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DIMENSIONS OF CHANGE IN HIGHER EDUCATION, CONFERENCE ON INNOVATION (3D, BARD COLLEGE, ANNANDALE-ON-HUDSON, NEW YORK, JANUARY 25-28, 1967). CONFERENCE SUMMARY.

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UNION FOR RES. AND EXPERIMENTATION IN HIGHER EDUC.

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REPORTED ARE THE PROCEEDINGS OF THE THIRD IN A SERIES OF FOUR CONFERENCES ON INNOVATION IN HIGHER EDUCATION. HELD AT BARD COLLEGE ON JANUARY 25-28, 1967, THE CONFERENCE INVOLVED REPRESENTATIVES FROM TEN COLLEGES. THE LECTURES AND PANEL DISCUSSIONS DEALT WITH THE TOPICS (1) SCIENCE AS A HUMAN ENTERPRISE, (2) THE TEACHING OF SCIENCE IN LABORATORIES AND CLASSROOMS, (3) THE PREDICTION OF SCIENTIFIC TALENT, (4) A NEW APPROACH--THE INTEGRATION OF SCIENCE THROUGH ECOLOGY, (5) FACULTY COLLABORATION IN SCIENCE INSTRUCTION, AND (6) NEW APPROACHES TO THE LOGISTICS OF STAFFING AND "STUDENTING" SCIENCE. ALSO REPORTED WERE THE PROCEEDINGS OF WORKSHOPS IN THE AREAS OF (1) INDEPENDENT, EXPERIMENTAL WORK FOR FRESHMEN IN SCIENCE, (2) SCIENCE MAJORS IN A SMALL COLLEGE WITHIN A LARGE UNIVERSITY, (3) DEVELOPING A SCIENCE COURSE FOR NON-MAJORS WHICH HAS SCIENTIFIC AND HUMANISTIC VALIDITY, AND (4) WHERE AND HOW TO START BEGINNING STUDENTS TO BETTER MEET THEIR INDIVIDUAL NEEDS AND DESIRES. THE TITLES OF THE OTHER CONFERENCES OF THIS SERIES LISTED IN THEIR CHRONOLOGICAL ORDER ARE (1) "DIMENSIONS OF CHANGE IN HIGHER EDUCATION," (2) "NEW PATTERNS IN THE LIBERAL ARTS COLLEGES," AND (3) "CLIMATES OF LEARNING AND THE INNOVATIVE PROCESS." A LIST OF PARTICIPANTS AND THEIR ADDRESSES IS INCLUDED. (DS)

3

innovation in the teaching of science

The Union for Research and Experimentation in Higher Education is a group of ten colleges that have joined to foster research and experimentation in higher education. It seeks to influence programs of undergraduate education both within and outside of the Union colleges. Member colleges are Antioch, Bard, Goddard, Hofstra University, Monteith of Wayne State University, Nasson, Northeastern Illinois State, Sarah Lawrence, Shimer, and Stephens Colleges. Headquarters for the Union is at Antioch College, Yellow Springs, Ohio.

TABLE OF CONTENTS

Conference Summary

DIMENSIONS OF CHANGE IN HIGHER EDUCATION

The Third Conference on Innovation, held January 25-28, 1967, at Bard College, under the auspices of the Union for Research and Experimentation in Higher Education.

Conference Reporter and Editor, Lawrence C. Porter, Antioch College

EDITOR'S NOTE

The addresses, panel discussions, and workshops herein reported have been edited in what might be called "third-person summary" form, to present a relatively brief account of the proceedings while retaining some of their flavor through the inclusion of direct quotation.

Full versions of any of these documents may be obtained by writing Dr. Samuel Baskin, President, Union for Research and Experimentation in Higher Education, Antioch College, Yellow Springs, Ohio, 45387.

INTRODUCTION

The Bard Conference, "Innovation in the Teaching of Science," held January 25-28, 1967, is the third in a series of four conferences on innovation in higher education. The other meetings were:

"Dimensions of Change in Higher Education," 19-23, 1966, Magnolia Manor, Massachusetts.

"New Patterns in the Liberal Arts Colleges," December 1-4, 1966, Loretto Heights College, Winter Park, Colorado.

"Climates of Learning and the Innovative Process," April 26-29, 1967, Shimer College and Chestnut Mountain Lodge, Illinois.

These conferences, funded by the United States Office of Education, were held under the auspices of the Union for Research and Experimentation in Higher Education, a consortium of ten colleges drawn together by a dedication to research and experimentation as ways of bringing much needed enrichment, excitement, and relevance to American higher education.

The hope and expectation is that these conferences will produce ideas and activities which will strengthen Union colleges (Antioch, Bard, Goddard, Hofstra, Illinois Teachers-North, Monteith, Nasson, Sarah Lawrence, Shimer, Stephens), but which will also suggest new ways and new programs of teaching and learning to colleges and universities across the country.

Samuel Baskin
President, Union for
Research and Experimentation
in Higher Education

SCIENCE AS A HUMAN ENTERPRISE

Albert Szent-Gyorgyi*

Szent-Gyorgyi opened his address by suggesting that humans are born with unprogrammed computers (central nervous systems) and that "the aim of education is to program our computer to play a fair game of life." This is especially difficult today, for the scientific revolution has created a complex world in which it is not clear what the programming should be.

One way of clarifying things is to examine them from "the elevation of natural history," which indicates that man's brain is his most important weapon for survival. This leads us to wonder what the brain was made to do, and when we admit that man's brain has not changed significantly in the past ten thousand years, we conclude that it was made not for today's life, but for a much more primitive one. If this is true, then the brain's chief function has to do with survival, not with the search for any truths other than the short range ones which enable man to stay alive.

