

MIDWEST BIOSCENE



ASSOCIATION OF MIDWESTERN COLLEGE BIOLOGY TEACHERS Vol. 2 No. 2 November, 1975

HONORARY LIFE MEMBERSHIPS CONFERRED

Members of the association who have been outstanding in their contributions to the association and the profession may be awarded Honorary Life Membership. This honor is conferred by the Steering Committee following nomination by the membership. Four such Honorary Life Memberships have been conferred in the past. Ruth E. McNair, Professor Emerita, Kansas University; Leland P. Johnson, Dean of Liberal Arts and Science, Drake University; Willis Johnson, Professor Emeritus, Wabash College; and J. Bennet Olson, Professor of Biological Science, Purdue University, received the award in previous years. John M. Hamilton and Jack Bennett were nominated and selected to receive the honor this year. Formal presentations were made at the banquet of the 19th Annual Meeting at Terre Haute.

John M. Hamilton is Findlay Professor of Science at Park College, Parkville, MO. He first came to Park in 1946 as Assistant Professor, was named Associate Professor in 1951 and Professor in 1956. He served as acting dean in 1955-56 and in 1964 through 1967.

John received the bachelors degree from Oberlin College in 1935. He holds masters degrees from both Wesleyan University (Conn.) and Yale University. He earned the Ph.D. at the University of Iowa in 1951. He is a member of Sigma Xi.

Dr. Hamilton has several research papers published in Science, The Transactions of the American Microbiological Society and the Proceedings of the Iowa Academy of Science. He has had almost seventy book reviews in The American Biology Teacher. John was a charter member of AMCBT and served as our treasurer from 1960 to 1962. His current biological interest is the evolution and intellectual history of the idea of natural selection.

* Jack Bennett is a Professor of Biology
* at Northern Illinois University. He has
* been at NIU since 1957. Prior to that
* time, he held various positions at
* Washington University and at the
* University of Oklahoma.

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* Jack was awarded the BS from the
* University of Wisconsin in 1949, an MA
* in Zoology from Washington University in
* 1953, the Ph.D. in Genetics-Zoology from
* the University of Wisconsin in 1959. Jack
* is a Fellow of the American Association
* for the Advancement of Science, a member
* of Sigma Xi, Phi Sigma and numerous
* professional organizations. He has
* served as President of AMCBT and the
* Illinois Academy of Science.

*
* He has published widely on his major
* research area, the behaviour and popu-
* lation genetics of Drosophila melanogaster,
* as well as the genetics of other species.
* In addition to his work as a research and
* teaching biologist, Dr. Bennett has also
* been active in working toward the
* improvement of the economic status of
* teachers and the interpretation of
* scientific information for the layman.

RESOLUTIONS CONCERNING EQUALITY OF OPPORTUNITY ADOPTED

Some of the resolutions adopted at the Business Session of the Annual Meeting encourage activity toward implementation on the part of the membership. The work of the Resolutions Committee will remain as no more than words on paper unless individuals take positive action on campuses and in other organizations seeking implementation.

Resolution I - Support for NSTA position regarding women in education.

WHEREAS IT HAS BEEN the aim of the Association of Midwestern College Biology Teachers to encourage members of the biology teaching community to help students regardless of their sex, to achieve their fullest potential;

WHEREAS the science skills and interests of men and women are influenced by:

- a. the manner in which all student-used materials portray men and women involved in science;
- b. their awareness of options available to them in terms of study and careers;
- c. the encouragement and guidance provided by the teacher toward achievement and careers in science;

BE IT RESOLVED that the AMCBT give full support to the NSTA position regarding women in science education.

- "(1) Any teacher whose charge includes the responsibility of evaluating and/or selecting instructional materials should demand that the materials (a) eliminate sex role stereotyping and (b) reflect a realistic female/male ratio, in relation to the total number of people portrayed. . .
- "(2) Science teachers must exert their influence to encourage counselors to treat female students identically to male students relative to career opportunities and program planning. . .
- "(3) Science teachers must consciously strive to overcome the barriers created by society which discourage women from pursuing science for its career opportunities."

BE IT FURTHER RESOLVED that the AMCBT will expend its individual and collective efforts to achieve equality of opportunity for males and females in biological education at the UNDERGRADUATE, GRADUATE, and PROFESSIONAL levels.

Resolution II - Equality at opportunity for all minority groups.

BE IT RESOLVED that the AMCBT will expend its individual and collective efforts to achieve equality of opportunity for all minority groups in biological education at the UNDERGRADUATE, GRADUATE, and PROFESSIONAL levels.

The discrimination practiced in admission to certain professions is well known. Since many of these professions are based in biology, the teachers of biological sciences may be in a unique position to intensify the assault on the exclusiveness practiced.

