DOCUMENT RESUME

ED 164 360 SE 026 556

AUTHOR Abraham, Michael R., Ed.; Fox, Fred W., Ed.
TITLE 1979 AETS Yearbook - Science Education/Society: A Guide to Interaction and Influence.
INSTITUTION Association for the Education of Teachers in Science.; ERIC Information Analysis Center for Science, Mathematics, and Environmental Education, Columbus, Ohio.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
PUB DATE Nov 78
NOTE 346p.
AVAILABLE FROM Information Reference Center (ERIC/IRC), The Ohio State University, 1200 Chambers Rd., 3rd Floor, Columbus, Ohio 43212 ($7.50 nonmembers, $4.25 members)

EDRS PRICE MF-$0.83 HC-$18.07 Plus Postage.
DESCRIPTORS Attitudes; Career Education; *Curriculum; Drug Education; Elementary Secondary Education; Environmental Education; Instruction; Science Course Improvement Project; *Science Education; Scientific Enterprise; *Teacher Education; *Technology; *Values
IDENTIFIERS Astrology; Creationism

ABSTRACT

The sixth yearbook of the Association for the Education of Teachers in Science (AETS) is focused on some of the issues and problems that face science teachers. The publication is divided into three parts with part I containing discussions of topics of concern to society which are either science-based or a function of science teaching. Part II deals with societal institutions or social movements which influence science education. Part III contains papers concerned with the nature of the science education/society interaction. Such themes as values, interdisciplinary concerns, and relevancy run through all three parts of the yearbook. (PEB)

1979 AETS YEARBOOK

SCIENCE EDUCATION/SOCIETY:
A Guide to Interaction and Influence

Edited by

Michael R. Abraham
The University of Oklahoma
Norman, Oklahoma

Fred W. Fox
Yearbook Series Editor
Oregon State University
Corvallis, Oregon 97331

Association for the Education of
Teachers in Science

ERIC Clearinghouse for Science, Mathematics,
and Environmental Education
The Ohio State University
1200 Chambers Road-3rd Floor
Columbus, Ohio 43212

November, 1978

The ERIC Clearinghouse for Science, Mathematics, and Environmental Education is pleased to cooperate with the Association for the Education of Teachers in Science in producing this Yearbook, funded in part through the Center for Science and Mathematics Education, The Ohio State University.

ERIC/SMEAC and AETS are currently cooperating on a seventh publication. We invite your comments and suggestions on this series.

Stanley L. Helgeson
Associate Director
Science Education, ERIC/SMEAC

Patricia E. Blosser
Research Associate
Science Education, ERIC/SMEAC

This publication was prepared pursuant to a contract with the National Institute of Education, United States Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent National Institute of Education position or policy.

PREFACE

AETS Yearbook VI was born in the minds of a few educators who are sensitive to the role of science in society. It was felt that there was/is a need for a document which contains summaries of major issues and problems facing the teacher in science and science education in general. Authors were identified on the basis that each could contribute material drawn from personal experience and insight that would come only after considerable thought and long involvement with the issue. It is fair to say that several of the chapters assumed new dimensions as the authors worked through the issues. Nevertheless, the basic structure of the book as originally conceived has been maintained.

Topics in this yearbook have been identified as issues which go beyond the content of science or methodology of science teaching. The chapters are not elements of philosophy reflecting the quandry of science teaching and its relationship to the nature of science. Rather, an attempt is made to discuss the influence of society on both science and science teaching as well as the influence of science teaching on society. Issues which are drawn from society and influence the teaching of science are readily identified. The conflict between science and other belief systems are discussed. Elements which reflect cultural values and therefore influence science and science teaching are developed without judgment.

It would be presumptuous of those of us involved in the production of this yearbook to suggest that the ideas represented here are all unique. Education has been in a state of ferment for a decade or more. During that period of time much has been written and numerous attacks have been made on science as it relates to society and on science content and science curricula. Such attacks would suggest that more effort must be devoted to bridging the gaps between the scientific community and the broader society. Teachers in science can play a significant role in identifying the knowledge needs of society. Teachers in science play a major part in the education of society as to the strength and potential of science.

It is believed that this yearbook can be a useful resource to those who are or will be confronted with questions and concerns that go beyond teaching methodology or subject matter content. Clearly, this AETS Yearbook does not provide answers to the issues of the day. Rather, the chapters are additional pieces of the puzzle or puzzles related to science teaching. It is thought that Science Education/Society: A Guide to Interaction and Influence will serve as a valuable supplemental reading for both preservice and inservice courses for teachers in science.

David H. Ost, President
Association for the Education
of Teachers in Science

January, 1978

ACKNOWLEDGMENTS

The Sixth AETS Yearbook has been developed over a period of one-and-a-half years. It was conceived and planned by David Ost and myself during several brainstorming sessions. Additional topics, suggestions of possible authors, and many helpful ideas were provided by the officers and members of AETS and of the Publication Committee. Without the help of these many people, the launching of this project would have been impossible. The author of a book usually has a large number of people to thank for their help; an editor is even more dependent upon others if his or her project is to be successfully completed. My list of debts is too long to be mentioned individually but those associated with this project were very fortunate to have the authors who wrote this Yearbook. As editor, I found my interaction with these scholars informative, unfailingly pleasant, and exciting. I will allow the quality of their work to speak for itself.

To David Ost, my thanks for the opportunity to do the project, and for his constant support during the project's development.

Michael R. Abraham, Editor

INTRODUCTION

Science/Society issues have become part of the public consciousness. The topics of "relevancy" are being debated by governments, business, and individuals; that these topics should become pertinent in the science classroom should be no surprise. The papers which make up this Yearbook are designed to explore Science/Society issues from the point of view of science education. The issues were chosen and discussed by their authors to explore two aspects of Science Education/Society: their interaction with and their influence upon each other. Part I of the Yearbook focuses on topics of concern to society which are either science-based or a function of science teaching. Part II deals with societal institutions or social movements which influence science education. Part III is concerned with nature of the Science Education/Society interaction. Common themes run through all these papers: themes of values, interdisciplinary concerns, and relevancy.

It is hoped that these papers will be practical as well as interesting. To this end the Yearbook is not a detailed and complete discussion of the subjects covered but instead provides the reader with an overview of most important issues, discusses the importance of the issues to science education, makes recommendations for more in-depth study of topics and makes recommendations to teachers concerning the topics. The subtitle of the Yearbook calls it a guide and that is just its intention: that the Yearbook be a sourcebook or issues book for Science Education/Society.

By nature the topics covered in these papers are controversial. It is not the intention of this Yearbook to present a particular point of view or to necessarily cover all sides of a controversy. The approach taken by the Yearbook was to allow experts on the topics to present their ideas. Hopefully, these papers will provide controversy and information to the extent that further reasoned consideration of the topics will result.

Although there is great overlap and correlation between and among the topics, each is treated separately and stands alone. The topics treated here are not exhaustive; Science/Society interactions give one a constantly changing list of possibilities. It is hoped that this Yearbook will prove useful and also interesting to Science educators.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

AUTHORS

GEORGE O. ABELL is Professor of Astronomy at UCLA. He is an active astronomer who has contributed numerous articles to professional journals and is the author of several books, the latest of which is Drama of the Universe. He has discovered many star clusters, planetary nebulae, clusters of galaxies, and three comets.

PAUL F. BRANDWEIN was Vice Chairman of Harcourt Brace Jovanovich Publishers until January 1, 1978. He continues as adviser in Education and Director of Research to the company. He is also Adjunct Professor, University of Pittsburgh, and a member of the National Humanities Faculty. He is author or co-author of numerous research papers in science and education, and some 55 books including Books of Methods and Sourcebooks in the sciences, as well as widely used programs of instruction for elementary and junior high school science, social science, and the humanities. His biography is to be found in American Men of Science and Leaders in Education.

JACK L. CARTER is Professor and Chairman of the Department of Biology at Colorado College in Colorado Springs, Colorado. He was a past president of the National Association of Biology Teachers, past associate director of BSCS, and past editor of The American Biology Teacher. He spends his time now teaching, writing, administrating the department, and directing student research.

THOMAS P. EVANS is Chairperson and Professor of Science Education at Oregon State University. He is an active contributor to scholarly journals and a member of numerous professional organizations in science education.

JOHN M. FOWLER is Director of Special Projects and Manager of Publications for the National Science Teachers Association. His activities in energy education are a fusion of his environmental interests (he is a Vice Chairman and founding member of the Scientists Institute for Public Information and an Executive Editor of Environment magazine) and his interests in science teaching (he was the Director of the Commission on College Physics from 1965 until 1972). His most recent books are Energy and the Environment, McGraw-Hill, 1975 and the Energy-Environment Source Book, NSTA, 1975.

GENE GENNARO is Associate Professor of Education at the University of Minnesota specializing in science education. He is a past secondary science teacher. He is a member of numerous professional societies in science education and is presently President of the Minnesota Science Teachers Association.

ALLEN D. GLENN is Associate Professor of Education at the University of Minnesota specializing in socidl studies education. He is a past secondary school teacher and is interested in simulation and games and their use in education.

HOWARD J. HAUSMAN retired from the National Science Foundation in 1974 having served there since 1956. He was Director of the Divition of Pre-College Education. He was trained as a research psychologist, and since retiring has been teaching, writing, and consulting on educational matters.

MARTIN HETHERINGTON is presently an Associate Professor at the Science and Mathematics Teaching Center, Michigan State University. He received his Ph.D. in Environmental Physiology from Purdue University in 1970. He taught junior and senior high biology for seven years. He continues to be very active in the environment and energy educational movement.

PAUL DeHART HURD is Professor Emeritus of Education at Stanford University. He was Chairman of the Human Sciences Curriculum Project for BSCS and has a long-standing interest in science/society problems and in Biology Education.

KEITH K. KLEIN is a graduate student at the University of Minnesota majoring in molecular and developmental genetics. A 1973 graduate of Minnesota in microbiology, he has an interest in the history and philosophy of science—particularly in the relationship of science and society as a whole.

MICHAEL B. LEYDEN is Associate Professor of science education at Eastern Illinois University. He is a past junior high school teacher and author of two junior high school science texts. He has an interest in career education and has written a monograph on the subject.

GEORGE G. MALLINSON is Distinguished Professor of Science Education and past Dean of the Graduate College of Western Michigan University at Kalamazoo, Michigan. He is a member of many professional societies in science and science education and is Chairman, Publications Advisory Committee of the American Association of Workers for the Blind. He is also Editor of School Science and Mathematics.

WILLIAM V. MAYER is Director of the Biological Sciences Curriculum Study and Professor of Biology at the University of Colorado. He was formerly Chairman of Biology and Associate Dean of Liberal Studies of Wayne State University in Detroit.

JOHN MAYOR is Assistant Provost for Research, Division of Human and Community Resources, University of Maryland. He was formerly Director of Education of the American Association for the Advancement of Science where as a part of his responsibilities he was director of the program under which Science -- A Process Approach was developed. As a part-time faculty member at the University of Maryland Mayor started the University of Maryland Mathematics Project (UMMaP) and also served as chairman of the junior high school committee of the School Mathematics Study Group (SMSG).

DONALD MC CARTHY is Associate Professor of Mathematics and Computer Science at St. John's University, Jamaica, New York. He has been involved in the alternative education movement and in recent years has developed an active interest in parapsychology. Since 1976 he has been a volunteer research associate at the Division of Parapsychology and Psychophysics at Maimonities Medical Center in Brooklyn.

ALBERT G. MEDVITZ is completing his doctoral thesis in Science Education at Harvard University. He has taught both elementary and secondary school. He was a research associate for the Science Education Program for Africa and has been a consultant for the Peace Corps training programs, the Educational Development Corporation, and others.

JOHN A. MOORE is Professor of Biology at the University of California, Riverside. He is a research associate for the American Museum of Natural History and was Chairman for the Commission on Science Education for AAAS. He is active in professional societies and is the author of numerous scholarly papers and books including texts at the college and high school levels. He was a participant in BSCS and chief editor of BSCS-yellow version.

EMIL JOE PIEL is Chairman, Department of Technology and Society in the College of Engineering at SUNY Stony Brook. He is Executive Director of the National Coordinating Center for Curriculum Development. He was the Executive Director of the Engineering Concepts Curriculum Project.

CHARLES J. PUGLISI, JR. is a science teacher in Hammond Middle School, Howard County (Maryland) Public Schools, and teaches science in grades 6, 7 and 8. He was graduated from the University of Maryland where he is continuing his graduate studies and has served the past two summers as a graduate research associate. As a staff associate of the American Association for the Advancement of Science for one year and in summers, he was a contributor to the development of some of the early grade modules of Science -- A Process Approach II.

BILL ROMEY is Professor of Geology and Geography at St. Lawrence University, Canton, New York. He was Executive Director of the Earth Science Educational Project, consultant to the Earth Science Curriculum Project, and instrumental in the Environmental Studies Project. He is a member of numerous professional societies in science and education, and is active in the humanistic education movement.

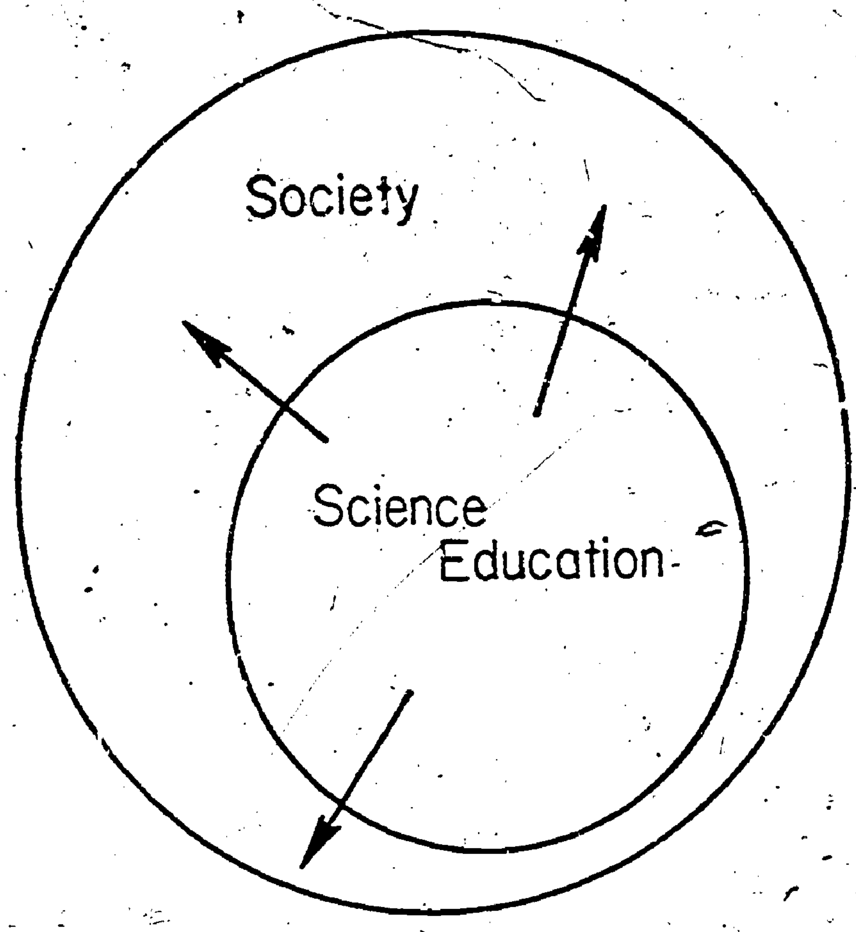
BOB SAMPLES is an Educational Consultant. He worked with several national curriculum projects and was Director of the Environmental Studies Project. He has been active in the humanistic education movement.

ROBERT J. STAHL is Assistant Professor of Education at Mississippi University for Women. He is a former high school teacher and an expert in social studies education. He has written extensively in values education and environmental education.

FLETCHER G. WATSON is Henry Lee Shattuck Professor of Education at Harvard University. He was Co-Director of Harvard Project Physics and past president of the Association for Education of Teachers in Science. He received the National Science Teachers Association's Citation for Distinguished Service in 1972. Currently he is Chairman-elect of Section Q (Education) of the AAAS.

MELVIN H. WEINSWIG is Chairman of Extension Services in Pharmacy, University of Wisconsin-Extension, and professor of pharmacy in the School of Pharmacy, University of Wisconsin-Madison. He received the Ph.D. (1961) degree in pharmaceutical chemistry from the University of Illinois. He has received awards for teaching and service. He has been extremely active in various professional organizations and is currently serving as Chairman of the Council of Faculties of the American Association of Colleges of Pharmacy. He has authored over 100 professional and research articles dealing with synthetic and analytical procedures of drugs, continuing pharmaceutical education, and drug abuse education.

VAL W. WOODWARD is a professor in the Department of Genetics and Cell Biology, University of Minnesota. He received his Ph.D. degree at Cornell University in 1953, and has been a teacher-scientist since that time--the past eleven years at the University of Minnesota. He is author of more than 50 research papers, one textbook, and several papers on the ideology-philosophy and politics of science. He also is a member of the International Committee Against Racism.



This part of the yearbook consists of twelve papers which focus on topics of concern to society which are either science-based or a function of science teaching. This part might be visualized as shown in the figure above. The papers have similar formats. Each provides an overview of the topic including appropriate background information and identification of major issues. Recommendations to teachers on how to handle the topic are then discussed. Where appropriate, suggested instructional units, broad curriculum proposals, or lists of "do's" and "don'ts" are proposed. If the author recommends to not deal with the issue in the science classroom, suggested defenses to use and actions to take are proposed. Each paper ends with a list of resource materials, suggested readings, or annotated bibliography.

Energy is certainly one of the most important science/society issues of our time. Government, the energy industry, and individual citizens are caught up in a morass of claims, changes, hopes, and fears. Education must make its contribution so that upcoming generations are not caught in the same problems we are. Martin Hetherington argues that for energy education to be effective it must consider the social and historical aspects of energy and be integrated throughout the school and curriculum. He presents a model for developing energy education materials which takes students through various levels of complexity from energy awareness to action.

ENERGY

Martin Hetherington

BACKGROUND IN ENERGY EDUCATION

In reviewing several textbooks used in middle and secondary school science programs one fact comes through very clearly. Energy is an important concept. Additionally, it is evident that most of the information deals with energy definitions, forms of energy, energy transfer, and energy technology. The fault I find with this is that energy is not studied in relation to the fuel that produces the energy, the state of the art of energy technology, or the time line necessary to develop this technology. There is no mention of the rate at which man uses his energy resources. Energy in its present forms is referred to as though it will always be present for man's use. The concept of entropy is not well developed in most programs.

One area of energy education I did not see adequately covered in any of the materials I reviewed was the interrelatedness of energy. We usually teach that all energy originates from the sun, but after that we seldom make connections as to how energy flows through a system. We do this for food webs or food chains. We also do some of this when we tell about machines and work but we do not connect the two systems in any way. The student does not get a complete view of energy flow or energy transfer.

We do nothing with the historical, economic or social aspects of energy in science. We lose track of the role energy has played in human civilization. These are all needed to study our historical use of energy and for students and teachers alike to better understand what we should expect in the future.

Specific Subject Matter

The sciences for years have divided energy into various disciplines. The biologist knows energy as it deals with living systems. The physicist knows energy by a series of laws, kinds of energy and types of

energy (such as nuclear energy). The chemist thinks of energy in terms of chemical reactions, energy levels of atoms, heat energy and gas laws. These are all important, but no one ever tells the student how all this energy works in the day-to-day operation of his life. Most people never make any connection between the conversion of energy to food when they think about energy. Most individuals only connect energy with types of fuel such as gasoline with transportation, natural gas with heat, coal with industry, and nuclear power with electricity. These are often the only connections made. Energy in the natural system is simply taken for granted or ignored. Light, sound, heat, wind, waves and all other natural forms of energy are not even considered except in theoretical discussions.

The physics student, reading that energy is the ability to do work, is not even thinking of the energy he is using when he is reading words and processing the information.

We must make energy education more meaningful. It must become more than "something I learned in a science class." It must become a way of life.

Energy Education Programs in the Schools Today

Energy education is being taught in many schools today. Some of the lessons are even being taught by teachers. Many more, however, are from first-hand knowledge. In the winter of 1976-77 we experienced one of the coldest winters in history. Many schools were closed because we ran short of natural gas. It was ironic that Texas, one of the leading states in the production of natural gas, was hit first by the gas shortage. Students are learning that fuel costs are up and this leaves less money for other things the family may want to buy. There is more talk about energy than ever before.

What is happening in schools about energy education? After the 1973 oil embargo the federal and state governments got busy to see what programs could be offered to schools. The Bolton Institute, through a grant from the Federal Energy Administration, offered Energy Education Workshops (Bolton, 1976). These workshops were designed for teachers and students at the middle and high school levels. The goal of the workshops was to establish, in each of the seven states where they were held, a better understanding of energy problems within the state. Students and teachers worked out projects and programs with the support of the state energy offices, state and local education offices, business, and industry. These projects were then implemented in their local schools.

Other projects have been conducted by local utility companies working with schools on energy education. Many materials, films, and teacher packets have been made available free or at very little expense by many industries. Some of these materials are well done and can be used by teachers and students in the classroom. Other materials are of no use to teachers because they are too technical or they are too biased in their presentation. The federal government, through several agencies

like FEA and ERDA, has also made material available to teachers. Oak Ridge had developed several programs to be used in schools. The Energy Environment Simulator is one example of cooperation between ERDA & Oak Ridge Associated Universities. These generally are an assembly type program which the whole school would attend; examples of these would be, "This Atomic World" and "Energy Today & Tomorrow." Programs, such as "Energy and Man's Environment," which works directly with the schools in the western United States, have been very effective. State programs which operate out of colleges and universities (Wert, 1977) have also joined to help schools with courses such as Pennsylvania State University's Nuclear Science Course for Teachers and Project Entropy which conducts workshops from Michigan State University. The National Science Teachers Association has developed Energy packets (Fowler, 1977) which look at energy from a social science viewpoint. These will be available in 1977 and can be used in science courses as well as social science classes. See the resource section of this paper for these and additional materials and programs.

Most of the energy education which is being taught in the schools today is on a single topic of energy. This is usually accomplished by a project dealing with energy or energy concepts taught in a science class. There seems to have been no attempt to incorporate energy as a subject into a wide variety of subject matter areas. People do not understand energy units, energy economics, energy conservation or many other important energy concepts that affect their everyday lives.

In 1976 the Federal Energy Administration had three projects which should help to determine what energy education should do in the schools.

One project was to prepare a bibliography of all energy materials available at that time (Jones, 1976). Another was to have a series of hearings to find out what education needed to teach about energy (Educational Testing Service, 1976) and the third project was the development of a K-12 curriculum matrix for energy education (Hetherington, 1976). All of these projects have been completed and the information is available to teachers. See the resource section for information on these projects.

ENERGY ISSUES

Science classes have dealt with the topic of energy in a very classic way as has been mentioned above. The time has come for the energy issue to be faced by teachers and students and for some real research to be done to look at all the factors which effect energy. This means to look beyond the energy "facts" to how decisions about energy resources, energy policy, and energy research are being made.

Resources

Most students are not informed about our fossil fuel supply. They are not informed about the differences between high sulfur and low sulfur coal. They are not aware of coal reserves or the problems

associated with strip mining and water supply or land reclamation. They are not aware of the rate of our use of fuel resources. They are not aware of the demands we place on other countries of the world because of our use of fuel. Many of our students are not even aware that our fossil fuels are non-renewable. In other words they think we can go on forever at an ever-increasing rate of energy use. The resource question must be looked at very closely. We must also look at fuels such as nuclear fuels to see how long they might last. We have not done a good job of teaching about all the other uses we have for petroleum other than burning it. If we had to list all the products which are made from petroleum we would find the list would be quite long. If we were to list all the energy used to produce, process, and transport our food we would be amazed.

Energy Resources should be studied very carefully by our students because they are the ones who will be affected most directly when the supply runs out.

Technology

Man has done many things by developing his technology. We have become smug about the ability to do many things by relying on technology. We always look for a technological fix to solve our problem. We fail to see or to teach our students the stages of technological development: idea stage to theory stage, to research stage to model stage, to implementation stage. Many of these things take 30 to 50 years from the idea stage to the actual working model. In this age of rapid problem solving we become accustomed to instant answers. We think everything can be accomplished by science if we spend enough money and time on the problem. We must remember that the easy problems have been solved. The ones yet to be solved are complex combinations of man and his environment working out a compromise. We, as science teachers, must be aware of the state of energy technology. We must know what is now commonly used in the production of energy, what is in the research stage and what is in the theory stage. We should also be aware of the capability of an energy system and what its limitations are. We should point out to our students that some problems cannot be solved by science alone. Some electrical generating systems are very acceptable to people in an area. For example, hydroelectric generation is one of those technologies we use which is cost effective. It also provides recreation and a water supply.

No cost is connected with the purchase of fuel, but it doesn't work if there is no water. On the other hand, nucl generating of electricity has had a difficult time establishing itself as an important way to generate electricity. People have blocked the building of these plants in many cases, not because we do not have sufficient knowledge of nuclear technology to build such a plant, but for a variety of other reasons. The human input into the decision of what technology will be used in the future must be a subject the science teacher addresses.

Alternatives and Trade-Offs

Alternative energy systems are very interesting to study and many teachers and students alike are interested in this area of energy education. The main thing to keep in mind here relates to what has already been said about technology. Some systems are more developed than others and many of the alternative systems are still not cost effective even though they exist. Many students think solar energy is the answer to all our problems until they research the field of solar energy. It is true that solar energy could be used in many systems for heating and cooling but when we look at it for generation of electricity, it is an entirely different matter.

We could learn to use less energy. This comes as a shock to many students but by wise use of energy we all could cut our energy consumption down by quite a bit. Energy conservation can be looked at as a trade-off. We can think of ways we can save energy so we can use it some place else. Many schools have reduced their energy consumption by 25-30 percent. This is a goal we could all strive for. Values and lifestyle are involved which students as well as parents and teachers are going to have to deal with.

Many times the figures the energy consumer compares are the dollar cost of energy, which are going up rapidly, rather than the units of energy used. Energy costs are going to continue to rise, but we can reduce the amount of energy we use by some careful thinking about our energy use and then changing our behavior to reduce energy consumption. Trade-offs of all types will be made. We must look at our energy use patterns in recreation, transportation, food, clothing, and housing. We must also investigate the energy used in the many products we consume from cars to hamburgers. Trade-offs are the ways we personally can make decisions about our energy use. First are those changes we make because we have certain values. Second, we must look at those trade-offs which have a positive pay-off for us or where incentives are given to change our behavior; and third, we will see trade-offs which have penalties if we do them. I think we see from most research that this last has the least effect on most people.

Food and the Energy of Life

We are producing more food in America today than ever before at an ever-increasing cost in energy. The plants are still as efficient in their conversion of energy as they always have been, but we do more processing to the raw plant material than in the past and this costs us energy. We also have food sent in from all over the world so transportation becomes a factor. We grow food in one area of the country and process it in another area, then to be used in the same area where it was grown. Some of these practices are not well thought out. Today a calorie of consumed food requires seven to eight calories of energy to get it from the sun's energy to the table. Food habits will have to change so that the food web is shortened. We should not eat as much meat as we do. We should eat more plant products. We should try to

grow as much of our own food as possible. These practices cut down energy use in transportation and processing. We should establish a diet with fewer calories. Most Americans eat too much and eat the wrong foods.

Societal Concerns and Conflicts

Today's society uses more energy than ever before in history. In the United States we plan our societal structure around the concept that there will be an ever-increasing supply of energy. We have had such an abundant supply of energy that we waste more energy than some countries use. We have even had the economic luxury of not paying the actual cost of fuel but have supported the concept of keeping fuel inexpensive so we could use more at a lower cost.

As a society in the United States we are mixed in our opinions about energy. In a recent poll over half of the people polled in the United States felt that energy problems are serious in the country. It was also indicated that not much was being done about these problems. The population is possibly willing to do something about energy but the policymakers are not ready quite yet. This might be due to not knowing what to do with such a complex issue as energy. We do not want to affect the economy but at the same time we know that certain changes in our energy policy would affect the economy. We want to create jobs; at the same time we know this requires energy. We know taking price controls off fuels can have an effect on energy use but it also has great effect on the poor. We would like to make the right choices as to where to spend our research money, but we know if we wait too long we will not have time to develop the technology to a point where it is ready to be used. We would like to use more coal and nuclear energy but we are uncertain about the environmental problems. We are faced with the energy problem of wanting more energy but not knowing if we can get it or what the best way is to get it.

The society with its leaders must face this very important energy question soon. We cannot continue to ignore it and hope it will go away. We must all work together to work toward solutions of the energy problem.

The Government's Role in Energy Policy

The federal government does not have an energy policy. This is one of the main reasons why many states or local governmental units have not established any energy policy. This is also why many people do not recognize the importance of energy. If there were an official policy on energy we could respond to it. We now are responding to the lack of an energy policy. We do have federal and state energy agencies, but even they are having difficulty dealing with priorities. They are asking what should they be doing. Should they be supporting exploration for fuel resources? Should they be promoting alternative energy development? Should they be developing programs on energy conservation? Should

they be teaching energy education to the public? Should they be pushing for existing energy technology? The answer is probably "yes" to all these questions and even more. We must decide what we want and what we can have in the energy future. We have to decide what technology should be supported and what research can be developed. These are not easy questions because at this time we are locked into a fossil fuel energy future and, even more than that, in the immediate future we are locked into petroleum as an energy source. This could be changed but it will be very difficult.

Some things we know will require laws and law enforcement to bring about changes. Some changes can be brought about by incentives of various kinds. We are almost certain the government will have a major role in our energy future. This may be made clear to us now that President Carter has stated his energy policy. He has already asked for an energy department at the cabinet level to consolidate the energy matters under one office. This will probably become a reality in 1977.

A MODEL FOR ENERGY CURRICULUM DEVELOPMENT

During the 1976 academic year my colleagues and I developed an Energy Conservation curriculum matrix for the Federal Energy Administration. This curriculum matrix is designed to take the student from an awareness level to an action-oriented level as he goes from K-12. The important part at each grade level is the decision building portion of the curriculum. The decision building concept is designed to teach students how to make decisions. At the same time the subject of energy becomes more complex with the introduction of new subject matter areas and certain constraints. This model has not only science concepts but also social concerns built in. For more detail see Figure 1.

In Figure 1 the grade levels are listed on the left. The systems to be studied are listed in each of the grade level groups. These systems start with those which are close to the student, in fact the student himself, to those systems further removed from the student, which he has less control over. Some students are also studied with various subsystems. Students observe certain inputs which require or represent energy use and outputs which represent products, waste, standard of living, labor, fuel, food, pollution, population, etc. The constraints in the model are designed to be used as a way to look at the system. To concentrate on the constraints listed for each system would be a way to teach students the many factors one must take into consideration before making a decision. The decision building portion of the model is designed to go from observations through a design for action at the upper grade levels. Energy education would be taught in all subject matter areas where it is appropriate with student and teacher education materials provided.

FIGURE 1

ENERGY CONSERVATION CURRICULUM MATRIX

GRADE LEVEL	SUBJECT AREA →	DECISION BUILDING
	ALL SUBJECTS (WHERE APPROPRIATE)	
1 2	SYSTEMS: INDIVIDUAL AND FAMILY INPUTS TO BE STUDIED ARE THOSE IMPORTANT TO THE INDIVIDUAL AND FAMILY (FUEL, LABOR, FOOD...) RESULTANT OUTPUTS WILL BE IDENTIFIED (LEISURE TIME, WASTE) NO CONSTRAINTS ARE INTRODUCED	OBSERVING CHANGE
	ALL SUBJECTS (WHERE APPROPRIATE)	
3 4 5	SYSTEMS: HOME/FAMILY, COMMUNITY, VILLAGE/CITY SUBSYSTEMS: TRANSPORTATION, SERVICES, RECYCLING INPUTS: ENERGY, MATERIALS, LABOR... OUTPUTS: IDENTIFIED (WASTE, WELL BEING, LEISURE...) AND RELATED TO CONSTRAINTS CONSTRAINTS: HISTORICAL AND TECHNOLOGICAL	LIMITS INTERDEPENDENCE
	LANGUAGE ARTS SOCIAL SCIENCE SCIENCE	
6 7 8	SYSTEMS: BUSINESS/INDUSTRY, STATE/REGION/NATION SUBSYSTEMS: PRODUCTION, CONVERSION, TRANSPORTATION... INPUTS: ENERGY, MATERIALS, LABOR, ... OUTPUTS: IDENTIFIED (WASTE, WELL BEING, STANDARD OF LIVING, ENVIRONMENTAL POLLUTION...) AND RELATED TO CONSTRAINTS CONSTRAINTS: LIFE STYLE, NEEDS/DEMANDS, ENVIRONMENTAL PHYSICAL (EQUILIBRIUM, EFFICIENCY)	ALTERNATIVES
	SOCIAL SCIENCE, HISTORY GOVERNMENT, [illegible], PHYSICAL SCIENCE, JOURNALISM WRITING, [illegible] ENGLISH, SPEECH DEBATE, HOME EC., [illegible] TECH., DRIVERS ED	
9 10 11 12	SYSTEMS: NATION, WORLD SUBSYSTEMS: ECONOMIC, CAPITAL INVESTMENT, PRODUCTION... INPUTS: ENERGY, CAPITAL, LABOR, MATERIALS... OUTPUTS: IDENTIFIED (WASTE, POLLUTION, POPULATION DISPLACEMENT/INSTABILITY, HEALTH...) AND RELATED TO CONSTRAINTS CONSTRAINTS: POLITICAL, ECONOMIC, (SUPPLY & DEMAND) PHYSICAL (ENTROPY, STABILITY)	ALTERNATIVES TRADE-OFFS ACTION

ENERGY CONSERVATION CONSIDERED UNDER INCREASINGLY COMPLEX CIRCUMSTANCES

Energy Concepts

There are many very important energy concepts. Selecting the six or seven most important is difficult. Following the Energy Conservation Curriculum Matrix, I would list the following concepts as the most important:

1. to identify different forms of energy.
2. to identify how man uses energy.
3. to relate how the energy from the sun is converted into the many forms of stored energy man uses.
4. to study the biological and physical principles of energy in the world.
5. to understand the relationship of energy and other human activities; e.g., economics, industry, and agriculture.
6. to study alternative energy systems.
7. to understand the relationships between energy and political decisions.

These are general concepts, but they reflect the complexities of energy education.

Grade Level Considerations

It is well known that many times we introduce concepts too early in the student's program, making it more confusing at a later time for the student to comprehend.

The student should first be introduced to the subject of energy in terms and ways which he can experience the concept directly. The teacher should find out what the students know about energy by asking them questions to which they can relate. (Can you describe some form of energy you use? Can you give an example of a fuel? etc.) The teacher might demonstrate forms of energy such as heat, light, sound, motion for the student to respond to. As students become more familiar with the concept of energy they should start to investigate how energy relates to other activities done by man; e.g., transportation, resources, waste, development of materials, etc. Then they may start to look at the physical and biological energy concepts; e.g., entropy, photosynthesis, energy transfer system, etc. Finally, the students look at the interrelationship of these systems to man's political and economic systems throughout the world. This also leads to life style changes and trade-off plans. The hope would be to help students to make wise decisions for the future, in energy use. As the concepts become more complex the student should become more action orientated in the upper grades.

Integrating Energy Education

We should not think of energy education as a single subject; it should be integrated into the existing curriculum. Energy is one of the most important things in our lives today and we cannot afford to leave it out of the curriculum. The question is how do we get another topic into an already crowded curriculum.

It does not have to be the entire course, but it should be related to topics the teacher plans to cover during the course. To do this teachers must be alert to the many opportunities they will have to consider energy as part of the class they are teaching. In the elementary program this can be part of the reading program. The Federal Energy Administration (FEA) has an "Energy Ant" program. The National Wildlife Federation has materials about energy for young children. Local utility companies have materials suitable for energy education at the lower grade levels. Energy education can also be part of a physical education and health program. This would be teaching students sports which require more physical energy and less expenditure of fuels. These sports such as swimming, bike riding, tennis could be compared to the types of sports which require transportation to a site to participate or spectator sports which require more energy for lighting, heating of buildings or TV viewing. As one goes through the middle school and high school curriculum there are many ways in which energy education can become part of the student's learning experience. Energy education can be integrated into homemaking with energy efficient practices in the home, industrial arts—how to retrofit a home to conserve energy. In drivers' education students can be taught how to look for energy efficient transportation and when and how to use a car in an energy efficient manner. In social science energy can be studied from the social aspects and how energy has changed our lives in the past and will change our lives in the future.

Expected Outcomes

With the predictions that many of our fuel resources are in very low supply or are to be depleted by the middle of the next century, our students have to consider the changes such shortages will cause in their lives. We must also point out the lack of technology we have in the alternative energy research, because of our reliance on fossil fuels. We must prepare the next generation to deal with these problems and all that accompanies them. Our hope must be that through our educational system we will produce solutions to these problems. It will be up to the educators to make the students aware of the energy problem and to equip them with the knowledge and techniques to deal with it in their lives. We would hope that education could play a major role in educating the students of today for the role they will play in the future.

FURTHER RECOMMENDATIONS

For years the schools have been teaching about energy from the point of view of science and technology. Some earth science courses have dealt with the topic of fossil fuel. The other issues about energy have been left out of the curriculum with the exception of the food chain and respiration in biology.

It was not until the oil embargo in 1973 that we became aware of new energy issues that students, or anyone else for that matter, should know about.

We suddenly were thrust into such issues as energy allocations, unequal distribution of fuel, alternative energy sources. The social issues dealing with energy were discussed in the press and at governmental agencies. It was not until much later that these issues got to the schools. There was some concern about energy availability to operate the schools. This has now become a reality in several states. The winter of 1976-77 was severe and some states had to close schools state-wide, while other states had schools on interrupted schedules because of lack of fuel.

Even with these realities some people still feel there is no energy problem. They still think the petroleum industry and government are fooling the people.

We must deal with energy problems honestly and with the facts that we have.

As teachers we may say it is hard to get unbiased information about energy. This is probably true, but we should present different sides of the energy issue. We should try to educate our students and not indoctrinate them. We all have our biases. We should tell students when information we are giving is our point of view and not backed by evidence. We should ask for documentation of data. We should always ask the source of the information. It is impossible to get an unbiased report on any controversial issue. At best we can educate our students to listen to or read the data on both sides and try to make the best decision.

The area of energy education is going to be taught in schools in a different way from many of the subjects we now teach. This is simply because many of the consequences of energy decisions are going to be immediate as well as long range. We are going to be living with energy mistakes which will have a direct effect on our lives and we will be trying to make the proper decision in energy planning for the future. This will make energy education a very exciting and important subject now and into the 21st century.

Energy Education in the Elementary Schools

Many of the elementary science programs list energy as one of the topics that is covered. Students who are in schools where these programs are in use generally have some concept of energy. We could expand on the student's awareness of energy use. If they were made aware of the energy they get from food by the activities they do through the day, most of them could see it takes energy to walk, have fun, and do work. They may never think of the energy it takes to keep them aware that all things require energy to function.

In the elementary school we could teach students to be more aware of how energy is used by their families. They could conduct simple studies of the ways energy is used in the home for everything from heat to transportation. Most elementary energy education could center around the awareness of energy use by the student and the student's family. We should start teaching about energy at an early age.

The secondary school energy education programs should be activity oriented. The students should start to take what they have learned and apply it to their own lives and their families' life style and the communities they live in. They should learn about how decisions are made about energy. They should find out who is responsible for making these decisions. These students could be a very important force in energy decisions in their schools and communities. They could be trained how to carry out research on energy questions. They could learn how to present the information they have to people in energy decision positions. They could help educate their families and friends. These same students could monitor energy policy in their states. They could act as aides to the state energy office.

There are many ways the secondary students could take an active role in energy education. This could also be an interdisciplinary approach. Students in social science could keep up on energy laws and the social impact energy has on their community. Science classes may work with industrial arts classes to build alternative energy systems and insulate homes in the community. The home economics classes can study energy use in the home and make people aware of ways to conserve energy. Physical education classes can stress ways of developing recreation programs with the least amount of energy used. Speech and English classes can work on presentations to be given to community groups. By doing many of these things the students would see the importance of energy in their lives and help others see this also.

REFERENCES

Curriculum Materials and Teaching Ideas

Curry, Wendell, et al. Energy Crisis. Salem, Oregon: Oregon State Board of Education, 1973. (ED 085 316)

This is a special publication for teachers suggesting school activities which stress individual responsibility toward the energy crisis.

Energy and Man's Environment project. John Jones, director. 0224 S.W. Hamilton, Skyline Building #3, Portland, Oregon.

This is a teacher-developed program in seven western states. Jones conducts teacher workshops in energy education.

Energy Conservation Understanding and Activities for Young People. Washington, D.C.: Federal Energy Administration (FEA), Office of Conservation Education, 1975.

Energy: environmental education curriculum. Topeka Public Schools. Washington, D.C.: DHEW/OE Bureau of Elementary and Secondary Education, 1974. (ED 093 649)

Fowler, John. Energy Education Materials. Washington, D.C.: National Science Teachers Association, 1971.

Much material is available including fact sheets on alternate energy technologies and six instructional energy packets. A project for an energy enriched curriculum will include 30-40 instructional packets on energy/environment/economics.

A Guide to Teaching Resources. Educational Services Program, Room 867, Consumers Power Company, 212 West Michigan Avenue, Jackson, MI 49201.

Although this list of free teaching materials and films is only available to schools in their service area, many utility companies have similar services.

Hengel, Wayne. Energy Key to the Future. Poughkeepsie, N.Y.: Dutchess County Board of Cooperative Educational Services, 1974. (ED 092 027)

This booklet contains teaching techniques for the understanding and conservation of energy.

Jones, John. A Bibliography of Energy Education Materials. Federal Energy Administration, Room 6507, State Technical Assistance Office, Washington, D.C.

This bibliography covers printed materials, films, simulation and computer games for grades K-12. It should be ready in the Fall, 1977.

Project Entropy. Joseph Janeti, director. Center for Environmental Quality, Michigan State University, East Lansing, MI.

This project has both developed curriculum materials and workshops for teachers.

Wert, Jonathan. Ideas and Activities for Teaching Energy Conservation. Knoxville, TN: Environment Center, University of Tennessee, 325 South Stadium Hall, 1977.

This is an energy education curriculum guide for teachers and students in grades 7-12.

Bibliography

AAAS. Energy Education. Washington, D.C.: American Association for the Advancement of Science, 1974. (ED 093 697).

Abelson, Philip H. (ed.). Energy: Use, Conservation, and Supply. Washington, D.C.: American Association for the Advancement of Science, 1974.

Bolton Institute, National Energy Inquirer. 4 Linden Square, Wellesley, Massachusetts, 1976.

This is a newsletter.

Educational Testing Service (ETS). Proceedings of Hearings on Teacher Needs in Energy Education. Washington, D.C.: Federal Energy Administration, Room 6507, State Technical Assistance Office, 1976.

This report covers the content analysis and interpretation of Five Regional Hearings to Determine Current Status and future needs of Inservice Energy Education.

Gwynne, Peter; James Bishop, Jr.; and S. G. Michand. "How Safe is Nuclear Power?" Newsweek, April 12: 70-75, 1976.

Hetherington, Martin. Feasibility Study for the Development of a K-12 Curriculum Matrix for Energy Education. Washington, D.C.: Federal Energy Administration, Room 6507, State Technical Assistance Office, 1976.

Moore, J. W. and E. A. Moore. "Net Energy: Figuring the True Yield." The Science Teacher, Vol. 43, No. 4:24-25, 1976.

National Wildlife Federation. "Special Report on Energy." National Wildlife, Vol. 12, No. 6:13-20, 1974.

Additional copies are $0.10 each from National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C.

RANN. Energy, Environment, Productivity. Washington, D.C.: National Science Foundation, RANN Program, 1974. (ED 096 154)

This is the proceedings of the first symposium on Research Applied to National Needs (RANN) which took place November 1973.

Wilhelm, John L. "Solar Energy, the Ultimate Powerhouse." National Geographic Magazine, Vol. 149, No. 3:381-397, March 1976.

Photography is by Emory Kristof.

Organizations

Edison Electrical Institute (EEI), 90 Park Avenue, New York, N.Y.

EEI has a list of resource guides and curriculum materials for use in K-12 classrooms.

Energy Research and Development Administration, ERDA, Office of Public Affairs, Washington, D.C. 20545.

ERDA has single topic information pamphlets on conservation of energy, fossil energy, solar, geothermal, advanced systems, environmental and safety, nuclear energy, and national security.

In addition, they have assembly-type programs which schools can access. Two such programs are "This Atomic World" and "Energy Today and Tomorrow." They can also supply the "Energy Environmental Simulator" a computer simulator used to forecast energy/environment situations. For more information about assembly programs and the simulator, contact the appropriate address for your location. East: Oak Ridge Associated Universities, Energy Education Office, P.O. Box 117, Oak Ridge, TN 37830. West: Northwest Colleges and Universities for Science, 100 Sprout Road, Richland, Washington 99352.

Federal Energy Administration (FEA), Office of Conservation Education, Washington, D.C.

Pennsylvania State University, 231 Sackett Building, University Park, Pennsylvania.

Warren Witzig conducts an extension program for teachers in nuclear science.

Youth Energy Conservation Corps, Energy Council of Ocean County, New Jersey, 127 Hooper Avenue, Toms River, N.J.

Contact Sally Burt for ideas and materials for organizing elementary school energy conservation clubs.

Population is usually thought of in narrow terms. Overpopulation is certainly a problem with many ramifications to the quality of life of individuals throughout the world. In this paper Robert Stahl has attempted to give a more general picture of population, which shows how the parameters of the concept lead to a large variety of interrelated ideas. He has done this by presenting a model which helps put many population-related ideas in perspective. Many ideas are introduced in this chapter which are expanded by other authors in succeeding chapters. Robert also suggests using values clarification as a technique for helping students with population-related concepts.

POPULATION

Robert J. Stahl

Conceptually speaking, "population" is the number of species within an area at a specified time or the total number of members of a given community at a given point in time. In human communities, the term "population" is synonymous with "people." In fact, the term population, like "mankind" and "humanity," is an abstract referent of people. In much the same way, the term "people" has become a very sterile referent to groups of individuals. Thus, the term "population" has come to refer to people which in turn refers to individuals; i.e., persons like you and me.

While this referent chain is apparent, the implications of moving "population" to a second level of abstraction of "individuals" are not so apparent. For example, one feels at ease advocating "population control programs" and "population policies" because these are removed from the more personal and perhaps unacceptable reality of "people control" and "people policies." Even more taboo are discussions of programs which seek to control, influence, or regulate individuals which, when it comes down to it, are the real focus of population programs and policies. Thus, as an abstraction, "population" is far less likely to be affected by science[1] than are people or individuals. It is the intent of this chapter to focus on how science affects and is related to population, especially those aspects of population which are related to groups of people and to the individual person.

---

[1]The term "science" will be used loosely throughout this entire chapter to mean any one or several of the following: (a) the methods and procedures of testing and/or verifying a hypothesis, (b) the body of knowledge acquired through these methods in disciplines referred to as the "sciences," (c) the equipment of the scientist, and (d) the application of scientific knowledge. One reason for this broad interpretation of the term "science" is based upon the uncertainty of when and where science starts and ends (e.g., a nuclear power plant, the polio vaccine, cloning). The classroom teacher is urged to help students distinguish between the various aspects of science just mentioned so that students do not equate a misuse of scientific information

POPULATION AND SCIENCE: ONE PERSPECTIVE

The classroom teacher has available a variety of ways of examining the relationships between population and science. One way of viewing these relationships, called the "population-related variables perspective," will be discussed at length in this segment of this chapter. Afterwards, a model to develop instructional materials for teaching via this perspective will be presented as well as annotated bibliography.

The "population-related variables perspective" examines four major categories of population-related variables (a) territory, (b) external factors, (c) social/societal factors, and (d) population/people, as separate and distinct variables and then studies their interrelationships. Not only do these four variables interact with one another, each ultimately is or can be affected by science. Within this perspective, in one way or another, each of the four population variables and each individual person is affected by each other as well as by science.

Nothing a human being does is done in isolation from the four major population-related variables mentioned above. One way of identifying more precisely each variable and of illustrating the interrelationships among these variables is through the presentation of a model. Figure 1 describes how three population-related variables interrelate with one another as well as with the fourth variable, people. In addition to an explanation of each of these four variables, the narration to follow also includes a short commentary as to how the particular variable affects population and may be affected by science.

Territory

This category of variables concerns itself with characteristics of territory or land. Included within this category are such variables as the size and location of a territory, its natural resources, geographical features, climate, and topography, and the neighbors of that land. Although the interrelationships among these various territorial variables and population may be self-evident, a brief review is provided.

The size and location of a piece of land influences how many people may live there, how they will live, and where they may live. The type and placement of natural resources may affect where the people will live and work, what they may do, how they will live, as well as the products and materials they are able to produce. Geographical features such as the availability and location of harbors, mountains, rivers, and the like may well determine where people will live and not live.

---

[1] (continued) by individuals or groups with science itself. This effort to distinguish between and among these aspects of science should be done before, during, and after any scientific issue is discussed or studied.

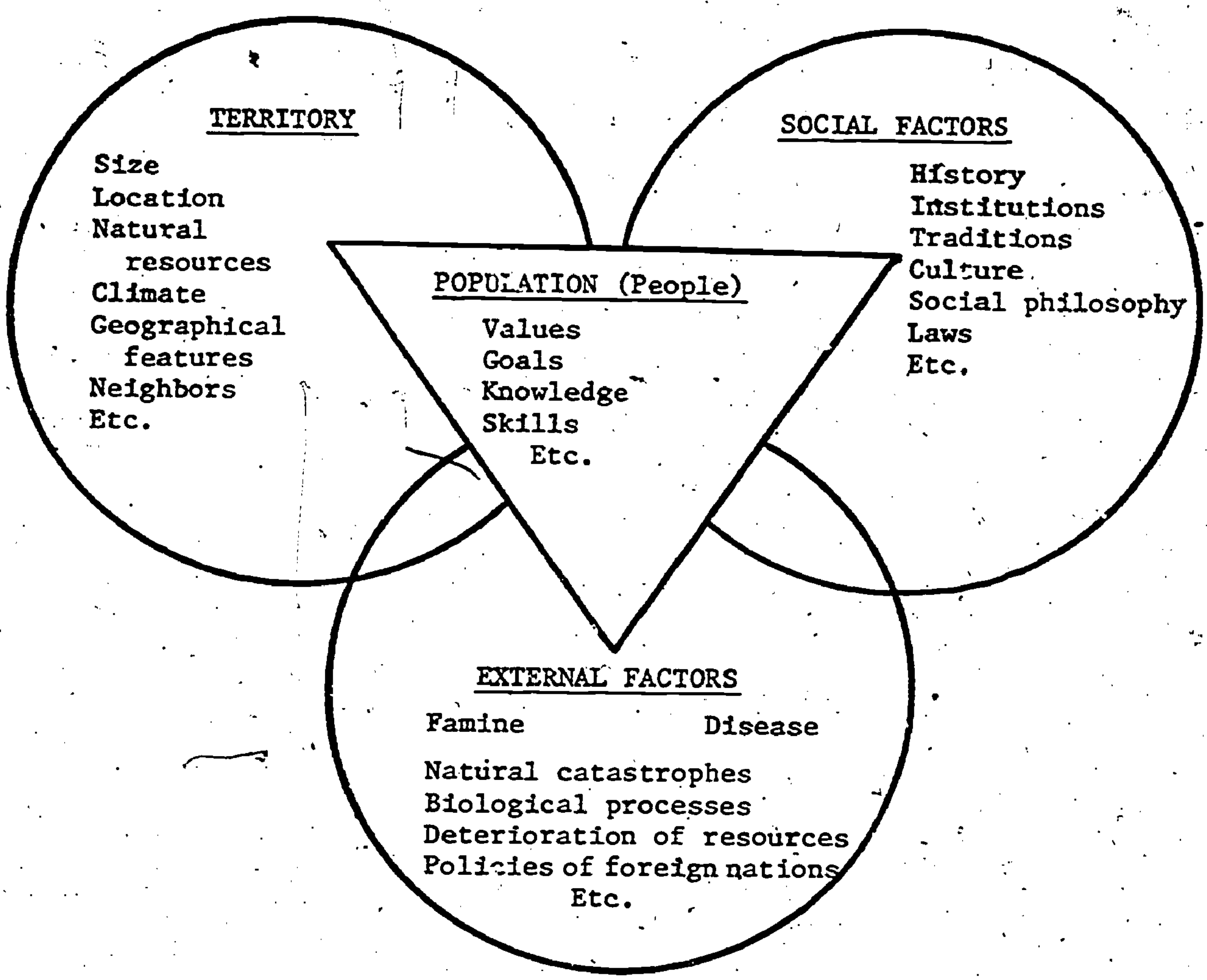


Figure 1: Model illustrating the relationships among the four categories of population-related variables which affect and are affected by population and science.

The climate of a territory may influence what is produced by its people and what they may develop as their lifestyle. The distance to neighboring communities, nations, and land may influence how a territory's people make use of their land and resources as well as how they live.

Using science, a people may be able to adapt various uninhabitable regions of their territory into livable space. The development of air-conditioning, synthetic insulations, and anti-freezes has altered the lifestyles of populations in many geographical regions. Science has helped to discover and reach natural resources, to process them, and to convert them into usable products and materials. Science has enabled man to move into marginal and heretofore uninhabitable regions without cutting him off from the rest of civilization. And, as these lands open up, people moving into them eventually multiply.

In addition to surface land, science is exploring ways to harvest and inhabit earth's non-territory; i.e., the oceans. Programs aimed at developing undersea life-support systems and stations, harvesting the oceans' edible resources, and mining their natural resources demonstrate ways which science is being used to investigate the use of non-land for land-oriented populations. Space is another non-territory being opened up to the domain of science and human population groups. The construction of an orbiting space station and the colonization of the moon are now within man's immediate reach. Furthermore, it has been established that U.S. weather satellites have saved American farmers over $4 billion in crop losses due to their ability to assist in the prediction of local weather conditions. Considering the loss of human and animal life from starvation <u>with</u> these crops, the extent of death from starvation which would have occurred <u>without</u> these crops is staggering to imagine. Hence, whether it be land or "non-land," to meet the needs and demands of today's and tomorrow's populations, science is fast becoming the critical factor as to whether a given population will continue to exist, will merely subsist, or will live with some degree of affluence.

External Factors

This category of variables concerns itself with natural occurring phenomena as well as with factors beyond the immediate control of a given population group. Certainly natural catastrophes such as floods, volcanic eruptions, tornadoes, hurricanes, and earthquakes affect the lives of people. Freak snowstorms, flash floods, famine, disease, and avalanches are also examples of catastrophes which annually take thousands of lives and affect millions of people. Biological conditions and processes involving all aspects of animal and plant life forms and their interactions provide us food, oxygen, and raw materials for various and endless products. The human dependence upon the natural abundance of these biological life forms and their processes eventually may lead to the deterioration of this abundance and even to the extinction of some of these life forms. Finally, the decisions of foreign nations or a neighboring country may directly affect a population group and how that population may use science.

Natural catastrophes affect population groups in numerous ways: people are killed and injured, buildings are destroyed, emergency help programs are established, and lives are altered. Science is currently being used to reduce the impact of such happenings. Scientific knowledge has been applied to the development of "earthquake-proof" buildings, the prediction of earthquakes, and the tracking of hurricanes. All of these applications will eventually save lives and reduce the effects of natural catastrophes on a population. Based upon average reproduction and mortality rates data, the saving of just 1,000 lives from a natural catastrophe in 1977 would mean the addition of between 20,000 and 39,000 people on the earth in the year 2050. Hence, the application of science in this area alone has implications not only for today's people but also for the population of all future generations.

