

MIDWEST: BIOSCENE



ASSOCIATION OF MIDWESTERN COLLEGE BIOLOGY TEACHERS

VOL. 10 (1), JANUARY, 1984

MESSAGE FROM THE EDITOR:

Cross country and downhill skiers must be enjoying this winter. I hope that they will come in from the cold and join me by a warm stove for stimulating conversation and arguments about biology. In this issue, you will find a diversity of articles by members of the organization, including several new features. Ed Cawley, Loras College, has agreed to edit and write a regular column about microcomputers in biology, "BIO-BYTES". Also on the subject of microcomputers, I have written the first of a series of reviews of software for the biology classroom. Attached to this issue is a form so that you can contribute to this column by preparing reviews about your favorite and not so favorite software. From the annual meeting at St. Olaf College, you will find a number of papers and summaries that should help you recall the meeting. Continuing our journey through midwestern colleges, Jack Bennett introduces us to the Biology Department at Northern Illinois University and Don Huffman tells us about the department at Central University of Iowa. So sit back in your easy chair and enjoy this issue of **MIDWEST BIOSCENE**. Since now is the time to set goals for 1984, I encourage you to include service to the **AMCBT** as a high priority. You can serve this organization in several ways:

1. **Renew your membership, now.**
2. **Encourage your colleagues to join AMCBT.** You can obtain informational handouts from the Central Office.
3. **Contribute an annotated bibliography, a software review, a description of your department, a laboratory outline, a letter to the editor or an article to MIDWEST BIOSCENE for the April edition.**
4. **Attend the annual meeting in 1984 at St Xavier College, Chicago, Il., September 28 and 29.**
5. **Present a paper at the annual meeting.** Volunteer your ideas to John Jungck, Beloit College, Beloit, WI.

MIDWEST BIOSCENE is published by the Association of Midwestern Biology Teachers, **AMCBT** Central Office, Rockhurst College, 5225 Troost, Kansas City, MO. 64110. Subscription free to **AMCBT** members. Editor: William Doemel, Wabash College, Crawfordsville, IN 47933 [(317) 362-1400 ext 219]. Opinions expressed by authors are their own and are not necessarily those of the Association nor the institutions with which the authors are affiliated.

***** POTPOURRI *****

FROM THE DESK OF THE EXECUTIVE SECRETARY

----Membership and Dues Notice: Coming out shortly will be the 1984 notice of dues. This notice will also be used to assist us in cleaning up our mailing list. **AMCBT** has carried some members beyond their last dues payment by a good margin, and retaining them is costing the Association time and money. We hope that those who wish to be dropped will let us know; however, no response will be considered as a negative response. There are also some other questions asked such as, what is your 9 digit ZIP (if you know it), and also your telephone number. This last is strictly for **AMCBT** purposes to facilitate communication. Also asked are some questions which appear on the new application forms that deal with areas of interest within Biology. Answers to these questions should assist the program chairs in planning Annual Meetings.

----1984 Annual Meeting: The 1984 Annual Meeting will be held in Chicago, Illinois this fall at St. Xavier College. A tentative theme title is, "1984--Brave New World?" and this sets a tone for the meeting. John Jungck is in charge of the program, and would welcome any suggestions you might have, and any or all of you as volunteers to present a paper. Contact John at the Department of Biology, Beloit College, Beloit, Wisconsin 53511.

----Honorary Life Membership: Do you know of someone in **AMCBT** who has served well and long? Would you want to nominate them for an Honorary Life Membership? If so, work up a brief biographical sketch, highlighting their role in **AMCBT**, within their institution, etc., and submit it to the Executive Secretary (Edward S. Kos, **AMCBT** Central Office, Department of Biology, Rockhurst College, Kansas City, MO 64110.). If more information is needed we'll let you know.

RESOLUTIONS ENACTED AT THE 1983 ANNUAL MEETING

(Editor's note: This version has been edited to improve clarity and reflect the recent change in the administration of the Department of the Interior. Neither the sense nor the intent of the original resolution was changed.)

Whereas:

- A. The Secretary of the Interior has shown insensitivity to environmental and conservation issues by (1) increasing oil and coal leasing; (2) reducing the wilderness areas; and (3) encouraging development rather than conservation;
- B. Tropical ecosystems are being destroyed at unprecedented rates with concurrent loss of genepools;
- C. The Environmental Protection Agency is not enacting regulations to reduce acid rain;
- D. President Ronald Reagan supports the present environmental and conservation policy of the government.

Now be it resolved that:

- A. Members of the Association of Midwest Biology Teachers continue their efforts to mobilize students toward a positive, appropriate relationship with the environment;
- B. members of the **AMCBT** become positive spokespersons for the maintenance and improvement of the quality of the environment;

- C. members of the AMCBT continue their personal efforts or initiate new efforts to improve their environment;
- D. members of the AMCBT continue to express in an appropriate manner their displeasure with the policies of the Secretary of the Interior and the president of the United States.

Resolutions for consideration at the 1984 meeting should be sent to Robert Satterfield (Department of Biology, College of DuPage, Glen Ellyn, IL 60137). I would like to publish the proposed resolutions in the August issue of BIOSCENE so that everyone has an opportunity to consider them carefully.

THANKS AGAIN TO HAROLD HANSEN, THE BIOLOGY DEPARTMENT, AND ST. OLAF COLLEGE FOR THE WARM WELCOME EXTENDED TO THE MEMBERSHIP OF THE AMCBT.

At the December meeting of the Steering Committee a tentative schedule for Annual Meetings during the next five years was proposed:

- 1984 - St. Xavier College (Sr. M. Johnson)
- 1985 - Augustana College (Dr. I. Larsen)
- 1986 - Sangamon State University (Dr. A. Larsen)
- 1987 - Beloit College (Dr. J. Jungck)
- 1968 - Quincy College (Dr. A. Pogge)

REQUEST FROM THE NOMINATIONS COMMITTEE:

Please travel to your local post office and purchase a post card. Send this card to **Don Scoby, Department of Botany, North Dakota State University, Fargo, ND 58102**. Urge Don to finish his manuscript for the BIOSCENE and suggest candidates for office in the AMCBT: President Elect and members of the Steering Committee. (Don promised to send me his manuscript with pictures for publication in this issue, but with your help, I am certain that all of us will hear about the ecology of Don's home.)

AMCBT COLLEGE BIOLOGY DEPARTMENTS

Don Huffman, Biology Department
Central University of Iowa, Pella, Iowa

Biology at Central University of Iowa (A.K.A. Central College) is strongly influenced by the broader goals of the college itself. CUI's enrollment of about 1,500 includes some 200 students who are off-campus at any one time as part of the college's programs in International Studies, with campuses in: Yucatan, Mexico; Granada, Spain; Vienna, Austria; Paris, France; London, England; and Carmarthen, Wales. Over 70% of CUI students spend a term or more of the 3x3 calendar at one of the international campuses; and, because of these associations CUI has a greater number of foreign students in the Pella, Iowa campus than one might expect--currently about 75 non-native English speaking foreign students from 22 foreign countries.

The Biology Department graduates about 15-17 majors per year. For the past 30 years there has been a striking diversity in vocational plans of our graduates. About 22% have entered one of the Health Sciences (including Medicine, Dentistry, Veterinary Science, Physical Therapy, Medical Technology, etc.); about 32% have entered professions in academic Biology, about half of these at the Ph.D. level; about 15% are engaged in Secondary School Biology/Science Teaching; about 11% are in some business operation; and, about 14% are in a

wide variety of vocations ranging from farming to law and the ministry. About 6% are still in degree programs, about 3/4 of these in the Health Sciences, 1/4 in Biology graduate programs. The foreign studies components offered by the college have strongly influenced the vocational choices of many of the graduates in the last 20 years; many of them continuing graduate or professional training related to an interest developed in foreign study programs. For example: several students have continued studies with bats from their natural history studies in Yucatan; one student began working with fish species of the cenotes (isolated water holes in the limestone sinkholes) of Yucatan; several students have entered medical school with plans to practice medicine abroad; and, several students have chosen marine biology as a result of work in the ocean habitats of the several foreign study programs.

At present the Biology Department consists of four persons; Ph.D.'s in Botany/Plant Pathology, Vertebrate Natural History/Ecology, Invertebrate Biology, and Physiology/Cell Biology. The curriculum is rather standard for those familiar with offerings of Liberal Arts Colleges; the principal distinction coming in the foreign study components and the opportunities for internships in the Urban Studies Program, and other research internships in business, industry, scientific laboratories, museums, and botanical/zoological gardens.

Central's science building, The Vermeer Science Center, has been called the "Liberal Arts College answer to the Little Red Schoolhouse." Principal feature of VSC is the large multipurpose laboratory with support labs, classrooms, stockroom, and instrument labs adjacent to or in proximity with the multipurpose laboratory. In an admittedly reduced space, the teaching programs have lived up to expectations and desires to reduce the barriers between the science disciplines. During our five years in VSC there has been an increase of cross-departmental course selection and a decidedly greater feeling of "science graduates" rather than narrowly specialized biologists.

Like many quality liberal arts programs, Biology at CUI requires an independent study (research effort) at the senior level supported by a Research & Design Seminar and three other seminar experiences prior to graduate. Both by design and fiat it appears that Central's students will continue to enter a broad spectrum of vocations, and there are no pre-professional ties to any particular vocational area.

 BIOLOGY AT NORTHERN ILLINOIS UNIVERSITY

Jack Bennett, Professor of Biology

The Department of Biological Sciences offers the Bachelor of Science, Master of Science and Doctor of Philosophy degrees in Biology with research areas including behavior, biochemistry, botany, cell and tissue culture, cell ultrastructure, development, ecology, endocrinology, evolution, genetics, immunology, microbiology, molecular and cellular biology, physiology, radiation biology, systematics, and zoology. The department has cooperative research and study arrangements with the departments of Geology, Chemistry and Psychology at NIU as well as with Argonne National Laboratory, the Field Museum of Natural History, Shedd Aquarium, Brookfield Zoo, Morton Arboretum and DeKalb AgResearch Inc./DeKalb-Pfizer Genetics. In addition field study areas are available at several University owned preserves and natural areas.

