Bioscene

Journal of College Biology Teaching

Volume 27(1) March 2001

Bioscene

Journal of College Biology Teaching

Volume 27(1) March 2001

A Peer-Reviewed Journal of the

Association of College and University Biology Educators

Co-Editors:

Timothy Mulkey
Indiana State University

Ethel Stanley
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Cover image: Unidentified fungal specimen. The fungus measures approximately 11 inches across. Photograph courtesy of William Brett.

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Please submit all manuscripts to either co-editor, Tim Mulkey or Ethel Stanley. We prefer receiving Rich Text Files (RTF) to facilitate distribution of your manuscript to reviewers and to make revisions. If you wish to attach a file to email, please address the subject line as BIOSCENE. Your submission should also include the title, author(s), name of your institution with the address, email address, phone and fax numbers, a brief abstract (200 words or less), keywords, and references in appropriate format that are cited in the manuscript. Graphics are welcome! Tables and graphs may be included in the manuscript file, but images should be submitted as individual electronic files. If you are unable to provide an image in an electronic format such as TIFF for Macintosh or BMP for Windows, please include a clean, sharp paper copy for our use. Your manuscript will be sent to two reviewers as coordinated through the Editorial Board. You will receive suggestions and comments from the reviewers prior to publication of the article. Once accepted, your article will appear in the Bioscene and will be posted on the ACUBE website: http://acube.org Authors retain copyright of their published materials.

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Suggestions for manuscripts include: announcements, web site and book reviews, labs/field studies that work, course development, technological advice, software reviews, curricular innovation, history of biology, letters to the editor, undergraduate research opportunities, professional school, funding sources, current issues, etc.

Deadlines for Submissions

April 1, 2001 for the May 2001 Issue

July 1, 2001 for the August 2001 Issue

An Activity to Demonstrate the Concept of Sampling Error for the Introductory Biology Classroom

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Abstract: An understanding of the concept of sampling error – the variation that exists in repeated estimates generated through sampling or imposing an experimental treatment on a subset of a population of interest – is vital to the interpretation of results of scientific investigations. However, students often have difficulty conceptualizing sampling error and appreciating its significance to research. As activities have proven useful in promoting student understanding of abstract concepts, an activity was developed to help students visualize the concept of sampling error. The activity makes students a part of an investigation that determines the frequency of a particular plant variety in a simulated population. It also provides an opportunity for students to observe the inherent variability of estimates, observe the relationship between sample size and sampling error, and consider aspects of research design.

Keywords: sampling error, activity, biology, research design, statistics

INTRODUCTION

Science is often characterized as a search for "truth." Used in this sense, truth refers to the description and explanation of natural phenomena. In actuality, science typically works by producing estimates, as it is often impossible or impractical to conduct investigations that include every member of a population of interest, or is replicated innumerable times.

Scientists typically generate estimates through the sampling of, or the imposition of an experimental treatment on, a subset of a population of interest. These estimates may then be used to draw conclusions about an entire population. However, before such generalizations can be made, one must consider and account for an important characteristic of estimates. They are inherently variable because different subsets of individuals included in a sample can generate different estimates. The variability of estimates is known as sampling error and an appreciation of this variability is vital to understanding the meaning of experimental results. Zales and Colosi (1998) observed the importance of students understanding the concept of sampling error, noting that '…when students must decide if observed differences are caused by a treatment effect or just due to chance based on sampling, they cannot appreciate their experimental results without understanding how sampling effects can result in different measured values. If students do not realize this fact, they cannot understand how we can declare that different means of two or more treatments are considered 'not statistically significant'." If appropriate methods are utilized to obtain representative sample units, the variability in estimates can be controlled through sampling procedures and experimental design. By including an appropriate number of individuals in an investigation, estimates can be generated that can be thought of as reflecting truth at a given confidence level.

One of the goals of the introductory biology course for non-majors at Middle Tennessee State University is to foster student understanding of the processes of science. The concept of sampling error is utilized to link aspects of scientific research design with statistical procedures for analyzing data. However, I have found that subsequent to discussions about sampling error and student calculation and comparison of measures of sampling error from supplied data sets, many students still have difficulty conceptualizing sampling error and appreciating its ramifications to scientific research. Because activities have proven useful in promoting student understanding of abstract concepts (Anderson, 1996; Woolfolk 1995), an activity was developed to help students visualize the concept of sampling error and appreciate its implications to scientific research.

The activity described in this paper allows students to be part of an investigation to determine the frequency of a hypothetical plant variety in a simulated population. Utilizing a research design that involves sampling, students use different sample sizes to estimate the percentage of the variety in the population. The activity provides an opportunity for students to observe the inherent variability of estimates, the relationship between sampling error and sample size and consider important aspects of research design.

Methods and Materials

The activity utilizes materials that are inexpensive and easily obtained:

Red beads (approximately 50 per student)
White beads (approximately 50 per student)
1 small paper bag (per student)
1 plastic cup (per student)
Overhead transparency of data table
Overhead transparency of axes

To form the simulated plant populations, place two quantities of different colored beads of the same size and texture in the desired proportions in small paper bags. Use plastic cups to contain the beads after they are drawn from the bag during the activity.

Prior to the activity, background information about the population of interest (see box below), a data table to record results, and axes to plot the results are passed out to students. After the students have read the description of the study, they are reminded that, in actuality, they will be involved in three studies, each utilizing a different sample size to answer the question: What is the percentage of the white-flowered variety in the plant population?

Background Information About Flora bicolor

Flora bicolor is a recently described plant native to the area. The plant's name reflects the fact that it exists in two varieties--One producing white flowers and one red. All known populations contain both varieties of the plant. Little is known of the plant's biology, including the percentage of each variety in populations. Recently, a large population of Flora bicolor was discovered locally on an accessible site. This population affords the opportunity to seek answers to some basic questions about the species, including determining the percentage of each variety in the population. Answering this basic question may lead to an understanding of the phenotypic variation within and the selective forces acting upon the species. We will utilize a research design that involves sampling to determine the frequency of the white flowered variety in the population.

The simulated plant populations (paper bags containing beads) are then distributed to students, and they are informed that each bag has the same number of red and white beads, representing the two varieties found in the plant population of interest. Students are then assigned a letter of the alphabet to identify their estimates on the data sheet. The following instructions are then provided:

1. Holding the bag closed, vigorously shake the bag, mixing the beads.
2. Draw the beads from the bag one at a time.
3. As you draw beads from the bag, place them in the plastic cup.
4. When you have achieved the desired sample size (4, 10, 30) stop drawing the beads.
5. Determine the percentage of the white beads (flowers) in your sample.
6. Record this estimate in the appropriate space on the data table (designated by letter).
7. Replace the beads in the bag.
8. Repeat steps 1-7 utilizing another sample size (4, 10, 30).

After the students complete the sampling procedures, they report their estimates by recording them on an overhead transparency of the data table. Students then complete their data tables, recording all of the estimates generated by the class.

Students utilize the axes provided to plot the distribution pattern of the estimates, using an asterisk to identify individual estimates. By stacking repeated estimates, students create a frequency histogram of the estimates.

To guide students through the activity, the following questions are provided:

1. Observe the frequency distributions of the three sampling procedures. Which distribution appears to have the greatest variability among its estimates? Which the least?
2. Given that the actual percentage of the white - flowered variety in the population is 53%, in which sampling procedure do the estimates appear to cluster most closely to the actual population percentage?
3. If you did not know the true population percentage of the white flowered variety, and you had a single estimate from each of the sampling procedures, in which would you have the highest confidence of being the most nearly accurate? Why?
4. How can you improve the confidence that you have in an estimate?
5. Based on your observations, what is the relationship between sample size and sampling error?

Results and Discussion

Figure 1 illustrates representative results generated from this activity. The variability inherent in estimates is readily observed within each of the three sampling procedures, with estimates ranging from 0-I00% with a sample size of 4, 20-80% with a sample size of 10, and 30-63% with a sample size of 30. The relationship between sample size and sampling error is made explicit as the variation among estimates can be observed to decrease with increased sample size. By comparing the distribution patterns generated by each sample size, students observe the tendency of estimates to cluster more closely to the true population percentage as sample size increases. Generally, the results allow students to observe that repeated estimates on the same population vary, the variation in estimates decreases with increased sample size, and the confidence that one can have in an estimate reflecting reality increases with sample size.

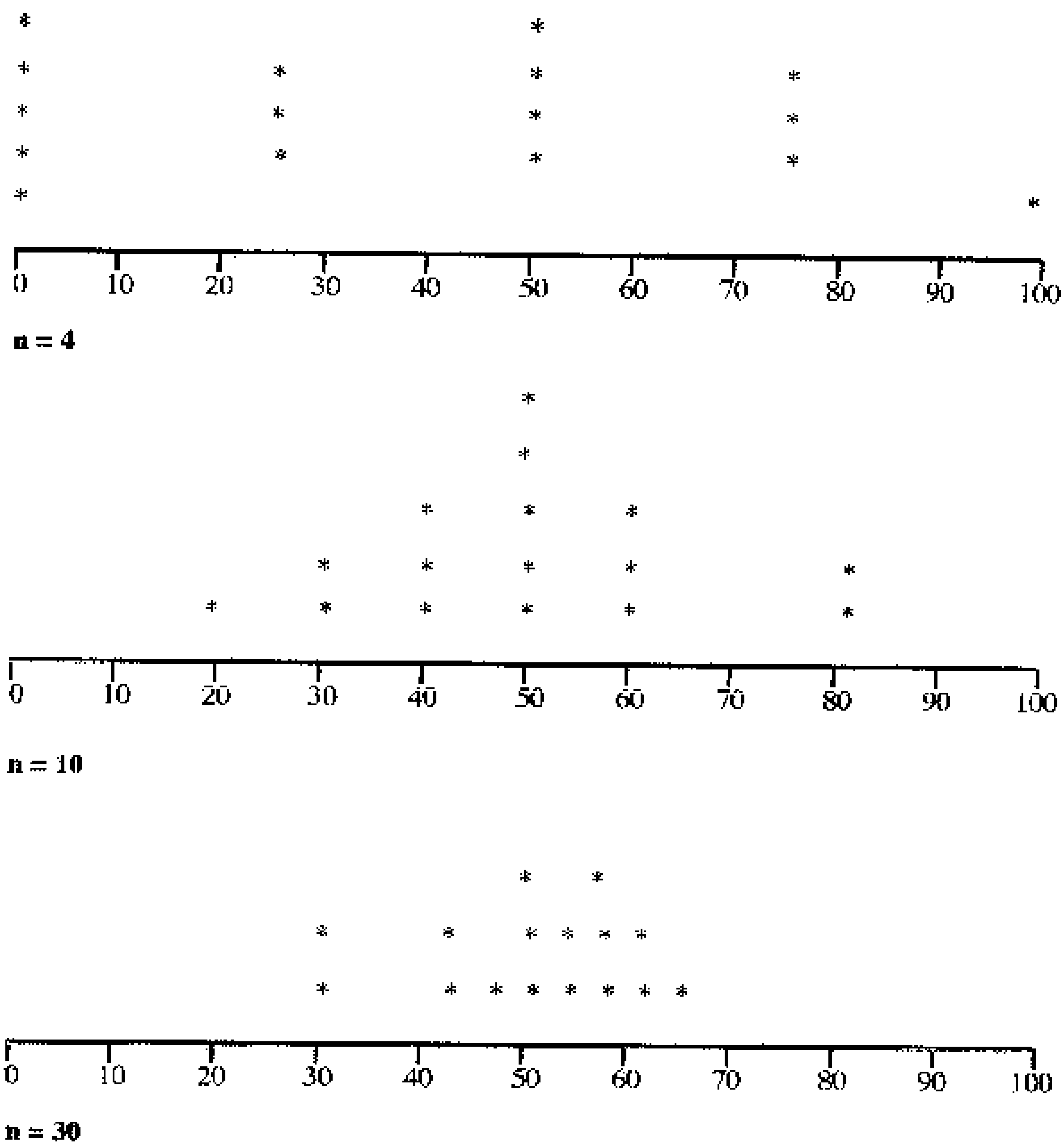

Figure 1. *Distribution Frequency of Estimates of Generated Using Varying Sample Sizes*

Students' engagement during the activity is typically high and it appears useful in promoting students' understanding of an important concept that some students find quite abstract. Students are eager to compare their results with others to determine which group's estimates are most nearly accurate. Students often request additional time to sample the simulated population with varying sample sizes. The activity takes about 30 minutes to conduct, and seems to provide a referent through which students ask questions about more advanced concepts such as standard error, hypothesis testing, and statistical inference. While the activity was designed for use in a non-major's biology course, colleagues have utilized it in courses for biology majors, as well as a business math course. Though the activity has not been formally evaluated, feedback from students and professors indicate that it is enjoyable and may help students to "visualize" the concept of sampling error, and appreciate the relationship between sample size and sampling error.

The activity is not without problematic aspects. The outcome is based on probability and it is possible that the relationship between sample size and sampling error may not initially be revealed due to chance events. This provides the opportunity to discuss the significance of chance events and illustrates the fact that a particular sample may not be representative of a population. Typically, additional applications of the activity generate expected outcomes. Increasing the difference in the sample sizes utilized in the procedures minimizes the likelihood of unexpected results.

Literature Cited

Anderson, E.J. (1996). Science in a bag: A strategy for making abstract biological concepts concrete. Journal of College Science Teaching, 26(1), 37-39.

Woolfolk, A.E. (1995). Educational Psychology, 6th ed. Allyn & Bacon, Boston.

Zales, C.R. & Colosi, J.C. (1998). An exercise where students demonstrate the meaning "not statistically significantly different," American Biology Teacher, 66(8), 596-600.

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Call for Nominations

John Carlock Award

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

Guidelines: The applicant must be actively pursuing graduate work in Biology. He/she must have the support of an active member of ACUBE. The Award will help defray the cost of attending the Fall meeting of ACUBE. The recipient of the Award will receive a certificate or plaque that will be presented at the annual banquet; and the Executive Secretary will provide the recipient with letters that might be useful in furthering her/his career in teaching.