Similarly, Szent-Gyorgyi suggested, our senses are not made to reveal "the real nature of things" so much as to conceal it--to protect us from the dizzying fact that a chair, say, is "a queer-shaped vacuum, with here and there a particle with electrons buzzing around it." Modern science, however, has revealed the real nature of things. If we examine such things as temperature, force, speed, and distance, we discover that we are able to handle them at levels which were familiar and important to early man. But when we begin talking about the H-bomb's 15,000,000 degrees, or its capacity to destroy cities in seconds; or when we realize that science has reduced distance in ways that make Viet Nam seem very close (and therefore much less what it might once have been: a war against outlanders whom we can kill without conscience)--when we are forced to

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*Albert Szent-Gyorgyi is Director, Muscle Research Institute, Woods Hole Oceanographic Institution.

think about these things with our primitively-geared minds and senses, we are quite helpless. "All this makes an entirely new world which demands a new mentality and political structure, and it is you who have to program for this world the living computers entrusted to your care." Fortunately, Szent-Gyorgyi said, we do not have to decide the kind of world we are programming for; we need only try to insure that we "inculcate into the computor those basic qualities which will enable it to establish a correct scale of values, and make the correct choices." One important instrument for doing this is the teaching of history; but a real history, not a false one: "the fascinating story of the rise of man from his animal status to his present elevation," a history which includes a number of heroes "who created new knowledge, new moral or ethical values, or new beauty." Such heroes are much more important than those about whom we are usually taught--the men who have torn down and destroyed--generals, kings, dictators, etc. History which emphasizes the destroyers (which, Szent-Gyorgyi noted, was the kind he was taught) is negative, and also--in that it usually omits "the lice, rats, malnutrition, and epidemics which had more to do with the course of things than generals and kings" --it is false. Since our values are "the result of the creative people of all ages, races, creeds, colors," we should teach the truthful history which would instill "the feeling of human solidarity, on which our survival depends."

Szent-Gyorgyi next discussed the so-called "two-culture" theory, indicating that the idea is nonsense since there can be only one culture. He began by theorizing that the full human being has a knowledge of past and present, an ability to think intelligently and to enjoy the intellectual and artistic beauty created by man. The sum of such knowledge is humanism, and since it is clear that science is illuminating problems concerning man's surroundings and his own nature, it is equally clear that "science has become a part of humanities, meaning by science a basic grasp of the nature of life and the structure of this universe." Science must be taught as "the greatest event of human history," but we must also admit and analyze the "enormous dangers it has exposed man to." Its most essential aspect is the scientific mentality: "clear, honest, straight, objective." Only in the spirit of such a respect for truth can we hope "to find and establish the social and national relations which make survival possible.."

Next, Szent-Gyorgyi remarked on sex, from nature's point of view important as a way of transmitting life, but socially extremely complicated, "balancing human life on the razor's edge between happiness and misery." Despite this, we teach our students very little about it, and maintain--in the face of scientific effects on sex ("the pill," penicillin, etc.)--an "outdated shallow medieval morality."

Szent-Gyorgyi closed with a series of comments on teaching (students spend relatively little time in school, and so our function is not to stuff them with knowledge, but to "whet their appetite for knowledge, teach them the pleasure of learning, knowing, discovering, understanding, creating"); books (they have the knowledge in them, are useful in sparing our minds for something better than memorization--for thinking and creating); the need for protecting children's minds from early damage, such as that created by teaching such things as "the childish biblic folklore"; and the aims of education, (to produce men who "can think and walk straight" in both private and public capacities so that the country "will be run by the people themselves, capable of carrying all their great historical responsibility, creating the right sort of world").

THE TEACHING OF SCIENCE IN LABORATORIES AND CLASSROOMS

John King*

(What follows is King's own summary of the substance of the Conference. A fuller report appears in the American Journal of Physics, Vol. 34, No. 11, November, 1966, 1058-1062.)

A student at M.I.T. attends lectures recitations, and labs, but he should also spend some time in a group working with one or two faculty members continuously on one subject for a number of weeks. Lectures by faculty and students, seminars, individual discussion, lab and library work, prescribed remedial work, reading and reports on reading, viewing movies, visiting research labs, problems for homework, tests would occupy students and faculty all the live-long day. A certain amount of interviewing and planning would be needed in advance to decide on topics to be considered. One would strive with minimal rigidity for a variety of goals including satisfactory exam work.

One faculty member working full time with sixteen students for a three or four week session each term (the rest of his time being fully applicable to research) would mean that considering sophomores and juniors in physics (256 students?) one would need sixteen professors out of an effective sixty or so. One also needs four good seminar rooms, lab space, and services (teaching assistants, graders, and technicians).

The advantages of this system are less fragmentation of time and effort, demanding and capitalizing on the ability to concentrate, tailoring drill and exercises to students' needs, faculty commitment - no saving bells, a more realistic personal and professional atmosphere (getting to know you).

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*John King is Professor of Physics and Director of "Project Laboratory," M.I.T.

The disadvantages are the cost, the fact that many _like_ fragmented time and effort (everyone is necessarily used to it), the steamy personal problems, forgetting other subjects.

Perhaps there are good precedents that would help to answer the only important question: would students gain more from concentrated study than from spending the same time in the usual way? From our experience with project labs, I would say that such concentrated study would be of great value, and I for one would like to try doing it.

If it can be established that such a system is workable and of value to students (perhaps compensating for the high cost by more use of mechanical teaching aids and other impersonal devices) it might be possible to attract able and dynamic research men to a small college for a few months of concentrated teaching each year, the remainder of their year being devoted to research elsewhere. Such a floating faculty might have a stimulating effect out of all proportion to the time they spend teaching, though there are obvious difficulties.

PANEL

A LOOK AT SCIENCE AS STUDENTS SEE IT

Chairman: Adolph Anderson, Dean, New College at Hofstra University. Student participants: Jeffrey Levy, Thomas Myers--Bard; Brenda Eckert, Betsy Selfo--Sarah Lawrence; Daniel Brady, Peter Constanteles--Hofstra. Faculty participant, Albert Stewart--Dean and Professor of Physics, Antioch.

The chairman noted that after their discussions during the day, the participants had thought it might be more appropriate to call their discussion "A Look at the Learning of Science as Students See it from their Own Experience." The first three major speakers were science majors, the last three non-majors.

Jeffrey Levy began by wondering what he had really expected when he went to college knowing that he would be a science major. Probably, he hadn't really known what he expected--perhaps the conventionalized view of the scientist, "in the lab coat with the frothing liquid on the desk." He hadn't thought that he would learn to think in science, nor that there would be as much opportunity for creativity. "I can safely say that the reason I am in science now is far different than the reason I entered science."