Undergraduate majors take two years of chemistry, a year of physics and calculus as prerequisites for their biological studies. They take a common core of biology classes, including zoology, botany, microbiology, genetics, cell structure, function and heredity, physiology, and ecology plus a few electives from a large selection of advanced courses at the junior and senior levels.

MS candidates may specialize and write a thesis, or take a wide distribution of classes with the non-thesis option. All must take biostatistics and seminar and stand a final oral examination on their work.

The PhD candidate may continue on from an MS or may elect to pursue the degree directly, after demonstrating a satisfactory level of performance in graduate work at Northern.

The faculty of 37 includes the following involved in research and graduate work:

Jack Bennett	population and behavior genetics
W.E. Briles	immunogenetics, physiological genetics, immunology
Thomas P. Conway	immunology, membrane biology
Mason G. Fenwick	fresh-water algae
Elon W. Frampton	microbiology, molecular biology
William A. Garthe	insect physiology
David W. Greenfield	ichthyology, biosystematics, zoogeography, marine biology
T. Daniel Griffiths	radiation biology, molecular biology
James H. Grosklags	mycology
Arnold Hampel	molecular and cellular biology, biochemistry
Laszlo Hanzely	ultrastructural plant anatomy and cytology, developmental botany
Malcolm T. Jollie	comparative anatomy, evolution, systematics
Florence Ledwitz-Rigby	reproductive endocrinology
Wayne J. McIlrath	plant physiology
R. Meganathan	microbial physiology
Peter L. Meserve	mammalogy, population, community and behavioral ecology, biogeography
John L.A. Mitchell	cell physiology
Sidney Mittler	genetics, mutagenesis
Cynthia Nyquist-Battie	developmental neurobiology, neuro-chemistry, neuropharmacology
K.V. Prahlad	developmental biology
O.A. Schjeide	cell growth and differentiation
Paul D. Sorensen	plant systematics and taxonomy
William E. Southern	ornithology, wildlife ecology
Marvin J. Starzyk	water microbiology, pathogenic microbiology
Ronald Toth	developmental botany
Patricia S. Vary	microbial genetics
Carl Von Ende	population and community ecology, aquatic ecology
Bruce Von Zellen	parasitology, protozoology
Jerrold H. Zar	ecological animal physiology, biostatistical analysis

The department has access to the university computers through terminals in Montgomery Hall and also has several small computers in various research laboratories.

Brochures describing the programs in more detail and answers to more specific questions may be obtained by writing: Department of Biological Sciences, Northern Illinois University, DeKalb, Illinois 60115-2854 or by calling: (815) 753-0433.

TRAINING BIOLOGY TEACHERS AT UWEC

We hear a great deal these days about the Crisis in Science Education. Headlines in newspapers, articles in science and education publications, and lead articles in Time and Newsweek all proclaim this great problem to our nation's population.

With the problem so stated, the next move in the scientific process is to form hypotheses as to how the problem might be solved and then to begin experimentation to test those hypotheses.

Fortunately or unfortunately, the scientific process is rarely used by politicians, educators, and/or others when attacking such a vast problem as this. Tests show that kids are not being educated as well as in the past (based on lower ACT and/or SAT scores) and the Russians have kept people in space longer than the U.S. has, thus something must be done to alleviate this "Crisis in Science Education". What should be done? Family situations have been blamed, kids need the backing and urging of their parents if they are to get the most from their education. Teachers cannot adequately work with students who are not in the correct mind set for learning. Longer school years and longer school days have been suggested. These ideas have met with much consternation and opposition from both parents and teachers, to say nothing of the thoughts of the kids! Pour more money (\$) into our schools and into programs which might help teachers to do a better job; money solves all problems! Raise the pay (\$) of High School teachers and they will all automatically and immediately do a better job of educating our kids. Money still solves all problems! And many more ideas have been discussed and set forth to solve this problem. I am certain that none of these solutions, alone, will be adequate to completely solve this crisis but that probably a combination of many will finally be used together in this quest.

There is one other aspect, however, which I believe is most important in attacking this problem, at least long range, and which I have not seen discussed; that is the aspect of the training or educating of our future high school science teachers. In the recent report of the National Commission on Excellence in Education published in The Chronicle of Higher Education, May 4, 1983, is the simple statement: "teacher-preparation programs need substantial improvement;". Since I am a teacher of a Biology Methods course and have long been interested in education at both the university and high school levels, I feel that the way in which our future teachers acquire their education and the ways in which they are trained to teach can and will have a profound effect on their own teaching.

I am aware that many college and university professors could care less about the training and/or the learning situations of these future teachers. Some have thoughts about their training but, not being in the School of Education, feel that they have no influence or bearing on the situation. During a panel discussion at the recent A.I.B.S. meeting in Grand Forks, I heard a well known biologist claim that the School of Education at his institution had no contact with the Biology Department and that future biology teachers may not even be Biology Majors, at any rate, he had no idea what or how many Biology courses these students were required to take. They were obviously undertrained and it was all the fault of the School of Education. It is easy to place blame elsewhere and take the burden off our own shoulders but this certainly is not going to help alleviate the problem!

With these thoughts in mind, and in hopes of stimulating discussion and a sharing of ideas about the training of future Biology teachers, I will describe the situation at U.W.E.C., especially with respect to the Biology Teaching Methods Course which is an area where I feel that I can have some influence on our future Biology teachers.

In Wisconsin, certification to teach biology is granted either to Biology Majors or to

Biology Minors if their Major is another of the Sciences (Chemistry, Physics, or Earth Sciences). This means that Minors with an English, Psychology, or Physical Education major are not certified to teach high school Biology! A Biology Major with a Physical Education minor would be certified to teach both Biology and Physical Education.

At U.W.E.C., a Biology Major must complete a minimum of 36 credits: 4 credits each of General Botany and General Zoology; 4 credits each of an Animal and a Plant Kingdom course; 4 credits of Genetics; 8 credits (two courses) in Advanced Botany; and 8 credits (two courses) in Advanced Zoology. In addition, one year of Chemistry is recommended and is a prerequisite to several of the advanced courses.

The minor must complete the same 16 credits of General Botany and Zoology and Plant and Animal Kingdom courses, along with one Advanced Botany and Zoology Course. These courses provide a broad base of both Zoology and Botany as background for these future teachers. It should be noted that the U.W.E.C. Biology Department recommends that only the Majors should teach, even though the Wisconsin Department of Public Instruction certifies the Minors as well.

In addition to the Major and Minor and General Education requirements, the students must complete the education sequence of courses. In the freshman and sophomore years Speech, Educational Psychology, Adolescent Psychology, and a Conservation course should be completed. In the junior year, Methods in the Major and Minor are required after the Introductory Education course. These courses are prerequisites for the student teaching experience. During this experience, the students are in the public school for a full semester. For the first half of the semester, the student teachers have one full day of Education classes each week at the University and observe and apply what they have learned for the next four days while in the high school classes. During the last half of the semester, the student teachers assume heavier teaching loads with classes in both their Major and Minor culminating in a full class load for the final couple of weeks. During the entire semester, the student teachers work under the guidance of a cooperating high school teacher and are visited by both a professor from the Education School and the Methods professor from their major discipline.

During the senior year, either before or after student teaching, History & Philosophy of Education and Reading in the Secondary School are required.

Having provided this overall picture of the educational requirements of future biology teachers at U.W.E.C., we will now focus on the Biology Teaching Methods course, a 2 credit course which meets twice a week for a total of 4 hours. The first meeting of the week is a one hour class devoted to discussion led by members of the class. The second meeting is a 3 hour class which is usually held in the laboratory and focuses on laboratory exercises, experiments, and the techniques of teaching in the laboratory.

The overall course objective for this class is that: Class members will begin to think and work like teachers. This is a radical departure from the learning experiences which most students have undergone to this time! They must now begin to plan their own work, plan for the work of their students, think about ways and means of presentation, analyze curricular materials and laboratory experiments, and think about the best ways to evaluate the work of their students. Instead of being assigned work and told what to do, they must now put the shoe on the other foot and, without prodding or a great deal of encouragement, must think about assignments and units to be studied by their students! How is this change accomplished?

The semester is divided into thirds with the first five weeks devoted to preparation of

the mindset, becoming comfortable with instructing others, organizing for instruction, and learning of available materials to use in teaching. The second five weeks consists of a good review of the curricular materials available to the biology teacher, both textbook type materials and laboratory manuals and associated experiments and exercises. The final five weeks is "putting it all together", a time for each class member (teacher) to take over and teach the rest of the class. At this time, a TV camera is trained on the "teacher" and after the experience the TV tape is viewed and reviewed by the "teacher" and the course instructor!

We will now look at each of these portions of the semester in more depth. During the one hour discussion periods of the first third, students are picked to be discussion leaders for the class. The general topics for discussion are: Impact, Objectives, and Foundations for Biology teaching; Approaches to and changes in Biology teaching; Organization and evaluation in Biology teaching; and Contemporary Biology Curricula. As background for these discussions, students read from five different texts: **Creative Biology Teaching** by Harding, Volker, & Fagle; **Teaching Science in the Secondary School** by Kahle; **New Directions in Biology Teaching** by Hickman and Kahle; **Science, Students, and Schools** by Simpson and Anderson; and **Biology as Inquiry** by Voss and Brown. Since these books are shared among the students, each student reads only selections from each assignment. The discussions bring out comparisons, examples, and problems from each of the texts as studied by a portion of the class.

During the three hour sessions of this third, several things are undertaken. 1. Some time is used to conclude discussions from the previous period. 2. Each student reports on one or two periodicals of interest to high school students and teachers. Comparisons are made and possible uses of these periodicals is discussed. 3. A review of AV equipment available for use in future presentations is undertaken. 4. Time is made available for discussion of computer use and "hands on" evaluations of software. 5. Time is spent with catalogues, looking up various items, checking catalogue numbers, comparing prices, etc. 6. Inquiry slides and filmloops and other "up to date" inquiry and IGE materials are studied. 7. Students attend the annual Northwest Wisconsin Education Association meeting held at Eau Claire's Memorial High School.