Application: Applications, in the form of a letter, can be submitted anytime during the year. The application letter should include a statement indicating how attendance at the ACUBE meeting will further her/his professional growth and be accompanied by a letter of recommendation from a member of ACUBE. Send application information to:

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

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

Frugal Fun With Fungal Cultures

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Abstract: A home kitchen can serve as a stock room to provide the supplies and equipment needed to culture fungi for classroom use. Some alternative media and cultural techniques are provided along with two alternative classroom investigations that can be employed by classes from elementary through college levels.

***Keywords*:** fungi, growth rate, mycology, sterile culture, mold

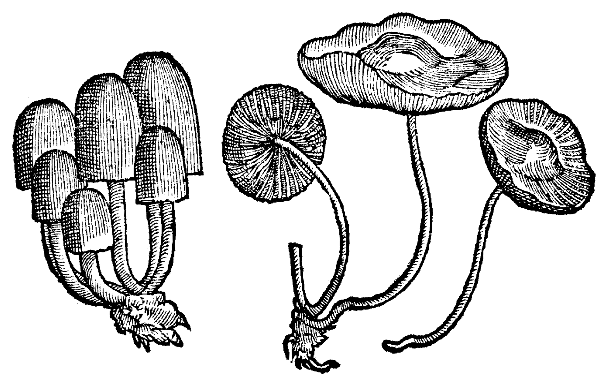
Introduction

FUNgi are FUN to work with and can be an inexpensive alternative to other organisms in studying a variety of life processes. The emphasis of this paper is to demonstrate a number of inexpensive alternatives to the usual laboratory procedures used to culture various molds. Although the protocols used in mycological research can be quite complex and the costs involved may be prohibitive for use in most K-12 classrooms, there are many simple investigations that can be fun, informative and inexpensive.

Alternative Materials and Media for Fungi.

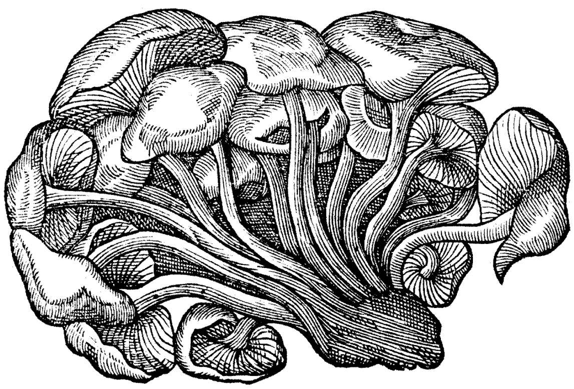
Sterile technique and basic microbiological procedures are generally employed when working with living cultures of plants and fungi. However, certain of the procedures may be eliminated and substitutes may be used in place of expensive media. For instance, the usual method of sterilization is to autoclave liquid media for 15 min. at 15 lb. pressure. One alternative to this is to use a kitchen pressure cooker, but even this are becoming rare in many households. A more commonly available alternative is the microwave oven; two minutes on high should be sufficient to "sterilize" media for routine use. When using the microwave, it is important to use a container of more than twice the volume being treated. For instance, to sterilize 250 ml of media, I use at least a 1 liter flask or beaker.

Although typically one covers the end of the container with a cap or foil cover while it is being sterilized, this is not necessary in a microwave if you are able to immediately pour your plates. If a cover is necessary, invert a glass beaker over the neck of the flask or cover it loosely with plastic wrap; do not seal it as the gas inside will expand greatly and cause sealed plastic wrap to burst.



In research labs, inoculations and transfers are performed in a transfer cabinet or laminar flow hood ($400.00-$5,000.00+). However, for routine classroom use, you can do such procedures on an open bench top, providing air movement in the room is kept to a minimum. Caution students not to move around in the room as classmates are working. They should also avoid all sudden movements around their work area while they are making sterile transfers. Alternatively, you can construct a homemade transfer cabinet from a cardboard box, aluminum foil and clear plastic wrap. Use foil to provide a washable lining that can be sprayed with a 10% commercial bleach solution for disinfection. Clear plastic wrap, e.g., Saran Wrap™, is essential sterile as it is pulled off the roll; use it to provide a sterile "window." You can also use Saran Wrap™ in place of Parafilm™ to seal petri dishes and other containers.

The most commonly used media for culturing fungi include: Potato Dextrose Agar ($60.00/500g), Corn Meal Agar ($140.00/500g) and Rabbit Dung Agar ($144.50/100 plates). The cost of these products derives in large part from the cost of Agar itself ($88.00/500g). Agar has two main advantages over its main alternative -- gelatin. First, most microbes do not digest agar and second, agar is more heat stable than gelatin and thus remains solid in incubators above room temperature. However, for general use in growing fungi, these characteristics are relatively unimportant. Thus, commercial gelatin can be substituted for agar in most media for classroom use. The following are grocery store formulae for fungal growth media:



Potato Medium

Peel and dice about 100g of white potatoes and boil for 1 hr in 350 ml of distilled water. Strain the supernatant through cheesecloth (or through a coffee filter) and bring the fluid back to 350 ml with additional distilled water. Add 10 g gelatin to solidify. You may also want to add 1 g sugar as a substitute for potato dextrose agar. Straining is necessary only to produce a clear medium. A simpler technique is to blend the potatoes and water to produce a liquid slurry. As an alternative to using whole potatoes, you may want to try instant potato flakes. The "active nutrient" in the potatoes is starch, you may also substitute soluble starch that is processed potato starch and works well. You also can use commercial cornstarch. Add sugar or not. Sterilize by pressure cooking or microwaving.

Oatmeal Medium

Mix 40 g Instant Oatmeal (for babies) with 750 ml distilled water and add 5 g agar (gelatin). Alternatively, you can blend 50 g of old-fashioned oatmeal in 800 ml distilled water. Leave it overnight in the refrigerator, then simmer it for an hour, bring up to 1 liter, add 7.5 g agar (gelatin) and sterilize (microwave). To obtain a clearer medium, simply filter this mixture through cheesecloth or a coffee filter prior to adding agar and sterilizing.

Cornmeal Medium

This recipe is similar to the oatmeal medium. Blend 50 g of cornmeal in 800 ml distilled water and let set overnight in the refrigerator. Simmer for an hour, bring to 1 liter, add agar (gelatin) and sterilize (microwave). Again, filtering may be done to produce a clearer medium.

Rabbit Dung Medium

Presterilize rabbit pellets, then blend equal volumes of pellets and distilled water. Add enough agar (gelatin) to make a 1.5% solution and sterilize.

Sterile Technique

In order to maintain pure cultures of organisms, and to prevent contamination by microbes such as bacteria or other fungi, it is necessary to use special techniques and procedures, collectively called sterile technique. When using sterile technique, assume that all surfaces are contaminated, so if any of your sterile instruments or a piece of tissue touches a surface, you should assume that it was contaminated and must be resterilized or discarded. Similarly, sterilize the work space before beginning any procedure. Sterilization is the process of destroying all organisms. In the laboratory, sterilization is accomplished through the use of heat, chemicals, or both. Instruments, such as scalpels, forceps, needles, etc., are usually treated by passing them through a flame. Larger equipment may be sterilized by heating in an oven at 165-170 C (325-340 F) for 2-3 hours. Instruments, and especially prepared growth media, are usually sterilized by exposure to steam under 15 lb. pressure (over 100 C) for at least 15 minutes. Bench tops, work surfaces, instruments and the surface of living tissue are usually sterilized by exposure to a 10% solution of household bleach in water for 5 - 10 minutes. The outer cells of the tissue will be killed by such a treatment and must be removed with a sterile blade before trying to culture cells or organs sterilized in this way. Bench tops are usually sterilized by spraying bleach solution on them and then wiping with a paper towel to spread the bleach (not dry the table -- leave it wet). Similarly, transfer chambers can be sterilized by spraying all inner surfaces with bleach or alcohol solutions. If a flame will be used to heat sterilize instruments, surface sterilize your area with bleach, not alcohol, to reduce the potential for fire. Of course, bleach has the potential to spot dyed clothing, so students should work carefully and preferably wear some kind of smock or lab coat.

The air space above a sterile work surface is also considered sterile. As a result, anytime something passes over the sterile field, assume the work surface became contaminated. Never pass your hand over the work area and be sure to heat sterilize any portion of an instrument that will be passed over the sterile field. Also, keep hand movements and air currents to a minimum to reduce the potential for airborne contamination.

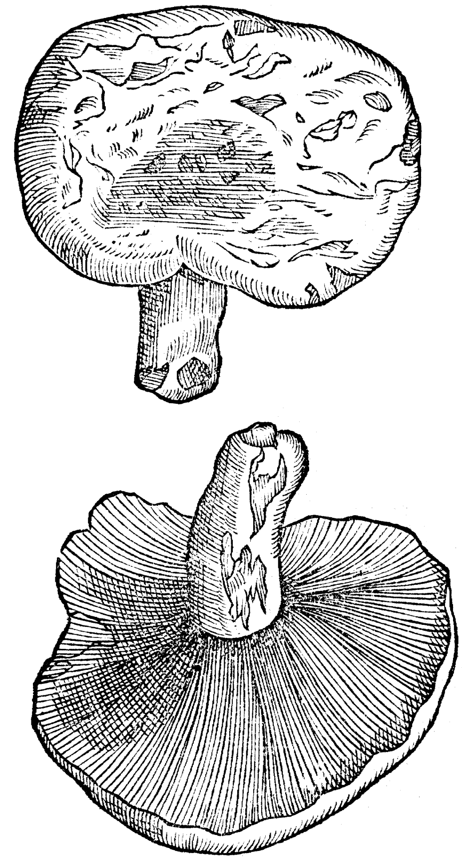
Before beginning work, wash your hands and arms, leaving them moist so that any potential contaminants will stick to your skin, rather than falling off and contaminating your sterile field. If you have long hair, tie it back or wear a hat or net to keep it out of the way. Avoid unnecessary talking to minimize air movement around your work area.

Some Alternatives to the "Bread-in-a-Bag" Types of Investigations -- The Great Fungus Race

The challenge is for student groups to produce the fastest growing fungal culture in the class. Students can use any medium they like, usually based on adaptations of one of the media listed above. They may grow their fungi under any environmental conditions they choose. Typically different temperature and light regimes are used in addition to different culture media. However, if gelatin is substituted for agar in any of the formulae, the medium will become soluble at higher temperatures, so incubating at above room temperature may turn what was a solid medium into a liquid one. There is not necessarily anything wrong with this as far as growing fungi, but it may cause some surprises for the students and it has the potential to become messy if students are not careful in handling the liquified cultures!

The first challenge is to obtain a pure fungal culture. Fungi may be isolated from the environment in a number of ways. The simplest method is to add bits of soil, dung, decaying material or debris to the surface of a prepared medium. One technique is to push the inoculant along the surface of the plate. Within a day or two, filamentous mycelia should be observed growing out from several locations. At this point, choose a likely looking mold candidate, and use a sterile blade to cut off some of the tip of the growing hyphae, including the chunk of medium it is growing on, and transfer it to a fresh plate of medium. You should now have a pure culture of the chosen fungus.

If spores are already present on a piece of potential inoculant (e.g.., some moldy food rescued from the home refrigerator), individual pure cultures can be started by the spore touch method. To do this, cut out a tiny chunk of sterile medium with a needle or blade tip and fix the chunk of medium on the tip by simply jabbing it. Now touch this chunk against the spores of your inoculant, then transfer it back to the sterile plate. The spores are the powdery, colored particles that form on the surface of growing molds. If you touched only a single type of spore, you will produce a pure culture of that species. Pure cultures of mushrooms and mushroom-like fungi can be started by sticking a small piece of fruiting body to the lid of a dish containing medium. Vaseline or a similar sticky paste can be used to fix the small piece of mushroom to the lid. After several minutes to several hours (depending on the species and the state of the specimen) spores will be shed onto the surface of the medium below.



Once students have chosen the fungus they want to race and isolated it in pure culture, they are ready to begin timing their competitor. To do this, they should inoculate the center of a plate of medium and record the time this was done. Once or twice a day for the next several days, measure the distance the fungal mycelium has grown from the original center of inoculation. The colony will be circular, so measure and average several radii to determine the average growth at that time. Record the time of measurement and the calculated average. When the culture nears the edge of its plate, make the final measurements and calculate the average rate in mm/hr. The best way is to calculate the least squares regression line for the data of distance and time. The slope of the line is the rate of growth. A crude approximation can be made from the final distance divided by the total elapsed time. The student group whose fungus had the fastest time (greatest rate) wins the contest.

The type of fungal isolate and any of the environmental variables can affect the growth rate obtained, sometimes in unexpected ways. For instance, incubating at high temperature, such as 37C as typically used for culturing bacteria, will produce slower growth in most fungi (remember that if your students are using a gelatin based medium, it will be a liquid at that temperature!).

Nutrient Effects on Colony Morphology

In addition to growth rate, environmental conditions, especially available nutrients, can induce considerable variations in colony morphology. This includes not only the texture, but also the color, size and shape of the colony. A challenge along these lines is to have a contest to see which student group can produce the largest number of different looking colonies from the same inoculant. A key analysis question here is how can they determine that two very different looking cultures at the end of their experiment are actually of the same fungus, rather than of the initial isolate and some kind of contaminant?

Some Important Rules for Safety.

Although the vast majority of molds that students capture will be innocuous, there is always the potential that a pathogenic organism will be isolated. Always assume that anything in culture is a potential pathogen. Be sure to use sterile technique and disinfect the table tops you are working on both before and after the experiment. Similarly, students should wash their hands before and after working. Initial cultures should be sterilized and disposed of as soon as subcultures have been made and pure cultures should be sealed closed once they are inoculated and not be reopened. Be sure that students sterilize and disposed of all cultures when they are finished.

Annotated List of Additional Sources of Information

The American Type Culture Collection, 14th Ed. *(1980). Catalogue of Strains.* Rockville, MD. Not only does this contain the catalog of microbes available from the collection, including the suggested media for culturing for various protocols, but it also contains media recipes.