Brenda Eckert cited her experience in a course in the history of the philosophy of science, and wondered if there could not be a bridging of the science and the non-science major by having a course taught by a philosopher and a scientist: "I think science itself has to start developing a philosophy;" something more than the scientific method--something like greater communication between philosophy and science. As to creativity, in her own experience in being allowed to pursue (in independent study) a question perhaps too difficult for her, she picked up basic data and at the same time had the feeling that people in, say, drama or dance must have. Science is more likely to be creative if students are not forced to do experiments everybody has done before.

Don Brady thought that although the science major is expected to become a good scientist and also a kind of Renaissance man, the course load in the sciences made it very difficult to take courses in other areas.

Also, Brady thought it very important for non-science students "to know more about science in a world that more and more depends on science."

Peter Constantelis raised the issue of courses for the non-science major who wants to develop a balanced knowledge of his world. Most non-science people seem to be afraid of science courses as something too detailed or too specific, with the details too often irrelevant to their needs. It was his feeling that science courses for the non-major should be generalized, should involve the philosophy and history of science as well as a little work in each of the major areas of science.

Thomas Myers also talked about the course for the non-major, wishing for a course that would integrate in the sense of looking at what science is and what it is doing today in terms of current research rather than of its history, etc. He expressed concern over the "funny feeling of a lot of evil men up to a lot of no good who are eventually going to 'get' all non-science majors." It would be interesting if non-major courses would include some things that the scientists don't know, some things that scientists are now trying to find out about. In addition, he too raised the issue of creativity in science, expressing interest in the degree to which it was similar to artistic creativity. Certainly, he thought, there was much room for greater contemporaneity in the study of science by non-majors.

Betsy Selfo noted that her interest was in scientific writing and that this might allow her to serve as the "bridge" that others had mentioned. She did not believe that science had to be "distilled for the layman." One important fact she wished to emphasize was that science "gives you the ability to find an answer and it suddenly opens up a realm of at least 50 more questions," a very frustrating but rewarding fact. What teachers should be handing students is not detailed knowledge of formulas, but "a frightening education, a frightening desire to know more."

Following these brief presentations, there was discussion between the participants and then between participants and audience.

PANEL

THE PREDICTION OF SCIENTIFIC TALENT

Chairman, Michael Rosenthal, Chemistry, Bard.
Panelists: Philip Harvey, Director, National Program for Graduate School Selection, Educational Testing Service; Hugh Templeton, Chief, Bureau of Science Education, New York State Education Department; Courtney Wemyss, Biology, Hofstra.

After Mike Rosenthal's opening comments, Hugh Templeton spoke, describing how New York State's Regents Examinations are prepared, and how they are used to determine science achievement. They are prepared by teachers in the various subjects, using material pre-tested with high school students; these tests are then "challenged" by various "elder statesmen" in education (principals, superintendents, etc.) who had once taught the subjects, with weak questions being thrown out.

Students do not have to take the Regents Examination; it is taken by those who wish a New York State Regents Diploma with a science major. Templeton was not certain about the correlation between the examinations and predictions of scientific talent, but he indicated that there was a very high correlation between success in the examinations and success in college. A combination of the Regents Examination with SAT would be best, he said, but of <u>single</u> indicators, the Regents Examination is the <u>best</u>.

The Examinations, he said, do have weaknesses, but these are outweighed by their benefits. Though such examinations might appear to inhibit experimentation in the schools, such is not the case; any school wanting to experiment with a course may do so by clearing with the appropriate offices, in which case the experimenters may submit their own examination, which will give Regents credit.

Next, Philip Harvey noted that Educational Testing Service has for years attempted to help fellowship sponsors and graduate schools predict scientific talent, but one basic problem is that ETS is not really sure what it is trying to predict. It is very hard to establish a scientific description of what is meant by "scientific talent." To this problem he added the fact that the examinations may operate in self-fulfilling ways: "You select the people to participate in your program, then you try to decide on the basis of what you use to predict with whether or not the people have been successful."

Thus, despite the fact that such examinations as the GRE have a fair degree of success in predicting doctoral attainment in graduate education, the correlations are quite low, and it should be possible to account for the variance that appears. Among other things, the factors involved would include motivation, perseverance, financial assistance, creativity; but there are still other variables not accounted for--difficult to measure, especially given the increased concern over invasion of privacy.

Harvey then discussed the GRE, composed of an Aptitude test (verbal and quantitative) and an Achievement test (about 21 tests in fields of study): how they are written, by whom, how scales are developed. He mentioned that in the past year a Graduate Record Examination Board has been formed, made up of representatives from member schools in the Council of Graduate Schools of the United States. This board is responsible for the test development of the GRE and will be responsible for describing the kinds of tests that will be used in this program--an important step, because ETS is thus giving graduate schools the responsibility for determining the kinds of tests to be given. This will lead to changes in the examination, particularly in the high level scientific field, in engineering, in aptitude testing.

At present, Harvey reported, ETS considers it essential to "get at some aspect of creativity," and is exploring all the ramifications of this area--including use of a technique now being used at the undergraduate level, an independent activity questionnaire.

Courtney Wemyss then raised some doubts, pointing out that the fact that the examinations (both Regents and ETS) are guarded leads to "a morbid interest in the anatomy of the examination before it is given" (in one instance leading to the hiring of a professional second-story man to steal an examination). Also, instructors are too likely to "teach for the examination."

There had been cases of this in schools at which he had taught, and some of his graduate students teach "a thing they call Regents Biology." Third, it is doubtful that it is at all possible to predict ability as a working scientist. Finally, he believes that the questions are often so childish that he is not impressed by any senior who places very much below the 97th percentile.

Harvey responded that such criticisms were often made, but that one had to remember that the examinations are designed by experts in the field, and that such criticisms (of necessity without having a copy of the test at hand) could be construed as a criticism of the field if one said the questions were trivial.

Michael Rosenthal then asked whether the questions on the GRE possessed a kind of trickiness (created by the very nature of the exam--that the respondent must make choices, sometimes "wrong" choices) and whether the way in which the respondent dealt with the questions had any relationship to the method used by the working scientist. Most science teachers give partial credit, say for choosing correct equations and procedures, though the answer (under examination pressures) may be wrong. The examination seems to offer no such "redeeming grace." What Rosenthal wondered, is the rationale for such a procedure?

Wemyss then said that he had submitted 25 questions for a preliminary National Board test students at his school took. Two years later he was on the committee making up the examination. The committee had a vast pool of questions and he asked of those dealing with his particular section, "What vicious depraved beast dared submit such things?' They were his own questions. He also found it interesting that faculty members submitting questions were asked to indicate the correct answer, "so as to avoid disputes among colleagues."