During the middle five week period, current curricular materials are examined in detail. In the one hour periods, textbooks and laboratory manuals are discussed and evaluated and a laboratory experiment is chosen by each teacher to set up and do during the three hour period. At this time, each teacher will have prepared a lesson plan and two quizzes for the particular experiment to be run. Materials must now be gathered and the experiment accomplished. Toward the end of the three hour periods, evaluation of each of the experiments is done by each of the teachers and there is time for questions and comparisons of the experiments with those in other curricular materials.

In the one hour periods of the final five weeks, student led discussions include: 1. Reviews of the various curricular materials, now that many have been studied in some detail; 2. Studies of optimal facilities and equipment for high school biology teaching; 3. What can be done without optimal facilities and equipment? 4. The problems of student teaching and job hunting for that first teaching position. 5. What might the future bring for high school biology teaching?

During the three hour periods of the last five weeks, each teacher gets two or three opportunities to teach the rest of the class. Smaller classes get more chances! The first presentation is a fifteen minute demonstration type of presentation. The final presentation is a 45 minute class period. Both of these presentations should be inquiry oriented and both are reviewed by the teacher and the course instructor. The teacher must

provide, before each session, a lesson plan and two quizzes, either of which could be used at the conclusion of the class period.

During the last three week period, each teacher must also complete the final exam. The problem is to outfit a new High School laboratory with equipment and materials to adequately teach a general biology course to 25 students. Order forms must be filled out and catalogues consulted to complete this project. A limit is set on the budget for each year and each teacher must include a summary of expenditures from each company to be presented to the school board.

The most difficult part of teaching this course for a science oriented person is the evaluation of the work accomplished by each of the teachers! The instructor doesn't have numbers and statistics to divide A's from B's, etc. Only observations of discussions, lesson plans & quizzes produced, taped teaching experiences, final exam orders, and attitudes expected of a teacher are at hand for the purposes of grading. Despite this drawback, there have been very few complaints about grades received for work accomplished during the course. This may be due to the fact that the instructor constantly emphasizes two points to these future teachers: 1. No one ever said that teaching was going to be easy! and 2. Life isn't fair.

Harding, O.E., R.P. Volker, and D.L. Fagle. Creative Biology Teaching. The Iowa State University Press, 1969.

Hickman, Faith M., and J.B. Kahl. New Directions in Biology Teaching. National Association of Biology Teachers, 1982.

Kahle, J.B. Teaching Science in the Secondary School. D. Von Nostrand, 1979.

National Commission on Excellence in Education. "A Nation at Risk: Imperative for Educational Reform". The Chronicle of Higher Education, May 4, 1983.

Sampson, N.D. and R.D. Anderson. Science, Students, and School. John Wiley & Sons, 1981.

Voss, B.E. and S.B. Brown. Biology as inquiry: A book of Teaching Methods. C.V. Mosby Co. 1968.

The Biology Core Curriculum

Robert D. Muckel, Doane College, Crete, Nebraska

At the AMCBT meeting I compared biology core curricula at selected colleges in 1965 and 1983. Also, I reviewed the recommendations of the 1967 study of core curricula in biology by the Commission on Undergraduate Education in the Biological Sciences (CUEBS). The discussion which followed was focused on the nature and development of the biology core curriculum. Because of the participant concern about the issue a subsequent meeting was held where individuals volunteered to attempt to identify major core topics that should be included in the education of all biology majors. This information will be collated and published in **BioScene** in order to allow evaluation and suggestions by all AMCBT members. It is hoped that these efforts will eventually lead to recommendations on the biology core curriculum.

(Editor's note: This next feature is a copy of Purdue University's "Core Biology Program Policy" which is reprinted here because of the interest generated by Bob Muckel's discussion. Hopefully, the April issue of **BIOSCENE** will include further discussions on this topic.)

WHY A BIOLOGY "CORE"?

The goals of biology are to describe the living world-- microorganisms, plants and animals--and to understand the phenomena that distinguish the living from the non-living world. The principal themes that concern biological scientists are individuality, structure-function relationships, heredity, nutrition and metabolism, growth and development, behavior, integration and regulation, evolution and the interaction of organisms with each other and their environment.

The knowledge provided by basic biological research can be applied to critical practical problems in health and medicine, agriculture and the management of other renewable resources, industry, and pollution and population control.

Since any one person can neither comprehend the total biological world in detail nor master all available techniques, individual biologists tend to focus on relatively few aspects of biology. Historically, an array of specializations has arisen, based on:

- 1) **the type of organism studied:** for example, botany, entomology, microbiology, and zoology;
- 2) **the environment in which particular organisms are found:** terrestrial, marine, arctic, tropical, etc.;
- 3) **the principal tools and research methodologies used:** biochemistry, bioengineering, biomathematics, and biophysics;
- 4) **the level of biological organization:** molecular, cell, organismal, and population biology;
- 5) **the type of phenomenon studied:** structural biology, genetics, physiology, developmental biology, ecology, systematics, evolutionary biology, neurobiology, etc.;
- 6) **the application of biology:** medicine and other health-related fields, agriculture, forestry, fisheries, microbial conversions, food processing, pollution control, etc.

All biological specialities depend upon the study of basic biological principles--the key generalizations that dominate research and the application of that research to biological problems. An awareness and understanding of such fundamental principles is sometimes difficult to achieve in a curriculum where biological systems are segregated into traditional animal, microbial, and plant courses. For these reasons, your undergraduate program in biology will be based on a sequence of courses, called the CORE, which describe and discuss basic biological principles at all levels of biological organization, from the molecular to the ecosystem. This sequence will provide a solid foundation and yet allow maximum flexibility for you to then specialize in a variety of fields of biology.

WHAT IS THE BIOLOGY CORE?

The biology CORE consists of a sequence of 4 courses (lecture and laboratory) which are required of all undergraduate majors. Undergraduate majors are then required to take an additional 12 credits of upper division biology courses, including one upper division laboratory course. There are three distinct features which make the CORE more than just a collection of courses. 1) The courses present the phenomenon of life in an integrated manner. No course can be labeled as a botany, a microbiology, or a zoology course, for each is organized according to the unifying principles of biology. In each course illustrative examples are chosen from among all groups of living systems (animal, microbial, and plant) so as not to obscure the universal properties of the living state. 2) The CORE deals with

properties of life at all levels of organization from the molecule to the ecosystem. 3) Each unit is designed as apart of an intellectually meaningful sequence in which the several major ideas of biology are developed more or less in parallel.

UPDATE ON IMMUNITY

By Sister Julia Van denack
Professor of Biology, Silver Lake College, Manaitowoc, Wisconsin

The current AIDS epidemic (Acquired immune deficiency syndrome) and the intense medical investigation that it has triggered is giving us a wealth of clues on how the immune system works normally. Although the U.S. has registered 1831 cases of AIDS by mid-July of 1983, with a 39% death rate, we have not yet found the killer. This failure has not been for lack of trying. In fact the latest break-through in lymphokine research may hold hope for treatment of AIDS victims, just as the use of monoclonal antibodies brightens the future for patients suffering from autoimmune diseases or from cancer.

Let us examine what we currently know of this complex immune system. Since 1970 we have been aware of the so-called major histocompatibility antigens, a group of genetically determined antigenic glycoproteins found on virtually all cell surfaces. We now recognize two class of these glycoproteins. Class I molecules embedded in cell surfaces are necessary for the body to distinguish "self" from "non-self". Class II molecules are present only on cells of the immune system and identify such cells to each other. This recognition is critical in the specific immune response which involves interactions among B lymphocytes, T lymphocytes, and phagocytic macrophages. The elucidation of this highly organized and cooperative effort is one of the most intriguing areas of modern medical research.

The first step after a foreign protein, bacterium, or virus has invaded the body seems to be initiated by the macrophages who present the antigenic determinants of the "foreigner" to the thymus-conditioned cells (T cells) and to the B cells (conditioned by gut-associated lymphoid tissue.) In vitro research shows that macrophages are depots for continuous slow release of antigens and antigen fragments of T and B cells. This contact sets in motion a series of events causing T and B cells to proliferate and produce "Memory" cells and Effector cells. Effector B cells differentiate into plasma cells that produce specific antibodies sometimes at a rate of 2000 per second that circulate through the blood and lymph. We term this antibody production the specific humoral immune response.

Antibody structure has been studied in great detail in recent years. We know that the heavy chain of the now familiar Immunglobulin G is composed of 440 amino acid units and the light chain of 220 units. The variable region and various arrangements of the light and heavy chains make possible the trillions of specific antibodies to combat the various antigens that may invade the body. The variable region of the antibody provides the receptor sites for the antigen to fit into like a specific key in a lock. Once latched on to the antigens, the antibody assumes the familiar "Y" shape exposing the complement site on the stem of the "Y". This allows the complement cascade to complete the work of the antigen-antibody complex and burst the outer membranes of the foreign invaders.

Besides illuminating the humoral or antibody immune response, we have made strides in understanding the cell-mediated immune response. The thymus-conditioned cells or T-cells are involved in this response. Along with the "memory" T cells, three types of effector cells are distinguished. The first kind is termed cytolytic or cytotoxic. These "killer" cells serve a special surveillance function in detecting and destroying abnormal cells. The

second and third types of T cells are helper cells and suppressor cells. The helper T cells activate the B-cells and cytolytic Ts while the suppressor T cells moderate the B-cells and other T-cells. These three types of lymphocytes produce proteins collectively known as lymphokines. The latest research shows that these lymphokines play a central role in the immune system and may even promise treatment for immune deficiency diseases such as AIDS. AIDS victims have less than half the required number of lymphocytes per milliliter of blood, with a very low number of helper T cells and a relative overabundance of suppressor Ts. Many victims come down with pneumocystis pneumonia and Kaposi's sarcoma much as do immunosuppressed transplant patients. We now have direct evidence that this mysterious AIDS disorder is transmitted by the blood and has a long incubation period. It is feared that the infectious agent, if there is one, is no longer present when the full-blown symptoms of AIDS become observable. This fact would explain why it has eluded the best and brightest in the medical field up to this time. A treatment for AIDS, however, may be in the offing with the lymphokine research being done in the U.S. and Japan. Interleukin II, one of the lymphokines elaborated by the T cells stimulates production of T cells that produce a B cell Growth Factor (BCGF) that eventually leads to antibody production. In vitro tests show that interleukin-2 improved the function of T cells from AIDS patients. At Sloan-Kettering Memorial Institute it was found that patients treated with interleukin-2 showed an increase in the number of helper T cells. With the cloning of the gene for interleukin-2, large quantities of purified interleukin-2 may become available for further testing.