Bold, Harold *C. (1957). Morphology of Plant. 1st ed* Harper and Bros. New York. The appendix to this edition contains a wealth of information on collecting and culturing plants, algae and fungi.

Carroll, Juliet E. (1994). *Learning Biology with Plant Pathology.* The National Association of Biology Teachers. Reston, VA. Chapters 6 and 7 cover media preparation, isolation, culture and maintenance of microbes. Chapter 8E covers soil fungi and 8F covers powdery mildews.

Koch, William J. (1973). *Plants in the Laboratory: a manual and text for studies of the culture, development, reproduction, cytology, genetics, collection, and identification of the major plant groups.* Macmillan. New York. Chapter 3 deals with methods in isolation and culture of fungi. Chapters 16 and 17 present special cultural methods for molds and mushrooms, respectively, and chapters 21-27 survey the various groups of fungi from slime molds to lichens.

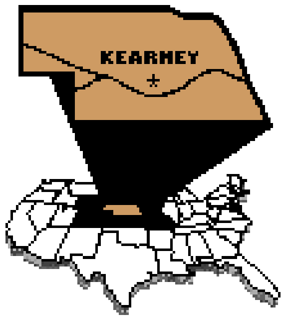
Morholt, Evelyn, Paul F. Brandwine and Alexander Joseph. (1966). A *Sourcebook for the Biological Sciences, 2nd ed.* Harcourt, Brace & World, Inc. New York. Chapter 13, Growing Plants Useful in the Classroom, includes sections on algae, slime molds and fungi, mosses and ferns. In addition, fungi are used as model organisms in reproduction and growth (Chapters 8 and 9 respectively) and ecology (Chapter 11).

Call for Nominations

President-Elect, Secretary & Steering Committee Members

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

If you wish to nominate a member of ACUBE for a position, send a Letter of Nomination to the chair of the Nominations Committee: Dr. Lynn Gillie, Dept. of Biology, Elmira College, One Park Place, Elmira NY 14901, Voice -- (607) 735-1859, E-mail --lgillie@elmira.edu



University of Nebraska at Kearney

Department of Biology
Kearney, Nebraska

Site of the 45th Annual ACUBE Fall Meeting

October 11-13, 2001

History: The University of Nebraska at Kearney began as the Nebraska State Normal School in 1905. In 1921, the name of the institution was changed to Nebraska State Teacher's College at Kearney. In 1963, it became Kearney State College. Both names were a part of system-wide changes for the state. In 1989, however, legislative action moved the institution from the State College System to the University of Nebraska System. The university community is in its 10th year as a NU System campus.

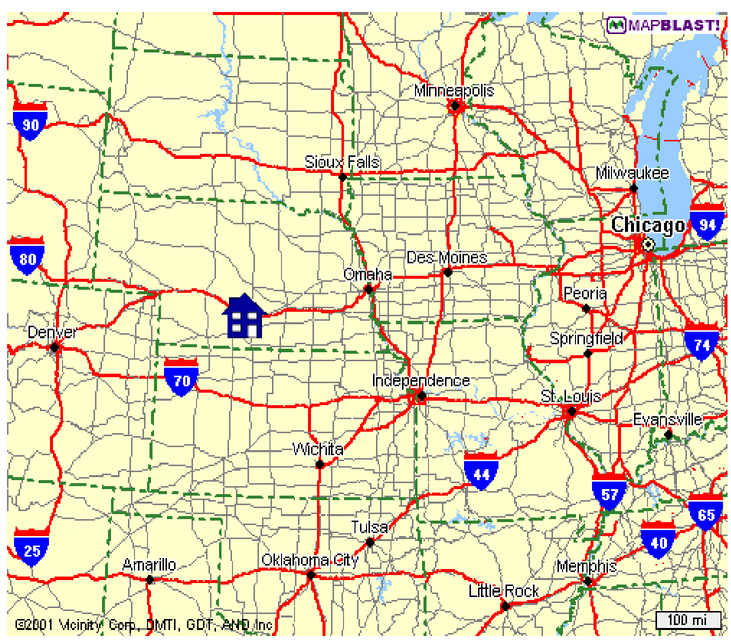
Mission: Today, UNK is a comprehensive residential university distinguished by its commitment to be the state's premier institution for undergraduate education. The university pursues the preservation, enrichment, and transmission of knowledge and culture across a broad scope of academic disciplines. It places the highest priority on programs of instruction and learning that educate students to be lifelong, independent learners. UNK has 350 faculty, 7000 students, and about 30,000 living alumni. UNK has 176 undergraduate programs, and offers masters degrees in several disciplines.

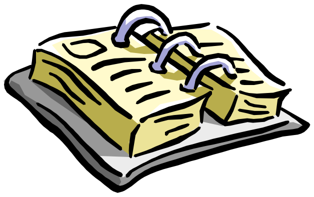
Department of Biology: The Department of Biology has 15 tenure track faculty, 3 full time lecturers, and about 250 majors. The Department also offers the thesis-focused M.Sc. degree as well as an M.Sc. science teaching (MSST) degree. The Department stresses both the content and processes of biology in seven emphasis areas; the comprehensive major, agricultural emphasis, environmental emphasis, environmental health emphasis, molecular emphasis, wildlife emphasis, and secondary biology education. All students complete an extended independent research project that culminates with a scientific research report written in the conventional fashion, a 20-minute oral presentation in the format of a scientific meeting, and submission of a poster. Student posters adorn the halls of the Biology floors celebrating the accomplishments of recent graduates.

The faculty typically teach "across the curriculum" with most involved in both majors and general education biology courses as well as lower and upper division offerings. Active faculty "groups" in prairie ecology and molecular biology have formed in recent years. This dynamic clustering of 3-5 faculty in each instance has enhanced undergraduate research opportunities.

Geography: The city of Kearney lies just north of the Platte River; the key water resource for wildlife and agricultural production across central Nebraska. Renown for the annual spring migration of some 500,000 sandhill cranes, the central "Big Bend" region of the Platte River harbors other migratory waterfowl in the spring, bald eagles in the winter, and an abundance of other wildlife. The Department of Biology utilizes or manages classic tallgrass prairie preserves in the lowland areas along the river and mixed grass prairie preserves in the upland loess hills minutes north of Kearney.

Kearney, a city of 30,000, is home to the Museum of Nebraska Art (MONA), the Great Platte River Road Archway Monument, a Cabela's sporting goods outlet, and Fort Kearny State Historical Park. The Fort adjacent to the Platte River along the Oregon, Mormon, and California Trails was a major staging ground for pioneers heading west.





Travel and Housing Preview

45th Annual ACUBE Fall Meeting
University of Nebraska at Kearney
October 11-13, 2001

Travel by Air

- Kearney has four arrivals and departures daily via United Express. All flights connect with Denver International Airport, the hub for United Airlines.
- Lincoln is just under 2 hours to the east of Kearney and is served by TWA, Northwest, United, and US Air Airlines. Omaha is just under 3 hours to the east with non-stop service several times a day from St. Louis (TWA), Chicago (United – O'Hare and Southwest – Midway), Minneapolis (Northwest), Milwaukee (Midwest Express), and Indianapolis (United).
- Eppley Express, a shuttle service, has three daily departures and arrivals from both the Omaha and Lincoln airports to Kearney. The fare is $34 one way from Lincoln and $42 from Omaha. The drop point in Kearney is the Country Inn Suites.

Travel by Car

- Kearney is 5 hours by car from Kansas City, 5 hours from Denver, 7 hours from Minneapolis, and 10 hours from Chicago.

Lodging

Kearney has 20 motels; several of which are on the Second Avenue corridor just off Interstate 80 and about one mile south and one mile east of the University of Nebraska at Kearney campus. Among those motels with tentative arrangements expressly for ACUBE meeting participants are:

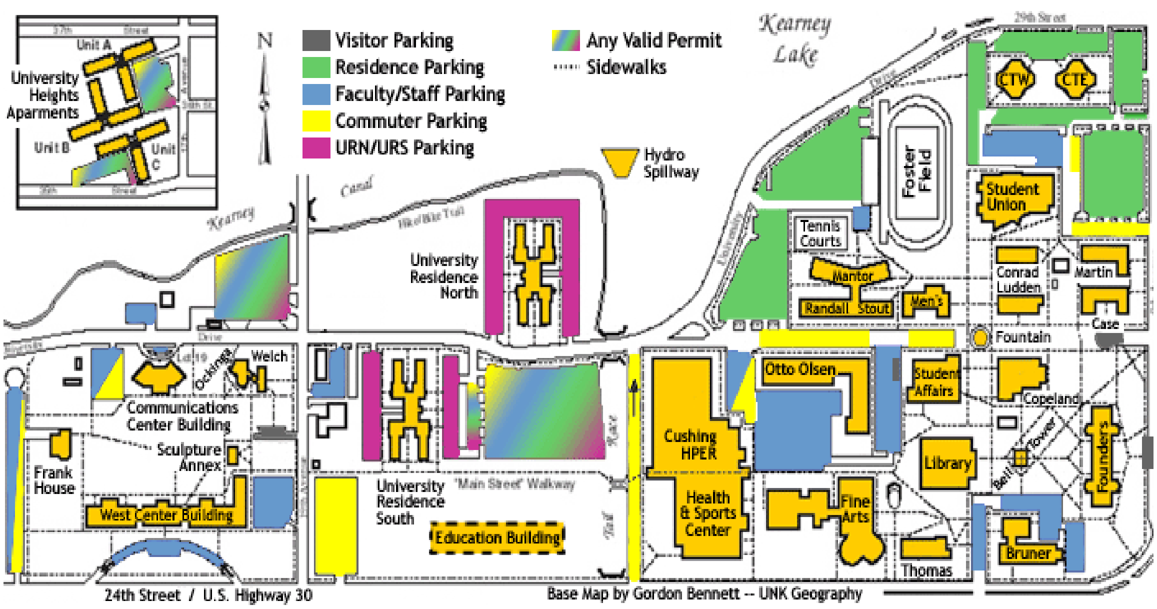
Holiday Inn
110 2nd Ave.
P. O. Box 1925
Kearney, NE 68847
308-237-5971 or 800-248-4460

Hampton Inn
118 3rd Ave.
Kearney, NE 68847
308-234-3400 or 800-426-7866

Wingate Inn
108 3rd Ave.
Kearney, NE 68847
308-237-4400 or 800-800-8000

Country Inn & Suites *
105 Talmadge St.
Kearney, NE 68847
308-236-7500 or 800-456-4000

* Location of the Eppley Express shuttle drop.



Promoting Creative and Critical Thinking Skills in College Biology

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Abstract: A model of creative and critical thinking is presented in which analogical reasoning is used to link planes of thought and generate ideas that are then tested by employing and "*if/and/then*" pattern of reasoning. Data are also presented suggesting that such thinking skills develop first in familiar and observable contexts before they can be used in less familiar and unobservable contexts. The principles of curricular design, based on the model and developmental sequence, are then used to construct an introductory college biology course in which students attempt to use the thinking skills as they inquire into increasingly complex and abstract phenomena. During a recent semester, a comparison of student pre-test and post-test scores on a test of reasoning skills found significant improvements suggesting meaningful gains in student thinking skills.

Key Words: Creative and critical thinking skills, general biology, curriculum design, inquiry, hypothesis and theory testing

Introduction

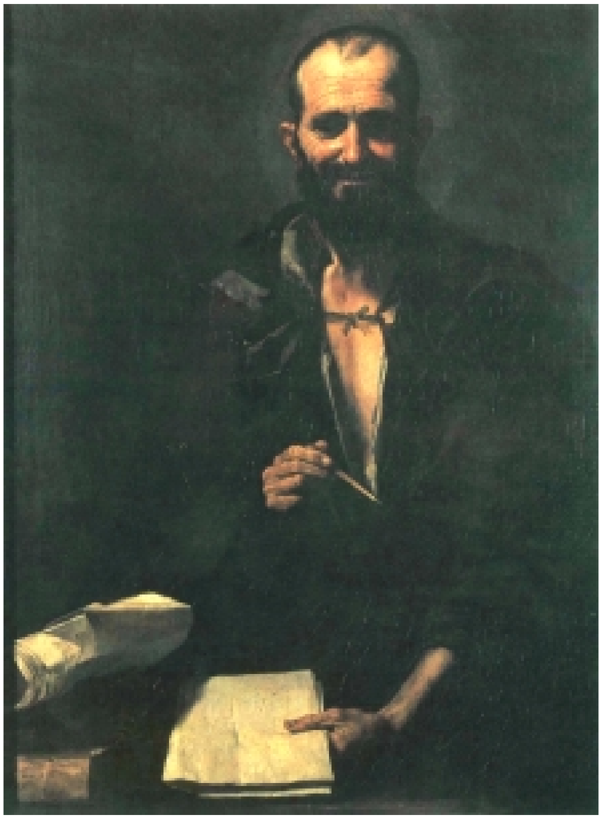
This paper describes a college biology curriculum designed to promote the development of students' creative and critical thinking skills as they participate in a series of biological inquiries. The paper first examines selected science case histories to develop a model of creative and critical thinking. It then derives the principles of curricular design based on the model. Two example of inquiry lessons are then presented along with data attempting to assess the extent to which student-thinking skills have been improved by the course.

A Model of Creative and Critical Thinking

According to Webster, to create means to bring into existence; cause to be; evolve from one's own thoughts or imagination (Merriam-Webster, 1986). Scientific creation has been described in terms of sequential phases of preparation, incubation, illumination and verification (Wallas, 1926; Sternberg & Davidson, 1995). During the creative process, the conscious mind mulls over a question or problem only to give up and turn it over to the subconscious. The subconscious then operates until it somehow produces a novel combination of ideas that spontaneously erupt into consciousness to produce a tentative answer or solution. From here the conscious mind guides a more critical testing of the novel idea to discover whether or not its value is real or illusionary (cf., Amsler, 1987; Boden, 1994; Koestler, 1964; McKellar, 1957; Wallace & Gruber, 1989).