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RECOMBINANT DNA MOLECULES:
 THE CHALLENGE OF A REVOLUTIONARY TECHNIQUE
*The Evening Address delivered at the
 19th Annual Meeting of AMCBT*

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 Massachusetts General Hospital, Boston, MA 02114

The idea that the new genetic technique of formation of recombinant DNA molecules in vitro represents a revolutionary advance in our ability to manipulate DNA molecules is by now familiar to most of you. Many scientists have been quoted to this effect - but none have captured the essence of it better or more whimsically than Sidney Brenner when he said,

"I would expect this technique to be comparable in impact to the use of radioactive isotopes as tracers in biology... It's going to be very widespread. Simply, it's going to allow us to tackle for the first time problems of the molecular genetics of higher organisms - of anything. Elephants. Sea urchins. It'll make a lot of things obsolete, the possible easier, the impossible possible. It is fully as important as radioactive isotopes - no, probably more profound in the questions it can reach. Why? Because these things self-replicate. You have a way of enhancing yield. You can detect things. You can put together combinations...even biological systems since the dawn of time have not had an opportunity to explore the complete range of combinations now suddenly possible. And, in principle, for any new (configuration) combination we can make the probability - one. One is a very large number in these things. We can put duck (DNA) and orange DNA together - with a probability of one."¹

As a prelude to what I hope will become a dialogue between us on the issues raised by the development of this revolutionary technique, I would first like to review the elements of the technique and some of its current and possible near future uses. Then I would like to review the highlights of the last two years as some of the involved scientists and other concerned individuals struggled to deal with some of the issues raised by the development of this technique. Finally, I would like to discuss with you some of the continuing issues that are currently being raised with respect to the development and application of this technique.

Most of the procedures involved in the formation of recombinant DNA molecules and an indication of its power are indicated in an experiment conducted by John Morrow and his colleagues at Stanford. They recombined DNA from 2 disparate sources, that of the ribosomal DNA from the African clawed frog, Xenopus laevis, and that from a plasmid called PSC101 a small, circular, independently replicating bit of DNA which multiplies in the common intestinal bacterium E. coli. The key which makes this in vitro recombination work is one of a group of enzymes called restriction endonucleases. These enzymes cut both Watson and Crick strands of DNA molecules at points of specific base sequences in such a way that a short single stranded region is left at each end of the cleaved DNA. Because of complementarity of base sequence, these end regions can form hydrogen-bonded associations with the ends of other DNA pieces cut by the same restriction endonuclease, and if the continuity of the DNA strands is restored by adding the enzyme DNA ligase, a covalently closed recombinant DNA molecule is formed. What makes this technique powerful and simple at the same time is the discovery that the bacterium will carry out the ligation as well as replicate

¹Judson, Horace Freeland. "Fearful of Science", Harper's Magazine, June, 1975.

the recombinant DNA species of interest, digest the mixture with the restriction endonuclease, add that digest to specially treated bacteria, and isolate those bacterial species which carry recombinant DNA molecules.

The power of this technique is apparent if you consider that this amphibian DNA can be any DNA, no matter what its origin, which the experimenter is interested in. This is thus a very general technique for cloning out and amplifying (through replication of the recombinant plasmid) specific DNA sequences and it has already been applied in several different types of basic molecular genetic research. It has been used to select and amplify the DNA sequences coding for histones in sea urchins by Drs. Kedes and Cohen at Stanford. It has been used to isolate and determine the chromosomal location of specific DNA sequences in the fruit fly Drosophila by Dr. Hogness' group at Stanford. These current applications of the recombinant DNA molecular techniques indicate that it is a major experimental breakthrough in developing the capacity to unravel the complex genetic organization of eukaryotic cells. This technique also represents a quantum jump upward in our ability to make new, manmade genetic combinations which have never existed before in nature. If effect, the technique overcomes many of the barriers to exchange of genetic information that exist at the cellular and organismic level. It can thus be used to add new specific genetic information to existing genomes, as contrasted with earlier genetic techniques which modify or delete genetic information.

Indications of the range of possible applications of this recombinant DNA molecule technique follow. One possible use of the technique is in transferring the genes for nitrogen fixation, called "nif" here, into common food plants. If this could be accomplished, and there are at least two groups working hard on this project at the present time, it might reduce the need for increasingly expensive fertilizer in agriculture. The recombinant DNA molecule technique might also be used to facilitate approaches to gene therapy for a small number of genetic diseases in individuals who lack gene functions. Without minimizing the technical and ethical problems which such proposals raise, let me sketch how recombinant DNA molecule techniques might facilitate this. The technique could permit the isolation and amplification of the human gene for HGPRTase, the enzyme missing in patients with the Lesch-Nyhan syndrome. One hypothetical solution is reintegrating the human gene segment into human chromosomal DNA via attachment to the DNA tumor virus SV40. Obviously, if this vector is used, there is a risk of integrating oncogenic virus information as well as the desired gene, and thus this may leave a great deal to be desired as a therapeutic treatment. I mention the process, however, because it would be quite possible to develop other vectors, with fewer deleterious side effects, which could be used to transfer new genetic information into human cells. Thus, I believe that recombinant DNA techniques have brought us to the threshold of techniques which will make certain kinds of human genetic alteration technically feasible.

What I have just said indicates the potential for applying recombinant DNA molecule techniques in areas as far apart as agriculture and medicine. The development of the recombinant DNA molecule technique using E. coli as the recipient cell also raised some significant problems even in its use for basic research. Essentially, the problem was whether the process of isolating and cloning pieces of foreign DNA in E. coli would lead to the creation of biologically hazardous organisms. The stages which various groups of scientists went through in handling this problem from the letter from the 1973 Gordon Conference on Nucleic Acids, to the Berg committee moratorium letter, to the Asilomar conference in 1975, have been the subject of articles in Science magazine and various newspapers, so I will not recapitulate those events in details. Let me, however, share some of my thoughts as a participant in that process with you.