Another line of research, that of production of monoclonal antibodies, has provided the medical profession with new tools for diagnostic screening, immunotherapy, anytigen purification, and basic research in biochemistry and immunology. Let us hope we are watching the sunrise of a new day in our battle against infectious diseases.

Bibliography

- Fuerst, Robert: Microbiology in Health and Disease, 15th ed. Philadelphia, W.B. Saunders Co. 1983
- Lewis, Ricki "Biotechnology - Applications and Implications" Biology Digest, April, 1983, 9(8):11-20
- Lewis, Ricki "Immunity Breakdown" Biology Digest, Sept., 1983, 10(1):10-20
- McAuliffe, Sharon and Kathleen McAuliffe "The Genetic Assault on Cancer" The New York Times Magazine, Oct. 24, 1982, 39-54
- Marx, Jean L. "Suppressing Autoimmunity in Mice" Science, Aug. 26, 1983, 221:843-845
- Marx, Jean L. "Chemical Signals in the Immune System" Science Sept. 30, 1983, 221:1362-1364

The Inquiry Approach to Teaching Non-Majors Biology

Marshall Andersen: Rockhurst College, Kansas City, MO 64110

One of the most difficult courses to teach among a biology department's offerings is the general biology course for non-majors. In some departments the non-majors and majors are combined into a single course; other departments try to keep the two separate. The latter alternative sometimes results in a "watered-down" version of the majors' course. A third possibility is that the non-majors course might over-emphasize human anatomy and physiology or systematics and phylogeny.

At Rockhurst College we have an introductory course for majors and a separate course

(BL 15, Biology of the Contemporary Scene) for non-majors to satisfy the general lab science requirement. Two of our department members, Dr. George O'Conner and myself, with considerable input from other department members, recently decided to examine BL 15 and, if necessary, revise the course contents and method of delivery. The results of our study included new course objectives, a different lecture format, a student study guide, a different exam format, and a different emphasis in lab.

For our course objectives we decided that we wanted the students to be exposed to the nature of science and to the use of the scientific method as a means of acquiring knowledge. We wanted the students to learn to both ask questions and then answer these questions using their own observations and deductive abilities. Because most non-majors, after completing a course of this nature, rapidly forget the biological terms normally covered during the semester, and because many students are intimidated by the new vocabulary which is normally presented in this type of course, our revised course attempts to reduce the number of scientific terms to those which are absolutely essential in a discussion of principal biological concepts. These terms are then used repeatedly throughout the course so that they might become part of the student's working vocabulary. This allows the student to concentrate more on the concepts than on the vocabulary. Finally, we wanted our students to observe, first hand, the use of the "scientific method" as a formal means of solving problems.

We next selected what we considered to be the main concepts in biology. These included: science and the scientific method, general chemistry and cell physiology, life, cell theory, organisms, biological inheritance, evolution, homeostasis, ecosystems, and behavior. We also decided on the basic principles involved in each concept with the understanding that the illustrations for these principles would be left to the discretion of the individual instructors.

We decided to utilize an inquiry-type format. Our intention was that students would respond to questions prepared by the instructor. In practice, these questions attempt to direct the students' thoughts in such a way that they, in essence, teach themselves basic ideas. Personally, I found developing questions for this type of format to be very difficult, and I frequently slipped back into the didactic style. To counteract this tendency I designed flow diagrams which consist of a series of questions with suggested general responses. These flow diagrams, which can be quite flexible, help me to stay with the inquiry format and also help me visualize the direction in which class discussion is heading.

Obviously, this inquiry format will work only if students are prepared to participate. To encourage this participation, students are given daily three to five minute quizzes over material they will be discussing in class. These quizzes are primarily objective. About five to ten percent of the student's grade is based also on actual participation in class discussion.

In addition to the final, three major lecture exams are given during the separate lab period. Different lab sections meeting at the same time take the same exam, regardless of which lecture section they are in. This arrangement means that the exams must be somewhat general to allow for individual instructor differences in presenting the material. It also means that the instructors must communicate with each other frequently with regard to lecture discussion content and vocabulary. This cooperation is accomplished by having the instructors sit in on each others classes and by weekly (or even more frequent) meetings. Although some questions on the exams are objective and rely primarily on memorization of terms, most of the questions are more indirect and require the student to utilize the material covered in their lecture discussion to "solve" the answers to the questions. The

contents of the problems or questions are often over material not discussed directly in class or in the text. Instead the students try to relate the questions to the appropriate model discussed in class. For instance, a problem might consist of a description of a physiology experiment. The student would read the description and then identify observations, questions, hypotheses, variables, controls and standards and state the significance of the results in relation to the hypothesis. Neither this specific experiment nor the subject matter of the experiment will have been presented in lecture or in the text, but other experiments will have been discussed as models.

Because this format often represents a new approach for the students, Dr. George O'Connor and myself prepared a study guide with the help of a local KCRCHE (Kansas City Regional Colleges of Higher Education) grant. Students are required to purchase this study guide at cost from a local printing establishment at the beginning of the semester. The guide explains the course format and objectives and gives a brief introduction, complete with working vocabulary and preparatory discussion questions, for each of the ten main concepts.

Finally, our lab sequence helps to emphasize the scientific method and the nature of science. Although some of the labs might be thought of as traditional, the emphasis is on scientific thinking. The first lab emphasizes observation and the difference between observations and inferences. We have the students "observe" a "black box" and attempt to formulate an hypothesis concerning the nature of the contents. Then we have them observe an orange. Next, the students learn how to use the microscope, but the microscope, but the emphasis is not on the microscope per se but rather on how tools can extend the limits of one's observation capabilities. This concept is reinforced by a lab on cells, which not only illustrates material covered in the lecture discussion, but also shows them a practical application of the microscope. Other labs teach quantitative skills, including graphic and tabular data presentation. Finally, a series of labs illustrates the process of hypothesis formation and testing. Included in these experimental design labs are uses of controls and standards.

We plan to continue revising the study guide and discussion questions and will be evaluating the students' reactions to the lecture and lab formats. Preliminary evaluations suggest that students are generally in favor of this type of biology course, but there is some confusion as well as some reservations stemming in part from the fact that this is a novel experience for many students and not what they might have experienced in high school biology. We also have the problem of dealing with students who have very diverse majors. We are hoping that by emphasizing biology as a science and science as one way of thinking and problem-solving, we can help more students see why science is important in their lives, regardless of major.

(Editor's Note: The following is an example of a quiz question used in this course)

In a factory many departments and pieces of machinery must work in harmony in order to produce a specific product. A similar requirement is also true of the organelles and other components of a living cell. Column A below lists several aspects of a manufacturing plant. Column B lists organelles and other cellular components. Based on function, match the cellular components from column B with their factory counterparts in column A:

Column A

- 45. janitorial staff (clean-up)
- 46. manufacturing machine
- 47. conveyor belt
- 48. power plant
- 49. packaging/shipping dept.
- 50. manager
- 51. energy for immediate use
(i.e., electric)
- 52. energy reserve (i.e., fuel oil)
- 53. spare parts for machines, etc.
- 54. blue prints for factory

Column B

- A. mitochondria
- B. nucleic acids (DNA)
- C. ribosomes
- D. proteins
- E. lysosomes
- F. fats
- G. Golgi apparatus
- H. endoplasmic reticulum
- I. nucleus
- J. carbohydrates

CREATIONISM OR EVOLUTION?

By Robert H. Buchholz, Professor of Biology, Mormouth College

The main criticisms of evolution raised by creationists are these: (1) the age of the earth is far too short for evolution to have occurred; (2) there are no transitional forms between major groups of organisms; (3) the fossil record does not show an increase in complexity of organisms when one compares later strata with earlier; (4) the Second Law of Thermodynamics denounces evolutionary trends from simple to complex and (5) the theory of evolution, like creationism, is metaphysics, not science; hence equal time should be allotted to creationism. Let us deal with each of these points.

(1) The determination of the age of sedimentary rocks by the radioactive decay of various chemical elements gives evidence that the age of the solar system, including our earth, could be 4.6 billion years. This would be ample time for evolution to have occurred.

(3) Biological evolution hypothesizes that, over the course of time, there are changes in populations of such magnitude that one recognizes descendants as different from ancestors. Transitional forms such as the Archaeopteryx (primitive bird) have been found. This is a fossil with characteristics of both reptiles and birds. The vertebrates (animals with backbones) are the best test case for tracing evolution since they have bones and teeth that fossilize well. There are numerous intermediate fossil forms linking the main types of vertebrates. The transition from reptiles to early mammals is well documented.

(3) Evolution implies a general trend from simple to complex structure. Early fossil records show only invertebrates (animals without a backbone). In later rock strata there is the appearance of fish-like organisms. Still later come the amphibians and reptiles and finally the birds and mammals. As a part of life genes mutate and recombine and as a consequence the individuals of a species come to differ from one another. Gradually the better adapted will survive and become increasingly different from their ancestors, and we will recognize that evolution has occurred.

(4) The Second Law of Thermodynamics states that organisms tend to run down without an external source of energy. If an animal stops eating or green plants are placed in the dark they die. Creationists tend to ignore external sources of energy and say that evolution from simple to complex organisms could not occur. The only energy required by the living world is the sum of that necessary for the individual organisms for growth and maintenance. There is a great increase in complexity as an organism grows from an embryo to an adult. If this can be done in spite of the Second Law, evolution will be possible. Energy is required only for living--not for evolving.

(5) The theory of evolution is science and not metaphysics. The central biological concept of evolution is scientific. The creationists base their attack on a statement made by philosopher Karl Popper: "Darwinism does not really predict the evolution of variety." They have taken great comfort in Popper's point of view. However, their infallible philosopher has changed his mind: "It does appear...that some people think that I have denied scientific character to the historical sciences such as palaeontology or the history of life on earth...This is a mistake and I wish here to affirm that these and other historical sciences have in my opinion scientific character: their hypotheses can in many cases be tested."