Consider for example, Koestler's (1964) version of the often-told story of Archimedes and the golden crown. As Koestler tells the story, Hiero was given a crown, allegedly made of pure gold. He suspected the crown was adulterated with silver, but did not know how to tell for certain. So he asked Archimedes. Archimedes knew the specific weights of gold and silver -- their weights per unit volume. Thus, if he could measure the crown's volume, he could determine whether it was made of pure gold. But he did not know how to measure the volume of such an irregularly shaped object. Clearly he could not melt down the crown and measure the resulting liquid. Nor could he pound it into a measurable rectangular shape. With these easy solutions blocked, Archimedes had a problem.

Using Wallas' terminology, Archimedes was engaged in the preparation phase of creative thought. Having hit numerous dead ends, Archimedes put the problem aside. Nevertheless, his mind was well prepared for progress as several blind alleys had been tried and rejected. In a sense Archimedes now shunted the problem to his subconscious to let it incubate. The next phase, illumination, presumably began while Archimedes was about to take a bath. While lowering himself into the tub, he noticed the water level rise. And in a flash it occurred to him that the rise in water was an indirect measure of his bodies' volume. Thus, presumably at that moment, Archimedes "saw" how he could also measure the crown's volume -- simply by immersing it in water. And once he knew its volume, he could calculate its specific weight to know if it were made of pure gold. Eureka! Archimedes had the solution.



Painting of Archimedes by Jusepe de Ribera (Spanish 1591-1652) in the Nuseo del Prado, Madrid Spain.

In Koestler's view, Archimedes' creative act can be understood essentially as one of joining two planes of previously unconnected thought to reach a target solution T. For example, Figure 1 depicts the plane of thought P_l that contains the starting point S and several thought paths that have unsuccessfully sought the target. Thus P_l presents the habitual rules that Archimedes used to measure volumes and weights, to determine the nature of materials, and so on. But as you can see, the target T is not contained on P_1. Instead, it is located on P_2 -- the thought plane associated with taking a bath. Thus no amount of thinking on P_l can reach T. Archimedes needs to shift his thinking from P_1 to P_2. To do this he needs a link L. As Koestler points out, the link may have been verbal (for example, the sentence: rise in water level in the tub equals melting down of my body); or it may have been visual in which the water level rise was seen to correspond to body volume and hence crown volume. Either way, the key notion is that both planes of thought must be active in Archimedes' mind -- albeit not both on the conscious level -- for the link to occur and for him to consciously "see" the solution. Once illumination occurs, verification can take place. To do this, Archimedes presumably thought through the steps of his newly-created path from S to T to satisfy himself that no crucial steps had been left out -- that the path really led to T. Another aspect of the verification phase is to actually put the new strategy to work to discover if Hiero's crown had in fact been adulterated.

The following summarizes the key argument:

If ... the crown is made of pure gold (pure gold hypothesis)

and … the crown is immersed in water and the displaced water is measured (planned test)

then ... the crown should displace the same volume of water as displaced by a known sample of pure gold of equal weight (expected result).

On the other hand,

If ... the crown has been adulterated by silver or by some other less dense metal (adulterated hypothesis)

then ... it should displace a greater volume of water than displaced by a known sample of pure gold of equal weight (alternative expected result).

Notice how the preparation, incubation and illumination phases of Archimedes' thinking were creative in the sense that they brought into existence a new piece of procedural knowledge (i.e., a procedure for measuring the volume of irregularly-shaped objects). On the other hand, the verification phase of his thinking can be characterized as critical in the sense that once Archimedes created the new procedure, he used it to analyze the metals in Hiero's crown. This critical thinking produced a new piece of declarative knowledge (i.e., the crown was not pure gold).

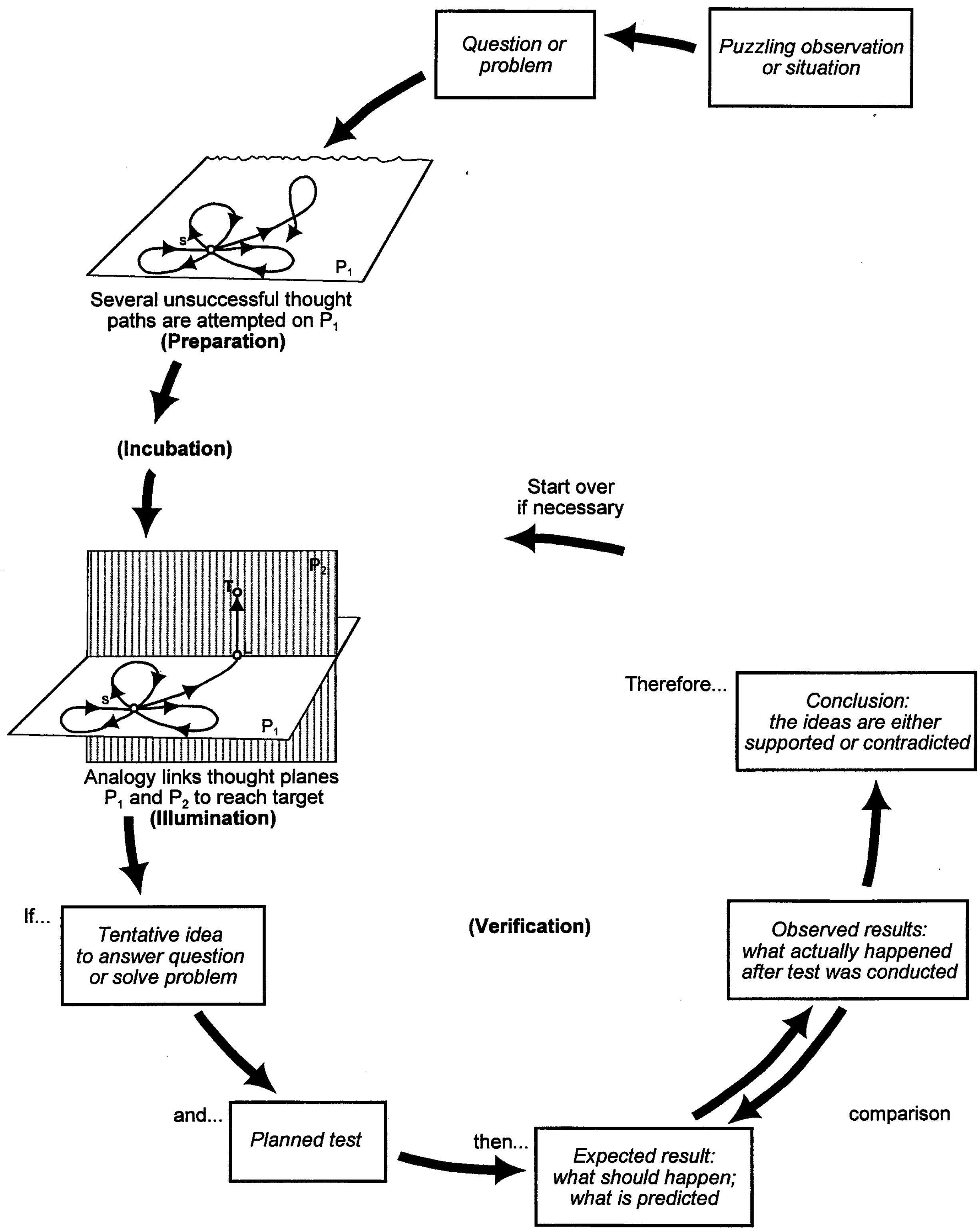


***Figure 1**. A model of creative and critical thinking depicting the phases of preparation, incubation, illumination and verification (after Wallas, 1926; Koestler, 1964; Lawson, 1995).*

Linking Thought Planes

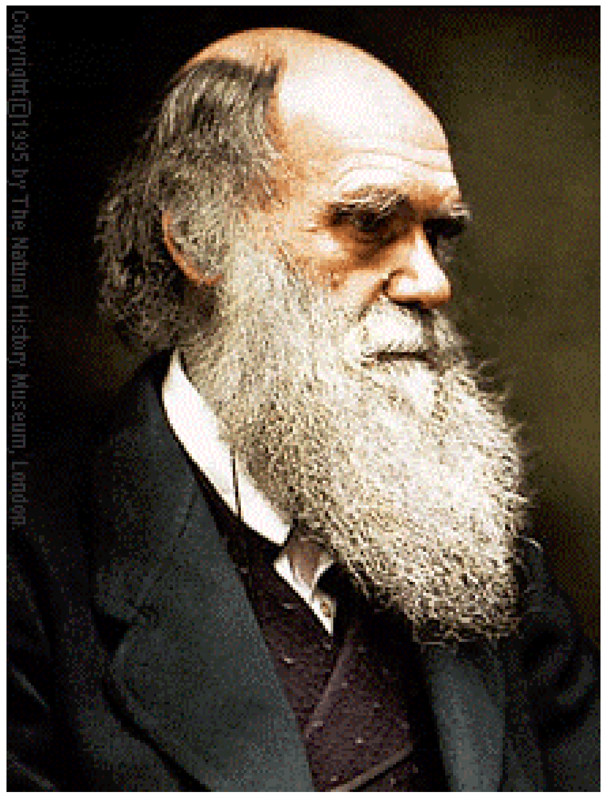
At the heart of this model of creative thinking lies the linking of two or more previously disconnected "planes" of thought. Consequently, the issue of how these planes are linked becomes of central importance. To see how thought planes might be linked, let's turn to the research of two biologists. As told by Beveridge (1950), while his family had left for a day at the circus one afternoon in 1890, Elie Mechnikoff half-heartedly watched some transparent starfish larvae as he tossed a few rose thorns among them. To his surprise, Mechnikoff noticed that the thorns were quickly surrounded and dissolved by the larvae. The thorns were being swallowed and digested. This reminded Mechnikoff of what happens when a finger is infected by a splinter. The splinter becomes surrounded by pus which, Mecknikoff surmised, attacks and eats the splinter. Thus, Mechnikoff's observation of the swarming larvae struck him as analogous to human cells swarming around a splinter. In this way the use of an analogy helped Mechnikoff "discover" the bodies' main defense mechanism – namely mobile white blood cells (phageocytes) that swarm around and engulf invading microbes.

Is Mechnikoff's use of analogy common in the history of biology? For example, can Charles Darwin's invention of natural selection theory also be traced to an analogy? Consider Darwin's words:

> It seemed to me probable that a careful study of domesticated animals and cultivated plants would offer the best chance of making out this obscure problem. Not have I been disappointed; in this and all other perplexing cases I have invariably found that our knowledge, imperfect though it be, of variation under domestication, afforded the best and safest clue (Darwin, 1898, p. 4).

Armed with this clue, Darwin tried to put the evolutionary puzzle pieces together. His attempt involved several unsuccessful trials until September of 1838 when he read Thomas Malthus' *Essay on Population* and wrote, "I came to the conclusion that selection was the principle of change from the study of domesticated productions; and then reading Malthus, I saw at once how to apply this principle" (quoted in Green, 1958, pps. 257-258). As Gruber and Barrett (1974) point out, Darwin had read Malthus before, but it was not until this reading that he became conscious of the analogical link between "artificial" selection and evolutionary change. Now that the link had been established, Darwin began marshalling the evidence favoring his new theory of "natural" selection.

Other examples of the use of analogy are numerous in the history of science. Kepler borrowed the idea of the ellipse from Appolonious to describe planetary orbits. Mendel borrowed patterns of algebra to explain heredity. Kekulè borrowed the idea of snakes eating their tails (in a dream) to create a molecular structure for benzene, and Coulomb borrowed Newton's ideas of gravitational attraction to describe the electrical forces that exist at the level of sub-atomic particles. The use of analogy -- the act of borrowing old ideas and applying them in new situations to invent new insights and explanations -- is sometimes called combinatorial thinking, analogical reasoning, or analogical transfer (cf., Biela , 1993; Boden, 1994; Bruner, 1962; Dreistadt, 1968; Finke, Ward & Smith, 1992; Gentner, 1989; Hestenes, 1992; Hoffman, 1980; Hofstadter, 1981; Hofstadter, 1995; Holland, et al., 1986; Johnson, 1987; Koestler, 1964; Wong, 1993). Thus, often (always?) an analogy provides the link -- the L -- between the thought planes so that the thinker can pass to the second plane and arrive at the target.



A Sequence in the Development of Thinking Skills

In addition to this model of creative and critical thinking, one more element needs to be in place before we can construct a curriculum to promote thinking skills. The three quizzes in Table 1 ask students to propose tests of two hypotheses. As you can see, students are asked to generate If/and/then/But/Therefore arguments complete with evidence that contradicts each hypothesis. During a recent semester, the quizzes were administered following lab activities in which the hypotheses in question were actually tested. In spite of this, quiz performance varied widely. Performance on the

Mealworm Quiz was relatively high as 82 % of the students succeeded in designing tests and in suggesting evidence that would lead to rejection of the hypotheses. But performance on the ***"A" Mountain Quiz*** dropped to 53 % and performance on the ***Osmosis Quiz*** dropped still further to only 18%.

Table 1. *The Mealworm, "A" Mountain, and Osmosis Quizzes.*

Mealworm Quiz

A student recently placed some mealworms in a rectangular box to observe their behavior. She noticed that the mealworms tended to group at the right end of the box. She also noticed that the right end had some leaves in it and that the box was darker at that end. She wondered what caused them to group at the right end.

Hypothesis 1: They went to the right end because it had leaves in it.

Hypothesis 2: They went to the right end because it was darker than the left end.

How could you test these hypotheses? 1. Describe your experiment. 2. What are the predicted results (assuming that the hypotheses are correct)? 3. What result would show that hypothesis 1 is probably wrong? 4. What result would show that hypothesis 2 is probably wrong?

"A' Mountain Quiz

A recent survey of organisms on "A" Mountain revealed more grass on the north-facing slope than on the south-facing slope. In response to the causal question, Why is there more grass on the north-facing slope?, a student generated the following hypotheses:

Hypothesis 1: Lack of moisture in the soil on the south-facing slope keeps grass from growing there (i.e., north is better shaded from the sun's drying rays).