My involvement with the recombinant DNA molecule problems started with the April, 1974, meeting at MIT, organized by Professor Paul Berg of Stanford University in response to a request from the National Academy of Sciences. As I recall, Dr. Berg

started by telling the rest of us about recent experimental work in Dr. Stanley Cohen's laboratory at Stanford. I recall being particularly impressed by his report that the process of cloning foreign DNA molecules in E. coli could be made rather simple (and thus presumably quickly widespread) by letting the bacterium do the enzymatic joining required to reseal the ends of the new recombinant DNA molecules. This, and the increasing number of requests for the necessary plasmid and bacterial strains, lent an air of urgency to the discussion. It strengthened several people's inclination, including my own, to urge some action that would slow the process of deploying this technique until more thought could be given to ways of dealing with the potential biohazards. This led to the decision to call for a voluntary moratorium on two particular types of experiments (Antibiotic resistance and oncogenic viruses) and to urge restraint in carrying out a third type ("shot-gun" or cloning bulk DNA). Another strong recollection which I retain from that meeting was our feeling that we needed to broaden the base of consultation with our colleagues--especially important if the voluntary moratorium approach was to be effective. Thus, while the Berg committee letter/report was in draft form it was discussed and debated at both the EMBO Conference on Restriction Enzymes in Belgium in May, 1974, and at the Cold Spring Harbor meeting on Tumor Viruses in early June, 1974. While there were individual scientists at both meetings who expressed skepticism or disagreement with the moratorium approach, the response from the majority of scientists at both meetings was more positive, and the call for a moratorium was subsequently published. Coupled with the call for the moratorium was a recommendation for a continued process of assessment including an international meeting to "review scientific progress in research on recombinant DNA molecules and to discuss appropriate ways to deal with the potential biohazards of this work."

I think it is safe to say that none of the signatories of the moratorium letter completely appreciated all of the effects it would have. Subsequent actions, such as the decision by the MRC in England to make the moratorium mandatory rather than voluntary, and some of the misinterpretations, in newspapers, of what the moratorium was all about were unanticipated. In retrospect, it is also clear that the terms of the moratorium were ambiguous in important respects. Although the overall effect of the moratorium call was to obtain the time required for a more in-depth assessment, it caused some confusion and created some difficulty as a precedent in the areas of technology assessment and science policy.

The moratorium letter of June, 1974, also called for the appointment of an NIH Advisory Committee on Recombinant DNA molecules and for convening an international meeting "to review scientific progress in this area (of recombinant DNA molecule research) and to further discuss appropriate ways to deal with the potential biohazards of recombinant DNA molecules". Although NIH at that time was under considerable pressure to decrease the number of its Advisory Committees for budgetary reasons, it nevertheless announced the decision to appoint an Advisory Committee on Recombinant DNA Molecules in November, 1974. Unfortunately, the process of selecting members of the Advisory Committee was not completed until late January, 1975, and the Advisory Committee was unable to hold its first meeting until after the Asilomar Conference.

In preparation for this Conference, three subcommittees of scientists met to initiate a more detailed assessment of the potential biohazards involved in three different areas of research involving recombinant DNA molecules. Their work formed the basis of the policy endorsed by a near unanimous vote of the approximately 80 American and 40 foreign scientists at the Asilomar meeting. The interim policy of recommended guide-lines which was adopted consisted of several basic premises and conclusions. The first premise was that it is both possible and desirable to classify different types of experiments involving recombinant DNA molecules according to severity of risk. The second premise was that it was both possible and desirable to match the estimated severity of hazard with a corresponding level of containment. Experiments with a high estimated severity of hazard would require a high level of containment

(a combination of physical and biological barriers to prevent escape of genetically altered organisms from the laboratory). A third premise is that it will soon prove possible to construct genetically altered strains of E. coli and the cloning vectors which have a reduced capacity to multiply except under very special laboratory conditions, and that employment of such "safer" strains would appreciably reduce the possibility of any biohazards which might be associated with experiments involving recombinant DNA molecule techniques.

Based upon these premises, a large majority of the scientists attending the Asilomar Conference concluded that a) assessment of potential risk and required containment procedures should be made part of every experiment involving the recombinant DNA molecule techniques, b) much of the research work utilizing construction of recombinant DNA molecules could proceed provided that appropriate containment guidelines were followed, and c) as an interim guide to investigators in the field, a rough classification of different types of experiments according to estimated risk and required level of containment was endorsed. In addition, a proposal was put forward for a peer review of risk assessment and local certification of containment facilities, which would institutionalize and oversee guidelines that the NIH Advisory Committee will eventually recommend.

Before the Asilomar guidelines were even revised to take into consideration changes made during the discussion the last morning of the Conference, the NIH Advisory Committee recommended that the Asilomar policy govern future awarding of NIH grants for research with recombinant DNA molecules. The National Science Foundation is similarly requiring "biohazard impact statements" and assurance that the Asilomar guidelines will be followed from their grantees who are doing recombinant DNA molecule research. Among the reasons for such haste was the difficult position of these research grant agencies, who found it difficult to make decisions about funding research grant applications involving recombinant DNA molecule techniques in the uncertain atmosphere created by the call for a voluntary deferral of certain types of experiments. This rapid and unanticipated action by NIH and NSF has elevated the Asilomar guidelines as published in the June 6, 1975 issue of Science into the current policy governing federally funded research with recombinant DNA molecules in the United States. These guidelines are currently undergoing review and revision by a subcommittee of the NIH Advisory Committee on Recombinant DNA Molecules, where, I have heard, there is some disagreement about how stringent the containment procedures should be for some experiments of the "shot gun" type.