Templeton noted that people who made examinations such a way ought to be criticized, but that the Regents Examinations were in the hands of the public the day they were given, so that people could examine them and object to anything they don't like. The fact that his office receives fewer complaints than it used to suggests that they may be learning. As to teaching for the examination, "The teacher who teaches for the Regents Examination for more than three weeks should be fired and so should his supervisor." (Wemyss--"You would have a labor problem.")

Templeton suggested that when hiring 100,000 people one didn't get all top-flight people, and New York no more has satisfactory teachers in every classroom than colleges do. The kind of criticism that seems most appropriate to him is that made by the teacher whose comment was that if his kids couldn't handle the Regents examination he had hardly started. Furthermore, these examinations are not dreamed up by some "weird-o;" they are pre-tested and worked over. "If you want to see some miserable examinations, scoop up some teacher-written examinations, be it high school or college and you will see some things that will make you shudder." He suggested that it might be very helpful if professors at teachers colleges would do what he does--teach in the public schools as a substitute a few days a year. He then offered to send old Regents papers to anyone who wanted them, noting that certain universities are requesting large numbers of them. (This has been going on for some 25 years in science.)

Paul Harvey responded to the earlier question about multiple choice tests by noting that even though colleges have the chance to test and evaluate a person over a four-year period by means of various devices, they are in a poorer position to predict graduate school grades than if they used the results of the GRE. The devices used by college teachers are much more subjective and unreliable, and ETS examinations are relatively free of the flaws ascribed to them in earlier comments. Certainly it is possible to build multiple choice questions which require knowledge, not a kind of "logic," to produce correct answers. This kind of examination is the best for evaluating large numbers of people across the world. Essay-type evaluations are important, but more for what they indicate about the person's ability to write and respond to essay-type questions; they do not provide the most accurate prediction of scientific talent.

Questions were then invited from the audience and some time was devoted to discussion.

A NEW APPROACH:

THE INTEGRATION OF SCIENCE THROUGH ECOLOGY

Helmut Buechner, Frank Egler,
Harry Van Deusen

1. The Office of Ecology at the Smithsonian Institution, Helmut Buechner, Head, Ecology Program, Smithsonian Institution.

In his opening remarks, Buechner pointed out that science has created a world in which it may be disastrous to think as we did thirty years ago: we are even now confronted by two threats to life on our planet: the Bomb or the fouling of our nest. With regard to the latter, he cited Kenneth Boulding's comparison of the earth to a space-ship, moving through space with all the supplies we need, but in finite amounts. Such a view, Buechner contended, leads to a new environmental awareness; "it means that ecologists or environmental ecologists have a big job right now." But we have too few people who are oriented ecologically, let alone trained along broad lines which cut across disciplines and, indeed, across cultures.

Buechner then described the program in ecology at the Smithsonian Institution and expressed the hope that the Smithsonian could (as a "private government related institution") act as coordinator and as a catalyst which can bring about a system that will produce the new breed of ecologists that we need and also bring to society's attention ways of handling immediate problems.

Among other things, the Smithsonian now, through its new foreign currency program, can pursue various kinds of research in countries where foreign currencies have been declared excess. Such funds make it possible for the Smithsonian to develop "a more complete history of man's environmental relationships as a basis for understanding his current behavior in various regional ecosystems," to develop programs to "study the structure and functions of natural ecosystems," and to move ahead in various other studies having to do with the ecosystems approach.

In addition, the Smithsonian is presently engaged in the terrestrial conservation program of the International Biological Program, inventorying and describing various aspects of "ecological benchmarks" (national parks, wilderness areas, small nature preserves, etc.) set aside for scientific research. Also, it hopes to enhance the success of the IBP through the Smithsonian training program, which will provide the young people necessary to the operation.

Buechner then described other Smithsonian activities which are related to ecological study, among these the Chesapeake Bay Center for Field Biology, a consortium with the Johns Hopkins University and the University of Maryland, the Smithsonian Tropical Research Institute in the Canal Zone.

The overall goal of the Smithsonian Program in Ecology, Buechner said, is "to contribute toward the cultural evolution of human societies in harmonious relationships within man's ecosystems," and the program "is focused on shaping fundamental principles and concepts in a new science of humanized ecosystems." This new science requires broadly oriented and carefully trained scholars; it will evolve first in free, innovative academic atmospheres; it will involve an integration of the humanities and the behavioral and natural sciences; thus, at the same time that it offers hope for "harmonious environmental relationship," it also provides a point of scholarly synthesis.

In closing, Buechner said that the Smithsonian Office of Ecology "would welcome an opportunity to join in a consortium with the Union for Research and Experimentation in Higher Education and the White Memorial Foundation with the objective of developing an undergraduate program oriented around man and his total environment."

II. Ecology, the One Science: Its Conceptual Basis, Frank Egler, Director, Aton Forest Eco-Systems Research Station.

Dr. Egler began with four introductory thoughts: 1) of the three major communication forms in our culture (education, advertising, public relations), education is "the simplest, most naive, and most ineffective;" 2) the term "science education of, by, for man" contains at least three assumptions: that the basic idea of science is that we can understand ourselves and the world, that education is "good," and that man in calling himself homo sapiens assumes this arrogant title only on the basis of his "short-term ability to over-breed and to pollute his environment;" 3) innovation itself is assumed to be good, whereas it is likely to be so only when it operates between the two extremes of conservatism and iconoclasm; and 4) it would appear that the future of the earth is dependent upon the development of a new science, techology, and methodology (the last because we cannot "experiment" without one earth; "If we unduly modify it, or accidentally destroy it, it is, simply, The End").

This last thought, Egler said, was based on the fact that "our increasing technologic cleverness in dealing with parts, not with wholes," has led us to over-population, increasing waste per person, increasing pollution of our resources, increased crowding, increased "uglification." If man is indeed "sapient," he will prove it by developing this new science.