Hypothesis 2: The sunlight itself is too intense for good grass growth on the south-facing slope (i.e., very intense rays disrupt the grasses' ability to conduct photosynthesis).

How could you test these hypotheses? 1. Describe your experiment(s). 2. What are the predicted results of your experiments) assuming that the hypotheses are correct? 3. What result would show that hypothesis 1 is probably wrong? 4. What result would show that hypothesis 2 is probably wrong?

Osmosis Quiz

When a thin slice of red onion cells are bathed in salt water the red portion of each cell appears to shrink. What causes the red portion to appear to shrink?

Hypothesis 1: Salt ions (i.e., Na^+ and Cl^-) enter the space between the cell wall and the cell membrane and push on the cell membrane.

Hypothesis 2: Water molecules (i.e., H_2O) are charged (i.e., thus leave the cell due to attractive forces of the salt ions.

How could you use model cells made of dialysis tubing, a weighing devise, and solutions such as salt water, distilled water, and glucose to test these hypotheses? 1. Describe your experiment. 2. What are the predicted results assuming that the hypotheses are correct? 3. What result would show that hypothesis 1 is probably wrong? 4. What result would show that hypothesis 2 is probably wrong?

Why did student performance vary so widely? The answer may lie in differences in the abstractness of the contexts as well as in subtle differences in complexity. For example, consider the following argument used to test hypothesis 1 of the Mealworm Quiz:

> ***If*** ... the mealworms went to the right end because of the leaves,
>
> ***and*** ... we place 10 leaves in one end of another box and then place 10 mealworms in the center,
>
> ***then*** … most of the mealworms should move toward the leaves.
>
> ***But*** ... suppose they do not.
>
> ***Therefore ...*** the leaves hypothesis would be contradicted.

Now consider this argument used to test hypothesis 1 of the Osmosis Quiz:

> ***If*** ... the onion cells shrink because ions push on their membranes,

And ... a dialysis bag, with membrane-like properties, is filled with a glucose solution and then placed in salt water,

Then ... the dialysis bag should appear smaller, but it should not lose weight. (The bag should not lose weight because the push presumably "compacts" molecules inside the bag but does not cause molecules to escape. This statement represents a theoretical rationale).

But ... suppose the bag does lose weight.

Therefore ... the ion push hypothesis would be contradicted.

Notice how the hypothesized cause in the mealworm argument (i.e., the leaves at one end of the box) is observable and familiar. The same can be said of the dependent variable of the planned test (i.e., mealworm movement). Notice also that the independent variable of the planned test (i.e., the number of leaves at each end of the new box) and the hypothesized cause are one and the same. However, things are more abstract and more complex in the osmosis argument. Here the hypothesized cause (i.e., moving ions) is non-observable. Further, the test requires an assumption about the similarity of cell membranes and dialysis bags. Still further, there is no direct connection between the experiment's dependent variable (i.e., change in bag weight) and the hypothesized cause, hence the need for a theoretical rationale. Presumably all of these factors, and perhaps others, make the osmosis argument more difficult to generate and comprehend. Consequently, student performance suffers. A similar analysis of the ***"A" Mountain Quiz*** reveals that it has characteristics intermediate to those of the Mealworm and Osmosis quizzes.

Curriculum Design Principles

With the above sequence and with the model of creative and critical thinking in mind, we can derive the following principles for the development of a curriculum designed to promote creative and critical thinking skills:

- Provide students with novel inquiries that provoke them to raise causal questions for which they have no ready answers (but do have several previous experiences that are in some way analogous so that they can serve as hypothesis sources).
- Challenge students to propose several possible explanations (hypotheses/theories) to answer the questions. Challenge students to design and carry out tests of their proposed explanations.
- Sequence experiences so that the complexity of the explanations and tests progresses from the observable and relatively simple to the non-observable and relatively complex.

Building the Curriculum

Table 2 provides an overview of the major topics and central questions raised during the course. As you can see, the course sequence attempts to take advantage of natural historical paths of inquiry -- an ontogeny recapitulates phylogeny approach to curriculum development. Consequently, the course starts at the familiar organismic level and extends into lower levels and into higher levels, and then returns to the familiar to follow additional inquiry paths extending farther down or up each time.

More specifically, students first explore whole-organism questions such as: Why do gazelles jump in the air when being chased by cheetahs? How do salmon locate their home streams to spawn? Initial theories include the ancient Greek four-substance theory and the theories of spontaneous generation and biogenesis. From here the course moves to basic theories of inheritance (cell theory, theories of mitosis and meiosis, and classic Mendelian genetics). Developmental theories are then addressed followed by general questions about plant growth (e.g., What materials do plants need for growth and where and how do they get them?). These questions allow the introduction of phlogiston theory, general atomic-molecular theory and very general theories of photosynthesis, respiration, combustion and decay.

Next, the course addresses theories of origins. Specifically, special creation theory is pitted against evolution theory as rival explanations for present-day species diversity. Introduction of the natural selection theory follows with a look at various mechanisms of speciation and extinction. The course then explores life's origin and its evolutionary products starting with prokaryotes, then protists, fungi, plants, animals and ending with humans. Next, basic concepts of behavior are explored as are basic ecological theories (e.g., kin selection theory, ecosystem dynamics theory, theories of biogeochemical cycling, competitive exclusion theory, succession theory and theories of biodiversity). Then comes physiological theories, first of plants and then of animals. Lastly, the course concludes with a look at very abstract and unfamiliar topics including kinetic-molecular level theories of photosynthesis, cellular respiration, and gene structure and function. We now turn to a description of two example inquiries.

Introducing Natural Selection Theory

Natural selection theory is introduced using a modification of a simulation inquiry first introduced by Stebbins & Allen (1975) and later revised by Maret & Rissing (1998). In the present version, students play the role of Gooney birds *(Gooney birdicus)*, which feed on mice known as *Microtus coloriferii* (i.e., 10 colors of paper "chips"). Students begin by spreading patterned fabric representing an environment such as a pond, meadow, or cave, over their table. They then take 10 mice of each color and distribute them randomly throughout the environment. At the instructor's signal, students capture mice and deposit them in nearby "nests". Each group captures 75 mice. The 25 survivors are then removed and reproduction occurs by adding three paper chips of the same color far each survivor. Students then repeat the predation and reproduction process at least two more times. Finally, the resulting numbers of surviving mice of each color are graphed, posted and compared.

***Table 2**. Curriculum Sequence and Central Questions Raised*

THE NATURE OF BIOLOGICAL SCIENCE

1. What is Biology?
2. What are Scientific Theories?

BASIC THEORIES OF INHERITANCE, DEVELOPMENT AND GROWTH

3. How are Characteristics Inherited?
4. How Do New Organisms Develop?
5. What Materials Do Plants Need For Growth?

BASIC THEORIES OF EVOLUTION AND SPECIATION

6. Were Organisms Created or Did They Evolve?
7. Why Do Some Species Evolve While Others Go Extinct?

THE EVOLUTION OF ORGANIC DIVERSITY

8. How Did Early Life Originate and Evolve?
9. What Protists, Fungi, and Plants Evolved?
10. What Animals Evolved?

BEHAVIORAL AND ECOLOGICAL THEORIES

11. What Behaviors Help Organisms Survive?
12. How Do Organisms Interact With Their Environments?
13. How Do Organisms Interact With Each Other?

THEORIES OF PLANT STRUCTURE AND FUNCTION

14. How Do Materials Move Through Plants?
15. How Do Plants Control Growth and Development?

THEORIES OF ANIMAL STRUCTURE AND FUNCTION

16. How Do Materials Move Through Animals?
17. How Do Animals Digest Food and Eliminate Wastes?
18. How Do Animals Process Sensory Stimuli and Protect Themselves From Disease?

ATOMIC AND MOLECULAR LEVEL THEORIES

19. How Do Living Cells Obtain and Use Energy?
20. What are Genes Made of and How Do They Work?

During the ensuing discussion, students note that the colors that increased seemed to be the ones harder to see. Conversely, those that decreased seemed to be the ones easier to see. To this the instructor adds that the colors that increased were "selected for" and those that decreased were "selected against". And because an analogous selection process presumably takes place in nature, biologists call it "natural" selection. The instructor then points out in more detail how the simulation and the process of natural selection are analogous (i.e., both require prey population variation, prey population increase is limited, one or more variable characteristics are heritable, and selection occurs over several generations). Thus, just as Darwin used the analogy of artificial selection to "invent" his theory of natural selection, students use the simulation analogy to "reinvent" Darwin's theory.

Next students are asked to generate another possible explanation for the changes in mice colors during the simulation. To this, one or more students invariably suggest that the color changes could have occurred randomly. In other words, some mice just happened to land on a spot that the predator just happened to glance at first, thus the mice just happened to be eliminated, and so on. Upon hearing this alternative hypothesis, the instructor introduces the phrase genetic drift to label the random process and challenges students to use the simulation materials to test the alternatives in the context of the simulation.

Most groups come up with a plan that can be summarized as follows:

> ***If*** … the mice color changes are caused by "directional" selection (natural selection hypothesis)
>
> ***and*** … we conduct the simulation two or more times using identical environments,
>
> ***then*** ...the colors that increase and those that decrease should be the same each time.

On the other hand,

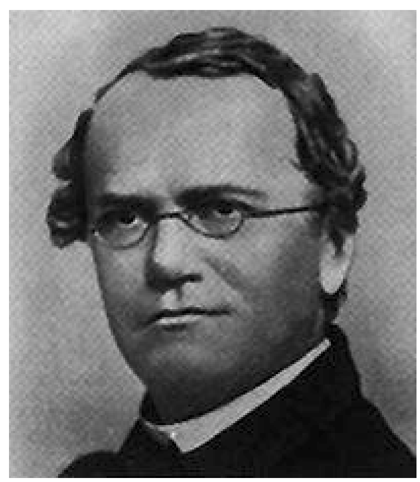
> ***If*** … the mice color changes are caused by "nondirectional" selection (genetic drift hypothesis)
>
> ***then*** ... the colors that increase and those that decrease should not be the same each time.

When these tests are conducted and students find similar results using identical environments, the natural selection hypothesis is supported. But the fact that the results are similar but not identical also provides some support for the genetic drift hypothesis. The lecture portion of the course now discusses "real world" tests and filings.

Using Analogies to Introduce Mendelian Genetics

Analogical reasoning is also used to help introduce Mendel's inheritance theory. This inquiry begins by posing the question: How do characteristics vary within species? Students know that members of a species share many characteristics, some of which are variable. But, are there patterns to this variation? And if so, what are they? To answer these questions, students obtain several mollusk shells and sort them into groups representing different species. Students then collect about 100 individuals of one species with at least one variable characteristic. For each individual, they determine the value of the characteristic chosen. Lastly, they plot frequency graphs, which are later posted on the board.

Student groups also obtain Indian corn and count the number of kernels of each color on each ear. Again they plot and post frequency graphs. Two additional frequency graphs are plotted and posted. For one, students roll two dice approximately 100 times and plot the sum of each roll. For the other, they flip two coins approximately 100 times and plot the number of flips resulting in one head and one tail, two heads, and two tails. The class then considers the shell graphs and tries to identify similarities. Most graphs show few shells with values at the extremes of the ranges but many near the middle. When this pattern is noted, the instructor tells students that the pattern is called a normal distribution. Other populations with normally distributed characteristics are discussed. The instructor now poses the following causal question: What might be occurring in nature to cause variations to be distributed normally? Students brainstorm to generate multiple explanations. They typically generate several environmentally-inspired hypotheses (e.g., there are few small shells because they are too weak to withstand wave pounding; and there few big ones because they are easy targets of predators). To insure a variety of hypotheses, the instructor randomly calls on students. Shell graphs that do not show normal distributions are also discussed and students speculate on why these non-normal patterns emerged. As mentioned, student hypotheses typically center around environmental causes. However, one or more students may suggest a hereditary cause. Even so, students are not likely to explain in any detail how heredity might lead to a normal distribution. This is okay because the dice graphs are then used to explicate the process. Students now compare the shell and dice graphs and note the similarity in pattern. Again normal distributions are seen and students are asked to discuss how the dice rolling activity might be related to the shell situation.



To introduce Mendel's theory, students are asked to imagine that one die is analogous to the female eggs and the other to the male sperm. They are asked to imagine that the members on the dice represent "factors" that somehow dictate observable characteristics in offspring -- the values of those characteristics being determined by the sum of the numbers shown in each combined egg and sperm. If one imagines that six possible "types" of sperm and six possible "types" of eggs (i.e., 1, 2, 3, 4, 5, 6) exist, then there are 36 total combinations of sperm and egg types: one combination totaling two (1 + 1 = 2), two combinations totaling three (1 + 2 = 3, 2 + i = 3), three combinations totaling four (1 + 3 = 4, 2 + 2 = 4, 3 + 1 = 4), and so on. It helps if the instructor draws the six hypothesized sperm anal egg types on the board and draws an arrow from each sperm to each egg to represent possible combinations resulting from fertilization. These combinations are then plotted on a frequency graph to show that a normal distribution results, just as was the case for the shells. Thus, if one assumes that such factors (now called genes) exist and behave as the rolling dice, we have an explanation for the observed normal distributions.

Now the class considers the corn graphs. With some hints, they see that the graphs reveal 3:1, 1:2:1, and 1:1 kernel color distributions. How can these distributions be explained? Do we need a new explanation or can Mendel's theory be somehow modified to work? When these questions are posed and the instructor lets student groups ponder, one or more students (ones who no doubt have previously heard about dominant and recessive genes) invariably comes up with the idea that the Indian corn has a small number of genes for color and that one gene may be dominating the expression of the other. When this idea strikes (Eureka!), the instructor has the opportunity to explicate the process and to introduce the terms dominance, recessive and blending inheritance to the entire class. The terms allele, genotype and phenotype can also be introduced.

Finally, the instructor emphasizes the point that no one has directly observed genes behaving in these ways. But we can imagine that they exist and can argue that:

If … genes exist and behave as claimed,

and ... the values of a variety of characteristics are measured and plotted on frequency graphs,

then ... normal distributions, 3:1, 2:1 and 1:2:1 ratios should be observed.

And ... these distributions were observed.

Therefore .. .we have initial evidence consistent with Mendel's theory.

Presenting Arguments and Evidence in Lectures

Lectures also present both historical and contemporary examples. At least once during each lecture, clues are provided and student groups are challenged to generate arguments and post them for others to evaluate.

For example, during the lecture on development, students imagine that they have unfertilized frog eggs, frog blastulas, and the ability to perform microsurgery. They then design an experiment to test the hypothesis that each new daughter cell of a developing embryo receives a complete set of genes from its mother cell. In other words, they try to complete the following argument:

If … each new daughter cell receives a complete set of genes (no-lost-genes hypothesis)

and ... _______ (planned test)

then... ________ (expected result).

On the other hand,

If … some genes are lost during successive cell divisions (alternative lost-genes hypothesis)

then … ____________ (alternative expected result).

You might want to try the assignment yourself before reading on. Most student groups are at least partially successful in generating an argument that goes something like this:

If ... each new daughter cell receives a complete set *of* genes (no-lost-genes hypothesis)

and ... the genes contained in the nucleus of one blastula cell are injected into a frog egg that has had its nucleus removed (planned test),

then … the egg should develop into a normal frog (expected result). The egg should develop normally because it presumably contains a complete set of genes, i.e., a complete set of "instructions" (theoretical rationale).

On the other hand,

If … some genes are lost during successive cell divisions (alternative lost-genes hypothesis)

then ... the frog egg should not develop normally because it presumably lacks some necessary instructions (expected result).

Once students have constructed these arguments, the observed experimental results are introduced, which are that the injected frog eggs develop into normal frogs. Therefore the no-lost-genes hypothesis has been supported. Lastly, the term cloning is introduced and medical and ethical implications are discussed.

Do Student Thinking Skills Improve?

During a recent semester, a test of scientific thinking skills was administered at the start of each semester and again at the end. The test consists of 13 written items based on reasoning patterns associated with hypothesis generation and test, i.e., identification and control of variables, analogical, correlational, probabilistic, proportional, and combinatorial reasoning (Lawson, 1978; Lawson, 1996). Test reliability and validity has been established by several studies (e.g., Lawson, 1978; 1980; 1983; 1992x; 1992b; Lawson & Weser, 1990; Lawson, et al., 1993). Figure 2 shows student performance on the test at the start and end of the semester -- a semester that enrolled 514 non-science majors ranging in age from 15.8 years to 47.1 years; mean age = 19.64 years, SD = 3.02. As you can see, post-test scores improved considerably (dependent T = 29.6, df = 513, p < .001).

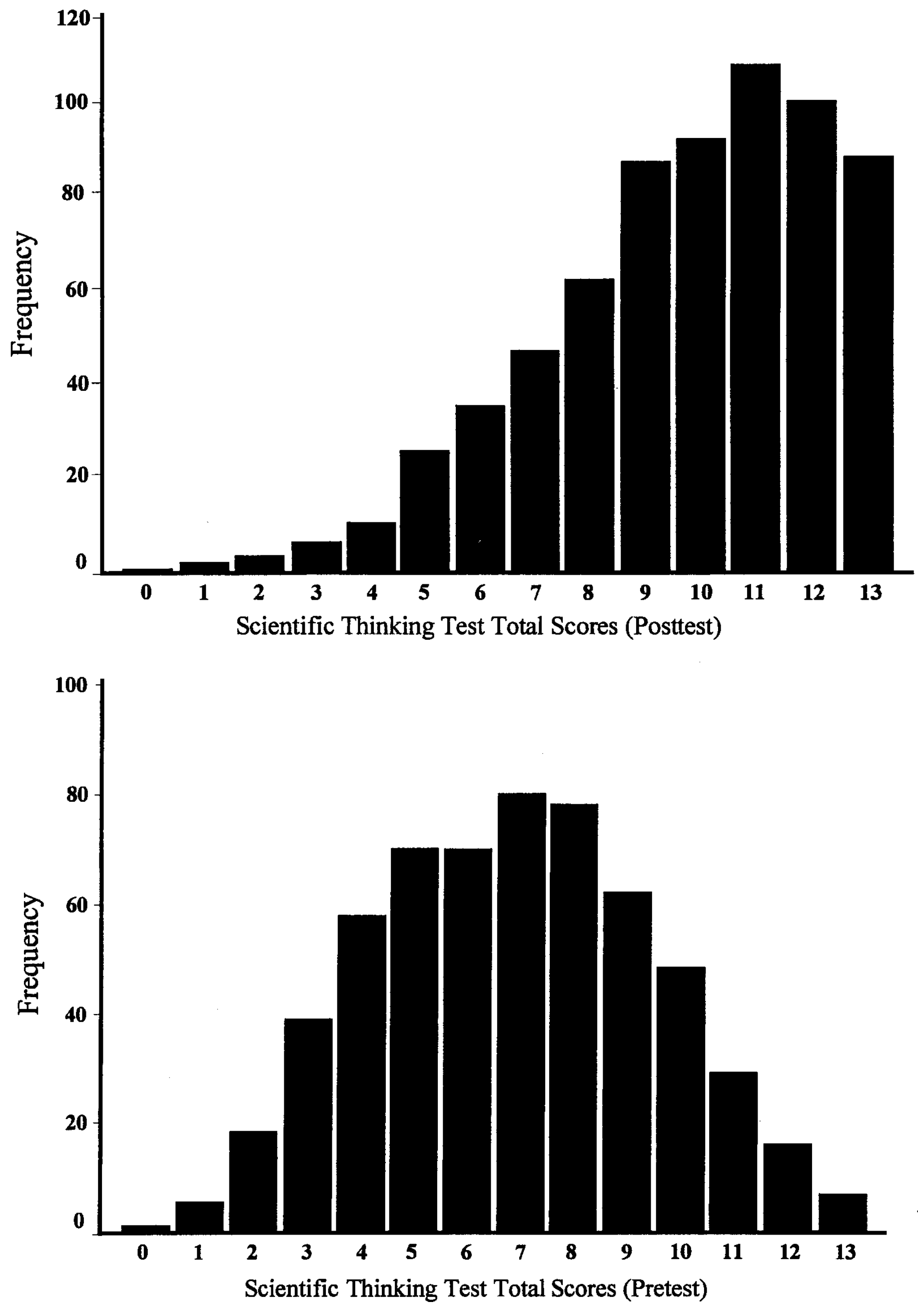


***Figure 2**. Distribution of student scores on a test of scientific thinking at the start and again at the end of the semester.*

Small pre- to post-test improvements have been traced to a test-retest effect (e.g., Lawson, et al., 1974). However, our former students' relatively poor performance on quizzes such as the ***"A" Mountain*** and ***Osmosis Quiz*** (see Table 1), suggests that the substantial improvements found here are difficult to come by and not likely to have been caused by a test-retest effect. Rather a more likely explanation is that our students did in fact become better at thinking scientifically. This conclusion is consistent with those of previous studies that have found that thinking skills develop if students are given repeated opportunities to generate and test hypotheses in familiar and observable contexts prior to attempting to do so with unobservable entities. For example, Westbrook & Rogers (1994) found that a 6-week ninth-grade unit on simple machines (e.g., levers, pulleys, and inclined planes) with readily observable variables was successful in promoting hypothesis-testing skills when students were explicitly challenged to generate and test alternative hypotheses. Also, Shayer & Adey (1993) found that the "Thinking Science Program" (Adey, et al., 1989) was successful in boosting the achievement of students on the British National examinations, not only in science and mathematics, but in English as well. The "Thinking Science Program" is designed to promote scientific thinking by exploring patterns and testing hypotheses first in observable contexts such as pitch pipes, shopping bags, and bouncing balls and then in unobservable contexts such as dissolving and burning chemicals. In short, it appears that efforts similar to those in the present course paid off for many students in a variety of courses.

Conclusion

In conclusion, evidence suggests that college students can obtain gains in creative and critical thinking skills when the curriculum is designed to explicitly promote such skills by sequencing inquiry instruction from the familiar and observable to the unfamiliar and abstract. Determination of the extent to which such improvements are generalizable to contexts beyond biology remains for future research. Nevertheless, previous research results, some of which were mentioned above, as well as anecdotal evidence gathered from some of our students, suggest that such improvements are generalizable to other college courses and perhaps to non-academic contexts as well.

Acknowledgements: This material is based upon research partially supported by the National Science Foundation under grant No. DUE 9453610. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the National Science Foundation.

Literature Cited

Adey, P., Shayer, M., & Yates, C. *(1989). Thinking Science: Classroom Activities in Secondary Science.* Surrey, England: Thomas Nelson and Sons.

Amsler, M. *(1987). Creativity and the Imagination.* Newark: University of Delaware Press.

Beveridge, W.I.B. *(1950). The Art of Scientific Investigation.* London: Heinemann.

Biela, A. *(1993). Psychology of Analogical Inference.* Stuttgart, Germany: Hirzel Verlag.

Boden, M.A. *(1994).* What is creativity? In Boden, M.A. (Ed.), *Dimensions of Creativity.* Cambridge, MA: The MIT press.

Bruner, J. *(1962). On Knowing: Essays for the Left Hand.* Cambridge: Belknap Press., Harvard University Press.

Darwin, C. *(1898). The Origin of Species by Means of Natural Selection.* New York: Appleton *(6th* Ed.).

Dreistadt, R. *(1968).* An analysis of the use of analogies and *metaphors in* science. *Journal of Psychology, 68, 97-116.*

Finke, R. A., Ward, T. B. & Smith, S. M. *(1992). Creative Cognition: Theory, Research and Applications.* Cambridge, MA: The MIT Press.

Gentner, D. *(1989).* The mechanisms of analogical learning. In S. Vosniadou & A. Ortony (Eds.), *Similarity and Analogical Reasoning.* Cambridge: Cambridge University Press.

Green, J. C. *(1958). The Death of Adam.* Ames: Iowa State University Press.

Gruber, H.E. & Barrett, P.H. *(1974). Darwin on Man.* New York: E.P. Dutton.

Hestenes, D. *(1992).* Modeling games in a Newtonian world. *American Journal of Physics, 55, 440-454.*

Hoffman, R.R. *(1980).* Metaphor in science. In P.R. Honeck & R.R. Hoffman (Eds.), *The Psycholinguistics of Figurative Language.* Hillsdale, NJ: Erlbaum.

Hofstadter, D.R. *(1981).* Metamagical themas: How might analogy, the core of human thinking, be understood by computers? *Scientific American, 249, 18-29.*

Hofstadter, D.R. *(1995). Fluid Concepts and Creative Analogies: Computer Models of the Fundamental Mechanisms of Thought.* New York: Basic Books.

Holland, J.H., Holyoak, K.J., Nisbett, R.E., & Thagard, P.R. *(1986). Induction: Processes of Inference, Learning, and Discovery.* Cambridge, MA: The MIT Press. (see especially Chapter 11)

Johnson, M. *(1987). The Body in the Mind.* Chicago: University of Chicago Press.

Koestler, A. *(1964). The Ad of Creation.* London: Hutchinson.
Lawson, A.E. (1978). The development and validation of a classroom test of formal reasoning. *Journal of Research in Science Teaching,* 15(1), 11-24.
Lawson, A.E. (1980). The relationship among levels of intellectual development, cognitive style and grades in a college biology course, *Science Education, 64(1),* 95-102.
Lawson, A.E. (1983). Predicting science achievement: The role of developmental level, disembedding ability, mental capacity, prior knowledge and beliefs. *Journal of Research in Science Teaching,* 20(2), 117-129.
Lawson, A.E. (1992x). The development of reasoning among college biology students. *Journal of College Science Teaching,* 21(6), 338-344.
Lawson, A. E. (1992b). What do tests of formal reasoning actually measure? *Journal of Research in Science Teaching,* 29(9), 965-984.
Lawson, A.E. (1995). *Science Teaching and the Development of Thinking.* Belmont, CA.: Wadsworth.
Lawson, A. E. (1996). *Classroom test of scientific reasoning: Revised pencil paper version.* Tempe, AZ: Arizona State University.
Lawson, A.E., Baker, W.P., DiDonato, L., Verdi, M.P. & Johnson, M.A. (1993). The role of physical analogies of molecular interactions and hypothetico-deductive reasoning in conceptual change. *Journal of Research in Science Teaching,* 30(9), 1073-1086.
Lawson, A.E., Nordland, F.H. & DeVito, A. (1974). Piagetian formal operational tasks: A crossover study of learning effect and reliability. *Science Education,* 58(2), 267-276.
Lawson, A.E. & Weser, J. (1990). The rejection of nonscientific beliefs about life: The effects of instruction and reasoning skills. *Journal of Research in Science Teaching,* 27(6), 589-606.
Maret, T.J. & Rissing, S.W. (1998). Exploring genetic drift & natural selection through a simulation activity. *The American Biology Teacher, 60(9),* 681-684.
McKellar, P. (1957). *Imagination and Thinking.* New York: Basic Books.
Merrium-Webster. (1986). *Webster's Third New International Dictionary.* Springfield, MA: Merrium-Webster Inc.
Stebbins, R.C. & Allen, B. (1975). Simulating evolution. *The American Biology Teacher,* 37(4), 206.
Shayer, M. & Adey, P.S. (1993). Accelerating the development of formal thinking in middle and high school students IV: Three years after a two-year intervention. *Journal of Research in Science Teaching,* 30(4), 351-366.
Sternberg, R.J., & Davidson, J.E. (Eds.), (1995). *The Nature of Insight.* Cambridge, MA. : The MIT Press.
Wallace, D.B. & Gruber, H.E. (1989). *Creative People At Work.* New York: Oxford University Press.
Wallas, G. (1926). *The Art of Thought.* New York: Harcourt Brace. (Reprinted in P.E. Vernon (Ed.), *Creativity.* Middlesex, England: Penguin Education).
Westbrook, S.L. & Rogers, L.N. (1994). Examining the development of scientific reasoning in ninth-grade physical science students. *Journal of Research in* Science *Teaching, 31(1), 65-76.*
Wong, E.D. *(1993).* Self-generated analogies as a tool for constructing and evaluating explanations of scientific phenomena. *Journal of Research in* Science *Teaching,* 30(4), *367-380.*

ACUBE 45th Annual Meeting

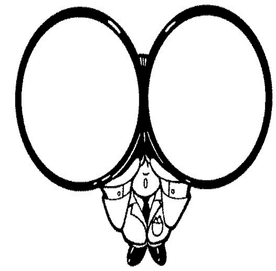
University of Nebraska at Kearny

Kearney, NE

October 11-13, 2001

Biology in the Light of Evolution

REAR VIEW MIRROR -- A LOOKING BACK



Edward Kos,
ACUBE Historian

When you have a plan of attack and it seems to work, the prudent person (or society) will keep to the plan as a whole, but revamp it a bit to include the new. This is what happened at the **5th Annual Meeting** of AMCBT held on October 20-21, 1961 at Illinois State Normal University in Normal, Illinois. While the meeting was primarily organized around presentations of latest advances in various disciplines within Biology (using the expertise of the membership---something which was realized early by our founders and continued throughout our history), there were include sessions on teaching techniques. The meeting was organized into three Panels.