Many individuals have no problem with cosmic evolution or evolution of organisms other than man, but the moment that man is mentioned in the evolutionary process all sorts of difficulties seem to arise in their thinking. While procedures of evolutionary science allow us to explain much about this natural world, the creationists stress that we cannot explain everything. This is true, but it would be as foolish to discard the theory of evolution with the overwhelming evidence as it would be ridiculous to disband the medical profession because there is not cure for the common cold.

BIBLIOGRAPHY

1. Beck, Stanley D. 1982. Natural Science and Creationist Theory. Bio Science 32:738-742.
2. Milne, David H. 1981. How to Debate with Creationists--- and "win". The American Biology Teacher. 43:235-245.
3. Moore, John A. 1982. Countering the Creationists. Academe March-April p. 13-17.
4. Numbers, Ronald L. 1982. Creationism in 20th Century America. Science. 218:538-544.
5. Popper, Karl. 1980. Evolution. New Scientist 21:611.
6. Root-Bernstein, Robert and McEachron, Donald L. 1982. Teaching Theories: The Evolution - Creation Controversy. The American Biology Teacher 44:413-420.

CREATION OF THE EVOLUTION LABORATORY

John R. Jungck, Department of Biology, Beloit College, Beloit, WI 53511

Evolutionary biologists continue to receive criticism from many sides; but primarily from creationists and antisociobiologists. While academicians in Ivy League or very large state universities may be isolated from this foray, those of us who teach in small colleges are frequently on the line because we may be the only evolutionist on campus. Furthermore, we may be ill prepared to deal with the onslaught from several directions because we feel that evolutionary thinking is so reasonable that any intelligent individual would obviously be convinced. Therefore, we certainly have not developed efficacious strategies to counter

the well-organized political movements which are challenging our basic academic freedoms. This has frequently resulted in many an academic evolutionist being artfully dissected by the smooth rhetoric of a national spokesperson with a spate of out-of-context quotes which have been carefully selected for their emotional appeal to their solicited audience. Needless to say those evolutionists who have scored evenly or even come out on top in this oratory battles have returned to the roundtable to share their dragon slayer stories; somehow such exercises seem counterproductive. While we may be doing excellent science in basic research and while our lecture-discussion courses may be very well prepared, one large disservice which we may have done ourselves is the lack of consistently offering evolution laboratories in conjunction with our courses. One reason for the perpetuation of this tradition may be that we have not sufficiently shared appropriate, workable laboratories with one another. I herein share with you some resources which may be useful in a variety of courses which emphasize evolutionary thinking.

It is surprising that there seem to be no published lab books purely devoted to evolution. On the other hand, a variety of lab books include individual exercises on evolution and several commercial vendors sell kits to illustrate evolutionary processes. In addition, the recent revolution in microcomputers has led to a large number of portable simulations at modest price. Furthermore, our own educationally oriented biology journals are a rich resource for seeing what some of our ingenious colleagues have developed to illustrate important concepts and processes in evolution. Hence, I do not feel that there is sufficient reason to hide any longer behind the set of excuses for not offering evolution labs: evolutionary experiments could never be done in a single semester, much less a year, because the time frame is too short to witness anything significant, since evolution is the unifying principle of biology, we already teach enough evolution in other courses, so there is no need for a whole separate course and lab devoted solely to it, simulations are cookbook and gedanken exercises only, etc.

On July 2nd, 1981, Professor Frank Price of Hamilton College in Clinton, New York presented the syllabus for his evolution lab to the participants in a educational workshop sponsored by the Society for the Study of Evolution and the American Society of Naturalists after their combined annual meeting at the University of Iowa. He feels that biology students are insufficiently exposed to mathematics and modeling. Therefore, he has combined his primary interest in evolution with a complete laboratory experience in computer simulations and data analysis. He takes his students through deterministic models of changes in gene frequencies due to mutation, migration, genetic drift, and selection, through stochastic models of the same processes, and then through both descriptive and inferential statistical analyses of the classic Bumpus data on stabilizing selection in sparrows. (Bumpus's 1899 article is reprinted in Carl Jay Bajema, editor, Natural Selection Theory, Benchmark Papers in Systematic and Evolutionary Biology, Volume 5, Hutchinson Ross Publishing Co.: Stroudsburg, PA, (1983), pp. 348-365.)

Professor Price's stochastic simulations have been accepted by CONDUIT so they probably become available in less than a year. His models are thoroughly researched and their use in his laboratory seems pedagogically and scientifically effective. He reports student growth and satisfaction with this laboratory experience. He is a recent recipient of the National Science Teacher's OHAUS Outstanding College Science Teachers' Award. In terms of the vogue use of "evolutionary stable strategies" (ESS), I would characterize Dr. Pirce's model as a pure strategy. For the sake of those of us who prefer diversity, let us explore some components of a more mixed strategy.

Since my own professional background is in chemical evolution and molecular evolution, I have enjoyed using a variety of experiments on the origin of life in my class labs. They frequently have the advantage of being classic experiments which intrigue students because

they have already heard or read something about them. The best collection of experiments which are well presented (which I am aware of) is Biology of the Cell: Laboratory Explorations by William DeWitt and Eleanor R. Brown (W.B. Saunders Company, 1977). Their experiments involve the synthesis of organic compounds from a simulated primordial atmosphere, polymerization of amino acids to form proteinoids, preparation of proteinoid microspheres and coacervates, microscopic comparison of cellular universalities and differences in the five kingdoms, and experiments on metabolism. Unfortunately, the experiments on catalysis do not employ proteinoids nor do the experiments on permeability make use of proteinoid microspheres or black thin film membranes; both of which have been widely explored in the chemical evolution literature.

When Luria and Delbruck won the Nobel Prize, I was extremely disappointed that the press did stress the impact of one of their first collaborative efforts as one of the finest experiments in the history of evolutionary research. The fluctuation test which they reported in 1942 was a significant test of teleology. While the experiment is easy to perform, many textbooks do not discuss it because the analysis of the data employs Poisson statistics. One fine discussion of the experiment is in William Stansfield's The Science of Evolution (Macmillan, 1977): A good lab write-up of the experiment is by B.W. Glover, "Luria & Delbruck Fluctuation Test," pp. 22-26 in R.C. Clowes & W. Hayes, eds., Experiments in Microbial Genetics, Blackwell Scientific Publs. (1968). Besides ruling out an environmentally directed origin of adaptations, the experiment was one of the first to yield accurate estimates of a gene's mutation rate. Most texts have supplanted this test of teleology with the Lederberg and Lederberg replica plating experiment which uses no mathematical analysis, but clearly demonstrates the existence of pre-adaptive mutations in the absence of the selective agent.

Along with many other evolutionists, I believe that every phylogenetic tree is an evolutionary hypothesis. Thus, any experimental analysis of taxonomic relationships seems perfectly appropriate for the evolutionary laboratory. A commercial kit entitled "Immunology and Evolution" allows students to stimulate the immunological cross-reactivity between man, chimpanzee, monkey, orangutan, and pig. If appropriate experiments are chosen, the construction of a dissimilarity matrix should be possible. An extensive computer package available from Professor Joseph Felsenstein at the University of Washington (Seattle) allows students to investigate a large variety of clustering algorithms for generating phylogenetic trees, phenograms or cladograms. Each tree developed from data which students have collected in a laboratory could be examined for reasonableness when compared with traditional classifications.

Besides employing antisera to explore phyletic distances, I have used paper chromatography of plant pigments and thin layer chromatography of essential oils to make chemotaxonomic comparisons. The Artemesias are quite good specimens which show considerable differences in their essential oils; some of the plants which store well include Dusty Miller, Silver King, Silver Plume, sage brush, wormwood, and a commercial variety just labelled as "artemesia." Extracts such as "Absorbine, Jr." contain sufficient material to make some inferences as to the plants employed in the commercial preparation. Care should be taken not to concentrate too much on some of the essential oils such as chamazulene, because some students (and I) react strongly to the odors. If you have a good gas chromatograph available, it will allow you to compare these specimens with much smaller samples, greater safety, and much more quantifiable results.

The use of gel electrophoresis to examine polymorphism and heterozygosity in natural populations has been extremely popular ever since the 1966 experiments of Lewontin and Hubby. Results from such experiments have revolutionized the way we have looked at the roles of selection and genetic drift ala the neutralists. In addition to classic work with

drosophila, extensive analyses have been performed with snails, bacteria, rodents, plants, etc.

Two frequently employed labs involve the classification of imaginary organisms. I have used Joseph Camin's caminalcules for years. Robert R. Sokal, "Numerical Taxonomy" in Scientific American 215(6):106-116 (December, 1966), for more pictures of Caminalcules, see Robert R. Sokal, "A Phylogenetic Analysis of the Caminalcules. I. The Data Base", Systematic Zoology 32(2):154-184 (1983). I have delighted in reading the imaginative scenarios which students have constructed to account for their differences. A colleague recommends the game "Hardwaria." He brings in a large number of washers, screws, nuts, bolts, cotter pins, nails, etc. and tells the students to pretend these are artifacts brought back from another planet by a NASA team. Their goal is to construct a meaningful classification. In either case, the students will tackle some very real decision-making problems in deciding upon groups and characteristics to be considered. I have students use these data as well as protein and nucleic acid sequence data with Felsenstein software to develop better ideas about classification and phylogenetic inference.

In class, we frequently discuss rapid speciation through allopolyploidy or simple polyploidy. Thomas R. Merton in "Student Investigations of Speciation in Tragopogon," Journal of Heredity 63 (1): cover, 39-42 (January-February, 1972), discusses a laboratory examination of the chromosomes of T. porrifolius L., T. pratensis L., and T. dubius Scop. and the two amphidiploid species T. mirus and T. miscellus which have twenty-four chromosomes instead of the twelve of the original stocks. He uses a vital stain to select pollen which is likely to be viable. Meiosis is studied in pollen mother cells. The interesting relationships between cauliflower, broccoli, rutabaga, mustard, and a variety of related plants is nicely discussed in the second edition of the genetics book by Suzuki, Lewontin, and Griffiths.