The remainder of the talk into three sections:

A. Developments from Classical Biology.

Egler began by surveying briefly the movement in this country of biological study--from organism-oriented to, presently, Molecular Biology (concerned with smaller components of organisms) and Environmental Biologies and Sciences (dealing with larger "wholes"), the latter now struggling for recognition. This division, Egler pointed out, was formalized in 1963 with the publication of three texts in high school biology under the BSCS program, one of these an ecology-oriented version. But in the universities, where the emphasis is more on research than on teaching, the ecologists have been dominated by the molecular biologists, whose approach leads to "ever-more-effective grantsmanship." Given this fact, Egler looks to the small liberal arts colleges "to point the way that the large universities will some day follow."

B. The Levels of Integration.

Under the dominant unifying concept of evolution, biologists (since mid-19th century) have been concerned with species and their evolutionary status, and because of this have been uninterested in the concept of Levels of Integration (which "says no more than that the whole is greater than the sum of the parts"), sister to the idea of "emergent evolution," which "looks for the evolution of new emergent qualities when parts combine in nature to form wholes." Now, however, there is a greater tendency to "look upon the world as wholes within wholes within wholes, without the sharp boundaries that separate one man from another."

Egler then went on to describe nine levels of integration and indicate the disciplines which deal with them: 1. subatomic (physics); 2. atomic (physics, chemistry); 3. molecular (chemistry, bio-chemistry, molecular biology); 4. cellular (cytology); 5. multicellular (traditional biology); 6. population (ecology); 7. communities (vegetation science, phytosociology, ecology in general); 8. ecosystem--larger than the community--an "operable unit in the world about us, like a lake" (ecosystem science); 9. the human ecosystem--"the idea that man-and-his-total-environment form one whole in nature that can be, should be, and will be studied in its totality" (human ecosystem science, not yet really in existence).

A human ecosystem science is important, Egler said, because of our habit of doing things first and then watching "the grim results" unfold over the years. Among examples of this are atmosphere-soiling bombs, insecticides, various elements which dirty our air and water. "The chief goal of a Human Ecosystem Science is a knowledge of, and a humanitarian-oriented technology towards, a permanent balance between man and his total environment--both operating as part of a single whole--that will afford a life of the highest quality." By adding man to ecosystem science, "we bring into orbit, as part of one and the same 'system,' all the man-centered fields of knowledge, not only medicine and law, political science and economics, psychology and sociology, but even the arts and humanities."

C. The Points of View.

Beginning with the assumption that specific subject matter at any Level of Integration be represented by a hexagonal pyramid (a model of which he showed the audience) and using biology as a case history, Egler indicated six ways (Points of View) in which "our knowledge, our understanding, our management engineering or technology tends to segregate itself" (though he was careful to indicate that these do not always remain distinct): 1. composition (of what is it made?); 2. morphology (what is its size and shape?); 3. function (what does it do?); 4. spatial properties (where is it?); 5. temporal properties (when was it? when will it be?); 6. environment (what is outside it?). (This last use of the word ecology, Egler pointed out, "as a point of view towards a subject matter rather than as a subject matter itself," has much to recommend it. But in America, ecology has been tied to the 7th Level of Integration, biocommunities, and taught in biology departments.)

The base of the pyramid, left to last, was now shown. It represented a seventh question: "How is it classified?" Classification, Egler said, is of absolute importance in science, and can be based on any of the six faces (Points of View) of the pyramid.

In conclusion, Dr. Egler looked to the liberal arts colleges as "the most promising single site for integrative interdepartmental and interdisciplinary innovations in the teaching of science," though even here unusual flexibility, breadth of view, and unselfishness will be needed. It was for this reason that he was "tossing the idea" at the Union colleges. He closed with a pessimistic note: that our Western Judeo-Christian heritage "pivots on the assumption that first man was created, then nature was created to serve man and to be exploited by man" so that our basic philosophy is "nature for man" and "man against nature." Given this, it may be that an all-embracing ecosystem technology will develop in the East, where man lives and operates with nature, recognizing and accepting with patience its limitations and its destructiveness.

III. The White Memorial Foundation's Institute for Man and the Total Environment, Harry Van Deusen, Science Program Director, White Memorial Foundation.

Van Deusen pointed out that Buechner had indicated the need for an improvement in the quality of the environment, Egler had established an intellectual frame within which such an improvement might be brought about, and it was his function to discuss the activities and aims of the White Memorial Foundation, "which has been created to implement these integrating ideas on a local regional level." To meet the challenges which confront us, the White Memorial Foundation, in cooperation with the Smithsonian Institution's Office of Ecology, has established the Institute for Man and the Total Environment, focusing on the theme of ecosystem ecology, with three main spheres of interest: research, education, communication. In research, the Institute will offer fellowships and assistantships to promote effort at the higher levels of biological and sociological integration, with special attention to developing a scientific foundation for harmonious adjustments between human societies and the environments in which they live." In education, it will attempt "to develop inter-institutional, interdisciplinary programs of liberal education, using the human ecosystem as a point of synthesis." This will include summer institutes for facult teacher-student workshops, undergraduate researc and seminars. In communications, the Institute will publish ecological study papers, news releases, journal and magazine articles, and an educational TV series, and will "strive to make available the sources of sound information and guidance for the benefit of government, conservation organizations, schools, and private citizen groups."

Van Deusen mentioned four additional fields of operation in which the Institute will use its resources:

1. To discover basic factors and mechanisms involved in human ecology and relate them so as to make "visible general principles that can be followed to bring about a favorable human environmental relationship."

2. To ask what will be the psychological and dehumanizing effects of a general deterioration of environmental quality.

3. To discover when and under what conditions we can hope to see population "stabilized in reasonable adjustment with environment."

4. To ascertain what is a favorable human ecology.

Mr. Van Deusen then described the setting of the White Memorial Foundation, which offers varied terrain and a complexity of sites--4000 acres of woodland and Bantam Lake shore front in Litchfield and Morris, Connecticut. The principles which guide the foundation are conservation, recreation, education, and research, and Van Deusen gave examples of each of these in operation. Given the Foundation's physical resources and the philosophy which guides it, it seems natural, he said, that a consortium should be formed between it and the Smithsonian's Office of Ecology.

FACULTY COLLABORATION IN SCIENCE INSTRUCTION

Edwards Lambe*

In his opening comments, the speaker wondered whether we should be on the side of innovation. By innovation Lambe would mean "major new inventions of certain kinds," and one reason one might not be on the side of innovation, say in science teaching, is that it is simply too expensive. Up to this point in the conference he had heard no one attempt to estimate realistically the cost of innovation in science education, but all indicators suggest that the cost is very, very great. Since society must bear the cost, one must know why it is being done, for how long, etc.