The Asilomar Conference and its resulting guidelines have been criticized by lawyers, for making public policy without the requisite authority and expertise and without sufficient public involvement. To a certain extent this criticism is correct, but only if the Asilomar guidelines are seen as the final word in this area, rather than the first step in an assessment process. Given the rapidly expanding use of these techniques in research, I believe that the Asilomar Conference has no alternative but to devise an interim policy which would guide the increasing number of researchers entering this area, until more comprehensive guidelines are established by appropriate national bodies. It is my hope that legislators and other interested members of the scientific community and the public will focus on the Asilomar guidelines, carefully scrutinize their premises and conclusions and indicate whether they agree or disagree with them. For while the Asilomar guidelines reflect a consensus position among the scientists at that meeting, they need review and either acceptance, modification or rejection by the public and its elected representatives.

Congressional interest in this area is already evident. Assessment of research with recombinant DNA molecule techniques forms part of a December, 1974, report prepared for the Subcommittee on Science, Research and Development of the Committee on Science and Astronautics, U.S. House of Representatives. More recently, the Senate Health Subcommittee held one day of hearings on public policy for recombinant DNA techniques in Washington on April 22, 1975. I believe the scientific community should welcome

this Congressional interest because it will help to ensure that our policy for employment of the recombinant DNA molecule technique will receive the careful scrutiny it deserves. However, I hope legislators will not succumb to the temptations of painting frightening scenarios to the public and rushing to enact overly restrictive legislation. I believe that scientists have an uncompleted educational job to do in explaining the policy endorsed at Asilomar to legislators and other interested members of the public - since I still find considerable misunderstanding exists regarding the meaning of the Asilomar Meeting.

Two other possible applications of the recombinant DNA techniques are their use to facilitate genetic therapy for selected human genetic diseases and to construct new weapons of biological warfare. In the case of gene therapy, recombinant DNA techniques should facilitate the isolation and amplification of specific sequences of human DNA carrying desired genes and the linkage of these human genes to vectors capable to integrating them into chromosomal DNA in human cells.

To some people, these possible applications of recombinant DNA molecule research are a source of concern. Although I share this concern, I believe it is essential that public policies be specifically designed to deal with these issues, and that such policies not be confused with policies adopted to deal with potential biohazards arising from use of recombinant DNA molecule techniques in basic research. In fact, both of these possible applications of recombinant DNA techniques are already under significant mechanisms of social control. In the case of biological warfare weapons, it is perhaps insufficiently appreciated that development of such weapons is now banned by an international treaty, "The Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons," which came into force on March 26, 1975. The United States, the Soviet Union and the United Kingdom are all signatories of this convention, as are over 100 other countries, Article I of this Convention states:

"Each state or party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

- (1) Microbial or other biological agents, or toxins whatever their origin or method of procedure of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;
- (2) Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict."

I see no reason why the use of recombinant DNA techniques for development of new weapons of biological warfare would not be prohibited by this Convention. This example illustrates a way in which it is possible to control possible misapplications of recombinant DNA molecule techniques, without restricting use of the techniques for other purposes.

Similarly, if the possible use of recombinant DNA molecule techniques for facilitating gene therapy is a source of concern, then I believe the appropriate point to debate this issue is before a particular proposed gene therapy is carried out in human patients. There are already extensive guidelines for regulation of human experimentation under existing Department of Health, Education and Welfare Regulations for the Protection of Human Subjects. Application of these regulations will help ensure that the risks and benefits of genetic therapy will be carefully weighed by institu-

tional Human Studies Committees and that such experimental genetic therapy will only be applied after the informed consent of the prospective patient-subjects has been obtained. I believe this system will prevent flagrant abuse of human genetic experimentation during the difficult time ahead when our ability to manipulate human genes may exceed our ability to accurately predict all the consequences of such genetic manipulations.

Attention should be called to what I believe to be a major unexamined issue posed by the recombinant DNA molecule techniques. Is there need for other mechanisms of social control to deal with possible commercial applications of the techniques since commercial organizations do not depend on Federal funding agencies for support?

What I have said, I think indicates that we have made a positive beginning in dealing with the issues posed by the development of the recombinant DNA molecule technique. The difficulties in knowing where to strike the balance between our interest as scientists in maintaining easy and universal access to research tools, and in minimizing the bureaucratization of research, and the safety of the public, continue to be immense. It seems to me that the Asilomar guidelines are a start in the correct direction of a policy which preserves the essence of the freedom to do research, and at the same time takes into consideration the potential biohazards. However, it is absolutely essential that we work for the widest possible examination and understanding of this policy.

I believe that, as biological scientists and teachers of biology, you all have a crucial role to play in the ongoing assessment of the policies governing research using the recombinant DNA molecule technique. First, I hope all of you will carefully examine the premises and conclusions of the Asilomar guidelines and assist your interested students in doing so. Then, ask yourself this question. Do the Asilomar guidelines, if applied in a thoroughgoing manner, constitute an adequate level of protection of the public from the potential biohazards associated with use of the recombinant DNA molecule technique? If you think they do, well and good. If you don't think so, write me your reasons and I will see that they get forwarded to the chairman of the NIH Guidelines Subcommittee for consideration.

If all of us participate in the ongoing process of assessment of the policy governing use and applications of the recombinant DNA molecule technique, then we will have taken a major step toward meeting the challenge which development of this revolutionary method has presented to us.

* * * * *

CAN SOMEONE WHO HATED LABS
BE AN EFFECTIVE TEACHER OF EXPERIMENTAL BIOLOGY?

John R. Jungck, Department of Biology
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As an undergraduate student (late Paleocene) and even as a graduate student (early Eocene) I hated labs. Labs were always in a room which had not been painted for twenty years. They were dark, dusty places, frequently in a windowless basement, usually smelling of formalin, hydrogen sulfide, pyridine, or something equally obnoxious. The equipment available would be very nice for a Museum of Science trying to improve its collection of instruments used by alchemists, Leeuwenhoek, or Harvey. Professors usually were present in the lab only to deliver some esoteric monologue on scientific method, precision, accuracy, or what results were supposed to be obtained. On occasion, they might pass through the lab to comment on how sloppy, clumsy, stupid, or slow I was. But for the most part, once "the professor" left the lab, I was left to suffer through some tedious procedure to get the "right"

results with only a water-spotted, wrinkled set of directions and a graduate teaching assistant trying to do his own studies. I was also forced to compete against the fraternity boys who were able to get the "right" results from fraternity files or one of the teaching assistants who belonged to their fraternity. Thus, while they spent a minimum amount of time in the lab, I was left to compete mostly with girls who all seemed to be neat, agile, smart, and swift. (Please excuse the sophomoric chauvinism.) How was I destined to ever become a science teacher?

Of course, there were the few laboratories that were exceptions. Plant physiology was held in a greenhouse which smelled lovely and had glorious sunshine most of the time. However, the professor's pet subject was firetrucks; so scratch that one. Radioisotope methodology lab, although in the basement, was meticulously clean, with white countertops and with modern equipment; however, "right" answers were still the goal of the day. Genetics lab actually seemed like biology because we had to be there when the fruit flies were ready, not when we were, or during the prescribed three hour weekly session; but even then the lab was in a dark, musty basement.

I was clearly destined to become a theoretician of science rather than one of those pragmatic labcoat wearers.

***BEWARE OF THEORETICIANS!**

*The theoreticians will get
you if you don't watch out!
To us he is anathema
To others just a joke.
Can he really be a biologist,
If he makes no stink nor smoke?*

*We speak of the theoretician,
The doer of bad deeds.
While real biologists lab coats wear,
He lounges in his weeds.*

*Computers work and think for him,
While he sits looking wise.
But all the while he's plotting
The naturalist's demise.*

Perhaps if undergraduates realized the existence of systems ecology, theoretical population genetics, numerical taxonomy, etc, we might not continue to lose the majority of theoreticians to physics, chemistry, and mathematics. However, as circumstances will have it, after doing a mathematical master's thesis, my Ph. D. advisor forced me unwillingly back into the lab. Besides gaining some pride in my own project, I was blessed to meet a postdoc who was incredibly human. He was always jovial, willingly taking considerable time to teach me techniques and discuss experimental design, but most importantly, conveying that it was only worth doing if it was fun!

Although I had long desired to become a teacher, when I took my first position and was assigned two freshmen cookbook general biology labs, it was almost too gruesome to hear. Here were sixty students being subjected to exactly what I had hated. Therefore, I became determined to change our curriculum so they could enjoy lab more and learn much more about what science is actually like.

Initially, I tried to develop the use of a project approach within the confines of the weekly three hour session available. Although many students appreciated this

~~*A minor modification of an anonymous poem appearing in Chemical & Engineering.~~

minimal chance to investigate, they began to ask questions like "What does that piece of equipment do?", "Can we use it?", "Do we have a . . .?", or more importantly "How can I keep my project going when the course is over?"

After two years of considerable debate, my former department made a serious commitment to begin an investigative laboratory. Our investigative lab was scheduled for a solid eight hours on one day and a separate recitation hour in which all four sections could meet. The students received a full three semester credit hours for the lab; there were no formal lectures or quizzes or textbooks, thus, they were able to concentrate on lab and library work. We had the asset of having all of our major equipment, such as refrigerated centrifuges, lyophilizer, culture bath-shaker, Warburg, etc., located in one room which was never scheduled for formal classroom use. Thus, students were able to use the facilities whenever they had the time to work. In order to overcome the problem of not really being able to free a professor's schedule for a solid eight hours, we solicited four seniors to serve as teaching assistants. In preparation for their fall teaching, these seniors read Postman and Weingartner, Teaching as a Subversive Activity; Epstein, A Strategy for Education, and CUEBS publication #33: The Laboratory: A Place to Investigate and discussed them with me over the course of the summer.

At fall registration, all sophomores were required to sign up for a section; however they were free to choose which professor(s) and/or problem they wanted to work for or on. They distributed themselves unevenly. A professor had anywhere from three to thirteen students for the semester. In each section the professor laid out the problem to be attacked. The problems chosen were well within the competence of the individual professor advising a given section. By stipulating the problem initially, the students had two good bases of security. First, they were able to begin library work on a very specific problem. Secondly, they were assured of equipment and personal expertise being available to them. The problems actually studied involved such things as the effect of ultraviolet light on regeneration in planaria, the melanization of blood cells in invertebrates, electrophysiology of turtle hearts, collection and culture of algae and protozoa, DNA:RNA hybridization as indicator of genetic homology, the evolutionary distribution of phosphagens among protozoans, development of a new assay for red tide, a search for neurotransmitters in Hydra, and selection for phototaxis in various strains of Drosophila.

The students were informed that they would be asked:

1. To develop worthwhile hypotheses that could be profitably attacked using the facilities available.
2. To design experiments that would help solve the problem.
3. To perform the experiments accurately; organize and interpret the data.
4. To communicate the results of the research accurately and intelligible both orally and in writing.
5. To evaluate the work of his scientific peers based upon his own knowledge and experience in a particular area of biology. (From CUEBS #33, P. 44)

The students were also given a copy of page 4 of the November, 1972, AMCBT News on behavioral objectives. Recently, we added some affective behavioral objectives to this list (cooperativity, curiosity, honesty, openness, reality orientation, risk-taking, objectivity, precision, perserverance, respect for theoretical structure, neatness).

Rather than going into depth about the types of reactions to the investigative lab, I will only cite a few. For an overall view, I think the reactions were amazingly similar to those reported by Volney Faw (cf. Carl R. Rogers, Freedom to Learn, pp. 47-51). Primarily the students loved the experience or decided to no longer major in biology. Each student was forced to become an active learner. Although aggressive personalities adjusted to active learning easier than others, eventually all of them were able to adjust. Those who liked the course expressed the feeling that it was the best academic experience they had had. Even those who transferred out of biology were happy to find out what biology was actually like before committing too much time to it.

A strong indication of how independent the students became during the investigative lab is demonstrated by two examples. Initially, the faculty had planned to switch sections halfway through the semester; however, the students called a general meeting and insisted that they be able to continue their projects. Secondly, one section, which seemed to be more passive initially than others, absolutely refused at the end of the course to allow one professor, who had not participated sufficiently in the course, to grade their notebook. These examples are very noteworthy in view of the fact that the campus was extraordinarily conservative.

The most important scientific achievements the students encountered were, that they could find errors in the literature, even as sophomores in college. They gained confidence that they could contribute to the literature, and they became skilled in the use of some sophisticated equipment. Individually they also became self-critical in a very positive sense.

Another important reaction to the course was that of the professors, especially the doubting Thomases. There was a unanimous agreement to continue investigative labs and not to revert to cookbook labs. One professor admitted that he had totally underestimated the students; as a matter of fact, he felt they were capable of doing M.S. level research. Our Chairman was motivated to write an equipment assistance grant proposal to NSF based on the investigative lab. Also, the department as a whole felt we actually knew the students better than ever before.

Not to be forgotten in the investigative lab was the important role played by and for the senior teaching assistants. Besides contributing significantly to the teaching of the labs, they felt that they learned much new biology as well as how to teach by the inquiry method and how to get students to "emit" responses. The sophomores also appreciated the senior teaching aides immensely because they were less intimidated to ask frequent questions. Also, many of the sophomores enthusiastically volunteered to become teacher aides in future years.

Another factor about the investigative lab which deserves noting is the physical plant. An important advantage of the investigative lab over the traditional cookbook lab is that only a few students use a piece of equipment at one time. Thus a department can invest more in capital expenditures for a larger diversity of equipment and equipment of research grade. I believe we should rethink the physical plant of most of our labs along more modularized lines; after all, would you design your own research lab to be like the labs you teach in?

In conclusion, if even a former lab hater can enjoy teaching an investigative lab, think of the possibilities!

* * * * *

NEW COROLLARY TO MURPHY'S LAW All lab workers are very familiar with Murphy's First Law, "If something can go wrong, it will!" Recently a new corollary, about the 13th, was discovered. "If something can go wrong, it will, especially if I am doing it!"

CORN COLEOPTILES FOR ASSAY OF GROWTH-PROMOTING SUBSTANCES

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Drake University, Des Moines, IA 50311

With the present interest in weed killers and their roles in pollution, a bioassay organism that is convenient to handle and reasonably sensitive to growth responses might well be used in General Biology laboratories. Being able to grow coleoptiles can give students an opportunity for studying the effects of a variety of substances on coleoptile growth and so give information about compounds which might have either an auxin or an anti-auxin effect.

Golden Bantam Sweet corn has proven a satisfactory seed source, but other varieties of sweet corn are satisfactory for use. An advantage of corn (*Zea*) over oats (*Avena*) is one of size of coleoptile and ease of handling. Oat coleoptiles are very small and the bulky over-lying bracts must be removed before use for growing the coleoptiles.

If the corn grains are coated with a fungicide, wash it off. Captan often is used in this way. Wash the corn repeatedly until the bulk of the fungicide has been removed, taking care not to get the wash water on cuts on the hand. Do not carelessly rub your eyes as this washwater smarts.

After the seeds have been washed to remove most of the fungicide, soak in water at room temperature over-night. The next day, prepare the seeds for germination as follows: Obtain a supply of gallon mayonnaise jars (or any other wide-mouthed jars), some aluminum foil for a cover, and some folded brown paper towels about 9½" wide. Soak a folded paper towel until it is very wet, lay the towel on some suitable support, and place each of about 10 corn kernels on the towel in a row. These grains should be placed in the middle of the towel, with the points of the kernels toward you. Upon germination, the shoot with its coleoptile and inner leaves tightly rolled up will grow away from the point of the kernel and the primary root will grow toward the point of the kernel. (Be sure to emphasize this to students when they prepare these packages, otherwise they will get an unwanted demonstration of geotropism!) The kernels should be spaced about an inch apart. After the kernels have been placed on the towel - beginning at one end, roll the towel and seeds into a package. The wet paper will hold the edge when the cylinder is completely rolled up. Put about a ¼ inch layer of water in the wide-mouthed jar and - remembering which end is up - place the cylinder in the jar with the pointed end of the grains toward the bottom of the jar. Repeat this process, making packages enough so that there will be adequate supplies of coleoptiles. You can expect to get perhaps 50% usable coleoptiles from each package. When the packaging is complete, cover the jar with aluminum foil, place the jar in the dark and leave it there for four days. During this time the corn embryos will sprout and grow. The shoot system will contain the coleoptile with the rolled-up underlying leaves having a yellow color. This yellow color will aid the student in determining the length of the ensheathing coleoptile.

The coleoptile segments for use in the bio-assay should have a length of at least 6 mm. and 10 mm. probably is not too long. A 10 mm. segment can be handled reasonably easily and it can be measured fairly accurately. The safest way to prepare a cutter is to use two stove bolts and some washers. Get two double-edged razor blades. Place a washer against the base of each bolt, and then place the razor blade on the bolts. Next, depending on the length of the cutter, place several washers on the bolt. Then, place the other razor blade over all the washers. Lastly, place another washer on the razor blade and then screw the nut onto the whole assembly quite tightly. It might be well to cover one edge of each blade with something like adhesive tape so that the student will not cut himself when making the cuts on the corn shoots. A pair of razor blades can be worked into a large cork at the

determined distances apart, but this, I feel, is not a very satisfactory cutter - besides it is a dangerous thing to prepare!

Petri dishes are satisfactory containers for the test solutions. They hold 20 ml. of solution easily. While the corn shoots are growing, the student can determine the design of the experiment. A stock solution of Indole-3-Acetic acid (IAA) is prepared by dissolving 0.175 grams IAA (Molecular weight is 175.19) in about 3 ml. of Isopropyl (or ethyl) alcohol as a co-solvent in a 100 ml. volumetric flask. Bring the flask up to volume with distilled water. This should make a $1 \times 10^{-2}M$ solution of IAA. There should also be a 1% sucrose solution as a carbohydrate supply for the elongating coleoptiles. Use a stock solution of 10% sucrose. Have the students determine the volume of IAA and sucrose to add, and water for a final volume of 20 ml. in each Petri dish. In determining concentrations of IAA to each Petri dish, the corn coleoptile responds about like the oat (*Avena*) coleoptile. Maximum elongation will occur at a IAA concentration of about $5 \times 10^{-5}M$.

When the corn shoots have grown such that the coleoptiles have reached a length which is adequate (this should be about the 4th day after the packages have been prepared), have the students prepare the necessary Petri dishes with their various treatments and a sucrose only control. Each Petri dish contains a final volume of 20 ml. It may be well to assign symbols to each Petri dish and record this in a notebook, so that when measurements are made, the measurer sees only a symbol on the dish and is thus less biased in measuring.

Keep the wide-mouthed jars in the dark until the solutions are prepared. Only then, and working in dim light if this is available, bring the jars out. Unroll the packages and using the coleoptile cutter, cut a segment from the upper portion of each coleoptile, making the cut about 1 mm. or so from the tip. It is important that the tip be removed as this is a site of auxin synthesis. It might be advisable to pool all sections and place them in the various treatments at random. This one refinement one can try, or the segments can be placed in the several Petri dishes as soon as they are cut.

How many segments should be put in each Petri dish? Probably 15 segments in each treatment should give statistically significant results. You might have your students determine this for themselves.

The segments float on the surface of the solution, and sometimes they grow on the surface in contact with the solution faster than the upper surfaces and become curved! Sometimes they will float and become attached end-to-end. These things you can talk about in "experimental error". As soon as the cut segments have been placed in the Petri dishes, put them in a dark place for 24 hours.

It is necessary to know how the coleoptile is cutting, so have the students make more cuts from the remaining material and then, using a plastic 6" ruler, measure the length of each segment as accurately as possible. If they can estimate to the nearest 0.5 mm. then have them do so. Of course, any other suitable measuring device may be used. This data should give some indication of the length of a segment at the start of the experiment.

After a 24 hour period, bring the dishes out and measure each segment in all treatments, recording the data in an appropriate way. Determine the average length of the coleoptile in each treatment and plot the data to show the results obtained. There will be some problem of measuring when the segments are not straight; this often happens. One can even do some sort of statistical analysis of this data if your students are so inclined. This treatment can give the student some idea of the variations within a set of measurements.

When your students have learned the technique of handling the corn coleoptiles there are many modifications that can be done. The materials needed are readily available, and the only problem in this is the timing of growing the coleoptiles. The packaging is somewhat time consuming, but this experiment seems to fit into a 5-day regime quite well. This is an experiment that works.

* * * * *

W H O K N O W S ?

*Correspondence concerning these items
should be addressed to the individual*

GLADYS ROBINSON, 7920 South LaFayette, Chicago, IL 60620, requests assistance from the membership. In her retirement she is working on a project involving the sketching of flower parts by reflected light. She has been unable to locate a *camera lucida*. She is willing to purchase or borrow one. According to her, none of the supply houses or microscope agencies have any available. Many of our member schools must have one of these stuck away in a cabinet.

GLEN J. KILPATRICK, Director LURIO, Lincoln University, Jefferson City, MO 65101, has requested information from the Association concerning guidelines for award of student credit hours and determination of faculty load in laboratory courses. His letter follows:

"Lincoln University is presently reevaluating its system of awarding student credit hours for natural science courses and also its "system" of assigning teacher loads for the faculty in the areas of the natural sciences. Our office has been assigned the task of determining if associations such as yours have any suggested guidelines related to these two questions.

"Generally, as far as student credit hours are concerned, a course worth four credits is broken down into three hours lecture credit and one hour laboratory credit, or two hours lecture credit and two hours laboratory credit. As far as we can determine, this formula has merely been accepted because "its always been this way." Could you advise us of any alternatives of this formula or at least a justification for this one.

"With regards to the question of faculty loading, a teacher in the area of natural science here at Lincoln has the same course load as a faculty member in any other area, there are no allowances made for laboratory preparation or laboratory hours. We're not sure if this is equitable or even an accepted norm."

This is an area of concern to all of us. Looking at the load that Lincoln University faculty carry, with no allowance for lab hours or preparation, it is apparent that they need some assistance in the form of input. If your institution has a standard, equilibrating laboratory hours, please send the appropriate information to Dr. Kilpatrick. Also send a copy to the Central Office of AMCBT. It would appear that this might well be an area where the Association could prepare some general guidelines. The Executive Secretary will collect the information submitted and organize it for consideration by the membership.

SYMPOSIUM: ENERGY, FOOD AND THE QUALITY OF LIFE January 8-10, 1976 at Indiana University. Topics: Nutrition and the Food Shortage; Nuclear Power, Pro and Con; Optimal Use of Land; Solar Energy; Genetic Engineering; Population in Tomorrow's World; Demonstration of Energy - Environment Simulator. Write Walter A. Cory, Coordinator for School Science, Indiana University, Bloomington, IN 47401, for details.

ASSOCIATION OF MIDWESTERN COLLEGE BIOLOGY TEACHERS

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. . . and some biologists receive \$50,000 grants to study cloning!

POSITIONS

Reply to the position number in care of AMCBT Central Office. Service is free to members. Others may use the service for a fee of \$1.00 per line of copy for each issue.

WANTED 7601 GENERAL BIOLOGIST Master's degree, 7 yrs teaching experience, sec., coll., and continuing ed. Interested in: biology for the non-major, science and human values, interdisciplinary science, methods, anatomy and physiology. Presently on temp. appt.

7602 SUMMER 1976, GENERAL BIOLOGIST Doctorate equivalent, 20+ years coll. teaching. Interested in biology for the non-major, science and society, methods, physiology. Experience includes industrial research, development of teaching materials, workshop direction.

SPECIAL GREETINGS The following mailgram was received by the Association at the Annual Meeting. "Please give my greetings to all - with a special hello to old friends. I am sure your meeting will be a profitable one - the program sounds very interesting. Next year at this time in Iowa I hope to be celebrating with you. With best wishes until 1976." Signed/Ruth E. McNair

WE'LL SHARE

Correspondence concerning these items should be addressed to the individual

BIBLIOGRAPHY AVAILABLE A bibliography of books and other instructional materials prepared especially for the biology major, covering topics in mathematics, chemistry, and physics, was distributed at the Annual Meeting. Members wishing a copy can secure one from the Central Office.

AMCBT AUTHORS As a special feature at the Bidecennial meeting at Drake, a display of book and manual publications and other instructional materials authored by AMCBT members has been suggested. Ask your publisher to send a copy of your work to the AMCBT Central Office. Please include privately published laboratory manuals and similar items. The sheer bulk of journal articles published by the membership would seem to preclude our even making a list of these. A bibliography of member publications will be prepared and the collected works displayed at the meeting. Share your efforts with the membership.

Part of the pleasure of discovery consists in the perception of new similarities and differences, contradictions, and intellectual difficulties; the acquisition of new intellectual and individual power by the reduction of the unknown to the known. Part also consists in the suitability of the occupation to the individual; the pleasures of activity, of pursuit, of anticipation, of success; the charm of mystery, and the excitement of uncertainty as to what will come next; and the anticipated value of the final result... The great and primary sources of error are the imperfect action and limited extent of all our powers, and especially that of the intellect. In order to avoid error and arrive at truth, all our lower powers require to be regulated and corrected by the higher ones; the bodily powers by the senses, the senses by perception and attention by comparison, and comparison by reason and inference... To believe we know that which, on account of its uncertainty or of our finite powers, we cannot know, is a greater error than to remain ignorant, because it misleads us; and the proper name for such a state of mind is conceited ignorance.

20th ANNUAL MEETING - AMCBT BIDECEENNIAL

DRAKE UNIVERSITY

DES MOINES, IOWA

OCTOBER 1-2, 1976

INPUT NEEDED FOR PROGRAM AND BUSINESS The Steering Committee will meet January 17, 1976. Plans for the Bidecennial Meeting will be the major item of business. Almost all other Association business is also handled at this winter meeting. Suggestions and concerns may be communicated to the appropriate committee or to any officer or member at large. Committee Chairpersons and addresses are given in the Directory elsewhere in this issue. Input from the membership regarding the content of the program, nominations for office, resolutions and suggestions for honorary membership are particularly requested by the respective Committee Chairpersons.

PUBLICATION DATES Copy for MIDWEST BIOSCENE should be submitted according to the following schedule: May issue by April 10, September issue by July 10, November issue by October 10, February issue by January 10. In addition to articles, remember that notes regarding positions, requests for information, information which will be shared, letters to the Editor are all desired. Formal articles may concern reviews of special areas, new programs, workable laboratory experiments, teaching techniques, etc. Only you, the contributing member, can make the publication of value to the membership.

SIGN UP A COLLEAGUE TODAY The membership campaign initiated last spring has brought in many new members from almost every state. Help to keep our association viable. New members, joining now, will be added to the membership role immediately, but their dues will be applied to the year beginning July 1, 1976. Help them take advantage of this bargain.

-----Detach Here-----

Application for Membership
ASSOCIATION OF MIDWESTERN COLLEGE BIOLOGY TEACHERS

Regular Member (\$6.00) Retired Member (\$3.00) New Renewal
Dues payable July 1

Name _____ Date _____

Title _____ Department _____

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