Panel 1: Recent Advances
- Topic 1. Contemporary Views in Cell Physiology and Biology Membranes—Electron Transport/Photosynthesis
- Topic 2. Recent Advances in Microbial Genetics
- Topic 3. Recent Advances in Parasitology
- Topic 4. Recent Advances in Animal Behavior

Panel 2: Teaching Large Numbers
- Topic 1. The Film and Television Course
- Topic 2. Films and TV as Teaching Aids

Panel 3: Teaching Devices and Techniques
- Topic 1. Lectures and Lecture Exams
- Topic 2. Lab Procedures and Exams
- Topic 3. A Report on the Current Status of College Biology Teaching.

At the Opening Session, Dr. E.L. Powers of Argonne National Laboratory spoke on “Energy and Life”. The Dinner Meeting featured speaker was George Beadle, Nobel Laureate, who spoke on “Genes and the Nature of Man”

The **15th Annual Meeting** held on October 1-2, 1971 at Wabash College in Crawfordsville, Indiana, followed a format different from 10 years earlier and more similar to the present. A central theme, for this meeting “The Changing Role of the Biologist”, was adopted and a series of various presentations by members and invitees was held. Topics included the following:

A Panel on the Changing Role of the Biologist---A Student view
The Changing Role/A new kind of College
The Changing Role/Multidisciplinary Research Teams
The Changing Role/A new method of teaching Numerical Taxonomy
AAAS Guidelines—Elementary/Secondary Teachers
The Changing Role/Interim Session
The Changing Role/Computer Usage in Undergraduate Biology courses
New Opportunities for Research and Training
The Changing Role – Community Development
The Changing Role - A New Type of Session
The Changing Role - Pre-Service Teaching experience
The Changing Role - The Community College

Also added were some hands-on workshops, “Environmental Monitoring with Membrane Filters”, and “Antibiotic Isolation”. Various field trips to local areas and Interest Group Breakfasts were also added.

The **25th Annual Meeting** took place at Carroll College, Waukesha, Wisconsin on October 2-3, 1981. The central theme of the meeting was "Teaching Biology in the 1980's". The switch from panels to individual presenters was well in place. At the opening General Session, Dr. Jane Kahle, Purdue University gave a talk on "Biology in 1984 and Beyond". The Banquet speaker was Robert Bullerman, Assistant Director of the Milwaukee Zoo. The other scheduled sessions were:

Group Meeting I:
- The Genetics Laboratory
- The Evolution Laboratory
- Microbiology Laboratory
- The Physiology Laboratory
- Computers in Biology

Group Meeting II:
- Integrated Lecture Laboratory Courses
- Summer Programs
- Evolution? Creation, the Debate Continues
- Computers in the Classroom

Group Meeting III:
- Video Programs in Biology
- The Mid Career Crisis for the Biology Teacher
- Laboratory Safety
- Computers in Biology IV

Group Meeting IV:
- Use of Physiology Equipment
- Sociobiology: An Emerging Discipline
- Biology for the Handicapped
- Biology for the Non Major and Mature Student

Because this was the 25th anniversary of AMCBT, a panel of past presidents was held before the concluding luncheon. Included in that group were Leland P. Johnson, 1st President (and basically founder) and Willis Johnson, 2nd President.

The **35th Annual Meeting** took place at Rockhurst College, Kansas City, MO, October 17-19, 1991. The theme of the meeting was "Teaching Biology to Majors and Nonmajors". Concurrent meetings, field trips and Interest Group breakfasts were general features of the meeting.

Concurrent Session I:
- Honors Biology: Teaching Research Design
- Use of the Winogradsky Column to Demonstrate Biodegradation
- Teaching Biology to Nontraditional Students
- Writing in Biology Courses: Increasing Critical Thinking / Research Skills
- Restricting Animal Use in Science Classes
- The George Engelmann Math/Science Institute-"Unifying Concepts"
- Computer Controlled Laser Disc: Presentation and Repurposing.

Concurrent Session II:
- General Education Biology
- The Communities of the Biological Crossroads
- Roundtable Discussion on Designing Effective Travel Courses
- A Trip to Monte Carlo: Using Random Numbers in Biology
- Why Alternatives to Dissection Don't Work
- Galileo Reconsidered

Concurrent Session III:
- Burnout: Causes, Preventions, and Interventions
- Roundtable Discussion on Outreach to Highschools
- AIDS
- Teaching the Difference Between Science and Religion
- Chronobiology: Teaching Endocrine Rhythms in the Lab

Enzymes Get Things Done: A Demonstration
Worldviews – a Needed Change

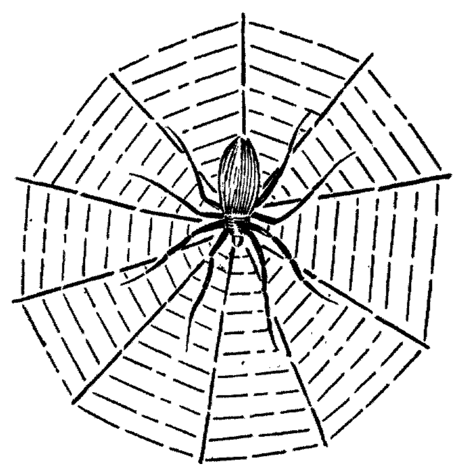
Concurrent Session IV:
Preparing for a Career in Physical Therapy
Reproductive Biology in General: Are We Missing the Point?
Thoughts on Presenting Biology Workshops for Highschool Teachers
Women in Science
From Food Webs to Restriction Maps
A Team-Taught Course in Bioethics

Workshops were all scheduled for one afternoon and included:
Chorio-allantoic Transplants in Chick Embryos
Using Cooperative Learning in Biology Teaching and Assessing
The Fungus Among Us
Computerized Data Acquisition in Physiology Laboratories
Immunoconjugates: an Emerging Biotechnology for Selective Delivery of Drugs to Diseases Organs or Tissues

The Keynote Speaker was Dr. Larry Martin, University of Kansas, Lawrence, KS, who spoke on "*Archaeopteryx* and the Evolution of Flight". At the Banquet, Dr. Angelo Collins, Florida State University, spoke on "Authentic Assessment in Biology Education".

Which brings us to the **45th meeting**, to be held at the University of Nebraska at Kearney, Kearney, Nebraska on October 11-13, 2001. We have come through one millennium and are in a new one, will our biology remain the same? Does it need to? Should it? Or will it, like our discipline, evolve? Come join us in Kearney where ACUBE will look at "Biology in the Light of Evolution".

Web Sight



Nancy Sanders

Locked in the frozen vastness of the Midwestern winter, I begin to dream of the sea. If you can't GO to the sea this time of year, the Monterey Bay Aquarium web site is certainly one that can "wet" your appetite a bit: http://www.montereybayaquarium.com will allow you to explore habitats and organisms, and has wonderful color images of creatures from diverse phyla. Common and scientific names are given, as well as descriptions of morphology, habitat and behavior. Images are printable as well. There are even quotes from Rachel Carson - a feast for the eyes and food for the soul.

If you are embarking in the study of genetics, why not read Gregor Mendel's original works? You can find the English translation at::http://netspace.org/MendelWeb/Mendel.plain.html#sB. This will give you and your students a more meaningful glimpse into the history of this field. This monograph is anything but dry, and certainly beats the usual textbook description of Mendel.

Finally, a place much in the news today is the Arctic National Wildlife Refuge. Take your students there if you can, but if you cannot, try the official web page: http://www.r7.fws.gov/nwr/arctic/. Here you can view the place, wildlife, and people of the north. You can see maps of caribou migrations, compare the region to other areas, and learn about current and planned oil and gas development. The many color images, maps and charts will allow you and your students to explore the region and have meaningful discussions about the biological and economic issues that are much talked about in the popular press. Enjoy!

News and Views

ACUBE Presidential Message

March, 2001

Dear Biology Colleagues,

This spring, I'm asking you to take a closer look at how much this terrific organization has to offer. It's main focus is the exchange of information to strengthen Biology education at every level. The best way for you to reap the benefits of ACUBE is to attend our annual meeting and meet fellow biologists, many of whom teach the same courses you teach and face many of the same challenges you face each day. It is revitalizing and encouraging to spend 2 days with others who have taken risks in the classroom or who may have been particularly successful in addressing a problematic item in their teaching. Most of us who attend our Fall meeting always borrow ideas from others that help our students learn just a little more effectively or with a new twist. ACUBE can help you extend your teaching enthusiasm and relight the fire of curiosity that we all want to transmit to our students. Thus, **participation** is the key to our organization.

This Fall's meeting at the University of Nebraska–Kearney focuses on the theme, "Biology in the Light of Evolution." You'll have an excellent opportunity to learn about the latest teaching strategies for putting evolution into your classes, as it truly is the common thread linking all living things. Two of our speakers will address application and integration of evolutionary biology into teaching. Many small group sessions will be offered on teaching evolution to majors and non-majors, to groups in the classroom and to students in field classes. We also have openings in our meeting program so that you may present some of your experiences with students that could be helpful for others. I always enjoy the discussion periods in these sessions where attendees, because they have taught similar courses, can ask some great questions and involve the group in the discussion. I invite you to come and participate with your fellow biologists.

Meanwhile, take advantage of other ACUBE resources available to you: One is a new email newsletter from the president that will keep you better informed of opportunities and events in which ACUBE is involved. Watch for it to arrive in April. A second resource is a new bulletin board site on the web where interested members can participate in discussions online at their discretion. This site will also enable easier communication between Steering Committee members throughout the year. Watch for this in early summer. A third resource is our updated and teacher-friendly website at http://acube.org. With help from Buzz Hoagland at Westfield State, MA, we recently added a link loaded with discipline-specific teaching resources that many members will find useful. And, with the generous help of Tim Mulkey at Indiana State, we are updating our online archives of our journal, *Bioscene*, so that each individual article published since 1975 will be accessible via pdf files. This will be a tremendous resource that I invite you to take a look at and use. Please consider submitting a manuscript on any aspect of your teaching. *Bioscene* is peer-reviewed and widely read by many biology educators nationwide. Your participation lets us all learn together more effectively.

So if you are a current ACUBE member, use the group to enhance your teaching and invite a colleague to join and seriously think about participating more in the constant challenge of teaching biology. If you are a new member, welcome! Please investigate our organization, attend a meeting, give a talk, submit a small manuscript or nominate yourself for a committee position. We would love to hear from you. Only through your participation can we help ACUBE enhance student learning in the biological sciences. I look forward to talking with you at future meetings.

Sincerely,

Tom Davis, President, ACUBE
Department of Biology
Loras College
Dubuque, IA
tdavis@loras.edu

ACUBE Steering Committee
Winter Board Meeting
February 3, 2001

Place: Stadium Room, Courtyard Marriott, Midway Airport, Chicago IL
Present: Charlie Bicak, Tom Davis, Ben Dolbeare, , Mary Haskins, Buzz Hoagland, Cynthia Horst, Ed Kos, Malcolm Levin, Pres Martin, Bob Wallace, Margaret Waterman
Time: 12:45

I. Call to order: Tom Davis
Announcements regarding logistics

II. Motion to approve amended minutes of October 2000 M/S/A

III. Reports

A. Executive Secretary Report – Pres Martin

See attached for details
Total assets: $15,417

Money from annual meeting has not yet been received from Indiana State University. While this is the same schedule as funds have been received from sponsoring institutions in the past, the board asks that this be faster if possible.

Approximately 50% of the membership has not paid dues.
The scheduling of dues collection was discussed and the following was agreed upon:

Do not try to collect past dues.
The dues year is the calendar year.
Any dues paid at the annual meeting is for the upcoming year.
Dues notices will go out before and after the annual meeting.

If dues are not paid by 1/15 then the member will no longer receive *Bioscene*.
As soon as dues are paid, the member's subscription to *Bioscene* will again commence.
No back issues will be provided as this is not feasible and the issues are on line with a few months of publication.

The success or failure of this plan will be reviewed at next year's winter board meeting.

ACUBE's tax exempt status is to be worked on later this Spring with the aid of AIBS.

ACUBE is a member of AIBS, as such we get some benefits, including the aforementioned help with the tax exempt paperwork. In addition, we get a one-time advertisement in *BioScience,* a half page size, and we get free exchange of mailing lists with other member organizations.

Mary Haskins and Charlie Bicak will draft a half page ad for the *BioScience* that will appear in a timely fashion to try to get higher attendance at the upcoming annual meeting. Pres will determine the deadlines from AIBS, and the ad will be submitted to board members for review before sending submitting it.

Pres Martin will obtain the AIBS mailing lists that seem appropriate as a way to identify those in the Kearney area who might like to attend ACUBE.

Approval of the Executive Secretary Report M/S/A

B. Membership Committee: Tom Davis

Another mailing is scheduled to go out this spring with McGraw Hill products (they have been inserting the ACUBE membership flyer on odd-numbered years).

A discussion of additional ways to get the word out about ACUBE:

Carroll College is sponsoring Tri Beta meeting this year.

Contact State Academies of Science with information and membership forms.

The Illinois Community College Biology Teachers has an annual meeting (at about the same time as ACUBE) and is worth investigating, as well as other state or regional organizations of community college biologists.

C. Nominations: Lynn Gillie

Names were suggested for the offices of President elect, Secretary, and two steering committee members at large. Lynn Gillie will contact those nominated to obtain approval and C.V.s.

D. Awards Committee:

No nominations for Carlock Award. Nomination for Honorary Life Award was made and approved last winter.

E. 2001 Annual Meeting at Kearney NE: Charlie Bicak and Mary Haskins

Theme: Biology in the Light of Evolution.
Dates: Thursday October 11, 2001 – Saturday October 13, 2001.
Speakers: Local expert on Cranes for opening talk.
Ideas for other speakers were shared.

Balloting: Keep at the banquet as was initiated at the 2000 meeting.

Field Trips: Some local sites (art galleries, the arch, museums, etc) will be suggested for on-your-own sightseeing on Thursday afternoon, but the biology field trips will be on Friday morning to the Platte River and on Saturday afternoon to the Loess ecosystem. This rearrangement of fieldtrips was decided since we predict many members will be staying over Saturday night to lower their airfare.

Facilities: Charlie Bicak provided a virtual campus tour with maps, photographs and floor plans for science buildings and likely meal sites. Tom Davis, Mary Haskins and Ed Kos will travel to Kearney in early March to do a walk about and make decisions. Classes will be in session on Friday October 12, 2001 but will have little impact on available facilities.

Margaret Waterman will send the electronic files of the registration forms to Charlie Bicak. Buzz Hoaglland will create the web pages for the conference, program, etc.

We would like a downloadable registration form.

We agreed to give out evolution teaching resources instead of a bag or mug this year. Malcolm Levin is researching possibilities from NSTA and NABT.

Exhibitors were discussed, and logistics of those arrangements.

An overall conference evaluation form is needed (new).

F. ACUBE logo

Tom Davis will contact Zachia Middlechild, an artist, with whom he discussed the logo briefly at the 2000 meeting.

G. Historian Report: Ed Kos

Ed Kos is working on a history of the organization, using "Evolution of a Society" as a theme.

H. Other new business:

It was agreed that ACUBE should have an organizational charge card for the Executive Secretary.

Adjourn for dinner: 4:45

Saturday February 3, 2001
7:45 p.m. Same people and place Call to order by Tom Davis

IV. Other Business

A. *Bioscene*

Neither co-editor was present, but several issues were discussed in response to an email from Tim Mulkey.

The need to get materials into *Bioscene* editors in a timely fashion will help speed up publication. Please refer to the schedule of materials needed from members of the steering committee to see when your things are due.

The minutes of this meeting will be posted via email to board members who were present, by February 26. Reply with changes to the Secretary, Margaret Waterman, within five days. The revised minutes will be posted then for approval with a motion to approve. Send vote to Tom Davis (todav@loras.edu).

The approved minutes will then be submitted by Secretary to *Bioscene* editors and other board members by email.

B. ACUBE Webpage and Electronic Communications

Move that all members be placed on the ACUBE listserve as a part of their membership in ACUBE. They may unsubscribe at will. Directions for unsubscribing will be sent out no less frequently than every two months.
M/S/A

An archive of all annual meeting programs and abstracts needs to be created and to be accessible on the web. Buzz Hoagland will coordinate. Past program chairs should send electronic copies of their files to Buzz.

Permission needs to be obtained from participants to put up their email addresses with their abstracts. Margaret Waterman will contact the presenters from the 2000 meeting.

C. Email from Executive Secretary to Membership

It was proposed that email newsletters to alternate with *Bioscene* publications be sent to the membership as a way to make a more frequent presence for ACUBE.

It is likely that some information would be repeated from the *Bioscene*, such as meeting announcements, calls for papers, etc.; but new information could also be included that would be unique.

New Member Letter: Tom will send it out again this year.

D. Constitution Review

It was noted that there are several typographical errors in the Constitution and By Laws that need to be corrected.

Except for the following proposed committee change, there are no major changes in either the Constitution or By Laws. The executive handbook needs to be reviewed for any changes.

Web Site Committee changes:

Rationale: An organization's web presence is a critical tool for communication, recruitment, publication, and involvement of its membership. ACUBE was a successful early entrant into the field of using the Internet for just these purposes, and those who have designed, updated and maintained the organization's web pages are to be highly commended, particularly Tim Mulkey and Ethel Stanley.

Because the Internet is such an important tool, the steering committee has suggested that the *ad hoc* web site committee become an official standing committee with a broader charge and greater responsibilities reflecting the increasingly complex capabilities and expectations of an organization's web site. The specific charge and responsibilities are to be defined in consultation with the membership, steering committee and members of the current web site committee.

The steering committee approved the following motion to be presented to the ACUBE membership at the annual meeting in October 2001.

Moved to increase the status and roles of the "Web Site Committee" to become a standing committee with increased responsibilities, and to be renamed the "Internet Committee." M/S/A

E. Future meetings

Austin Brooks and Nancy Sanders need to be contacted to determine whether or not their schools will sponsor the 2003 meeting.

2002 -- Columbia College of Chicago
2003 -- Westfield State College

Adjourn 9:20 p.m.

Respectfully submitted
Margaret Waterman
ACUBE Secretary

ACUBE
Web Site

http://acube.org

The Association of College and University Biology Educators (ACUBE), placed the organization's rich archive of materials online for the benefit of the members and interested biology educators. Nearly 45 years of society's publications and resources are currently accessible.

Featuring the Online ACUBE archives:

Bioscene: Journal of College Biology Teaching (1975-present)

AMCBT Newsletter (1964-1974)

AMCBT Proceedings (1957-1972)

ACUBE Organizational Information:

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

Call For Resolutions

The Steering Committee of ACUBE requests that the membership submit resolutions for consideration at the 2001 Annual meeting to the Chair of the Resolutions Committee. Submit proposed resolutions to:

Dr. Richard Wilson, Dept. of Biology, Rockhurst University, 1100 Rockhurst Rd
Kansas City, MO 64110, Phone (846) 501-4048, wilson@vax1.rockhurst.edu

Call for Nominations

Honorary Life Award

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

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

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

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Manuscript Guidelines for
Bioscene: Journal of College Science Teaching

A publication of the Association of College and University Biology Educators

Manuscripts submitted to the Bioscene should primarily focus on the teaching of undergraduate biology or the activities of the ACUBE organization. Short articles (500-1000 words) such as introducing educational resources provided by another organization, reviews of new evolution software, suggestions for improving sampling methods in a field activity, and other topics are welcome as well as longer articles (1000-5000 words) providing more in depth description, analyses, and conclusions for topics such as introducing case-based learning in large lectures, integrating history and philosophy of science perspectives into courses or initiating student problem solving in bioinformatics.

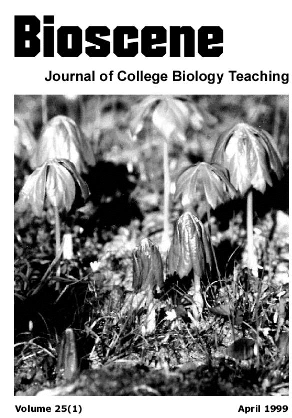
Please submit all manuscripts to editor(s):

Ethel Stanley
Department of Biology
Beloit College
700 College St.
Beloit, WI 53511
stanleye@beloit.edu
FAX: (608)363-2052

Timothy Mulkey
Department of Life Sciences
Indiana State University
Terre Haute, IN 47809
mulkey@biology.indstate.edu
FAX: (812) 237-2418

We prefer receiving manuscripts as Rich Text Format or RTF files to facilitate distribution of your manuscript to reviewers and to work on revisions. You can mail us a disk or attach your file to an email message with the subject line as **BIOSCENE**. All submissions should be double-spaced and may follow the style manual for publication you are currently using such as APA. You will also need to include:

- title
- author(s) information:
  - full names
  - name of your institution with the address
  - email address, phone number, and/or fax number
- brief abstract (200 words or less)
- keywords
- references in an appropriate format



Please refer to issues of the Bioscene from 1998 or later for examples of these items. You can access these issues at: **http://acube.org/bioscene.html**

Graphics are desirable! Lengthy sections of text unaccompanied by tables, graphs or images may be modified during layout of the issue by adding ACUBE announcements or other graphics. While tables and graphs may be included in the manuscript file, images should be submitted as individual electronic files. If you are unable to provide an image in an electronic format such as TIFF for Macintosh or BMP for Windows, please include a clear, sharp paper copy for our use. At this time, graphics will be printed as color images with a minimum resolution of 300 dpi and a maximum resolution of 1200 dpi. Cover art relating to an article is actively solicited from manuscript contributors.

Upon receipt of your manuscript, an email or fax will be sent to the author(s). The editor will forward your manuscript to the chair of the editorial board. Within the next two weeks or so, your manuscript will be sent to two reviewers. You should receive comments when changes are recommended from the reviewers prior to publication of the article. Manuscript format is usually retained as accepted; however, limits of publishing the issue may affect the length of an article. Graphics may be added by the editors when lengthy sections of text are unaccompanied by tables, graphs or images. Previously published work should be identified as such and will be reviewed on a case-by-case basis. Your article will appear in the Bioscene and then on the ACUBE website: **http://www.acube.org** shortly after the issue date.

Call for Presentations

Association of College and University Biology Educators (ACUBE)

45th Annual Meeting
University of Nebraska at Kearney
Thursday October 11- Saturday October 13, 2001

Biology in the Light of Evolution

Theodosius Dobzhansky stated, “nothing makes sense except in the light of evolution”.

Evolution has, once again, claimed national attention because some states have either removed and/or downplayed evolution from the curriculum objectives in the K-12 system. Although the scientific community understands the distinction between science and religion, the public may not. The upcoming PBS television broadcast on evolution will continue to promote public discussion and controversy. How can we address our students’ need, and the public’s need, to understand this distinction?

Presentations, posters and workshops addressing other topics are welcome, but here are some examples of possible presentations:
Issues in teaching evolution to non-majors/majors (creationism vs. evolution; Simulation software used in lecture and/or labs; Investigative labs; Evolution of ideas and/or theories in scientific disciplines; Evolution of Scientific methodologies; Evolution of processes, human practices and/or cultures; Analogies used in teaching evolution

Many of you have addressed these issues in creative ways. Please consider sharing your ideas and techniques at the ACUBE 45th Annual Meeting in Kearny, NE in 2001.

Please email your abstract **AND** mail or FAX a hard copy of the abstract with the completed form BEFORE **July 1, 2001** to:

Mary Haskins, Biology Department, 1100 Rockhurst Road,
Rockhurst University, Kansas City, MO 64110
Phone (816)501-4006 FAX: (816)501-4802 email: mary.Haskins@rockhurst.edu

Proposed Title:____
Presentation type: Poster 45 minute paper 90 minute workshop
Name of presenter : ____
Work address of presenter : ____
____
Equipment/facilities needed:
____ 35 mm slide projector
____Overhead projector
____ Macintosh projection system
____ Macintosh computer lab
____ PC projection system
____ PC computer lab
____ Other: (explain)

Phone No. presenter: ___________________ email _________________________________
Please include names and contact information for additional presenters and a 200 word abstract:

ACUBE

Association of College and University Biology Educators

NAME: ____ DATE: _________________

TITLE: ____

DEPARTMENT: ____

INSTITUTION: ____

STREET ADDRESS: ____

CITY: ______________________________ STATE: ____________ ZIP CODE: __________

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CITY: ____________________________ STATE: ____________ ZIP CODE: ______________

WORK PHONE: _________________ FAX NUMBER: ________________________________

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

RESOURCE AREAS (Areas of teaching and training): _____________________________

____

RESEARCH AREAS: ____

____

How did you find out about ACUBE? ____

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

DUES (Jan-Dec 2001) Regular Membership $30 Student Membership $15 Retired Membership $5

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

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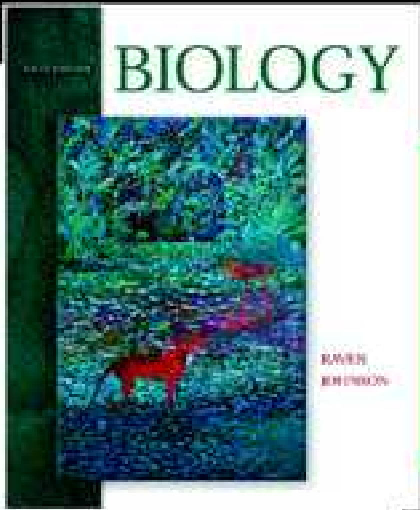

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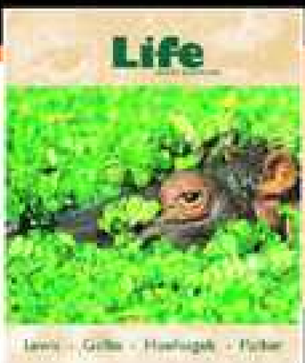

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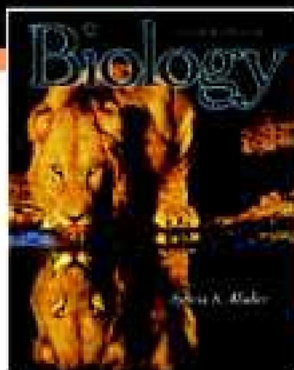

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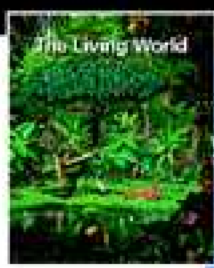

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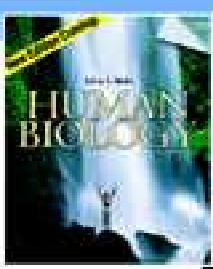

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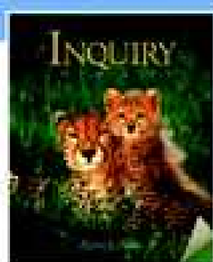

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