Lambe then looked at where innovation might be found in the instructional process and what in fact is being done that is innovational, and attempted to assess its impact:

1. From the point of view of the student: here we mean innovation in the fundamentals of how one presents things for the student to learn. At the college level, almost none of this is going on. Such things as bookkeeping details constrain innovation, especially at large campuses. Credits, grades, the calendar, etc. are enormous barriers and unless we acquire cheaper bookkeeping procedures, really innovative instruction is a good distance off.

2. In the area of teaching and teachers: individual teachers of courses "innovate" all the time; that is, their presentations are normally refreshed and changed in point of view. But this is not what Lambe means by innovation. He means "a radical reorientation toward the teacher's material every time he presents it." This is not likely to happen, because we are all too busy and it is time-saving to follow the old paths.

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3. In subject and form for the material dealt with: this area has been the main focus of agencies which work in innovation, and it is here that we have some impression of what it costs. In college physics there have been four or five major projects to innovate--mainly in introductory courses. At Cal Tech the cost was two full years of a professor's time. At Berkeley and MIT the cost is probably a million dollars each in human effort and broad support.

Though this may be discouraging, it was Lambe's opinion that the job can be done if resources can be found with which to do it. But the cost is so substantial as to make careful planning necessary, and no one should assume that federal funding will escalate to meet these needs.

Lambe then described an experience which grew out of the problem of designing physics material suitable for non-science majors. The approach was not to say "We will write the materials for a stated curriculum," because no one knew what the appropriate design is. Instead they got 30-40 very able physicists and said "invent--do what you want, but it should be new and directed to this particular audience." This was in 1965 and Lambe went on to describe some of the products which have developed since that time: some 12-14 monographs, which in themselves present little that is new, but there apparently is no way of getting physicists to produce really new approaches for a body of students who don't expect to take physics. But, Lambe said, there were some new things, among them an optics lab designed to be presented by a computer, so that at the end the student had only to take the examination, though he could get help along the way. Lambe used it and found it worked rather well with freshmen. Also, a number of films were designed and made on the computer, but these probably had more interest for physicists than for non-science students.

In addition, working groups of physicists and graphic designers and film-makers were formed. Lambe had one of their products with him, a film done by a well-known movie maker, Philip Stapp, who made it to show some of the aspects of symmetry.

(This film was then shown. Lambe cited its cost as $5,000.00 a minute.)

The problem of innovation in instruction, Lambe continued, is enormously difficult. Certainly innovation is greatly needed, but there are few persons (in this case physicists and artists) who can do it well, even if they are able to work together, even if we have the money (which we haven't). However discouraging this may be, we must continue to try, and one way would be to get teams of the sort needed established in our universities--people "dedicated to the idea that research and development is an enterprise which the universities do by themselves, in an organized way, utilizing some 10% of their active, operative resources." Lambe saw some signs that this was happening --at SUNY, for example, and also at Florida State and in the educational laboratories being established across the country by the Office of Education.

"I've been more pessimistic than I should be about instant innovation, but this is because I think innovation is so important and so rare. I would urge people carefully to consider what must be thought through before this can be a successful venture."

Lambe's presentation was followed by a question-and-answer period.

PANEL

NEW APPROACHES TO THE LOGISTICS OF STAFFING AND 'STUDENTING' SCIENCE

Participants: Jeffrey J. W. Baker, Commission on Undergraduate Education in the Biological Sciences; Peter Buri, Chairman, Division of Natural Sciences, New College, Sarasota, Florida; Albert Stewart, Dean and Professor of Physics, Antioch (for the Great Lakes Association).

Stewart opened by summarizing the results of research (given in a series of charts he handed out, "Baccalaureate Origins of Doctorates in the Sciences") intended to "discover how a number of liberal arts colleges were doing as undergraduate sources of doctorates in the sciences." This analysis compared the baccalaureate origins of doctorates in five groups of liberal arts colleges with those of the ten universities which are the leading sources of undergraduates who earn the Ph.D. Among the findings was that the liberal arts colleges as a whole "have increased their contribution to science doctorates by a greater percentage than their undergraduate enrollments," while in the universities enrollments have risen faster than the number of undergraduates who go on to the Ph.D.

Stewart went on to say that it seemed to him that the direction in which many colleges (the Union colleges, e.g.) are moving is toward increasing initiative in science students, so as to enable them to have important experiences themselves; using students in teaching others; creating ways for students to have experiences which would place them in a better position to select ways of spending their time in science; and finding some way of altering the departmental structure as a way of determining certain aspects of teaching, while retaining it as a way for faculty to identify. One way to deal with the last point, might be to associate liberal arts college faculties with universities, where the discipline aspect is strong; perhaps John King's suggestion would be useful here, Stewart thought: concentrated teaching followed by affiliation elsewhere.

In the Great Lakes College Association there is some activity in programmed instruction; one such project, in organic chemistry, has been quite widely used in the Association. Also, an intern program in biology and chemistry has been developed for young Ph.D.'s who want to test their teaching in a small liberal arts college.

Jeffrey J. W. Baker gave a brief description of what CUEBS is and does, and then gave some impressions of the conference. He found it interesting because of the number of comments with which he disagreed and of those by which he had been disappointed. He was particularly disappointed by one reaction to the film shown by Edwarde Lambe--the horror expressed as its $5,000-per-minute cost. Is not the film's cost redeemed by what its effect was? Or this conference: was it worth the money? Certainly.

Peter Buri wondered whether small colleges could offer a sufficient program in the sciences. The staffing problem, he felt, could be dealt with by careful selection. One way of meeting the problem of wide offerings by a small staff would be, when hiring, to diminish the influence of departments operating as separate entities--instead stressing that it be a cooperative venture involving all members of all departments. With regard to students, Buri said that small liberal arts colleges attract able students and have a responsibility to them--to provide, among other things, pre-professional training. If colleges cannot do so, then they should stop trying to attract such students.

A question-and-answer period followed.

WORKSHOPS

Each of the four Workshops met for four hours and a general session of an hour-and-a-half was devoted to their reports. Each Workshop led out of one institution's work as a case study.