Efforts to decrease the number of deaths from such diseases as cancer, sickle cell anemia, diabetes, etc. also have ramifications for population groups. Deaths caused by such diseases help to reduce the total number of persons within a given population and, if these deaths occur early enough in an individual's life, to prevent the creation of future generations from this potential parent. The figures cited earlier relative to the saving of lives from catastrophes are equally appropriate to the saving of lives by disease prevention and cures. The development of the swine-flu vaccine and subsequent mass inoculation program in America during 1976 have definite effects upon the population of this nation. Eventually, all decisions regarding the use of science to find cures for diseases, to produce wonder drugs, or to produce disease-prevention products have implications for the number and lifestyle of a given population. Interestingly, a decision <u>not</u> to use science for such efforts also has implications for the same group of people.

One of the major external variables is that of the lives and life processes of animals and plants. Needless to add, the needs and decisions of a population both affect and are affected by these biological organisms and their processes. The development of miracle grains through eugenic research, of hybrid strains of plant forms, and of selectively-bred animals have altered man's food and biologically-obtained resources around the world. Not only have crop and livestock yields increased in number, but the size, quality, and substance of many plants and animals have been altered.

Science has also been used to develop appropriate fertilizers to nourish the ground and to develop the insecticides and herbicides to protect the plants once sown. However, the products of science may eventually pollute and deteriorate the environment, destroy animals and plants, and poison humans. The effects of DDT, PCB, and chlordane are well known. Eventually, as the size of a population increases and as the lifestyle and needs of that group change, the magnitude of their dependence upon biological organisms and processes will increase geometrically. The former abundance of natural biological products must now be developed and obtained via artifically- or man-assisted biological processes. As mankind becomes more dependent on these products in order to survive and live, the more dependent man will become on science as the means to fulfill his wants and needs. In

some cases, man will have to increase his use of science just to remain at the level his group has already attained.

Finally, the decisions of a foreign nation may have a significant impact on the population of a second nation. The decisions of a government to send or not to send food to a famine-plagued nation, to initiate or prevent a war, or even to accept or reject free or inexpensive medicines, contraceptives, and health-care services offered by another country directly affect some population group. In each of these cases, science had some role to play. Science may have helped to produce the surplus; to refine the weapons of war, to perfect the medicines, contraceptives, and services; and to develop the means of delivering these things to foreign shores. Thus, without the use of science, there may be fewer decisions for governments to make (e.g., there would be no surplus to send, reject, or offer; no weapons to test or use, etc.). Currently, the use of science to find alternative fuels and energy sources to decrease this nation's dependence on foreign oil is a vivid example of the ability of a foreign nation to directly affect both a population and the use of science.

Social/Society Factors

This category of population-related variables includes those variables which are directly related to a population group as it exists and functions as a group. Sub-variables in this category include the history, traditions, culture, social values and philosophy, institutions, laws, and religious leanings of the group. In part of these areas of society each has been affected and shaped by the various territorial and external factors presented above. But each of these social/societal factors also stands alone. Each has a definite identity, a relationship with population, and a potential to affect and be affected by science. In addition, these variables interrelate and in some cases overlap with one another. In all cases, the procedures and findings of science available to and sought by a population group are subject to these diverse social variables. Science does not dictate to these social areas what it should be used for or how its findings could be used. These various social areas have to perceive science as relevant (or not relevant) to their particular domains and may allow themselves to be influenced by what science has found or can do.

Take, for instance, the critical population activities of conception and birth. A society may believe that each individual has the right to freedom of choice regarding her/his own behavior. Such a society may allow certain freedoms of sexual behavior within a social institution (marriage) but forbid such behavior outside the same institution (rape, adultery, and incest). And, although the society may even support the use of contraceptives, it still allows the individual to decide whether or not a contraceptive will be used. Furthermore, a religious group may advocate the sanctity of life and the wrongness of using contraceptives to prevent the creation of life or of using abortion as a means of terminating an unwanted pregnancy. The government of the same society may pass laws to provide free contraceptives to individuals upon demand and to open up abortion clinics to terminate pregnancies. That same society may even provide child-support payments to parents

of children who are born out of wedlock. Another society might let part of its people starve to death and live undernourished while at the same time protect an abundant source of food (India). Yet another society may feel so threatened by its relative loss of population that it offers a bounty for the birth of additional children within the same family (Greece).

While science did not influence the decisions of these various societies and institutions, science did and does provide the contraceptives, the medical knowledge, the drugs and products, the technical equipment, and the fertility pills to make such decisions possible or to carry out decisions already made. Furthermore, whether a society allocates its money, time, energies, and personnel to develop a cure for cancer to develop a biochemical warfare arsenal is done without a mandate from science. Thus, society and all of its various social factors determine what science shall do, what scientists shall work on, and what shall be done with the products, information, and equipment of science. And, even though the social institutions may make decisions not directly related to science, ultimately some aspect of those decisions or their aftermath will tie into science and to population.

Population/People Factors

This category of variables may be viewed as those personal factors of a group as they concern the individual and the group as a whole. Variables in this category include the number and race of people in a given population group as well as the personal values, goals, attitudes, and abilities of each individual member. Certainly whether a group contains 10,000 or 1,000,000 people has a great deal of impact on how its people live and upon the life of each of its members. Each individual can decide how much she/he values children, sex, life, death, aging, etc. Each individual person makes decisions relative to her/his own reproductive behavior. And each individual makes decisions relative to an endless number of issues and activities related to some population variable. In nearly all of these situations, today's individual has available some science information or product related to the decision or its aftermath.

For instance, prior to the discoveries and advancements of science, there existed only one reproduction mode for the human species. Here the male deposited sperm in or near the female vagina, and when all conditions were met, the sperm united with the egg to form a zygote: presto, conception!! As a result of science, today's world looks to such reproduction modes as test tube babies, embryo transplants, selective breeding via artificial insemination techniques, and cloning. Whereas our parents were limited to their own physiological reproductive capabilities, our children will grow up in a world with at least five different means of reproducing their own kind. Science is continually being used to investigate artificial wombs, test tube embryonic development, and cloning in order to bypass the "womb" in its more traditional sense. Considering the problems of overpopulation caused by only one reproductive mode, the implications of having five different modes operating simultaneously are scary.

Genetic research leading to discussions of genetic engineering and to ongoing programs of genetic counseling have focused on the pre-conception (and genetic) existence of the individual. Science has been used to explore hereditary diseases and abnormalities in individuals resulting from genetic-carried or genetic-caused factors. As scientific knowledge is accumulated about causes of certain diseases or abnormalities and what can be done to reduce or eliminate such problems in offspring, the information may determine who shall, and who shall not, be parents. Scientific investigations have also produced the fertility pill. Thus, a product is now available which will enable many women who were incapable of conceiving to conceive. While science on the one hand has produced information which could be used to keep individuals from becoming parents, on the other it has developed the means to make parents of individuals who would not normally be able to reproduce. In such cases, science has the potential to determine who will be conceived and who will be conceivers. Again, the critical population activities of conception and birth are affected by the individual's decisions regarding the use or non-use of science products and findings.

As science has been influential in matters concerning the origins of our life, so it has been applied to the preservation and termination of our lives. Uses of scientific knowledge and products to prolong life via chemotherapy, miracle drugs, prescribed diets, artificial life-support systems, medical care, organ transplants, and plastic bubble environments are well known. Also well known are our efforts to apply science to the area of offensive and defensive weapons of war. Bio-chemical warfare agents, deadlier bombs, and faster and more efficient methods of destruction are examples of areas where science has been put to use to assist mankind terminate lives. In each of these various life preservation and termination dimensions, all population groups feel the effects of those lives which are preserved and those that are not.

Ultimately, all matters concerning population are matters which concern individuals. All population decisions made by individuals directly tie to one of three questions. These questions are: (1) Who shall live? (2) How shall they live? and (3) Who shall die? Because these three questions are crucial to every population group and because how a population group answers each of these three questions is critical to its own survival, this fourth population-related variable (i.e., Population/people) is the most important variable.

Thus taken separately and in combination with one another, these four variables are important to any and all population groups. All facets of the existence and well-being of a population group are tied to the interrelationships existing among these four variables. And, as has been pointed out in this chapter, science also affects and is affected by these variables and their relationship to one another.

SUMMARY AND CONCLUSIONS

Science is involved in population in ways far beyond the "womb to tomb" existence of the individual person. Science is concerned with individuals long before their womb existence begins and maintains this concern up to and beyond the point of their deaths. In between, science studies ways to keep people alive, to improve their living conditions, to postpone the deaths of some, and to speed up the deaths of others. Each piece of information science reveals concerning these areas of human existence ultimately affects all people and all population groups. Science, as it explores every facet of human life, either directly or indirectly provides information relevant to critical population-related activities and events.

Individuals in today's world must come to understand that science does <u>not</u> determine how its procedures and information will be used or who will use them; such decisions are made by the users of science. For example, a decision whether or not to seek a cure for cancer is not a science decision, it is a decision made by those who would want to use science towards this end. Nor did science decide to build A-bombs or to drop them: people decided to build them, to test them, and to drop them. Science merely provided the means by which people could obtain and use information and a product. In cases such as these which ultimately affect a population group in some way, one cannot fail to see the relationships which exist among people, population, and science.

VALUES CLARIFICATION AS AN INSTRUCTIONAL STRATEGY

Comprehending and utilizing scientific knowledge about population-related factors and life-and-death issues relative to human existence is one of the most important goals of Population Education. In the pre-college curriculum, Population Education focuses on the acquisition of scientific knowledge and procedures and the application of these towards assisting students in making better decisions in matters that will ultimately affect population and their own reproductive behavior. One way of incorporating scientific understandings within decision-making processes concerning population is to engage students in content-centered values clarification learning episodes.

Values clarification is really an internal cognitive process that involves the consideration of data, alternatives, values, feelings, and criteria. Since these processes really take place in the mind of an individual, one might assume that if students were orally using statements that were congruent with these internal processes, then the individual was engaged in the process of clarifying his values. As defined by Casteel and Stahl (1975), "values clarification" is the use of specific patterns of language by students that are consistent with these internal valuing thought processes and from which a teacher may reasonably infer that internal valuing processes are taking place. These valuing processes incorporate the comprehension of available data and information, the identification of relationships, the consideration of alternatives, consequences, and criteria, and the consideration of

values, preferences, and emotions. Because this approach to values clarification stresses the use of these processes within subject-centered classrooms, students should be expected to demonstrate comprehension and use of scientific content and procedures, to identify the connection between what is being studied and the focus of the instructional unit, and to consider the relationship of science to values, decisions, and choices. Thus, teachers who posit values clarification as an instructional goal should design activities to get students to use these specific patterns of language during class discussions.

For the sake of convenience, the types of language students should use to indicate that they are in fact internally clarifying their values can be described in terms of blocks of categories or subprocesses. When the teacher deliberately goes after and obtains student statements consistent with these blocks of categories, then we consider this effort a "values clarification strategy." This strategy consists of four of these blocks of language pattern or categories which are referred to as "the phases of values clarification." These four phases are (1) the comprehension phase, (2) the relational phase, (3) the valuation phase, and (4) the reflective phase. Each of these four phases is described below. While these four phases are presented in sequence, during actual classroom learning episodes students may move among these phases, especially the first three, as necessary in order to think through and clarify their values and value choices.

(1) The Comprehension Phase. When values are being considered and clarified as part of a decision-making situation, there is an object of valuation. This may be a personal condition (e.g., deciding whether or not to abort a fetus); a social condition (e.g., apathy towards receiving swine flu vaccines); a population issue (e.g., sending large quantities of contraceptives to an underdeveloped country); or a combination of personal, social and population conditions. At other times, this object of valuation may be scientific knowledge (e.g., cloning); a problem-solving situation (e.g., deciding whether or not to send food to a nation whose people refuse to eat home-grown food supplies); or a dilemma where scientific knowledge may be used or misused to cope with a problem ultimately tied to population (e.g., dropping the A-bomb on one population in order to save the lives of another population group). If the condition, problem, or situation is to be accurately assessed and rationally valued, it is necessary that the object of valuation be understood.

During the comprehension phase, students use patterns of language that reveal the level of their understanding of the condition or situation. They identify factual information providing evidence of their basic understanding. They translate and interpret this factual information. When necessary, students define terms and clarify previously made statements. When used in combination with one another, statements such as these provide verbal evidence that the object of valuation has been understood by students. Such statements provide the teacher with data suggesting his or her students have gained knowledge and understanding of the object they are studying and around which they are to clarify their values.

(2) The Relational Phase. Being content-oriented, this approach integrates values clarification with subject matter through the relational phase. This phase allows the classroom teacher to assist students in clarifying their values related to population issues while simultaneously understanding and applying the population subject matter content studied in their instructional unit. Failure to integrate values clarification processes and content-related learnings may allow students to infer that there is no relationship between the subject matter of population and the values they possess or clarify regarding population conditions, data, and decisions.

During the relational phase, students relate the situation or condition they are studying to previous knowledge learned in the unit. Students may relate the situation or condition they are studying to current events or happenings in the world. Students may state how the situation and data being studied are tied to the major concepts at the focus of their entire unit of study. Students may state how the knowledge or conditions already studied are similar to or different from other knowledge or conditions being studied. The integration of subject matter with the valuing process also helps students to see the relevance (relatedness) of materials currently being studied to the content and activities previously examined.

(3) The Valuation Phase. When students engage in the valuing process, they assign and examine personal preferences and values. Frequently, they attach labels such as "good," "bad," "right," "best," "poor," and "worst" to actions and objects. Not only do students assign such labels but they often must consider their ratings in terms of several other objects that they also prefer. Hence, preferences may be given different value ratings according to how each student (or the peer group) chooses to organize his priorities. Choices of policies and the criteria used to select such policies are the result of individual preferences and values. Consequences of decisions, of choices, and of suggested policies may be examined in relationship to their value base. Students may express their personal feelings and emotional reactions. They also may empathize with individuals whose conditions are being studied.

To be most effective, the valuation phase assumes students have already engaged in or are simultaneously engaging in comprehension and relational phase thinking. Such experiences ensure students are engaged in clarifying their values in light of an adequate comprehension of the learning situation and an understanding of its relationship to the focus of the unit.

Each successful values clarification activity requires the interactive use of the three phases just described. The completion of these three phases within one values clarifying episode generates data that may be used during the reflective phase, the fourth phase of this values clarification strategy.

(4) The Reflective Phase. Internal consistency is a highly valued human behavior. This phase is designed to enable students to examine the consistency of how they assigned their value ratings as well as the

consistency of their use of these assigned ratings. Therefore, the data used during this phase are taken from previously completed values activities incorporating phases one through three.

Once students have completed at least three values clarification episodes containing the first three phases and related to the same instructional focus, they are ready to commence the reflective phase. During this phase, the teacher seeks to assist students in examining:

how they obtained their knowledge and understandings;
how they formed relationships;
how they determined relevance;
how they assigned and used values;
how they used criteria; and
how they expressed their feelings.

An exploration into these critical areas helps students to reflect upon and reconsider their understandings, value assignments, feelings, and personal values choices. If warranted, students may wish to modify or reorganize their learnings or their value ratings. Instruction designed to enable students to successfully complete all four phases is appropriately labeled a "values clarification strategy."

The Value Sheet

One way of getting students to clarify their values is to locate or to develop and assign value sheets. Value sheets are carefully planned and written activities designed to get students to use the language patterns associated with values thinking. The use of value sheets in connection with on-going instructional units helps the teacher avoid the danger that students will perceive valuing and values clarification as forms of experiences isolated from and not related to the cognitive tasks they are engaged in and the content they are learning. Thus, the teacher need not break the flow of subject matter instruction in order to take time out for values clarification activities.

Value sheets may be written in at least six different formats (Casteel and Stahl, 1975). Each format stresses procedures one may use to get students to clarify their values and learn how to make decisions. Schematically speaking, value sheets are one way students may link Population Education content learning, decision-making skills, and valuing behavior (see Figure 2).

Every value sheet contains at least two elements. First, there is a resource providing information towards which students are to react. This resource or context presents a focus for values clarification and establishes the context within which students are to respond. This context may simply describe an event that occurs or has occurred or that is contrived by the teacher. This context may also present the students with a role and a situation within which they are to fulfill the assigned role.

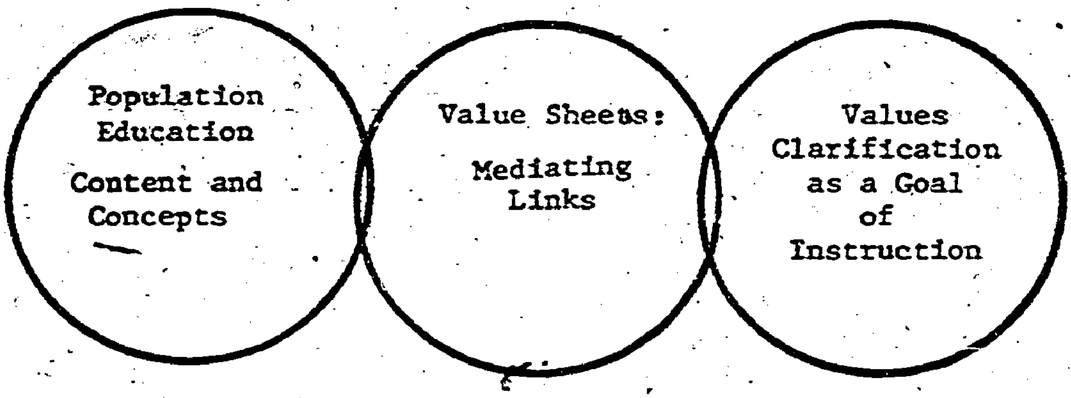


Figure 2: Illustration of how value sheets tie population content and concepts to decision-making and valuing instructional objectives.

Secondly, there are eliciting questions in the form of "discussion starters." These questions provide a frame of reference through which the teacher can guide students towards understanding the focusing context and content, towards relating this content and situation to the focus of the entire unit, and towards having students express their personal values and feelings. Although these questions help teachers guide the follow-up discussion, the teacher needs to be flexible and open. Questions prepared in advance are not to be rigidly adhered to nor followed in the sequence suggested by their order on the list. More effective questions would be similar to those provided as examples following the sample value sheet but are spontaneous reactions to ongoing class dialogue.

According to the approach of Casteel and Stahl (1975), there are at least six different formats in which value sheets may be written. Below is an example of one of these formats. The reader may wish to examine this value sheet in light of the model of values clarification presented above.[2]

Focus of the day's lesson and this value sheet: Genetics: Should genetics be used to limit or control population growth?

Social and Scientific Context:

The newly elected government of India has selected a committee whose members have come from all over the world to solve India's ever-increasing problem of overpopulation. The committee is composed of eight members: two geneticists, two economists, two agricultural leaders, and two religious leaders. Before deliberations begin, the committee reviews the situation and events leading to their presence.

[2]This value sheet was developed by a pre-service science teacher using the model described in this article and other materials co-authored by Stahl. The student's name is Ms. Rachel Milstead, a student of MUW. This activity is being used with her permission.

The total population of India is presently above the 600 million mark in an area of 1,300,000 square miles. This is more than twice the population of the United States, in only one-third the area. Statisticians project the population figure will reach one billion by the year 2000. Twenty-seven million people now live in only nine of India's largest cities. Eighty percent of the population live on small farms, the average size being about four acres. Most of India's people are very poor; a few are quite wealthy. Only some have moderate incomes of about $450 per family per year.

Agriculture, forestry, and fishing are the source of livelihood for four-fifths of the people. Increases in farm yields and production have increased significantly but still farms produce only 30 percent of the food necessary to sustain the population of India. Imports and aid from other countries of the world have always made up for this food deficit. Several successive years of unstable climatic conditions in the major food-producing nations have decreased the food surpluses of these nations. India has been informed that it can no longer expect to be fed by the rest of the world. At present, India can expect to have adequate food resources for about three years.

Faced with impending mass starvation, India's former government attempted to enact a mass, mandatory sterilization program. Outraged by this action, the people elected a new government which promised to solve the problem in a more rational way. The formulation of governmental committees and sub-committees along with public debates has led to the proposal of five possible policies for solving the problem. Interestingly, for the first time in memory, the mood of India's people is towards curbing their population. Public opinion polls have revealed that these are policies the public would support as long as all five were not enacted at the same time.

However, public opinion demands that only one policy be tried on a trial basis. If, and only if, this policy really begins to ease the situation will the people allow the implementation of any other policy. They are willing to give one policy a three-year trial. They give the government permission to bring in an outside panel of experts to decide which policy should be tried first. You are a member of this special outside committee.

The policies the Indian Government is considering for possible enactment are as follows:

A. All farm land will be taken over by the government to ensure maximum food production on state-run communes. Farmers are to receive four-fifths payment for their land and are to remain on their farmlands to work for the government.

B. The government will extend India's fishing rights by 250 miles and nationalize the entire fishing fleet. This will increase the food supply by only about 15 percent and will run the risk of war with other fishing nations.

C. All males and females of child-bearing age who choose to undergo sterilization procedures will each receive a government allowance of $50 per person for ten consecutive years.

D. All individuals who have been or are found to have "defective genes" are subject to immediate sterilization and all deformed or genetically-defective babies are to be destroyed at birth.

E. Crimes of murder, theft, bribery, and assault will be punishable by death. The sentence is mandatory and must be carried out within three days of the guilty verdict.

The Committee of Eight is asked to select <u>one</u> of these policies for immediate enactment by the Indian Government. You are one of that committee. When asked to identify which policy you recommend be adopted, you say ....

Your reasons for adopting this particular course of action are:

<u>Discussion Starters</u>:

1. In India, what is the major source of food for its people?

2. In the story, what is the cause of the present dilemma?

3. In the story, what event brought the new government to power?

4. What is the difference between the methods the old and new governments employed in seeking a solution to the population and food problems?

5. What is the relationship between genetics and sterilization?

6. What constitutes a "defective gene"?

7. If your policy is finally accepted for enactment, would you be happy for the people of India?

8. How would your Committee's decision affect India's population?

9. If you, as a citizen of India, had to choose between starvation and eating a "sacred cow," would your decision be an easy one?

SUMMARY AND CONCLUSIONS

Population Education instructional units seek to help students clarify relationships between population knowledge and situations and their personal values and decisions regarding population matters. A major aim of these units is the rational consideration and use of

scientific data as individuals examine alternatives and set policies which affect human populations and individuals. As described here, the values clarification strategy is one way population education teachers may plan for, implement, and achieve this instructional objective.

RESOURCES

Bibliography

Gustavus, S. O. and C. A. Huether. "Population Education in the Social Studies Classroom: A Survey of Social Studies Teachers." Social Education, Vol. 41, No. 1:28-32, 1977.

Gustavus, S. O. and C. A. Huether. "Population Education in U.S. Schools: A Status Report." Family Planning Perspectives, Vol. 7:203-207, Sept-Oct, 1975.

Population Education: Sources and Resources. Washington, D.C.: Population Reference Bureau, 1972.

Social Education (entire issue), Vol. 36, No. 4: 1972.

Organizations

In the area of Population Education, countless books and articles have been written and many of these are available on bookstore shelves and in nearly all libraries. Rather than present an extensive list of books, I have chosen to present a list of the major reference agencies, corporations, and institutions which could provide detailed bibliographies, pamphlets, and other instructional materials and information.

Bureau of the Census
Public Information Office
Department of Commerce
Washington, D.C. 20233

Center for Population Education
University of North Carolina
Chapel Hill, North Carolina 27514

Center for Population Research
National Institute of Health
Bethesda, Maryland 20014

Columbia Bookstore
915 15th Street, N.W.
Washington, D.C. 20005

Environmental/Population Studies
Huxley College
Western Washington State College
Bellingham, Washington 98225

Exotech Systems
525 School Street, S.W.
Washington, D.C. 20024

Office of Population Affairs
Dept. of Health, Education and Welfare
Washington, D.C. 20201

Planned Parenthood/World Population
810 Seventh Avenue
New York, New York 10019

The Population Council
245 Park Avenue
New York, New York 10017

Population Curriculum Center
College of Education
University of Delaware
Newark, Delaware 19711

The Population Institute
100 Maryland Avenue, N.E.
Washington, D.C. 20002

The Population Reference Bureau
1755 Massachusetts Avenue, N.W.
Washington, D.C. 20036

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Zero Population Growth
Los Altos, California 94022

REFERENCES

Casteel, J. D. and R. J. Stahl. Values Clarification in the Classroom: A Primer. Santa Monica, CA: Goodyear, 1975.

In the paper which follows, John Fowler has provided a succinct summary of this Nation's half decade of battle against pollution. He points out the strong overlapping of energy and environmental problems. In his view, education must include pollution of air, water, and land among its concerns. And since these problems cannot be pigeon-holed in the traditional disciplines, he urges that environmental education be interdisciplinary. The urgency of the environmental problems, the long lead times needed for solution, and the richness of their real-life examples encourage him to recommend that they be considered as part of the basic school curriculum building process.

POLLUTION

John M. Fowler

Pollution is a people-problem. People create it and it is people who define it. Pollution is something people don't want, a substance which they have added to the environment and which damages something they value: their health, their crops, or the beauty of their vistas, for instance.

Pollution has, therefore, grown with the human population. Early humans coughed in the smoky recesses of their cave homes, and later humans coughed and wheezed in the coal smoke of London and sickened from that city's fouled air and water at the beginnings of the modern era. Although isolated abuses (such as the burning of the smelly "sea coals" in 18th century London) did bring official concern and remedy, it has only been during the past few decades that the confluence of industrialization and explosive population growth has brought pollution the status of a national (and to some extent an international) problem.

It was during the national introspection of the 1960s that most of us finally looked around us and saw that the air and water were becoming foul and the land scarred and ugly. It was also in the '60s that accumulated medical and other scientific evidence began to convince us that this careless stewardship was costing us money. And that made a difference.

Earth Day, inaugurated in April, 1970, is perhaps the landmark of our growing environmental consciousness but the acts of our national conscience were those passed by Congress during the first half of this decade. The frontrunner was the National Environmental Policy Act (NEPA) of 1969 which was accompanied by the establishment of the Environmental Protection Agency (EPA). Also important were the 1970 Amendments to the Clean Air Act, the Water Quality Improvement Act of 1970 with its Amendments in 1972, the Solid Waste Disposal Act of 1965, the Resource Recovery Act of 1970, the Toxic Substances Control Act of 1976, the Ocean Dumping Act of 1972, and the Noise Control Act of that same year.

The early '70s were thus the years of environmental ascendancy. Strict auto emission controls were proposed, power plants were required to drastically lower the sulfur content of their fuels, cities and towns were given deadlines for "cleaning up their acts," and industries were required to establish timetables for meeting rigorous standards for air and water pollution.

Then we began to run out of energy. The beginnings of Oil Embargo in October, 1973, as we look back, may assume the same kind of importance in the history of pollution as did Earth Day. It is not yet clear whether it will be the beginning of even more effective environmental protection or the high water mark from which the "environmental movement" steadily ebbs. There are contrasting indications. The implementation of the original strict auto emission standards has been twice postponed. A major argument against them has been that they increase gasoline consumption. There has been a strong attempt in Congress to amend the Clean Air Act to allow power plants more freedom to burn coal. But this Congress did, finally, pass a strip mining bill that puts some federal muscle into that troublesome area of regulation.

Contrasts are also apparent within the administration's energy package. A great expansion in the use of coal, the most environmentally troublesome fuel, is called for. At the same time, there is a strong push for conservation which is from an environmental point of view, the single most beneficial energy policy possible.

It is not clear where the final balance will be struck. What has become abundantly clear since the embargo is that most environmental problems are energy problems, that the two crises now almost completely overlap. One will not be solved without solving the other.

It is thus not really possible to separate a full discussion of pollution from energy. For the purpose of this brief article, however, after these initial warnings, we will concentrate as narrowly as possible on pollution and read the nation's scorecard in the battle against it.

POLLUTION TODAY

The major areas of present-day pollution concern are air, water and land—which covers all of man's habitat. There are in addition to these broad areas a growing number of specific pollution targets. Noise pollution, hazardous substances such as pesticides (and others like asbestos, beryllium and mercury) and solid waste are the most important examples. There is a belated but widening concern over the purity of drinking water. What is the score after a half decade or so of struggle?

Air Pollution

The five "criteria" pollutants for which air quality standards have been set are particulate matter, the sulfur oxides, carbon monoxide, nitrogen dioxide, and the hydrogen oxides. A rough indication of where

each of these comes from and whether we are winning or losing in our efforts to control them is given in Figure 1.

There are both encouraging and discouraging signs in this graphic compilation of data, but the first point to note is that air pollution is, as we have earlier claimed, an energy problem. Only for the particulates does any other source challenge the supremacy of the automobile and the electric power plant.

As for trends, the most encouraging picture is for particulate matter, unburned carbon (soot), ash and other visible smoke components. The shift away from coal by electric utilities, the installation of control equipment on industrial and power plant furnaces and stricter regulations of the burning of solid waste have reduced this pollutant emission from 27 million tons per year in 1970 to 18 million tons in 1975. The anticipated large-scale return to coal may offset some of this gain over the next five years.

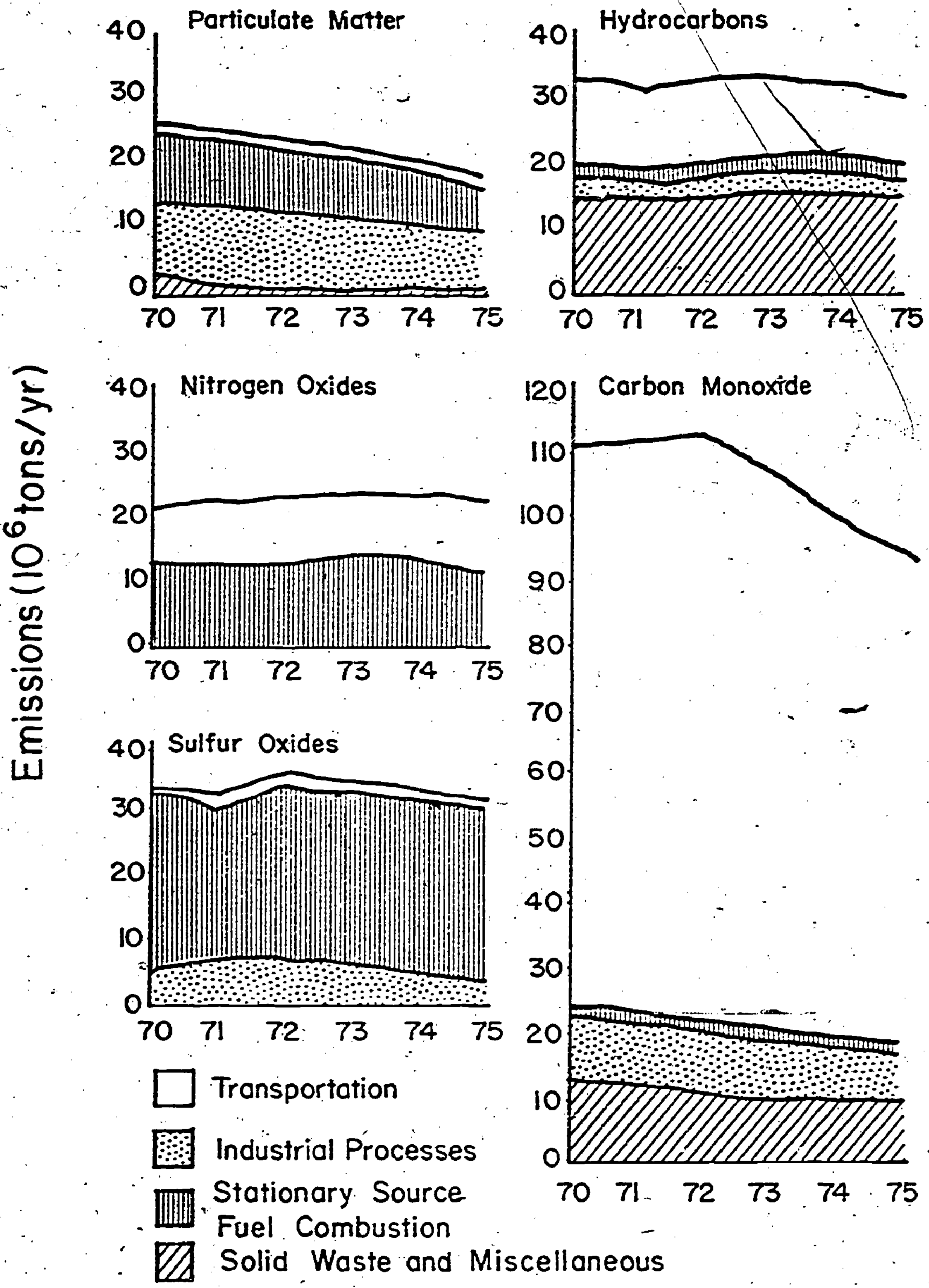
Sulfur oxide is formed when sulfur-containing fuel is burned. These emissions also decreased slightly, from 34 million tons in 1970 to 33 million tons in 1975. (They reached a peak level of 37 million tons in 1972.) Sulfur oxides are almost entirely a byproduct of the generation of electricity (and do their damage as sulfuric acid in smog.) They are the largest area of air pollution concern as we gear up to use more coal. Although this graph does not show it, the sulfur oxide pollution in metropolitan areas has fallen more rapidly than the average as more and more of the big power plants are moved to less densely populated areas and tall stacks are used to disperse the effluents. The "dirty" areas are getting cleaner but the "clean" areas are getting dirtier. (We can now see the Empire State Building a little more clearly but it's getting hard to see New Mexico's Ship Rock.)

The other large improvement was made in the control of carbon monoxide. This toxic substance is formed when carbon is not completely burned, and most of the nation's total is almost all from automobiles. The gradual appearance of new cars with better emission controls has reduced this pollutant from 114 million tons in 1970 to 96 million tons in 1975.

Unburned hydrocarbons are also largely a contribution of the automobile, formed by the inefficient combustion of gasoline. They have been brought under control by the emission standards but the reduction in their emission from automobiles has been offset somewhat by increases in their emission from industrial sources, from evaporation at gasoline stations (as our use of gasoline increases) and from the increasing use of solvents. The change from 34 million tons in 1970 to 31 million tons in 1975 is a 9 percent decline.

The emission of nitrogen oxides has increased, going from 23 million tons in 1970 to a peak of 26 million tons in 1973 and then falling back to 24 million tons in 1975. Nitrogen oxides are, along with the hydrocarbons, the most important ingredients of "photochemical" smog, the eye-searing, throat-irritating haze for which Los Angeles is famous (but which most urbanites now know).

Fig1: Calculated Total Emissions of Criteria Pollutants by Source Category, 1970-1975



Nitrogen oxides are formed whenever a hot fire exists in air. The responsibility for putting them into the air is shared by automobiles and power plants. They are now controlled to some extent in automobile emission but not in power plants. Further regulation apparently waits on better documentation of this hazard.

Generally speaking, the nation's air has improved over the past half decade. What about its water?

Water Pollution

Among the many different types of water pollutants, the ones of major interest are the decaying organic materials which deplete the water's oxygen (measured in terms of the biochemical oxygen demand: BOD), the total suspended solids (TSS), and the heavy metals and other industrial pollutants. Among the diverse sources, the three major categories are municipal waste water (sewage), industrial sources, and "nonpoint" sources such as agricultural and urban runoff. The contributions of BOD and TSS from each of these three classes of pollutants are shown in Table 1.

Table I*

Source	Pollution Contribution in billions of pounds/year	
	TSS	BOD
Municipal Wastewater	5.9	5.6
Industrial Discharge	117.9	4.3
Nonpoint Sources	3,698.0	45.0

*From The Seventh Annual Report of the Council on Environmental Quality, U.S. GPO, $3.50, 1976.

The regulatory focus has been on the improvement of municipal water treatment and industrial water treatment. About $5 billion was spent on water pollution by the federal government in 1976, largely for the construction of primary and secondary treatment plants and this will increase to almost $7 billion in 1977.

That all this attention is obtaining results is beginning to show up in this country's rivers. Of the 12 major rivers being monitored, most have shown slight decreases in pollution as measured by such indicators as fecal coliform bacteria and BOD. But these improvements start from a baseline condition (measurements began in the early '70s) in which almost all measurements showed pollution levels that made the water unfit for human contact.

The lakes are also in bad shape. In a recent stuc of a group of northeastern and north central lakes and reservoirs which were affected by municipal sewage discharges, 81 percent were in an advanced stage of eutrophication (the kind of nutrient enrichment that leads to unbalanced algae growth). As this nutrient enrichment process is gradually being understood, it becomes clearer and clearer that the triggering pollutant is usually either phosphorous or nitrogen. It is also clear that these pollutants are not just from sewage. Agricultural runoff is the most grievous offender, and the most difficult to regulate.

We have made only small improvements on our water. It must undergo complex physical and chemical treatment before we can drink it (and we still find 4,000 or so cases of water-borne disease each year). We are denied the pleasure of swimming in most of our rivers and in a growing number of our lakes. How is our land doing?

Land Pollution

Among the many different types of land use problems awaiting solution, the two forcing themselves more and more on our national conscience are mining and land reclamation and the disappearance of farm land.

The strip mining picture has brightened a little in the past five years. State requirements have been tightened and now there is a new federal law, but there is a long way to go. As is shown in Figure 2, of the 2,542,682 acres needing reclamation, the laws will require reclamation of only 614,239 acres—about a quarter of the total. We also see from this figure that coal surface mining accounts for about half of this land. If we double our coal output by 1985 and rely on strip mining for half of this, the total land problem will grow.

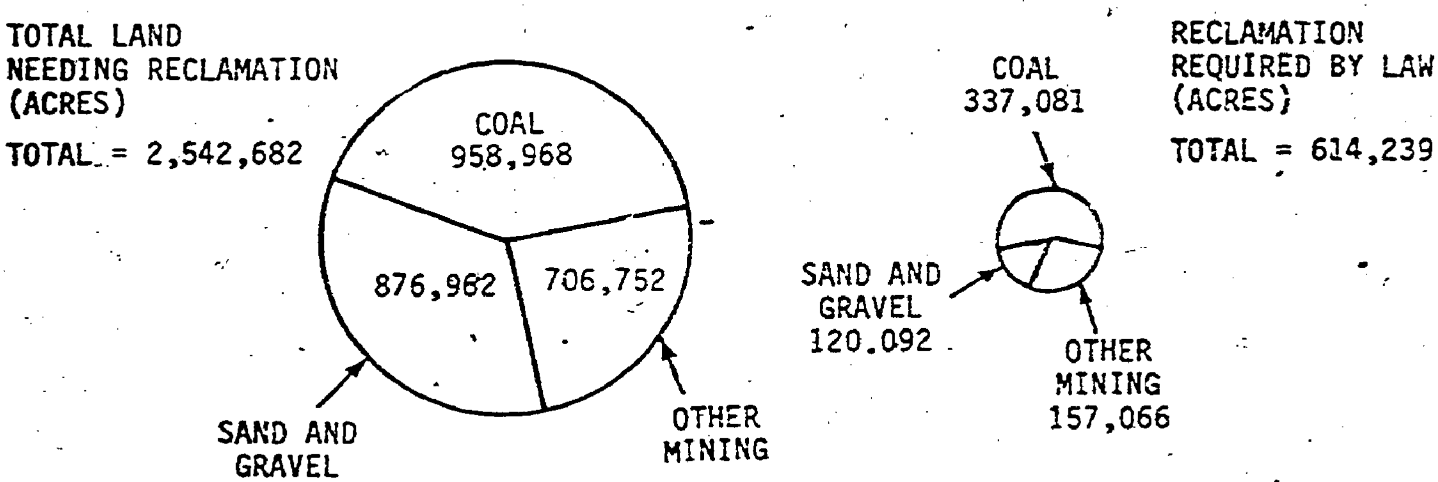


Figure 2: Status of Land Disturbed by Surface Mining in the United States as of January 1, 1974.

Figure 2 showed us that there were about a million acres of coal land needing reclamation. We are, however, losing a much larger chunk of land each year, for which there is no reclamation—the 1.25 million acres per year that are set aside for urban expansion, roads, and reservoirs. Much of this land is rural cropland. Although urban land and roads make up only 2.7 percent of our total land, the amount of land set aside for these purposes has doubled since 1950. Before we become overly concerned for the future, however, we can take heart from the statistics which show that, since 1970, non-metropolitan population is growing faster than that in the metropolitan areas (even though the farm population continues to fall) and this may slow urban expansion. In some parts of the country (Suffolk Co., Long Island, is the prominent example) the rich farm land is being deliberately protected from development.

Solid Waste

Disposal of our leftovers has also been a land use problem but it is now spreading its disfavor to air and water as landfill space becomes scarce. This nation generates about 4.5 billion tons of waste per year (170 million tons of this collected by municipalities). This annual throw-away includes, for instance, 48 billion cans, 26 billion bottles and jars, 7.6 million television sets, 7 million cars and trucks, 30 million tons of paper, and 4 million tons of plastic.

It is costing us more and more to dispose of this waste, a cost rising toward $25 per ton. The energy crisis helps us here because serious efforts are under way to convert the organic waste to fuel and to recycle the metals and some of the paper. Solid waste is becoming a "resource," but recycling and conversion won't provide a complete solution. We must, finally, develop energy-economic, long lasting and recyclable consumer goods. ("A bottle in the hand is worth two in the brush!")

Other Pollutants

We have touched on the major topics perhaps, but the actual list goes on and on. State, federal, and local governments are just beginning to wrestle with noise and more battles, such as New York's opposition to the SST are ahead. The nuclear power controversy has kept radiation and radioactive waste before us. We have only begun to look at pollution in the workplace and to worry about the health of those who work with dangerous metals, poisons, and carcinogenic materials. DDT is regulated but not forgotten, and new dangers from pest control chemicals are constantly being uncovered.

The battle costs money. The Council on Environmental Quality estimates a cost to this country of $325 billion from 1973-1982, $195 of this federal money. As large as this is, the incremental amount is not frightening. Costs of pollution control will probably not be more than 1 percent of the GNP in any year and are expected to add, at most, 0.3 percent to price inflation. When the added jobs,

the energy savings, and the original goal—a better environment—are added in, it seems a battle with the price.

POLLUTION AND EDUCATION

As I have written elsewhere with respect to energy, there are certain definite criteria we should apply when we consider the introduction of social/environmental/economic issues into the curriculum. They must be urgent, they must be long-lived, and they must be teachable at different grade levels and in different disciplines.

The urgency is clearly there for pollution. I would require that the problem be long-lived—that its urgency be measured in at least half-decades—in order that it match the slowness of innovation in education. The problem must still be there at the end of curriculum development, testing, revision and textbook infusion. The pollution problems will still be there.

The issues must be teachable at a variety of grade levels and in a variety of disciplines. Said in another way, education must see a role for itself. There are roles. The first is to raise consciousness levels, create awareness. It is important, in fact, that pollution education move beyond the "nature walk" level and become a vehicle for conventional education. Even in the brief resume of this article, one can easily see opportunities for teaching/learning materials in the sciences, social studies (civics, cultural comparisons, individual and group responsibility), mathematics, career planning, home economics, and many others. The need and opportunity for value clarification and decision-making exercises are equally evident.

The major advantages that teaching on and about and with this country's pollution problems would bring to education is that they are real problems and thus demand that the classroom open its doors and windows to the real world. And like all real problems they resist being pigeon-holed under titles of history, civics, physics, chemistry, biology, etc. If education is to treat them properly, then the interdisciplinary component of teaching will increase and education will be better for it. If education prepares a new citizenry which understands these problems and is committed to the search for solutions, we will all be better for it.

POSTSCRIPT

I have so far written in the spirit of a new discovery: "Look what I found, look what we can do." Pollution or perhaps we should say "environmental education" has been in fact growing in strength in our classrooms over the same five years. It has, however, grown without plan or design and in many different directions. A critique or review of EE programs is beyond the scope of both my experience and the space allotted to this article. The brief bibliography which follows has some suggestions for further reading. It does appear

clear from the current literature that educators and environmentalists are still searching for the most productive ways to integrate an understanding of and concern for the environment and of the way humans pollute and abuse it, into the total curriculum. It is the intent of this article to provide some evidence for the continued urgency of that task. For pollution is a people problem; people create and define it. And people must solve it.

RESOURCES

Following is a brief list of resources. Pollution is such a large subject that only basic source documents are provided. The reader should use them to find material of particular interest.

Environmental Education

Disinger, J. F. (ed.). Environmental Education Information Report: A Directory of Projects and Programs in Environmental Education, Third Edition. ERIC Information Analysis Center for Science, Mathematics and Environmental Education. Columbus, Ohio: Ohio State University, 1975.

Marlett, Robert (ed.). Current Issues in Environmental Education. ERIC Information Analysis Center for Science, Mathematics and Environmental Education. Columbus, Ohio: Ohio State University, 1975.

Tanner, R. T. Ecology, Environment, and Education. Lincoln, Nebraska: Professional Educators Publications, Inc., 1974.

Gargliano, L. J. and B. J. Knape (eds.). Environmental Education in the Elementary School. Washington, D.C.: NSTA (#471-14712), 1977.

Pollution

Dasbach, J. M. Science for Society, Sixth Edition. Washington, D.C.: American Association for the Advancement of Science, 1976.

The sixth in a series of useful and comprehensive bibliographies.

EPA. EPA Protecting Our Environment. Washington, D.C.: Office of Public Affairs, United States Environmental Protection Agency, 1977.

This is a very brief concise summary of pollution as seen from EPA.

EPA. Trends in the Quality of the Nation's Air. Washington, D.C.: Office of Public Affairs, United States Environmental Protection Agency, 1977.

This is a very brief but quantitative summary of air pollution with good graphics.

USGPO. Environmental Quality, The Seventh Annual Report of the Council on Environmental Quality. Washington, D.C.: USGPO (#041-010-0031-2), 1976.

This report was $3.50. These reports are issued each year and are the single best summary available. The eighth annual report, covering 1977, will be available in mid-January 1978.

Journals

The teacher who wants to keep abreast of developments in either environmental education or pollution is referred to the following journals.

The Journal of Environmental Education, Heldref Publications, 4000 Albermarle Street, Washington, D.C. 20016.

The EPA Journal, U.S. Environmental Protection Agency, Superintendent of Documents, USGPO, Washington, D.C. 20402.

REFERENCES

Fowler, J. M. "Energy Education and the 'Wolf Criers'." The Science Teacher, Vol. 43, No. 3:25-32, 1976.

Energy, Population, Pollution, and now Natural Resources; the subjects covered in the first four papers of this yearbook might be considered the "big four" of science/society issues. They are not, of course, four topics, but rather one large four-dimensional super topic and super problem. How our generation deals with this super problem will affect the future of our planet. Jack Carter has chosen to look at natural resources from the point of view of a need for conservation. He proposes the need for education to help create a new ethic of conservation.

NATURAL RESOURCES

Jack L. Carter

INTRODUCTION

A large number of thoughtful people with diverse backgrounds and training have accepted the hypothesis that when we consider our available natural resources, available usable energy, rate of pollution, increasing world population, present economic systems and established value systems, the destiny of mankind is presently on a collision course. The problem has been defined but the time line has not been well established, thus the unbalanced equation for this formidable reaction is still in process. Our formal system of education, plus other communication systems including the mass media, have a major role to play in identifying the paths this reaction may take, and in aiding all mankind in attempting to balance this equation.

If this homeostatic equation for the planet earth's life support systems is as seriously tilted and out of balance as it presently seems to be, then not just science teachers, but all teachers, have an obligation to identify this equation for their students and to help their students to see the relationship that exists among present knowledge and skills, value systems, and the power of mankind to define the future of all life on earth.

Public school science teachers could become the people who will tip the scale toward survival. But based on our present limited picture of holistic science and homeostasis, and our inability to conceptualize and teach problem-solving, plus the value system we convey by our methods of teaching and evaluation, this may not be possible. Unless major changes are made in our methods of teaching science, especially to those students who do not plan careers in science, it seems unlikely that we will make contributions equal to those who teach the social sciences and humanities.

BACKGROUND

Natural resources have been defined as those actual and potential forms of wealth that mankind can utilize for welfare and survival. The availability and distribution of natural resources over the earth vary greatly in quantity, quality and reuseability, thus it is impossible to separate their use and misuse from world politics and economics. One who has lived or traveled over the green and fertile upper midwestern United States, and has then had the experience of traveling through the dry barren rock-strewn and dusty countrysides of north central India or the dry deserts of northern Mexico, cannot help but be thankful for the opportunity to live in a portion of the earth that is rich in natural resources and that has an equable climate.

The most widely accepted and usable classification of natural resources is presented by Oliver S. Owen in his textbook titled <u>Natural Resource Conservation: An Ecological Approach</u>. I present it here with the author's permission.

I. <u>Inexhaustible</u>

A. <u>Immutable</u>. Seemingly incapable of much adverse change through man's activities.

1. <u>Atomic energy</u>. Vast quantities of fissionable materials available in granitic rocks.

2. <u>Wind power</u>. The result of climatic conditions.

3. <u>Precipitation</u>. An unlimited supply. Man, however, will very likely alter the distribution pattern in the future through weather modification.

4. <u>Water power of tides</u>. Resulting from sun-moon-earth relationships.

B. <u>Misusable</u>. Little danger of complete exhaustion, but when improperly used their resource quality may be impaired.

1. <u>Solar power</u>. The total amount received by growing plants has been reduced by air pollution caused by man.

2. <u>Atmosphere</u>. Local and world-wide pollution because of smoke, exhaust fumes and nuclear fall-out.

3. <u>Water of oceans, lakes, and streams</u>. All currently being polluted at increasing rates as a result of human activity.

4. <u>Water power of flowing streams</u>. The reaction of water to gravity.

5. <u>Scenery in its broadest sense</u>. Aesthetic values subject to impairment by human activities. Examples: Mt. Rainier, Blue Ridge Mountains, Oregon and Maine coastlines, Grand Canyon.

II. Exhaustible

A. Maintainable. Those resources in which permanency is dependent upon method of use by man.

1. Renewable. The living (biotic) or dynamic resources whose perpetual harvest is dependent upon proper planning and management by man. Improper use results in impairment or exhaustion with adverse socio-economic consequences for man.

a. Water in place. The quantity and quality of water in specific places of use: streams, lakes, subterranean sources.

b. Soil fertility. The ability of soil to produce plant substances desirable to man. Renewing soil fertility takes time and money.

c. Products of the land. The resources grown in or dependent on the soil.

1) Agricultural products. Vegetables, grains, fruits, fibers, and so on.

2) Forests. Source of timber and wood pulp.

3) Forage land. Sustains herds of cattle, sheep, and goats for the production of meat, milk, leather, and wool.

4) Wild animals. Deer, wolves, eagles, blue birds, bullfrogs, spotted salamanders, sphinx moths, fireflies, etc.

d. Products of lakes, streams, and impoundments. Freshwater fish: black bass, lake trout, catfish, etc.

e. Products of the ocean. Marine fish: herring, tuna. Marine mammals: porpoises, gray whales, fur seals, etc.

f. Human powers. Physical and spiritual.

2. Nonrenewable. Once gone there is no hope of replacement.

a. Species of wildlife. The passenger pigeon, great auk, and Carolina parakeet have become extinct. They represented the end products of perhaps a million years of evolution.

b. Specimen wilderness. Within several human life spans wilderness values cannot be restored even with the most dedicated program.

B. Nonmaintainable. The mineral resources. Total quantity is static. Mineral resources are regarded as wasting assets. When destroyed or consumptively used, they cannot be replaced.

1. Reusable. Minerals whose consumptive usage is small. Salvage or reuse potentialities are high.

   a. Gem minerals. Rubies, emeralds, etc.

   b. Nonconsumptively used metals. Gold, platinum, and silver; some iron, copper, and aluminum. These metals can be extracted and reworked into new products: jewelry, silverware, vases, etc.

2. Nonreusable. Those minerals with a high or total consumptive use. Exhaustion is a certainty.

   a. Fossil fuels. When consumed, gases (potential pollutants), heat, and water are released.

   b. Most nonmetalic minerals. Glass sand, gypsum, salt, etc.

   c. Consumptively used metals. Lead in high-octane gasoline and in paint, zinc in galvanized iron, tin in toothpaste containers, iron in cans, etc.

This classification system is of special value to teachers and students because it not only lists our available natural resources, but it categorizes our natural resources in a manner that places the responsibility on man to determine the future availability and usability of many of the resources. By carefully studying this classification system we come to realize that the future availability of any single resource is not in the hands of the gods, but rests in the ability of mankind to determine the use of these natural resources, and consequently the future of all life on earth.

Historical Attitudes

The historical roots of the Western tradition have resided in the bedrock of arrogance toward nature. The Christian religion, which is considered by most authorities of the religions of the world to be the most anthropocentric, has encouraged mankind to take dominion over the earth, and to exploit nature to his own ends. The Christian concept of continual progress, which is unknown to many religions of the world, has encouraged man to exploit the environment for his fulfillment. If the day-to-day activities of Western cultures and the attitudes we demonstrate toward all life on earth are any indication of our belief systems, the Copernican proposal that the earth is not the center of the solar system, and the Darwinian theory of evolution have never been fully accepted by Western societies. A large segment of our society is as anthropocentric today as it was in the Dark Ages. The idea of a cycle of life, of which death is natural for all forms of life including man, continues to limit our ability to live a life of consideration and respect for other forms of living things.

In the past century this nation has become aware of two intrinsic dilemmas; one is the conflict of private property vs. public property, and the other confronts the interface of a philosophy of increased consumption (growing economy) and that of decreased consumption and conservation. President Theodore Roosevelt first identified this national conflict when he recognized the need to protect national interests in such resources as water, timber, wildlife, soil and minerals. In 1908, President Roosevelt invited governors, interested congressional leaders, and scientists to the first White House conference on natural resources. Based on the conclusions of this conference, several hundred million acres were withdrawn from private use, and conserved as part of our natural resources inventory.

Since this first national major effort practically every president has made some contribution to the national conservation movement. Franklin D. Roosevelt created the National Resources Board, the Civilian Conservation Corps (CCC), the Soil Erosion Service, and the Tennessee Valley Authority (TVA) in 1933, and in 1937 he took a leadership role in the passage of the Wildlife Restoration Act. To varying degrees, all of our recent presidents have considered the conservation of our natural resources a major national objective. Except for periods of national emergency; i.e. World War II, Korean War, and the war in Vietnam, we have devoted a considerable portion of our national wealth to conservation. It is also important to observe that at times when the national economic picture has been lagging we have used conservation programs to reduce unemployment through such activities as the Public Works Administration (PWA), the CCC of 1933, and the Youth Conservation Corps (YCC) of the past decade.

The Development of Conservation Ethic

Over the past several thousand years Homo sapiens have been transformed from paleolithic hunters and gatherers that moved in search of food and exploited the available natural resources as they traveled, to an agricultural-intensive and pastoral species that have for several reasons become confined to smaller areas or single localities for their livelihood. But in spite of this more sedentary life that has allowed the human population to skyrocket and cities to grow, the gene pool of man, the exploiter and hunter, has not been greatly altered. We live and earn our daily bread in cities, but on weekends we exodus to the country. A summer home on a lake or in the mountains is the ultimate objective of vast numbers of city dwellers. Changing the biological (genetic) evolution of man is a slow process and will require centuries, but for good or bad, with time man is adapting to new conditions.