Directional selection for geotaxis and phototaxis in drosophila set up easily, "A Circular Countercurrent-Distribution Behavioral Genetic Maize," J. Heredity 68:123-125 (1977) (Kordek, Jungck, etc.) and easily illustrate the principles in a reasonable period of time. However, not all students seem to have the patience required for these experiments. Thus, classical population cages may be readily employed in larger classes. Chemostat experiments are perhaps best for most rapid illustrations.

Variation can also be studied morphologically in a nice commercial kit employing common sunflowers, Helianthus annuus. Students can easily construct a histogram which looks quite Gaussian (we have found that sunflower seeds sold as commercial bird food works just as well as the kit). A similar effective display at Harvard's Agassiz Museum of Comparative Zoology employs snail shells with different banding patterns.

One of the questions asked by evolutionists relates to why there are so many different kinds of organisms. In an interesting twist, Professors Raup and Michelson (Science, '65) "Theoretical Morphology of the Coiled Shell", was able to generate shell morphologies on both analog and digital computers with striking resemblance to most of the contemporary and extinct gastropods. One of the questions they asked is: since our simple model could account for so many other forms which seem to never have existed, why didn't those other forms over evolve?

I usually include four field trips amongst my evolution labs. First, we are close to a number of excellent quarries and road cuts which are good for fossil collecting. Second, we make one all day trip to Milwaukee and fit in the Milwaukee Public Museum with its excellent dinosaur diorama, the Mitchell Dome Conservatory with its superb diversity of flora, and the Zoo. Third, we travel to Chicago to the Museum of Science and Industry which has an

excellent display on the evolution of hemoglobin and of Raup's coiled shell simulation and the Shedd Aquarium. Finally, the last trip is again to Chicago to the Field Museum of Natural History for their annual systematics symposium which focuses on evolution.

My students usually begin the lab course in evolution with a confidence approaching arrogance that they know what evolution is all about. Part of the way into the course, they have tried enough labs that they question not only their confidence, but also the ability of evolutionists to make any sense of all the material they are being presented: especially they have difficulty in constructing phylogenies and in understanding the regularities of stochastic processes. Delightfully, before the course is half over they acquire a new sense of confidence which is seemingly developed out of the competence of performing labs rather than just reading or listening. Therefore, labs will remain an important part of my evolution class. If you have other ideas for evolution labs, please share them with me.

UNDERGRADUATE OPPORTUNITIES IN SCOTLAND FOR BIOLOGISTS

Nancy J. Doemel, Director, GLCA Scotland Program
Wabash College, Crawfordsville, IN 47933

Why should the humanities and social science majors have all of the fun? Traditionally, few undergraduate science majors have felt free to consider a year abroad for a number of reasons: (1) few study abroad programs offer options permitting science students to take science courses; (2) those programs which do offer science may not measure up to the quality of science courses taught at the home institution, and thus advisors have been reluctant to promote those programs; (3) the curriculum for science majors is generally highly structured, and students think that they must not leave campus because they fear missing particular courses required for the major; and (4) science majors often take the MCAT during the junior year, and they fear postponing that test until senior year when they are back on campus.

We think we have an answer to those problems. The Great Lakes Colleges Association (GLCA) is a consortium of colleges in Indiana, Michigan, and Ohio. Included are Albion College, Antioch College, Denison University, DePauw University, Earlham College, Hope College, Kalamazoo College, Kenyon College, Oberlin College, Ohio Wesleyan University, Wabash College, and the College of Wooster. Seven biology majors from those colleges have studied abroad at the University of Aberdeen, Scotland, in the past five years. All have had a successful experience, and all have taken one, or more than one, science course at Aberdeen.

The University of Aberdeen is an old British university with approximately 5,000 students. Offering both undergraduate and graduate degrees, it is also the center for much geological, biological and chemical research in Scotland because of its ties to both the petrochemical industry (the North Sea oil production has created a real boom in Aberdeen) and to the historically productive agricultural region in northeastern Scotland. Because of these factors, the undergraduate science departments at Aberdeen are generally well staffed and well equipped, and the research programs of the faculty there provide many interesting opportunities for students.

Students enrolling in the GLCA Scotland Program for 1984-85 will attend regular university classes, live in university dormitories and immerse themselves in Scottish student activities. The academic year goes from October 1 through May 15 for American students, with two three week vacations at Christmas and during spring. Cost of the program will be \$6,850 for tuition, student activity fee, orientation and group activities, and round trip transportation. Room and board is approximately \$1,500 per year. Although the

program is designed for GLCA students, other students are welcome.

The structure of the Aberdeen biology curriculum differs to some degree from that of American colleges. During the first and second years, students follow a pattern somewhat similar to the American pattern; that is, they attend lecture several times a week and have one three hour laboratory per week. But during the third and fourth years, the Scottish student spends all day working in his or her major department. Therefore, courses are taught in 6 week modules, and require a student's attention for most of the day, every day. For example, a third year student taking the 6 week Marine Biology course would have 54 lectures (6-9 per week) and 2 laboratories of 5-6 hours each per week. For this reason, it is virtually impossible to schedule a 3rd year biology course plus a course in chemistry, for instance. It is possible, however, to schedule two or three six week biology modules if they meet during different 6 week blocks of the calendar. And it might be possible, depending on the specific biology course, to schedule one first or second year humanities or social science course at the same time.

The problem, of course, is making sure that junior science majors have had the kind of prerequisites required to take 3rd year courses. That can be done by identifying, early in their college careers, those students who might like to study abroad, and then helping those students design a curriculum plan which will permit the inclusion of the year abroad.

Biology majors have two other alternatives at Aberdeen. One is to plan not to take science courses at Aberdeen, but rather to take only humanities and social science courses. In that case, we would counsel the science major in the same way we advise non-science students. This might work particularly well for a science major who still needs to take Physics I and two distribution courses. The final alternative would be for the student to take two modules of third year courses and spend the last twelve weeks working on an independent study project with a faculty advisor at Aberdeen. The special research interests of the staff are published in departmental syllabuses, and correspondence between the student's home advisor and the Aberdeen faculty researcher would make that option possible.

The usual biology course offerings occur at Aberdeen. Students with the proper prerequisites may choose from anatomy, biochemistry, biomedical physics, botany, cell biology, developmental biology, ecology, evolution, genetics, human growth and development, immunology, microbiology, parasitology/entomology, pharmacology, physiology, soil science, and zoology. Several of the third year modules are worth special mention. A module in tropical biology is particularly good, although surprising at a school so far removed from the southern hemisphere. Scottish Highlanders during the Empire period established and managed the large plantations in the tropics, and thus Scottish biologists did much of the original research on tropical botany and zoology. This research continues today. Because of the development of the North Sea oil fields, Aberdeen's marine biology course is a very good one. Also worth mention is a course in biotechnology, where students are introduced to the new techniques of modern molecular biology including cell culture, cell fusion, DNA manipulation, plasmid transfer and antigen variation.

Students who need to take the MCAT can take it in Scotland. It is offered during March each year at Sterling, about 2 hours from Aberdeen.

We are not particularly trying to "drum up" business for the GLCA Scotland Program. But we did want you to know, in all the AMCBT biology departments, that there is a school in an English-speaking country where biology majors can have the best of both worlds: they can live in a foreign culture and they can take academically solid biology courses. The application deadline for 1984-85 is ~~March~~ 1.

For information, contact Ms. Nancy J. Doemel, Director, GLCA Scotland Program, Wabash College, Crawfordsville, Indiana 47933, 317-362-1400 x 282.

OBSERVING AND RECORDING SKELETAL MUSCLE CONTRACTION WITH OSCILLOSCOPE AND CAMERA

Joe Kapler, Loras College, Dubuque, Iowa 52001

The frog gastrocnemius muscle is used extensively in undergraduate physiology laboratories to study the functional properties of skeletal muscle. It is convenient to use because it has a handle at both ends; the femur bone at its origin and the Achilles tendon at the other end. This muscle is easily mounted on a recording apparatus for a study of its responses to stimuli. The muscle can be stimulated directly or through the sciatic nerve if a nerve-muscle preparation is used.

We used Thornton electronic equipment, but different types and combinations can be used. The frog gastrocnemius muscle is held by a femur clamp and connected to a displacement transducer which sends signals to an amplifier and then to the oscilloscope. For the studies reported here, we stimulated the muscle directly by using fine copper wires (#32) as electrodes implanted directly in the muscle. The arrangement of this equipment is described in the Thornton Laboratory Guide to Physiology.

Single pulses from the stimulator will produce single twitches in skeletal muscle. Two successive stimuli can produce the summation effect, and a series of stimuli can tetanize the muscle if the frequency is high enough. In discussing the response of muscle to stimuli and how to best utilize our equipment to show and record these phenomena, a student offered a suggestion that proved to be quite useful. The student, John Weber, is also an accomplished musician and is familiar with electronic instruments and devices used by many of today's musicians.

One of these devices is a delay unit used for echo effects. It produces a second pulse with the same duration and amplitude as the initial pulse. We used a Boss DM-2 unit with a delay range from 20 to 300 milliseconds. This device can be switched on and off. When it is off, only the initial pulse passes through. When it is on, the second pulse produced by the delay unit follows the initial pulse from 20 to 300 ms. later, depending on the setting.

To study the summation effect in muscle, we connected the delay unit to the stimulator output and the output of the delay unit was connected to the electrodes in the muscle and to Channel B on the oscilloscope. The output from the displacement transducer and the amplifier was connected to Channel A. With this arrangement, the time of the second pulse and its effect on muscle contraction could be observed on the oscilloscope screen. Beam sweep was set at 50 ms./cm., so the time lapse between the first and second stimuli could be accurately determined.

A Thornton Type 492 Digital Storage Module can be used to store signals from the muscle response and reconvert them for oscilloscope display or to a strip chart recorder. Photographs of responses as shown on the oscilloscope screen can also be made. To do this, we utilized a Tektronix Type 516 oscilloscope and a Polaroid CR-9 camera adapted for oscilloscope trace recordings. Polaroid Type 667 film with a three second exposure at f16 gave us good photographs. A few trials are necessary to determine proper beam intensity and

scale illumination. Utilizing the oscilloscope and camera enables students to observe muscle contraction phenomena and obtain copies of the screen image in a matter of minutes which can then be used for study and analysis. The photographs can also be copied and from the copy an overhead transparency can be made. I have found these transparencies from photographs or strip chart recordings to be very useful for classroom discussion, and they can be made in minutes after the muscle response is recorded.

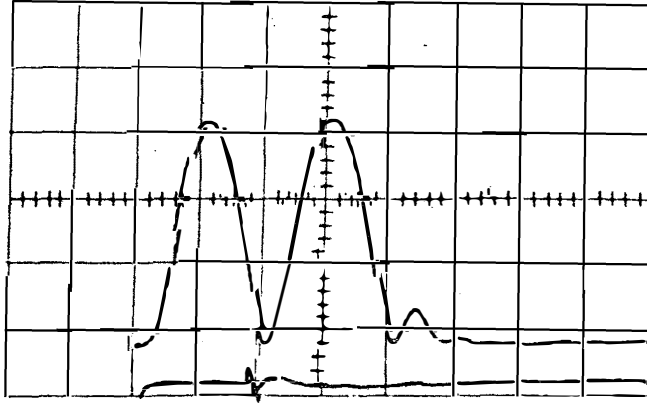


Figure 1. Two successive isotonic single twitches. The lower beam trace shows the time of the second stimulus, 92 ms. after the first. The small bump after muscle relaxation is the muscle lever rebounding.

Figure 1 shows two successive single twitches resulting from the initial stimulus (4 volts for 6 ms.) which triggered the beam sweep and the second stimulus from the delay unit which came 92 ms. later. Figure 2 shows the summation effect when the second stimulus arrived 66 ms. after the first. Superimposed on this tracing is the summation effect when the second stimulus came 50 ms. after the first. In Figure 3, the muscle was stimulated for the second time at 20 ms., the shortest time possible with this unit. At first glance, it may appear to be the same as a single twitch as shown in Figure 1, but the contraction trace is 1.2 cm. higher, indicating summation. All of the responses shown in Figures 1-3 were from the same stimulus and the same frog muscle. The only variable was the time between the first and second stimuli.

The minimum delay of 20 ms. with this equipment is too long to show the refractory period of frog skeletal muscle, which is reported to be about 5 ms. In one frog, however, we were able to show the refractory period at 20 ms. The isotonic twitch resulting from two stimuli 20 ms. apart was identical to that produced by a single stimulus. It showed no summation. We attributed this to the poor condition of the frog which was one of a batch obtained in the spring of the year. The single twitch response of this frog was more than twice as long as that of a healthy frog. We have found that frogs and turtles obtained in the fall of the year are generally much healthier after a summer of activity and feeding than those which have been thought to hibernate. This is one of the reasons we schedule the physiology course in the fall semester.

I have recently observed that two subthreshold stimuli within a short time period will produce a response. This is shown in Figure 4. The muscle did not respond to the first stimulus (0.25 volts for 6 ms.), but the same stimulus 125 ms. later did produce a contraction, although not as strong as that from a threshold level stimulus. This appears to be facilitation or temporal summation. It is possible that the second stimulus is stronger than the first, but this is not evident where two stimuli produced two single twitches as shown in Figure 1. More study will be done with this response as produced by this equipment.

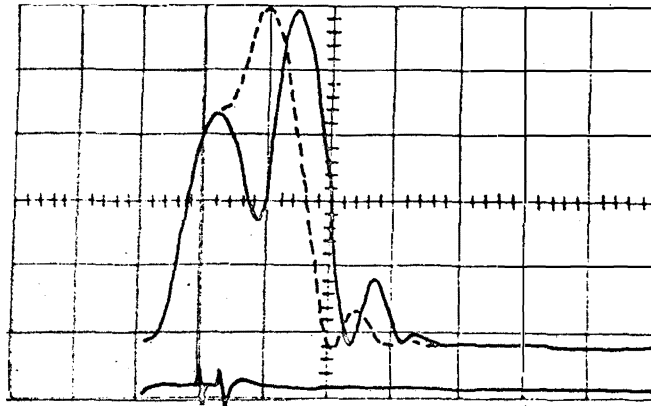


Figure 2. Summation effects (superimposed) from two stimuli 66 ms. (solid line) and 50 ms. (dashed line) after initial stimulus.

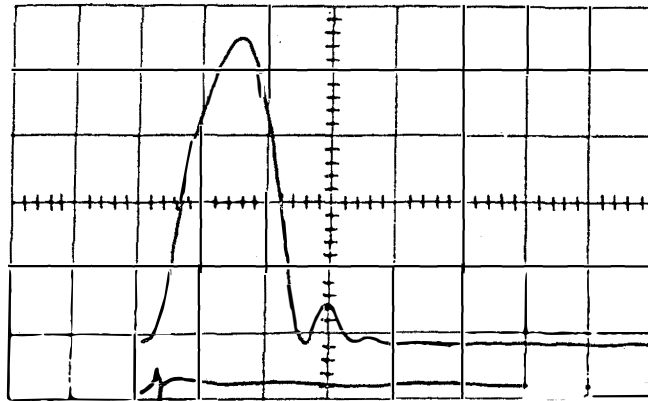


Figure 3. Summation of muscle contraction when second stimulus arrived 20 ms. after the first. Summation occurs before muscle relaxes.

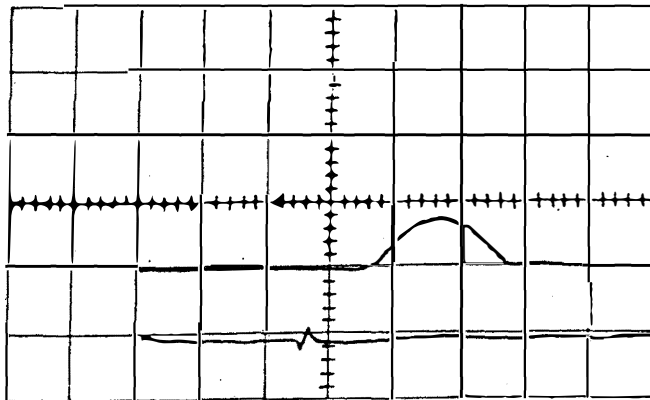


Figure 4. Muscle response to a second subthreshold stimulus at 125 ms. after the first. No visible response to the first subthreshold stimulus.

The summation effect can also be shown by increasing the frequency of continuous pulses, but the delay unit is particularly useful to show this effect with just two stimuli.

By reducing the time interval from 300 to 20 ms., students can see exactly where summation begins and at what point its maximum effect is attained. Thus the delay unit enhances the capabilities of recording equipment at a reasonable cost.

BIO-BYTES

Edward Cawley, Dept. of Biology, Loras College

Microcomputers are here to stay and we are all picking up large problems and small short cuts. Often these are, not important enough for a major article so they may get lost. I decided that a periodic column which would gather these ideas together for the use of the AMCBT members might be useful. I'll supply some, both original and from the literature and pass on any you send me.

"Easy editing on the Apple." or
what the apple manual doesn't tell you.

It is possible to edit anything on the screen display by using the cursor move commands, (escape - followed by I, J, K, M, if your apple has auto start monitor ROM, or esc A, esc B, esc C, esc D if you do not have an autostart ROM) and then the right arrow to copy the screen. The major problems that most people have in this process is to drop the first digit from the line number or include spaces in strings which continue over one line on the screen. There is a simple solution for both of these problems. To prevent dropping the first digit from the line number be sure that you use the cursor commands to place the cursor on the first digit of the line before you use the space bar to get out of the edit mode, the right arrow will then copy the entire statement. To prevent spaces in the copied strings or to save the need to return to the edit mode to return to the left margin, use the immediate command POKE 33, 33 before you list the line you wish to edit. This will set the width of the window to the right edge of the output on the screen. You may then use the right arrow with the repeat key continuously to the end of the statement without inserting spaces into the string. After you are finished editing use a POKE 33, 40 to reset the window. Simple!

Send any tips to: Edward Cawley, Dept. of Biology, Loras College, Dubuque, Iowa 52001

VISICALC

William N. Doemel, Wabash College, Crawfordsville, IN

Visicalc is a "spreadsheet" program designed for microcomputers. Sold by Personal Software Inc., the program is available for a diversity of microcomputers including those made by IBM, DEC, Radio Shack (Tandy Corp.), and Apple. In this article, I will review the versions available for the Apple II and Apple IIe.

Why would a biologist want to purchase a program intended for business?

Business executives use Visicalc for four basic functions: (1) to perform calculations of sets of values; (2) to organize the results so that anyone can understand the data; (3) to store the data so that it can be used in the future; (4) to project future business activity. Biologists have similar needs for data manipulation and storage. We calculate data, make presentations to colleagues, store data, and form hypotheses about future

activities. To accomplish these tasks, many of us use a calculator or write a program in BASIC or PASCAL. Calculators are limited both by their memories and by their inability to generate typed reports. Writing a BASIC program with a suitable file structure to handle the data takes time and requires an understanding of the language. Too often with computer programs, even the most elegant one is a black box in which students enter numbers and retrieve results. They are not exposed to the analysis and the critical assumptions of the computation. Visicalc, on the other hand, is open; anyone can write a Visicalc program after spending one hour with a tutorial. Having entered the results, the user can manipulate the data within the program, print reports or save the data to disks. With a special file structure, the data can be transferred to other programs for statistical analysis or for graphic presentation. I have used Visicalc to prepare spreadsheets for the analysis of C^{14} incorporation, chlorophyll content, bacterial growth, enzyme kinetics, chemical analysis, grade reports, departmental budget, and taxes.

The Visicalc spreadsheet is an array of 63 columns and 254 rows making a matrix of more than 16,000 cells. Each column is indicated by letters, each row by a number. When you boot the Visicalc disk (two disks are used in the Advanced version), a segment of this spreadsheet appears on the screen with the cursor in position A1. Because of the size limits of the screen it is like a window enabling you to see only a small segment of the entire sheet at any time. With the arrow keys (Apple IIe) or the arrow keys and space bar (Apple II), you can move the cursor to any position on the spreadsheet, bringing another segment of the sheet into view.

FIGURE 1: DATA ENTRY

	COL. B	COL. C	COL. D	COL. E	COL. F	COL. G	COL. H	COL. I	COL. J	COL. K	COL. L	COL. M
ROW 7												
ROW 8												
ROW 9												
ROW 10	Depth	liters		412.00	434.00	480	630.00	645.00	654.00	663.00	665.00	412.00
ROW 11	(meters)	filtered		SAMPLE	SAMPLE	SAMPLE	SAMPLE	SAMPLE	SAMPLE	SAMPLE	SAMPLE	SAMPLE
ROW 12												
ROW 13	SAMPLE C	7	0.50	.6837	.7943	.3646	.0916	.1788	.2852	.3757	.3639	.9112
ROW 14	SAMPLE B	7	0.50	.7077	.8158	.3761	.0915	.1794	.2858	.3772	.3654	.9267
ROW 15	SAMPLE A	7	0.50	.6744	.7716	.3504	.0891	.1711	.2726	.3637	.3532	.8677
ROW 16	AVERAGE=	7										
ROW 17		6	3.50	.2541	.2803	.1185	.0264	.0326	.0736	.1279	.1275	.3113

	COL. B	COL. C	COL. D	COL. N	COL. O	COL. P
ROW 7						
ROW 8						
ROW 9						
ROW 10	Depth	liters		434.00	663	665.00
ROW 11	(meters)	filtered		SAMPLE	SAMPLE	SAMPLE
ROW 12						
ROW 13	SAMPLE C	7	0.50	.6902	.2646	.2653
ROW 14	SAMPLE B	7	0.50	.6937	.2659	.2676
ROW 15	SAMPLE A	7	0.50	.6343	.2538	.2564
ROW 16	AVERAGE=	7				
ROW 17		6	3.50	.1926	.088	.0922

Each position on the sheet can hold either a label, a value, or a formula. In the example shown above, I prepared a spreadsheet to calculate the chlorophyll and pheophytin concentration of a lake. Figure 1 shows the first part of the sheet where the raw data are entered. Figure 2 shows the segment of the sheet where the data are calculated. The rows and column labels for the matrix are also displayed. In the calculation segment of the worksheet

FIGURE 2: CALCULATED DATA

ROW 8	COL T	COL. U	COL. V	COL. W	COL. X	COL. Y	COL. Z	COL. AA	COL. AB	COL. AC	COL. AD
ROW 9		MONOCHROMATIC METHOD				TRICHROMATIC METHOD			Plant	Phaeo-	
ROW 10		Depth	Chlor a	Pheo. a	Percent	663/665	Chlor a	Chlor b	Chlor c	Carot.	pigment
ROW 11		(meters)	ug/l	ug/l	Pheo. a	ratio	ug/l	ug/l	ug/l	uSPU/1	ug/l
ROW 12		-----									
ROW 13	SAMPLE C	7	59.02	40.26	40.55	1.42	79.62	38.68	87.92	29.17	46.52
ROW 14	SAMPLE B	7	58.59	41.55	41.49	1.41	79.94	38.82	87.80	30.09	47.80
ROW 15	SAMPLE A	7	57.36	38.59	40.22	1.42	77.17	36.58	86.17	28.03	44.15
ROW 16	AVERAGE=	7	58.32	40.13	40.75	1.41	78.91	38.03	87.30	29.10	46.16
ROW 17		6	2.73	2.20	44.69	1.39	4.05	0.24	4.73	1.35	2.23

each block contains a hidden formula; only the results are displayed. In Figure 3, the formulas for each of the blocks is shown. Notice that instead of numbers references are made to other positions on the spreadsheet. For example, in Cell V17, the formula refers to cells K17, P17, and D17 in the data entry segment of the sheet. Cell F9 refers to a constant. This reveals the power of Visicalc, for this segment enables me to do these calculations on a data entered in the first part of the sheet.

Visicalc also enables you to simplify calculations by using functions. With the function @ SUM (A1...A20) you sum all of the values in positions A1 to A20. Other functions include @ MAX and @ MIN which return the maximum or minimum value from a range of values and @ AVERAGE and @ SQRT which returns the average of a range and the square root of a value. Other functions include natural log, logarithm, sine, cosine, tangent, arctangent, arccosine, arcsine and pi. There are also logical functions, @ IF, @ AND, @ OR, @ NOT, @ TRUE and @ FALSE which enable you to set up logical arguments. For example, @ IF (A1>fB1, 24, C1) means if A1 is greater than B1 then 24 is entered in the cell; however, if A1 is not greater than B1 then the value in cell C1 is entered. These logical functions enable you to use the program to test hypotheses. Two other functions @ LOOKUP and @ CHOOSE also deserve mention for these enable you to enter a table and then lookup values from the table or select values from a range.

There are several versions of Visicalc available for Apple II computers: Visicalc for the Apple II+ with up to 64K of memory, Visicalc for the Apple IIe, and Advanced Visicalc for the Apple IIe equipped with the Extended 80 Column Card (128K of memory) and 2 disk drives. The Advanced Visicalc which was originally introduced for the Apple III has been modified and upgraded for the Apple IIe. The first two versions are primitive when compared to this Advanced Version and other spreadsheet programs that are now available, like Multiplan.

With the Advanced Version several useful capabilities are available. In the older versions, all columns were the same width. With the advanced version, each column width can be adjusted individually. An "attribute" command has been added which enables you to change the format of each cell of the grid. For example, you can have the value displayed as a percentage, as an integer, as a dollar amount, as a label, or with a set number of digits behind the decimal point. You can even hide the contents of a cell. With this version, you can set up a "template" which can be repeatedly used. The template can be constructed to permit value or label entry only at certain positions. Rather than using arrow keys to move the cursor, you can design the template so that the user uses the "TAB" key to move the cursor to the desired positions. This makes the program extremely "user friendly."

FIGURE 3: FORMULAS FOR SAMPLE SPREADSHEET

This shows the FORMULA used to calculate the chlorophylls & phaeophytin

ROW	COL T	COL U	COLUMN V	COLUMN W
ROW 12		Depth	Chlor a	Pheo. a
ROW 13		(meters)	ug/l	ug/l
ROW 14				
ROW 15				
ROW 16				
ROW 17	SAMPLE C	+C17	$((26.73*(K17-P17)*F9)/(D17*1))$	$((26.73*((1.7*(P17))-(K17))*F9)/(D17*1))$
ROW 18	SAMPLE B	+C18	$((26.73*(K18-P18)*F9)/(D18*1))$	$((26.73*((1.7*(P18))-(K18))*F9)/(D18*1))$
ROW 19	SAMPLE A	+C19	$((26.73*(K19-P19)*F9)/(D19*1))$	$((26.73*((1.7*(P19))-(K19))*F9)/(D19*1))$
ROW 20	AVERAGE=	+C20	@AVERAGE(V17...V19	@AVERAGE(W17...W19
ROW 21		+C21	$((26.73*(K21-P21)*F9)/(D21*1))$	$((26.73*((1.7*(P21))-(K21))*F9)/(D21*1))$

ROW	COLUMN X	COLUMN Y	COLUMN Z
ROW 12			
ROW 13	Percent	663/665	Chlor a
ROW 14	Pheo. a	ratio	ug/l
ROW 15			
ROW 16			
ROW 17	$(W17/(V17+W17))*100$	+K17/P17	$((11.6*(K17))-(2.16*(I17))+(.1*(H17))*F9)/(D17*1)$
ROW 18	$(W18/(V18+W18))*100$	+K18/P18	$((11.6*(K18))-(2.16*(I18))+(.1*(H18))*F9)/(D18*1)$
ROW 19	$(W19/(V19+W19))*100$	+K19/P19	$((11.6*(K19))-(2.16*(I19))+(.1*(H19))*F9)/(D19*1)$
ROW 20	@AVERAGE(X17...X19	@AVERAGE(@AVERAGE(Z17...Z19
ROW 21	$(W21/(V21+W21))*100$	+K21/P21	$((11.6*(K21))-(2.16*(I21))+(.1*(H21))*F9)/(D21*1)$

ROW	COLUMN AA
ROW 12	
ROW 13	Chlor b
ROW 14	ug/l
ROW 15	
ROW 16	
ROW 17	$((20.97*(I17))-(3.94*(K17))-(3.66*(H17))*F9)/(D17*1)$
ROW 18	$((20.97*(I18))-(3.94*(K18))-(3.66*(H18))*F9)/(D18*1)$
ROW 19	$((20.97*(I19))-(3.94*(K19))-(3.66*(H19))*F9)/(D19*1)$
ROW 20	@AVERAGE(AA17...AA19
ROW 21	$((20.97*(I21))-(3.94*(K21))-(3.66*(H21))*F9)/(D21*1)$

ROW	COLUMN AB	COLUMN AC
ROW 12		
ROW 13	Chlor c	Plant Carot.
ROW 14	ug/l	uSPU/l
ROW 15		
ROW 16		
ROW 17	$((54.22*(H17))-(14.81*(I17))-(5.53*(K17))*F9)/(D17*1)$	$(4*(G17)*F9)/D17*1$
ROW 18	$((54.22*(H18))-(14.81*(I18))-(5.53*(K18))*F9)/(D18*1)$	$(4*(G18)*F9)/D18*1$
ROW 19	$((54.22*(H19))-(14.81*(I19))-(5.53*(K19))*F9)/(D19*1)$	$(4*(G19)*F9)/D19*1$
ROW 20	@AVERAGE(AB17...AB19	@AVERAGE(AC17...AC19
ROW 21	$((54.22*(H21))-(14.81*(I21))-(5.53*(K21))*F9)/(D21*1)$	$(4*(G21)*F9)/D21*1$

ROW	COLUMN AD
ROW 12	
ROW 13	Phaeo. pigment
ROW 14	ug/l
ROW 15	
ROW 16	
ROW 17	$((26.7*((1.7*(P17))-(L17))*F9)/(D17*1)$
ROW 18	$((26.7*((1.7*(P18))-(L18))*F9)/(D18*1)$
ROW 19	$((26.7*((1.7*(P19))-(L19))*F9)/(D19*1)$
ROW 20	@AVERAGE(AD17...AD19
ROW 21	$((26.7*((1.7*(P21))-(L21))*F9)/(D21*1)$