(The first three reports are presented in full, as rendered by their respective reporters. The fourth has been edited to reduce its length.)

#1 Independent, experimental work for freshmen in science. Sarah Lawrence: Jewel Cobb, Melissa Richter.

I. Philosophy - Mechanism for personal involvement in the "doing" and "thinking" of science.

II. Implementation -

1. Case study of such freshmen (meaning the first year in the subject) biology courses as taught at Sarah Lawrence.

Allow the student to ask her own questions. The first semester is organized by the teacher and includes principles and laboratory techniques in broad areas. The second semester involves planning, discussion, execution and evaluation of an independent lab experiment. Emphasis is on method, and negative results are irrelevant. It may or may not be original work. The teacher guides the choice of work, based on practical concerns (space, time, and equipment) and the ability of the student.

Value of such independent study: it rewards the bright, oriented student and often excites the mediocre student. A prerequisite for success in this program is not a particular level of previous exposure to science but an ability to work step by step as the experiment proceeds. End of case study.

Have specialists in given biology areas work with these students during the experimental period. Released faculty time for these student projects. Have students select from a group of topics that are best handled by the particular faculty member and with the available equipment. Use of dormitory room as a physical setting for the lab experiment. Use of seniors as adjunct teachers in independent scientific study. Use of nearby graduate school students as adjunct teachers. Observation that students help each other (animal injection procedures) and indeed often learn most from each other.

III. Selection:

A. Students can be given the choice of continuing formal course presentations or the independent experimental work. Otherwise there are no special criteria.

B. Faculty must want to teach this way and often fall into two groups: those who are traditionalists and those who will find the idea exciting. There are also personality factors to consider. Some science teachers like or dislike the close personal relationship needed. How the administration feels about this is also important.

IV. Drawbacks:

Costly to the college budget due to space, equipment and faculty necessary.

Getting enough faculty (possessing the needed diverse knowledge) who want to teach this way.

Fear on the part of students of "failure."

Omission of certain subjects due to time factor.

The burden of independent experimental operation is placed strongly on the student.

It requires that the student use a new way of problem solving, one that requires weeks, rather than ten minutes, to reach an answer. Failure in an experiment, if not handled properly, can be traumatic.

V. Miscellaneous observations:

Students should be warned what to expect in graduate school before they get there.

The method of independent experimentation is used in the Social Sciences at Monteith. Also the choice is offered to students at Nasson.

Still to be worked out are the mechanics of extrapolation to a large college population.

#2 Curriculum and concentration for science majors in a small college within a large university. New College, Hofstra: Efrem Rosen, Azelle Waltcher.

New College of Hofstra provided the case study for this workshop's subject. Before going into anything else, the educational philosophy on which the curriculum of New College is based was presented. The philosophy is basically to present the best possible liberal arts background possible to everyone.

After this, the group then went into the nature of the curriculum at New College. First to be explained was the prescribed general program to be taken by everyone at New College, including problem sessions and discussion groups. Then there was a description of the concentration program in Natural Science. It was explained by the representatives of New College that there was an emphasis in mathematics, physics, chemistry, or biology, with a research program and a senior thesis hoped for in the third and final year.

In the progress of the workshop several potential liabilities and specific problems came to the surface. Two particular problems were recurrent: integrating with and satisfying the requirements of the university and satisfying graduate school requirements.

The first problem seems to become one because of a resentment within a large university of a small college. Rancor can develop and breakdown in communications take place at times. The credit system is almost useless at New College, but this is insisted on by the university, as is the giving of grades: both the administration and the graduate schools seem to want it. Problems often develop because in order to offer students at New College a good choice of courses it becomes necessary at times for them to take courses on the regular campus. The issue of these students having to have certain specific prerequisites can cause problems in that an adequate course equivalency is very difficult to estimate. This can make it difficult for students to take the course they'd like or they need to finish at New College.

The second basic problem, that of meeting graduate school requirements, was also very important. This brought up the very basic question of whether the New College program offered enough to the science student: was the science concentration offered enough for the good science student? were the many courses in the humanities given at the expense of an adequate science program? An actual answer as to how New College students in science will fare with graduate schools must wait, since the first graduating class isn't until next June and there are almost no science students at present. It is hoped that graduate schools will accept New College students with natural science degrees (with specialization in mathematics or science) on the basis of their own individual qualities.

During the course of the workshop many people joined in the discussion. Regarding the heavy stress on liberal arts with only concentrations in a science, it was said that, "The science program is inadequate," and "You're anti-science." It was also said that because of the nature of the program, "You won't attract the good science student." Some praise was given, such as, "You are the 'in' group." As to the problems between New College and Hofstra's regular campus, some comments were, "You're going to have to have freedom," and, "You have to fight." The one statement that summed up everything, however, was, "I would like to take something about your group back to my school." This, after all, was the whole reason for the workshops. Perhaps if other schools attempt something like New College they will at least be ready to handle then some of the problems that the New College experience showed them could develop.

#3 The development of a science course for non-majors with scientific and humanistic validity. Bard College: Richard Clarke, Peter Skiff.

Initially a presentation of Bard College Natural Science course was given by Dr. Skiff and Dr. Clarke.

Following this the group set forth six questions to which they might address themselves -

a. Why require science? What is the object of science? Does the same object hold for non-majors?

b. What is the relevance of content (subject matter) in a course for non-science majors?

c. What is the relevance of laboratory sessions?

d. How does one make contact with students?

e. What mathematics and chemistry is needed?

f. Empiricism?

Discussion followed in random fashion, relating to overlapping questions and non-related questions with equal rapidity. The summary which follows is a synthesis of the discussion and not of necessity an answer to a question posed.

Objective of science for non-science major:

To expose students to phenomena of the discipline;

To show the relevance of science in world: approaching the universe with a certain fluidity or plasticity--persistent in taking structures lightly;

To achieve scientific literacy: what is science, what are scientists like? what are the roots of science?

Scientists sometimes fall into the same trap as the historians, who sell their courses as background for everything else. The paradigm approach can resolve this for non-science majors: "Can get into everything using anything" Example: Using the brain as paradigm can lead into physiology, electron transport, etc.; or using the paradigm of a scientist--one carefully chosen biography. (The Search, C.P. Snow suggested.) Objection to paradigm approach was raised in consideration of the failure of the case study approach made popular by Conant at Harvard.