The Spanish, French and Dutch explorers who first came to North America were in many ways exploiters and plunderers just as were many of the first hunters and trappers who roamed the western United States. But the geometric increase in our population and the migration of Homo sapiens to the ends of the earth have placed pressure on man to relinquish the Horace Greeley philosophy of "go west, young man" and to follow the teaching of Henry David Thoreau to maintain and improve the quality of life in the place where we are, be it Walden Pond or the Concord, Massachusetts, jail.

In recent times the writings of Aldo Leopold, Barry Commoner, Garrett Hardin, Paul Ehrlich, John K. Galbraith, Kenneth Boulding, Rachael Carson and others have made us aware of the concept of limits, which is not only contrary to our biological nature but challenges the religious, social, economic, and political systems of the United States. Like the difficulty man has accepting death, so some economists, politicians and a few scientists have said it cannot happen here and continue to speak out against any philosophy of limits and the acceptance of an environmental ethic that would result in the conservation of our natural resources.

But ever so slowly, the kicking and screaming as we go, we are moving toward a natural resources conservation ethic. E. F. Schumacher has reminded us in his book, Small is Beautiful, that this title holds meaning for much of the world, and it can also hold meaning for those of us who have lived our adult lives in the United States. We are discovering that smaller portions of fresh meat, smaller homes, smaller cars, smaller families, and smaller budgets can all be beautiful. The acceptance of this idea can make economic sense, improve our physical and mental health, and allow us to share a larger portion of our national wealth with a poverty stricken and hungry world. While one segment of our society is saying we must produce and purchase more "things" if we are to preserve our capitalistic form of government and come to know joy, those folks that are interested in performing services to their fellow man are saying sharing is where the joy of living resides. The ethics of serving, conserving and sharing are important enough to a growing segment of our society that they are willing to carry their banner against those who would shout for more competition, private ownership, and increased personal property. So a conservation ethic continues to grow because we can afford to share and conserve with our fellow Homo sapiens; but also because we dare not overlook this opportunity to share and conserve with all forms of life.

A MODEL FOR NATURAL RESOURCES CONSERVATION EDUCATION

Like most major concepts and ideas we teach in our schools, natural resources conservation is an integrative idea and probably should be taught as appropriate throughout the science, social science and humanities curricula. Rocks, trees, and birds are intricate parts of our natural ecosystems about which scientists have gathered information, economists have designed monetary schemes, and artists have written sonnets and cantatas.

As is true with most subjects taught in schools, when teachers want to express their views or feel a need to teach some aspect of natural resources conservation it will be placed on the printed or unprinted agenda. But only when teachers develop the personalized intrinsic need to expose their students to this subject and feel safe handling such a large integrative idea will natural resources conservation become a regular part of the curriculum.

Past experiences have taught us that if we want to maximize learning, planning and scheduling will be required. This is especially true with large and diverse concepts. We often teach bits of knowledge such as the structure and function of parts of corn or bean seeds, but seldom do we integrate this knowledge into a larger concept such as the relationship that exists among the evolution of double fertilization and endosperm, the evolution of primates, and the economic and cultural problems related to feeding the world. This kind of teaching demands thoughtful planning, and a very different kind of curriculum development.

Proposed here is a three-part attack on the task of developing a natural resources conservation education model. The approach described is not unique, and it has been used by the author as a procedure for developing courses and instructional units within a variety of biology courses. In this model we must 1) recognize the need for knowledge or a body of sound information, 2) have an interest in developing cognitive skills in our students and preparing students to use inquiry skills in their own learning, and 3) identify, develop, and clarify those values that are important in a conservation ethic.

Learning and Teaching About Natural Resources

Many teachers have an inadequate basic knowledge of the earth's known available natural resources. Their backgrounds and college experiences in the field of natural resources conservation are limited. Textbooks of elementary and middle school science, as well as secondary and college textbooks of the physical, earth and biological sciences contain little information describing the world's available natural resources. If this is the situation then a major obligation of those who teach science, and those who teach teachers of science, is to surround themselves with the available literature and to develop habits of reading and studying this literature. If a teacher is going to stimulate students to want to learn, the teacher must want to read and study. Many teachers continually encourage their students to become knowledgeable and informed. But when we examine the reading and study habits of teachers, as students do, we recognize these teachers as somewhat dishonest, because they are not scholars and students of their discipline. No one recognizes this dishonesty and insincerity as quickly as do students.

The bibliography of this paper contains the titles of ten common journals and periodicals that publish a variety of articles that can add to the knowledge of those who wish to stay informed about the current available data and issues concerning natural resources. These are only a few of the many such journals available to teachers. Beyond these major publications teachers have an obligation to be aware of state and local issues and to bring these issues to the attention of their students.

Teachers must also work with administrators and help them to be informed of new and important library and audio-visual materials. An excellent way for a teacher to obtain such information is to read the book review and audio-visual columns in many of the journals listed in the bibliography of this paper.

Field experiences can paint a vivid picture of the need for natural resources conservation that will persist forever in the lives of many students. Such problems as overgrazing, erosion, air and water pollution, improper strip-mining practices, and inadequate bus service surround us and are available for all of us to observe and study. But many times, as students grow up surrounded by these problems, they fail to see them unless the well-informed teacher brings them to their attention.

Improving Cognitive Skills of Students

A major objective for all education is to improve cognitive skills. The science teacher must accept the responsibility for improving the basic cognitive skills; i.e., reading, writing and arithmetic, plus the specialized skills appropriate to the science they teach. Teachers at all levels continually seek scapegoats on whom they may lay the blame for their students' inability to read, write and handle numbers. Only when teachers of high school and college science accept the students where they are when they enter their classes and see themselves as teachers of reading, writing and arithmetic, plus other vital skills, just as elementary school teachers are teachers of a wide variety of cognitive skills, will secondary schools and colleges start to realize their full potential toward strengthening democratic systems.

The ultimate objective of cognitive learning is to carry students of all ages through Jean Piaget's four levels of development to where students can use formal operations to solve immediate and long-range problems. For far too long we have centered our teaching on concrete operations and failed to teach the skills necessary for formal operations. But then all too often, in order to get nice bell-shaped curves in our grading, we have tested for formal operations. We are slowly beginning to realize that the fault does not lie with students but must rest squarely on teachers. Defining terminology and labeling the parts of the various systems is only the first phase of concrete operations, and these steps must lead to a synthesis of knowledge and a demonstrated understanding of the interdependence among species to live within the known and unknown limits in our available natural resources.

Learning the skills of comparative reading and questioning are a step in the right direction and must be encouraged. Designing individualized and group activities that involve laboratory and field experiments and result in interpreting data and presenting data are valuable experiences. Studies of local habitats including the chemistry and biology of ponds, aging of plants and animals (including man), and studies of weather and earth science all bring students in contact with real and important problems. Interviews with elected political officials, civil servants, parents and older citizens within a community can establish a picture of the local natural history and the need for conservation of natural resources including land, water, and energy.

Values and A Conservation Ethic

Teachers and their styles of teaching and evaluation have great influence on students. Just as parents, television and peer groups have all played a major role in influencing the behaviors each of us conveys to those in our environment; so the behaviors of those of us who teach influence students who attend our classes. This places teaching near the pinnacle of influence and responsibility and makes those values that we demonstrate to our students of prime importance to future generations.

If the concepts of conservation, sharing, openness, honesty, and trust are desirable behaviors for the larger society, then we must design classrooms and class activities that encourage and reward these values. If we hope to promote exploitation, competition, closure, dishonesty, and distrust in the community and throughout the world, then we must design activities that will foster and reward these behaviors. Each teacher makes a personal decision regarding the behaviors he or she will reward and the path their classes will follow. As we write our lesson plans, design and administer evaluative instruments, select the reading assignments, and design class activities for our students we are altering their behaviors. If our objectives include sharing, then the class activities should be designed in such a way that only through cooperation and sharing can the activity be successfully completed. A classroom can operate out of a threat system and a teacher can gain respect through fear of reprisals against those students who do not give respect, or the same classroom can build trust out of respect for a teacher model that exemplifies an open society on which a democratic society can survive and flourish. Many of the basic concepts we will want to identify in teaching students to understand the need to conserve our natural resources demand that we will be willing to share. We do not all need homes on lakes or in the mountains, because through our tax dollars we can enjoy thousands of lakes and mountain scenes that are being conserved for us to enjoy now, and for our children and grandchildren to enjoy through the ages. Through sound conservation practices we can all enjoy whooping cranes from Padre Island off the coast of southern Texas to northern Canada, as they cross North America twice each year. This is sharing for the common good because we all have an investment in the success of this endangered species. This same principle of sharing can be stimulated and encouraged through classroom activities that are based on cooperation rather than competition.

Can Homo sapiens learn to conserve and share our natural resources? Will we balance the homeostatic equation for the planet earth in time to save our life support systems? Can those of us who teach convey the necessary knowledge, teach the vital cognitive skills, and set an example through our value system that will keep mankind from tumbling headlong into extinction? The present student generations can make a difference, but will they?

RESOURCES

Bibliography and References

Atwood, Genevierie. "The Strip-Mining of Western Coal." Scientific American, Vol. 233, No. 6:23-29, 1975.

Barbour, Ian G. Science and Secularity. New York: Harper and Row, 1970.

Bates, Marston. The Forest and the Sea. New York: Mentor Book, New American Library, 1960.

Bethe, H. A. "The Necessity of Fission Power." Scientific American, Vol. 234, No. 1:21-31, 1976.

Brainerd, John W. Nature Study For Conservation. New York: The MacMillan Company, 1971.

Brainerd, John W. Working With Nature—A Practical Guide. New York: Oxford University Press, 1973.

California State Department of Education. Ekistics. Sacramento: Bureau of Publications, California State Department of Education, 721 Capitol Mall, 1973.

Commoner, Barry. Science and Survival. New York: The Viking Press, 1966.

Daedalus, The Oil Crisis in Perspective. Journal of the American Academy of Arts and Sciences. Cambridge, MA: Harvard University, Vol. 104, No. [illegible] 1975.

Dasmann, Raymond F. Environmental Conservation. New York: John Wiley and Sons, Inc., 1972.

Detwyler, Thomas R. Man's Impact on Environment. New York: McGraw-Hill Book Company, 1971.

Eggert, James. What is Economics? Los Altos, CA: William Kaufmann, Inc., 1975.

Ehrenfeld, David W. Biological Conservation. New York: Holt, Rinehart and Winston, Inc., 1970.

Ehrlich, Paul R. and Anna H. Ehrlich. Population, Resources, Environment. San Francisco: W. H. Freeman and Company, 1970.

Food and Agriculture, A Scientific American Book. San Francisco: W. H. Freeman and Company, 1976.

George, Susan. How the Other Half Dies. Montclair, NJ: Allanheld, Osmun and Company Publishers, Inc., 1977.

Giddings, J. Calvin and Manus B. Monroe (eds.). Our Chemical Environment. San Francisco: Canfield Press, 1972.

Hamilton, Norman, K. and J. Galen Saylos (eds.). Humanizing the Secondary School. Washington, D.C.: Association for Supervision and Curriculum Development, 1969.

Harmin, Merrill. What I've Learned About Values Education. Bloomington, IN: Phi Delta Kappa Educational Foundation (Fastback Series), 1977.

Harte, John and Robert H. Socolow. Patient Earth. New York: Holt, Rinehart and Winston, Inc., 1971.

Holdren, John P. and Paul R. Ehrlich (eds.). Global Ecology. New York: Harcourt Brace Jovanovich, Inc., 1971.

Leopold, A. A Sand County Almanac. New York: Oxford University Press Inc., 1949.

Mangum, Thomas E., III and Thomas R. Mertens. Ecology—The Environmental Crisis. Chicago: Educational Methods, Inc., 1973.

Owen, Oliver S. Natural Resources Conservation: An Ecological Approach. New York: The MacMillan Company, 1971.

Pollard, William G. "The Long-Range Prospects for Solar-Derived Fuels." American Scientist, Vol. 64, No. 5:509-513, 1976.

Potter, Van Rensselaer. Bioethics—Bridge To The Future. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1971.

Putman, John J. "India Struggles to Save Her Wildlife." National Geographic, Vol. 150:298-343, 1976.

Sale, Larry L. and Ernest W. Lee. Environmental Education In The Elementary School. New York: Holt, Rinehart and Winston, Inc., 1972.

Schumacher, E. F. Small Is Beautiful. New York: Harper and Row, Publishers, 1973.

Stoker, H. Steven and Spencer L. Seager. Environmental Chemistry. Glenview, IL: Scott, Foresman and Company, 1972.

Tuan, Yi-Fu. "Our Treatment of the Environment in Ideal and Actuality." American Scientist, Vol. 58, No. 3:244-249, 1970.

White, L. "The Historical Roots of our Ecological Crisis." Science, Vol. 155:1203-1207, 1967.

White, Peter T. "This Land of Ours—How Are We Using It?" National Geographic, Vol. 150:20-67, 1976.

Woodwell, George M. "Managing the Earth's Surface." Natural History, Vol. 85, No. 10:16-18, 1976.

Journals and Periodicals

The following publications commonly carry articles concerning natural resources conservation that are of value to teachers and students.

The American Biology Teacher, 11250 Roger Bacon Drive, Reston, Virginia 22311.

American Scientist, 345 Whitney Avenue, New Haven, Connecticut 06511.

BioScience, 1401 Wilson Boulevard, Arlington, Virginia 22209.

Catalyst: For Environmental Quality, 274 Madison Avenue, New York, New York 10016.

Ceres, UNIPUB, 650 First Avenue, P.O. Box 433, Murray Hill Station, New York, New York 10016.

Environment, 415 Madison Avenue, New York, New York 10017.

National Wildlife, 534 N. Broadway, Milwaukee, Wisconsin 53202.

Natural History, Membership Services, P.O. Box 6000, Des Moines, Iowa 50340.

The Science Teacher, 1742 Connecticut Avenue, NW, Washington, DC 20009.

Scientific American, 415 Madison Avenue, New York, New York 10017.

By their very nature science/society issues are interdisciplinary. One of the difficulties with dealing with these issues in the school setting is the emphasis on disciplines as an organizing function in schools. This approach has served our schools in the past, and attempts at developing interdisciplinary courses have been disappointing so far. Nevertheless, new classification systems must be developed if the school is going to consider "real world" problems which have an interdisciplinary nature. Paul Hurd proposes a need for a study of human behavior. What he means by this and how it might be carried out is discussed in the following paper.

HUMAN BEHAVIOR

Paul DeHart Hurd

BACKGROUND

Efforts to understand why human beings act as they do have challenged philosophers, religious teachers, and people generally since the onset of human existence. People wonder about their own actions and their interactions with others. The sum of these actions is described as human behavior. The phrase "human behavior," implies that the behavior of humans is not wholly like that of other organisms but is special. The central question is: What is unique about human behavior?

The study of human behavior is an exploration of the ways human beings adapt to their total environment. The total environment includes all aspects of our natural, man-made, and social surroundings. Human behavior is the way we respond to some situations within our environment, including other people. Responses may be biological in origin or they may be a product of learning; they are seldom purely one or the other. Human behavior is closely related to societal processes and are influenced by one's culture. The human adaptive capacity is more complex and exceeds that of all other organisms.

The primary purpose of education has always been to influence the behavior of people—on the one hand increasing the adaptive potential of the individual, and on the other, fostering the social good. At various times the educational conditions necessary to achieve these purposes either conflict with human needs or become outmoded. Society changes, the culture assumes wider dimensions, or the human image acquires new perspectives. Unless the curriculum keeps pace with these changes it becomes maladaptive for the individual, a potentially disintegrating force in society; a crisis in the educative process itself results. We are now experiencing such a curriculum crisis especially at the intermediate and secondary school levels.

Along with changes in our society, culture, self-image, and environment are those taking place in the scientific enterprise itself. Social processes, life events, environmental conditions, science and technology have become irrevocably intertwined and mutually dependent. We have no term to describe what is emerging nor is it possible at this time to identify all the interacting components. It does seem evident that an effective resolution of the problems and issues affecting human behavior today depends upon differing modes of thinking and a reconceptualization of relevant knowledge. For the teaching of science this means a greater recognition of the science/society/individual intersects for linking science teaching to human actions.

RATIONALE

Why has the question of human behavior become a curriculum concern in the teaching of science? The concern emerges from a number of sources. It arises from a combination of individual, societal, and science happenings th[illegible] have come into focus within the past decade.

Of the many surveys of student interests in or out of science the results are remarkedly similar: ... students want to know more about themselves, more about other people, more about how to get along with people and more about life and living. If these results are taken as educational goals they add up to a demand for a study of human behavior ~~to be~~ part of the curriculum. The recent pressures by students for greater "relevance" (human concerns) in the curriculum substantiate their interests.

Society has reached a turning point—a leap forward or backward—the direction is not clearly indicated. Human beings have only recently become aware that they are the first animals to be fully responsible for their own future evolution: How people act toward other people and toward their total environment will determine not only our quality of life but also whether *Homo sapiens* should be regarded as an endangered species.

Scientists in general and biologists in particular (the neobiologists) have increasingly, in recent years, expressed a need for developing a science of humankind. Bertalanffy in his book on *Robots, Men, and Minds* (1967) states that what we need is a "scie[illegible] of and for man." Margaret Mead's presidential address at the 1976 convention of the AAAS was a plea for "the development of a fully human science." The new college-level programs in human biology, human ecology, science-technology-society, and environmental science are representative of current efforts to formulate a science of humankind.

Little is being done in schools generally (although there are noteworthy efforts) to help young people understand and "find" themselves in this new world which Boulding (1965) has described as a "cultural mutation." It hasn't taken long, however, for the charlatans, the pseudoscientists, the mystics, the psychics, and the peddlers of drugs to move in with recipes for modifying human behavior. In general, excluding a few schools of psychotherapists, what youth is offered is

a hodgepodge of nonintellectual, nonscientific substitutes for realistic problem-solving behavior. Drugs, mystical experiences, food fads, therapies (analytic, behavioral, humanistic, or transpersonal), new "religions," megavitamins, meditation rituals, stylistic exercises, modeling and mimicry, exotic dress and life styles, encounters, astrology, a variety of new "gods" and gurus, and more all represent devices, procedures, or efforts to modify human behavior. There has been a modest, short-lived positive impact from some of these efforts, tremendous harm from others, and almost no understanding of human actions for emerging life conditions. What is indicated, however, is the importance of a serious study of human behavior as a part of the elementary and secondary school curriculum.

Whatever our behavior as human beings, it is interpreted as adaptive or maladaptive. A major goal of science teaching ought to be to increase adaptive capacities favorable to human existence. The demands upon the human organism today exceed its genetic adaptability; adjustment to life conditions depends largely upon learned capabilities.

ISSUES

A major issue in developing science curriculum materials about human behavior is the lack of a holistic science of human beings. There is no theory to guide the study of matters concerned with the well-being and survival of humankind. There is no single discipline that can properly be called the science of human beings. There are, however, a number of disciplines that can be classified as "human sciences," some of which are relatively new. A few of these fields are human, urban, and social ecology; human engineering management; biochemistry and biophysics; psychobiology, psychochemistry, and environmental psychology; human biology; biogeography; human paleontology; physical and cultural anthropology; experimental and social psychology; sociobiology; bioethics; archeology; ethnology; human physiology, genetics, anatomy, and medicine; sociology; evolutionary history; plus a long list of related fields (for example, linguistics, economics, political science, philosophy, religion). In one way or another all of these disciplines harbor information relative to human behavior, and in varying degrees any study of human behavior overlaps a range of these disciplines. Human behavior emerges from systems of responses: it is complex, comprehensive, multicausal and interactive. The curriculum task is one of getting it all together: a task of selecting relevant concepts, as well as developing a synthesis.

A meaningful presentation of human behavior requires that it be taught in an integrative mode and in a transdisciplinary context. Opportunities must be provided for students to experience concepts shared (for example, biological and cultural evolution) by several disciplines. What is sought is unity in the study of human behavior. What exists is an aggregate of separate concepts with discipline labels that need to be brought into an integrated curriculum framework.

No one has yet developed an accepted classification of human behaviors. There is agreement, however, that human actions have an individual and a social dimension and these interact. It is recognized that every individual is genetically unique, not only from all humans now on earth but those yet to be born. Each person interacts with the natural environment and social milieu in ways that are distinctive and which vary in time, context, and perceptual development. For these reasons we may never have a widely accepted taxonomy of human behaviors.

Biologically, culturally, socially, and philosophically the conditions influencing human behavioral patterns are greatly affected by the part science and technology (and its handmaiden industrialization) play in our lives. Without some degree of scientific, and technological enlightenment, it is not likely that a person in our society can successfully meet the contingencies of modern living.

Society and culture change, creating ever new demands on human actions. Under these conditions human behavior must, if it is not to be maladaptive, possess an element of plasticity. A few of the cultural shifts which currently call for new behavioral patterns are: changes in family structure, urbanization, industrial automation, longevity, world economic and ecological interdependence. Failure to recognize change or inability to respond to it results in confusion, frustration, discouragement, apathy, loss of confidence, a weakening of self-image, loneliness, and hopelessness in young people—all maladaptive responses.

The growth and development of the individual as a biological and social organism is also a form of change which influences how human beings respond and cope. As we mature biologically, cognitively, and affectively our perceptions of people, society, and the world about us changes and so does our behavior. What is appropriate behavior for a child is not considered responsible behavior for an adolescent, and adolescent behavior differs from that of adults. What is appropriate behavior at any phase of development is influenced by the interaction of biological factors, cultural forces, social norms, learning, and perceptual insights.

If we wish to study human behavior as it really is then we cannot avoid moral and value issues. Human behavioral responses are interpreted as good or bad, desirable or undesirable, cooperative or antisocial, ethical or unethical, moral or immoral, either for the individual or for society. The same behavior may be acceptable in one culture or subculture but not in another. Aggressive behavior is viewed one way in war times or in competitive sports but differently in other circumstances. Laws, customs, codes, sanctions, religions, and norms exist to interpret the acceptability of human actions. There are times when people need to define new sets of values. Currently we are faced with this problem. Bioethics has become a new field of study and the questions being raised affect all of us.

The decisions (choice of actions) people make are influenced by the values they accept as well as by the knowledge they possess.

Making decisions is a major way human behavior is expressed. Valid and reliable decision-making processes thus become a major component in teaching human behavior. The cognitive skills required for rational decision making differ in many respects from those of scientific inquiry.

The complexity of human behavior is undoubtedly a factor in its neglect in the school curriculum at the precollege level. Another factor is its multidisciplinary nature which makes it difficult to assign a place in the conventional curriculum. A third factor is that the scientific study of human behavior is only a few decades old and then only recently has generalizable knowledge started to emerge. Not the least of these factors is the science teacher's feelings of insecurity about his/her own knowledge of human behavior. This situation arises from college and university science courses taught as "pure" disciplines, neglecting the humanistic and social ramifications of the subject matter. Only by accident is a teacher likely to have even the minimum number of courses from the range of disciplines that include the elements of human behavior.

The study of behavior has more roots in the biological sciences than in the physical sciences. While the study of animal behavior has been a part of elementary and secondary school science for a century, the teaching of human behavior has been avoided. Modern social studies programs include aspects of human behavior, particularly those topics with a cultural relevancy. The fastest growing subject, in terms of offerings and enrollment in high schools, is psychology. Psychology courses typically include generalizations about individual human behavior but neglect social behavior. Sociology, seldom taught, focuses on the group behavior of people. Literature, business, health, economics, political science and philosophy courses typically include topics on some phase of human behavior. Because we lack a science of human beings (only beginning to emerge), human behavior is everybody's curriculum interest and, as it turns out, no one's in particular. The student never sees the "picture" of what it means to be a human being or to learn in any coherent manner how people adjust to reality. Until such time that we develop a generic curriculum for the elementary and secondary schools, the scientific study of human behavior could properly be a part of the science curriculum.

The behavior of organisms has long been a part of the elementary and secondary school science curricula. Human behavior, however, has not been taught directly. The emphasis has been on analogies between animal and human behavior based on data from observations of rats and chimpanzees. And this is the issue: Human behavior is not like that of sub-human species, though similarities exist. For instance, deprivation of normal social experience during early life affects the normal development of human beings and of some animals, but not of others. Because of language the adaptive behavior of human beings is cumulative. Other animals, including our closest relative the chimpanzee, know little more than 10,000 years ago, and their behavior is little different. Behavior is not predictable across species nor does an environmental condition bring about the same response in all animals. The spectrum of human behaviors exceeds that of all other animals in number and character. Human actions are more variable,

less predictive, and more adaptable than that of other animals. Experimental studies of animal behavior are important for the hypotheses they generate for exploring human behavior. Any meaning for human actions, however, must be validated in a human context. There is a value in teaching the behavioral characteristics of a vertebrate and then showing how culture added to these characteristics differentiates corresponding human behaviors. Human behavior is unique among animals.

Learning about human behavior is most meaningful when experienced in terms of real-life problems and issues. This suggests a curriculum organization based on current science/social problems that students can investigate as participant observers. In this way the student becomes aware of his own behavioral patterns and recognizes the diversity of responses among his peers, other age groups, and subcultures. At the same time students gain experience in value clarification, decision making, and how scientific knowledge can be applied to human affairs.

SCIENCE-RELATED TOPICS IN HUMAN BEHAVIOR

A representative sampling of science courses, curriculum projects, science textbooks, and articles on teaching human behavior at the pre-college level provides a list of topics now being taught. These topics have been grouped about as they appeared in the literature with some overlapping. Omitted from the list are nonscience-based topics about human behavior such as those emerging from religion, philosophy, economics, political science, and those more purely social in nature. Also omitted are topics exclusively from primate behavior studies where human actions are not the direct focus of attention. The listing should be regarded as just that and not as a course or module outline for any particular grade level.

I. <u>Nervous system and behavior</u>

 A. Autonomic functions

 B. Central nervous system

  1. Learning
  2. Thinking
  3. Habits
  4. Memory and forgetting
  5. Artificial intelligence and computers

 C. Sensory responses

  1. Sensation (sensory structures)
  2. Visual and auditory development
  3. Sensory deprivation
  4. Perception (biological and cultural factors)

II. Biological rhythms

A. Sleeping/waking cycle

1. States of sleep
2. Sleep deprivation
3. Dreaming

B. Hypnosis

III. Growth and development

A. Biological

1. Infancy
2. Childhood
3. Adolescence
4. Adulthood (maturity)
5. Aged (senescence, senility)

B. Experiential (cognitive, affective)

1. Social
2. Cultural

C. Development of self-image (self-awareness)

IV. Chemicals influencing behavior

A. Biochemical changes within body

1. Hormonal control of behavior
2. Mineral deficiencies and excesses
3. Chemical additives to food
4. Protein deficiencies

B. Psychoactive drugs

1. Sedatives (depressants)
2. Tranquilizers
3. Stimulants, energizers (amphetamines)
4. Addictive drugs
5. Hallucinogens

V. Biophysical environment

A. Behavioral adaptations to climate and geography

B. Environmental cycles influencing behavior

C. Environmental pressures (population density, depletion of resources, pollution)

D. The designed environment (human habitats, architecture)

E. Physiological efficiency (health)

VI. The natural history of human beings

A. Biological evolution of behavior

B. Cultural evolution of behavior (cultural patterns)

C. Social norms, rules, roles, etc. in behavior

D. Social organization (people as groups)

1. Family, peer groups, gangs
2. Adaptive rituals
3. Sex roles
4. Shared behaviors

VII. Science, technology, industrialization

A. Effects of goods and services on behavior and l[illegible]e styles

B. Changing family life patterns

C. Blurring of differences in male and female work patterns

D. Human-factors engineering (bioengineering)

E. Behavior patterns in nonindustrial societies compared with high technology countries

VIII. Motivation (factors)

A. Physiological (pain, fear, hunger, thirst)

B. Learned motives (urges, drives, sentiments)

C. Species maintenance (sexual)

D. Gender factors and culture

IX. Communication

A. Verbal (language and human evolution)

B. Nonverbal (gestures, facial expression, posture)

X. Personality

A. Socialization (enculturation)

B. Physical/social environmental factors

C. Coping behaviors

XI. Bioethics

XII. Maladaptive behavior

A. Errors of metabolism (protein deficiency, obesity, PKU, epilepsy, albinism)

B. Retardation (causes)

1. Neurological
2. Biochemical

3. Chromosome impairment
4. Trauma (birth, disease, accidents, strokes)

C. Abnormal behavioral factors

1. Neurological

a. Disturbances in sensory input and motor output
b. Brain scars and epilepsy
c. Lack of oxygen
d. Genetic (PKU, Down's syndrome)
e. Microorganisms (meningitis, syphilis, sleeping sickness)
f. Hormonal (Parkinson's disease)
g. Degenerative (senility, multiple sclerosis)

2. Psychological (neurobiological)

a. Neurosis (anxiety, depression, hysteria)
b. Psychosis (schizophrenia)
c. Social (stress, poverty)

INVESTIGATING HUMAN BEHAVIOR

The methods for studying human behavior, while scientific in approach, are not typically like the classical experimental techniques used in science laboratories. Human biological and culture diversities limit the extent to which precise definitions, exact measurements, replicable findings and non-biased explanations are possible in behavioral studies.

In the human sciences there is always the question of whether data obtained under laboratory conditions can be applied in principle to relevant nonlaboratory actions. The results of experimental studies of physiological processes, sensory responses, skill learning, and psychochemical effects on body functions are examples of research translatable outside the laboratory with dependability. Studies of stress, attitudes, social roles, emotional responses, motivation and other culturally related factors are typically not translatable.

People live as they do and do what they do under circumstances as they now are. These are the conditions of the real-world laboratory. Direct observation under natural conditions and without the subjects' knowledge of the investigation is one of the most useful ways of studying human behavior. The investigator may function as a participant observer (a member of the "gang") or as a detached observer (reacting to a "mugging" on film). In both instances information is gathered, ordered, and conceptualized. In both the hard sciences and behavioral sciences the methods and tools used for seeking information on a problem vary with the characteristics of the problem. Some of the information gathering techniques in the behavioral sciences in addition to experimental procedures are: 1) case studies; 2) surveys and sampling; 3) interviews (open, structured, depth); 4) tests and inventories; 5) records (medical, school, employment); 6) artifacts and tools; 6)

questionnaires; 7) self-inquiring; 8) content analysis; 9) verbal reports or testimony; 10) photography. Much of the information one learns about human behavior comes from directed "people watching," and lots of it.

RESOURCES

Curriculum Materials

Federal agencies and private foundations have supported various curriculum development groups to produce materials on human behavior. Most of the projects were financed after 1965 and represent the "second generation" of curriculum development. Completed or experimental materials are available at all grade levels from preschool through high school. The authors of the different modules present their special orientation toward the study of human behavior; however, in varying degrees each has used a transdisciplinary approach in designing instructional materials. The projects illustrate the possibility of a sequential and hierarchical organization for a curriculum theme based on human behavior.

Exploring Human Nature

(Education Development Center, Inc., Cambridge, Massachusetts)

A transdisciplinary curriculum for 11th or 12th grade using recent data from the biological and social sciences, focused upon developing an understanding of human nature and human behavior. (NSF financed)

The Human Behavior Curriculum Project

(In development 1977 Carleton College, Northfield, Minnesota) A series of modules for high school incorporating a scientific approach to the study of human behavior. (NSF financed)

Biomedical Interdisciplinary Curriculum Project

(In development 1977 Leonard Hughes, M.D., director, Oakland, CA) Unit IV. "What Influences Human Behavior?" The central concept of this unit is the impact of social influences on behavior; includes attitudes toward drug use. (NSF financed) For high school.

Exploring Childhood

(Educational Development Center, Newton, Massachusetts) A series of modules on human development and behavior in which older students associate with younger children in various contexts. (NSF supported) For junior and senior high school.

The Schools Council Integrated Science Project

(Longmans, Essex, England)
"Human Behavior" is one of the topic books (units) in the SCISP curriculum for high school. It includes descriptive material on a range of topics about human behavior.

Schools Council Integrated Science Program (England)

(Available through Penguin Books, Baltimore, MD)

"Science and Decision Making" is an independent module (topic book) in the Schools Council Integrated Science Project (SCISP). The author (William Hall) uses six case studies in science "to illustrate the many decisions that have to be taken on the 'balance of probability'." Designed for secondary school level.

Unified Science Program

(Educational Research Council of America, Cleveland, Ohio)

"Perceiving My World" is a transdisciplinary unit designed to assist students in exploring one aspect of human behavior. For grades 7-10. The use of instruments to extend the human senses is emphasized. A second unit, "It's Time for a Change," is designed to develop an awareness of and adaptability to a changing society.

Constructive Resolution of Aggression-Producing Situations

(A curriculum project cooperatively developed by the Lakewood Public School System (Ohio), The Education Research Council of America (Cleveland, Ohio), and The Ohio State Department of Education.)

A developmental curriculum to help young people acquire an understanding of 1) the complexity of human behavior, 2) the motivations that may underlie various forms of abuse behavior, and 3) how to resolve daily frustrations constructively. Teacher and student materials available for the programs at each educational level.

"The Model Me" (Senior High School)
"Dealing with Aggressive Behavior" (Middle School or Junior High)
"Dealing with Causes of Behavior" (Grades 1-5)

Human Sciences Program

(Biological Sciences Curriculum Study, Boulder, Colorado)

Behavior is an experimental module in this program and includes activities involving both human and animals. Two other modules in the program, Rules and Perception include activities designed to develop an awareness of human behavior patterns and their significance. (NSF financed) For grades 6-9.

Project Social Studies Curriculum Center (University of Minnesota)

Unit I: "Man's Behavior, the Physical Basis," a resource unit, for grade 7, on human behavior with an emphasis upon biological factors. (USOE financed)

Man: A Course of Study

(Curriculum Development Associations, Washington, D.C.)

A series of 60 units in which children compare animal and human behavior and also cultural differences in human behavior. The

central theme is "What is human about human beings?" For grade 5. (NSF financed)

Social Science Laboratory Units

(Science Research Associates, Chicago, IL)

A series of grade level units (grades 4-8) on human behavior. (USOE financed)

Anthropology Curriculum Project

(University of Georgia, Athens, Georgia)

"Development of Man and His Culture" (Grades 2 and 5)
"Cultural Change: Modernization and Industrialization" (Grade 6)
"Life Cycle" (Grades 7-9)

The materials are designed to provide a cross-cultural study of human behavior. (USOE financed)

Human Behavior and Potential

(Educational Research Council of America, Cleveland, OH)

A series of pupil units and teacher handbooks on human behavior for each grade level from preschool through grade six. Separate Teachers' Course Books and Readings in Human Behavior have been developed for use by teachers at the elementary school and the secondary school levels.

Audiovisual Materials

There are literally hundreds of films or slide series which deal with human behavior for use in schools. It is not possible to describe each series but information is available from commercial distributors and most university film service centers. The Educational Development Center (Newton, MA) has produced projected materials for the curricula it has designed. Other sources of films (a representative list) on human behavior are:

BFA Educational Media
2211 Michigan Avenue
Santa Monica, CA 90404

McGraw-Hill Films
1221 Avenue of the Americas
New York, NY 10020

Science and Mankind, Inc.
Two Holland Avenue
White Plains, NY 10603

A Selected Bibliography on Human Behavior

The emerging "science on humans" is essentially a new discipline whose roots lie in many disciplines. Its newness consists of efforts to bridge these fields and to reconceptualize the relevant knowledge from each to form a unified discipline of "human science." The literature on "human science" is expanding rapidly as writers seek to place their specialty in a broader context than that of a single discipline. One who wishes to be informed about the "new movement" must read widely but selectively.

The books in this bibliography provide a background for the topics that are commonly found in a science curriculum which includes the study of human behavior. The list is not intended to be exhaustive, but rather the reverse—to provide an overview. Most of the books are available in paperback editions.

Aronson, E. The Social Animal (2d ed.). San Francisco: W. H. Freeman, 1976. [An examination of the relevance of sociopsychological research in terms of major problems besetting contemporary society.]

Berelson, B. and G. A. Steiner. Human Behavior: An Inventory of Scientific Findings. New York: Harcourt Brace, and World, 1964. [This book is a classified inventory of research "findings" about human behavior that are generalizable and for which there is a good amount of scientific evidence.]

Brown, R. and R. J. Herrnstein. Psychology. Boston: Little, Brown and Co., 1975. [A general psychology introductory textbook organized around problems of common interest to college students rather than seeking to present a unified theory of psychology.]

Chapple, E. D. Culture and Biological Man: Explorations in Behavioral Anthropology. New York: Holt, Rinehart and Winston, 1970. [The book has a strong biological focus in considering such dimensions of culture as the interplay of environment and technology, and the importance of cooperative human actions.]

Cohen, Y. A. (ed.). Man in Adaptation: The Biosocial Background and Man in Adaptation: The Cultural Present (2d ed). Chicago: Aldine, 1974. [The two volumes provide a systematic overview of the biological, social and cultural adaptations of man in his emergence and evolution.]

Darbach, J. M. (ed.). Science for Society: A Bibliography (6th ed). Washington, DC: American Association for the Advancement of Science, 1976. [The best single source of references to the major science-society issues about which all socially and morally responsible individuals must sooner or later make decisions.]

Doby, J. T.; A. Boskoff; and W. W. Pedleton. Sociology: The Study of Man in Adaptation. Lexington, MA: D. C. Heath, 1973. [An overview of human social behavior with an emphasis upon concepts of knowledge, technology, organizations, and ideology in the context of human adaptation.]

Eisenberg, J. F. and W. S. Dillion (eds.). Man and Beast: Comparative Social Behavior. Smithsonian Annual III. Washington, DC: Smithsonian Institute Press, 1969. [A symposium report on the origin and basic mechanisms of social behavior in animals and man.]

Gelatt, H. B.; B. Varenhorst; and R. Carey. Deciding (Student book) and Deciding: A Teacher's Guide. Princeton, NJ: College Entrance Examination Board, 1972. [Deciding is a course to assist junior and senior high school students in how to make well-informed and well-considered decisions about themselves, their education, and their future.]

Hilgard, E. R.; R. C. Atkinson; and R. L. Atkinson. Introduction to Psychology (6th ed.). New York: Harcourt Brace Javanovich, 1975. [An overview of psychology with an emphasis upon 1) the biological and experimental, and 2) the personal and social aspects of human behavior.]

Hinde, R. A. Biological Bases of Human Social Behavior. New York: McGraw-Hill, 1974. [The author examines animal behavior and its relevance to human behavior and then, for most of the book, explores aspects of human social behavior.]

Jorgensen, J. G. (ed.). Biology and Culture in Modern Perspective. Readings from Scientific American. San Francisco: W. H. Freeman, 1972. [The articles are selected to present an overview of explanations about the origin, biological variations, and social development of man.]

Potter, Van R. Bioethics: Bridge to the Future. Englewood Cliffs, NJ: Prentice-Hall, 1971. [The author explores the relation between ethical values and biological facts and the meaning this relationship holds for dealing with presentday bio-social problems.]

Proshansky, H. M.; W. H. Ittelson; and L. G. Rivlin (eds.). Environmental Psychology: Man and His Physical Setting. New York: Holt, Rinehart, Winston, 1970. [A selected series of papers dealing with the relationship between behavior and the man-defined environment.]

Reynolds, V. The Biology of Human Action. San Francisco: W. H. Freeman, 1976. [The author uses a biological frame of reference to relate cultural and normative ideas and discusses their meaning for understanding human behavior.]

Roe, R. L. (ed.). Anthropology Today. Del Mar, CA: CRM Books, 1971. [An introductory anthropology textbook with over thirty contributing writers emphasizing a holistic approach to the study of human comparative behavior. The book is not a collection of articles.]

Superka, D. P.; C. Ahrens; J. E. Hedstrom; L. J. Ford; and P. L. Johnson (eds.). Values Education Sourcebook. Boulder, CO: Social Science Education Consortium, 1976. [Summarizes approaches to the teaching of values and reviews a wide variety of educational materials dealing directly with values and value issues. The book also includes an annotated, classified bibliography of over 400 citations on values education materials.]

REFERENCES

Bertalanffy, Ludwig von. Robots, Man, and Minds: Psychology in the Modern World. New York: G. Braziller, 1967.

Boulding, Kenneth E. The Meaning of the 20th Century: The Great Transition. New York: Harper Colophon Books, 1965.

Mead, Margaret. "Towards a Human Science," Science, Vol. 191, No. 4230:903-909, 1976.

The working title of this paper was: "Hypothesis: Current Programs Concerned with Sex Education are Inadequate." The statistics cited in this paper are frightening. William Mayer has written a very powerful paper. In his own words: "I have written this article in response to literally hundreds of letters we get annually from teachers regarding problems of sex education. Not only are teachers largely ignorant of the facts of sex education but they are not equipped to counter attacks on them and the school system by organized anti-sex educationists. It seems to me the greatest service that could be accomplished in the ABTS Yea[illegible] is to provide such ammunition to be communicated to teachers o[illegible] teachers." (From correspondence with the editor.)

SEX EDUCATION

William V. Mayer

BACKGROUND

In the process of curriculum development, needs assessments are required in order to demonstrate the necessity for the introduction of new material into a given curriculum. But what of materials currently in the curriculum? What does observation tell us about their effectiveness? Are they meeting the needs of today? Curriculum content is in need of continuing assessment. If curriculum content is to be changed, then evidence must be presented that such change is necessary. This paper considers demonstrated need for expanding current sex education programs and the data here presented support the thesis that sex-related information is needed. Because of the controversial nature of sex education and its role, science educators, teachers and teacher trainers must have significant data at hand to support the need for sex education and to counter anti-sex-related information pressures.

In addition, however, sex education programs must be evaluated to insure that they are doing an adequate job. Many schools, under one name or another, offer information concerning sex but observation has led to the formulation of the hypothesis that current programs of sex education for America's youth are inadequate either because they do not reach those needing the information or they do not emphasize the concerns of the target population. If this hypothesis is correct, what evidence is there to support a change in our current approaches to sex education? The following data[1] are presented regarding the effectiveness of current sex education programs both within and without the curriculum as well as for use as indicators of need by which to direct future efforts in sex education.

---

[1]The data in this paper not otherwise credited are from Chapter 8, Sex Education, by William V. Mayer, in the "Biology Teachers' Handbook," 1978. John Wiley and Sons, Inc., New York.

Sexually Transmitted Diseases

As evidence of the role sexual activity has come to have in health treatment, health officers now refer not just to venereal disease alone but often use the term sexually transmitted diseases (STD). There are at least 14 separate diseases now identified as being sexually transmitted and they have exploded into a world-wide epidemic. For just one of these, Dr. Bruce Webster of the New York Hospital of the Cornell University Medical Center said: "The public would panic if any other disease were advancing at the rate gonorrhea is" (Blakeslee, 1975).

It is estimated that if venereal disease keeps climbing in Los Angeles at the present rate, fully one in five of the city's present high school students will have contacted either gonorrhea or syphilis by the time he/she graduates. As infectious diseases, syphilis and gonorrhea are out-ranked in incidence only by the common cold. These venereal diseases are now first among reportable communicable diseases. The number of VD cases reported each year exceeds the number of cases of strep throat, scarlet fever, measles, mumps and hepatitis combined. It is estimated that 800,000 American women have gonorrhea but don't know it and can easily pass it on to sex partners. There were 874,161 new cases of gonorrhea reported in this country in 1974, the highest in 55 years of recordkeeping. Because only a fraction of the cases are reported, it is estimated that gonorrhea infects 2.5 million Americans. A five-year average in Colorado for gonorrhea was 5,387 new cases annually; for syphilis, 345 new cases annually. These statistics also indicate that venereal disease is not primarily an adult phenomenon. Persons 15 through 19 accounted for nearly 21 percent of the gonorrhea cases in Colorado and a little more than 5 percent of the syphilis cases reported in 1975. Only 2 percent of the VD patients treated in St. Louis clinics were prostitutes. "Prostitution is not where it's at with VD," says Robert M. Nellis, an investigator with the San Francisco City Clinic, "It's Johnny next door and Suzie up the street" (Newsweek, 1972).

There are a half million Americans with untreated syphilis today and this year their ranks will be joined by 85,000 new cases. Data indicate that VD strikes hardest in the cities. There are 12 cases of syphilis for every 100,000 persons nation-wide. But, Newark ranks first among cities with 124 per 100,000, followed by Atlanta and San Francisco. For gonorrhea, the national case rate is 308 per 100,000 but in Atlanta the incidence is an astronomical 2,511 per 100,000, and in San Francisco 2,067. Fully 6 percent of the women having babies at one major hospital in Los Angeles had gonorrhea. It would be unfair to indicate that this is just a city problem. Reported gonorrhea cases quadrupled between 1969 and 1970 in Arlington, Virginia. In Prince Georges County, Maryland, a major suburb of Washington, D.C., gonorrhea has increased five-fold in the last decade. It is particularly rampant among young Americans. At least one in five persons with gonorrhea is under 20. In 1971, more than 5,000 cases were found among youngsters between 10 and 14 and 2,000 among children under 9. Dr. Walter Smartt, Chief of the Los Angeles County Venereal Disease Control Unit estimates that the probability that individuals will acquire VD by the time they are age 25 is about 50 percent (Newsweek, 1976).

In the third paragraph it was indicated that sexually transmitted diseases were minimally 14 in number; yet available data describe only two, the classic venereal diseases gonorrhea and syphilis. This is primarily because laws require this reporting, so that more data on them are available. However, other sexually transmitted diseases such as the herpes simplex virus (HSV) of the genitals are now skyrocketing in incidence. It was estimated that some 250,000 cases of HSV would be reported in 1975. In Atlanta's Grady Memorial Hospital about 1 percent of the maternity cases have active genital herpes infections during their pregnancy and as many as one-quarter of these have the infection at the time of childbirth. Present data suggest that if a baby from such a patient is not delivered by caesarean section, it stands at least a 25 percent chance of dying from a herpes infection and, of those who survive, about one-third will have serious medical problems. These data are reported by Dr. Andra J. Nahmias, Professor of Pediatrics and Chief of Infectious Diseases and Immunology at Emory Medical School (Leger, 1974). In addition, pregnant women with herpes type II virus have about three times as many spontaneous abortions as women without the infection, and there is a definite link between venereal herpes and cancer of the cervix. In one study, women with herpes infections were shown eight times more likely to develop localized cervical cancer than the control group. Six percent of the women who get herpes type II infections will contract cervical cancer within five years, and this is data on just one of the numerous sexually transmitted diseases. We are in the midst of an epidemic of venereal diseases to which children as young as nine years of age are contributing a disproportionate share of the data.

Childhood Pregnancy

A second source of data that supports the hypothesis that our present mechanism of providing sex-related information is inadequate is childhood pregnancy. Every third pregnancy in the United States involves a teen-ager, and 30,000 of these pregnancies are in girls under 15 years of age. More than 200,000 teenagers gave birth out-of-wedlock in 1974. In 1975, illegitimate births (4,988) in Washington, D.C. exceeded legitimate births (4,758) to make it the first American city in which this has occurred. Forty-six percent of these illegitimate births were in the teenaged population. More than half of all the illegitimacy in the country occurs in the teenaged population and the numbers are rising. Between 1971 and 1974 there was a 12 percent increase in illegitimate births to white girls age 15 to 19 and a 5 percent increase among black teenagers. In the same three-year period, illegitimate births to white girls under 15 increased by 32 percent, with a 3 percent increase for blacks. If not for quite a number of "quickie" marriages to turn pre marital conceptions into legitimate births, these data would be even more gloomy. These figures also discount abortions, without which the illegit-imacy figures would rise even higher. Again in 1975 in Washington, D.C. the number of abortions (9,819) exceeded the number of births (9,746) (Denver Post). One-third of all abortions involve teenagers (Denniston, 1976).

Officials of the Planned Parenthood Federation of America confront a disturbing new problem—how to handle the increasing number of young teenagers seeking birth control information. Girls of 9, 10 and 11 years

of age regularly ask for birth control devices. In 1974, 15,000 girls under the age of 16 requested help from the 165 Planned Parenthood medical affiliates around the country—a 25 percent jump over the previous year. The San Francisco/Alameda, California Office Medical Director, Dr. Gerry Oliva, estimates that 10 percent of the teenagers seeking counsel are 14 or under and she says that she is not surprised to see 12-year-olds anymore (Newsweek, 1976).

This change has come about at a time when there are more teenagers in the population and when teenagers are becoming sexually more active earlier. Because of better nutrition, the age of menarche is falling by three or four months every decade. In 1850, it was 16-1/2 years, today it is 12-1/2 years; thus, there are more teenage years when a girl can become pregnant and, with the swing away from early marriage, more years when she can have an illegitimate child.

Data continually show ever-increasing sexual activity at earlier and earlier ages accompanied by abysmal ignorance. An Ann Landers column for April 20, 1976, printed a letter from a high school senior listing the following "facts" circulating among the 13 to 18 year-old age group:

1. A girl can get pregnant only one day out of every month.

2. The first time a couple has sex the girl can get pregnant, but she is safe the second or third time the same day or evening.

3. It isn't possible to get VD more than once. The medication that cures VD gets into the system and makes you immune for life.

4. If a girl doesn't have a climax she won't get pregnant.

5. It isn't necessary to take the 'pill' regularly. If a girl takes it just before she has intercourse, she is safe for 24 hours.

6. If a pregnant girl eats a lemon every day for two weeks, she will have a miscarriage.

In 1973, Judith S. Rubenstein, while conducting research for a doctoral dissertation at Harvard, administered the sex education vocabulary checklist (Rubenstein, 1974). This consists of 112 randomly-ordered, sex-oriented words to which the student reacts through four options or degrees of interest varying from "very much" to "not at all" and including "I don't know what the word means." The administration of the checklist to 166 ninth-grade students revealed the ten top interest items for both girls and boys were: venereal disease, birth control, sexual intercourse, love, pregnancy, enjoyment of sex, abortion, sex offenses, guilt about sex, and prostitution. The 11 least known items common to both boys and girls were: voyeurism, prophylactic, Wasserman test, celibacy, sodomy, double standard, saltpeter, promiscuity, masochism, I.U.D., and transvestism. Girls were more interested

than boys in the reproductive aspects of sexual intercourse. The four top high-interest items were: birth control, abortion, pregnancy, birth control pill. Boys, on the other hand, were more interested in the non-reproductive aspects with the top three high-interest items being venereal disease, sexual intercourse, and enjoyment of sex. Each sex displayed an ignorance about matters relative to the other. The least known words unique to girls were: scrotum, nocturnal emission, and condom. The least known words unique to boys included: hymen, hysterectomy, cervix, menopause, and douches.

These data support the contention that teenagers don't yet seem able to cope with their emerging sexuality. Three out of four unmarried pregnant girls questioned in a 1971 study by Drs. Kanter and Selnick said they had not wanted to become pregnant, but only 13 percent of them had been motivated enough to use contraceptive methods (Westoff, 1976, p. 15). Most of them didn't know what time of the month they could become pregnant and many of them believed that nothing would happen because they were either too young or did not have sex frequently enough. Others said they were afraid of getting cancer from the pill. Many don't understand how the pill works. If they forget to take it for four days, for example, they will take four all at once.

Social Consequences and Responses

The data on the direct results of sexual ignorance, venereal diseases, and teenage pregnancies are discouraging enough, but there is a secondary and frequently overlooked series of consequences that impose several social, human, and financial burdens on society at large. These deal with the teenage mother. Without financial help from parents, teenaged mothers are usually dependent on getting a job but, since they have probably not finished school, chances of earning sufficient money are slim. They can get some welfare money from Aid to Families with Dependent Children but not enough. For many child mothers whose parents don't take over the major share of responsibility for the new infant, worries of money, childcare, schoolwork, housing, adequate food, medical care, and finding available social services, if they exist, are too much. They become saturated with a sense of desperation and alienation. Rather than seeking each other out, they remain aloof and suspicious. One girl couldn't cope any longer and dropped her baby down a two-flight stairwell. Fortunately, he landed on something soft and survived. Some mothers just give up and commit suicide. Teenaged mothers frequently treat their babies as they treated their dolls, loving them one minute and chastising them another. They are more apt to slap, hit, and shake their babies than are more mature mothers. Cases of child abuse, of battered and neglected children, are closely related to the age of the mother. According to Douglas Besharov of the Department of Health, Education and Welfare, a major proportion of young mothers are responsible for a disproportionate share of child abuse (Westoff, 1976, p. 64). There are one million cases of child abuse per year. Of this number about 2,000 end in deaths.

If a child of a child survives, a study by Dr. Janet Hardy, Professor of Pediatrics at Johns Hopkins, provides further discouragement (Westoff, 1976, p. 63). Her study found that among children who

were below grade level in school, 75 percent had teenaged mothers. In addition, young mothers have more premature babies and more fetal and newborn deaths and were more susceptible to toxemia, a condition which leads to hypertension and high blood pressure.

It is obvious that the above data indicate a failure on the part of society to provide adequate sexual information, and the consequences of ignorance are written in the sexually transmitted diseases statistics, the rise in teenage pregnancies, and the unwanted and abused children, many of whom become burdens upon society at large.

It appears safe to assume that no one is desirous of acquiring a sexually transmitted disease and that the majority of teenage pregnancies were not planned even though some are (Fosburgh, 1977). By withholding or providing too little information regarding sex, all segments of our society are culpable. Parents have frequently failed their children because of their own ignorance or embarrassment and leave it to their children to muddle through their developing sexuality as best they can. Many organizations devoted to the task find themselves incapable of handling the increase in attention required by teenagers and pre-teenagers. For example, Planned Parenthood's literature and counseling methods are primarily designed for adults and appropriate material to handle the sexual requirements of younger and younger segments of our population is not readily available. Sex education courses in school are frequently ineffectual. Many teachers are uncomfortable with the subject matter. In many schools VD is dealt with, if at all, in moralistic tones more suitable to a Chatauqua meeting than to a health class. Outside pressures negate efforts at relevant sex education. Dr. Walter Smartt, Chief of the Los Angeles County Venereal Disease Control Unit, says that when a child learns that diphtheria exists and yellow fever exists, she or he ought to learn that gonorrhea exists too (Newsweek, 1972). But in California, then-Governor Ronald Reagan vetoed a bill that would have exempted VD instruction from a state law requiring schools giving sex education courses to notify parents and give them a chance to review the study materials used. The law had, in effect, crippled sex education in the state but the proposed bill would have encouraged VD instruction as part of health courses.

It is one category of insult inadvertently to fail to provide necessary information, quite another to deliberately legislate its excision. Fortunately, in only one state, Louisiana, is there a state law (State of Louisiana, 1950) prohibiting the teaching of some aspects of human sexuality. This law specifically prohibits any instruction relating to sexual intercourse. House Bill 170 (1977 regular session) is designed to modify the current Louisiana law to allow local option sex education if such courses are euphemistically titled "Family Living and Character Education." Wisely, it provides that teachers of such courses must attend an in-service education program but removes local option by specifying that all curricular materials must be approved by the State Department of Education. It contains an unusual pejorative provision that specifically prohibits the use of all SIECUS materials. This house bill would place the decision regarding whether a given student would take the course or not with the parents who must give their written permission. Both the citizens and the educational

establishment of the State of Louisiana have so far acquiesced in the law's provisions. Reaction to the amendment is yet to surface. The absence of a legal test of the law in the courts of Louisiana attests to apathy and inertia concerning the importance of sex-related information. Certainly legislative fiat is not the best way to develop curricula. It is to be hoped that the Louisiana legislation regarding sex education is an isolated instance, not a national trend.

With parents unprepared to handle the sex education of their youngsters, thinking of their young sons and daughters still as children, the schools hamstrung, and the statistics crying for remedial action, what course of action should be taken? Certainly someone, somewhere, has to communicate to teenagers and pre-teenagers the potential tragedy of unplanned sex and its harrowing consequences. As problems of sexual ignorance affect us all, it behooves all of us to concern ourselves with them. This means parents, schools and communities. This means educators and medical personnel, clinics and community counseling services working together not only to rectify mistakes already made, but to help prevent them from re-occurring. In Newsweek for January 24, 1972, the statement was made: "Because of the stigma of VD, efforts to educate the public about syphilis and gonorrhea have lagged about as badly as research." This stigma needs to be removed and funds need to be made available for research on sexually transmitted diseases in as open and public way as funds are solicited for cerebral palsy, cancer, or heart disease. Several cities have taken remedial steps by having community groups establish telephone "hot lines" to provide worried callers with advice on sexually related matters, particularly sexually transmitted diseases. There is general agreement, however, that massive, educational effort should be made in the schools starting with the earliest feasible age group. Dr. John R. Pate, Chief of the District of Columbia's VD-Control Division, says: "We almost have to beat puberty because they are coming into the clinics so young" and he cited in this connection a nine-year-old girl who had contracted VD from a boyfriend aged thirteen (Newsweek, 1972, p. 47).

Not only has research on sexually transmitted diseases lagged far behind research in more esoteric diseases affecting but a tiny fraction of our population, but research on the effectiveness of transmission of sex-related information is also relatively sparse. We have data that indicate that driver education is a positive factor in setting good driving attitudes and skills. Insurance companies and state licensing bureaus acknowledge in their practices the effectiveness of driver education programs. The time appears ripe for a similar assessment of the effectiveness of sex education programs. For example, it would be valuable to know how many of the children who had unwanted pregnancies or contracted venereal disease had been exposed to a formal course in sex education. More studies are needed as to where children receive their information on sexually related matters. Further correlations should be able to be established between information sources, the validity of such information and the role sex subsequently plays in the life of those exposed to such sources. If it could be established for sex education, as it has for driver education, that children who have been exposed to education programs profit by them, then those exposed to adequate and accurate sex-related

information would be expected to have fewer pregnancies, contract fewer sexually transmitted diseases and, in general, accept responsibly their developing sexuality. These data would lessen the emotionally charged diatribes based on the concept that sexual information leads to irresponsible action.

There is no question that our present system is inadequate. Recommendations have been made that schools should offer sex education and relevant family education courses from the early grades on so that teenagers and their parents, who must make quick and crucial decisions, can at least comprehend exactly what the odds are. We are not doing a good enough job now but, more discouragingly, we are not making a concerted effort to initiate proper programs that can evolve into still more adequate information sources for larger population segments. A large measure of the responsibility for continued sexual ignorance must rest with groups and individuals who, however moral and high-minded their motives, work to keep sexual knowledge unavailable —a puritanical mode of ignoring sexual activity in the hope that it will go away.[1] The constant drumfire of the anti-sex educationists must bear a considerable burden for the unplanned pregnancies, the unwanted children, and the skyrocketing sexually transmitted disease statistics.

We must not consider ignoring sexuality or depreciating sex education programs for such actions do nothing but exacerbate the situation. We should be considering parent-community-school consortiums to remedy the supported hypothesis that our present efforts to deal with emerging sexuality are inadequate. New and expanded programs that deal with human sexuality are needed not only in schools but on a community-wide basis. It is essential that we reach our present target populations with more effective materials than those who are outside the school population have available; the information that will allow them to avoid the consequences of ignorance To those who say sex-related information is dangerous, I can only respond that, if so, I prefer dangerous information to dangerous ignorance.

SAMPLE PROGRAMS

There are a number of local or regional sex education programs in the United States but no broad, consequential, national curriculum. The following four are representative of the types of programs currently available:

1. Cedar Rapids Community School District, Cedar Rapids, Iowa. THE YEARS OF UNCERTAINTY: EIGHTH GRADE FAMILY LIFE EDUCATION. Edited by Mary Carson, et al. Available from

---

[1]A case study of anti-sex education activities is given in Oh! Sex Education! by Mary Breasted, Praeger, New York, 1970. Despite the "cute" title this is a serious job of reporting the methods and motives of anti-sex educationists using the relatively conservative Anaheim, California, program as a target.

Teaching Resource Center, Cedar Rapids Community School, 346 Second Avenue, S.W., Cedar Rapids, Iowa 52404. Price $5.00.

A series of daily lesson plans for 29 one-hour class sessions. Topics covered include: problem solving, knowledge and attitudes, male and female reproductive systems, contraception, pregnancy, birth, birth defects, venereal disease, dating, peer group influence, emotions, values clarification, and decision-making.

2. Montclair Public Schools, New Jersey. EDUCATION IN HUMAN GROWTH AND DEVELOPMENT. Two volumes. Spans grades K-12. This is a curriculum guide with resource materials for teachers, parents, and students.

3. Portland Public Schools, Maine. FAMILY LIVING AND SEX EDUCATION CURRICULUM GUIDE. Grades 5-9, containing individual lesson plans and suggested activities.

4. Rochester City School District, New York. SCIENCE, HEALTH, SAFETY CURRICULUM GUIDE: UNIT REVISION FOR FAMILY LIVING CURRICULUM K-6. Designed to be correlated, integrated, and articulated with the total educational program. Includes concepts of human sexuality and provides activities to motivate student learning. Five topics are treated at the primary, early intermediate, and later intermediate levels. They include the individual personality, the family, peers and environment, physical growth and reproduction, and male and female sexuality. Includes suggestions to the teacher to aid in presentation of the materials comfortably and effectively.

RESOURCES

Books

Bender, S. J. Venereal Disease. Dubuque, IA: William C. Brown, 1975.

Blanzaco, A.; W. F. Schwartz; and J. B. Richmond. V.D.: Facts You Should Know. Glenview, IL: Scott, Foresman and Company, 1970.

Child Study Association of America Conference. Sex Education and the New Morality: A Search for a Meaningful Social Ethic: Proceedings. New York: Child Study Press, 1966.

Child Study Association of America. Sex Education: Recommended Reading. New York: Child Study Press, 1969.

Crow, L. D. and A. Crow. Sex Education for the Growing Family. North Quincy, MA: Christopher Publishing House, 1959.

Dalla , D. M. Sex Education in School and Society. Atlantic Highlands, NJ: Humanities Press, 1972.

Educational Broadcasting Corporation. V.D. Blues. New York: Avon Books, 1973.

Fischer, H. L., et al. Sex Education for the Developmentally Disabled: A Guide for Parents, Teachers, and Professionals. Baltimore: University Park Press, 1974.

Grams, A. Sex Education: A Guide for Teachers and Parents. Danville, IL: Interstate, 1970.

Haims, L. J. Sex Education and the Public Schools. Lexington, MA: Lexington Books, 1973.

Hottois, J. W. and N. Miller. Sex Education Controversy. Lexington, MA: Lexington Books, 1975.

Johnson, E. W. V.D. New York: Bantam Books, 1974.

Johnson, W. R. Sex Education and Counseling of Special Groups. Springfield, IL: C. C. Thomas, 1975.

Keller, D. E. Sex and the Single Cell. Indianapolis: Bobbs-Merrill Company, Inc., 1972.

Kilander, F. H. Sex Education in the Schools: A Study of Objectives, Content, Methods, Materials, and Evaluation. Riverside, NJ: Macmillan, 1970.

Kramer-Greene, J. Venereal Disease Bibliography for 1974. Troy, NY: Whitston, 1976.

Minnesota Council on Family Relations. Family Life, Literature and Films. Supplement to Family Life, Literature and Films. Minneapolis, MN: Minnesota Council on Family Relations, 1219 University Avenue, S.E., 1972, 1974.

Minor, H. W., et al. Sex Education: The Schools and the Churches. Atlanta, GA: John Knox, 1971.

Osofsky, H. J. Pregnant Teen-Ager: A Medical, Educational and Social Analysis. Springfield, IL: C. C. Thomas, 1972.

Podair, S. Venereal Disease: Man Against a Plague. Belmont, CA: Fearon, 1971.

Powers, P. and W. Baskin. Sex Education: Issues and Directives. New York: Philosophical Library, 1969.

Rogers, R. (ed.). Sex Education: Rationale and Reaction. New Rochelle, NY: Cambridge University Press, 1974.

Sex Information and Education Council of the U.S. Study Guides. New York: SIECUS Publications.

A series of short pamphlets on a variety of topics relative to sex and reproduction available from the SIECUS Publications Office.

Singer, L. J. and J. Buskin. Sex Education on Film: A Guide to Visual Aids and Programs. New York: Teachers College, Columbia University, 1971.

Uslander, A. S. and C. Weiss. Sex Education for Today's Child. New York: Association Press, 1977.

WHO Meeting, Geneva. Pregnancy and Abortion in Adolescents: Report. Technical Report Series No. 583. Albany, NY: World Health Organization, 1974.

Willke, J. C. and Mrs. Willke. Sex Educatic The How To For Teachers. Cincinnati, OH: Hiltz and Hayes, 1971.

Wiseman, B. Sex-Ed. New York: Dell, 1971.

Magazines and Journals

The Family Coordinator. The National Council on Family Relations, 1219 University Avenue, S.E., Minneapolis, MN 55414.

Journal of Marriage and the Family. The National Council on Family Relations.

Medical Aspects of Human Sexuality. Clinical Communications, Inc., 18 East 48th Street, New York, NY 10017.

REFERENCES

Blakeslee, A. "Sexually Transmitted Diseases Have Exploded Into Epidemics." Associated Press, Part One of two-part article. Printed in Boulder Daily Camera for August 6, 1975.

Breasted, Mary. Oh! Sex Education! New York: Praeger, 1970.

Denniston, L. "Teen Births an Epidemic." Denver Post-Washington Star News. Release printed in the Denver Post (December 29, 1976.)

Denver Post. "Abortions in Washington Exceeded 1975 Birth Total." A.P. News Release printed in the Denver Post (November 11, 1976.)

Fosburgh, Lacey. "The Make-Believe World of Teen-Age Maternity." New York Times Magazine, 29-34.(August 7, 1977).

Leger, R. R. "Viral Venereal Disease is Highly Contagious and Won't Go Away." Wall Street Journal, Vol. 90, No. 77 (April 19, 1974).

Mayer, William V. "Chapter 4-Sex Education." Biology Teachers' Handbook. New York: John Wiley and Sons, Inc., 1978.

Newsweek. "VD: The Epidemic," 46-50 (January 24, 1972).

Newsweek. "Sex and the Young Teen," 49 (January 12, 1976).

Rubenstein, Judith S. "A Comparison Between Student Interest and Book Information in Sex Education for Teenagers." Ed.D. dissertation, Harvard University, June, 1974.

State of Louisiana, Section 281 of Title 17 of the Louisiana Revised Statutes of 1950.

Westoff, L. A. "Kids with Kids." *New York Times Magazine* (February 22, 1976).

Val Woodward and Keith Klein have written a provocative and controversial paper. Their position is that science is too far removed from the people and that it is used and controlled by a power elite not necessarily for the good of mankind. They use genetic related issues of recombinant-DNA and Sociobiology to illustrate their ideas.

GENETIC ISSUES

Val Woodward and Keith Klein

INTRODUCTION

One of the long-standing debates among science teachers is whether to teach science "as such" or to teach science "within the social context." This debate cannot be examined in full here, but even so we argue that the knowledge necessary to transpose scientific facts into desired social policies, or services, cannot be found within the technology-methodology paradigm out of which the facts arose. For example, we have today a technology-methodology, popularly known as gene splicing, which permits the formation of novel recombinant DNA molecules (rec-DNA). The methods are easy to learn and technically effective as judged by the results, but the methods do not provide the wisdom whether to make DNA hybrids or to what end. Therefore, even though the teaching of gene splicing techniques will produce technicians proficient in making rec-DNA, there is no evidence that these technicians will be more knowledgeable about whether to make such molecules, and to what end, than persons unskilled in making rec-DNA.

Therefore, in this paper we advocate that science teaching include science within the social context, e.g., science as a socio-political resource. In part this position can be supported by the historical evidence that the exercise of democracy depends upon an informed citizenry...informed not only about the dominant ideology, but also about the realities the ideology is intended to hide. Within this frame, if science teaching is to enhance democratization, then science teaching will include both the knowledge of science and knowledge of the socio-economic-political setting within which science takes place.

In defense of this position we show that science is not apart from society, but integrally a part of society. Science influences and is influenced by society, and for this reason science cannot be neutral, or autonomous, or objective in all of its aspects. Rather, science is used to achieve goals; in many cases science produces "data" demanded of its benefactors. It is important to discover who the benefactors of science are, and what kinds of data are requested by them, and to what end the data are used. Knowledge is potential power, and power is used to serve those who own and control it. Is it then not important to investigate the material nature of the relationships between those who own and control power and those who don't? All of us in the trade (teaching) refer to these as "sensitive issues," and many of us have

been socialized into believing that sensitive issues are best left alone, for to discover their correct interpretation is to demand participation in the unveiling of the ideological masks which for too long have kept us innocent of realities. Two examples serve to illustrate this point... the technology of gene splicing and the ideology of sociobiology, two of the hottest issues ever to arise out of biology.

ISSUES

Recombinant DNA

The history of asexual, recombinant DNA molecules can be traced to the first known bacterial transformation experiment, reported in 1928 (Griffith, 1928). By 1944, it was known that DNA is the transforming principle, i.e., DNA in chemically pure form can be isolated from one strain of bacteria, introduced into a different strain, and thereby transform a few of the recipient cells into the genotype/phenotype of the donor strain (Avery, et al., 1944). The techniques of DNA transfer have been refined in recent years to make it possible to combine fragments of DNA (fragments containing from one to many genes) of any species of plant or animal with bacterial plasmid DNA, and to clone the recombinant molecules within bacterial host cells (Ian, et al., 1973; Chang, et al., 1977).

DNA isolated from any species can be cleaved into small fragments by the enzymatic action of restriction endonucleases. These restriction enzymes cleave such that the ends of each fragment are left single stranded. The single strand on the end of one fragment can then be bonded to the single strand end of another fragment by the action of the enzyme polynucleotide ligase. For example, fragments of DNA isolated from human liver cells, mixed with cleaved plasmid DNA, in the presence of ligase, will produce recombinant plasmids containing both human and bacterial DNA. The next trick is to get the recombinant plasmid into a bacterial host cell, where, if the transfer is successful, it will be replicated or cloned. The final expectation is that the human gene(s) will program synthesis of the same protein within the bacterial cell as was programmed by it within human cells. In June, 1977, it was reported that the insulin gene from rat liver cells had been spliced into a bacterial plasmid (Time, 1977), but in that case the gene did not produce insulin within the bacterial cell.

It is possible to understand the social significance of rec-DNA technology without an understanding of how to make rec-DNA molecules; this understanding is aided by the fact that the issue of gene splicing has developed into a major controversy. The controversy was amplified by the first successful gene-splicing experiment. In 1971, a student of Paul Berg (Stanford) reported the successful splicing of DNA isolated from the African Green Monkey virus, SV40, to bacteriophage lambda DNA, and the insertion of the recombinant molecule into the bacterium, *E. coli* (Slesin, 1976). Following the report, a discussant pointed out that in the event the bacterial cells escaped the laboratory, the bacteria could provide a novel infection route for SV40 to be transmitted to humans. Berg decided to cancel the experiment

because SV40 is known to cause cancer in some animals and to transform human cells in vitro to cancer-like states (SV40 is not known to cause cancer in humans, but the risk is believed to be a real one). In an open letter to Science, Berg and others (1974) called for a moratorium on further recombinant DNA experiments until such time that a panel could review the hazards and recommend containment procedures.

Such a panel met, at Asilomar, California, in 1975, to begin the task of setting guidelines for rec-DNA research. The initial guidelines have since been modified and adopted by the National Institutes of Health (NIH), and the guidelines apply to all NIH-funded research. However, the effectiveness of the guidelines is a function of the scientists, since the guidelines are not legal elements accompanied by authority to issue sanctions. Even within the short time of their existence, the guidelines have been broken (the group that spliced the insulin gene into a bacterial plasmid, in their push to get ahead of competitors at Harvard, began their experiments using a plasmid that had not been approved by the NIH committee (Wade, 1977). Even though many scientists may be trustworthy individuals, all scientists work within high intensity competitive environments, a condition that often reduces self-regulation to the level of no regulation.

Fears of mass infection of SV40 virus are clear enough, but many proposed recombinations are less clear. Some outcomes of gene splicing may be trivial; some may be catastrophic; others may be unidentifiable at this time. A few potential risks have been discussed, for example the possibility that human, rat, corn, and other eukaryote DNA functioning within bacterial cells might endow the bacterium with new, unforeseen properties, e.g., pathogenicity, toxicity, the capacity to compete for new ecological niches, carcinoginicity, and so on (Wade, 1976). At the time of this writing there is no experimental evidence in support of these possibilities; however, it is known that a plasmid, once created, can escape and establish itself with high frequency of transfer to other extant strains (Sadowski, et al., 1978).

The claims made by avid proponents of rec-DNA research are equally innocent of a data-base. Some advocates suggest the creation of nitrogen-fixing cereal crops (Berg, 1976); others tell us that the promise of cures for genetic diseases caused by single gene mutations (phenylketonuria, sickle cell anemia, Tay Sachs disease, etc.) more than offsets the risk factor, and they flavor the promise with aspirations of success against diseases whose causes are unknown. e.g., cancer (Baltimore, 1976); many advocates, however, stick to the basics, and promise only that continued rec-DNA research will lead to a better understanding of genomes (Cohen, 1977; Wilson, et al., 1977). This last point seems fair enough but for the disturbing reality that the phenotypic outcomes of moving "foreign" genes into bacterial genomes are unpredictable and dependent upon both the environment and the other genes within the genome. Furthermore, the action of a eukaryotic gene in a bacterial host may not reflect its function in its original context. This contingency is compounded in that the function of more than three-quarters of eukaryote DNA is unknown, even within its native habitat. The gene theory is not sufficiently advanced to help much with predictions about how spliced gene/bacterial genes/environment interactions will influence phenotype.

The rec-DNA controversy, then, is aligned around two well defined camps, the pro and the con. The positions of both camps are weak as judged by hard evidence. However, as judged by vulnerability to hard questions, or by the liberties taken through speculation and accusation, differences between the two camps do surface. What we really want to know is whether the promise to use rec-DNA technology to ameliorate starvation or to correct inborne errors of metabolism or whether the accusation that the critics of rec-DNA technology are advocating limits to the freedom of inquiry or whether the claim that the risks of rec-DNA technology are small arise out of empirical evidence or from behind a smokescreen of advocacy.

The same can be asked of the con position. Why are caution and improved containment facilities urged? Are risk factors invented out of desire to stop scientific progress? Is there any evidence that other technologies will lead to an understanding of genomes (Federation Report, 1976)? or that harmless experiments will help assess the risks of at least some rec-DNA proposals (Levin, 1977; Curtiss, 1974)? Clearly, the societal needs, today, for the results of rec-DNA technology are secondary to, for example, large-scale resistance to antibiotics; therefore, the wait-test-and-see attitude is not an intrinsic thorn in the behind of scientific progress. This assertion brings us to that aspect of the argument that clearly irritates certain members of the pro group, and that is ethics and politics. Even the questions whether the public should participate in the decision-making processes and whether scientists have a responsibility to inform the public are treated as roadblocks rather than as questions. And the gap widens when it is asked, directly, whose political interests are served by continuation of "technology as ideology" (Ellul, 1964), the unabashed advocacy position of the pro camp.

Before getting at some of the ethical/political aspects of modern genetics, we introduce the "new" sociobiology, since it raises some of the same questions.

Sociobiology

No doubt the main attraction of the new sociobiology arises from the claim that it is now possible to unify all hitherto fragmented concepts of behavior, animal and human, abnormal and normal, individual and social, into a single paradigm, or, as E. O. Wilson calls it, "the new synthesis" (1975). This Wilsonian unification is dependent upon genes, the universal causal agents of behavior. This is no small assertion, and reactions to it vary. At one extreme certain people are comforted knowing that science has finally discovered why humans behave as they do; at the other extreme sociobiology is viewed as but another attempt, in a long train of attempts by scientists to prove that existing social and political structures are biological imperatives. Between these extremes are found more questions than answers.

To begin an analysis of sociobiology at the point of its scientific underpinnings, we ask whether the genes of sociobiology and the genes of genetics are one and the same. Even casual inspection shows that they are not. The genes of genetics arise from two methodological

paradigms, Mendelian genetics and molecular genetics. The Mendelian gene is defined as a "unit of inheritance" and the molecular gene is defined both as a physical-chemical molecule and as a unit of function (Woodward and Woodward, 1977). Both definitions are restricted by the methods of study that gave rise to them, while the most profound advance in the history of the gene theory was the discovery that the Mendelian and the molecular methodologies describe different properties of the same entity: the gene. The data produced by these two methodologies have been generalized into a theory, and this theory of the gene has served as a good scientific theory should; that is, from the theory hypotheses have been generated. These hypotheses have been subjected to experimental tests (for falsifibility). These tests yield additional data which both modify and enrich the theory. The gene of genetics has been shown to exist in thousands of species and to influence many aspects of phenotype. But, genes defined in this way have not been demonstrated to have a cause-effect relationship with normal human behavior, individual or social.

If the new sociobiologists are not talking about the genes of genetics, what kinds of genes are they talking about? The kindest answer is hypothetical genes, but this answer does not reveal the tortured logic used to manufacture them. In effect this logic asserts a) that social behavior is adaptive, and b) that adaptive traits are gene-determined, but if we examine carefully we find that this logic is used as a substitute for data in that it literally borrows genes from gene theory and the concept of fitness from the theory of evolution. With borrowed genes and the concept of fitness, the new sociobiologists demonstrate gene-phenotype relationships. In practice this amounts to, first, observing a "behavioral trait," preferably one that is species "universal," and, second, rationalizing the trait's fitness. This sociobiological logic differs from science in several important ways, the most striking way being the absence of empirical data and a methodology for producing data. Judgments of sociobiology guided by the philosophical structure of empirical science unquestionably lead to the verdict: scientific malpractice.

A few attempts have been made to skirt this embarrassment. For example, Barash (1977) insists that sociobiology does have access to methodology, and thence to data. His "methodology" includes a) the historical method, called behavioral phylogeny; b) the evaluative method, a formal way to say common sense; c) the correlational method, often misused by posing correlations as cause-effect phenomena; and d) the predictive method, or central theorem approach. As it turns out, none of these methods can produce empirical data, as Barash inadvertently admits when he refers to the first three as being post hoc. If the first three are post hoc, the last is window dressing since predictability (making hypotheses from theory) is based upon empirical data.

In sociobiology the case for a cause-effect relationship between genes and behavior cannot be made, except through the use of hypothetical genes. This is very different from the gene-phenotype relationships demonstrated for "inborne errors of metabolism." For example, the gene causing sickle cell anemia not only obeys the inheritance laws of Mendel but is known to code for a specific polypeptide. Many

such examples can be cited. But nothing is known about the hypothetical genes of sociobiology, neither about their passage from one generation to the next nor about proteins coded by them nor about the relationship between coded proteins and behavior. And, clearly, the cause of these hypothetical genes is not helped by the "guesstimate" that genes cause only 10 to 20 percent of the variation in human social behavior. The ~~act of~~ estimating the contributing influence of genes to social behavior adds insult to injury. However, since the genes ~~were borrowed~~ in the first place, it's not surprising that they have been accorded a modest piece of the pie. But in real life there isn't a shred of evidence in support of these estimates of the respective contributions of genes and environments to social behavior.

But once the dam of hypothetical genes breaks, the erosion of reason honors no boundaries. Wilson (1975) suggests that a "planned society" in controlling aggressiveness (the desire to own and dominate, and violence), might suppress cooperation, creativity, and athletic zeal...because the genes determining the former may be linked with those determining the latter. Thus, the planned society would, in the "ultimate sense...rob man of his humanity." Pierre van den Berghe (1975) argues that aggression, dominance, hierarchy, territoriality and their political consequences are biological; e.g., van den Berghe calls racism brutal, but he says nothing can be done about it because it is genetic. Barash (1977, pp. 310-11) agrees that racism is genetic, but he says that this fact does not "legitimate it." We wonder how something can be inevitable and not legitimate. Indeed, it is the definition of racism used by van den Berghe and Barash that underpins the precise legitimization of racist terror practiced by the Ku Klux Klan and the Nazis.

Another play on words is found in Dawkins' The Selfish Gene (1976) where we find an updating of Samuel Butler's aphorism, "a chicken is an egg's way of making another egg," to read that people are the genes' way of making more genes (Dawkins, 1976, p. ix). This twist of evolutionary logic is accomplished, again, by assertion rather than with data. The assertion is that genes survive for their own sake, and that human phenotypes ("huge lumbering robots" within which "genes swarm," says Dawkins) are nothing more than vehicles for transmission between generations. Dawkins tells us that since genes are so very selfish, "be warned that if you wish...to build a society in which individuals cooperate generously and unselfishly towards a common good, you can expect little help from biological nature" (1976, p. 3). This view of the mass of humanity is popular within the ruling classes who often possess the power to reify abstractions by way of social policies, but reified abstractions are not equivalent to scientific data.

When it is suggested that science is financed by and serves the ruling class, many scientists respond defensively claiming that science is neutral, autonomous, and objective. Anyone who has studied the history of science knows better. But in the case of sociobiology it isn't necessary to resort to history because the contemporary political message stands in full view for all to see. This message takes two forms: first, there is the passionate defense of the status quo by way of asserting that the status quo is determined by genes; second,

many sociobiologists call for modifications of social policies based upon "new discoveries" of genetic potentials of individuals and of groups. Since all that is needed for making new discoveries is an observed behavioral difference and a corresponding hypothetical gene, it is safe to conclude that the social policy modifications are nothing more and nothing less than political advocacy. The disguise used to hide the advocacy, again, is the claim that, in effect, the suggestion for social policy modification itself was coded by genes.

Both aspects of sociobiological political intervention are buttressed by a host of gene-determined behaviorisms: male dominance, male promiscuity, homosexuality, territoriality, xenophobia, spite, altruism, reciprocal altruism (euphemism for capitalism), competition, religion and patriotism, warfare and genocide, etc. Of course, no evidence is offered for any of the "traits," and all of the definitions are taken from a cultural, not an experimental, context. The rationale given by some sociobiologists that gene-normal behavior relationships are real comes from a long list of gene-pathological behavior studies. For example, phenylketonuria is both a single gene disease and a pathological phenotype. But this analogy is patently false. The gene responsible for PKU fails to program phenylalanine hydroxylase, which results in failure to convert phenylalanine into tyrosine. The phenylalanine accumulates and in sufficiently high quantities, during certain stages of development, excess phenylalanine impairs normal brain function.

The politics of sociobiology is not overly complex. The long list of gene-determined behaviorisms can be dispensed with on the grounds of no evidence. The advocacy of political social policies based on the claim that genes determine political social structures is but a self-made Catch-22. If the criteria of experimental falsifibility are applied, the apparent contradiction evaporates. But, biological determinist theories have never depended for their health upon their scientific underpinnings, as the long list of historical sagas illustrating the use of determinist theories as social weapons attest. These theories, like organized religions, are designed not to explain human nature, but to control it (Sociobiology Study Group, 1977).

The new sociobiology comes hot on the heels of its ill-disposed predecessor: IQ psychology. The reason is not hard to find. The dominant classes have always needed an ideological weapon with which to fend off exposure of the lie that race, sex, and class inequalities are biologically inevitable. This particular intent of sociobiology is impossible to hide.

SCIENCE IN ITS SOCIO-POLITICAL CONTEXT

The insulin gene from rats is now located within a bacterial plasmid. If this gene can be "turned on" to program insulin within the bacterial cells, as it does in rat pancreas cells, it should be possible to produce inexpensive insulin. Diabetes is advertised as being a dominant killer, second among diseases behind cardiac diseases, a fact that supports the contention that inexpensive insulin is important.

However, upon probing why so many people die of diabetes it is found that the price of insulin is not a major factor. Many people with the disease are never diagnosed; many never see a physician. Many cannot afford to see a physician; most probably do not understand the symptoms. This is one side of the coin. On the other side, one of the persons who worked on the insulin gene project is a key figure in Genetech, a corporation that will market the insulin as soon as the bacterial cells can be made to synthesize it (Wade, 1977; People, 1977). Insulin produced by spliced genes, then, is destined to bring profits to the corporation, but there is no evidence that public health will be the better for it.

The causes of public ill-health are many. However, the general health of the rich is substantially better than the general health of the poor. The causes of this differential are not to be found in medical technology or in genes for wealth and genes for poverty, but in the class nature of society. While it is advantageous for young doctors to specialize in diseases of the rich, millions of poor people never see a doctor. Those millions who live below the poverty datum line (the assessed minimum income necessary to sustain life) cannot afford health care at any price. Therefore, it is a false promise to say that insulin-producing bacterial strains will abate the health problems of the masses. It may be true that gene-spliced insulin will undercut the present producers of insulin, but to <u>solve</u> the diabetes problem, as one example, it is necessary to eliminate unemployment, train enough doctors to service <u>all</u> the people, and distribute medicines and health care services equitably among <u>all</u> of the people. This is not to say that we should stop working on small projects, only that misconceptions of the impact of small projects upon the greater social dilemmas are often used to hide the bigger realities.

Science is even further removed from the people than is medicine. Science is comprised of societies of experts monopolized by the professions and estranged from the people. Science does not offer either the intellectual or the material tools needed to exercise self-determination, self-administration, or self-rule, in any walk of life, including science. Yet workers often view scientists as members of the ruling class. This is incorrect. Scientists are as dependent as any other worker upon the ruling class...for jobs, money, honors, and prestige. In addition, scientists are victimized as are other workers, not because they can't find jobs (this is changing), but because they are specialized and socialized only to produce the kinds of knowledge the ruling class wants. Therefore, the idealistic concern for people evidenced by such promises as improved public health is nothing but an ideological cover for the request to allow science to carry on its business as usual, and for the fact that <u>scientific labor is not designed to serve the people</u>.

The complete meaning of science cannot be found within scientific knowledge as such, but must be sought, at least in part, in the power scientific knowledge gives. This power has the potential to detract from or to enhance the quality of life of all people, and for this reason the uses of scientific power mirror the ideology of the users. If this power is focused toward serving the power elite, ideology will

be used to disguise reality. If this power is used to enhance the quality of life for all people, ideology will be used to expose reality and to prepare all people in its usage; it will not belong exclusively to the power elite. This latter alternative mandates that every science curriculum, and every science teacher, share with every science student the uses of scientific power, whether of herbicides designed to destroy ecology for profits, neutron bombs designed to kill people and save buildings, or spliced gene insulin designed to make profits.

Where will science teachers find this information? Certainly not in the textbooks. For the most part textbooks strive to idealize science. In point of fact the sources of such information are not easy to find. But history is helpful, as illustrated by the history of hereditarian theories of human nature. For example, during pre-Civil War days when the question of slavery polarized the U.S. population, certain scientists came to the aid of the pro-slave camp by providing evidence that blacks are more ape-like than human (Van Evrie, 1853). And when the popular view of women was restricted to virginity and making babies, Victorian medicine men defined women as "ovaries, uterus, and other accoutrements" (Bart, 1977), and women who sought liberation from this "scientific" definition, by seeking a career or masturbating, were pronounced diseased. The cure? Removal of the diseased organs... and to this day the popular solution to "women's problems" is the same: ovarectomy.

Herbert Spencer (1851) found the "scientific" explanation for British imperialism. His thesis came to be called Social Darwinism, and its central theme was that Britain (the civilization) was biologically superior to other nation-states. He also concluded that it is incorrect to eliminate poverty with charity and welfare because "the poverty of the incapable, the distresses that come upon the imprudent, the starvations of the idle...are the decrees of the large, far-seeing benevolence... Under the natural order of things society is constantly excreting its unhealthy, imbecile, slow, vacillating, faithless members...." (Spencer, 1851, p. 51). In 1940, Konrad Lorenz (1940) explained the sorry human condition in terms of domestic cattle becoming dependent upon human care for survival; i.e., "The selection for toughness, heroism, social utility...must be accomplished by some human institution if mankind, in default of selective factors, is not to be ruined by domestication-induced degeneracy. The racial ideal as the basis of the state has already accomplished much in this respect" (Lorenz, 1940, p. 71), and, "We MUST...and we may...rely upon the healthy instincts of the best of our people" for the "extermination of elements of the population loaded with dregs" (Lorentz, 1940, p. 75). In 1973, Richard Herrnstein (1973) said that the good life is not for everyone because social hierarchy is in fact a genetic meritocracy. Herrnstein's argument in support of a genetic meritocracy rests on the claim that equal opportunity has existed in this country for some 200 years! From Galton (1869) through Terman (1916), Burt (Kamin, 1975), Eysenck (1971), Jensen (1969), and Shockley (1972), we see the predecessors of the new sociobiology and the attempts made by them, through science, to show that the status quo, social-political structures of society are determined by genes.

However, the new sociobiology, as the name implies, has developed a new wrinkle, and it has to do with the concept of fitness. Darwinian fitness is a concept of reproductive success, or lack of success, of individuals. New sociobiology speaks of inclusive fitness, which is the sum of Darwinian fitness and what is called kin selection. Kin selection is family, or tribal, fitness, a concept that takes into account that a family member whose individual Darwinian fitness is zero; e.g., a homosexual, might enhance the survival potential of his or her relatives by way of altruistic and cooperative behavior. These cooperative acts by a non-reproductive family member are, however, the genes' way of making more genes; i.e., his or her relatives will pass on his or her genes. Robert Trivers, in the introduction to The Selfish Gene (Trivers, 1976), asserts that it is in the "interest of the genes" to program the human brain such that clear thinking is impossible, otherwise the brain might initiate plans for its own survival, and thereby derail the strategies of the genes. Wilson (1975) agrees, saying that people would rather believe than know, and from this he argues that planned societies can't work. The argument is a prima facie assertion that the only "reality" accessible to humans is mythology, and that the strategies of genes dictate war, genocide, racism, sexism, nationalism, etc. Wilson says this is why soldiers die for God and country.

If sociobiology is to become a complete synthesis, it must take the final step. George Pugh has obliged, as follows: If genes determine the desire to be led, the desire for indoctrination, and social structures based upon leading and being led, then genes must determine human values (Pugh, 1977).

Of course, there is no scientific evidence that genes determine human values, or that genes produce the "faithless, dregs" and residues of "failures" in society. There is no evidence that the social roles of sex, race, or class are determined by genes. Nor is there evidence that the new sociobiology will contribute to the alleviation of the oppression caused by the institutional enforcement of the alleged gene-determined social roles. Indeed, the tenets of the new sociobiology lead to a distortion of the forces that do shape the social-economic-political structures of societies. In fact, these tenets are in direct opposition to other realities; e.g., the fact that the U.S. is ruled by a small (in number), rich and powerful ruling class (Domhoff, 1967), and that the affairs of the ruling class are cared for by a relatively large managerial class, and that the wealth of both is derived from the surplus labor value of a large working class.

Those who have questioned and criticized the momentum of that sector of the science community that is moving ahead with rec-DNA and biological determinism have been likened by the pro camp to the attackers of Galileo. This analogy stresses reason even more than does the "gene" for reciprocal altruism. Galileo produced data! Galileo introduced the empirical approach to science, and in doing so he inverted the primacy of authority over knowledge. The real anti-Galileans are those who attempt to restore the medieval dependence of expertise upon authority.

There can be no doubt but that it is in the interest of the ruling class to protect the status quo and to maintain control over the uses of scientific knowledge. This is not an indictment, but a statement of fact. And many there are who agree that this is the way things should be. Certainly many scientists agree as evidenced by putting forth "scientific" evidence that the status quo is a biological imperative and by providing the "tools" with which the ruling class improves its grip upon the world's resources including the people. This is not a conspiracy either on the part of the ruling class or of its cadre of scientists. The former acts to promote its self-interests, that is to own and control; the latter acts in its self-interests; i.e., to prevent poverty, obscurity, and mortality. To confuse the forces that produce social motion with morality is a mistake. Not only does the confusion misdirect the attacks of those who work for change, it also leads to a misunderstanding of the material basis of social structure.

RECOMMENDATIONS

If science educators are to teach science within its social context, then there lies ahead a protracted struggle. The struggle includes hard work for preparation (re-tooling) and against continuous opposition from conservatism. For the preparation it is necessary to know how science is funded, how the choices are made to fund some projects and not others, the effects upon universities of the ties made between them and the funding agencies, the effects upon the quality and content of teaching of highly competitive science, and, importantly, the overall function of teaching as seen by those who monitor and control its quality. It is also important to understand the content and methodologies of science, but not just at the technical level necessary to do science. The little book, Biology as a Social Weapon, offers several illustrations of this last point (Ann Arbor Science for the People, 1977).

The protracted struggle against conservative opposition is most difficult in isolation. Teachers must begin to place discussions of this sort on the agendas of teachers' meetings, whether local, regional, or national. When large numbers of teachers object to status quo training and begin to prepare programs for progressive education, it will be possible to influence awareness of the effects of ideology upon mass oppression as well as upon the quality of mentation. The objective is not to destroy science but to enhance its quality and its uses. Since science cannot, simultaneously, act in behalf of the profit-making capability and in the interests of the world's masses, then assessments of the quality of science will be made from its uses—and the same will be true for teaching. There is ample evidence of a firm relationship between the kinds of questions scientists ask and the political-economic context within which scientists work, and again the same is true for teaching. The analyses of scientific facts isolated from these relationships is as ascientific as an analysis of genes isolated from the environment within which they influence development. We therefore advocate that science teachers begin the process of analyzing and studying science,

not with the ideology that facts are our only access to reality (logical positivism), but with the objective understanding that interactions among elements within systems, and between systems, profoundly influence their properties and qualities. It is important to know the properties and qualities of science—and the forces that influence them.

REFERENCES

Ann Arbor Science for the People (ed.). "Sociobiology: A New Biological Determinism." Chapter in Biology as a Social Weapon. Minneapolis: Burgess Publishing Co., 1977.

This little book contains several chapters showing the role biological determinism has played and is playing in fostering racist and sexist social policies.

Avery, O. T.; C. M. MacLeod; and M. McCarty. "Studies on the Chemical Nature of the Substance Inducing Transformation of Pneumococcal Types." Journal of Experimental Medicine, Vol. 79:137, 1944.

This is one of the classic research papers in genetics.

Barash, D. P. Sociobiology and Behavior. New York: Elsevier, 1977.

This book is more to the point than Wilson's in that the relationship between evidence and conclusions is ignored almost completely.

Bart, P. B. "Biological Determinism and Sexism: Is it all in the Ovaries?" Chapter in Ann Arbor Science for the People (ed.). Biology as a Social Weapon. Minneapolis: Burgess Publishing Co., 1977.

Berg, P.; D. Baltimore; H. Boyer; S. N. Cohen; R. W. Davis; D. S. Hogness; D. Nathans; R. O. Roblin; J. D. Watson; S. Weissman; and N. D. Zinder. "Potential Biohazards of Recombinant DNA Molecules." Science, Vol. 185:303, 1974.

Most of these scientists changed their minds on the potential harm of recombinant DNA.

Berg, P. Proceedings of a Conference on NIH Guidelines for Recombinant DNA Molecules. Public hearings held at a meeting of the Advisory Committee to the Director of NIH, Washington, DC: Department of Health, Education and Welfare, 1976.

Chang, A.C.Y.; S. N. Cohen; H. Boyer; and R. B. Helling. "Genome Construction Between Bacterial Species In Vitro: Replication and Expression of Staphylococcus Plasmid Genes in Escherichia coli." Proceedings of the National Academy of Science, Vol. 71:1030, 1974.

In the papers of this volume can be found the technology of gene splicing.

Curtiss, R. "Open Memorandum to Paul Berg, et al." Cambridge: MIT Program in Oral History of Science, August 6, 1974.

Cohen, S. N.; A.C.Y. Chang; H. Boyer; and R. B. Helling. "Construction of Biologically Functional Plasmids In Vitro." Proceedings of the National Academy of Science, Vol. 70:3240, 1973.

Cohen, S. N. "Recombinant DNA: Fact and Fiction." Science, Vol. 195: 654, 1977.

Davis, B., and R. H. Sinsheimer. "The Hazards of Recombinant DNA." Trends in Biochemical Sciences. Elsiever, Holland: International Union of Biochemistry, n 178, 1976.

Dawkins, R. The Selfish Gene. Oxford: Oxford University Press, 1976.

The thesis of this book is that genes are the striving biological entities, and that people are but gene-controlled vehicles bridging gene generations.

Domhoff, G. W. Who Rules America? Englewood Cliffs, NJ: Prentice-Hall, 1967.

Ellul, Jacques. The Technological Society. New York: Alfred A. Knopf, and Random House, 1964.

Eysenck, Hans. The IQ Argument: Race, Intelligence and Education. New York: Library Press, 1971.

Eysenck is the most widely read proponent of gene-IQ ideology in Britain.

Federation Report. "Promise and Hazards of Recombinant DNA Research: Three Schools of Thought." Federation of American Scientists Public Interest Report, Vol. 29, No. 4: 1976.

Galton, F. G. Hereditary Genius: An Inquiry into its Laws and Consequences. New York: MacMillan, 1869.

Galton is known as the "father" of eugenics.

Griffith, Frederick. "The Significance of Pneumococcal Types." Journal of Hygiene, Vol. 27:113-156, 1928.

This paper is of historic interest in that it illustrates a developmental process of scientific advance. The significance of Griffith's data was not understood for nearly 20 years.

Herrnstein, Richard. IQ in the Meritocracy. Boston: Atlantic-Little Brown and Co., 1973.

Herrnstein carried the IQ argument of Jensen to its fascist conclusion, that we live within a gene-determined meritocracy.

Jensen, A. R. "How Much Can We Boost IQ and Scholastic Achievement?" Harvard Educational Review, Vol. 39:1-123, 1969.

This is the famous paper that triggered the most recent gene-IQ controversy.

Kamin, Leon. The Science and Politics of IQ. Potomac, MD: Lawrence Erlbaum Assoc., 1975.

Kamin's book describes the discovery of the fraudulent nature of Sir Cyril Burt's IQ psychology conclusions.

Levin, B. R. and F. M. Stewart. "Probability of Establishing Chimeric Plasmids in Natural Populations of Bacteria." Science, Vol. 196:218, 1977.

Lorenz, Konrad. "Durch Domestikation verursachte Storungen arteigenon Verhaltens." Zeitschrift fur angewandte Psychologie und Characterkunde, Vol. 59:56-75, 1940. Quoted in W. Cloud "Winners and Sinners." The Sciences, Vol. 13:16-21, 1973.

Lorenz's view of human nature influenced and was influenced by his advocacy of fascism in Nazi Germany.

Novick, R. P. "Present Controls are Just a Start." Bulletin of the Atomic Scientists, Vol. 33, No. 5:17-22, May 1977.

People. "Will Tinkering with DNA Produce Supergerms and Monsters? Scientist Herbert Boyer Says No." p 49, June 20, 1977.

Progressive Labor Party. Who Rules the U.S.? Progressive Labor Party pamphlet, 220 East 23rd Street, New York, NY 10010, 1967.

Pugh, G. E. Sociobiology: Implications for Human Studies. Address presented at the California Symposium on Science and Human Values. San Francisco State College, CA, June 14-15, 1977.

Pugh, G. E. The Biological Origin of Human Values. New York: Basic Books, Inc., 1977.

Sadowski, P. L.; B. C. Peterson; D. Gerding; and P. P. Cleary. "Use of Restriction Endonuclease to Establish the Persistance and Epidemic Spread of a Single R Plasmid in the Hospital Environment." In D. Schlessinger (ed.), Microbiology. Washington, DC: American Society for Microbiology, 270-272, 1978 (in press).

Shockley, W. Dysgenics, Geneticity, and Raceology. Phi Delta Kappan, Vol. LIII, No. 5:305, 1972.

Shockley's proposal for sterilization of low IQ persons has had the financial backing of reactionaries, e.g., Pioneer Foundation, for years.

Slesin, L. "Recombinant DNA Research: A Chronology." MIT Laboratory of Architecture and Planning. Occasional Paper #2, November 10, 1976.

This is a good history of gene splicing.

Spencer, Herbert. Social Statics. London: Chapman, 1851.

Spencer is credited with inventing social Darwinism.

Terman, L. M. The Measurement of Intelligence. Boston: Houghton Mifflin, 1916.

Terman revised the intelligence tests of Binet into the Stanford-Binet IQ tests.

Time. "One for the Gene Engineers," p. 68, June 6, 1977.

This article points up two political aspects of DNA technology: (1) the popular concept of science, and (2) the fact that the popular press is a good place to "publish" research results in order to establish priority—but only if the research is sanctioned by those who own and control the media.

Trivers, Robert. Introduction to Richard Dawkins' The Selfish Gene. Oxford: Oxford University Press, 1976.

Van den Berghe, Pierre. Man and Society: A Biosocial View. New York: Elsevier, 1975.

Excellent illustration of subjectivity and ideology posing as science.

Van Evrie, J. H. Negroes and Negro Slavery: The First an Inferior Race...The Latter, Its Normal Condition. Baltimore in G. Osofsky The Burden of Race. New York: Harper and Row, 104-110, 1967.

This book is an eye-opener in showing how science and ideology become intertwined.

Wade, N. "Recombinant DNA: A Critic Speaks Out." Science, Vol. 194:303, 1976.

Wade, Nicolas. "Recombinant DNA: NIH Rules Broken in Insulin Gene Project." Science, Vol. 197:1342, 1977.

Wilson, E. O. Sociobiology: The New Synthesis. Cambridge, MA: Harvard University Press, 1978.

This is a large book, most of which is descriptive, with a conclusion (synthesis) only metaphysically related to the "evidence."

Wilson, J. T.; B. G. Forget; L. B. Wilson; and S. M. Weissman. "Human Globin Messenger RNA: Importance of Cloning for Structural Analysis." Science, Vol. 196:200, 1977.

This is an introduction to molecular genetics.

Donald McCarthy defines parapsychology as the scientific study of psi phenomena (interactions between an observer and his environment which are not mediated by any currently known sensorimotor channels). His insistence on scientific study, and his elimination of the pseudoscientific fads which are sometimes lumped into parapsychology, make this a paper which deserves serious study.

PARAPSYCHOLOGY

Donald McCarthy

AN OVERVIEW OF PARAPSYCHOLOGY

What is Parapsychology?

Parapsychology is regarded here as the scientific study of psi phenomena. According to one definition of the term "psi phenomena" involve interactions between an observer and his environment which are not mediated by any currently known sensorimotor channels. A traditional classification of psi phenomena has distinguished between ESP (extrasensory perception) and PK (psychokinesis). In the former, the observer receives information from (or is influenced by) some aspect of the environment, and in the latter he imparts information to (or influences) his environment—in each case via means not presently understood. Thus, if an individual were able to alter the path of a moving object (or a laser beam, say) without direct contact or the use of any observable force or energy, it presumably would be an instance of PK. If he were able to describe in detail a picture that another person were viewing (or otherwise "read the thoughts" of that person) under conditions that prohibited ordinary sensory exchange of information, this would be an instance of ESP.

Traditionally, several varieties of ESP have been delineated, the major types being telepathy, clairvoyance and precognition. In contradistinction to telepathy, in clairvoyance the observer obtains the information without benefit of assistance from the minds of others; in precognition, he obtains information about events before they occur. Thus the example of ESP cited above would be an instance of telepathy rather than clairvoyance. On the other hand, if an observer were able to describe correctly the order of playing cards in a deck which had been thoroughly shuffled but not examined prior to his description, we could regard this as clairvoyance; if he made his (correct) description before the deck were even shuffled, we could class the phenomenon as precognition.

There are some serious limitations to the use of this terminology, however, and it is not profitable to regard parapsychology as consisting of the investigation of phenomena which fit neatly into the categories of telepathy, clairvoyance, precognition and psychokinesis.

For one thing, the categories are not so neat; e.g., it is not hard to devise situations where the same phenomenon could be variously interpreted as belonging to several of these categories. Indeed, even the distinction between ESP and PK may at times appear highly artificial, and there are psi phenomena that don't seem to fit comfortably into either category. Nor are the activities of parapsychologists narrowly confined by these categories; various investigators are involved with psychic healing, out-of-body experiences, poltergeist phenomena—among other things. Some researchers are actively involved with the question of personal survival after bodily death, others view parapsychology as being ultimately concerned with the nature of man, and of reality. But in all cases, insofar as they are functioning as parapsychologists, researchers are pursuing a scientific approach to the investigation of psi phenomena.

This should provide some idea of what parapsychology is; for emphasis, it may be helpful to consider a few illustrations of what parapsychology is not. Parapsychology is not some sort of general catch-all for the investigation of unexplained phenomena of every stripe. The Bermuda Triangle, UFO's, Bigfoot, etc. are simply not part of the subject matter of parapsychology as we have defined it. Similarly, parapsychology is not to be lumped together with astrology, numerology, spiritualism, or any other occult system of belief; in parapsychology as in any science (ideally at least) there is no pre-established dogma or prescriptive world-philosophy, and, above all, no hypotheses are seriously entertained which are in principle incapable of experimental falsification. Parapsychology is the scientific study of psi phenomena.

Brief Outline of the History of Parapsychology

There are indications that psi phenomena have existed from the earliest times, but the first major effort toward scientific investigation of these phenomena was begun by the Society for Psychical Research (SPR), founded in London in 1882. Three years later, under the aegis of William James, the American Society for Psychical Research was established. While some experimental work was done by the early "psychical researchers" (mostly telepathy experiments), the major emphasis was on the authentication and classification of spontaneous cases of apparent psi phenomena. A full-blown experimental approach was begun around 1930, with the establishment of a parapsychology laboratory at Duke University under J. B. Rhine.

The work at Duke was highly quantitative. The primary means of testing ESP was via "card-guessing" experiments involving decks of 25 cards, each imprinted with one of five geometric symbols. The number of correct guesses on each run through the desk provided numerical data in a form which was particularly convenient to deal with using statistical techniques. (Investigation of PK was similarly quantified using dice tumbling down a chute.) The methodology adopted by Rhine had a powerful influence in stimulating experimental research in parapsychology. His basic techniques were used by a number of independent investigators to produce an impressive mass of

data supporting the existence of ESP. This was met with a careful and critical examination of the evidence by the scientific community in the 1930s, and various weaknesses in experimental procedure were indicated. These weaknesses were eliminated in many subsequent experiments, but the controversy over the existence of ESP was not fully resolved.

For the most part, until the mid-1960s parapsychological research was concentrated primarily in a single center—Rhine's laboratory; this is no longer the case. Also, the card-guessing and dice throwing methodologies which dominated the early phase of experimental parapsychology have since been augmented by a wide variety of sophisticated experimental procedures. Acknowledgment of the legitimate status of the field came in 1969, when the American Association for the Advancement of Science granted official affiliation to the Parapsychological Association (an organization of professionals founded in 1957). Some of the most exciting work in parapsychology has taken place since that time, but nevertheless there is still some scientific controversy over the reality of psi phenomena.

The Controversy About Psi Phenomena

Despite the prevalence of reports of spontaneous cases of psi phenomena throughout history, the traditional attitude of many scientists has been one of extreme skepticism, even to the point of out-of-hand dismissal. In the 1930s, however, the experimental work in parapsychology did receive the careful scrutiny which is essential for scientific advance. According to Honorton (1976, p. 200):

> The critical issues raised during this period were, for the most part, legitimate ones, and the experimentalists were quick to modify their procedures to accommodate valid criticism. By 1940 there was, if not a general concensus on the reality of ESP, at least a general concensus on what constituted a good ESP experiment. Yet despite the adequacy of many of the experimental studies, conceded even by the leading critics of the period, and despite the continued accumulation of new experimental confirmations, the active confrontation between establishment science and claims of the paranormal went into hibernation for a decade and a half.

In 1955, active criticism of parapsychology was renewed with the publication in Science of an article by G. R. Price, a medical researcher who contended that psi phenomena are fundamentally incompatible with the basic principles of modern science. In his opinion, any extra-chance results in ESP experiments which were not attributable to clerical and statistical errors and unintentional use of sensory clues should be regarded as due to "deliberate fraud or mildly abnormal mental conditions" on the part of the experimenters (a view which was subsequently retracted; Price, 1972). Price argued further that while he had no evidence that the leading experimenters were guilty of fraud, if it were merely shown that they could have cheated, then we should be reluctant to accept the results of their experiments as providing convincing evidence for the reality of ESP.

This last idea was pursued in detail by a more recent critic (Hansel, 1966) who has tried to show how fraud could have produced the observed results in some of the classic ESP experiments. One parapsychologist (Thouless, 1972, p. 92) has commented on the situation: "It is clear that the evidence for ESP is strong, so strong that conviction of its reality can only be avoided by supposing that a number of apparently honest and reliable investigators are deliberately deceiving the world as to their results."

How strong _is_ the experimental evidence for the reality of psi phenomena? Quite a few experiments of good quality have been reported in which the results obtained deviate very significantly from those expected if one denies the possibility of psi phenomena; indeed, where the odds against similar results being obtained by chance alone are several hundred millions (or even billions) to one. On the other hand, such astronomical odds are generally obtained by carrying out a very large number of trials involving an effect which may scarcely be visible in the short run. It has been the case that psi effects produced in the laboratory have typically been weak, transient and not readily reproducible; statistical analysis may be required merely to detect the presence of any effect at all. In such a situation, where no satisfying explanation of the possible mechanism of these effects is provided, it is perhaps understandable that a critical-minded individual would be reluctant to accept the reality of phenomena which otherwise seem to him to be highly implausible. Consider, for example, this statement by a psychologist:

> Why do we not accept ESP as a psychological fact? Rhine has offered enough evidence to have convinced us on almost any other issue, where one could make some guess as to the mechanics of the process. ...Personally, I do not accept ESP for a moment, because it does not make sense. My external criteria, both of physics and physiology, say that ESP is not a fact, despite the behavioral evidence that has been reported. I cannot see what other basis my colleagues have for rejecting it...Rhine may still turn out to be right, improbable as I think that is, and my own rejection of his view is, in a literal sense, prejudice. (Hebb, 1951, p. 45)

Such a view ultimately involves some form of _a priori_ rejection of the possibility of psi phenomena. Often this is done on the grounds that psi phenomena are incompatible with the laws of physics. This argument carries some weight within the framework of nineteenth century deterministic physics, but in view of modern scientific developments,

> the _a priori_ claim that ESP violates specifiable laws of physics can no longer be considered to be of more than historical interest. ESP and other psi phenomena, while no longer incompatible with physics, are not yet accounted for by physics; but then, neither are the more familiar processes of memory and conscious experience. (Honorton, 1975, p. 112)

What of the overall quality of the research in parapsychology? One research worker (Morris, 1976, p. 303), commenting on the responsibilities of instructors teaching courses in parapsychology has remarked that

> Parapsychologists are very accustomed to viewing themselves as a maligned minority group, the victim of intellectual prejudices. Yet in truth many of the attacks against the field do have some solid basis. Many of us still do very sloppy work and indulge in naive theoretical meanderings in public places. This must be acknowledged from the start.

Granted, then, that some of the work in parapsychology is sloppy. On the other hand, in the view of Collins and Pinch (1978), whose specialty is the sociology of science, "It seems likely that the best of modern parapsychology comprises some of the most rigorously controlled and methodologically sophisticated work in the sciences." Collins and Pinch also believe that some of the criticisms of parapsychology "seem visibly influenced more by the desire to reject psi in particular, than by considerations of universal standards. Thus many of the criticisms would have a devastating effect if turned against parts of orthodox science." In particular, this is true of the accusation of widespread fraud, especially when this can "be put forward without any empirical evidence that fraud actually took place." The traditional means of dealing with such a problem in science lies not in attempting to design a "fraud-proof" experiment (as suggested by Price and Hansel), but rather in seeking independent replication.

Actually, one of the recurrent criticisms of parapsychology has been a lack of replicability, a failure to produce a "truly repeatable" experiment; i.e., a sort of fool-proof recipe for producing psi phenomena that any competent investigator could use to generate his own evidence. In reply, parapsychologists have often pointed out that the situation is not quite so simple; that unlike the macroscopic phenomena we are familiar within the natural sciences, psi phenomena are elusive and often seem to require a suitable psychological climate, free of a critical-test atmosphere or extreme skepticism. Critics are (understandably) not overly impressed with this argument. A different approach to this issue has been taken by Honorton (1976) who examined the problem of replication in parapsychology in the larger content of replication of findings in the behavioral sciences generally. He makes an impressive case that in many instances the degree of replication in parapsychology is considerably superior to that in other areas where the results have been accepted without question. Thus, by the standards of replication traditionally applied in psychology, it would seem that psi phenomena (and various characteristics of psi phenomena) are very well established facts indeed. Some additional weight may be lent to this line of argument by recent work of Collins (1974, 1975) who examined the problem of replication in physics; specifically, in the detection of gravity waves and the construction of lasers. His findings indicate that (even in physics) replication is by no means a simple, routine

task; and indeed, the very notion of replication is far from unambiguous. Collins' work explores some of the ideas of T. S. Kuhn (1962) on the nature of scientific controversy and the manner in which science advances. These ideas may be particularly relevant to parapsychology.

As Honorton (1973, p. 118) remarks, it may turn out that the "ESP controversy" has less to do with the adequacy of experiments in parapsychology than with the challenge posed to epistemological assumptions underlying western science. We seem to be involved in a "paradigm clash": psi phenomena are anomalies in the prevailing reality view or paradigm. Unless and until our world-view incorporates the possibility of psi phenomena, we can expect the controversy to continue.

In any case, the primary concern of much of the recent work in parapsychology is not the demonstration of the existence of psi phenomena but rather the development and testing of hypotheses concerning the nature of these phenomena and the factors which influence their occurrence.

Some Current Trends in Parapsychology

Perhaps one of the chief characteristics of the contemporary period in parapsychology is an extremely broad diversity in methodology. In addition to cards and dice, parapsychologists have utilized all kinds of specially devised equipment, as well as such "standard" items as plethysmographs, magnetometers, electronic random number generators and sophisticated biofeedback equipment. Experiments have involved plants, yeasts, and enzymes as well as cats, rats, mice, gerbils, lizards, fish, and even cockroaches. The following sampling of a few current lines of investigation will serve to indicate something of the variety of the work being done.

Not all of contemporary parapsychology is confined to the laboratory. The case-study approach to spontaneous occurrences of apparent psi phenomena has not been entirely abandoned (Rhine, 1961; Stevenson, 1970), and can be combined with an experimental approach by suggesting new hypotheses for testing (Stanford, 1974). An interesting source of psi phenomena is the clinical setting provided by psychoanalysis, where telepathic and precognitive dreams seem to occur (Eisenbud, 1970). This, too, can lead to new experimental approaches (Ullman, et al., 1973). Some parapsychologists engage in field investigation of reported instances of poltergeist phenomena and "hauntings" (Roll, 1972; Maher and Schmeidler, 1975). Finally, in investigating claims of unusual abilities of particular individuals, it is not always possible to exercise the degree of control attainable under laboratory conditions (Eisenbud, 1967; Wilhelm, 1976).

Most of contemporary parapsychology, however, does involve experimental work carried out under strictly controlled conditions. One traditional area of investigation deals with psychological factors. A large body of data has been gathered on the relationship of ESP performance to various factors—e.g., personality traits, attitude,

interpersonal relationships in the experimental setting (Palmer, 1977). A contemporary goal is to use this data to gain insight into the way ESP operates. For example, if certain factors (such as belief that ESP is possible in the experimental situation) are related to successful ESP performance, why should this be so? Specific hypotheses should be framed and tested.

An example of such "process-oriented" research is provided by recent attempts to investigate the way ESP responses are mediated into consciousness, and to optimize the conditions favorable to production of ESP (Braud, 1975; Honorton, 1977). In these experiments, subjects are asked to direct their attention inwards and are provided with a "free-response" ESP task (e.g., pictorial material is used as an ESP target and is matched against stream-of-consciousness reports of the subject's mental imagery). It is hypothesized that reduction of sensory and bodily stimuli, and elimination of internal distractions should facilitate ESP when focusing attention inward on one's mental processes. To test this, techniques (such as deep relaxation, sensory isolation, meditation) are employed to induce states which satisfy this hypothesis. Moreover, the effectiveness of these techniques in inducing the desired states can be monitored by combining introspective state reports with physiological measurements (e.g., of brain waves, muscle tension).

This last represents another trend: the search for physiological correlates of successful psi performance. Sophisticated physiological monitoring devices have been used for another purpose as well; namely to detect bodily reactions which may be indicative of ESP responses below the level of conscious awareness. For example, there is some evidence that the brain wave activity of a subject can be influenced by flashing a strobe light in the eyes of another person in a different room, yet the subject is quite unaware of his own response. This points up the fact that "we tend to think of psi as rare, but perhaps it is only the recognition-detection aspect which is rare. ...It is possible that psi is an important mediator of behavior below the level of recognition and detection" (Honorton, 1973, p. 120).

Indeed, it has been suggested that non-intentional psi may be an ordinary and significant part of our everyday lives. To investigate this, attempts have been made to induce spontaneous psi phenomena in an experimental setting (Stanford, 1974). These experiments show that people seem capable of producing psi phenomena that serve their needs (e.g., prevent them from being assigned to a boring task) without being consciously aware of these needs—or even that they were participating in a parapsychological experiment.

Another line of research (which has also been employed to investigate non-intentional psi) involves the use of sophisticated equipment for producing random processes. This line of work was initiated by a physicist, Helmut Schmidt, whose early experiments indicate that people (and perhaps animals) seem to be capable of precognizing and/or influencing the outcome of effects produced by radioactive decay and other random processes. Many of his elegant experiments are fully automated (in terms of the recording and analysis of data), and yield strong results with some startling implications (Schmidt, 1976).

Schmidt (1975) has also begun development of a mathematical model for psi phenomena. This last (along with examples cited earlier) is indicative of another characteristic feature of contemporary parapsychology: the development of low-order theories which can be tested experimentally. Attempts are also being made (Stanford, 1977) to reconceptualize the basic nature of psi phenomena.

Rationale for Including Parapsychology in the Curriculum

It has frequently been observed that psi phenomena have tremendous potential significance. For example, in an article highly critical of parapsychology, Price (1955) indicated that ESP, if genuine, would have important practical applications. He suggested that given a group of subjects with reliable (even though very weak) ESP ability it would be possible, using existing techniques of information theory, to develop an ESP communication network which could transmit information "as accurately as by telegraph" (although the transmission might require a relatively long time). He speculated that this could be put to practical use in espionage, or in the development of an early warning system against surprise nuclear attack. While this last remains in the realm of speculation, the underlying principle alluded to by Price has been demonstrated on several occasions; e.g., in one such demonstration a subject with weak but consistent ESP ability recovered five 3-digit numbers with perfect accuracy (Ryzl, 1976, pp. 175-186). Others have suggested the potential value of psi ability in medical diagnosis and healing, as well as in commercial ventures.

Still, it seems fair to say that as yet there are no "practical" applications of psi phenomena. To put this in proper perspective, recall that a few centuries ago demonstrations of static electricity doubtless seemed as inherently trivial as the ability to score slightly above chance at a card-guessing task does today. The ultimate practical value of the principles underlying such phenomena is difficult to evaluate in advance, and easy to underestimate.

Quite apart from direct practical application, deeper understanding of psi phenomena could lead to advances in other branches of science. At various times it has been suggested that the principles behind psi phenomena may be at work in other settings as well: in evolution, in embryological development, in memory and creativity, in ordinary sense perception. For example, some of the leading neurophysiologists have (somewhat reluctantly) concluded that the brain is, in itself, not sufficient to account for all the phenomena of mind. Sir John Eccles "believes that ESP and PK are weak and irregular manifestations of the same principle which allows an individual's mental volition to influence his own material brain, and the material brain to give rise to conscious experiences" (Koestler, 1972, p. 76).

The whole question of the nature of possible interactions between mind and body, between observer and environment, has been a central concern of physicists and philosophers as well as parapsychologists. In this context, the data of parapsychology could lead to a drastically altered view of the nature of man and of reality—with profound implications. A leading philosopher, H. H. Price, has commented that

"psychical research is one of the most important branches of investigation which the human mind has undertaken"; that it seems likely "to throw entirely new light upon the nature of human personality and its position in the universe"; and that in time "it may transform the whole intellectual outlook upon which our civilization is based" (Koestler, 1973, pp. 139-140).

In view of its potential significance, it would seem that parapsychology may well merit a place in the curriculum. The argument is strengthened by the general interest that seems to exist in the topics dealt with by parapsychology, along with the tremendous amount of misinformation available on these topics. Morriss (1976, p. 67) argues that:

> Youth are attracted to the occult, and with increased media coverage of the paranormal, there is a growing need for an educational program in the secondary schools that would not only give serious treatment to the sound research in parapsychology but would also offer the kinds of information and experiences that would help gullible adolescents to differentiate between serious scientific research in this field and the superstitious and pseudo-scientific claims of various cults.

In connection with this last, inclusion in the curriculum of an appropriate unit on parapsychology would not only fill a desperate need for reliable information but also would provide an excellent path for the study of science. For one thing, parapsychology is an area in which the need for careful experimentation and critical judgment is paramount, hence it can serve as a powerful vehicle for demonstrating the methodological requirements of sound scientific research. On the other hand, since parapsychology has not yet been absorbed into the mainstream of orthodox science, it provides a marvelous setting for illuminating important aspects of science that all too often remain in the background.

For example, discussion of the controversy over the existence of psi phenomena can reveal a great deal about the nature of scientific controversy in general and the ways in which new evidence and ideas are introduced and absorbed in science. This approach drives home the point that "science is not a monolith pronouncing truisms, but an ongoing process of disagreement, discovery, synthesis and resolution of conflicting positions and ideas" (Morriss, 1976, p. 70).

Parapsychology can also serve as a means of opening minds to the possibility of new discoveries, to the concrete realization that our current knowledge of the world is far from complete.

The study of parapsychology also provides fine opportunities for displaying (and cultivating) the open-mindedness, critical judgment—and patience—required of any good scientific investigator. As one parapsychologist has remarked (Thouless, 1972, p. 3),

> The quality of mind required of a psychical researcher is not an inclination to believe in stories of the marvelous

or an inclination to reject them, but a willingness to allow the degree of his belief or unbelief to be determined by the evidence and not by his prejudice or by his wishes, or by current fashions of thought.

PARAPSYCHOLOGY IN THE CLASSROOM

Educational Objectives

In presenting a unit on parapsychology, at the secondary or college level, it seems desirable to place the subject in a larger context. A rationale for such an approach has been indicated in the previous section. Stated succinctly, the chief objectives are as follows:

(1) To present students with activities and information that will stimulate critical thinking. More specifically, to encourage the cautious evaluation of unusual claims in conjunction with a willingness to remain open to new ideas and new ways of viewing the world.

(2) To place parapsychology in the context of the development of science. This serves the dual purpose of providing an appropriate setting for examining the claims of parapsychology, and for studying the nature of scientific controversy.

(3) To provide reliable information about the current state of knowledge in parapsychology. And, in conjunction with this, to develop sufficient background to be able to evaluate intelligently the fall-out from an explosion of media interest in the paranormal.

(4) To develop (familiarity with) the attitudes and skills of a careful scientific investigator. Also, if desirable, to provide exposure to the hypothesis-testing methodology used in the behavioral sciences.

Other goals can be set. Additional ideas on this, as well as suggestions for implementation, can be gleaned from McConnell (1971), Morris (1976) and Morriss (1976). The last of these also contains the results of a survey of high school students on their knowledge, attitudes and interest in parapsychology and may be helpful in assessing strategies for attaining particular objectives. The following material is intended to provide suggestions for possible topics and activities for use in the classroom.

Need for a Critical, Open-minded Approach

By definition, psi phenomena involve transmission of information by means other than the known sensory channels. Thus, to conclude that an ostensible instance of ESP is genuine, it is necessary to make sure that the information was not communicated by sensory means. The need

for caution can be driven home by demonstrating dramatic "psi" effects which are actually accomplished by trickery. At least one parapsychologist spends time at the beginning of his courses

> demonstrating various techniques for simulating psi, such as muscle reading, trick blindfolds, stacked card decks, telepathy codes, audience stooges, various seance-room techniques, ... how to phrase and time public predictions, and so on. Most students soon learn that impressive psychic demonstrations can be faked surprisingly easily, and this starts them reevaluating the process of logic by which they infer communication in the world around them (Morris, 1976, p. 304).

Most books on stage magic contain simple techniques which can be used to produce dramatic pseudo-psi effects. A good source of tricks for use with a younger audience is Rawson (1962); the first few items in Chapters 5 and 9 are especially appropriate. Ryzl (1976, pp. 14-15) contains a nice example of "mind-reading." Christopher (1970) provides some excellent material relating to the history of fraudulent claims in parapsychology. In this connection, see also Thouless (1972, Chapter 7, as well as pp. 19-23, 31-33, 41-42) and Wolstenholme (1969, pp. 131-155). Some suggestions on how contemporary parapsychologists may have been fooled are offered by The Amazing Randi (1975, especially Chapters 11, 13).

Quite apart from deliberate deception, instances of pseudo-ESP can occur unintentionally: sensory cues can be transmitted and/or received without conscious awareness (Thouless, 1972, pp. 19-22). Such possibilities can be eliminated in a carefully designed experiment, but any conditions which fall short of tight experimental control demand very close observation. Some good rules of observation are given in Ryzl (1976, pp. 39-43). The limitations of our untutored observations can be revealed not only by demonstrations of stage magic (where misdirection and false assumptions play a key role), but by other techniques as well. Schrank (1972, pp. 2-9) has a number of suggestions along these lines, including the following:

> Stage a 'surprise' event. Have some person not in the class enter the room to make an announcement, call someone out of the room, start an argument, or simply walk across the room and leave. After the outsider has left, ask the class for an accurate description of the person in writing. Ask specific questions, such as color of hair, eyes, height, clothing. Compare the descriptions with the correct answers, and discuss the experience (p. 8).

Further ideas along the same lines may be found in the book by Beveridge (1957, Chapter 8), who remarks that "accurate observation of complex situations is extremely difficult, and observers usually make many errors of which they are not conscious."

One factor contributing to poor observation is that our perceptions are often dominated by our assumptions—we see only what we expect to see, and impose standard interpretations on sensory data. Sometimes shock tactics help get this point across. For example, if you hold a

pencil horizontally near one end (loosely between thumb and forefinger) and jiggle it up and down rapidly, the pencil will appear to be made of rubber. Other means for raising questions about the mechanism of perception include optical illusions: a nice little book suitable for younger children is Carini (1970); another source of striking visual illusions is Gregory (1970). In a slightly different vein, Schrank (1972, p. 34ff.) offers material that can be used in revealing hidden assumptions; these can be blocks to creativity as well as perception. Adhering rigidly to our assumptions about reality can serve as a barrier to new ideas; many important advances in science would not have been possible without abandoning (at least temporarily) old ways of looking at the world.

The importance of being open to alternative ways of viewing the world is underscored by the realization that our basic perception of reality is shaped by a variety of factors (cultural and physiological, as well as psychological). For example, Hall (1966, pp. 44-45) points out that "space perception is not only a matter of what can be perceived but what can be screened out. People brought up in different cultures learn as children, without ever knowing that they have done so, to screen out one type of information while paying close attention to another." He concludes (p. 181) that "there is no alternative to accepting the fact that people reared in different cultures live in different sensory worlds." He provides fascinating examples of this throughout his book (but especially in Chapters 7, 11, 12). Alternative world-views can be explored through a variety of means, including the enormously popular writings of Carlos Castaneda (1972, 1974), the delightful science fantasy Sphereland (Burger, 1968), or the "relativity parables" offered by Schrank (1972, pp. 174-176).

The world-view of most people is probably quite different from that of a physicist (or a mystic) and is certainly different from that of a blind man or an insect; yet too often we identify reality with our individual perception of it. Ornstein (1972, pp. 20-21) points out that "we cannot possibly experience the world as it fully exists—we would be overwhelmed. We are restricted by our physical evolution to only a few sensory dimensions. If we do not possess a 'sense" for a given energy-form we do not experience its existence." And when we do possess such a sense, it may be extremely limited: e.g. the human eye can detect light in what amounts to only a tiny slice of the electromagnetic spectrum. Consider the following demonstration: bring a radio to class and turn it on so that the room is filled with music; then find out how many people are comfortable with the idea that the music was (in a genuine sense) already present in the room before the radio was turned on—indeed, that it was in the room even without the radio at all. The extent of the (anticipated) discomfort may lend some substance to the following remark (Koestler, 1973, pp. 127-128). "We are surrounded by phenomena whose existence we studiously ignore; or, if they cannot be ignored, dismiss as superstitions. Until the thirteenth century, man did not realize he was surrounded by magnetic forces. Nor do we have any direct sensory awareness of them; nor of the showers of neutrinos which traverse us; nor of other unknown 'influences'."

Students might like to speculate on how our view of reality would be altered if a sort of "psychic lodestone" were discovered which revealed the presence of psi phenomena in much the same way as a natural magnet gave some awareness of the existence of magnetic forces. Another topic for speculation: suppose psi phenomena were genuine, widespread and (ultimately) controllable; what consequences would this have for our society?

Science and Parapsychology

It is instructive to place the claims of parapsychology in the context of the history of scientific discovery. One good topic involves an examination of the way in which some important ideas in science were initially received. "Many discoverers of unexpected properties of the physical world have been laughed at, much as students of ESP are laughed at today. Leibnitz himself wrote of the theory of gravity:

> That one body should attract another with no intermediary is not so much a miracle as a sheer contradiction, for 'tis to suppose a body can act in a place where it is not.' And when it came to research into electro-magnetic phenomena, Galvani was ridiculed at first for his interest in the twitching legs of a frog, Röntgen for his discovery of x-rays and Becquerel for suggesting that uranium salts could emit radiation. Then, in 1901, came Marconi's wild idea of sending wireless signals from Cornwall to Newfoundland. Men still living remember how contemporary scientists laughed at that. 'The earth is round,' they said, 'and radio waves go straight.' One of them remarked that Marconi's idea was as silly as that of telepathy. Soon afterwards the Heaviside layer was discovered (Heywood, 1964, p. 31).

Further examples of this sort can be found in Beveridge (1957, Chapter 9).

A related theme deals with the way in which controversy is dealt with in science. McConnell (1971, pp. 69-70) points out that until 1800 the highest scientific authorities, including Lavoisier, thought there were no such things as meteorites.

> After all, there are no stones in the sky; so stones cannot fall out of the sky. Only a superstitious person would believe in meteorites. ...Eventually, of course, the leaders of science decided that meteorites do come from outer space and they revised the textbooks accordingly. But in doing so they forgot to mention that there had ever been any argument about the matter.

This last may be typical of the progress of science; to some extent history is rewritten with the textbooks—which present only our current understanding and give little indication that longstanding arguments abound in science. Moreover, the resolution of scientific controversies is not always a simple matter of rational thought guided by hard evidence. E.g., Max Planck, one of the founders of modern physics, commented that "a new scientific truth does not triumph by

convincing its opponents and making them see the light but rather because its opponents eventually die, and a new generation grows up that is familiar with it" (Kuhn, 1962, p. 150).

In the view of the historian of science Thomas Kuhn, scientific development should not be regarded as a process of steady accretion of factual knowledge; rather, the fabric of science is periodically reshaped by the incorporation of revolutionary new ideas. For example, it is clear that at various times in the past, science has included bodies of belief quite incompatible with the ones we hold today; our current perspective is the product of a series of "scientific revolutions." Such revolutions are initiated by discoveries of anomalous results which are in conflict with the prevailing world-view under which science is operating; resolution of the conflict ultimately involves the adoption of a new scientific "paradigm," a new world-view. Major revolutions of this sort were associated with the adoption of the theories of Copernicus, Darwin, Einstein—to name a few. It has been suggested that the data of parapsychology may precipitate yet another scientific revolution of comparable magnitude. At any rate, Kuhn's ideas shed an interesting light on the controversy over psi phenomena and, conversely, parapsychology can be used as a case study for examining Kuhnian views on the nature of scientific controversy. More on this can be found in Kuhn (1962), McConnell (1968), Tart (1966), Ornstein (1972, Chapter 1), Stanford (1977).

Another worthwhile topic is the compatibility of parapsychology with physics. This is treated in the very readable books of Koestler (1973) and LeShan (1974a). The latter also examines the analogies between the world-view of contemporary physics and that of mysticism; this last is also the subject of the excellent book by Capra (1975). For those interested in the connection of parapsychology with the life sciences, we recommend the survey article by Morris (1977), portions of the book by Randall (1976) and the articles by Grad (1967) and Eisenbud (1976).

Evaluating the Evidence in Parapsychology

The following includes some sources and activities which can be used in engaging in a critical examination of the evidence for psi phenomena. This should be placed in the larger context of developing sufficient background and judgment to be able (at least) to distinguish between serious scientific work in parapsychology and the mass of unsubstantiated claims and pseudo-scientific activities that dominate the information on psi phenomena available through the public media.

Reliable general information about parapsychology can be found in the readable books of Rhine (1975) and Pratt (1973). Also, Wilhelm (1976) has written a popular book which provides an excellent example of an open-minded but critical approach to examining recent claims. A brief survey of some of the stronger evidence for psi phenomena is given in Thouless (1972, Chapters 8 and 10). A more detailed examination of the classic evidence can be based on the material in Murphy and Dale (1961). Professor R. A. McConnell has prepared "An Evidential

Bibliography of Parapsychology" intended for skeptical scientists interested in sampling the experimental literature in parapsychology; single copies can be obtained by writing him at this address: Biophysics and Microbiology Dept., University of Pittsburgh, PA 15213.

Surveys (by parapsychologists) of the major criticisms of the evidence for psi phenomena can be found in Honorton (1975) and Ransom (1976); see also Thouless (1972, Chapter 11). Interesting discussions can be based on the critical article of Price (1955) and the various rejoinders (Soal, Rhine, et al., 1956) which appeared in Science. These are available in pamphlet form from the Bobbs-Merrill Company in their Reprint Series in the Social Sciences, P-279. Other sources of criticism are Gardner (1957, Chapter 25) and Hansel (1966). The appendix to Honorton, Ramsey and Cabibbo (1975, pp. 139-149) provides an interesting case study of some contemporary criticism.

With regard to activities for developing critical judgment, Morris (1976) mentions several techniques he employs in his parapsychology courses. Throughout, he utilizes two texts, one positive and one negative, and assigns comparable readings from each. "This helps the students to retain a balanced view and also serves as a constant reminder that gifted writers can be emotionally persuasive without necessarily being factually accurate" (p. 305). Another idea was "The Airport Project," in which students selected paperback books of the sort found on newsstands at airports—in this case, ones that emphasized techniques for psychic development. The assignment was to do a book report which would review in some detail "the exact procedures for becoming a psychic as outlined in that particular book, and then criticize it with respect to what we've covered so far in class" (p. 311). A favorite exam question asks students "what they would investigate and how they would do it if they were members of a Nader's Raiders task force assigned to parapsychology," the aim being to help people avoid being easy prey to "psychic rip-offs" (p. 307).

In this context, it seems worth noting that the claims of commercial "ESP training" and "mind control" programs have been largely unsubstantiated; for a critical review, see Stanford (1976). There are other claims which have gained popular attention which are not well supported by experimental evidence; examples which may be worth examining critically are "primary perception" in plants (Kmetz, 1977) or "pyramid power." Another topic on which there is a lot of popular misinformation is parapsychological research in the Soviet Union; reliable information can be found in the article by Pratt in (Wolman, 1977) as well as in (Ryzl, 1976, pp. 199-212) and (Pratt, 1973, Chapter 3).

Conducting Your Own Experiments

As Louisa Rhine (1975, p. 218) comments, "It is not easy to prove that psi exists but, oddly, it is not difficult to try," and "both individual and classroom experiments are easy and fun to make and need not be at all complex." Her book includes brief but detailed instructions for conducting a variety of standard card-guessing tests,

along with some helpful comments. She warns that "because the level of scoring is likely to be low, it is generally necessary to repeat the tests a number of times. This is where boredom comes in, and it is a killer" (Rhine, 1975, p. 219). Indeed, the dull, repetitious nature of card-guessing tasks, combined with the lack of insight they afford to the percipient, has led many parapsychologists (e.g., Tart, 1966) to question their efficacy. The main advantage of such tests is that they are easy to prepare, administer and evaluate. There are alternatives suitable for classroom use that share most of these merits, which may prove less boring.

One minor variation is to replace the cards by more suggestive material; e.g., photographs could be used. Each photo could be either in color or black-and-white (guess which), or the subject of each photo could be male or female, cheerful or unhappy, etc. Some ideas on this can be found in Ebon (1971, Chapter 5). In a different vein, ESP tests reminiscent of the game of "battleship" can be devised. In one version (Honorton and Barker, 1976), one square of a five-by-five grid is selected at random and designated as target; the subject tries to "guess" which one. By a subterfuge, the results can be scored in essentially the same manner as card-guessing. (Namely, regard the task as consisting of two separate guesses: one for the row containing the target square, another for the column. This is equivalent to attempting to guess the symbols on two cards, where each card contains one of five possible symbols. Just as a card-guessing test ordinarily involves more than two guesses, here, too, more than one target grid should be prepared in advance.) The procedure lends itself to group testing, where (for each target) every member of the group is provided with a separate copy of the grid on which to record his guess.

Several tests designed for use with children are given in the book by Ebon (1971, Chapter 4). More of these, along with a number of ESP games can be found in Ryzl (1976, pp. 121-134); Ryzl also presents detailed procedures for a variety of psi experiments (pp. 76-102). A very careful description of proper experimental procedure for card-guessing tests is provided by McConnell (1971, Appendix 4).

A radical departure from the card-guessing type experiment involves the use of "free-response" methods. In one classic approach, an agent draws a simple "target" picture, and the subject (located elsewhere) makes his own drawing; the results are subsequently compared. A long series of informal experiments of this sort was conducted by the novelist and social reformer Upton Sinclair, with his wife as subject. Many genuinely striking results were obtained and are described in the book <u>Mental Radio</u> (Sinclair, 1971; see also McConnell, 1971, pp. 71-78). Since the subject's drawings may not bear any remarkable resemblance to the target picture, proper evaluation of the results of such an experiment may require "blind" matching of drawings by an independent judge. A suitable judging procedure, along with detailed instructions for conducting a picture-drawing experiment, is given by McConnell (1971, Appendix 3).

Another type of free-response test has the subject provide a verbal report of his impressions rather than a drawing. Generally the target consists of pictorial material, such as magazine photos,

art prints, viewmaster reels. In evaluating the results here, a good alternative to blind matching of verbal reports to actual targets is to have the subjects themselves rank order a small set of materials consisting of the real target and several pretenders. Then the same statistical procedure used in evaluating card-guessing can be employed here (e.g., a correct "guess" could correspond to ranking the actual target in first place).

Free-response experiments seem to be most effective when combined with techniques designed to enhance ESP performance. An excellent review of the internal procedures utilized by successful subjects (such as Mrs. Sinclair) in developing their abilities is given in the article by White (1964); reprints can be obtained from the American Society for Psychical Research. Use of various meditative techniques may also be helpful. LeShan (1974b) has written an excellent practical introduction to meditation. Various methods can also be employed by the experimenters to assist subjects in arriving at "psi-conducive" states. For example, the subject can be given instructions for progressive relaxation; relaxation exercises suitable for use with children, as well as adults, can be found in Hendricks and Wills (1975, Chapter 4). A more dramatic, and perhaps more effective, technique involves inducing a mild form of sensory isolation: a uniform visual field (ganzfeld) can be created by placing halves of ping-pong balls on the subject's eyes; a monotonous background sound can be provided through stereo headphones. Under these conditions, subjects often experience a pleasant state characterized by an increase in spontaneous mental imagery. The paper by Terry and Honorton (1976) contains a detailed procedural description of a verbal free-response experiment using the ganzfeld technique; included are some striking examples of correspondences between targets and subjects' reports.

Another way to enhance ESP performance generally is to provide a suitable atmosphere. McConnell (1971, pp. 54-55) points out that in parapsychology "aside from the mechanical arrangements, the main responsibility of the experimenter is to try to establish the unknown psychological conditions for success. ... The mechanical procedures necessary to eliminate the possibility of error and fraud must be made as unobtrusive as possible. Preferably the entire procedure should appear as a game to the percipient." And, in commenting on the role of the experimenter Rhine (1976, pp. 218-219) remarks that "subjects are affected very much by the atmosphere he radiates. It must be the kind that stimulates the subject to want to perform well while it puts him at ease and makes him comfortable." There is good evidence (Honorton, Ramsey and Cabibbo, 1975) to indicate that subjects tend to do better when handled by an experimenter who is friendly and supportive, rather than one who is abrupt and unfriendly.

This last provides an example of a hypothesis about psi phenomena that students might like to test, rather than merely trying to demonstrate the existence of ESP. Other examples: do people who believe in the possibility of ESP tend to score better than those who don't; does relaxation (or meditation) tend to improve performance on ESP tests? Additional ideas of this sort can be found in Rhine (1976, pp. 235-236), Ryzl (1976, pp. 103-108) and Thouless (1972, pp. 79-82 and 123-124).

Proper evaluation of the results of experiments in parapsychology generally requires the use of statistical techniques. This may provide an opportunity to acquaint students with the hypothesis-testing methodology employed in the behavioral sciences. On the other hand, McConnell points out (1971, p. 10) that "it would be regrettable if the students were allowed to acquire a misconception about ESP that is common among scientists, namely, that ESP research is a matter of routinized card-guessing plus elementary probability theory." The point being that "statistical method, although commonly used in this research, is merely a tool made necessary by the fact that in most ESP experiments the effects are too weak to be recognized by inspection" (McConnell, 1971, p. 10). At any rate, the statistical techniques needed can be found in the following sources. Rhine (1976) and McConnell (1971) provide just enough information to evaluate the experiments they describe. Ryzl (1976, pp. 135-150) has a somewhat more extensive discussion. The book by Weinberger and Schumaker (1974) provides an excellent introductory treatment of statistics, although not specifically oriented towards parapsychology. For the latter, consult the chapter on statistical methods in the Handbook of Parapsychology (Wolman, 1977) as well as the articles of Stanford and Palmer (1972) and Zenhausern (1974).

RESOURCE MATERIALS IN PARAPSYCHOLOGY

For anyone involved with the teaching of a unit on parapsychology at the secondary (or college) level, probably the most helpful all-around reference is the ESP Curriculum Guide (McConnell, 1971). This small book contains a useful annotated bibliography of "hard-core" parapsychology, as well as some very good material illustrating how parapsychology can be used in studying science. Another valuable source for teachers is the symposium on Education in Parapsychology edited by Shapin & Coly (1976). Of particular interest are the papers contributed by James Morriss and Robert Moris (cited separately in our reference list). The first of these describes a module in parapsychology which was being developed for use in secondary schools, and the second is based on the author's experience in teaching college courses in the subject. These two books are useful in providing ideas for curricular material in parapsychology; reliable information on the subject can be obtained from the sources mentioned below.

A sound introduction which is aimed partly at a younger audience (junior high on up) is PSI, What Is It? by Louisa Rhine, the wife of J. B. Rhine. This book is a good antidote to the dry technical accounts with "all those big words" that can dampen enthusiasm for even so fascinating a subject as this. While never sacrificing accuracy, and always emphasizing the need for careful experimentation, Mrs. Rhine takes pains to hold the reader's interest. The book is liberally sprinkled with accounts of spontaneous occurrences (which are regarded as suggestive rather than conclusive) and even the experimental work is often described in a mildly anecdotal style which makes for a pleasant reading experience.

An excellent book for the intelligent general reader is ESP Research Today by J. Gaither Pratt, one of Thine's early co-workers. Pratt gives a very fine overview of parapsychology and provides some insight into what it's like to be a researcher in the field. His is a solid little book which manages to present a lot of information in a short span, and still remain highly readable and enjoyable. Despite the subtitle "A study of developments in parapsychology since 1960," it should be kept in mind that this is not quite an up-to-the-minute account; interesting developments have occurred since the book appeared in 1973. Some of these developments are reported in the recent book by Tart (1977).

Two popular books are available which describe very recent work (e.g., on "remote viewing") done at Stanford Research Institute: Mind-Reach and The Search for Superman. The first is written by physicists Russell Targ and Harold Puthoff, who conducted the research; the second by journalist John Wilhelm, who set out to examine their claims. Both books are readable, interesting—and worth comparing.

Another recent book is Parapsychology and the Nature of Life, by John Randall, a biologist. The first part of this one is concerned with religion and science, and the author traces the roots of the materialist view implicit in much of modern scientific thinking. His belief is that the findings of parapsychology may lead to a broadening of our concept of reality and the reinstatement of religious values. The second part provides an excellent survey of parapsychology (through 1974), and a third part examines some of the implications of these results.

A very fine book which provides a more detailed view of early "psychical research," as well as some theoretical speculations on the nature of psi phenomena is Beyond the Reach of Sense, by Rosalind Heywood. Mrs. Heywood is an unusually lucid thinker, a talented writer—and a gifted "psychic." She has also written a fascinating autobiography, ESP: A Personal Memoir, which provides insight into spontaneous psi phenomena from the vantage point of direct personal experience.

For the serious reader, a good casebook is Gardner Murphy's Challenge of Psychical Research. The intent here is "to show what psychical research is by giving documented examples of the kind of data available...and asking always this one recurrent question: What can a thoughtful reader think about these things?" (pp. 5-6). The material here is largely drawn from "classics" in parapsychology. A more current source of technical information and state-of-the-art surveys is the authoritative Handbook of Parapsychology edited by Benjamin Wolman.

The very serious reader may wish to sample the literature in the Journal of Parapsychology, the Journal of the American Society for Psychical Research, or in Research in Parapsychology. This last represents the proceedings of the Parapsychological Association and contains much valuable information on current research activities. It is published annually in book form, and since the same publisher also produces other important works in parapsychology, the address is

given here: Scarecrow Press, 52 Liberty Street, P.O. Box 656, Metuchen, New Jersey 08840. Another organization which publishes an annual symposium (and which maintains an extensive parapsychology library available for public use) is the Parapsychology Foundation, 29 West 57th Street, New York, New York 10019.

A very extensive annotated (and thoroughly cross-referenced) bibliography is provided, along with other useful information on the field, in Parapsychology: Sources of Information, compiled by Rhea White and Laura Dale. Another useful book in the same vein is Robert Ashby's Guidebook for the Study of Psychical Research, which contains a separate bibliography for "beginning students."

Useful information on parapsychology is available from several agencies. One of these is the Education Department of the American Society for Psychical Research, 5 West 73rd Street, New York, New York 10023. Upon request they will supply an information sheet on studying parapsychology, as well as a listing of available educational materials. These materials (such as ESP cards, and an annual list of "courses and other study opportunities in parapsychology," as well as various bibliographies and articles) are available at a moderate cost. Materials can also be obtained from the Institute for Parapsychology (the successor to the Parapsychology Laboratory at Duke University) at the Foundation for Research on the Nature of Man, P.O. Box 6846, College Station, Durham, North Carolina 27708. The Parapsychological Association has an Information Service Committee which can be contacted through Howard Zimmerman, Executive Secretary, Parapsychological Association, P.O. Box 7503, Alexandria, Virginia 22307. Another source of information, aimed primarily at educators, is ISPE (Information Services for Psi Education), P.O. Box 2221, New York, New York 10001.

A special exhibition on parapsychology, PSI SEARCH, is touring the country. The itinerary includes various museums and universities; for information write to Smithsonian Traveling Exhibition Service, Washington, DC 20580. The exhibition has been highly praised, and a recent book based on this material (Bowles & Hynds, 1978) should also be good.

A number of films on parapsychology are available for rental; probably the best two are "To Solve the ESP Mystery" and "Psi: Boundaries of the Mind." Both are suitable for high school (or adult) audiences. The first is available from Document Associates, Inc., 880 Third Avenue, New York, New York 10022; the second, from BFA Educational Media, 2211 Michigan Avenue, Santa Monica, California 90404.

The items included in the list of references have been selected primarily on the basis of utility and reliability. Many other books on parapsychology are readily available; some are good, others are mediocre and many are crammed with misinformation—so caution is advisable in selecting unknown material.

REFERENCES

Ashby, R. H. The Guidebook for the Study of Psychical Research. New York: Samuel Weiser, 1972.

Beveridge, W. I. B. The Art of Scientific Investigation (Revised edition). New York: Norton, 1957.

Bowles, N. and F. Hynds. Psi Search. New York: Harper and Row, 1978.

Braud, W. G. "Psi-Conducive States." Journal of Communication, Vol. 25:142-152, 1975.

Burger, D. Sphereland: A Fantasy About Curved Spaces and an Expanding Universe. New York: Thomas Y. Crowell, 1968.

Capra, F. The Tao of Physics. Berkeley, CA: Shambhala Publications, 1975.

Carini, E. Take Another Look. Englewood Cliffs, NJ: Prentice Hall, 1970.

Castaneda, C. Journey to Ixtlan. New York: Simon and Schuster, 1972.

Castaneda, C. Tales of Power. New York: Simon and Schuster, 1974.

Christopher, M. ESP, Seers & Psychics. New York: Thomas Y. Crowell, 1970.

Collins, H. M. "The TEA Set: Tacit Knowledge and Scientific Networks." Science Studies, Vol. 4:165-186, 1974.

Collins, H. M. "The Seven Sexes: A Study in the Sociology of a Phenomenon, or the Replication of Experiments in Physics." Sociology, Vol. 9:205-225, 1975.

Collins, H. M. and T. J. Pinch. "The Construction of the Paranormal: Nothing Unscientific is Happening." To appear in R. Wallis (ed.), Rejected Knowledge, Sociological Review Monograph, 1978.

Ebon, M. (ed.). Test Your ESP. New York: Signet (New American Library), 1971.

Eisenbud, J. The World of Ted Serios. New York: William Morrow, 1967; republished, New York: Paperback Library, 1969.

Eisenbud, J. Psi and Psychoanalysis. New York: Grune & Stratton, 1970.

Eisenbud, J. "Evolution and Psi." Journal of the American Society for Psychical Research, Vol. 70:35-53, 1976.

Gardner, M. Fads and Fallacies in the Name of Science. New York: Dover, 1957. [Originally published, 1952.]

Grad, B. "The Laying-on of Hands: Implications for Psychotherapy, Gentling, and the Placebo Effect." Journal of the American Society of Psychical Research, Vol. 61:286-305, 1967.

Gregory, R. L. The Intelligent Eye. New York: McGraw-Hill, 1970.

Hall, E. T. The Hidden Dimension. New York: Doubleday, 1966.

Hansel, C.E.M. ESP, a Scientific Evaluation. New York: Charles Scribner's Sons, 1966.

Hebb, D. O. "The Role of Neurological Ideas in Psychology." Journal of Personality, Vol. 20:39-55, 1951.

Hendricks, G. and R. Wills. The Centering Book. Englewood Cliffs, NJ: Prentice Hall, 1975.

Heywood, R. ESP: A Personal Memoir. New York: E. P. Dutton, 1964. [Originally published in England under the title The Infinite Hive.]

Heywood, R. Beyond the Reach of Sense. New York: E. P. Dutton, 1974. [Originally published in 1959 in England, under the title The Sixth Sense.]

Honorton, C. "Parapsychology and Consciousness," in Research in Parapsychology, 1972. Metuchen, NJ: Scarecrow Press, 118-121, 1973.

Honorton, C. "Error Some Place!" Journal of Communication, Vol. 25: 103-116, 1975.

Honorton, C. "Has Science Developed the Competence to Confront the Claims of the Paranormal?" in Research in Parapsychology, 1975. Metuchen, NJ: Scarecrow Press, 119-223, 1976.

Honorton, C. "Psi and Internal Attention States," in B. B. Wolman (ed.) Handbook of Parapsychology. New York: Van Nostrand-Reinhold, 1977.

Honorton, C. and P. L. Barker. "Locating Hidden Coordinates," in Research in Parapsychology, 1975. Metuchen, NJ: Scarecrow Press, 32-33, 1976.

Honorton, C.; M. Ramsey; and C. Cabibbo. "Experimenter Effects in Extrasensory Perception." Journal of the American Society for Psychical Research, Vol. 69:135-149, 1975.

Kmetz, J. M. "A Study of Primary Perception in Plant and Animal Life." Journal of the American Society for Psychical Research, Vol. 75:157-169, 1977.

Koestler, A. The Roots of Coincidence. New York: Vintage Books (Random House), 1973.

Kuhn, T. S. The Structure of Scientific Revolutions. Chicago: University of Chicago Press, 1962.

LeShan, L. The Medium, the Mystic and the Physicist. New York: Viking Press, 1974(a). [Also available in paperback: Ballantine Books, 1975.]

LeShan, L. How to Mediate: A Guide to Self-discovery. Boston: Little, Brown, 1974(b). [Also available in paperback: Bantam Books, 1975.]

Maher, M. and G. R. Schmeidler. "Quantitative Investigation of a Recurrent Apparition." Journal of the American Society for Psychical Research, Vol. 66:341-352, 1975.

McConnell, R. A. "The Structure of Scientific Revolutions: An Epitome." Journal of the American Society for Psychical Research, Vol. 62: 321-327, 1968.

McConnell, R. A. ESP Curriculum Guide. New York: Simon and Schuster, 1971.

Morris, R. L. "The Responsibility of Instructors in Parapsychology," in L. Shapin and L. Coly (eds.) Education in Parapsychology. New York: Parapsychology Foundation, 300-312, 1976.

Morris, R. L. "Parapsychology, Biology and Anpsi," in B. B. Wolman (ed.) Handbook of Parapsychology. New York: Van Nostrand-Reinhold, 1977.

Morriss, J. E. "Parapsychology in the Secondary School Curriculum," in B. Shapin and L. Coly (eds.) Education in Parapsychology. New York: Parapsychology Foundation, 58-80, 1976.

Murphy, G. with L. A. Dale. Challenge of Psychical Research: A Primer of Parapsychology. New York: Harper and Row, 1961.

Ornstein, R. E. The Psychology of Consciousness. San Francisco: W. H. Freeman, 1972.

Oteri, L. (ed.). Quantum Physics and Parapsychology. New York: Parapsychology Foundation, 1975.

Palmer, J. "Attitudes and Personality Traits in Experimental ESP Research," in B. B. Wolman (ed.) Handbook of Parapsychology. New York: Van Nostrand-Reinhold, 1977.

Pratt, J. G. ESP Research Today. Metuchen, NJ: Scarecrow Press, 1973.

Price, G. R. "Science and the Supernatural." Science, Vol. 122: 359-367, 1955.

Price, G. R. "Apology to Rhine and Soal." Science, Vol. 175:359, 1972.

Randall, J. L. Parapsychology and the Nature of Life. New York: Harper and Row, 1976.

Randi, J. (Pseud. The Amazing RANDI). The Magic of Uri Geller. New York: Ballantine Books (Random House), 1975.

Ransom, C. C. "Recent Criticisms of Parapsychology: A Preview," in R. A. White (ed.) Surveys in Parapsychology. Metuchen, NJ: Scarecrow Press, 1976.

Rawson, C. (Pseud. The Great Merlini). How to Entertain Children with Magic You Can Do. New York: Simon and Schuster, 1962.

Rhine, J. B. Extra-Sensory Perception. Boston: Bruce Humphries, 1964. [Originally published in 1934.]

Rhine, L. E. Hidden Channels of the Mind. New York: Sloane, 1961.

Rhine, L. E. PSI, What Is It? New York: Perennial Library (Harper and Row), 1975.

Roll, W. G. The Poltergeist. New York: New American Library, 1972.

Ryzl, M. ESP Experiments Which Succeed. Privately printed; available from the author at P.O. Box 9459, Westgate Station, San Jose, CA 95157. [$9.50]

Schmidt, H. "Toward A Mathematical Theory of PSI." Journal of the American Society for Psychical Research, Vol. 69:301-319, 1975.

Schmidt, H. "PK Effect on Pre-recorded Targets." Journal of the American Society for Psychical Research, Vol. 70:267-291, 1976.

Schrank, J. Teaching Human Beings. Boston: Beacon Press, 1972.

Shapin, B. and L. Coly (eds.). Education in Parapsychology. New York: Parapsychology Foundation, 1976.

Sinclair, U. Mental Radio. New York: Collier Books (Macmillan), 1971. [Originally published in 1930.]

Soal, S. G.; J. B. Rhine, et al. "Replies to G. R. Price, "Science and the Supernatural." Science, Vol. 123:9-19, 1956.

Stanford, R. G. "An Experimentally Testable Model for Spontaneous Psi Events." Journal of the American Society for Psychical Research, Vol. 64:34-57 and 321-356, 1974.

Stanford, R. G. "Scientific, Ethical, and Clinical Problems in the 'Training' of Psi Ability," in R. A. White (ed.) Surveys is Parapsychology. Metuchen, NJ: Scarecrow Press, 1976.

Stanford, R. G. "Are Parapsychologists Paradigmless in Psiland?" in B. Shapin and L. Coly (eds.) The Philosophy of Parapsychology. New York: Parapsychology Foundation, 1-18, 1977.

Stanford, R. G. and J. Palmer. "Some Statistical Considerations Concerning Process-oriented Research in Parapsychology." Journal of the American Society for Psychical Research, Vol. 66:166-179, 1972.

Stevenson, I. Telepathic Impressions. Charlottesville, VA: University Press of Virginia, 1970.

Targ, R. and H. Puthoff. Mind-Reach. New York: Delacorte Press, 1977.

Tart, C. T. "Card Guessing Tests: Learning Paradigm or Extinction Paradigm?" Journal of the American Society for Psychical Research, Vol. 60:46-55, 1966.

Tart, C. T. "Did I Really Fly? Some Methodological Notes on the Investigation of Altered States of Consciousness and Psi Phenomena," in R. Cavanna (ed.) Psi-Favorable States of Consciousness. New York: Parapsychology Foundation, 1970.

Tart, C. T. Psi: Scientific Studies of the Psychic Realm. New York: E. P. Dutton, 1977.

Terry, J. C. and C. Honorton. "Psi Information Retrieval in the Ganzfeld: Two Confirmatory Studies." Journal of the American Society for Psychical Research, Vol. 70:207-217, 1976.

Thouless, R. H. From Anecdote to Experiment in Psychical Research. London: Routledge and Keegan Paul, 1972.

Ullman, M. and S. Krippner with A. Vaughan. Dream Telepathy: Experiments in Nocturnal ESP. Baltimore, MD: Penguin Books, 1974.

Weinberg, G. H. and J. A. Schumaker. Statistics: An Intuitive Approach (3rd edition). Monterey, CA: Brooks-Cole, 1974.

White, R. A. "A Comparison of Old and New Methods of Response to Targets in ESP Experiments." Journal of the American Society for Psychical Research, Vol. 58:21-56, 1964.

White, R. A. (ed.). Surveys in Parapsychology: Reviews of the Literature with Updated Bibliographies. Metuchen, NJ: Scarecrow Press, 1976.

White, R. A. and L. A. Dale. Parapsychology: Sources of Information. Metuchen, NJ: Scarecrow Press, 1973.

Wilhelm, J. L. The Search for Superman. New York: Pocket Books (Simon and Schuster), 1976.

Wolman, B. B. (ed.). Handbook of Parapsychology. New York: Van Nostrand-Reinhold, 1977.

Wolstenholme, G.E.W. and E.C.P. Millar (eds.). Extrasensory Perception. A Ciba Foundation Symposium. New York: Citadel Press, 1969. [Originally published in 1956.]

Zenhausern, R. "Damn Lies or Statistics?" Journal of the American Society for Psychical Research, Vol. 64:281-296, 1974.

According to George Abell, ASTROLOGY is an ancient religion which will be rejected by most intelligent students once they understand what it is and how it differs from science. What he does in this paper is present the information necessary to an understanding of the nature of ASTROLOGY.

ASTROLOGY

George O. Abell

HOW DOES ONE DEAL WITH ASTROLOGY?

By my own polls, and those of my colleagues across the country, I estimate that about one-third of all Americans have a positive belief in astrology, and that 90 percent of them are at least open-minded toward it—which means that they do not reject it as an outmoded concept like the idea of a flat earth. Thus science teachers can hardly afford not to understand astrology, and to be able to put it in perspective.

Why, in an age of advanced technology, should so many people still cling to an ancient religion? In part, because astrology purports to tell us something about ourselves, and all of us are interested in ourselves. Many of my colleagues have suggested that acceptance of astrology is also in part a rejection of the traditional scientific disciplines. More important, though, I think it is because astrology is presented in the name of science by its modern practitioners, and most people simply are not equipped to tell the difference.

In fact, astrology was never a science. It was never based on any kind of investigation or exploration of natural phenomena. It was always, as it is now, a religion—based on a magical correspondence between the gods of antiquity and the planets that bear their names. These ideas, however, were not incredible to people of 2000 years ago, who regarded the earth as made of base material—the four elements (earth, air, fire and water) and the heavens to be something quite distinct, crystalline, perfect, immutable. Indeed it was the time of Newton before it was appreciated that the laws of nature apply to the celestial world as well as to the terrestrial one. The role of the sun in influencing our daily and yearly lives is obvious; it was a natural extension to attribute other powers to the other planets as well. In any case, during antiquity all great scholars believed in astrology.

Astrology began approximately 1000 B.C. in Babylonia, whose people associated the planets with their deities. Babylonian astrology is what we call mundane astrology—it applied to monarchs and kingdoms, but not to individuals. Astrology spread from Babylonia in the sixth century B.C. and reached as far east as India, where it

flourishes today. The Egyptians, meanwhile, developed their own kind of astrology. But the astrology practiced today was developed largely by the Greeks, who synthesized the ideas of the Babylonians and Egyptians and enriched them with concepts from their own fertile imaginations.

WHAT ASTROLOGY IS ABOUT

The Fixed and Wandering Stars

To understand astrology, we must first take a look at the sky. Today we know that the stars extend to enormous distances from us, but the sky certainly gives the impression of being a great hollow sphere with the stars affixed to its inner surface. Indeed, people of antiquity believed in the literal existence of such a celestial sphere. The stars themselves seemed to maintain fixed patterns on this sphere, and many of these patterns were named in honor of the characters and animals of mythology. Today we still recognize these star groupings by the Latin translations of the names given them by the Greeks, such as Orion, Sagittarius, and Scorpius.

Because the earth rotates, the celestial sphere appears to turn around us each day, pivoted at points on a line with the earth's axis of rotation. This daily turning of the celestial sphere carries the stars around the sky, causing most of them to rise and set, but still the star groupings, the constellations, maintain their fixed patterns, just as the continent of Australia maintains its shape on a spinning globe of the earth.

Now on any given day the sun occupies a nearly fixed place on the celestial sphere, so the turning of the sphere carries the sun above the horizon in the east in the morning and to its setting in the west in the evening. The glare of sunlight hides the stars in daytime, of course, but the ancients were aware that the stars are up there then even as they are at night. Moreover, the ancients knew that the sun slowly moves on the celestial sphere, causing different stars to be up at night during different times of the year. This apparent motion of the sun is simply a reflection of the earth's annual revolution about it; as we see the sun from different places in our orbit, it apparently passes in front of different background stars during the year. This annual path of the sun around the celestial sphere is called the ecliptic. Each day the sun moves about one degree along the ecliptic. During the course of a month, it moves about 30 degrees.

The moon, revolving about the earth each month, also has an independent motion in the sky. The moon, however, changes its position relatively rapidly. Although it appears to rise and set each day, we can see the moon changing position with respect to the background of stars during as short an interval as an hour or so. The path of the moon around the earth lies nearly in the same plane as the earth's path around the sun. It is tilted at only about 5 degrees, so the moon is never seen very far from the ecliptic in the sky.

There are five other objects visible to the naked eye that also appear to move with respect to the fixed background of stars on the celestial sphere. These are the planets Mercury, Venus, Mars, Jupiter and Saturn. All of them revolve about the sun in nearly the same plane as the earth does so they, like the moon, always appear near the ecliptic. Because we see them from the moving earth, however, the planets behave in a somewhat complicated way, their movements being reflections both of their own independent motions about the sun and our motion as well.

Today we know the sun is a star, typical among the myriads of stars we see in the sky, that the moon is a satellite of the earth, and that the other planets are worlds much like the earth. To the ancients, however, the sun, moon and other planets all had one thing in common that distinguished them from the fixed stars: they change positions gradually during the days, months and years. Thus the sun, moon and other planets visible to the naked eye were all called <u>planets</u> in antiquity; the word <u>planet</u> is Greek for "wanderer." So there were the fixed stars and the wandering stars. Although the planets, or wandering stars, had independent motions that in some cases were evidently quite complex, even the ancients recognized a regularity in those motions.

<u>Planets and Gods</u>

The Greek gods were immortal but otherwise had the same attributes of anger, happiness, jealousy, rage and pleasure as humans did. And these same attributes were assigned to the planets that either were the gods, were their abodes, or at least represented them. Each god, and thus each planet, served as a center of force but how that force prevailed depended on how it was tempered by the effects of other gods.

Now, if the gods were capricious, at least the planets were potentially predictable in their movements. It was natural, therefore, to attempt to understand the whims of the gods by understanding the motions of the planets. Because our own lot in life is so unpredictable, it must be purely at the mercy of the gods. But if the gods are the planets, or at least somehow associated with them, we have only to learn the rules of the motions of the planets to understand the whims of the gods and how they shape our own lives.

As the Greek astronomers learned more about the motions of the planets in the sky they felt they were learning more about the ruling forces of their own lives as well. The Greeks had the prophetic wisdom to suppose that the motions of the planets are indeed governed by some precise laws of nature—perhaps transcending even the will of their humanesque gods—and thus by inference they presumed that our own lives are similarly preprogrammed by the predictable motions of the planets. What then can determine our own individual lots? Only the moment that we happen to enter the world and fall into step with the eternal and predestined movements of the heavens.

So the belief developed that each of our lives is pre-set by the precise configurations of all of the planets in the sky at the moment

of birth; all of the motions of the planets thereafter follow the laws of nature and hence the influence of the planet gods must similarly be constrained by their predictable relations with other planet gods in years to come. Thus the key to the future of an individual was the map of the heavens showing where each planet was in the sky at the precise time and place of that person's birth. This is the religion of natal astrology; it was invented by the Greeks in the first century or two before Christ.

The Horoscope

The key to natal astrology is that chart which indicates the directions of the planets in the sky as seen from the earth at the time and place of one's birth; that chart is called a natal horoscope. The first natal horoscope prepared or cast by Greek astrologers was probably about the first century B.C. It is a simple enough matter for an astronomer to observe the current positions of stars and planets of the sky, but to prepare such a chart for some time in the past when an individual was born, or for some time in the future when it might be desirable to know how the ruling forces will then shape his life, it was necessary for the Greek astrologers to know how the planets moved—that is to have some scheme or computational method so they could predict those directions for any time in the past or future. A strong motivation for the development of Greek astronomy was, therefore, the study of the motions of the planets. That study culminated in the elaborate scheme of Claudius Ptolemy in the second century A.D. It is beyond the scope of this article to describe the earth-centered Ptolemaic cosmology, but suffice to say it was a remarkable achievement and it predicted the motions of the planets to the precision of naked eye observations for hundreds of years. It was not substantially revised until the time of Copernicus. Thus the Greeks had devised means of preparing horoscopes for times in the past or future.

Two different kinds of coordinates are used in a horoscope. The first of these involves the zodiac, that belt around the sky centered on the ecliptic through which the sun, moon and planets all appear to move with respect to the stars. One point in the zodiac is the position of the sun on the first day of spring when its path along the ecliptic carries it from the southern half of the sky across the celestial equator to the northern half. That point is called the vernal equinox. Obviously the position of the sun on the ecliptic with respect to the vernal equinox determines the season of the year.

The ancients divided the zodiac into twelve equal sectors or signs. The first sector begins with the vernal equinox and extends 30 degrees eastward along the zodiac. That sector is called the sign of Aries. The vernal equinox, at the beginning of this sign, is the first point of Aries. The next 30-degree sector along the zodiac is the second sign—the sign of Taurus. The subsequent zodiacal signs in order to the east are Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces. All but Libra (the scales) are named for animals or people; thus zodiac means "the zone or circle of the animals." The signs of the zodiac take their names

from the constellations of stars that were in the same directions in the sky two thousand years ago when the zodiac and its signs were invented.

Each planet, at any given time, occupies a particular position in one of the zodiacal signs. For example, if the date is between the 21st of March and the 20th of April, the sun is in the sign of Aries. If you were born during this interval your <u>sun sign</u> is said to be Aries, or in the modern vernacular, <u>you</u> are an <u>Aries</u>. Each of the other planets has a position which can be specified by the sign it occupies and the number of degrees into that sign. Thus in the preparation of a horoscope, the first task is to assign each planet to its proper position in the zodiac. Today modern astrologers do this by consulting standard tables. Few, if any, modern astrologers would be able to calculate from theory where the planets should be in the zodiac, but the ancient astrologers were astronomers as well and hence were very competent in this field.

Specification of the planets in the various parts of the zodiac tells where they are with respect to the fixed background of stars but does not specify their directions in the sky as seen from a particular place, because the sky is constantly turning due to the earth's rotation. On the other hand, if we knew the precise direction of the vernal equinox with respect to the horizon and also the latitude of the place, we would be able to specify the orientation of the zodiac with respect to the horizon, thereby giving the directions in the sky as well. This orientation is accomplished through a knowledge of <u>sidereal time</u>. Sidereal time is simply a measure of how far the vernal equinox has progressed since it passed from the eastern to the western half of the sky—that is across the <u>meridian</u>, a north-south line running through the observer's zenith. Once the location in the sky of the vernal equinox (or sidereal time) is known, the positions of all the signs and hence of the planets are specified with respect to the horizon.

The second coordinate system used in astrology has the purpose of orienting the planets and signs with respect to the horizon. It is the system of astrological <u>houses</u>, which are zones of the sky that are fixed with respect to the horizon. As the celestial sphere rotates, all the signs and planets are carried successively through the twelve houses distributed around the sky. The first house is that sector of the sky immediately beneath the eastern horizon; it contains those parts of the celestial sphere that will rise within the next two hours. The second house is the next one below the first; and the third through sixth houses are the remaining ones below the horizon, the sixth, containing objects that have set within the past two hours. Houses seven through twelve stretch across the upper half of the sky from west to east. This description, although essentially correct, is somewhat vague because several precise but different definitions of the houses have been used by astrologers throughout the ages, and even today.

A complete horoscope is usually represented by a circle denoting the center of the zodiac (the ecliptic) with the twelve houses indicated as sectors inside the circle. The signs and their boundaries

are also located on the horoscope as well as the positions of the seven planets. Sometimes the positions of the more conspicuous stars of the zodiac are indicated as well. Figure 1 shows my own horoscope. It is a chart of the directions of the planets with respect to the vernal equinox and also with respect to the horizon as they appeared from Los Angeles on March 1st, 1927 at 10:50 p.m.

The pie-shaped divisions numbered from 1 to 12 are the various houses. Notice that the planet Saturn, symbolized by ♄, was in the first house. Notice that the eastern horizon intercepted the ecliptic in the sign of Scorpio; thus Scorpio was rising in my natal horoscope. Notice that the sun, in the fourth house, was in the sign of Pisces. Also in Pisces were the planets Jupiter, ♃ , Mercury, ☿ , and Uranus, ♅.

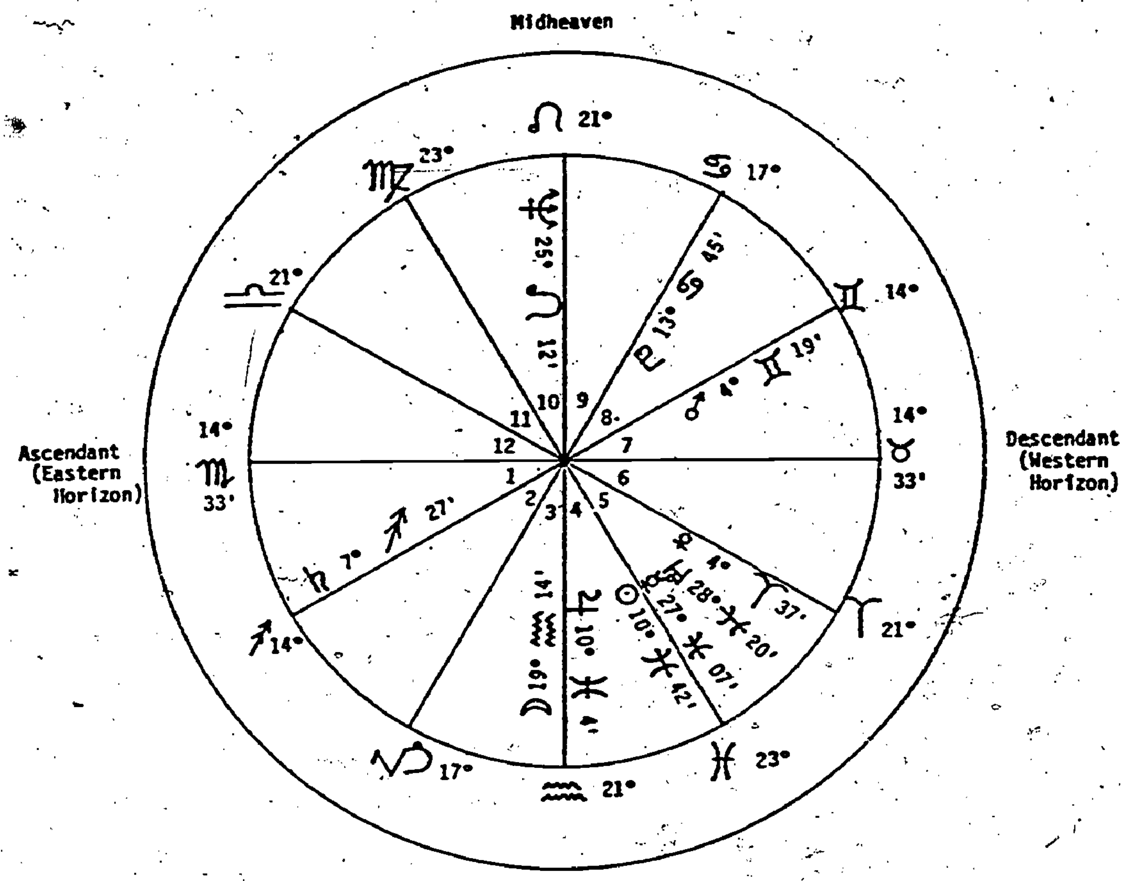
The planets Uranus, Neptune and Pluto were discovered after the invention of the telescope. Modern astrologers include them in the horoscope as well as the traditional planets. The alleged influences of the newly-discovered planets are just those you would expect for gods of the same name.

Note that my horoscope shows, in addition to the precise position of each planet in its sign, the precise position in each zodiacal sign of the boundary between each pair of houses. All of these numerical details give the horoscope a somewhat complicated appearance but it is straightforward astronomy to construct it. (I have used the definition of house boundaries due to Placidius to construct my horoscope.) The astrologer need now only interpret my horoscope to learn about my characteristics, my personality, my friendships, my health, my death, my marriages and all other events of my life.

Interpretation of the Horoscope

According to astrologers, a person's entire horoscope must be examined to analyze his character. Thus the column that appears in daily newspapers entitled "Your Daily Horoscope" is not a horoscope at all but simply daily advice based on your sun sign alone. According to astrologer Sidney Omarr, advice based on one's sun sign is about as useful as the taking of a patent medicine; it may be of some value but can hardly be considered definitive.

In addition to the sign containing the sun (the sun sign), other important things in the horoscope include the ascendent (what is about to rise), what is culminating (what is about to cross from the east to the west half of the sky), and a host of other things. Since each planet is a center of force, according to astrology, and because each sign is ruled by a planet, the influence of that planet is amplified or weakened by whether it is in its own sign, or in one sympathetic with the sign it rules. Aspects are important too. For example, what planets are trine (about 120° away from each other), or in opposition (opposite in the sky), or squared (90° away), and so on.



SIGNS OF THE ZODIAC

♌ Leo, the Lion

♋ Cancer, the Crab

♊ Gemini, the Twins

♉ Taurus, the Bull

♈ Aries, the Ram

♓ Pisces, the Fishes

♒ Aquarius, the Water Bearer

♑ Capricorn, the Goat

♐ Sagittarius, the Archer

♏ Scorpio, the Scorpion

♎ Libra, the Balance

♍ Virgo, the Virgin

SUN, GREATER PLANETS

♆ Neptune

♇ Pluto

♂ Mars, Tuesday

♀ Venus, Friday

♅ Uranus

☿ Mercury, Wednesday

☉ Sun, Sunday

♃ Jupiter, Thursday

☾ Moon, Monday

♄ Saturn, Saturday

Fig. 1: Astrological Symbols

In addition, each house has a certain role in a person's make up; so the planets (and signs) in the various houses play key roles. For example, the first house (just below the eastern horizon) controls temprament and personality. Mars, the aggressive god of war, in that house might dispose one to an aggressive career (perhaps military or athletic) especially if Aries, the sign that Mars rules, is also rising and hence is in that first house. In my horoscope, Saturn is in the first house; this is supposed to give me a mystical temperament. The second house is supposed to relate to one's wealth and fortune. The third, to his siblings; the fourth, to his parents and so on. The planet assigned in the eighth house, which deals with death, might well tell the astrologer how the subject will die.

As a person goes on living, the earth goes on turning and the planets go on moving through the zodiac. The astrologer, however, keeping track of these motions and always relating them to the client's natal horoscope, believes he can foretell times of significant events in the subject's life, what times are happy ones for the subject, what ones good for important journeys, and (if the astrologer is confident of himself) even when the subject may suffer calamities or death.

Moreover, each sign of the zodiac is presumed to relate to a given part of the body; thus Aries rules the head, Leo-the heart, Cancer-the stomach, Scorpio-the genitals, and Pisces-the feet. Mars in the sign of Aries in the natal horoscope might predispose the subject to a tendency toward headaches all his life, and Uranus in Cancer might plague him with stomach cramps. In the Middle Ages most physicians believed in and practiced according to this medical astrology. Even today, according to astrologer Noel Tyl, doctors frequently consult him for help in diagnoses.

The zodiacal signs were also associated with hot and cold, wet and dry, and the assumed elements: earth, air, fire and water. The planets were associated with various metals: the sun with gold, the moon with silver, Mercury with quicksilver and so on. Even nations were thought to be ruled by signs and planets. Not only were individual characteristics of people such as stature, color of hair and eyes attributed to details of their horoscopes, but also these characteristics of entire races, according to the signs and planets assigned them.

As you can see, the subject is enormously complicated. Many of the influences of the different planets and signs tempered by their relationships to each other may seem contradictory. Thus part of the art of the astrologer is to weigh the influences to arrive at an accurate description of the subject. The rules by which the astrologer analyzes the horoscope—that is the assumed influences that he must weigh—go back to antiquity. But they are not based on statistical studies of thousands of individuals as some modern astrologers would have us believe. Rather they are based on magical correspondences between planets and the gods that bear the same name, and the signs and constellations and the animals or beings for which those signs or constellations are named. To verify this assertion, one need only go back to the principal authoritative document of antiquity—the Tetrabiblos of Ptolemy. Ptolemy was one of the greatest astronomers of antiquity;

he was also the most important astrologer. He summarized the astrological knowledge of his time in the four books that are now the bible of modern astrology. The astrological doctrines are almost entirely based on the Tetrabiblos or on subsequent works in turn based on it.

In the Tetrabiblos, we can read of the effect of Jupiter passing through the tail of the lion or of Mars in Virgo. But Ptolemy himself evidently saw a rationale for some of these influences. Thus we read that the moon, being the nearest planet to the earth, soaks up moisture from the earth and so has a dampening influence. Further we read that Mars, being the nearest planet to the sun (as was thought according to the Ptolemaic cosmology) was hot and arid and so had a drying influence. Saturn, being far from the earth and sun, was cold; it also moved slowly and so was mystical in its influence. (Incidently, we know today that the moon is bone dry but that Mars has a great deal of water—although currently frozen as permafrost or in ice caps at the poles.)

Astrologers do not all insist that one's entire life is absolutely dictated by the motions of the planets. Many modern astrologers will say that the stars impel but do not compel. Even Ptolemy ascribed three influences on people: environment, heredity and astrology. Yet some of the more orthodox astrologers still argue that the entire course of one's life is dictated in detail by the motions of the planets through the zodiac; if only we understood the influences and laws thoroughly enough, they think, the entire course of one's life could be forecast with precision.

Tropical and Sidereal Astrology

Not only does the earth rotate on its axis and revolve about the sun, but it has a host of other motions as well. One of the more subtle of these—one discovered by the astronomer Hipparchus in the second century B.C.—is precession. The earth is not a perfect sphere but, because of its rotation, is slightly bulged at the equator. This bulge is only about 27 miles; nevertheless, the gravitational tidal forces of the sun and moon pulling on that equatorial bulge attempt to alter the direction of the earth's axis of rotation. Like a spinning top or gyroscope, however, the earth's axis does not yield in the expected way to this tidal force but rather describes a slow conical motion called precession. The result is that the positions of the celestial poles are not fixed on the celestial sphere but describe circular motions in the sky, taking about 26,000 years for one complete cycle. It is an astonishing tribute to Hipparchus that he was able to discover this subtle motion.

An effect of precession is to cause the vernal equinox to slide westward along the ecliptic during that same 26,000 year period. The result is that the signs of the zodiac are slowly sliding westward with respect to the constellations that bear the same names. Thus, today, the sign of Aries no longer corresponds with the constellation of Aries but with the constellation of Pisces. Rather soon now, the vernal equinox will have slid all the way through Pisces and into the constellation of Aquarius. That is when the Age of Aquarius is said

to begin. The exact time when this occurs depends on what boundary one chooses between the various constellations. The ancient charts are equivocal or non-committal on this topic; I doubt if many astrologers would be very interested in using the arbitrary divisions assigned by the International Astronomical Union in 1928.

At any case, whereas you may be a Taurus, the sun was actually in the constellation of Aries at the time you were born. We must not accuse the astrologers of ignorance of this motion of the signs with respect to the constellations; they are well aware of it. Indeed Hipparchus was an astrologer as well as an astronomer. Ptolemy understood precession very well indeed. Nevertheless the traditional or classical school of astrology is based not on the fixed constellations but rather on the moving signs. It makes some sense because the seasons depend upon the sun's position in the zodiac with respect to the equinoxes and solstices which slide westward with the signs and have nothing really to do with the position of the sun among the various constellations. This conventional school of astrology is called tropical astrology.

There is a school, however, called sidereal astrology, that bases its horoscope upon the constellations and not the moving signs. Perhaps it seems more logical (in the illogical way of astrology) to associate the planets with the constellations, rather than the arbitrary division of signs. Some tropical astrologers argue that the signs remember the influence of the constellations that corresponded with them two thousand years ago. I don't know how they explain why those same signs do not also recall the influences of other constellations that corresponded with them in even earlier millenia.

In The Course of History

The dark ages saw a decline in the influence of astrology because it clearly conflicted with the Church's view of free will. However, by the time of the Renaissance, astrology had a resurgence. By the time of the Reformation, nearly all scholars believed in astrology and many universities had chairs in the subject. The great astronomers Tycho Brahe and Kepler evidently believed in astrology. Both cast and interpreted horoscopes as a major part of their duties.

Following the astronomical discoveries of Kepler, however, science gradually turned away from astrology. We had learned that the planets not only obey precise laws but that they are the same laws that govern things here on earth. We found that the earth and the planets were made of the same stuff—the same kinds of atoms. Science in a sense unified the universe. Moreover we learned that there were many thousands of times as many worlds, even in this solar system, 35 had been supposed by the ancients, let alone the countless numbers of planets that must revolve about other stars: planets that we may never know about. We learned the tremendous distances of the planets and of their masses, that many have satellites of their own, that the stars are suns, that our sun is but one star in a vast galaxy of stars. In the light of this new knowledge of the true nature of the universe, and the truly

universal laws that govern its behavior, the belief in planet gods of antiquity seemed as incredible as the notion of spontaneous generation —that rats and mice are generated spontaneously in dirty laundry or that fortunes can be told from the entrails of animals.

Thus scientists turned from astrology by the time of Newton and never turned back. We would think that in the twentieth century a belief in such an ancient religion would stretch the credibility of even the most gullible among us. And yet, we find tens of millions of Americans not only believe in astrology, but many regulate their lives according to it. Why is this so?

I think it is because of the increased specialization of science. As the frontier of knowledge is pushed forward, science has become more and more complex and scientists themselves increasingly specialized. Every new sub-branch of science develops its own jargon and each of these new languages is incomprehensible to the non-scientist and, indeed, even to scientists of other disciplines.

Consider the following terms: deceleration parameter, trine, progression, Robertson-Walker metric, rectification, Hubble constant, periastron, cusp, spicule, refraction, ascendant. How is the average person to know which of these terms is scientific and which relates to astrology? How, indeed, can he know what is science and what is not?

RATIONAL RESPONSE TO ASTROLOGY

In my view, most intelligent students will reject astrology once they understand what it is and how it differs from science. I suggest attempting to explain its origins and structure as objectively as possible rather than ridiculing it or people who believe in it, or rather than simply appealing to authority. When seen in perspective, astrology debunks itself. However, there are persistent claims that astrology is proven, and it is probably useful here to evaluate their basis.

Is There A Scientific Basis for Astrology?

Most modern astrologers often claim a scientific basis for astrology and many cite mechanisms by which it works. Let us consider some of these mechanisms.

I have met astrologers in television debates who have claimed that tidal forces exerted on people by planets can influence them. "Consider the lunar tides on the oceans," they say. "If the moon can raise tides of several feet in the waters of the ocean, think what it can do to the fluids in our own bodies." What they fail to understand is that the lunar tides on the oceans are acting over the entire 8,000 mile diameter of the earth. Even lunar tides on a small object like a human being are exceedingly negligible; planetary tides are

enormously smaller yet. For example, a typical textbook, held six feet away from a person, exerts on him some fifty million times as strong a tidal force as Mars does, when Mars is at its nearest to the earth.

Astrologers also claim that radiation plays a role. One form of radiation is light. But babies are generally born indoors, shielded from light from the planets. Anyway, all the light of all the planets combined is millions of times less than even subtle variations of the total light output of the sun.

One astrologer once told me that we astronomers only recently learned of the bursts of radio radiation from Jupiter. "Surely," he said, "those radio bursts must exert profound radiation effects on us humans." But we only discovered those radio waves from Jupiter when we had learned to build enormous radio telescopes capable of detecting those very, very weak signals; on the other hand, even a small transistor radio that you carry in your pocket can easily pick up the waves from a 100-watt transmitter a hundred miles away. The radiation from man-made radio and television transmitters all around us swamps by many hundreds of millions of times that from the planets.

Magnetic fields similarly play no role. We could not have known of the magnetism of certain planets until we sent delicate magneto-meters on space vehicles to the vicinity of those planets. In contrast, the magnetic fields of the permanent magnets in the loudspeaker of that same transistor radio are enormously strong in comparison.

To be sure, the sun affects us, and very much so, but in ways understood without invoking ancient gods. And the moon produces tides and reflects sunlight to us. Moonlight can influence the harvester and the hunter and doubtless can produce psychological effects as well. On the other hand, many of the "well-known facts" such as that at times of full moon more violent crimes are committed, or that more people are admitted to mental hospitals—are not borne out by recent objective investigations (Lester, et al., 1969; Pokorny, 1968, 1964; Pokorny and Jachimczyk, 1974). For example, statistical studies of 2,497 suicides and 2,017 homicides in Texas between 1959 to 1961, or another 2,491 homicides in Texas from 1957 to 1970, or 339 suicides in Erie County, New York, and of 4,937 mental hospital admissions, all show no correlation either with the phases or the distance of the moon.

In short, there is no way in terms of known laws of nature that the planets' directions in the sky can influence human personality and fortune in the manner predicted by astrology. If the planets were to exert an influence on us, it would have to be through an unknown force and one with very strange properties: that force would have to emanate from some, but not all celestial bodies, it would have to affect some but not all things on earth, and could not depend on the distances, masses or other characteristics of those planets giving rise to it. In other words, it would lack the universality, order and harmony found for every other force and natural law ever discovered that applies in the real universe.

What then are the properties of such a force and what evidence is there that it exists? The astrologers answer "Astrology works" and I must acknowledge that most people who have their horoscopes analyzed by an astrologer say that the descriptions they receive of themselves are accurate. However, the descriptions are generally rather vague and sometimes contradictory and they almost always reveal a good grasp of human psychology on the part of the analyzer. Among the many experiments concerning people's surprise at the success of the astrologer I shall describe only one especially interesting one.

In a test of the computerized horoscope industry, the French psychologist Michel Gauquelin (1968) sent ten sets of birth dates, times and places to a major advertiser. In order not to reveal himself, he used addresses of various friends. The birth data were genuine but were not of himself or of his friends. They were the birth times and places of the ten most heinous criminals for which he could find records. One of these, for example, Dr. Marcel Petiot, was born in Auxerre at 3 a.m. on January 17, 1897. He was executed on May 26, 1946 after a spectacular trial. He had posed as an underground agent promising to help refugees from Nazis escape then-occupied France. When the unfortunates would arrive at Petiot's home, with all of their money and most prized possessions, he would murder them and dissolve their bodies in quicklime in a secret chamber of his house. Although indicted for only 27 such murders, Dr. Petiot, cynical to the end, boasted of 63. What did his horoscope say? In part:

> As he is a Virgo-Jovian, instinctive warmth or power is allied with the resources of the intellect, lucidity, wit.... He may appear as someone who submits himself to social norms, fond of property, and endowed with a moral sense which is comforting—that of a worthy, right-thinking, middle-class citizen...The subject tends to belong wholeheartedly to the Venusian side. His emotional life is in the forefront—his affection towards others, his family ties, his home, his intimate circle...sentiments...which usually find their expression in total devotion to others, redeeming love, or altruistic sacrifices...a tendency to be more pleasant in one's own home, to love one's house, to enjoy having a charming home....

Next Gauquelin placed an advertisement in a Paris newspaper offering: "Completely Free! Your ultra-personal horoscope; a ten-page document. Take advantage of this unique opportunity. Send name, address, date and birthplace...." There were about 150 replies. To each correspondent Gauquelin sent the same horoscope—the one he had received for Dr. Petiot. With each he sent a self-addressed envelope and questionnaire asking about the accuracy of the reading. Ninety-four percent of the respondents said they recognized themselves (that is, they said they were accurately portrayed in the horoscope of a man who murdered several dozen people and dissolved their bodies in quicklime), and for 90 percent this positive opinion was shared by their families and friends.

Are Scientists Narrow Minded?

Our society today is deluged with literature, motion pictures, and television programs claiming evidence of paranormal phenomena and exploiting the public fascination of experiences out of the humdrum of everyday life. But usually experts in fields most nearly associated with a particular phenomenon are the most skeptical. Thus oceanographers and high naval and merchant marine officers discount any mystery associated with the so-called Bermuda Triangle, biologists doubt the existence of a Loch Ness monster and abominable snowperson, botanists take no stock in talking to plants, and astronomers reject astrology.

This is not to say that unexpected things do not occur in nature. Meteorites falling from the sky and gorillas, both once treated skeptically by the scientific community, do exist. We cannot rule out the existence of a species of large unknown animals (especially in the deep oceans), nor even that space vehicles from other planets may have visited the earth. Nearly all scientists confidently expect many surprises to turn up in the course of future research. But remote possibilities do not make facts, and certainly do not justify widespread sensational and often exploitative claims.

Yet the skeptical professionals with the inevitable doubts raised by their own knowledge and experience are very frequently denounced as prejudiced, reactionary conservatives, afraid of new ideas. More often than not, these charges are made by the very persons claiming paranormal phenomena.

It is hard for me to understand how scientists, particularly astronomers, can be thought of as resisting new ideas. I cannot imagine a field in which more radical ideas have been seriously entertained and often accepted in recent years: pulsars and neutron stars, nucleogenesis of heavy elements (including those that make up our own bodies) inside stars, prehistoric rivers on Mars, black holes, organic molecules in space, the possibility of interstellar communication, even the existence of a background of microwave radio radiation now interpreted as evidence that our present universe has evolved from a hot gas—the dying embers, as it were, of the primeval fireball that started the expansion of the universe! It seems to me to be particularly incongruous that astronomers are charged with conservatism by the astrologers who accept and practice the same dogma and rules made up by Greeks of antiquity two millennia ago.

Is Astrology Harmless?

I am frequently asked, is not a belief in astrology a harmless recreation? I suppose to the extent it is a recreation, it is relatively harmless. On the other hand, to the extent people regulate their lives and their journeys and to the extent that some even base medical diagnoses on astrology, it is not harmless.

I have seen a job requisition of one Republican congressman looking for a secretary; at the bottom he indicated: "no Democrats, no minorities, and no water signs. Not that there is anything political

about astrology; the most recent bill introduced to the California State Legislature to create a gubernatorial appointed board to license astrologers was introduced by Democratic State Senator Dills, from Riverside. That bill failed to pass, as have others introduced from time to time in recent decades. But perhaps it's only a matter of time.

I believe the survival of the human race, or at least of civilization, requires the diligent application of our highest intellectual efforts. We are facing severe problems of environmental degradation, depleting energy resources, of rising crime, of atmospheric and water pollution, and above all, the tremendous crush of overpopulation. To solve such problems, surely we need the best of rationality our science can offer, rather than the occult mysticism of an ancient religion that has not changed since the time of Ptolemy.

RESOURCES

Abell, G. O. "Astrology." The Science Teacher, Vol. 41, No. 9, 1974.

Abell, G. O. Drama of the Universe. New York: Holt, Rinehart and Winston, 1978.

This text contains a considerable discussion of astrology.

Cohen, D. The Magic Art of Foreseeing the Future. New York: Dodd Mead Co., 1973.

A good historical account of astrology and its influence.

Couderc, P. L'Astrologie. Paris: Presses Universitaires de France, 1974.

An excellent critical look in French.

Gallant, R. A. Astrology, Sense or Nonsense? Garden City, NY: Doubleday and Co., 1974.

A very readable, although somewhat elementary, critical book on astrology.

Gauquelin, M. Songes et Mensonges de l'Astrologie. Paris: Hachette, 1969.

This is an excellent critical book on astrology in French. It contains, however, in its last chapter an account of some controversial findings of its author.

Graubard, M. Astrology and Alchemy, Two Fossil Sciences. New York: Philosophical Library, 1953.

A good historical account of astrology and its influence.

Objections to Astrology. Buffalo, NY: Prometheus Books, 1975.

This is a well advertised statement on astrology endorsed by 186 leading scientists, with accompanying articles by Bart Bok and Lawrence Jerome, and reprinted from the Sept-Oct, 1975 issue of the Humanist Magazine.

Shumaker, W. The Occult Sciences in the Renaissance: A Study in Intellectual Patterns. Berkeley: The University of California Press, 1972.

This is a good historical account of astrology and its influence.

REFERENCES

Gauquelin, M. Science èt Vie, No. 611, 1968.

Lester, D.; G. W. Brockoff; and K. Priebe. "Association Between a Full Moon and Completed Suicide." Psychological Reports, Vol. 25:598, 1969.

Pokorny, A. D. "Moon Phases and Mental Hospital Admissions." Journal of Psychiatric Nursing and Mental Health Services, Vol. 6, No. 6: 325-327, Nov-Dec., 1968.

Pokorny, A. D. "Moon Phases, Suicide and Homicide." American Journal of Psychiatry, Vol. 121:66-67, 1964.

Pokorny, A. D. and J. Jachimczyk. "The Questionable Relationship Between Homicides and the Lunar Cycle." American Journal of Psychiatry, Vol. 131, No. 7:827-829, July, 1974.

In this paper John A. Moore discusses one of the hottest topics in biology education; whether to include creationism as an alternative approach to evolution as a theory of the origin and development of life. The approach of this paper is historical, tracing Darwin and his critics to modern times.

CREATIONISM

John A. Moore

Except for the individuals intimately concerned, those contentious debates swirling around the teaching of evolution in the schools produce a feeling of deja vu. Essentially the same things have been said throughout the past century yet the problems are no more solvable today than when they were first encountered. The teacher and school administrator who is forced to deal with these matters can be assured that there is a vast and vigorous literature to which he may turn for information, inspiration, or solace. Some of this literature is truly first rate, well worth pursuing for its own sake: few can match, in prose, the reason and ridicule of grand old Thomas Henry Huxley as he thundered across the Victorian landscape.

My purpose will be to provide perspectives for the science teacher and school administrator. First, there will be a review of the attacks by creationists and others on evolutionary biology. Second, the argument will be developed that the conflict is on-going and unlikely to be resolved. Third, depending on the stance the teacher or school administrator wishes to adopt, a variety of scenarios will be suggested.

DARWIN AND HIS CRITICS

During the first half of the 19th century tremendous advances were made in geology and biology. The geologists, among whom Charles Lyell was pre-eminent, came to believe that the earth was exceedingly old—far older than suggested by Judeo-Christian tradition. Furthermore, it was recognized that the stratified rocks of the earth's crust represent material deposited long ago, usually under water. The materials were slowly changed to rock and in some instances contemporaneous remains of animals and plants were included in the deposits. Thus, it became apparent that the sedimentary rocks were, in a useful sense, a running diary of the earth's past. Careful studies, therefore, might tell much about the earth's crust and its denizens of long ago.

The biologists of that half century were concerned mainly with inventorying all species of animals and plants. By mid-century there was a general knowledge of the species of animals and plants and their geographic distribution. The incredible variety of living creatures raised in the minds of some of the more inquisitive naturalists the question of origins.

For most, however, the question had already been satisfactorily answered: the creatures of the earth were the products of a Divine Creator who had peopled the earth with the various species of plants and animals. It was believed that each species was fixed, that is, it was essentially constant in its characteristics and isolated from all others by an inability to cross-breed.

Useful references to the intellectual antecendents of the Darwinian Revolution are Gillispie (1951), Greene (1959), Eisley (1958), Adams (1938), and Geikie (1905). Lyell's classic Principles of Geology (1830) is still a joy to read. Editions prior to 1859 will be especially useful in showing how a great mind viewed the natural and living worlds before Darwin.

Darwin's hypothesis was presented to the world in a joint article with Alfred R. Wallace in 1858 and, more definitively in 1859, in On the Origin of Species. Darwin agreed with numerous other scientists that evolution had occurred but, more importantly, proposed a mechanism: natural selection. Many scientists had found themselves unable to accept the notion of evolution simply because they could not suggest how it might have come about. Everything they knew seemed to indicate that species were fixed and could change only slightly from an average condition. Huxley wrote that "The Origin provided us with the working hypothesis we sought" (1888, p. 197).

It is usually assumed that the Origin provided a strong factual basis for evolution. It did not. Darwin looked upon the Origin as an abstract of a multi-volume work that was to be prepared later. The complete work would provide the full data then available. Lyell wrote, "It is a splendid case of close reasoning, and a long sustained argument throughout so many pages; the condensation is immense, too great perhaps for the unitiated..." (Francis Darwin, 1888, Vol. 2, p. 206).

Darwin's argument can be broken down into these five elements. First, there is considerable intraspecific variability in natural populations. Second, the rate of reproduction of all species is greater than the carrying capacity of their environment. Third, this means that there will be a struggle for insufficient resources. Fourth, in this struggle for life, presumably any individuals that were more fit would have a greater chance of surviving than the less fit. Fifth, with the passage of time, the population would come to consist of evermore fit individuals, that is, individuals better able to survive and to leave offspring. The elimination of the less fit by nature was called natural selection.

In 1859 there seemed to be no doubt that the first two elements of the argument were correct. The remaining three were not solidly based on observation or experiment but were proposed as a reasonable hypothesis of what might occur. This was the hypothesis to be tested.

And it was tested first in the forum. The debates that started in the autumn of 1859 saw a few scientists, plus even fewer churchmen and others, supporting Darwin. The majority, scientists and non-

scientists alike, were against his hypothesis. Much of the opposition was on scientific grounds: it was felt that the scientific basis for evolution by natural selection was wholly inadequate. This point must be emphasized. All too often it is assumed that the opposition was based solely on the fact that Darwin's views were in conflict with those of the church. That was not the case.

The broad spectrum of opponents to the Darwinian world scheme did include, of course, the fundamentalists—those who say Genesis contains the only admissible explanation of organic diversity. The fundamentalists may have been pleased that there were scientific reasons to doubt Darwin but, even had there been none, their opposition would have been as vehement and vitriolic. In substituting a naturalistic explanation for organic diversity in place of Divine Creation, Darwin was attacking the veracity of the Bible and hence the very foundations of Western civilization.

It is instructive to outline some of the main arguments brought against Darwin in the first decade following the publication of the Origin. To a discouraging degree these are the same arguments advanced today by some of the creationists—long after answers satisfactory to the scientific world have been obtained:

1. There is no evidence that one species can change to another. Critics suggested that natural selection was more likely to weed out the less hardy, less prolific, and more extreme types. Thus it would tend to make species more uniform rather than lead to a slow change of one species into another. Darwin had made much of what could be done with artificial selection, especially with pigeons. Pigeons had been selected for thousands of years and many peculiar varieties had been obtained. However, no new species had been obtained as evidenced by the fact that even the more extreme varieties can be crossed and the offspring survive. Thus, the critics saw these data refuting rather than supporting the Darwinian hypothesis.

Evolutionists then and now will agree that one does not observe one species changing into another or, as one of Darwin's critics demanded "see some tapir caught in the act of becoming a horse" (Duns, 1860). Data on the rate of evolution were scarce in the 1860s. Today rough estimates are possible, and it is clear that evolutionary change takes a very long time. Smith (1975) uses genetic data to estimate that it might take 300,000 generations for the evolution of a new species. Paleontological data are cited by him that suggest, during the Pleistocene, 500,000 years were required for the evolution of a new species of mammals. There are more extensive data for the time it takes for genera to evolve: the numbers are in the millions of years.

With a time scale like that, the evolutionists must agree with the creationists that one does not observe tapirs changing into horses or, except in the most unusual instances, one species changing into another. These unusual instances, of which there are a few, involve hybridization of two species of plants followed by a doubling of the number of chromosomes (Grant, 1971, Chapter 13).

One must conclude, therefore, that the lack of examples of one species changing to another before our very eyes cannot be considered a useful criticism of the Darwinian evolution. Our eyes just don't last that long. Huxley (1895b, p. 43) dealt with this argument in his inimitable fashion: "The objection sometimes put forward, that no one yet professes to have seen one species pass into another, comes oddly from those who believe that mankind are all descended from Adam. Has any of them yet seen the production of negroes from a white stock, or vice versa?"

2. Artificial selection has no relation to events in nature. Artificial selection, Darwin's critics pointed out, results in changes that may be very useful to human beings but are usually highly disadvantageous to the organism. Thus, domesticated plants and animals usually require careful culture and protection. They serve us well but we have molded their characteristics so much that they can rarely survive in nature. Furthermore, the variants that do arise are almost always monsters of some sort. One simply does not observe the appearance of favorable variations. Thus, artificial selection cannot be considered a model for the origin of better adapted forms since it does the reverse.

It was impossible for the evolutionists to deal with this criticism adequately until after 1900—when genetics began to tell us about genes and their mutations. Even then it was obvious that most of the new mutations were harmful to some degree. The mutational changes that Morgan and his coworkers observed in Drosophila were nearly always demonstrably deleterious. How, then, could mutations lead to a better adapted individual if they were always conferred some type of disadvantage?

Eventually, this paradox was seen to have an acceptable solution. One had to add the parameter of time. The genes of a species would all be mutating, at a slow though finite rate. One could imagine that any mutation that could occur would have occurred many times before. Thus, if a rare mutation did convey some selective advantage, it would have increased in frequency long ago and become the normal allele at the gene locus. At any one time the genotype of a species would be the result of what natural selection had been doing over the ages. The chance of any beneficial mutation being encountered by an observer is, therefore, exceedingly unlikely.

Such an argument might be convincing to an evolutionist but a creationist might suggest that it is ungarnished sophistry. But adequate data are now available. If a species finds itself in a new environment—one that has not been selected for over the ages—beneficial mutations can be observed to appear. Much of these data are making news today. One reads of numerous examples of insect pests rapidly developing resistance to insecticides. The resistance is due to gene mutations that confer resistance. In an environment that does not contain the pesticides, such mutations would have been deleterious. Industrial melanism in moths and drug resistance in microorganisms are other examples (Dobzhansky, 1970, pp. 211-215).

3. <u>The fossil record does not support the Darwinian thesis</u>. Darwin's critics were quick to point out that evolution demanded the origin of today's organisms from very different sorts of organisms living in the remote past. Thus, birds and mammals were thought to be fairly recent products of evolutionary change—possibly derived from ancient reptiles, but the links between reptile and bird and reptile and mammal were missing. In fact, all the links between major groups were missing in the 1860s. Evolutionists could offer the apology that the fossil record was inadequate but, given the fact that fossilization does occur, a necessary deduction of the evolutionary hypothesis was that fossils intermediate between major groups must exist—and, with luck, be found.

And in time they were dug up. The first major "missing link" to be discovered was Archaeopteryx, with its combination of reptilian and avian characteristics. Today there are fossils that link all the major groups of vertebrates. In some instances there are very few links (reptiles to birds) but in others there are numerous intermediate forms (reptiles to mammals). The paleontological data showing the evolutionary trends of the vertebrates are better than for any other phylum. This is correlated with the fact that this is the most recent major group to evolve and most vertebrates have hard parts (bone, teeth, and cartilage) that fossilize well. Very little is known about the evolutionary trends in those invertebrate phyla which are both very ancient and consist largely of animals with soft parts that fossilize poorly.

Good discussions of the data of paleontology are to be found in Simpson (1967), Colbert (1969), and Romer (1966).

4. <u>The earth is not old enough for the postulated evolutionary changes, from monad to man, to have occurred</u>. Darwin needed lots of time, possibly as much as half a billion years from the Cambrian to the present. A generation growing up with Bishop Ussher's and Vice-chancellor Lightfoot's pinpointing of the moment of creation as 9 a.m. October 23, 4004 B.C. was not willing to grant Mr. Darwin all that time. Yet more and more geologists were coming to the conclusion that the earth was immensely old. Hutton (1788, p. 304) had concluded his epoch-making <u>Theory of the Earth</u>: "The result, therefore, of our present enquiry is, that we find no vestige of a beginning—no prospect of an end." Yet there were many physicists in the late 19th century who felt that the age of the earth was much less than the evolutionists required for their hypothesis.

Creationists today continue to believe in the earth's youth—often suggesting an age of only a few thousand years. They maintain this position long after it has become possible to date, with a fair degree of accuracy, many of the rocks of the earth's crust by means of their radioactivity. As more and more rocks are studied, with more and more methods, the times for many events in the earth's past are becoming increasingly certain. Thus, the formation of the earth's crust is put at about 4,600,000,000 years ago. The onset of the Cambrian Period, when fossils first become abundant, is about 570,000,000 years ago. The Age of Reptiles, the Mesozoic, started about 225,000,000 years ago. The onset of the Tertiary Period is placed

at 65,000,000 years ago. Eicher (1976) gives a fine history of the problem of determining geologic time and provides us with the currently accepted dates.

5. Complex structures and processes are so exquisitely adaptive that they cannot be imagined as a consequence of variation and selection. Thus, it is almost impossible to imagine how any organ so complex as the eye could have been formed by the selection of chance mutations. At every stage of development the structure must have been advantageous—otherwise it would not have been selected. What good is a half eye? Or as the creationist Gish (1972, p. 14) expresses it: "In the fish-to-amphibian transition, many features would have to change. It should be easy to trace the conversion of the fins of the fish into the feet and legs of the amphibian in the fossil record. According to the evolution story the fossil record should show a fossil with 5 percent feet and legs and 95 percent fins, one with 10 percent feet and legs and 90 percent fins, one with 25 percent feet and legs and 75 percent fins, one with 50 percent feet and legs and 50 percent fins, and so forth, until almost all traces of fins have disappeared in the forms.... However, no one has been able to find a single transitional form showing part fins and part feet."

The problem when put that way might be expected to amuse and confuse a naive audience. Is one to expect an exactly intermediate stage to have two fins and two feet? If so, one must admit that the paleontologists have not exposed such a fossil. Nevertheless, Devonian fish are known that have skeletons in their fins that are so much like the limb skeletons of the tetrapods that there seems no problem in deriving limbs from fins (see, for example, Figure 117 in Romer, 1966).

Nevertheless, the details of the evolution of complex structures, such as eyes, and behavior patterns are almost always unknown. The chief difficulty is the soft structures, such as eyes, are almost never present in fossils (and behavior patterns, never). One is left, then, in the position of being able to do no more than to suggest what might have happened. In spite of this, the procedures of comparative anatomy, embryology, and more recently of comparative biochemistry generally allow one to present an acceptable hypothesis for how a complex structure may have evolved. In a similar manner, the behavior patterns of different species can often be arranged in a sequence that serves as a hypothesis for the evolution of the behavior pattern. A recent synthesis of this field has been provided by E. O. Wilson (1975).

When one turns to a consideration of structures that can be fossilized, facts replace hypotheses. Thus, the general picture of the evolution of the vertebrate skeleton is well understood. Even such remarkable evolutionary changes, such as the conversion of some bones of the jaws into the bones of the ear, have been well documented.

6. Evolution is impossible due to the constraints of the Second Law of Thermodynamics. This is a point being actively pushed by some creationists today. The argument is complex but basically it is this: the Second Law maintains that all self-contained systems gradually pass from a state of greater order to one of lesser order. Heat is lost and, with the passage of time, complex arrangements of matter become simple. Thus, the question is asked, how could evolution, which has been characterized by a slow change of organisms from simple to complex, possibly occur? This argument when advanced by a creationist and buttressed by mathematical equations is enormously effective with naive audiences. Evolution can be portrayed as not only wicked but also against the law! Most of the people who advance such an argument are probably well aware that it is totally invalid, yet why abandon such an effective device? The correctness of the Second Law is not questioned yet one must remember that our earth is not a closed system. Energy is reaching it in large amounts from the sun and such energy can be and is used in the construction of the complex from the simple. If one will grant that the energetics of the universe are such that a fertilized ovum can develop into a complex adult, then the Second Law is not going to interdict evolution. There is no need for extra energy for evolutionary events. If there is enough for the development and life of organisms no more is required.

7. Darwinism in heresy. And finally we have reached the main argument. All of the others which have a scientific basis can be dealt with by scientists. This one, however, is based on mutually incompatible systems of thought and belief. The Reverend John Duns (1860, p. 26) of Scotland put it well: "Mr. Darwin's work is in direct antagonism to all the findings of a natural theology, formed on legitimate inductions in the study of the works of God; and it does open violence to everything which the Creator Himself has told us in the Scriptures of truth, of the methods and results of His workings." And coming to this side of the Atlantic, Francis Bowen, Alford Professor of Natural Religion, Moral Philosophy, and Civic Polity in Harvard College, puts it this way (1860, p. 504):

> After all, for the defense of the great truths of philosophy and natural theology, it is hardly necessary to spend much time in refutation of such fanciful theories of cosmogony as this by Mr. Darwin. A proper view of the nature of causation, a clear recognition of the great truth that the natural no less than the super natural, the continuance no less less than the creation of existence, the origin of an individual as well as the origin of a species or a genus, can be explained only by the direct action of an intelligent creative cause—places the vital doctrine of the being and the providence of a God on ground that can never be shaken.

So if one accepts the Judeo-Christian accounts of the origin and diversity of life, the findings of science must either be ignored or somehow adjusted to what is said in Genesis. The second section of this paper will deal more with this matter, but before that is done, it will be useful to mention some of the important references to Darwin and his critics. As you might suspect the literature is enormous—and still growing rapidly.

The first general statement of Darwin's views on evolution appears in a joint essay with Wallace (Darwin and Wallace, 1858). The first edition of Darwin's Origin was in 1859. The sixth, and last, edition was in 1872. Peckham (1959) has provided a variorum. The Origin was reviewed extensively. Important reviews that found the argument wanting are Bowen (1860), Duns (1860), Wilberforce (1860), and Jenkin (1867). Critical though favorable reviews were presented by Gray (1860) and Huxley (1859, 1860). The original journals in which these reviews were published are available usually only in the larger research libraries. Fortunately there is more readily accessible material. Glick (1974) has edited a series of essays that describe the reception of Darwinism, country by country. The essay on the United States, by Michele L. Aldrich, is largely bibliographic and, as such, provided an introduction to the literature. An earlier work of Kennedy (1957) provides the same service. Useful anthologies of 19th century reactions to Darwin are Appleman (1970), Daniels (1968), and Hull (1973).

General discussions of the impact of Darwinism are to be found in Eisley (1958), Irvine (1955), Ghiselin (1969), Hull (1973), and Russett (1976).

Evolutionary biology has come a long way since Victorian times. Good introduction to current points of view are Smith (1975), Stebbins (1977), Ehrlich, Holm, Parnell (1974), Eaton (1970), and Volpe (1977). Smith, Stebbins and Volpe are in paperback editions. Four classics of the modern synthesis of evolutionary theory are Dobzhansky (1937 and later editions), Mayr (1942), Simpson (1944), and Stebbins (1950). Three have been extensively revised: Dobzhansky (1970), Mayr (1963, 1970), Simpson (1953). Still more recent and also important are Lewontin (1974) and Dobzhansky et al. (1977).

I do not know of a single modern book that deals specifically with the arguments of the creationists that they claim cast doubt on the theory of evolution. Not too surprising, I guess—neither do I know of a modern book on astronomy that deals with the Ptolemaic system, a serious challenge to the Copernican system or that gives equal time to the two theories of earth shape—flat or spherical. Neither do the chemists seem too concerned whether the atomic theory is correct of not. Evolutionists simply do not consider the creationist arguments serious threats to science—though no evolutionist questions the mischief they can do to science education.

IMMISCIBLE PARADIGMS

Even the most rational human beings use a variety of thought patterns for a variety of purposes. The same person may have one paradigm for dealing with nature, another for human beings, and still another for art. Thus, a scientific description of a great painting might have little resemblance to the description of a connoisseur. We could imagine the first dealing mainly with the chemistry of pigments, the wave lengths of the reflected light, and the scientific names for any objects illustrated. The second would be more concerned

with composition, balance of colors, and, more importantly, to the emotions evoked and allusions suggested. Most of us, surely, would be more interested in what the connoisseur had to say. We would look to him, more than to the scientist, to increase our pleasure and understanding.

The problem we are dealing with in this paper arises because both scientists and creationists attempt to describe nature—using conflicting paradigms. The scientist attempts to uncover the secrets of nature by observation, experiment, and reason—but reason that excludes any involvement of supernatural forces. That is, explanatory statements can only invoke materials and processes that can be demonstrated to occur in nature. These materials and processes must be discoverable by anyone with the proper training, equipment, ability, and patience. Essentially no scientific understanding becomes complete or acceptable with one discovery. First insights into a difficult problem will be incomplete and probably, to a considerable degree, erroneous. As more and more scientists study the problem, additional facts are obtained and the explanations will improve. But the statements are almost never said to be absolutely true. They are accepted as the best answer that can be obtained with the available data. This professional caution of the scientist often seems a little excessive: the belief that pure water is composed only of hydrogen and oxygen does seem rather certain.

As an illustration of how explanatory statements change, consider the question of a physical basis of inheritance. Darwin convinced himself, but few others, that there <u>was</u> a physical basis for inheritance: that is, some substance passed from parent to offspring and determined the characteristics of the latter. His particular postulated substance was shown to be inadequate. Later in the 19th century biologists came first to believe that the physical basis resided in the nucleus and later in the chromosomes. The data, however, were only suggestive. After 1900, and especially with the work of Thomas Hunt Morgan, the chromosomes and parts of them (the genes) were clearly implicated. Finally in the 1950s, a host of workers, most notably James Watson and Francis Crick, determined the chemical nature of the gene. Today we have a fairly complete understanding of the structure of genes and less, though considerable, information on how they function. Thus, we can now make some statements about the physical basis of inheritance that are true beyond a reasonable doubt. "Beyond a reasonable doubt," that is as far as a scientist should be willing to go.

Evolutionary biology has had a similar history. Darwin presented a plausible hypothesis and provided some data. The generations of scientists that followed Darwin's lead have provided a wealth of data. The growth in understanding has been enormous. De Solla Price (1963) has estimated that scientific information doubles every 10-15 years (10 years for the total information and in 15 years for high quality information). This period of doubling seems to hold generally in all sciences and has been occurring since the middle of the 17th century (when the Scientific Revolution got underway). Thus, if we use a 15-year doubling time for information in evolutionary biology, there will

have been eight doublings between 1859 (date of the Origin) and 1979—and a 256-fold increase in our understanding of evolution. To many, this will seem like a fairly conservative figure.

The procedures now used by scientists to obtain information about the natural world did not come into general use until the 17th century. One of the founding fathers of the new science was Francis Bacon (1561-1626). For him valid knowledge was to be, first, gathering the facts and, then, seeing what statements could be induced from them. His inductive methods were at variance with the scholastic methods that had prevailed for centuries. To the Scholastics, knowledge came ultimately from reasoning or revelation. The first was primarily the domain of the philosopher, the second of the theologian. Since clear reasoners were rare and recipients of revelations excessively so, most of the Schoolmen of the Middle Ages sought wisdom from the works of the great minds in philosophy and theology. For them Agassiz's aphorism, "Study Nature, not Books," should have been rendered, "Study Books, not Nature."

There is an amusing caricature of the Scholastic mind, possibly from the pen of Francis Bacon, that does convey the flavor of the method (cf. Taylor, 1941, Vol. 1, p. 41): In the year of our Lord 1432, there arose a grievous quarrel among the brethren over the number of teeth in the mouth of a horse. For a full 13 days the disputation raged without ceasing. All the ancient books and chronicles were fetched out, and wonderful and ponderous erudition such as was never before heard in this region was made manifest. At the beginning of the 14th day a youthful friar of goodly bearing asked his learned superiors for permission to speak, and straightway, to the wonderment of the disputants, whose deep wisdom he sore vexed, he beseeched them to unbend in a manner coarse and unheard of and to look in the open mouth of a horse and find answer to their questionings. At this, their dignity being grievously hurt, they waxed exceeding wroth; and, joining in a mighty roar, they flew upon him and smote him, hip and thigh, and cast him out forthwith. For, said they, surely Satan hath tempted this bold neophyte to declare unholy and unheard-of ways of finding truth, contrary to all the teachings of the fathers. After many days more of grievous strife, the dove of peace sat upon the assembly, and they as one man declared the problem to be an everlasting mystery because of a grievous dearth of historical and theological evidence thereof, so ordered the same writ down.

A fundamentalist, to the extent that he accepts the infallibility of Genesis as a guide to the origin and history of life, follows in the footsteps of the Scholastics of the Middle Ages. Their procedures are the same: relying solely on the products of philosophy or revelation for understanding. These procedures were abandoned by many scientists in the 17th century though, in the majority of cases, this did not lead to the abandonment of a diety. But as the procedures of science began to provide acceptable explanations for events so long relegated to the sphere of the supernatural, even a diety began to seem superfluous. For many intellectuals in the 18th century Age of Enlightenment the traditional diety was abandoned or replaced by a radically different concept. In this period, reason, freedom, and humanitarianism began to gain dominance over dogmatism, repression, and intolerance.

But the Enlightenment, or Age of Reason as it was also called, was of limited pervasiveness. A powerful Church, which a century earlier had been able to humble Galileo Galilei and incinerate Giordano Bruno, continued to cast its pall over the slowly-developing modern science.

There is no avoiding conflict between a system of thought based on revelation and authority and one based on observation and experiment. The current attacks of the creationists on evolution are but a skirmish in that long war. The literature on this conflict is enormous. Two classics of the 19th century are Draper (1874) and White (1896). Two of the volumes of Huxley's Collected Essays, namely, Science and Christian Tradition and Science and Hebrew Tradition are useful and fascinating. Good bibliographies are given by Kennedy (1957, pp. 110-114) and Aldrich (in Glick, 1972). Some older material is also to be found in the anthologies of Appleman (1970), R. J. Wilson (1967), and Daniels (1968).

An especially valuable survey of the field is Barbour (1966). Other useful sources are Greene (1961), Gay (1966), Dillenberger (1960). Hofstadter's now classic Anti-intellectualism in American Life (1963) has much to say about the fundamentalists and their attacks on evolution, humanism, and the modern world. Also of interest in his study of Social Darwinism (1944).

The Scopes Trial was one of the most dramatic confrontations of fundamentalists and evolutionists. It is dealt with by Allen (1925), Ginger (1958), Tompkins (1965), and very effectively and completely by de Camp (1968). Lawrence and Lee (1955) based a play on the trial.

TO TEACH OR NOT TO TEACH, THAT IS THE QUESTION

The first part of this paper sought to establish that Darwin's hypothesis of evolution, as modified by subsequent generations to become the Darwinian theory of evolution, has proved to be a powerful tool for understanding the history and diversity of life. It is the only scientifically acceptable paradigm for these phenomena. The second part of this paper emphasized that there are non-scientific, largely religious, paradigms for explaining these same phenomena. Furthermore, ardent proponents of either paradigm are unlikely to admit the correctness of the antagonistic paradigm.

We have now reached the question, "What *is* a biology teacher to do?" There is no single answer to that question. Were one to approach the question on scientific grounds alone, the answer would be simple. But often the choice cannot be made solely on scientific grounds. What if the citizens place social, religious, or political considerations above the scientific? Does the non-teaching portion of the community have the right to say what is to be taught?

What is taught will depend on how one answers these questions. I will suggest some of the more obvious answers and outline briefly how one might proceed. The scenarios will be arranged in a sequence beginning with an exclusively scientific approach and extending through those that take into account non-scientific pressures.

Science Only

This is the common pattern of teaching evolutionary biology in the schools. The Darwinian hypothesis is explained and then supported by the data of paleontology, comparative anatomy, comparative embryology, and more recent developments in population biology. Essentially all of the introductory, intermediate, and advanced books in evolutionary biology adopt this approach—as do the textbooks of general biology. All supernatural explanations are ignored. Students are assured that all scientists who have studied the matter accept fully that there has been an evolution of life, that a satisfactory general theory can accommodate the observed phenomena, and that new information is being added rapidly to the field of evolutionary biology. Some of the students wonder, no doubt, why the issue of creationism is ignored.

Many important scientists and educators believe that the "Science Only" approach is proper and sufficient. Biology is a science and biological classes should restrict their discussions to science. Nothing useful is to be gained by taking note of the creationists or their views.

Evolutionary Biology in Perspective

But do we serve the best interests of the students and of biology by pretending that there is no opposition to evolution? If one answers this question with "no," then one should deal with the opposition carefully and explicitly. This is the scenario that I would prefer—which sets me aside from most fellow evolutionists. I believe that much is to be gained for the student and for science by discussing the nature of the objections to the theory of evolution. Such an approach has a valuable carry-over to other contentious fields where society has difficulty deciding what to do.

Here the approach would be to cover evolutionary biology in the standard way (Scenario 1) and then present the main arguments of those who do not wish to accept evolution. The main emphasis here would be to contrast the procedures of evolutionists and creationists in seeking answers to questions. The scientist's answers must, in the final analysis, be based on what observation and experiment can tell us about the events in nature. The explanations can invoke only natural products and processes. All suitably trained individuals can be expected to reach essentially the same answers when they employ the same methods and can make the same observations.

The explanations of the creationists, on the other hand, are based ultimately on ancient texts, in this case Genesis. It is assumed that the statements in these ancient texts were passed by word of mouth for unknown generations but their origin was a revelation to one or a few individuals. These revelations are accepted as true and, therefore, the events of nature must be understood in their terms.

Once this dichotomy of approach has been established, the discussion might proceed to discuss the very different consequences of these approaches. During the century since the Origin was published the

scientific approach has been highly productive. Our understanding of the history of life has increased enormously. We now have some knowledge of the very ancient forms of life that lived more than 700 million years ago, much data on the variety of fossil organisms that lived at later times, even more data on the interrelations of organisms that had hard structures, such as bones and teeth that fossilize well, and much data on the dynamics of the evolutionary process. Nevertheless, the student must understand that although much has been accomplished, new information is being obtained at an ever increasing rate.

Scientific Procedures Work!

On the other hand, the creationists have accumulated no new information or understanding—it's all in *Genesis*. Their efforts for the past century have been mainly in pointing out that evolution cannot explain everything—to which the evolutionist must agree.

Despite its superficial simplicity, evolutionary theory is often not easily understood by high school students. For this reason some teachers prefer to use medicine as an example of scientific and nonscientific approaches to problems. The argument might be developed as follows: Little progress was made in understanding the nature or treatment of disease so long as it was assumed that sickness was a consequence of the displeasure of some god or evil spirit. The scientific study of disease, which has become increasingly possible during the past century, has made great progress. But, once again, there is much to learn.

Thus in a comparison of the usefulness of scientific versus supernatural procedures in studying natural events (organisms, disease, etc.) most people will reach the conclusion that one works and the other does not.

Giving Equal Time

The final scenario that I will mention meets the demands of some creationists that, if the history of life is discussed at all, equal time should be given to the evolutionist's and creationist's paradigms. (There is an obvious fourth scenario—teaching only creationism—but one who selects that solution has nothing to learn from me.)

Equal time does present a problem. The basis of creationism is *Genesis I* and the first nine verses of *Genesis II*, all of which can be read in three minutes. On the other hand, even the most summary review of the evidence on which the theory of evolution is based would require at least three class hours. Nevertheless there are other ways to devote the required equal time to creationism. One is to discuss the fascinating reasons for the two very different accounts of creation in *Genesis*: one in *Genesis I* plus the first four verses of *Genesis II* and the other in *Genesis II* verses 5-9. Long ago biblical scholars concluded that *Genesis* is a compilation of several very different sources. The *Genesis II* account of creation is very old. It is thought to represent a very ancient story that was finally written down in the

10th century B.C. The Genesis I account of creation is much more recent. Apparently it was not formulated until after the Jews had returned from captivity in Babylonia in the 6th century. This account is remarkably similar to the creation myth of Babylon and, apparently, the priests drew heavily on that source. A good general account of the biblical scholarship that led to these conclusions is Buttrich (1952).

Some creationists have insisted that creationism be treated as a scientific theory (see, for example, John N. Moore, 1973 and Gish, 1973). (I should emphasize the difference between the John Moores. John N. Moore is a creationist. I am John A. Moore, an evolutionist.) If this is done, one should subject the statements of Genesis I and Genesis II to the rigors of scientific procedures. Thus, the statements should be accepted as provisionally true hypotheses and deductions made from them. These deductions should then be tested to see if the hypothesis is false or possibly true. Not surprisingly, such tests give no support for the statements in Genesis. These are complex matters and deserve a fuller treatment than is possible here. I have dealt with this problem in much greater detail (J. A. Moore, 1975).

There is another and quite serious problem associated with including creation in a science course. Which account of creation? There are hundreds of stories of creation, each associated with a specific race or sect. One could maintain that, in all fairness, students should be exposed to many more than the one in the Judeo-Christian tradition. But the problem here is that, since most are entirely different, all cannot be correct and there is no procedure to select a "correct" one. The point should also be made that a sect believes its own story and usually regards all others as myths. But that is what myths are: the other fellow's sacred or traditional beliefs. And one should add, none of this is science and, if it is to be treated at all, possibly it should be in anthropology or social studies courses.

Some of the problems involved in the creationist controversy are dealt with by Nelkin (1976a, 1976b, 1977), Chambers (1977), Mayer (1973, 1977), Cloud (1977), J. A. Moore (1974), Le Clercq (1974), Stebbins (1973), Dobzhansky (1973), Hardin (1973), J. N. Moore (1973), Gish (1973), Cory (1973), Aulie (1972), Ost (1972), and Newell (1974).

POSTSCRIPT

A generation ago, when science was basking in the glory of its accomplishments in World War II, when the Space Program was beginning to conquer those other worlds, and when the gene was identified and its code cracked, few would have anticipated the anti-science climate of our times. Today we find science under attack, not because it fails to increase our understanding of nature but, more probably, because it succeeds too well. It is now clear that scientific knowledge used without restraint can lead to the advantage of the few and the disadvantage of the many, to over-exploitation today at the risk of the destruction of tomorrow. In our concern for our lives and profits we sometimes fail to remember that science is neutral, though

the uses to which it can be put are not. Thus many see science as the demon when, instead, they should see themselves. The thoughtless then seek to control science when they should seek to control human nature.

Be that as it may, some of this antiscience is reflected in attempts to have the foundation theory of the biological sciences taught as no more than probable hypothesis or tentative theory and the creation myth of the Judeo-Christian tradition promulgated as its scientific equal. A determined minority has been able to incorporate these views in some of the laws of the land.

Scientists normally expect that scientific matters will be resolved by data, not emotion. They may look upon those who reject the rigors of scientific proof as somewhat benighted. But in a democracy those who dwell in the light and those who dwell in the dark share equally in deciding what shall be taught. A generation ago we in America watched in disbelief as the Russians repealed Mendel's Laws of Inheritance. Today some of our states seem to be doing the same for even more fundamental laws of biology.

It is clear now that no amount of scientific evidence will convince creationists of the vacuousness of their position. The controversy they have started will be resolved only when the scientists convince the voting majority of our citizens that the procedures of science work when we seek to understand nature and that supernatural and transcendental procedures do not.

Biology teachers have more to teach than biology!

REFERENCES

Adams, Frank Dawson. The Birth and Development of the Geological Sciences. New York: Dover, (1938) 1950.

Allen, Leslie H. Bryan and Darrow at Dayton. New York: Russell and Russell, 1925.

Appleman, Philip (ed.). Darwin. A Norton Critical Edition. New York: Norton, 1970.

Aulie, Richard P. "The Doctrine of Special Creation." American Biology Teacher, Vol. 34:261-268, 281, 1972.

Barbour, Ian G. Issues in Science and Religion. New York: Harper and Row, (1966) 1971.

Bowen, Francis. "On the Origin of Species..." North American Review, Vol. 90:474-506, 1860.

Buttrick, George Arthur. The Interpreter's Bible. New York: Abingdon Press, Vol. 1, 1952.

de Camp, L. Sprague. The Great Monkey Trial. Garden City, NY: Doubleday, 1968.

Chambers, Bette. "Why a Statement Affirming Evolution?" The Humanist, Vol. 37:4-6, 23-24, January/February, 1977.

Le Clercq, Frederic S. "The Constitution and Creationism." American Biology Teacher, Vol. 36:139-145, 1974.

Cloud, Preston. "Scientific Creationism—A New Inquisition Brewing?" The Humanist, Vol. 37:6-15, January/February, 1977.

Colbert, Edwin H. Evolution of the Vertebrates; a History of the Backboned Animals Through Time (2nd edition). New York: Wiley, 1969.

Cory, Lawrence R. "Creationism and the Scientific Method." American Biology Teacher, Vol. 35:223-225, 1973.

Daniels, George (ed.). Darwin Comes to America. Waltham, MA: Blaisdell, 1968.

Darwin, Charles. On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life. Cambridge, MA: Harvard University Press, (1859) 1964.

This is a facsimile of the first edition.

Darwin, Charles and Alfred Wallace. "On the Tendency of Species to Form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection." Journal of the Linnean Society of London. Zoology, Vol. 3, No. 9:45-62, 1858. Reprinted in Principles of Zoology by John A. Moore. New York: Oxford University Press, 1957. Also reprinted in Evolution by Natural Selection by Charles Darwin and Alfred Russel Wallace. Cambridge, MA: Cambridge University Press, 1958.

Darwin, Francis (ed.). The Life and Letters of Charles Darwin, Including an Autobiographical Chapter (three volumes). London: John Murray, 1888.

Dillenberger, John. Protestant Thought and Natural Science. A Historical Interpretation. Nashville: Abingdon Press, 1960.

Dobzhansky, Theodosius. Genetics and the Origin of Species. New York: Columbia University Press, 1937, 1941, 1951.

Dobzhansky, Theodosius. Genetics of the Evolutionary Process. New York: Columbia University Press, 1970.

Dobzhansky, Theodosius. "Nothing in Biology Makes Sense Except in the Light of Evolution." American Biology Teacher, Vol. 35:125-129, 1973.

Dobzhansky, Theodosius; Francisio Ayala; G. Ledyard Stebbins; and James W. Valentine. Evolution. San Francisco: Freeman, 1977.

Draper, John William. History of the Conflict Between Religion and Science. New York: Appleton, 1874.

Duns, John. "On the Origin of Species..." The North British Review, American Edition, Vol. 27:245-263, 1860.

Eaton, Theodore H., Jr. Evolution. New York: Norton, 1970.

Ehrlich, Paul R.; Richard W. Holm; and Dennis R. Parnell. The Process of Evolution (2nd edition). New York: McGraw-Hill, 1974.

Eicher, Don L. Geologic Time (2nd edition). Englewood Cliffs, NJ: Prentice-Hall, 1976.

Eisley, Loren. Darwin's Century. Evolution and the Men Who Discovered It. Garden City, NY: Doubleday, 1958.

Gay, Peter. The Enlightenment: An Interpretation. New York: Vintage Books (Random House), 1966.

Geikie, Archibald. The Founders of Geology. New York: Dover, (1905) 1962.

Ghiselin, Michael. The Triumph of the Darwinian Method. Berkeley: University of California Press, 1969.

Gillispie, Charles Coulston. Genesis and Geology. A Study of the Relations of Scientific Thought, Natural Theology, and Social Opinion in Great Britian, 1790-1850. New York: Harper and Row, 1951.

Ginger, Ray. Six Days or Forever? Tennessee v. John Thomas Scopes. Boston: Beacon Press, 1958.

Gish, Duane T. Evolution: The Fossils Say NO! San Diego: Institute for Creation Research, 1972.

Gish, Duane T. "Creation, Evolution, and the Historical Evidence." American Biology Teacher, Vol. 35:132-140, 1973.

Glick, Thomas F. (ed.). The Comparative Reception of Darwinism. Austin: University of Texas Press, 1972.

Grant, Verne. Plant Speciation. New York: Columbia University Press, 1971.

Gray, Asa. "Review of Darwin's Theory on the Origin of Species." American Journal of Science and Arts (2nd series), Vol. 29: 158-184, 1860.

Greene, John C. The Death of Adam. Evolution and its Impact on Western Thought. Ames, IA: Iowa State University Press, 1959.

Greene, John C. Darwin and the Modern World View. Baton Rouge: Louisiana State University Press, 1961.

Hardin, Garrett. "Ambivalent Aspects of Evolution." American Biology Teacher, Vol. 35:15-19, 1973.

Hofstadter, Richard. Social Darwinism in American Thought. Boston: Beacon Press, 1955.

Hofstadter, Richard. Anti-Intellectualism in American Life. New York: Vintage Books (Random House), 1963.

Hull, David. Darwin and His Critics; the Reception of Darwin's Theory of Evolution by the Scientific Community. Cambridge, MA: Harvard University Press, 1973.

Hutton, James. "Theory of the Earth, or an Investigation of the Laws Observable in the Composition, Dissolution, and Restoration of the Land Upon the Globe." Transactions of the Royal Society of Edinburgh, Vol. 1:209-304, 1788.

Huxley, Thomas Henry. "Time and Life: Mr. Darwin's 'Origin of Species'." Macmillan's Magazine, Vol. 1:142-148, 1859.

Huxley, Thomas Henry. "Darwin on the Origin of Species." Westminster Review, American Edition, Vol. 73:295-310, 1860.

Huxley, Thomas Henry. "On the Reception of the 'Origin of Species'." In Francis Darwin (ed.) The Life and Letters of Charles Darwin, London: John Murray, Vol. 2:179-204, 1888.

Huxley, Thomas Henry. Science and Hebrew Tradition. New York: Appleton, 1895b.

Irvine, William. Apes, Angels, and Victorians. The Story of Darwin, Huxley, and Evolution. New York: McGraw-Hill, 1955.

Jenkins, Fleeming. "The Origin of Species." North British Review, Vol. 46:277-318, June 1867.

Kennedy, Gail (ed.). Evolution and Religion. The Conflict Between Science and Theology in Modern America. Boston: Heath, 1957.

Lawrence, Jerome and Robert E. Lee. Inherit the Wind. New York: Random House, 1955.

Lewontin, R. C. The Genetic Basis of Evolutionary Change. New York: Columbia University Press, 1974.

Lyell, Charles. Principles of Geology: Being an Inquiry How Far the Former Changes of the Earth's Surface are Referable to Causes Now in Operation. London: John Murray, 1830-1833.

Mayer, William V. "Evolution and the Law." American Biology Teacher, Vol. 35:144-145, 162, 1973.

Mayer, William V. "Evolution: Yesterday, Today, Tomorrow." The Humanist, Vol. 37:16-22, January/February, 1977.

Mayr, Ernst. Systematics and the Origin of Species From the Viewpoint of a Zoologist. New York: Columbia University Press, 1942.

Mayr, Ernst. Animal Species and Evolution. Cambridge, MA: Belknap Press of Harvard University Press, 1963.

Mayr, Ernst. Populations, Species, and Evolution. Cambridge, MA: Belknap Press of Harvard University, 1970.

Moore, John A. "Creationism in California." Deadalus, Vol. 103, No. 3:173-189, 1974.

Moore, John A. "On Giving Equal Time to the Teaching of Evolution and Creation." Perspectives in Biology and Medicine, Vol. 18:405-417, 1975.

Moore, John N. "Evolution, Creation, and the Scientific Method." American Biology Teacher, Vol. 35:23-26, 34, 1973.

Nelkin, Dorothy. "Science or Scripture: The Politics of "Equal Time." In Gerald Holton and William A. Blanpied (eds.) In Science and Its Public: The Changing Relationship. Boston: D. Reidl, 1976a.

Nelkin, Dorothy. "The Science-Textbook Controversies." Scientific American, Vol. 234, No. 4:33-39, April, 1976.

Nelkin, Dorothy. Science Textbook Controversies and the Politics of Equal Time. Cambridge, MA: MIT Press, 1977.

Newell, Norman D. "Evolution Under Attack." Natural History, Vol. 83, No. 3:32-39, April 1974.

Ost, David H. "Teacher-Training Use of ABT 'Creationism' Controversy." American Biology Teacher, Vol. 34:349, 1972.

Peckham, Morse. The Origin of Species by Charles Darwin. A Variorum Text. Philadelphia: University of Pennsylvania Press, 1959.

Price, Derek de Solla, Jr. Little Science, Big Science. New York: Columbia University Press, 1963.

Romer, Alfred Sherwood. Vertebrate Paleontology (3rd edition). Chicago: University of Chicago Press, 1966.

Russett, Cynthia Eagle. Darwin in America. The Intellectual Response 1865-1912. San Francisco: Freeman, 1976.

Simpson, George Gaylord. Tempo and Mode in Evolution. New York: Columbia University Press, 1944.

Simpson, George Gaylord. The Major Features of Evolution. New York: Columbia University Press, 1953.

Simpson, George Gaylord. The Meaning of Evolution. A Study of the History of Life and Its Significance for Man (2nd edition). New Haven: Yale University Press, 1967.

Smith, John Maynard. The Theory of Evolution (3rd edition). Baltimore: Penguin Books, 1975.

Stebbins, G. Ledyard. Variation and Evolution in Plants. New York: Columbia University Press, 1950.

Stebbins, G. Ledyard. Processes of Organic Evolution (3rd edition). Englewood Cliffs, NJ: Prentice-Hall, 1977.

Stebbins, G. Ledyard. "The Evolution of Design." American Biology Teacher, Vol. 35:57-61, 1973.

Taylor, L. W. Physics, the Pioneer Science. New York: Dover, 1941.

Tompkins, Jerry R. (ed.). D-days at Dayton. Reflections on the Scopes Trial. Baton Rouge, LA: Louisiana State University Press, 1965.

Turner, Frank Miller. Between Science and Religion. The Reaction to Scientific Naturalism in Late Victorian England. New Haven: Yale University Press, 1974.

Volpe, E. Peter. Understanding Evolution (3rd edition). Dubuque, IA: William C. Brown, 1977.

White, Andrew Dickson. A History of the Warfare of Science With Theology in Christendom. New York: Appleton, 1896.

Wilberforce, Samuel. "On the Origin of Species..." Quarterly Review, Vol. 108:225-264, 1860.

Wilson, Edward O. Sociobiology. The New Synthesis. Cambridge, MA: The Belknap Press of Harvard University Press, 1975.

Wilson, R. J. Darwinism and the American Intellectual. A Book of Readings. Homewood, IL: Dorsey Press, 1967.

Melvin Weinswig presents a straightforward and informative look at drugs. He breaks the discussion into drugs of abuse and antibiotics; the bad and the good aspects of the drug world. In a society as obsessed and dependent on drugs as ours is, educational institutions have a serious responsibility to look at all aspects of drug use.

DRUGS

Melvin H. Weinswig

In order to prepare today's youth to face the complexities of our society, we must educate them in every way possible. One issue they will face is that of drug use and abuse. The temptations are enormous and sometimes overwhelming, and our drug-oriented society does not set the best example for them to follow. Education must make them strong in their conviction and so they are not misled by false claims that "it won't hurt you" or "come on, everybody's doing it."

It is important to be armed with factual, accurate information in order to make sense out of the conflicting claims that assault us daily. Drug education programs must present the terms used to discuss drugs, the drug problem itself, and finally be able to present the information in a rational way so that each student can determine for himself the "harmfulness" of a substance currently being used and abused. There must be open communication and understanding between teacher, pupil, and parent if the program is to succeed. The emphasis must be on education. Education must become the aggressive combatant in the battle over drug use and abuse. The information must be developmental, factual, and nonjudgmental. It must not moralize, yet it must attempt to place the issue of drugs into a proper perspective.

This chapter is designed to give you the basic information and you can expand upon it according to your areas of strength and interest.

Due to the limited space, only two categories of drugs will be covered in this chapter. The categories will be antibiotics and those drugs that act on the central nervous system (CNS). The majority of prescriptions filled in the world each year would be for these two classes. Unfortunately, the CNS drugs have the greatest potential of drug abuse than all other classes combined. Before considering these classes individually, it is important to understand the definition of "a drug" and related terminology as well as the factors that influence how a drug works.

A drug is defined as any substance that affects living processes and that can produce more than one response (effect) in the body. If the effect is good, it is called a desired effect and if it is bad, it is called a side effect.

Pharmacology is the study of drugs and their effects on the body. This study includes the history, original source, physical and chemical properties, mechanism of action, absorption, excretion and therapeutic uses of a drug.

It is difficult to predict exactly how a drug will react in the body and how many such effects it will actually have. The effects that a drug will have in the body are determined by several factors:

1. Route of administration (oral, rectal, injection)

2. Rate of absorption (how quickly it gets in the blood stream)

3. Structure of the drug (how large a molecule; its solubility)

4. Site of action of the drug (is it absorbed in the blood or does it remain local)

5. Drug interactions

5. Characteristics of the patient (weight, age, sex, tolerance)

To understand how these factors influence the drug effect, let us follow the pathway of a drug from the administration to the excretion. In order to determine by what route the drug should be administered, it is important to know the size of the molecule, whether it is fat- or water-soluble, and its chemical properties. The larger the molecule, the slower the rate that it can cross the cell membrane and therefore the slower the onset of action. If it is fat soluble, the drug can be stored in fat deposits and will be released more slowly and for longer periods of time. These two factors therefore will determine dosage (how much drug) and how frequently it must be given. If the drug effects last for a long period of time, fewer doses need be given. Small changes in the chemical structure can change the chemical properties of the drug and change the total response and the toxic effects. In sor ways, the structure can be modified to increase the desired effects and decrease the dosage, which also results in a decrease of side effects.

The drug is then administered, eventually gets into the blood stream, and exerts its effects in the body. A certain amount of time passes and then the drug enters the liver or kidneys where it is changed chemically (detoxified or metabolized) and then is excreted either in the urine or feces.

To add to the unpredictability of a drug response are the patient's weight, age, sex, tolerance to the drug as well as when was the drug taken, were foods present, and is the patient taking any other drugs? If a patient weighs 250 pounds he will require a different dose than if he weighs 100 pounds. If this dose is high, will it exert any toxic side effects in the 250 pound person? If the patient takes the drug on an empty stomach, will more be absorbed and, therefore, could a lower dose be administered? And last of all, the drug response can be modified if taken with another drug or given prior to a second drug.

Sometimes the effects can be beneficial and improve therapy, and this knowledge is put to use in a number of conditions. Other times, it can interfere completely with the effect and eliminate the response of both drugs or it can cause serious adverse reactions. The effects that result when two or more drugs are given at the same time are called drug interactions. This can be a special problem when a patient requires a number of medications such as in the geriatric patient or in a cardiac patient with high blood pressure.

From this brief description, one can appreciate the complexity of drugs acting in the body when administered by a physician to treat a specific illness and taken in the proper dosage. The picture becomes more complex when one considers drugs of abuse and their effects on the body without normal supervision and not in normally accepted doses.

No group of drugs has influenced man in both a positive and a negative way than those drugs that affect the CNS. This category contains drugs that relieve the severest of pain, drugs that have improved treatment for mental disorders miraculously as well as corrected conditions of narcolepsy, hyperkinesis in children, and insomnia. Unfortunately, this category contains the greatest number of drugs that are abused and misused today by people of all ages. Therefore, the drugs of the CNS will be presented from the point of view of abuse potential and then methods to control and eliminate the drug problem.

DRUGS OF ABUSE

Classification of the drugs of abuse has become a much larger problem in recent years than previously. Until recently, there were only a few materials, mostly of plant origin, that were abused in their application by man. Today there are a host of substances, not only from plants but from minerals and from laboratories as well. In addition, there are cults that claim to find a mind-expanding activity, or an enlargement of wisdom, or greater creativity by use of certain substances.

Adding to the complexity of our problem of classification is the fact that some people are constantly finding additional means of "turning on." The ingestion of household nutmeg or morning glory seeds leads to hallucinogenic states, and the sniffing of glue or gasoline—the latter more common among the youngest teenagers—also can intoxicate. To add to the problem, there are some prescription cough remedies that are abused for their intoxicating effects.

This abuse of common substances poses new problems. One can pass laws to control the production and distribution of drugs, but how does one regulate the sale of nutmeg, flower seeds or gasoline? Alcohol and tobacco will not be considered in the scope of this chapter due to a lack of space. Alcohol itself is a drug that is abused by the greatest numbers and the widest variety of ages of people in the United States.

It is necessary to review the nomenclature of some common terms that have become commonplace in usage but, nevertheless, are misused and misunderstood. The following terms cover a varying degree of drug use or response:

a. Habituation: Frequent, often regular, indulgence but with psychic dependence only; e.g., the feeling sometimes described after missing one's customary cup of coffee.

b. Addiction: Habituation with physical dependence; physical disturbance occurs upon withdrawal of the substance.

c. Psychic Dependence: The drug is desired, but no serious physical effects are noted if it is not obtained. This is rather characteristic of stimulating drugs; it may lead to antisocial acts.

d. Physical Dependence: Serious physical and mental effects appear when the drug is withdrawn. This is more characteristic of depressive drugs and also may lead to anti-social acts.

e. Tolerance: An increase in the dose is required after a time to produce the desired effects. This effect occurs only with sedative, depressing drugs. "Learning to drink" alcoholic beverages is an example of developing tolerance.

f. Drug Dependence: The terms addition and habituation frequently have been used interchangeably, but this is incorrect practice. The World Health Organization (WHO) has suggested replacing both these words with a single, more general term, "drug dependence." It may be defined as "a state arising from repeated administration of a drug on a periodic or continuous basis." All three terms very likely will become a part of drug abuse terminology, with "drug dependence" the favorite of medically oriented groups, and "addiction" and "habituation" being favored by legislative and law enforcement circles.

Usage of the term "drug abuse" here will refer to the use, usually by self-administration, of any substance in a manner which deviates from the approved medical or social patterns.

Preliminary to the classification, one more point needs emphasis. It is important to remember that some substances have valid applications in good medical practices; they need only be used under appropriate circumstances, in appropriate doses, and for appropriate periods of time. Drugs are good! Respect them, and appreciate them.

There are six main groups of substances subject to abuse although the last one to be described includes a heterogeneous mixture of items of varied chemical background.

1. Narcotics: Medically defined, these are drugs which produce insensibility or stupor due to their depressant effect on

the central nervous system. Included in this definition are opium and its derivatives morphine, codeine, and heroin, plus the synthetic opiates such as hydromorphone and methadone. Natural and synthetic morphine-like drugs are the most effective pain relievers in existence. They are all narcotic (sleep producing), they are all addicting (producing physical and psychic dependence), they all produce side effects that make them less than ideal analgesics, and yet they still are to be counted among the most valuable agents in the physician's armamentarium. Any opiate drug presents an addiction picture which typically develops in three stages:

A. Tolerance—when increased doses are needed to get the desired effects.

B. Habituation—psychic dependence occurs, giving the patient the impression that he must take the drug and that there is some benefit derived from it. Habituation is not easy to change or eliminate. Mild withdrawal symptoms at this level may occur even before physical dependence develops.

C. Physical dependence—alteration of the cells from normal occurs and in this altered form the presence of the drug is necessary for continued function. The drug is almost a nutrient for the cells and without it they cannot perform normally, causing abnormalities of function.

The symptoms of withdrawal from narcotic analgesics are typical of many drug addictions and include restlessness, irritability, shivering, muscular tremors, headaches, flushed skin, chills, mydriasis, insomnia, abdominal cramps, excess sweating, delirium, severe muscular tremors approaching convulsions, vomiting and diarrhea, which after several days lead to dehydration and weight loss. Finally, a feeling of desperation and an obsessional desire to secure a "fix" occurs. The intensity of withdrawal symptoms varies with the degree of physical dependence. This, in turn, is related to the amount of drug customarily used. Typically, the onset of symptoms occurs about 8-12 hours after the last dose. Then the symptoms increase in intensity, reach a peak between 36 and 72 hours, then gradually diminish over the next 5 to 10 days. However, weakness, insomnia, nervousness, and muscle aches and pains may persist for several weeks. In extreme cases, death may result.

2. Sedatives (Depressants): This group includes a variety of old and new drugs which have a depressant effect on the nervous system. The barbiturates, which are the most commonly abused, are among the most versatile depressant drugs available. They are used for epilepsy, high blood pressure, insomnia, and in the treatment and diagnosis of mental disorders. Their most frequent clinical use is for insomnia. How these drugs work is only dimly understood, because the phenomenon of sleep itself still awaits complete explanation.

The incidence of compulsive abuse of barbiturates cannot be stated with accuracy. Taken together with related drugs,

hypnotic abuse probably exceeds that of opiates. Illegal traffic in these drugs is common. Opiate users frequently employ barbiturates to boost the effects of weak heroin, and many heroin addicts are physically dependent on both opiates and hypnotics.

The short-acting (the term refers to onset and duration of action) barbiturates such as pentobarbital ("yellow jackets") or secobarbital ("red devils") are preferred to the long-acting agents such as phenobarbital.

Most users take the drugs orally, but there are a few heroin and morphine users who take barbiturates intravenously. It has been observed that the combination of amphetamines and barbiturates produces more elevation of mood than either drug alone, but the mechanism of this additive effect is not clear.

Both the acute and chronic effects of mild barbiturate intoxication resemble those of intoxication with alcohol. The intoxicated individual shows a general sluggishness, difficulty in thinking, slowness of speech and comprehension, poor memory, faulty judgment, narrowed range of attention, emotional lability, and exaggeration of basic personality traits. Irritability, quarrelsomeness, and moroseness are common. There may be laughing or crying without provocation, untidiness in personal habits, hostile and paranoid ideas, and suicidal tendencies. Because the abuser is prone to stumble or drop objects, he often is bruised and has cigarette burns.

Chronic misuse of barbiturates is accompanied by the development of tolerance and both psychological and physical dependence. Physical dependence appears to develop only with continued ingestion of doses much greater than those customarily used in the practice of medicine.

In a physically dependent barbiturate abuser, abrupt withdrawal is extremely dangerous. Elimination of the drug should always be supervised by a physician in such cases.

In withdrawal the same signs appear 8 to 12 hours after the last dose, as with narcotics. At approximately 24 hours the blood pressure is extremely low and when the person stands abruptly, he often faints. Within 36 to 72 hours, convulsions resembling epileptic seizures may develop and these can be fatal. Whether or not convulsions occur, there may be a period of mental confusion.

Delirium and hallucinations similar to the delirium may persist for several days and be followed by a long period of sleep. The delirium and hallucinations are felt by many investigators to be a manifestation of an underlying psychosis.

3. Stimulants: This group includes drugs which directly stimulate the central nervous system. The most widely known stimulant used in this country is caffeine, an ingredient of coffee,

tea, cola, and other beverages. Since the effects of caffeine are relatively mild, its usage is socially acceptable, and it is not an abuse problem. Another naturally occurring material which is an abuse problem is cocaine.

Cocaine is obtained from the leaves of the coca bush, found in certain South American countries. It is an odorless, white crystalline powder with a bitter taste, producing numbness of the tongue. The leaves have been used for centuries by the natives in Peru and Bolivia to increase their endurance, an effect which is correlated with stimulation of the central nervous system. This effect is sometimes misinterpreted as an "outgoing nature" in an individual who becomes talkative, restless, and easily excitable. As with most stimulants, the stimulation is soon followed by depression; in the case of an overdose, death may result from respiratory failure. The most important action of cocaine, clinically, is its ability to block conduction of nerve impulses, hence its use as a local anesthetic. Cocaine's local action on the eye is of particular importance and because of its powerful action is not used orally or by injection. Its abuse potential is more significant than that of the amphetamines and is almost indistinguishable from those effects obtained with large amounts of amphetamines.

Amphetamines are the principal drugs of concern among the stimulants. In the U.S. and England, amphetamines are seldom used alone when abused but usually are combined with barbiturates and alcohol. This may be an attempt to reduce the anxiety and jitters produced by the amphetamines, but the potentiation of the euphoric effects by barbiturates may also play a role in combining these classes of agents.

Again, we must note that drugs producing central nervous system stimulation have therapeutic values in the management of various ailments including depression states, narcolepsy (involuntary attacks of sleep), hyperkinetic children (exaggerated state of over-activity) and in counteracting excessive drowsiness caused by sedative drugs. Amphetamines have become subject to abuse as a popular treatment of obesity, since they unquestionably depress the appetite. Their effectiveness as appetite depressants over a long period of time is questionable.

A certain amount of habituation does occur with chronic use of amphetamine, but this does not assume the same proportion as the habituation and addiction of the narcotics or sedatives previously mentioned. Withdrawal of the drug does not result in significant symptoms. Some authorities say that stimulants produce only mental and not physical symptoms upon withdrawal whereas the depressants produce both kinds.

There have been a number of reports of individuals using the amphetamines by injection. An acute psychotic episode may occur, or a drug psychosis may develop either from the chronic use of large oral doses, or administration of these drugs by the intravenous route.

4. Tranquilizers: This group of drugs differ from the barbiturates in that its members calm but theoretically do not produce sleep or cause drowsiness.

Their principal usage dates from the early and mid-1950s when many mental hospital wards were transformed because of the introduction of two drugs that helped ease disturbed minds. Neither drug, reserpine (made from rauwolfia, a root found in India) nor chlorpromaz[illegible] [illegible] synthesized in France) cures sick minds. Each, ho[illegible] [illegible] violence, relieves anxiety, and increases communi[illegible] [illegible] enabling patients to benefit from psychotherapy and [illegible] to return to home and job. These two drugs and their derivatives constitute the so-called "potent" or "major" tranquilizers. They are useful in severe mental disorders (psychoses). In addition, both have other medicinal uses. Reserpine is used to treat high blood pressure; chlorpromazine is used as an antiemetic, for severe allergies, and for many other conditions.

The mild or "minor" group of tranquilizers includes a number of drugs of varying chemical nature. For the most part, they are not effective in psychotic conditions. They are widely used, however, in the treatment of emotional disorders characterized by anxiety and tension. Many are useful as muscle relaxants.

Through the years, it has been found that some members of this second group of tranquilizers occasionally have been abused. The two drugs most often reported have been meprobamate (Miltown, Equanil) and chlordiazepoxide (Librium). Chronic abuse of these drugs, involving increasingly larger daily doses, may result in the development of physical and/or psychological dependence similar to that seen with barbiturates. Chronic use of high doses can result in convulsions if the drugs are suddenly withdrawn. To date, the abuse of tranquilizers has been infrequent and has not become a street problem.

Th[illegible] [illegible]ef of anxiety is so important in our society that tran[illegible] [illegible]zers are now among the most commonly prescribed drugs in the [illegible].S. They account for approximately one in se[illegible] prescriptions.

5. Hallucinogens: This group of drugs includes LSD, mescaline, nutmeg, morning glory seeds, DMT, STP, psilocybin (from mescal bean) and lastly, marijuana. All of these chemical substances with the exception of marijuana are not as widely abused as they were during the Viet Nam War protester era.

Distortion of perception, dream images, and hallucinations are characteristic effects of this group variously called hallucinogens, psychotomimetics, dysleptics, or psychedelics. At present, they have no general medical use but there are a few research applications. One of the most talked-about drugs of recent years, LSD, has fascinated scientists both because of its tremendous potency—1/300,000 ounce can produce a trance

in which a man may dance with his own shadow—and because its action offers clues to nerve cell chemistry.

The symptoms other than hallucinations are: irrational conversation and feelings of anxiety, although the individual does not think he has lost consciousness or awareness. In addition, a number of peripheral effects are observed such as mydriasis, sweating, and increase of blood pressure.

Marijuana, while chemically distinct from those substances mentioned above, is also considered a hallucinogen. At present, this is the most popular illicit drug abused today and it is also the drug about which most misinformation exists. Some of the confusion regarding marijuana may stem from the fact that, while not a narcotic, it has been controlled by the Bureau of Narcotics and Dangerous Drugs. This classification has given rise to reports that the effects of this drug are as damaging and as addictive as those of heroin. Those with knowledge of drugs know this to be untrue and therefore assume all information on marijuana is incorrect.

The active principle in marijuana is tetrahydrocannabinol. The most concentrated supply of cannabinols is found in the preparation called "hashish" available from the Far East and is obtained from a resin in the flower clusters. The potency of any marijuana preparation varies with the growth conditions encountered by the plant. This is the main reason for such a variance in strength between marijuana grown in different geographic locations.

Marijuana is green, not brown; smells like alfalfa when burned; and appears on the illicit market in the bulk form or as cigarettes made by rolling the weed in paper and tucking in the ends. The "joints" burn hotter than tobacco cigarettes, and the tip is brighter.

Marijuana presents a drug abuse pattern which includes psychological dependence and certain undesirable side effects. After inhaling the smoke the user notices a feeling of "inner joy" described as being "high." If he is alone, he may "trip off" and be drowsy, or watch a passing parade of technicolor illusions. In company, he may be talkative and hilarious. His awareness, touch, and perception are altered, particularly as they relate to time and space.

If a negative influence is insinuated, he may become anxious, slightly paranoid, and apprehensive. This experience is known as a "bring down," and a "downer," or a "bummer."

The effects of a "trip" last from three to five hours, after which the user feels slight lethargy and hunger. Most trips are reputed to be innocuous affairs with less destructive effect than an alcoholic binge. For this reason many persons do not recognize the true dangers of the drug.

The psychological effects of marijuana are as varied as the range of human personality and as complex as the factors which influence the user each time he smokes. If in a good mood when he takes the drug, he may sing, laugh, joke, and enjoy himself. Or he may enter an automobile and with "teashades" (sunglasses worn because of the dilated pupils) over his handicapped eyes and with impaired reflexes, he may plow through a crowd of pedestrians. He may meditate on the beauties of art, nature, and music, or he may step out of an 18-story window to catch a butterfly.

Opinion varies on what effect marijuana has on sexual response. It is not an aphrodisiac, but it does release restraints. By distorting time and space it makes orgasm seem more prolonged and intense.

The use of marijuana as an intoxicant is second only to that of alcohol. It usually is obtained by contact with friends who are users.

There seems to be little lasting physiological harm occurring from the occasional use of marijuana. But, stressing this and seemingly ignoring the adverse psychological effects of the drug, proponents of marijuana advocate its legalization.

The casual user, the curious one-timer, and the investigator may take the drug without deleterious effects. But the chronic user develops a psychological dependence; he is just as "hooked" as the people we call addicts. This person develops inertia, lethargy, and indifference. Ever if he does not have psychotic or pseudopsychotic episodes or begin a criminal or violent existence, he becomes a blight to society. He "indulges" in self-neglect. Even though [illegible] give the excuse that he uses the drug to enlarge his understanding of himself, it is the drug experience which becomes the principal interest. <u>The drug serves as a crutch and replaces healthier modes of self-discovery.</u>

6. <u>Other Substances</u>: This is a catchall for a variety of chemicals which presently does not include substances ordinarily consumed in unit dose forms, either orally or parenterally. Ether and chloroform are, of course, used medically, chiefly by inhalation. Most of the products in this category, however, are industrial solvents. Some call this group "deliriants." Gasoline and some other substances can be obtained by most abusers in near pure form, but toluene, benzene, xylene and similar solvents are not readily available to many people, so they sniff glue, lighter fluid, nail polish or other products. Thus, the fumes of a volatile agent or agents are inhaled to achieve a state of intoxication similar to that obtained by drinking alcoholic beverages but occasionally are accompanied by hallucinations.

The physical damages of glue sniffing usually include effects upon the kidneys, blood, and nervous system. An additional

danger is the chance of suffocation either from the overwhelming presence of fumes in a closed space or from the plastic bag often used to hold solvents and glue up to the face.

The following symptoms are characteristic of abuse: loss of interest in school and social relationships, inability to relate to others, failure to accept responsibilities, lack of ambition for the future, marked alteration of behavior patterns, deterioration of physical and personal appearance, problems with parents or peer groups, withdrawal and uncommunicativeness, overt hostility and outbursts of temper, lethargy, quick changes of mood, and development of furtive habits.

"Drug abuse continues to be a serious social problem in America. My goals are to discourage all drug abuse in America—and also discourage the excessive use of alcohol and tobacco—and to reduce to a minimum the harm drug abuse causes when it does occur. To achieve these goals with the resources available, effective management and direction are essential."[1]

ANTIBIOTICS

Probably no group of drugs has done more to increase life expectancy of man than the antibiotics. Antibiotics are agents produced or derived from living cells which can kill or inhibit the growth of microorganisms. All of the clinically useful antibiotics are more toxic to the organisms than to the patient and may be used internally to treat systemic infections.

Alexander Fleming, while working at a London hospital in 1929, accidentally isolated a mold that possessed antibacterial activity against some bacteria. The name he gave this product was penicillin. After many subsequent clinical trials and purification, a new era of treatment was begun. Newer antibiotics are still being discovered and refined with less side effects and more specificity for the particular infecting organisms. Over-use has produced strains of bacteria that become resistant to certain antibiotics. This has resulted in physicians trying to culture the organisms for identification before prescribing the antibiotic that is best suited for treating that organism.

Antibiotics are selectively toxic to the parasite and yet cause minimum harm to the host or patient. Some of these drugs kill the parasite (bacteriocidal) while others inhibit the growth of the parasite (bacteriostatic).

The spectacular success of antibiotics in the treatment of the diseases in man has prompted their expanded use in a number of related fields. Extensive use of their antimicrobial power is made

[1] President Carter's Drug Abuse Message to Congress, August 1977.

in veterinary medicine. The discovery that low-level administration of antibiotics to meat-producing animals resulted in faster growth, lower mortality rates and better quality has led to extensive use of these products as feed supplements. A number of antibiotics are being used to control bacterial and fungal diseases of plants. Their use in food preservation is being studied carefully. Indeed, such uses of antibiotics have made necessary careful studies of their chronic effects on man and their effect on various commercial processes.

The success of antibiotics in therapy and related fields has made them one of the most important products of the drug industry today. Antibiotics are produced by several million pounds annually in the United States and represent a value of several hundreds of million dollars. Research activity has been directed toward finding new substances to treat viral infections (so far untouched by antibiotic therapy) but so far this has met with limited success. Many promising discoveries have been made that produce an anti-infective agent active against certain cancers. Since these cancers are viral in origin, the future development of more antibiotics effective against viruses seems to be assured.

PROPER USE OF DRUGS IN TODAY'S SOCIETY

We are a drug oriented society. Advertisement continuously indoctrinates the adults and the youth with the adages "Better Living Through Chemistry." You may:

Come up -	with Vivarin
Go down -	with Sominex
Relax -	with Compose
If annoyed -	use Excedrin

and of course, for the indefinable "blahs"—use Alka Seltzer to feel good again.

Drug education has as its objective, regardless of the level of instruction, the proper use of drugs. At one time, drug education for the layman was concerned only with the narcotic problem that resulted in addiction. Today, with a more sophisticated and knowledgeable society, drug education encompasses an appreciation of the medical properties of drugs as well as the problems of drug misuse and abuse.

This is the main reason why the professionals' efforts on this behalf are so vital. We have a professional duty to see that our students get the correct information about drugs. To the average layman, especially the impressionable youngster, drugs are exotic, mysterious substances. He may read or hear that some drugs are capable of producing pleasant effects on his mind, but he doesn't know much more than that. Because of your training as an educator, you are better able to explain to the student both the good and the bad properties of certain drugs and thus keeping their use and misuse in proper perspective.

In conclusion, if professionally responsible people do care, now is the time to show it. Talk is easy but action and time often betray the verbalization of commitment and dedication. Sincerely dedicated members of our community can improve the health care of the entire public by education.

To quote an 18th century remark—"the mischief is not really in the drug but in the people."

RESOURCES AND REFERENCES

Blum, R. H. and Associates. Society and Drugs. San Francisco: Jossey-Bass, 1969.

Blum, R. H. and Associates. Student and Drugs. San Francisco: Jossey-Bass, 1969.

Freedman, D. X. "Drug Dependence and Its Treatment. I." Post-graduate Medicine, Vol. 47, No. 1:110-114, 1970.

Freedman, D. X. "Drug Dependence and Its Treatment. II." Post-graduate Medicine, Vol. 47, No. 2:150-154, 1970.

Goodman, L. S. and A. Gilman. The Pharmacological Basis of Therapeutics. A Textbook of Pharmacology, Toxicology, and Therapeutics for Physicians and Medical Students (5th edition). New York: Macmillan, 1975.

Griffenhagen, G. B. "A History of Drug Abuse." In Drug Abuse Education A Guide for the Professions (2nd edition). Washington: American Pharmaceutical Association, 26-34, 1969.

Jaffe, J. H. "Drug Addiction and Drug Abuse." In L. S. Goodman and A. Gilman (eds.) Pharmacological Basis of Therapeutics (5th edition). New York: Macmillan, 284-323, 1975.

Smith, D. E. (ed.). "The New Social Drug." Cultural, Medical, and Legal Perspectives on Marijuana. Englewood Cliffs, NJ: Prentice-Hall, 1970.

Weinswig, M. H. and D. W. Doerr. Drug Abuse: A Course for Educators. A Report of the Butler University Drug Abuse Institute, Indianapolis: Butler University, 1968.

Weinswig, M. H. Use and Misuse of Drugs Subject to Abuse. New York: Bobbs-Merrill, 1973.

Weinstein, L. "Chemotherapy of Microbial Disease." In L. S. Goodman and A. Gilman (eds.) Pharmacological Basis of Therapeutics (5th edition). New York: Macmillan, 1090-1246, 1975.

Technology has been viewed as problem-solver and problem-maker by our society. If any topic lies at the intersect between science/society, this is it. Joe Piel examines some of the "blessings" of technology and then positive and negative spinoffs.

TECHNOLOGY

Emil Joe Piel

THE SITUATION

It would be impossible to discuss in any detail all of the aspects of technology which affect humanity today. Since other chapters of this yearbook concern themselves with population, energy, pollution, drugs and natural resources, all of which are involved with technology, the author of this chapter will attempt to avoid duplication of information as much as possible.

Technology does affect all of humanity. To go back to the time when people were not affected by technology would be to revert to an era before man invented weapons for hunting or even sharpened sticks to scratch the soil for planting seeds.

Modern society, as we know it in the U.S., is rather well blessed and cursed with technology. Some of the "curses" have been discussed in previous chapters, and therefore this one will deal with some of the "blessings" and their positive and negative spinoffs.

The Elevator

Let us take, for example, the elevator. Contrary to popular assumptions the elevator is a rather old technological device. One of the first on record was invented by our old friend Archimedes about 250 B.C. We suspect that the Egyptians must have had some kind of an elevator to get the stones beyond the first few layers of the pyramid. However, it wasn't until the late 1800s that the elevator began to be used in any great numbers. As structural steel was developed near the end of the 19th century, it became possible to build tall buildings rather than five- and six-story buildings using brick, stone and concrete. However, without a convenient means of getting people and materials to upper floors there was no point in building tall buildings. A marriage of the two technologies: elevators and structural steel made possible the skyscraper. The first skyscraper (a ten-story building in Chicago) was the force which set up an instability in the entire concept of a city. It made it possible for a landowner to provide considerably more office and living space than his competitor next door who owned a five-story building on the same size lot.

Obviously, then, skyscrapers begat skyscrapers, and the downtown areas of cities drew more and more people for whom additional sanitation, transportation, feeding and similar services needed to be provided. In the approximately 100 years since the first skyscraper, the instability still continues. The abandoned apartment buildings which make up a large portion of the South Bronx, which President Carter viewed with such horror in 1977, are six-story walkups whose tenants have moved to either the suburbs or high-rise apartments with elevators.

The Twin Towers office complex in Lower Manhattan famous for an aerial tight-wire act in 1976 (and the human fly who scaled one of them in 1977) also was the inspiration for the book and movie "Towering Inferno." This is a story based on the inescapable fact that fire-fighting technology has not been able to keep pace with the building technology which makes such buildings possible. The building also requires 80,000 more kilowatts of power than does the city of Schenectady, New York, with a population of 100,000 people.

Do we now say that the elevator and structural steel should never have been developed, or do we look toward a system of technology assessment which might show how to prevent one technology from outstripping another technology as well as showing society how to keep pace? Or, isn't this an appropriate topic for a science class?

The Automobile

At the turn of the 20th century when the skyscrapers and other factors were attracting more and more people to the cities, the chief means of urban transportation was the horse. Talk about pollution!! Horses deposited 600,000 gallons of urine and 2 million pounds of manure on the streets of New York City every day. Horses had to be fed whether they worked or not and had to be sheltered when not working, particularly in cold weather.

Along came the automobile, and for a while it was the answer to the sanitation worker's dream. It was also a force which tended to push the urban transportation system into instability. It also had a fantastic effect in the U.S. and in the world. While bringing more people to the cities to work, it also enabled more to move to the suburbs. It changed the mores and morals of entire generations. It enabled people to get out of their immediate neighborhoods in a short time to do things they would never have done close to home. It spawned the drive-in movie, drive-in restaurant, drive-in bank and even the drive-in church. It provided the need for highways and freeways and has now presented the urban dweller with carcinogenic pollutants at breathing level instead of plant food underfoot. It kills more Americans in one year than were killed in combat in the entire Vietnam Conflict.

Should we go back to the horse-and-buggy era, or should we encourage future scientists and engineers to work on the design of automobiles to make them safer, less polluting and cheaper to operate? Should we use valuable science class time to teach the future "average

citizen" some of the basic principles behind the automobile so that they are more competent auto users? Twenty years ago the author taught an entire college prep physics course around the automobile before it became fashionable for high school students to worry about whether an electron was a wave or a particle. For the record, a larger percentage of his students went on to study physics and engineering than do the students from the so-called theoretical physics classes presently being taught.

The Television

About the only comment we hear about one of the technological marvels of the 20th century, TELEVISION, is that it is bad. The programming is bad, sitting too close to the color set will cause cancer, too many hours of watching T.V. cuts into school performance and interest, advertising on T.V. sends us out to buy items which we don't need with money that we don't have.

Used properly, television is an outstanding medical tool, which when teamed up with another technology, fiber optics, makes it possible for a doctor to view situations inside the patient which could only be seen through destructive surgery or autopsy. Teamed up with fixed orbit satellites, television enables people in remote areas to receive education in areas of study which would be impossible any other way. Used properly by the university, television makes it possible to provide continuing education to thousands of graduate students in local areas, eliminating the need to travel to the university, thereby saving much time, money and gasoline.

While a detailed technical study of each component of a color T.V. set is more appropriate for a course in a technical vocational school, the graduate of a comprehensive high school should know enough to question the advertisement for color television which brags about four color electron guns when all the colors the eye and brain can interpret can be formed by varying brightness and combinations of the three primary colors: red, green and blue. Here is an opportunity for the biology, physics and consumer education teachers to combine forces for real education.

Prosthetic Devices

Another interdisciplinary area of cooperation among biologists, doctors and engineers is in the various technologies involved with prosthetic devices—aids for the senses (specifically sight and hearing), interior organs such as the heart, and exterior limbs. The bionic man, woman, dog or whatever, so popular on television, has considerable foundation in fact and demonstrates some interesting spinoffs from other technologies.

It is interesting to speculate whether the failures of our early space rockets stimulated further research into miniaturization of electronic sensors, amplifiers, computers, transmitters and receivers, or whether the U.S. emphasis on miniaturization would have continued

even if our 1957 generation of rockets had been as large and as successful as those of the Russians.

Be that as it may, the fact is that we do excel in miniaturized electronics and that miniaturization was spurred on by the space program. What does all this have to do with the development of prosthetic devices? A look at the history of the cardiac pacemaker* shows how technology developed for one use finds valuable application in an entirely different field. From Galvani's discovery that muscles reacted to electrical stimulus to the present implantable cardiac pacemaker is a history of the interaction of science, medicine and engineering. For 150 years following Galvani's discovery, there were occasional reports of an individual being restored to life by electrical shock after his heart had stopped, but it was not until the 1950s that the technology called radar, which led to the development of electronic circuits to generate repetitive pulses, was combined with the medical knowledge that electric pulses were the stimulus for heartbeat that the pacemaker was born.

The first pacemaker was about the size of a table model T.V. set and had to be wheeled about on a rolling table. The next version was smaller but still mounted externally strapped to the waist of the patient. Wires from this external device ran through the skin into the chest cavity and were sewn to the outside of the heart during an open-chest operation. The advantages to this external pacemaker were: batteries could be replaced and electronics repaired easily, and the patient could vary his own heart rate by setting a dial. Disadvantages were that the region where the wires entered the skin became infected, and, second, the device was rather cumbersome.

In 1958 Dr. Adrian Kantrowitz and his brother Arthur, an electrical engineer, collaborated using electronic components which had been miniaturized and made extremely reliable for military and space projects to build a pacemaker small enough to be implanted.

In the early 1950s it was often the practice to place newly born infants in oxygen tents to prevent respiratory ailments. Sometimes the breathing of almost pure oxygen caused blindness. In one such case, the daughter of John C. Linvill, an electrical engineer at Stanford University, became blind. Leading a group of researchers, Professor Linvill developed the optacon. This device consists of a two-dimensional array of photocells held by the patient over the printed words. Each cell is connected to a vibrating reed. When the device is held over the word "the," the photo cells over the darkened part (the letters t, h, and e) detect the absence of light. The electrical signals from the photocells then cause the reeds in the shape of the letters t h e to vibrate, one letter at a time. The reader feels these vibrations in his finger resting on the top of the vibrating part and "reads" the word. The blind person then moves the

*The cardiac pacemaker is a device which supplies pulses to the heart muscles to provide the proper pumping action of the heart. It is not an artificial heart, but merely an auxiliary device which takes over when the normal signal is blocked.

"camera" across the page to the next word. With practice the blind person can read printed words and even handwriting. This frees the blind to read current magazine articles and even handwritten letters.

Another technological device which has broad implications for students, professionals and the average person on the street as well as the blind is the variable speed tape recorder and player. This device, which is the same size and shape as a standard portable cassette player, has the unique capability of speeding up or slowing down the tape without changing the pitch. The potential uses for this device are very exciting. Students can tape classroom lectures and play them back at double speed for review. Entire books can be dictated onto audiotape for fast playback for the blind. There is nothing so boring as listening to a long tape of a single voice at normal speed, yet when the tape is speeded up the need to listen more carefully relieves the boredom. I have listened to accelerated speech tapes of professional meetings while driving in the car on the Long Island Expressway without it interfering with my driving or my ability to gather the major points of the taped talks. In attempting the same system with tapes playing at normal speed, I find that I do not recall any of the information from the tape.

Computers

No paper on technology, however brief, would be complete without mention of the digital computer. While we are all familiar with the large computer housed in a computer center and connected to remote terminals for input and output, or the batch process monsters which were the devices which introduced many of us to the computer age in which we live.

Many of the devices previously discussed have built-in computers, for example the variable speed tape player. Not a day goes by that we do not see reports of new-improved calculators and computers. A catalog has just crossed my desk with the title "Products that Think." Among the products listed are the following:

-A microcomputer that senses and digitally displays exact body temperature in seconds.

-Liquid crystal display calculators only 1/4-inch thick which can double as watches and even alarm clocks.

-Home pinball machines; computer scales for weight watchers; telephone answering systems which have a single tape which will record over 25,000 phone calls without replacement and will play back messages when you call your own phone from anywhere; a motion-sensing microcomputer which can be used as a home burglar alarm without any installation and will operate even if the burglar cuts your power line; and finally a pocket CB radio which measures 3/4" x 1-1/2" x 5-1/2" which will fit into your shirt pocket and has a beep-tone paging system allowing you to call another user by pressing a call button the cost is $19.95 per unit.

All of the devices listed above operate on some type of integrated circuit including microprocessors. The microprocessor has made possible the microcomputer at a price which is an order of magnitude less than its older brothers. Small portable microcomputers are now flooding the market. It all started with the Altair 8800.

MITS, the developer of the Altair 8800, pioneered a new market into which many companies (mostly small) rushed. Among the "first generation" of microcomputers which survived the initial shake-out, in addition to the Altair 8800, were the Altair 680, the IMSAI 8080, and the Southwest Technical Products 6800. All of these computers are well-made and provide adequate computer support for the typical classroom (pre-college or university). Although each has unique features, all perform at roughly comparable levels, and all cost in the order of $2,500-$3,000 for a computer with 16 K bytes of random access memory (RAM), a keyboard, a video monitor and interface, and an audio cassette recorder (for mass memory) and its interface. The detailed characteristics of these computers have been described widely in company literature and in hobby computer literature (Byte, Personal Computing, Dr. Dobbs Journal, Peoples Computer Company, etc.). For this reason, these characteristics will not be detailed here. We shall reserve our space here for descriptions of more recently announced computers which have been designed for the home user to a much greater degree than the computers mentioned above, which were aimed at the hobbyist.

It is worth pausing a moment, at this point, to salute one of the pioneers in bringing microcomputers into schools: Dr. Peter Grimes of the San Jose Unified School District. Under Dr. Grimes' direction about a dozen microcomputers have been installed in San Jose schools. These microcomputers have been used to enhance the district's computing capacity at a cost significantly lower than would have been required to expand the existing mini time-sharing system.

Before we describe the characteristics of the newly-available "second generation" microcomputers, we shall digress briefly to indicate how far computing has come since 1945. Linvill and Hogan (1977) of Stanford University compare the ENIAC computer with the Fairchild F8 microprocessor to which has been added 2K bytes of read-only memory (ROM), 8K or RAM, and a teletype interface. The table below was developed from Linvill and Hogen (1977).

Characteristic	ENIAC	F8	Ratio
Size	3,000 ft^3	0.011 ft^3	3×10^5
Weight	30 tons	1lb.	3×10^4
Clock Rate	100 KHz	2 MHz	20
Add Time	200 u sec for 12 digits	150 u sec for about 8 digits equal	
Mean Time to Failure	hours	years	10^4
RAM memory	1K	8K	8

Since 1975, there has been a gradual, but persistent, improvement in the reliability and capabilities of existing microcomputers plus the development of a wide variety of interesting peripheral devices. The prices on these computers has fallen steadily from $3,000 for the computer and its Input-Output devic[illegible] in 1975 to $600 in the fall of 1977. In the same period, hand calculator prices dropped from $100 to $25 for comparable models and automobile prices went from $3,000 to $4,000 for compacts.

TECHNOLOGY IN THE CLASSROOM

As indicated at the beginning of the chapter, the previous examples are a very small sampling of the technological devices and systems which have affected and will affect the world society. The next problem is how to prepare teachers of science to work with the problems involved with the interaction of technology and society.

A system which has proved quite effective is to use a technique of technology to work on the problems of technology. The techniques of decision making which have been developed are varied and in some cases unnecessarily complicated. The one which is described below is simple enough and in most cases effective enough to give students an opportunity to examine not only the problem, but the possible effects of potential solutions. In brief outline form it consists of:

I. Studying the problem

II. Setting criteria (the goal to be accomplished)

III. Examining the constraints (all factors related to the problem which might help or hinder the final achievement of the goal)

IV. Developing the model of the problem and its potential solutions

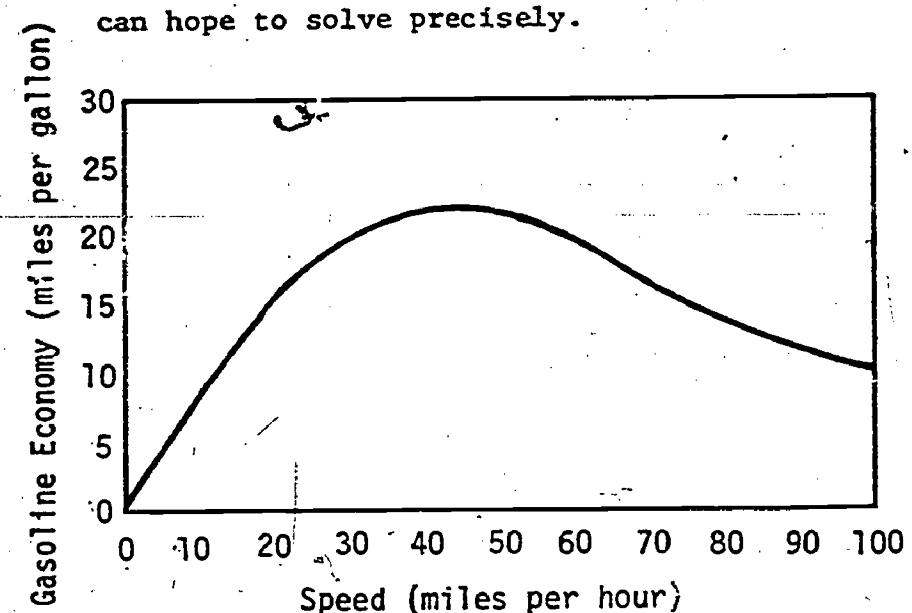
V. Examining the alternative solutions

VI. Examining the alternative solutions in light of the criteria and constraints

VII. Choosing from among these alternatives the one or two which best fit the model (OPTIMIZATION)

The engineering approach to decision making as described in <u>The Man Made World</u> provides operational descriptions of the terms MODEL, CRITERIA, CONSTRAINTS, and OPTIMIZATION. Suppose we wish to determine the most economical speed to drive in order to save gasoline and time on an automobile trip.

1. Model. The model is the mathematical or quantitative description of the problem. In our example, we are interested in obtaining the maximum gasoline economy; hence the model is the curve of Figure 1, which shows how gasoline economy depends on the speed. The model is the item which changes the problem from one of intuition or common sense into a quantitative problem which we can hope to solve precisely.



2. Criteria. The criteria are the goals or objectives of the decision-making problem. In our example, the criteria are to achieve the best possible gasoline economy and to arrive at our destination in as short a time as possible. When there are several criteria which are incompatible, we have to select a criterion which is a compromise among these.

   One of the most dramatic decision problems occurs when there is a major catastrophe (fire, explosion, earthquake, or battle) with a very limited number of doctors available. The problem is to decide how to use the doctors in the best way. The injured people are then sorted into three groups: those who cannot be saved, those who can probably be saved by a doctor, and those who will survive without immediate attention by a doctor. The decision problem is then normally solved by the doctors working on only the middle group.

3. Constraints. Constraints are added factors which must be considered in the solution of the decision problem. In our speed example, the speed limits represent constraints. Other constraints in our example would be unsafe road conditions and driver fatigue. (Speed may be limited by road conditions, and the time involved in long trips may have to include rest periods.) Thus, the constraints specify the region within which we should look for a decision. We must find the best solution which satisfies the constraints.

4. Optimization. Once the problem is formulated (the model), we decide what we really want (the criteria), and we know what is permissible (the constraints), we are ready to try to find the

best, or optimum, solution. In our speed problem, we find a solution by merely examining the model and considering the constraints. In more complex problems, it may be necessary to find special engineering or mathematical techniques; in many practical cases, we have to use a trial-and-error approach.

The alternatives to a major problem usually fall into three categories:

Educational—those alternatives which will convince the general public to drive at speeds which will be economical of both gasoline consumption and time. These might be radio-TV programs, newspaper articles, or editorials.

Legislative—those alternatives which require some governmental decisions: the 55 mph speed limit, tax on gas guzzlers, tax on gasoline, rebates on purchase of small cars, etc.

Technological fixes—more efficient engines and transmission systems, lighter automobiles, more efficient fuels, etc.

These alternatives are not necessarily mutually exclusive; actually in the gasoline shortage problem of the 1970s all of the suggested alternatives have been used.

The system of benefit/cost analysis in which we attempt to quantify the benefits and costs of a particular alternative solution is often used and is usually demonstrated to students in the solution of very simple problems. As problems get more complicated, the factors involved in setting up a benefit/cost ratio become extremely complex. For example, Operation Snowpack which would use weather control technology to increase the snowfall on the Rocky Mountains by 50 percent in order to increase the water supply and electricity in Las Vegas and the Los Angeles area has a benefit/cost ratio of 18/1. This means that for every $1.00 spent to increase the snowfall by 50 percent, the benefit in additional water and electricity downstream on the Colorado River would be $18.00. When we take into account the loss of livestock, inconvenience, possible drought east of the Rockies the benefit/cost ratio is much less than 18, but these factors are at best difficult and in many cases impossible to measure.

The interaction of technology and society is so complex and the solutions to the problems are so tenuous that high school science teachers are tempted to forego the entire subject and leave it up to the social science teachers, who in turn say that the technology is so complicated and quantitative that they will leave it up to the science teachers.

This is an area in which engineers, natural scientists, and social scientists at the college and university level must cooperate in the preparation of the teachers who will be teaching in the high schools in the 21st century.

RESOURCES

THE MAN-MADE WORLD
Engineering Concepts Curriculum Project
McGraw-Hill Book Company, NY 1971

MAN AND HIS TECHNOLOGY: PROBLEMS AND ISSUES
Piel and Truxal
McGraw-Hill Book Company, NY 1973

TECHNOLOGY: HANDLE WITH CARE
Piel and Truxal
McGraw-Hill Book Company 1974

Up-to-date information on Technological developments can be obtained from current issues of the following periodicals:

TECHNOLOGY REVIEW, MIT Alumni Association, Massachusetts Institute of Technology, Cambridge, MA

FUTURIST, World Future Society, P.O. Box 30369, Washington, DC 20014

ENVIRONMENT, 438 N. Skinker Blvd., St. Louis, MO 63130

BULLETIN OF THE ATOMIC SCIENTISTS, 1020-24 E. 58th Street, Chicago, IL 60637

Information on The Impact of Technology on Society can be obtained from:

PROJECT INPUT—Increasing Public Understanding of Technology
The Pennsylvania State University Project Director Rustum Roy
102 Materials Research Laboratory
The Penn State University
University Park, PA 16802

Newsletter on Science Technology & Human Values
Aiken Computation Laboratory 231
Harvard University
Cambridge, MA 02138

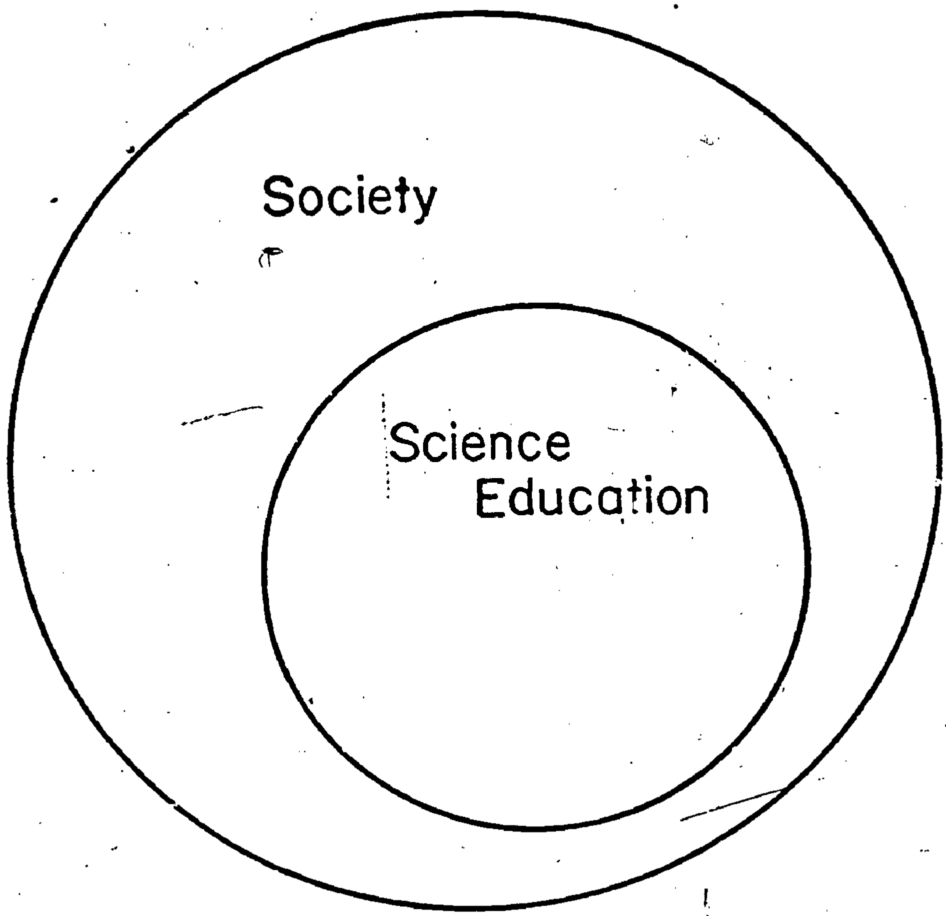
STPP News
Program in Science Technology and Public Policy
Department of Political Science
Purdue University
West Lafayette, IN 47907

Newsletter—Department of Technology and Society
College of Engineering and Applied Sciences
State University of N.Y. at Stony Brook
Stony Brook, NY 11794

REFERENCES

Linvill, J. G. and C. L. Hogen. "Intellectual and Economic Fuel for the Electronics Revolution." Science, Vol. 195, No. 4283:1107-1113, March 18, 1977.

PART II: SOCIETY AND ITS INFLUENCE ON AND INTERACTION WITH SCIENCE EDUCATION



Part II of the yearbook deals with social institutions and movements which influence science education. The assumption underlying this part of the yearbook is that there are numerous social institutions or movements that affect science teaching directly and indirectly and subsequently give direction to science teaching. The source of much of this influence is government, business and the demands of society itself. Several of the papers in Part I identified some of these sources and hinted at their influence. The role of this part of the yearbook is to isolate the most important agents and examine their roles. All of the authors in this part have had extensive experience in the topics they discuss and are, therefore, able to add a personal note to their comments.

The last twenty years has seen a phenomenon unique in the history of the United States: the federal government support of curriculum development. That it had a profound effect on education in science is a fact denied by few. John Mayor and Charles Puglisi look at these 20 years from the views of a curriculum developer and a teacher. The blend of the historical with the practical is helpful in seeing where we've been and where we're going.

TWO DECADES OF CURRICULUM PROJECTS

John R. Mayor and Charles J. Puglisi, Jr.

HOW IT ALL STARTED

The schools and the children they were intended to serve have experienced, in the past quarter century, the remarkable phenomenon of the curriculum projects. Sometimes these experiences came with anticipation, too often with uncertainty, but always they were received with curiosity and excitement. As long as there has been teaching there have been curriculums and, often in the past century, the development of a curriculum has become a "project." The curriculum projects of the past two decades, with which this paper is concerned, have been different in a number of very important ways.

First of all, these curriculum projects are the work of teams of teachers and scholars. Their development and their work have been sponsored by a variety of agencies not previously involved in producing curriculums for the schools. The work has almost always been supported by an outside agency, either private or public, and the amount of support in quite a number of instances has in itself been very great, indeed. The product has in many instances been bold in concept and sometimes suited only for the more gifted or too costly to be practical for the schools.

The public seems generally to assume that the 1957 Sputnik was the event to spark the beginning of this curriculum movement. Indeed, this is true for the National Science Foundation major support of secondary school science curriculums, the first of which was the course in physics of the Physical Science Study Committee (PSSC), conceived and developed under the inspired leadership of Jerrold R. Zacharias. However, PSSC started its work in 1956 and by Sputnik time, work had already been underway at the University of Illinois on new mathematics for high schools with another dynamic and imaginative leader, the late Max Beberman. The Carnegie Corporation of New York had the vision and foresight to support the Beberman efforts, which represent in this country the beginning of a movement which has had a profound effect on the teaching of mathematics worldwide.

The Ninth Annual Report of the International Clearinghouse on Science and Mathematics Curricular Developments covering the period 1956-74 provides brief reviews of more than 200 curriculum products in the United States and an even greater number in other parts of the world (Lockard, 1975). This indication of the wide extent of the curriculum movement is perhaps the most objective information available of its influence as a societal institution. In this paper, those topics are discussed which are believed to be most relevant in describing the science curriculum projects as a social movement.

Brief reference is first made to support the sponsorship, more adequately treated in subsequent chapters. Then the team approach, the writing sessions, and the tryout which were characteristics of the major projects and in many ways unique in curriculum development are treated. Included in those treatments are the insights of a middle school science teacher who participated in the writing and tryout of one of the projects and in the teaching of another. The section heading, Hierarchies and Hands On, was chosen to emphasize those aspects of the curriculum movement which seem to him to be most helpful and promising. Finally, a summary of gains and needs is offered with a final statement on what this means for the future.

SUPPORT AND SPONSORSHIP

A major part of the support of curriculum development projects in the natural sciences, mathematics, and social sciences has been provided by the National Science Foundation. The Office of Education and later the National Institute of Education, which inherited the Research and Development Centers of the Office of Education, have also provided some support. Because of the available NSF support through the sixties, other agencies, both government and private, tended to favor projects other than those in the natural sciences and mathematics. During 1976 the National Institute of Educa ion (NIE) maintained a panel of educational leaders to conduct an in-depth study of curriculum development and support of these efforts. In its IDEA project, the Kettering Foundation is presently making a broad study of curriculum practices and related issues.

Some curriculum projects attracted simultaneous support of federal government and private sources. Probably the Education Development Center (EDC) in Cambridge, for a time also supported as an R and D Center, was most successful in this respect. The direct contribution of industry to curriculum development has been limited. Examples are the Cessna Aircraft Company development of materials to teach about aviation, and the General Motors Corporation development of modules to assist in teaching technical and engineering concepts closely related to the technology of the motor industry. Before and during the sixties, many state departments of education maintained curriculum committees in the several disciplines and produced state guidelines which had a considerable influence on what was going on in the schools and some influence on the major curriculum projects.

It is reasonable to conclude from all of these efforts that support from federal and state governments, from private foundations and from industry have served educational development well and should be continued. Diversity is important because the need is so great, but also because it is important that the broad spectrum of American society be represented in these efforts.

Most curriculum projects were named by the sponsoring agency. The Biological Sciences Curriculum Study (BSCS) or the School Mathematics Study Group (SMSG) are examples. These groups in turn had other sponsors or agencies which gave them direct encouragement if not direct sponsorship. The American Chemical Society certainly provided "moral" support for the two high school chemistry projects, and the American Mathematical Society and the Mathematical Association of America for SMSG. Others were associated in name with a university which provided housing, and in some instances, monetary support as well: the University of Maryland for the University of Maryland Mathematics Project, and the University of California-Berkeley for the Science Curriculum Improvement Study (SCIS). For a number of years, the University of Colorado was home and fiscal agent of BSCS. The Central Midwest Regional Educational Laboratory (CEMREL) and Southern Illinois University were joint sponsors of the Comprehensive School Mathematics Program.

Diversity in the nature of sponsors is probably even more important than diversity in sources of support, as important as that is. The attachment of a project to a university lends a rich source of intellectual support to the project and some prestige to the university. Association of a project with a professional society also provides prestige for the project and a ready source of personnel from among nationwide membership. Not only the American Association for the Advancement of Science (AAAS) but also the physical, chemical, biological, geological, engineering and mathematical societies were involved in a number of different ways important for the projects with which they were associated. For the future, the authors of this paper look forward to continuing curriculum development sponsored by universities, professional societies, state and local education agencies, regional educational laboratories and R and D Centers, private educational consulting firms, and, by all means, commercial publishers. Each kind of sponsorship can make an important contribution to education necessary to a well-balanced American educational system.

A TEAM APPROACH

The single most important characteristic of the curriculum projects reviewed in this paper is the team approach—the work was done by teams of scholars and teachers. Not that similar teams had not functioned before but with the advent of the curriculum projects and their early successes, it seemed no other method was acceptable or possible! What an important phenomenon for the future of education when a university professor finds he can sit down with an elementary school teacher and have a stimulating, learning experience in considering how an idea can best be taught. What an important phenomenon for

the teacher to acquire a new respect for an education colleague of another level, based on equality rather than rank!

In all of the projects to which reference is made in this paper, the planning and writing was a product of a scholar-teacher point of view. In some, the scholars did most of the work with the teacher merely looking over his shoulder. In others, the teacher produced the text after exploration of ideas with the scholar. In still others, the best ones, true teamwork was developed, accompanied by an honest equality of responsibility.

The terms, teachers and scholars, are of course misleading and inaccurate; the teacher usually referring to the teacher in the schools, the scholar to a college or university professor. In the successful teams, the teachers were scholars and the scholars were good teachers at the college level. Because this topic is concerned with science teaching, the terms scientists and teachers will be used with apologies to both groups.

WRITING SESSIONS

Each summer for five summers, the AAAS Commission on Science Education brought together teams of scientists and teachers to write exercises, try them out with elementary school children, and to develop materials for use by children in their investigations. This operation plan was typical of a number of the major projects and is described here as an example. The number of participants in the summer writing groups varied from 30 to 50, through the five summers, and writers worked for periods of six to eight weeks.

The scientists included astronomers, biologists, chemists, geologists, mathematicians, physicists, and specialists in science education. The teacher group included teachers from all levels from kindergarten through grade six, and a few from junior high schools. Elementary school supervisors and principals were also among the writers. Writers were brought from all parts of the country, and from different types of institutions of higher education, and from elementary schools in different kinds of geographical and economic settings. Each summer (except, of course, the first summer) the majority of writers had worked at least one earlier summer, but each summer new persons were also brought in to provide new ideas and new points of view on ideas advanced during earlier summers. The summer writers were selected from among hundreds of persons recommended to the Commission by scientists, school people, and professional organizations throughout the U.S. Over 100 scientists and teachers from half of the states participated for one or more summers during the five-year period.

The summer writing team members usually worked in small committees designated by one of the processes of science. There was a committee on classifying, a committee on measuring, a committee on defining operationally. In some instances, small committees were organized around content or concepts such as earth science, or energy, or animal behavior. In later summers, there was a committee on evaluation.

Each team member wrote exercises, including the behavioral objectives and an associate competency measure. Each team member was responsible for development of equipment needed in teaching the exercise. The authors of an exercise also wrote science background papers for the exercise when they thought the teacher would need easy access to this kind of information. A committee on teacher education was established after the need for teacher training became more clear as a result of the tryout in the schools. A goal was to have each summer writer be an active participant in the development of all the kinds of materials: children's activities, evaluation, inservice teacher education materials, teaching aids. During the summer writing sessions, the small committees were each given a two- or three-week assignment and then new committees were organized. This arrangement was followed so that during a summer each writer had the opportunity to work with at least half of the other participants. Sessions of the whole group were scheduled about once a week with each committee reporting so that everyone knew just what was being accomplished by other groups.

Young teachers never before involved in curriculum development joined a summer writing session with some trepidation. For those involved with Science—A Process Approach, some found early security in the prescribed format of the exercises and the chart of hierarchy relating the objectives of the exercises. First came something called the objectives, then came something called the rationale which appeared to explain the need for the lesson, then came the activities where a young teacher's imagination might run riot, and finally, the evaluation of the lesson. Thus, curriculum developers were making lesson plans as they were taught to do in methods classes. The successful teacher participant sensed that this summer work could give teachers new freedom during the year to develop new ideas and work more closely with children.

THE TRYOUT

For Science—A Process Approach and many of the other projects, classes of children were available to summer writing sessions for tryout of the materials. These tryouts, preferably taught by the writers of the materials (including the scientists), were the first major test of the materials' acceptability. The real tests came during the school years between writing sessions when extensive tryout was conducted in schools identified as tryout centers. Once word got around about the tryout, there were generally more schools offering to try out the materials than could be accepted. The tryout centers were chosen to represent all kinds of schools and on the whole operated with a minimum of supervision. A special effort was made to involve schools with children from limited economic backgrounds as well as from the more affluent groups.

All tryout centers reported regularly on teaching experiences. Tryout teachers were brought together to exchange ideas on experiences, on a regular basis locally, and from all centers across the nation once or twice a year. For Science—A Process Approach one local person was designated center coordinator and a local scientist

as consultant scientist, sometimes one person held both of these positions. The tryout teachers were urged to consider themselves members of a research team. While commercial publishers have supported broad tryout at times, it seems likely that teachers in these tryouts did not have the same sense of being an important part of a broad national research effort, a point of view promoted by the curriculum developers.

INSIGHTS FROM A CLASSROOM TEACHER

Hierarchies and Hands-On

In many of the curriculum projects that were developed in the post-Sputnik era, an emphasis was placed on new educational trends. To one teacher participant, the use of hierarchies and the almost complete dependence on the hands-on approach were most impressive. As the projects were assembled in the sixties, some educators felt that the need for a road map or hierarchy was apparent. In the AAAS Science—A Process Approach program, such a map or hierarchy was made available. The hands-on approach to teaching became a major thrust of most all of the projects. With the availability of a "road map" accompanied by utilization of the hands-on approach, the teacher is enabled to become a resource to the student, instead of being an authority; the one with the last word. These devices for curriculum development, as seen by a young teacher participant, will be developed by two anecdotes.

The Vacation: His retort was strong enough to lift the dust from the dash of a blue compact, the scene of an ensuing battle. "No, I don't need a map! If you want to get to Washington State, you follow the sun and the street signs!" A frustrated and now dust-choked wife tried again to persuade her husband that the sign said Washington, DC, and that the sun was quickly drawing its shades for the evening, "But dear, the sign says... We're not going to stop for a stupid map! Who can read them anyway?" The small car slowly sputtered out of earshot into a silence that was only broken by an occasional exclamation by the insistent fellow at its wheel. If only the gentleman in the blue compact would listen to his wife, he would discover the freedom that a road map has to offer. With a map, the arguing couple could go anywhere in the world, give or take a few oceans, and with the map they could find out exactly where they were on the globe. But no—"The map is confusing!"

An analogy can be drawn between the road map and a hierarchy such as the one prepared for Science—A Process Approach. Both offer freedom and both harvest neglect from many. A hierarchy can easily take on the guise of a schematic diagram for a micro-circuit. Such a guise, when placed on a large sheet of paper, dwarfs a description such as "confusing." Awesome is much more appropriate. It is that schematic diagram that provides the freedom of a hierarchy. This freedom encompasses convenience in identifying a prepared unit plan and ready orientation. With a thoroughly mapped unit plan, it is much easier to determine the course of action for lessons, and the orientation enables the inclusion of materials from other sources with ease.

Parallel units or lessons from two programs are much more readily identified when the hierarchy chart is used. This freedom extends further to the student. Pre- and post-testing is made easier and it is much more possible to introduce a new student to a program. The student might also use the chart to determine his own course of action for lessons. Furthermore, the chart provides an excellent opportunity for the construction of learning stations and other auto-instructional or student-posed activities.

<u>The Damselfly</u>: "What's that?" "It's a damselfly, Ernie. A member of the order Odonata." The reply registered but, by Ernie's expression, it was not enough. "If you could catch that damselfly with your bare hands, you'd be the champion catcher of the entire world! Scientists have trouble capturing them with a..." He was on the prowl. An emerald damselfly flitted about the reeds of a small pond completely unaware of the approaching creature. The boy had carefully slid into the silt-bottomed pond, clothes and all. The sun wrapped a reflection of a silver ribbon about the undersides of his crouched chin and extended arms. A slight rustle of water... clap! "I got it! I got it! I'm the champeen catcher of the whole world! Wait till I tell my friends that I caught a... What is this bug again? Why don't you tell me? Here's the field guide."

In the above anecdote it is apparent that the teacher and the student had increased interaction which led to more feedback than would have been the case without the hands-on approach. It is also apparent that Ernie was allowed to discover the excitement of science. During this discovery, Ernie's mind escaped into higher levels of thought, and the textbook became an important resource instead of a prison of rote memorization. The hands-on approach provides an excellent setting for feedback between the student and the teacher. This increase in feedback enhances the communication between the two. If Ernie was placed before a text and asked to read, far less interaction would have occurred. The teacher, an important resource, would not have been tapped, and the student, a still more important resource, would not have been tapped.

By allowing Ernie to use his hands, he discovered the excitement of a discipline, an excitement which led all of the founders of that discipline to strive for more discovery, to exercise their minds. Ernie's mind was not required to remain at the rote level but was shown the freedom of other levels. It would not be practical to assume that a textbook would execute this introduction successfully. Rather, the textbook is used in the hands-on approach as another resource, as further support for the growing mind.

<u>The Enthusiasm!</u>

"If you'll all please quiet down for just one moment, I'll give each of you your own pair of magnets..." "...magnets to work with." "It's moving! It's moving all by itself! Look at my magnet!" A tidal wave of small bodies scrapped over the top of one another to see the interaction of the pair of magnets just given to a small knobby-kneed young lady, sporting braces and blue butterfly glasses.

The curriculum projects elicit such enthusiasm from youngsters; children at an age who are plagued with inexhaustible energy. This enthusiasm lends itself to much improved student, teacher and parent relationships. Surely once a child has had his interest aroused he will ask an endless number of questions....welcome questions to the ears of a teacher. These questions enable the teacher and student to communicate. The teacher gains much insight into students and conversely the students gain insight into the teacher, as answers and more questions are returned. At times, the enthusiasm of the small balls of fire reaches the parents. This not only provides esteem for the teacher, the administration and the school system but also provides avenues for present and upcoming trends in community education.

Many teachers of the curriculum projects shared the enthusiasm of the children as they found they had more time for their job, time which could be spent developing new ideas and consulting with other teachers and students. Thus, they are better able to become resources to students.

SOME GAINS

On a number of occasions in the past decade, the authors have responded to questions about the gains of the two decades of curriculum projects. In the course of these responses, there has been a sifting or shaking down of perceived gains which tend to recognize the value of the process more than the product. Those who gained the most were, no doubt, the participants in the development processes and their colleagues, no small group and no small achievement. Also, a major gain was the bringing together of teams of teachers and scientists who found communication surprisingly easy and who gained tremendous new respect for each other and the institutions each represented. Other perceived gains follow.

The curriculum projects made it possible for contemporary scientific development to influence school curriculum. By mid-century, concern was growing in many quarters that in the most scientific nation of the world, the scientific advances since the turn of the century had had so little real influence on science in the schools. Sputnik I saw these concerns turned to action. The schools and the public readily accepted the goal of bringing contemporary science, including the modes of thought in contemporary mathematics, into schools. We almost certainly will not let this breakthrough languish, and the greatest gains of the new teamwork are surely yet to come.

The curriculum projects made it possible for thousands upon thousands of students to discover that study and challenge can be great fun. Testimony from some of the boys and girls in elementary and in secondary schools in all of the projects confirmed that they experienced new stimulation and new fun in study of science and mathematics. These were often the brightest who had tended to be bored with the old chemistry or the old mathematics. There were also instances of the students who never succeeded before taking hold in the new courses which would reveal to them a new purpose or challenge

which so often passed them by before. There were those for whom the experimental and "hands-on" approach provided the needed motivating factor. There were also those for whom the discovery of structure and reason provided a satisfaction, even a thrill, never before experienced.

The curriculum projects did the same for hundreds of teachers, adding great new zest to the joy of teaching. This is the greatest gain of all. When teachers came face to face with the new curriculums they found the structure, the emphasis, the logic, the vocabulary unfamiliar. To many, this was a refreshing challenge which soon brought forth their most energetic effort. They flocked to summer institutes to study mathematics and science so that they could meet the new challenge. Even when the new ideas seemed far beyond them, renewed humility, perhaps almost forgotten, was acquired (also a great gain for their students and their schools).

Countless times an educator has visited a colleague and picked up a great teaching technique or a small grabber. Countless times an educator has visited a colleague to find that his colleague has struggled to develop a similar unit or device. In short, both of the teachers invented the wheel...again! A curriculum project is the product of an ensemble of hundreds of inventors of the wheel at all educational levels: a gold mine. A curriculum project provides a nearly infinite source of new teaching strategies thoroughly tested by the experienced. If a teacher elects to follow a curriculum project, he is freed from the struggle of inventing the wheel and can devote his time to guiding his pupils in learning to use the wheel effectively.

A visit to the classroom of the teacher of one of the new curricula often revealed a sense of pride in being on the forefront of the new science and a sense of pride in new achievement. For those fortunate enough to be a tryout teacher of one of the new programs, satisfaction from being a member of the "research" team brought zest both to living and teaching. So many teachers sensed and reacted to the excitement of being a participant on the frontiers of scientific knowledge and on the frontiers of a vitally important new movement in education—a kind of partnership of educators of all levels. The NSF-supported summer institutes brought thousands of new educational experiences, and a new relationship with university scientists, and new friends across the country.

The curriculum projects made it impossible for tens upon tens of dull textbooks to survive. Textbook selection committees in the schools began to examine quite critically old copyrights, the works of long-retired authors, and even the professional experiences of younger authors. Those publishers who claimed their products had been exposed to the new curriculums received ready welcome. The publishers sought new blood and new texts.

The curriculum projects interested many specialists in higher education in the schools. Professors of Harvard and M.I.T., of Michigan, and of Stanford became in great demand for addresses at teachers' conventions and at statewide in-service groups. They

became editors of the new textbooks, and joint appointments in universities between science and education became quite respectable and quite sought after. Even as the curriculum movement became less active in the seventies, still the schools and academicians maintained important relationships.

The curriculum projects, in many instances, provided convincing evidence that there is not just one right way to teach or learn any discipline. Particularly in mathematics was this true where any one of us learned algebra and geometry much as our grandfathers did, and the topical order in elementary arithmetic had become fixed and rigid in the minds of so many teachers and textbook authors. The new biology and the new physics brought about not only new topics for study, but also entirely new ways of going about learning them. Note the emphasis on logic and structure and especially the hands-on approach, almost universally accepted where it can be afforded, and the nearly universal present acceptance of the teacher as a resource.

SOME NEEDS

Curriculum projects with broad, interdisciplinary approaches are needed to point the way to the future of precollege education. The projects on which this paper is based tended to focus on particular disciplines. Similar effort in other disciplines and integration of disciplines would assist school personnel in developing well-balanced programs. The ISIS program, based at Florida State University, shows an approach to secondary school science that provides a model for innovation at other levels and for coordination, if not integration, of several disciplines. Studies of ways to relate and coordinate several different programs for different disciplines could be of great value to schools.

Development of a wide variety of modules to supplement present curriculums can provide much needed additional choices for teachers and students. Modules for self-study could become an important part of lifelong learning, and at the same time, serve special groups of students at several levels. More attention needs to be given to the development of programs for special groups of students. This can be accomplished without at the same time implying that students should be grouped by age, ability, special interests, or other criteria. In the school of the future, not all students in a given class or group need be studying the same material if multiple materials are available.

The curriculum projects brought into focus many topics for research on how children learn that should be investigated on a wide scale. Following the development of experimental mathematics texts for grades seven and eight, the University of Maryland Mathematics Project turned its attention to research on the learning of mathematics under the guidance of a distinguished psychologist. This proved to be even more stimulating to the UMMaP staff than the curriculum development work and served to broaden the scope of the Maryland mathematics education program. Much more of this kind of

follow-up of curriculum projects is essential for the educational health of the next decades.

Difficulties with and shortcomings in the evaluation of the curriculum projects point up not only the necessity for more adequate evaluation of all curriculum development but more importantly a need for in-depth studies of evaluation procedures and the development of new procedures. It seems doubtful that those responsible for any curriculum project were satisfied with the evaluation of the product; there were always so many unanswered questions. The schools and the public were even less satisfied. One of the most extensive evaluation efforts was that of the regional educational laboratory at Syracuse University which undertook an extensive testing and evaluation of Science—A Process Approach. Unfortunately, federal funds were cut off before the work could be completed or widely disseminated. Each project should conduct its own evaluation and, at the same time, evaluation should be conducted by an outside agency as was undertaken by Syracuse.

Experimentation with methods of implementation could make a new generation of curriculum projects more effective. Probably the curriculum project materials most used by the schools have been those published and sold by commercial publishers, under arrangements like those agreed upon between the BSCS and the publishers. Another example of an implementation plan was the Yale University Press publication and distribution of the School of Mathematics Study Group Materials in paperback form of the experimental editions. Each of these implementation methods, and others tried in the past decade, had advantages and many other methods are possible and should be tried.

The curriculum projects of state and local education agencies are deserving of greater consideration and support and, in many instances, of broader dissemination than they have generally received. Although this paper has been devoted to the major curriculum projects that attracted national attention, the authors fully recognize the importance and the quality of many local and state efforts, and what many of the nationally-oriented developers learned from these efforts. Better means are needed for making state and local materials available to curriculum developers everywhere.

WHAT THIS SAYS FOR THE FUTURE

The curriculum projects of the sixties and seventies represent one of the major educational events of the past 40 years, perhaps the most significant new educational component since the publication of the reports of the Progressive Education Association. Though the latter were subject to widespread criticism, their influence is pervasive still today and the curriculum projects almost certainly will be influential in school planning into the early part of the 21st century.

There is increasing potential for support of curriculum development in its broadest sense by private funding agencies. The recent

studies of the Curriculum Development Task Force of the National Institute of Education have made a case for continued support of curriculum projects and research on related issues by the federal government. Surely, greater support for wide review and study, if not actual development, will be provided by state and local education agencies. What we have so far learned about implementation of new curriculum materials and what will be learned from yet-to-be-developed studies of implementation methods will make it impossible for good materials to rest in program cemeteries.

A special responsibility rests with the professional societies and the universities to see that this new educational component of our time becomes an ever-increasing educational challenge. No agency has a greater potential for doing this than the Association for the Education of Teachers in Science.

REFERENCES

Lockard, J. David. Science and Mathematics Curricular Developments, Internationally, 1956-74. AAAS Commission on Science Education and the Science Teaching Center, University of Maryland, 1975.

Publishing is one area where private business has had its greatest influence on science education. Publishers assist in the preparation of textbooks and publish them. Textbooks for good or evil were and are central to schooling. This influence seemed to be waning during the heyday of government-supported curriculum development with its emphasis on laboratory approaches. It seemed as if half of all the research in science education was aimed at comparing "textbook approaches" to "laboratory approaches." But publishers' influence made a resurgence (if indeed their influence was ever low), and with an emphasis on a wide variety of types of materials (including textbooks) are stronger than ever. Paul Brandwein studies this influence and shows the compatability of the textbook with sound learning principles by elaborating a theory of instructed learning.

THEORY IN CURRICULUM AND INSTRUCTED LEARNING: THE TEXTBOOK IN SCHOOLING

Paul F. Brandwein

The purposes of this paper are first to elaborate a theory of instructed learning which directs the function of the textbook; second, to suggest a theory of curriculum which undergirds the function of schooling, and hence the corresponding utilization of textbooks.

Note the title, please. It is not "the Textbook in Education" but "in Schooling." Schooling and education are, for the large part, apposite functions of society and of the individual. Schooling is an effort by society to pass on the concepts, values, and skills which it prizes. Education, in apposition, is the lifelong search for personhood; its goal is the full mature personality which eventually is "finished with itself" (Schweitzer's term). The attempts at "alternate education," "schools within schools," indeed an individual's "dropping out" and the individual's attempts to achieve a "moratorium" (Erikson's term) are perhaps critical efforts to educate oneself.

Actually the major effort of the schools is to conserve and transmit knowledge and values. In a narrow sense the schools rectify and expand knowledge; in science, it is permissible to rectify and expand knowledge greatly, but values glancingly. In the social sciences and the humanities, rectifying and expanding of certain kinds of knowledge and certain values is done at great risk. Even in the sciences, the application of knowledge to social problems (sex education, pollution, pesticides, population, poverty, to name but a few) is done gingerly. Even teaching—perhaps one should say instruction—in so well-established an area of knowledge as "evolution" still has its risks. The risk incidentally is accepted by teachers of science, for a teacher is as large as life and will stand against the community's pressure. But the risk of displeasing the community is not readily accepted by instructors per se who are only as large as a prescribed

course of study. Whatever the case, much of the small skirmishes and great battles in the education of an individual in his or her search for personhood, in the search to "transcend his or her nothingness" (Malraux's phrase) have been fought without reference to a proper definition of schooling and education.

This is not to say that the textbook has no function in education; indeed it does. For example, if nothing else, the textbook is a "compact delivery system of the culture" (Bruner's phrase)—for the young, it recapitulates the past; as such it is a useful, accurate, economic, compact, ready resource. It yields information which may affect the choice and extension of a means of livelihood; it is a constant reference work for scholars; it is useful to the adult who looks to change a career. Education, and the correlative function of the textbook as art form, is a considerably different area and the confines of this paper do not permit its discussion. Nevertheless, the textbook is central to schooling; it is useful in "instructed learning" (Bruner's term); it advances the courses of teaching and instruction, of curriculum and courses of study. Our researches indicate that the pupil and the teacher take a major part of the information central to the curriculum with which they are concerned from textbooks. And, of course, textbooks are produced by teachers, scholars, editors, printers—working within the environments of school, university, and publishing house. A kind of ecology, or environment of intelligence, is central to the development of the textbook.

TEXTBOOKS—AS BASES FOR "INQUIRY"

Gagné informs the thesis of "inquiry" and the attendant aspects—"problem solving" and the "heuristic mode"—which are integral to it thus:

> Obviously, strategies are important for problem solving, regardless of the content of the problem. The suggestion from some writings is that they are of overriding importance as a goal of education. After all, should not formal instruction in the school have the aim of teaching the student "how to think"? If strategies were deliberately taught, would not this produce people who could then bring to bear superior problem-solving capabilities to any new situation? Although no one would disagree with the aims expressed, it is exceedingly doubtful that they can be brought about by teaching students "strategies" or "styles" of thinking. <u>Even if these could be taught (and it is possible that they could), they would not provide the individual with the basic firmament of thought, which is subject-matter knowledge. Knowing a set of strategies is not all that is required for thinking; it is not even a substantial part of what is needed. To be an effective problem solver, the individual must somehow have acquired masses of structurally organized knowledge. Such knowledge is made up of content principles, not heuristic ones.</u> (Gagné, 1965, p. 170.)

A textbook is indeed a reservoir of "structurally organized knowledge"; it is indeed "a basic firmament of thought, which is subject-matter knowledge." To derive a definition from Gagné's statement and mate it with a statement of Bruner's mentioned earlier: a textbook is structurally organized knowledge in a given domain of discourse which is skillfully devised as a compact delivery system of the culture.

Bruner, commenting on "discovery," puts it this way:

> It seems to me highly unlikely that given the centrality of culture in man's adaptation to his environment—the fact that culture serves him in the same way as changes in morphology served earlier in the evolutionary scale—that, biologically speaking, one would expect each organism to rediscover the totality of its culture—this would seem most unlikely. Moreover, it seems equally unlikely, given the nature of man's dependency as a creature, that this long period of dependency characteristic of our species was designed entirely for the most inefficient technique possible for regaining what has been gathered over a long period of time, i.e., discovery. (Bruner, 1968, pp. 101-102.)

Indeed, a textbook is an "efficient technique for regaining what has been gathered over a long period of time, i.e., discovery." The textbook then is a base from which one contemplates a variety of modes of discovery and, arguably, learns modes of probing nature useful in the past and present.

Yes, the textbook presents and tells—even as the lecture does—but in a different way. Probably most students can close the textbook and contemplate what it means to say—open it, close it, etc., etc.,—but the skills of contemplation and "closing off" in the presence of the lecturer are hazardous. As Ausubel informs us, we have enough decent research to know that "one good economical way of learning a principle, or concept, is that of being told about it." The textbook "tells"; textbooks, in a way, furnish broad shoulders on which learners can stand. Certainly learners "stand on the shoulders of others" so that they can see farther.

TWO THEORIES—REFLECTING ON THE TEXTBOOK

A theory is, of course, an explanatory model. Out of a considerable number of observations and study of textbooks, teaching, and instruction in classrooms over the world, the writer offers up the following theories of "instructed learning" and "curriculum." Bruner has offered us a base for a theory of "instructed learning," but alas has not stated one; his eventual statement will surely make our tender attempt obsolete. In any event what we witness generally in the classroom is not learning per se, but "instructed learning"; that is, learning in a prepared and structured environment. My observations in 4,972 classrooms over 20 years substantiate this proposition.

In order to consider the utilization in instructed learning of the textbook, we are required to probe an initial, tentative statement of a general theory of teaching. Otherwise, there is always the high tide of the polemic, without a base. Any theory is tentative; certainly what is offered here is meant to be a target to be struck down and replaced quickly by one informed with greater precision and accuracy through the results of further research. General theories must court obsolescence.

A GENERAL THEORY OF TEACHING

Perhaps we might state a general theory of teaching as follows:

In any specified act of instructed learning a new environment is created from recognizable objects or familiar events so that learners, in all their variety, respond by initiating activity involving the manipulation or transformation of the new environment leading to increased capacity in conceptual, psychomotor, affective, or conative behavior as evidenced in the generation by the learners of verifiable orderly explanations of the newly observed objects and events, or as evidenced in the development of enactive, iconic, symbolic devices, or models, assisting in the successful recognition or explanation of the object or event which is the objective of the specified act of instructed learning.[1]

In simplified form, this statement could read:

In any specified act of instructed learning a new environment is created; in responding to the changed environment a learner gains capacities not achieved through prior experience but specified in the given act of instructed learning.

<u>Corollary</u>: A textbook places in non-random sequence the objects and events which are common to the cognitive (conceptual), psychomotor, affective, or conative environment (the domain of discourse) so that a new environment may eventually be the task of instructed learning.

It seems clear, and it is demonstrable, that textbooks assist "in the generation by learners of verifiable orderly explanations" (Brandwein, 1966, p. 10) of the new or changed environment, if only in those areas where prior knowledge is essential. Where the state of affairs in a given area is being subjected to analysis, the learner undertakes "the development of enactive, iconic, symbolic devices, or models" (Brandwein, 1966, p. 10). Surely a learner should not pass off a model already "perfected" as his own—nor should he reinvent the wheel—again and again and again. Perhaps he or she—if a lifetime is available—can and should reinvent the wheel, but one must be certain he or she has not seen the wheel, or read about it, prior to invention.

---

[1]Modified from Brandwein, 1966, and based in part in discussions in Bruner, 1966.

Too often our schools reward only the right answer, and so many learners are not encouraged to be honorable in their invention; briefly, they reinvent wheels they have already invented. To learn must mean to do something "new"—whether this be a modification of an old act or not. Hence the emphasis on a new environment.

A GENERAL THEORY OF CURRICULUM

Perhaps this theoretical statement will be useful:

In the design of a curriculum, non-random ordering is imposed on domains of experience; in turn these are reconciled in compatible orders designed to increase the effectiveness of instructed learning described in objectives defining specified behavior (Brandwein, no date).

Corollary 1: Curriculum is a search for patterns of order (systems of meaning) in instructed learning.

Corollary 2: A textbook is a non-random ordering imposed on *related* (italics ours) domains of experience.

Corollary 3: A textbook is "experience in search of meaning" (Einstein's phrase which he used in defining science).

Corollary 4: Where the textbook is part of a "system" of instruction (laboratory materials, manuals workbooks, films, filmstrips, TV, machine-assisted instruction, etc., etc.), non-random ordering is imposed on elements of the system to serve the objectives of instructed learning.

These two theories are not primarily normative (dealing with the "ought"), but are descriptions, perhaps, of the factual (what "is").

THE UTILIZATION OF THE TEXTBOOK WITHIN A "SYSTEM" IN SCHOOLING

We want to know in advance: we don't want to be surprised by ordinary phenomena; we want, as far as possible, to control our environment. Textbooks (or the textbook within a "system" of AV materials, laboratory materials, reading tests, TV, film, etc.), or instructional materials— in whatever forms which are part of the curriculum—are designed to assist us in our quest.

Because the world is full of clutter and the "seven slots" with which we take in stimuli, we do not attend to everything. Ausubel, Cronbach, Bruner, Hilgard, Conant, Brandwein and a host of others have developed schemata for "experiences in search of meaning" which run somewhat as follows.

a. Because we cannot attend to everything, we select what we shall attend to.

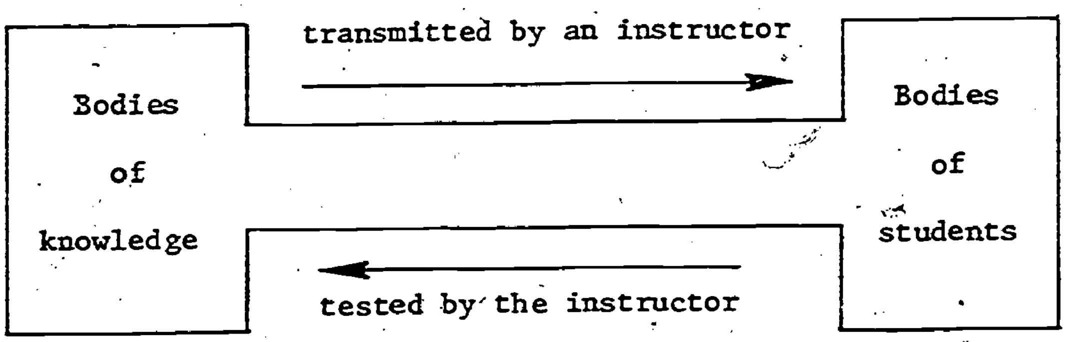
b. Because the mind seeks cues and signals in what it attends, we select a part of the object to signal us of the "whole." We economize. (A bird's color "tells us" the whole bird.)

c. As we attend to the object or event, we connect other experiences to what is being attended to; so we make a "whole." (The bird signals the kind of environment; a grebe does not usually signal the same environment as that of a robin.)

d. As we attend, select, economize, and connect, we develop an explanatory model—a concept, a myth, an art form, a metaphor, etc. These explanatory models are tested against experience; we use them increasingly to assist us in knowing in advance. (Witness extrapolation of the phenomena of weather, environmental pollution, population, etc.)

The sequences in a to d are indeed the sequences of a textbook, a unit in a textbook, a lesson, a film, a filmstrip. Most instructional materials depend on this sequence. At times instruction initiates the entire sequence, leaving little to the student. (Cronbach [1968, p. 20] calls this "didactic material.") At times, portions of the sequence (perhaps directed by questions) are left to the student ("discovery," "inquiry," "investigation," the "heuristic approach"; "opensure" rather than "closure").

Nevertheless, the writer's observations in some 5000 classrooms over the past 20 years leave little doubt that the major form of instruction in the United States, indeed the world, may be described in this model:

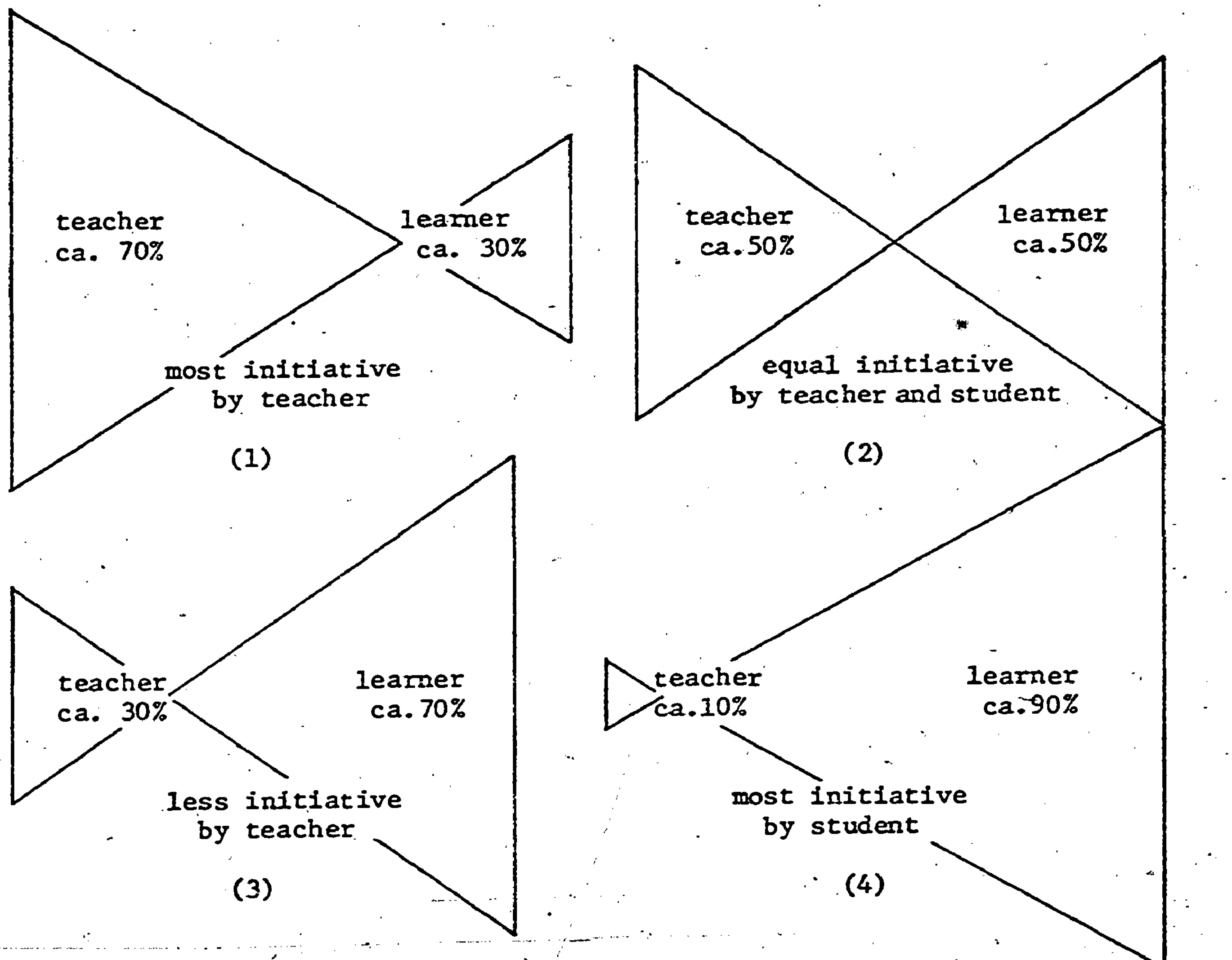


Within such a model of schooling the textbook is central. The writer's observations (over the past ten years) indicate that the teacher's telling (lecture or lecture-demonstration) is:

about 40–60 percent in levels 4–7
about 60–70 percent in levels 8–9
about 70–80 percent in level 10
about 80–95 percent in levels 11–12

Are we to consider a laboratory session in which the student follows a workbook, mimeographed sheet, or oral instructions "discovery" or "individualization"? Probably not. It is perhaps another form of "presentation." In my observation, less than 0.05 percent of our classrooms offer true individuation—namely, a method by which the individual learner has a clear choice (even a wrong one) of method and means in solving a problem; preferably, the problem is stated by the individual. [The teacher should intervene only when there is danger of accident.]

There is, however, a growing sentiment for careful organization of schooling over 12 years in order to establish the following model. The area of the angle (in the model below) indicates time and responsibility taken by teacher and learner. Note that in (3) and (4) there is an open end—meaning less limitation on time used by the learner in "inquiry," or the heuristic mode. There can be a progression such as:



In my observation, in the elementary school models (1) and (2) are becoming increasingly evident (from .01 percent of schools in 1950 to 2 percent in 1975). In the junior high school model (3) is increasingly evident (3 percent of schools in 1975); and in high schools model (4) is practiced sporadically but is increasing in

practice (from a trace in 1920, to a heyday in the period of progressive education and the years 1954-65, and at the present about 1-2 percent. Individualized modes of learning fall within the model (particularly models 3 and 4). In such a model, although the textbook is a basic form of reference, other references (a variety of them) are utilized.

Nevertheless, in some 98 percent of the 5000 cases observed (including the "open initiative" models presented above), all teachers consulted (some 3,700) showed this writer the textbooks which were basic to their curriculum. In recent years (1950-1977) in the high school some 87 percent used "basic" textbooks in the junior high school (all used textbooks as reference); and 100 percent of all elementary school teachers used programs of which the textbook was part, single textbooks, units in science. