus on our every move. This lab gave us many new skills and much more careful and precise technique. Learning to use hemocytometers was amazing. [Unreadable section] This has probably been the most interesting, valuable, meaningful, tedious, long, informative lab I've ever done. I would love to do it over. As I look back, it is amazing how much we have all learned from it.*

As this above passage indicates, to gather better data on such the cell culture project's impact on attitudes and learning, it would probably be a good idea to conduct interviews of students before and after the experience.

Challenges

Another observation made by the professors is that many students struggled with considering the role of controls and repeats in experimental design. Their initial proposals often included confounding variables that they were not even aware of. In addition, they often failed to consider the importance of staggering times of well set-up to prepare for the time needed for data gathering at the end. In other words, they would start many wells at the identical time, but then discover that counting cells took many hours. Therefore, some wells had incubated for much longer than others.

The presentation of the project in the form of a poster or written report revealed many experimental errors to the students. They often indicated a desire to have more time during the term to repeat the experiment more carefully. Although more time was not available during CMB class, Transylvania biology students get many more opportunities to do independent projects in later classes, so the impact of this learning experience is seen in other settings.

During one semester, one of the professors who supports this project was on sabbatical and the other had part-time administrative duties which often required her to be out of the building. During that semester, some students indicated frustration with lack of access to an "expert" to consult when a problem arose. Based on that experience, we would recommend that this project be undertaken when the professor and/or laboratory assistant can have a high level of visibility to students throughout the term.

Discussion

In summary, students seem to benefit greatly from inclusion of the cell culture project in CMB. Their ability to manage time, design experiments, work with a group, and imagine cells as dynamic, interactive entities appears to improve. In addition, most students report that they enjoy the independence of asking their own questions. There are, of course, a few

exceptions. Some students prefer a more "cookbook" approach because it is simpler, takes less time, and does not require that they depend on others. Students who have traditionally gotten very high grades by working alone and in a more regimented fashion sometimes find the cell culture project uncomfortable. The project does require some intense time by both the professors and the laboratory technical assistant, particularly during the training sessions, but the cost is not prohibitive and the benefits seem to be high.

We began this project in an attempt to more actively engage sophomore level students the scientific process as a part of CMB class. In doing so, we asked whether it is feasible to permit undergraduate students with no previous experience using cell cultures the opportunity to design and carry out their own cell culture experiments as part of a sophomore level core course in biology. The answer to that is clearly affirmative. The time and money expenses invested are not unreasonable. The most expensive items are a laminar flow hood, which we have shown is not essential, and an incubator. Disposable supplies are not insignificant, but are reasonable (less than $75 per student). One of the greatest challenges was getting the students to work with 24 well plates for their experiments after teaching them the techniques using flasks. In the future, we plan to try to teach the students to observe and split cells directly in the 24 well plates rather than ever working with flasks.

In addition, we asked whether the open-endedness of an inquiry-based cell culture laboratory put more responsibility on students to think about what they are doing and thus foster greater autonomy and better learning. We also asked if students got a better concept of cells as dynamic entities after working with the cell cultures. Survey results seem to indicate that the answers to these questions are also affirmative. Our informal observations definitely indicate greater autonomy and responsibility on the part of the students. To further foster student learning, we would like to more strongly link the cell culture project with many of the subjects discussed in a CMB class. For example, how could the cells be used to specifically study membrane transport? Could they be used to study respiration, energetics, or organelle function? Could their structure be examined through microscopic techniques? If the model system was used not only by the students in one project of their own design, but also in other experiments designed by the professors, it might assist the students even more in demonstrating relationships between cell structure and function.

In conclusion, we recommend that others try working with cultured cells early in a biology education for undergraduate students. This model system provides an opportunity for students to gain a variety of scientific skills and to have fun doing so. It can provide a foundation for further class-based research projects as students advance through the major.

Acknowledgments

We wish to thank Joni Wiseman, the Transylvania laboratory technical assistant, for her tireless efforts in support of this and many other projects. She handled all of the ordering, prepared all of the solutions, taught the students sterile technique, and answered endless questions from both students and professors as each student project was implemented. Sunny Saelinger kindly sent the gift of a fresh supply of fibroblast cells each term, saving us having to maintain our own cultures between terms. FIRST II provided the impetus and guidelines for preparation of this manuscript. Detailed information on instructions given to students and solution recipes are available by contacting Peggy Shadduck Palombi at ppalombi@transy.edu.

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Alu Insertions and Genetic Diversity: A Preliminary Investigation by an Undergraduate Bioinformatics Class

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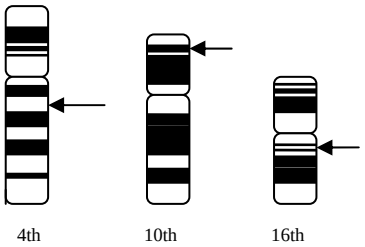
***Abstract*:** *Alu*-insertion polymorphisms were used by an undergraduate Bioinformatics class to study how these insertion sites could be the basis for an investigation in human population genetics. Based on the students' investigation, both allele and genotype *Alu* frequencies were determined for African-American and Japanese populations as well as a control. The three populations were tested for the presence of *Alu*-insertions on the 4th, 10th and 16th chromosomes.

***Keywords*:** bioinformatics, *Alu* insertions, SINES

Introduction

Alu elements, short interspersed elements (SINES) have been gathering within the human genome throughout the evolution of primates. *Alu* elements belong to a larger group of mobile elements which compose over 45% of our DNA (Batzer & Deininger, 2002). They are selfish pieces of DNA in that they don't encode for any proteins, they freely replicate and finally insert themselves into new chromosomal locations. These "jumping genes" are also known as transposable DNA [transposons] and were once studied in corn by Nobel Laureate, Barbara McClintock. *Alu* elements are specific to the primate genome and appeared roughly 65 million years ago (Carroll et al., 2001). With all of the replicating and raiding of chromosomes through insertions, *Alu* elements make up the largest of the SINES within humans; reaching over 1 million copies per genome and making up ~10% of the genome (Roy-Engel et al., 2001, Carroll et al., 2001). However this being said, it should be made clear that not all *Alu* insertions are the same. Once an *Alu* element becomes 'comfortable' in a new location, it starts to collect new mutations at the same pace as the surrounding DNA. Based on these new mutations, *Alu* elements are separated and organized into distinct lineages built on inheritance patterns. Since each *Alu* insertion is secure over evolution it is inherited by basic Mendelian genetics from parent to offspring. Consequently all individuals having an *Alu* insertion at a specific locus share a common ancestor from which they inherited the fragment. As a result, many of these *Alu* insertion sites are considered "landmarks" in the evolution of the human genome (Smit, 1996; Deininger & Batzer, 1999). Considering these factors, it was felt that the *Alu*-insertion polymorphisms would be an ideal topic of investigation in human population genetics for an undergraduate bioinformatics course. It was the intent of these bioinformatics' students to find differences in both the allele and genotype *Alu* frequencies by comparing two distinct ethnic populations (Japanese and African American) against a control. This was accomplished by using three different primers to detect specific *Alu* insertions on the 4th, 10th, and 16th chromosomes (Figure 1). Here, we present an analysis of our findings for these populations using *Alu* insertions.

Figure 1. *Alu* Insertion Sites on Chromosomes 4, 10 and 16.Arrows represent the approximate location of the *Alu* insertion on the respective chromosomes (National Center for Biotechnology Information). *Figure generated by Nancy L. Elwess.*



Methods and Materials

DNA Isolation Procedures (modified from the DNA Dolan Learning Center)

The students had the task of collecting over 60 DNA samples, this included ~20 samples from the control group; and each of the test groups (Japanese and African-American). The student investigators collected the samples from students on campus. Prior to the collection of samples, one liter of a 0.9% saline solution was made (9 grams of NaCl/1000 mL dH_2O). 10mL 0.9% saline solution was aliquoted into 50 mL polypropylene tubes.

To summarize the Dolan DNA Learning Center procedures, participants in this investigation were asked to swish 10 mL of 0.9% saline solution for approximately 30 seconds in their mouth, this was collected. In addition they were asked to sign a consent form. From each sample, one milliliter of the saliva-saline solution was placed into a 1.5 mL screw cap microcentrifuge tube and labeled with a number in order to identify the participant. The samples were concentrated for 1 minute at 12,000 rpm. A white pellet (containing cheek cells) resulted. The supernatant was removed and the pellet resuspended in 30 µl of saline solution.

To each resuspended sample 100 µl of 10% Chelex® was added. All the samples were placed in a boiling water bath for 10 minutes. The sample tubes were cooled on ice and spun for one minute at 12,000 rpm in a microcentrifuge. This step separated the DNA from the cellular debris. 30 µl of the top layer of supernatant from each sample tube was collected and transferred into a fresh 1.5 mL tube with the corresponding number, the resulting samples of DNA were used for the Polymerase Chain Reactions (PCR). The samples were stored on ice or placed in the freezer until they were needed for the PCR reactions.

DNA Amplification using Polymerase Chain Reaction

Reagents

Alu specific primers (Table 1) were ordered through Integrated DNA Technologies (IDT), each primer was diluted to a working concentration of 20 uM. The primers were designed to target regions upstream and downstream of a specific *Alu* insertion site. Each *Alu* fragment is approximately 300 base pairs in length. For example if there is no *Alu* insertion for Yb9NBC10 the size of the PCR product will be 197 base pairs, however if an *Alu* insertion is present the PCR product will be 524 base pairs for that primer.

Table 1. Primer sequences: Primer sequences for the three sets of *Alu* elements that were targeted for this study. Human diversity is classified as: High Frequency (HF) insertion polymorphism where the *Alu* element is present in all individuals tested except for one or two; Intermediate Frequency (IF) insertion polymorphism: the *Alu* element is present or absent in at least one population. We did not use any Low Frequency (LF) *Alu* insertion polymorphisms: these are *Alu* elements which are absent from all individuals tested except for one or two individuals.

Name	Primer Sequence	Chromosome Location	Human Diversity	Product Size (bp) With	Without
Yb9NBC10F Yb9NBC10R	5’ GTT TTC CTG GTG TGC CCT AAA TA-3’ 5’ TTT ACC TAA CTC ACA AGA CCC AAA G-3’	4	IF	524	197
Yc1NBC60F Yc1NBC60R	5’ GAAACCGCCAAGATTCTCACC -3’ 5’ TCTCCATCATGATTCCCAACTGA-3’	10	IF	522	205
PV92F PV92R	5’ GGA TCT CAG GGT GGG TGG CAA TGCT 5’GAA AGG CAA GCT ACC AGA AGC CCC A-3’	16	IF	731	416

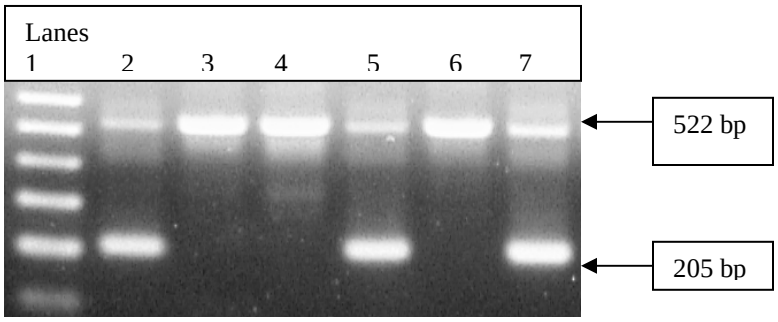
Procedures

Ready-to-Go PCR® tubes (GE Healthcare) were numbered with the corresponding sample numbers. To each tube, 17.5 ul of sterile dH_2O was added along with 2.5 ul of the desired forward and reverse primers for a specific *Alu* locus. Finally, 2.5 ul of each DNA sample was added to the corresponding numbered tube. The total final volume for each Ready-to-Go PCR® tube was 25 ul (17.5 ul of sterile dH_2O, 2.5 ul of each primer and 2.5 ul of DNA). Each sample tube was overlaid with 50 ul of mineral oil (since the thermal cycler did not have a heated lid) and added to the thermal cycler.
The thermal cycler was programmed for 30 cycles for the following cycle:
-Denaturing temperature and time: 94°C for 30 seconds
-Annealing temperature and time: 68°C for 30 seconds
-Extension temperature and time: 72°C for 30 seconds

DNA Gel Electrophoresis

20 µl of the amplified sample was retrieved from under the mineral oil for each sample and expelled into a new, labeled microcentrifuge tube containing 5 µl of loading dye. Each sample was loaded into a well on a 2% agarose gel (which contained 10 µl of 100 mg/mL ethidium bromide per 50 mL volume agarose). One lane was reserved for the 100 base pair ladder. Following electrophoresis, images of the gel were captured using a UV light box and a Kodiak gel documentation system, then interpreted (Figure 2)

Figure 2. A 2% agarose gel containing a 100 base pair standard (Lane 1) and six Japanese DNA samples (lanes 2-7) that were amplified with the Yc1NBC60 primers targeting chromosome 10. If the *Alu* insertion was present, a 522 base pair (bp) product was produced. If the *Alu* insertion was not present, then a 205 bp product was produced. Lanes 2, 5, and 7 contained the 10th chromosome's *Alu* target with the insertion and the 10th chromosome's *Alu* target without the insertion (+/-), hence the presence of two different sized bands. Lanes 3, 4 and 6, with only one band, designate these individuals as having the presence of two insertions (+/+) for the targeted *Alu* area.



Results

In this experiment the frequency of specific *Alu* insertions within different ethnicity groups were compared. Japanese and African-American groups were compared to the control group of random individuals for *Alu* insertions on the 4th, 10th and 16th chromosomes using the primers Yb9NBC10, YcNBC60 and PV-92 respectively. Table 2 shows the results for the genotype frequencies for each group and for each of the tested chromosome sites. If the insertion was present on both chromosomes, the individual was +/+, if the individual had one insertion on a chromosome and none on the homologous chromosome, then that person was +/-; finally, if no insertions were found on either chromosome then the person was -/-.

Table 2. Genotype frequencies; Genotype frequencies for the two test groups and the control group for the 4th, 10th, and 16th chromosomes. +/+ represents *Alu* insertions are present on both of the targeted chromosomes; +/- represents an *Alu* insertion is present on one of the targeted chromosomes; -/- represents that no *Alu* insertions are present for the targeted chromosomes.

	Control			**African-American**			**Japanese**		
Chromosome	+/+	+/-	-/-	+/+	+/-	-/-	+/+	+/-	-/-
4th	0%	18%	82%	0%	29%	71%	0%	0%	100%
10th	68%	14%	18%	33%	27%	40%	55%	36%	9%
16th	7%	13%	80%	0%	12.5%	87.5%	56%	13%	31%

The biggest differences that were seen for the genotype frequencies occurred on chromosomes 10 and 16. On chromosome 10, the majority of the Control group and Japanese groups had +/+ (68% and 56% respectively) compared to the African-American test groups with only 33% +/+. The Japanese test group did show differences from the Control and African-American groups for the 16th chromosome. The majority of the Japanese had +/+ (56%) while the Control and African-American groups had 7% and 0% respectively for +/+.

Figures 3-5 provide the results for the allele frequencies for the targeted 4th, 10th and 16th chromosome *Alu* insertion sites. The allele frequency was determined by comparing the number of copies for a specific allele to the total number of alleles present. For example if the results had 10 +/+ individuals, 5 +/- individuals and 5 -/- individuals, the allele frequency would have a total of 25 + (insertions) and 15 – (no insertions). This would result in a 62.5% + and 37.5% - allele frequency. There was not that big of a difference in allele frequency between the three groups for chromosome 4 (Figure 3). However, there were differences in allele frequencies on Chromosome 10 for the African-American group (Figure 4) and on Chromosome 16 for the Japanese test group (Figure 5).

Figure 3. Distribution of allele frequencies for *Alu* insertions on the 4th chromosome.

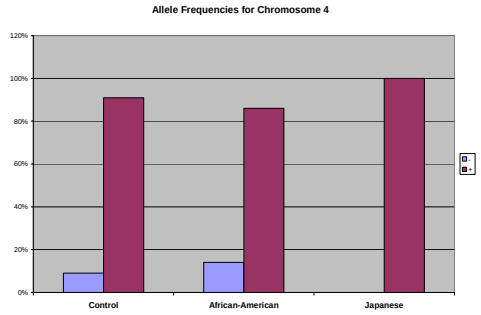
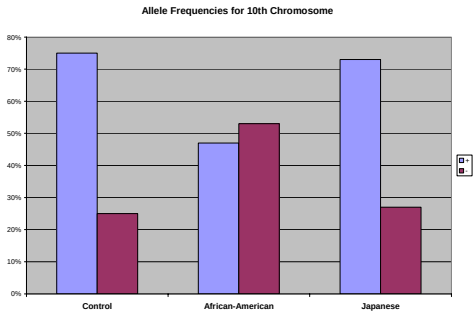


Figure 4. Distribution of allele frequencies for *Alu* insertions on the 10th chromosome.



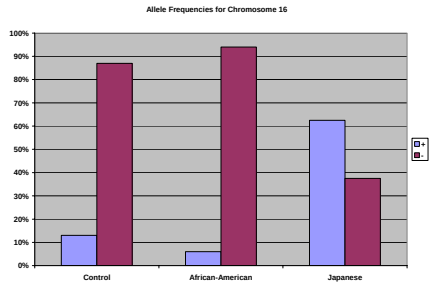
Discussion

Comparisons to data from past research and the literature can also be drawn from this experiment. For example, the Dolan DNA Learning Center (www.geneticorgins.org) provides a database of allele and genotype frequencies for the PV-92 *Alu* insertion (on the 16th chromosome) from over 40 populations around the world. According to the database the African-American allele frequency for this *Alu* insertion was 20%, whereas only 6% of our African-American test group had this insertion present. However, this discrepancy in the data may be due to the small population size for not only our study (21 samples) but also in the Dolan DNA Learning Center database (42 samples). More sampling using the African-American population, needs to be done to establish a reliable set of data.

The Dolan DNA Learning Center database (and other sources) did not have any data on the frequencies of the PV-92 *Alu* insertions in the Japanese population. So whatever data we could provide added to the knowledge in the field. However, the Japanese population was compared to other Asian

populations, which were known to have a high et al., 2001). There was a 90% + allele frequency for the Taiwanese population, 86% for the Chinese, 80% for the Filipino population as compared to the 62.5% + allele frequency in our Japanese test group.

Figure 5. Distribution of allele frequencies for *Alu* insertions on the 16th chromosome.



Further comparisons were made to published results of the Yb9NBC10 (Chromosome 4) and Yc1NBC60 (Chromosome 10) *Alu* elements (Roy-Engel et al., 2001). According to the published results the African-American test group had 37.5% +/+, 12.5% +/-, and 50% -/- for the Yb9NBC10 *Alu* element this frequency of the *Alu* insertion at this site (Comas was different from our results of 0% +/+, 29% +/-, and 71% -/-. It should be noted, however, that the Roy-Engel et al. article (2001) findings were based on only 8 samples compared to our 21 samples. When comparisons for the African-American populations were made concerning the Yc1NBC60 *Alu* element between the Roy-Engel paper and our study, there were once again differences. We had 33% +/+, 27% +/-, and 40% -/- for our African-American samples compared to their results of 33.33% +/+, 50% +/-, and 16.66% -/-. Here again the Roy-Engel paper had a smaller sample size then our study.

We could not make these direct comparisons for our Japanese results. The only published results that were close were for Asian/Alaska natives. This made our findings even more exciting due to no other published results for a Japanese test group.
Finally, in addition to our *Alu* findings, the bioinformatics students researched and presented findings from journal articles about genetic disorders/diseases that happen as a result of an *Alu* insertion within a gene. If time had allowed, we would have added more populations to sample and additional *Alu* locations to study.

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Charting a New Direction: Results of the ACUBE Member Survey

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Abstract: The ACUBE Steering Committee and President conducted an online survey of members from November 2007-January 2008. The survey asked members for input on a variety of issues facing ACUBE, ranging from participation in the association to satisfaction with annual meetings, *Bioscene*, and the webpage. The survey was completed by 34% of the membership resulting in 34 pages of data and comments. A preliminary report was delivered at the 2008 Annual Meeting at Hopkinsville Community College; this document is intended to provide more details about the results and inform members who were unable to attend the annual meeting. Based on the results of the survey, the Steering Committee has approved four goals for a still developing Strategic Plan for ACUBE. The Strategic Plan is a work in progress and will rely heavily on results from the member survey. This report provides a suggestion of where ACUBE may be headed in the future as that Plan continues to develop.
Keywords: ACUBE, survey, strategic plan

Introduction

The Association for College and University Biology Educators (ACUBE) has benefited from a dedicated membership committed to promoting biology education as demonstrated by the 50th anniversary of the society in 2007. In 1957 there were 44 members from 11 Midwestern states. In 1997 the name of the society was changed from the Association of Midwest College and Biology Teachers to its current name as a reflection of the growing national membership. In 1998 the society had grown to 340 members from 30 states. Today there are 270 active members who are diverse in many ways, including: stage of career, type of institution employed at, field of biology trained in. However, the membership of the society is a very small portion of the estimated 65,000 biologists who teach at post-secondary institutions in the United States (Bureau of Labor Statistics, 2008). While ACUBE has never sought to capture all biology educators as part of its membership, or to be the largest biology related society, it does seek to serve its constituency through the following objectives as stated in the constitution of the organization:

1) To further the teaching of the biological sciences at the college and other levels of educational experience;

2) To bring to light common problems involving biological curricula at the college level and by the free interchange of ideas; endeavor to resolve these problems;

3) To encourage active participation in biological research by teachers and students in the belief that such participation is an invaluable adjunct to effective teaching;

4) To create a voice which will be effective in bringing the collective views of the college and university teachers of the biological sciences to the attention of college and civil government administrations.

As ACUBE enters its second 50 years, the society is facing many questions about the future of the society, as outlined by current ACUBE President, Conrad Toepfer, in his letter published in *Bioscene* in December 2007. These issues include maintaining and increasing membership and increasing the impact of ACUBE in biology education. The steering committee led small-group discussions of these issues over lunch at the annual meeting at Loras College in October 2007. From these initial discussions, a decision was made to collect more feedback from the society. This article is a summary of the results from that survey, and reflections from the steering committee of ACUBE about priorities for the next few years to meet the expectations of the members and the goals of the organization.

A link to the electronic survey was sent to the all members in November 2007. The anonymous

survey was available for six weeks, and a reminder was sent to all members in December 2007. Thirty-four percent of the ACUBE members completed the 27-question survey.

Results

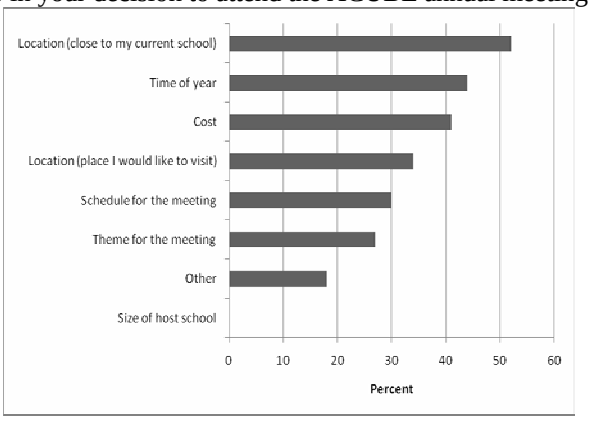
Information on Survey Respondents:

Forty-one percent of survey respondents have been members for less than five years. Thirty-four percent of those who participated in the survey have been members for over ten years. Even with a large number of respondents who have been members for a significant length of time, only 10% of respondents have been to four or five annual ACUBE meetings in the last five years. Almost 40% of respondents have not been to any ACUBE annual meetings in the last five years. Sixty-four percent of survey respondents indicate that they are in a tenure-track or tenured position at a college or university. Other job titles included: retired (15%), full-time instructor (8%), adjunct or part-time instructor (2%), graduate student or post-doc (2%), or other (9%). The job titles in the "other" category included administrators (or part-time administrators), librarians, and limited-term professors. Sixteen percent have served on the *Bioscene* editorial board, and 34% have participated in the governance of ACUBE at some point during their membership. Approximately one-third of the survey respondents have submitted an article to *Bioscene* for publication.

Annual Meeting

Members most frequently indicated that the location of the ACUBE annual meeting is an important factor in their decision to attend, followed by the time of year of the meeting, and the cost of attendance (Figure 1). In the "other" category, several members indicated that time for interactions is an important factor, particularly for members who have been part of the society for many years (including founding members). The theme for the meeting was only selected by 27% of respondents as an important factor in their decision to attend the meeting. This is particularly surprising because 52% of respondents indicated that "content" was the best thing about the annual meeting. Thirty percent of respondents indicated that interactions with colleagues were the best thing about the meeting. Only 4% indicated that the current "tone/style" of the meeting was the best feature of the annual meeting. Two-thirds of the respondents indicated that they had presented at an annual meeting in the past.

Figure 1. Factors determining attendance at the ACUBE annual meeting. The survey question asked: "Which of the following is an important factor in your decision to attend the ACUBE annual meeting? (select all that apply)"



Overwhelmingly, 90% of members agree that 45-minute talks at the annual meeting is an effective presentation type. Only 15% of respondents agree that the 90-minute talks are effective. The keynote address and poster presentations were equally supported by 42% of attendees as effective presentation types. Overall, the survey respondents are supportive of trying new presentation types, including targeted workshops, panel presentations, and shorter presentations (Figure 2)

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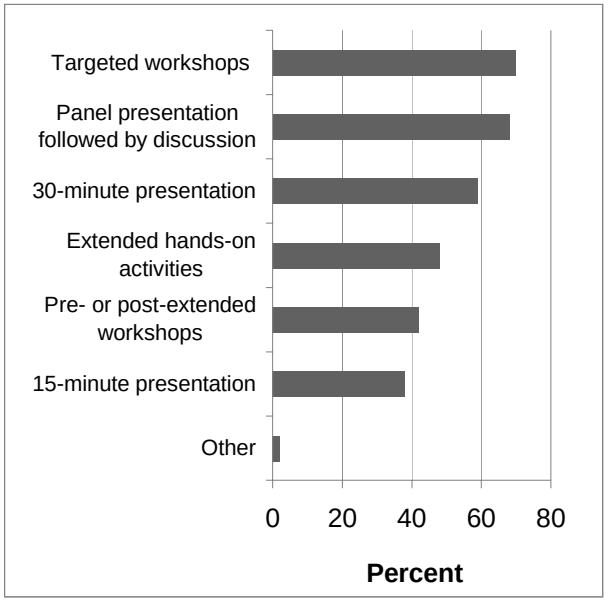
Figure 2: Suggestions for new presentation types at the ACUBE annual meeting. The survey question asked: "It has been suggested that we try new presentation types in the future at the ACUBE annual meeting. Which of the following would you find useful in delivering information (select all that apply) "



ACUBE members were asked to give their opinion on changes to the annual meeting including location, time of year, and methods of advertisement. These results are summarized in Table 1. Overall, the membership appears supportive of changes to the annual meeting, except altering the Thursday-Saturday schedule. Ideas that received the strongest support (in terms of percent who indicated that they agreed or strongly agreed that the following should be done to improve the annual meeting) included devoting an issue of *Bioscene* to the meeting theme, advertise to increase the number of people attending the meeting, announcing meeting locations two years in advance, and advertise to bring in more graduate students

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Table 1: Survey respondents were asked to give their opinions on possible changes to the annual meeting (scale ranged from strongly agree to strongly disagree). Percents for "agreed and strongly agreed" were combined, as were "disagreed or strongly disagreed", as shown on the below. Suggestions are ranked in descending order based on the percent of respondents who agreed with each statement.

Possible changes to ACUBE annual meeting	Agree or strongly agree	Neutral	Disagree or strongly disagree
Devote a *Bioscene* issue per year to the meeting theme, giving presenters the option of publishing	86	11	3
Increase advertising to increase the number of people who attend the meeting	85	11	4
Announce the meeting locations two years in advance	81	12	7
Advertise to bring in more graduate students	80	12	8
Announce the themes for the meeting earlier in the year	66	26	8
Alternate meetings between large cities and small cities	64	18	18
Hold the meeting in more convenient locations near a major airport	62	27	11
Post a board on the website for ride sharing to the meeting	56	38	6
Alternate meetings on a two year cycle; regional meetings one year, national meeting the next	55	28	17
Offer travel funds to junior faculty	53	27	20
Hold meetings outside of our current range	48	20	32
Decrease the registration fee for first time attendees	48	35	17
Move meetings to larger cities	45	17	38
Change current Thursday-Saturday schedule	11	34	55

When asked what locations were suggested for future ACUBE meetings, there were no clear trends. Several respondents indicated that they would like the meeting in locations that are easier to get to (nearer to a major airport), however there was

also support for keeping the meetings on college campuses rather than in hotels. Several individuals ask that the meeting be held outside of the Midwest, however many suggested locations in the Midwest (Madison, Minneapolis, Kansas City were mentioned several times). Two quotes from members on how to improve the annual meeting:

- "As a first-timer, it would have been helpful to have been contacted by someone in ACUBE prior to the conference to talk about logistical concerns such as "dress code" for events, customary method of presentation, etc. Also, it would be nice to have a least one familiar person to find at the beginning of the conference. ABLE has a breakfast session on the morning of the first day for first-timers. Members of the board explain what can be expected, answer any questions, and give suggestions. "
- "Discussions with colleagues are an important part of the meeting and I would like to see more opportunities for 'round-table' discussions of various teaching topics."

Other suggestions included increasing the attendance to get more energy and new ideas, hold the meeting in conjunction with other societies some years, recruiting more post-docs to attend and hold the meeting at a different time of year (because of many conflicts in October).

ACUBE website

Thirty-five percent of survey respondents indicated that they find the ACUBE website useful. It is telling however, that 57% have not used the website recently. Members were asked to indicate what they found the most useful about the website for the society, and overwhelmingly access to *Bioscene* was mentioned as the most useful feature. Several others indicated that the website is useful because it is uncluttered, and easy to find information about the annual meeting. Adding a calendar of events to the website was supported by 80% of members who participated in the survey. In addition, support was present for links to related sites and employment opportunities. A "members only" area of the website was only recommended by 11% of members.

Bioscene

Two thirds of the members who participated in the survey had not submitted a paper for publication in ACUBE. Lack of time to prepare a submission was cited by 42% of the individuals as the reason they had not yet published in ACUBE. Only 7% indicated that they preferred to publish in another journal. Most members (88%) use *Bioscene* to get teaching ideas primarily, with 52% indicating that they use *Bioscene* to get information on the annual meeting. Other comments on the uses of *Bioscene* include: giving them to high school teachers as resources, following trends in biology education, and to keep up with the business of ACUBE.

Members were asked to indicate if they would like to see additional features in *Bioscene*. A section devoted to columns describing useful websites was supported by 71% of members, a section for undergraduate research articles was supported by 58%, and book reviews were supported by 53% of members. Other ideas included: having targeted issues on themes, textbook reviews and critiques, articles on industry connections, articles on grant opportunities and grant writing. Some concern was expressed about website reviews, indicating that websites are frequently changed or removed, making the article not applicable in a short time. It was suggested that this might be more suitable for an e-newsletter.

No clarity was given by the membership about the future format of *Bioscene* (print, online or both). Thirty four percent of members indicated that they preferred to receive *Bioscene* in print, 33% preferred online, and 33% preferred both formats. However, 58% of members indicated that they would be willing to get *Bioscene* only in an online format in exchange for other services from ACUBE (24% indicated it depended on the service offered). One suggestion was to make individuals who get paper copies pay more for their memberships. Forty-eight percent of members do not see the need to print a full run of *Bioscene* on a CD, however 25% said they would use the CDs to find articles, and 18% said they would give the CDs to recruit new members.

ACUBE Membership

Over 60% of members indicated that they first learned about ACUBE from a colleague, confirming the importance of networking to the organization. Twenty percent first learned about the organization through a flier. Members were asked if they agreed or disagreed with a number of ideas for increasing membership in the society. These results are summarized in Table 2. Overall, members supported networking with other societies to make sure our webpage is a resource to their members. In addition, advertising at other professional conferences and publications was thought to be useful in increasing membership. Some ideas from members on how to increase membership included:

- "Need to increase the "name brand" of the society. Needs to grow to truly be a national organization"
- "Invite high school science teachers that offer college advanced credit or advanced

- placement courses on their high school campuses"
- "Offer "departmental" memberships to promote more members of departments to participate and also offer "multi-year" memberships (at a slightly reduced cost) so people may be more likely to keep their membership active"
-

Table 2: Survey respondents were asked to give their opinions on possible strategies to increase membership. Percents for the responses "useful and very useful" were combined, as were "don't know and no effect", as shown on the below. Suggestions are ranked in descending order based on the percent of respondents who thought the recruiting mechanisms may be useful.

Possible changes to ACUBE annual meeting	Very useful or useful	Not useful	No effect or don't know
Make sure our website is listed as a link on other professional websites	94	1	5
Advertise at other professional conferences	87	3	10
Recruit graduate students by contacting gradate student organizations	78	4	18
Encourage members to give a presentation or display information at other conferences	77	2	21
Develop a small ad to go into professional publications	74	6	20
Alternate years with regional/national meeting	46	6	48
Have a member recruitment contest	26	19	55

Members were asked what services they thought would be beneficial in increasing their satisfaction with ACUBE. All suggestions received support from the members. The ideas that has the greatest percent of members indicating that they thought the service would be "very beneficial" in increasing their satisfaction with ACUBE were: more advocacy by ACUBE on educational issues, travel grants for faculty to attend ACUBE, and mini-grants offered on a competitive basis for pedagogy ideas. Other services that could be offered by ACUBE to its members included: access for members for lab and class activities, grant resources, list of members and expertise areas, informational newsletters via email, a listserve to share ideas and discuss problems, service to review manuscripts or grants.

Comments from "new" members of ACUBE (less than three years) were solicited about their opinions of ACUBE and how the organization can retain them as members:

- "I am drawn to the organization because of the teaching-centered approach to the meetings and publications."
- "It seems to have a unique niche potential as an advocate nationally for biology education, and I would like to see that expanded."
- "ACUBE is very welcoming and has lots of valuable information in *Bioscene* and at the meetings. The low cost is very attractive."
- "I like that that association has a journal. Build the journal. Find a way to promote the submission of more articles and publish more frequently."

Comments from members who have been with ACUBE for over three years about how ACUBE can stay valuable during their career:

- "There isn't a comparable society that focuses on biology education at the college level. I think the opportunities for *Bioscene* as a journal will keep me a member - and improvements to the annual meeting. I would like the society to really become a "national" society. Many people have never heard of ACUBE who are biology teachers."
- "The atmosphere of learning and cooperation. I feel like the annual meeting is somewhere I can go to get new ideas and get re-energized about teaching biology."
- "The pedagogical focus of annual meetings and articles in *Bioscene* is what I find valuable; keep that and you keep me."

All members, regardless of the time they have been part of the organization were asked which issues are critical to keep the same, and which issues/parts are critical to change. While very diverse answers were given, some themes emerged from the submissions. First, members think it is critical to keep *Bioscene* as part of the organization, and continue to strengthen the journal. Second, the organization needs to increase the size and expand its reputation and reach. Third, it is important to members that we keep a low cost of membership. Lastly, it is important to keep a collegial environment at the meetings and plenty of opportunities for networking. Members were asked to identify the most important issue for the organization to address in the near future. The suggestions that were

repeated the most frequently were to strengthen the size and reputation of the organization through advocacy, advertising, cooperation with other societies and continue to publish a strong journal.

Participation in the Governance/Activities of ACUBE

Thirty-eight percent of survey respondents indicated that they did not know enough about the governance of ACUBE to indicate if they would be willing to participate in some way. Forty percent expressed willingness to serve on the *Bioscene* editorial board. Only 19% indicated that they would be unwilling to participate in the governance of ACUBE. Time was listed at the major limiting factor for most members for getting more involved in ACUBE. Eleven percent indicated that the travel commitment (both time and funds) would prevent their participation in the governance of the organization.

Discussion

The strength of ACUBE since its founding as AMCBT has been the members. The expertise and creativity that we as individuals bring to our classrooms have undoubtedly influenced generations of college biology students. Participation in ACUBE either through attending the annual meeting or publishing in *Bioscene* allows each of us to continue to improve our individual skills. However, collectively we should be able to accomplish even greater things. The major themes of increasing membership, becoming advocates for education, and communicating the best teaching ideas to each other have been recurring since the founding of ACUBE over fifty years ago. Our task should be to critically examine what we are as an association and begin to plan what we want to be in the future. The membership survey was an attempt to begin a critical examination, and the Steering Committee likely will be returning to the 34 pages of data again and again in the coming months. You as members had a lot to say about the current and future state of ACUBE. The governance of ACUBE will do its best to address many of your concerns and suggestions over the course of the next year.

The member survey was organized around four themes: membership, the face of ACUBE (*Bioscene* and the webpage), the Annual Meeting, and the larger role of ACUBE in biology education. While efforts for developing a long-range Strategic Plan are in their infancy, a few events have already developed and discussions are underway to determine if and how our approach to these issues should be adjusted.

Membership

Membership levels in ACUBE appear to have been cyclical since our founding, and the discussion of what to do to increase membership has also been a virtual constant. The survey shows rather dramatically that most of us were recruited by colleagues. We can always work on members of our departments, but we need to always keep ACUBE in our thoughts as we participate in other venues. It is likely that all of us participate in at least one other society and attend a variety of conferences, summits, etc. where we may run into receptive peers. There can be no better advocate for the association than a satisfied member. To aid you in recruitment of your peers at other meetings one of the Steering Committee members, Tara McGinnis, developed three different recruitment posters. All three posters are available on the ACUBE website; please feel free to print them off and hand them to colleagues.

One of the potential limitations in our recruiting is visibility. The top choices in the survey involved strategies that should be relatively easy to implement. We currently are listed as a member of AIBS and have our website cross-linked with the websites for the Association for Biology Laboratory Education (www.ableweb.org) and the Association of Southeastern Biologists (www.asb.appstate.edu)...dig deep enough in their sites and you will find our association. Clearly we can do better than this. There are a number of websites that should have a link to ACUBE, an omission that should be easy to remedy.

We know that ACUBE is valuable to us either through presentations, *Bioscene* papers, or conversations over a meal at the Annual Meeting. Many members who have joined in recent years have commented that they had no idea that ACUBE existed before chatting with one of our members. Our challenge will be to make sure that even more faculty become aware of the existence of the association and recognize how valuable it is to each of us as we continue to strengthen our teaching.

Public face

Nonmembers of ACUBE are most likely to gain their first exposure to the association through either *Bioscene* or the website. We need to be sure that both resources continue to be high quality as they could serve as recruitment tools in addition to their continued value for members. *Bioscene* appears to serve two main purposes for members, a source of teaching ideas and providing information about the annual meeting. Both functions should be equally useful. *Bioscene* has a long tradition as a high-quality publication but various challenges with journal production will make it increasingly difficult to maintain its current quality. Some adjustments can be made fairly quickly and easily. For example, the current editor, Steve

Daggett, is open to increasing the diversity of material in the journal. Material such as letters to the editor and book reviews are encouraged and additional material is welcome. A greater challenge, however, is the rapid increases in both printing and mailing costs. In January 2008, it became clear that the organization would have difficulty covering expenses for a full 4-issue run of the journal during the year. Shifting to either partial or complete online publication brings its own challenges. The June 2008 issue of *Bioscene* is currently available online. For at least the next two years, *Bioscene* will be available only in to two issues a year with one issue published online in the early summer and a second print issue published at the end of each year.

The website is a similar bridge between members and nonmembers and could serve as a recruiting tool for the organization. Members use the site primarily for accessing information about the annual meeting and back issues of *Bioscene*. Both topics would be useful for nonmembers, but we do need to consider how the site appears to those not already "in the know" about our organization. Is our site compelling enough for people not already familiar with the organization? Does its appearance reflect an organization with plans for the future or one that is comfortable with the way we've always done things? Our website may be the first thing a prospective member sees so we should be cognizant of how it reflects the entire organization. We individually know why we joined and remained in ACUBE, are we presenting those aspects to those who are not already members?

Another continuing challenge is the difficulty of managing the site with a group of volunteers. Bobby Lee and Tim Mulkey have produced a site that is viewed as useful and easy to navigate and their dedication of their time and effort has been greatly appreciated but not always recognized. We need to begin an examination of whether how we do business with the website is still viable. Many members of the organization may not be qualified to handle the technical challenges of maintaining a website. The result is that either a few highly dedicated volunteers have to make long-term commitments to the organization or the turnover of volunteers results in inconsistencies in the structure and style of the website. We need to examine whether we should continue maintaining the website internally or if we should pay for the website to be maintained by an outside organization.

Annual Meeting

The annual meeting is consistently rated as one of the most valuable services provided to ACUBE members with over two-thirds of the members having been to at least one meeting. Attendance has been slowly declining for the past several years, however. For many members the decline may be because of issues such as declining professional development funds or a lack of time.

Suggestions from the membership survey were wide-ranging with many ideas that would be easy to implement immediately and many that will require extensive study before implementation. Laura Salem, the Program Chair for 2008, has already started implementing changes in the types of presentations. The 1.5 hour workshops were viewed as least useful and will likely decline over time. One of the highly rated possible additions to annual meetings has already appeared. The majority of members had favorable opinions of roundtable discussions. One roundtable discussion spontaneously developed at the 2007 Annual Meeting at Loras College, but six discussions occurred at the 2008 meeting at Hopkinsville Community College. The roundtable discussions were popular with attendees at the recent meeting and coordinators of those discussions were encouraged to submit synopses to *Bioscene*.

Long-term changes in the meeting will be more challenging. A discussion regarding the locations of meetings has been ongoing for several years in the Steering Committee. We have traditionally located meetings along the corners and in the center of the core area of the membership. Having a meeting in a large city outside the Midwest has been discussed for several years within the Steering Committee. While cost has been a major concern, the idea does merit further examination. Suggestions about meeting locations that were more strongly supported in the survey will be more easily addressed. The 2008 (Hopkinsville, KY) and 2009 (Kansas City) meetings will alternate between small and large cities, a suggestion supported by over 60% of the survey respondents.

A final long-term issue that will require further study is the timing of the annual meeting. We have traditionally held the annual meeting during the fall break of the host institution. Perhaps it is time to give full consideration to holding the meeting at other times of the year. This would reduce unintentional conflicts like the conflict this year with the NABT meeting, but more importantly would allow us to consider holding joint meetings with other societies. Members have suggested holding meetings with ABLE, various state Academies of Science, or research societies such as the Southeastern Association of Naturalists. Joint meetings would have the added benefit of exposing our group to a larger pool of potential new members.

Advocacy

ACUBE is the only organization of its type, an association devoted entirely to improving biology education at the college/university level. Since this is our sole purpose, it seems like we should have a larger role in education at the national level. Going back through old issues of *Bioscene* and the AMCBT newsletters, it becomes clear that this has been a topic of concern for decades.

Tom Davis, Executive Secretary, and Conrad Toepfer, President, attended an educational summit in Washington, D.C., that was jointly sponsored by NSF, AAAS, and Sigma Xi. The intention of the summit was to begin a dialogue about the potential to develop a national-level biology curriculum, similar to the standards in chemistry established by the American Chemical Society. Attendees at the summit represented at least 30 different societies. While many representatives were from educational subcommittees of research-oriented societies, the only societies that were specifically focused on teaching were ACUBE and NABT. Two factors became evident during the summit: (1) ACUBE is resource-poor compared to the other societies, and (2) NABT has already spent a considerable amount of time and resources on developing a standard curriculum. While we may be able to collaborate with NABT on this particular issue, it will be difficult at this time for ACUBE to have much of a national voice. For example, one educational subcommittee of a professional society has an annual budget 2-3 times higher than ours, has paid staff, and has a $10 million endowment.

An organization such as ours depending entirely on volunteers and with a break-even annual budget will have difficulty competing for attention at events like the recent summit. While we have a valid mission, we need a serious examination of what we want to be doing in terms of education advocacy. We also need to consider our financial limitations and perhaps start looking for additional collaborations or funding opportunities.

It is clear from the membership survey that there are many things that ACUBE has been doing well and many things that our members find highly rewarding. It is also equally clear that there are many things that we can be doing differently, some easy to accomplish, some more difficult. The organizers of the 2008 meeting and the Steering Committee have already implemented some of the easier suggestions. The more difficult suggestions will necessitate further study and incorporation into a Strategic Plan. After examining results from this survey, the Steering Committee has proposed four goals for the Strategic Plan: (1) Lead the academic agenda in biology education, (2) Modernize the face of ACUBE, (3) Develop a plan to increase membership, and (4) Create an atmosphere where creativity and new ideas are encouraged. Members of the Steering Committee have been assigned to each of these goals and will be developing objectives and tasks to fulfill those objectives over the coming year. Any member, however, is more than welcome to volunteer to participate in development of any of the four main goals (contact conrad.toepfer@brescia.edu if interested).

The President and Steering Committee of ACUBE are committed to looking ahead and planning for the future of the society. ACUBE has provided a great service to its members and has had an impact on biology education in its first 52 years. We should continue that tradition and look to expand our impact in the next half century. Changes have already occurred but stay tuned for even more to come!

References:

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2008-09 Edition*, Teachers—Postsecondary, on the Internet at h**ttp://www.bls.gov/oco/ocos066.htm** (visited *March 25, 2008*).

Book Review

Biostats Basics. A Student Handbook. *With BioStats Basics Online: an interactive tutorial and basic collection of statistical tests including questions, glossary, and data sets*

James L. Gould and Grant F. Gould.

W. H. Freeman and Company, New York, New York, 2002, 422 p.,
ISBN: 0-7167-3416-8
ISBN-13: 978-0-716-73416-1
Estimated U.S. Price: $38.00

Biostats Basics is an easy-to-read introduction to statistics for science majors and non-majors that require a foundational statistics course. Commonly used statistical tests are discussed using simple, yet effective examples to stress the important criteria for employing, and most importantly, differentiating between specific tests. The chapter layout has engaging text, effective graphics, a summary and "Review exercises". This chapter format, along with traditional statistical tables, a glossary, and the inclusion of a summary guide entitled "Choosing the Right Test", underscore the authors' commitment to making statistics understandable to all students. The book's size and spiral-bound paperback format truly makes this book a convenient and affordable "student handbook".

Information about "Cause and Effect" and "Data", required underlying knowledge to understand and apply basic statistics, are covered in the first two chapters. From this point on a mini "Choosing the Right Test" flow chart precedes each remaining chapter's specific statistical test discussion. For students to grasp the math of the book's statistical tests, a sound algebra background is adequate. Furthermore the explanations are not "bogged down" with too much theory as the presentation of statistical concepts simulates a face-to-face classroom lecture dialogue that provides the basic mechanics for each specific test. Throughout each discussion are sidebars that remind us of basic definitions for a particular test. Graphical representations of specific tests and/or criteria, as well as corresponding example data sets, are well labeled and thoroughly discussed in the text and the figure legends. The chapter summary "Points to remember" compliments the text material, and together with the "Review exercises" provides effectual learning tools. Answers for the exercises are provided with sufficient explanations to reiterate important "points to remember". To enhance the learning experience for advanced students, a "More Than the Basics" section is included at the end of most statistical test chapters. Finally, Chapter 14, entitled "Once Over Lightly", is a succinctly written overview of the entire book with highlighted bold-print terminology for easy reference.

As expected, parametric and nonparametric data discussion and examples comprise a majority of the book. However, the authors' wit shines with their "None of the Above" chapter which made me smile with their clever subtitles "The Quick and Dirty Approach", "The Academic Approach", and "The Hard Way: Monte Carlo Simulations". All of these discussions provide statistical solutions to data sets that many of us have encountered, i.e., "unusual data and special cases".

Additionally, the each chapter has separate textboxes which identify corresponding interactive statistical applications that can be accessed via an online component through the publisher's website (http://www.whfreeman.com/gould/). Unfortunately for the majority of students *now*, this feature is probably not available due to the *Biostats Basics Online* software requirements for operating systems ("Macintosh OSX, 9, nor Windows XP, ME, 2000 systems are not supported"). Despite this online aspect, the book would work well in any course where students are required to apply introductory or more advanced statistical tests.

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Department of Biology
University of Wisconsin-River Falls

Editorial

In the December 2007 issue of *Bioscene,* Tom Davis, secretary of ACUBE, wrote an editorial calling for national standards for a college biology majors (*The Time is NOW for National Standards for a Biology Major*, Bioscene vol. 33(4): 42-43). The National Association of Biology Teachers (NABT) have displayed their standards on their website (http://nabt.org/sites/S1/index.php?p=614). Our membership would be well-advised to study these. In addition, membership should review standards

established by the Association for Midwest College Biology Teachers (AMCBT), the predecessor of ACUBE. These were published in *Bioscene* in December 2001 (*AMCBT Guidelines for Evaluating Undergraduate Education in Biology*, *Bioscene* vol. 17(3): 16-17). They are as follows:

- 480 hours of classroom work in biology (33 semester hours)
- 360 hours of laboratory/field work in biology (approximately one three hour session per week of the semester per course)
- A core curriculum the covers evolution, prokaryotic biology, eukaryotic biology, systematic biology, cell and molecular biology, ecological and environmental biology, genetics, physiological biology, structural (anatomical) biology, and experimental design/biometrics
- Capstone experience such as a senior seminar
- One year of advanced work in biology or in allied fields that is outside of the core
- An undergraduate research experience
- One year of mathematics/computer science
- One year of physics
- Two years of chemistry to include biochemistry

An AMCBT approved program would also include the additional evaluation of:

- Faculty size (minimum of four biologists, three fourths of them with Ph.D.'s in biology)
- Teaching loads (maximum 12 contact hours per week, including labs)
- Examinations, syllabi, and student research reports
- Faculty compensation
- Faculty professional activities
- Library collection (20 subscriptions to refereed journals, access to Biological Abstracts)
- Facilities and equipment
- Budget and administrative structures, support personnel
- Textbooks and use of primary literature
- Placement of graduates

I believe that ACUBE can take a leadership role in this process. I think these guidelines should be discussed among our membership (perhaps in letters to the editor). Feel free to comment by emailing me (stephen.daggett@avila.edu) or contacting me at the address given in our editorial information.

Stephen S. Daggett, Ph.D.
Avila University

Become a member of ACUBE

Becoming a member of ACUBE has become more convenient. Go to our website (http://www.acube.org, click on the membership menu, and click where it says membership form. Mail the forms and fees to our secretary Tom Davis.