Relevance of laboratory: Premise from which the discussion worked: "Science is like what is done in the laboratory." Unless one goes into the laboratory, one has no concept of what a scientist is or does. Objection raised: "Non-science majors do not have sufficient motivation to profit by laboratory experience." But it was pointed out that they can see the phenomena and be engaged in data-analysis and experimental design.

Objection to an approach differing for science and non-science major:

1. It is incongruous that in the mid-half of 20th century there be such a timid approach to science - Course differentiation results in a humanistic training of the scientist but not of a scientific orientation for the humanist.

2. In a course balanced between history, philosophy and science subject matter the teacher is not displaying his own discipline to advantage.

The objections were overruled. It was still thought valid to have such a course for non-science majors although the science major could well profit from course. Bard plans to make this course the basis for scientific literacy for both science and non-science majors.

Mathematics in Natural Science: "Can one eliminate the quantitative aspect and have a suitable course? Does this aspect alienate students?" Solution - Teach mathematics properly so that the students could come into physics knowing mathematics as a language. Teach some college algebra, logic, linear programming, game theory, probability. The idea of probability is inherent in the nature of science. Present the idea of mathematics as a study of internally controlled conceptual systems, which can be used as models to be tested empirically by science itself. This gives a picture of the existing world, allows for making science relevant. Science work for a general student should be concerned about generalizing--ideas--finding the relevance of science to life situations

Role of "interest" in the development of science courses: Students become interested in science by seeing how it relates to their area of study. When a teacher tells students what they should know, the teacher is unrealistic, since he does not have real knowledge of the world himself. Should he allow students to pick and choose as interest dictates? Any need for rigor? Let the student determine need for rigor and seek it out when the time comes and the need arises? In the biological aspect of the natural science school, rigor in reasoning is shown particularly in the paradigm in genetics - the development in depth of its ideas.

The session ended with general comments and questions:

Outlining a course on paper does not insure that the student is learning something.

How much wheel-spinning is necessary before learning and acquisition of knowledge begins?

Do any colleges have specialization first and common knowledge later?

#4 "Flexible access" and starting students "in the middle of things." Antioch: Albert Stewart, Oliver Loud.

1. The Freshman Program at Antioch. Members of the Antioch faculty spoke about the new first year program, which has replaced the level one general education requirements at Antioch, giving freshmen freedom to do what they want to do. As a result of the program, level one general education courses have ceased to exist as prerequisites, and the endeavor now is to get departments to define prerequisites functionally. There is difference of opinion about the program's effect on potential science majors, but it seems clear that, given the option, students are spending less time with faculty than before, while independent study and library use have increased.

One discussant wondered why the program had not been designed for the senior year. Another asked how many students were able to meet the responsibility of self-direction. Was Antioch losing more students than before? Still another felt that freshmen were getting "a real break" because they got something different than what they had had in high school.

In response to the question, "What made you decide on this kind of program," Antioch faculty members responded that it was a number of things: to meet student needs and desires; to move students further along in autonomy, motivation, and self-discipline in learning. The Antioch student said that one of the advantages of the new system is that "fellows who would do nothing under the old system are still doing nothing, but they are beginning to ask themselves, 'Why am I doing nothing?' This gets pretty scary."

Are students happy when the cuffs are put back on them in the sophomore year?--Some students go Antioch Abroad, others want more independent study. There is considerable pressure from this group to extend the freedom of the freshman program to the second year.

Opposition to the program was characterized by the Antioch faculty members as rising from those departments which tend to define success in terms of "exposure." The program has "cut deeply into educational issues," among these the role of the faculty member vs. the student. Many see advantages, and some faculty members have found satisfying changes in themselves as a result of the chaos of the freshman year.

2. Starting in the Middle of Things. The discussion then turned to the abolition of prerequisites, which students dislike and can often see no reason for. One Antioch faculty member said that prerequisites have frequently been overrated, and that, losing interest in giving a watered-down chemistry course for non-majors, he decided to give some advanced work to students who had no preparation. He thought that he had succeeded. Instead of going down line after line he started from a center and branched out--beginning, say, with proteins. In courses for majors they are going to try to put organic chemistry I, II, and III together and team teach it so that students can find their own level.

Another Antioch faculty member noted that he is giving an electronics course for science and liberal arts students as well as engineering students. There are no prerequisites. Instead of the expected 16 students there were 30 last year and this year there are two sections, 57 in the science-liberal-arts section and 17 in the engineering section. They are doing well with the elctronics lab units. The two sections are not really different--the level of the course is not being dropped for liberal arts people.

To the question, "Is the first year program's validity mainly dependent on Antioch's high admission standards?" the Antioch student responded that it would seem that what makes the program possible is rather the faculty and students who are already at Antioch when the freshmen come in--the atmosphere for learning which exists.

The difficulty of starting a new experimental college from within a mother-institution was mentioned, the conclusion being that all educational innovation is met eventually by a counter-attack from the old guard. But even if the old guard wins, the institution which engaged in experimentation cannot ever "go home again." And, too, other institutions could take up the innovation from the point where the first faltered.

At the end of the session a recommendation was made that each Union college should send to Sam Baskin's office a brief annotated list of study guides, program materials and syllabi that were developed in new science courses. On this list should be indicated where these materials could be obtained. Baskin's office could then make these available to member colleges.

3. Oak Ridge College, etc. Most of this session was devoted to Sumner Hayward's presentation of the plans for the College of Oak Ridge. The aim of this college is to educate socially concerned scientists, humanists, and social scientists who understand what technology is doing in the world. Some unusual features: using some undeveloped area as a minor subject, the student to spend a semester there; a four-week January "term" between the two regular semesters, when students would learn about a critical world problem; a foreign field term, but also a domestic field term (in Appalachia). Stress is on first-hand exploration, followed by questions as to how science and technology can be used to solve problems.

Other participants mentioned the possibility of using Latin America and urban centers as experiential areas. It was pointed out that the Oak Ridge Laboratory would be used in a co-op program.

The distinctive quality of Oak Ridge College was mentioned and there was some discussion of the need for such a quality to justify establishing new colleges and, indeed, to survive.

The session closed with the recommendation that each Union college should select a liaison person to whom people at Antioch could write as the Sloan program develops, as a way of keeping all schools informed and perhaps linked to the program in some way.

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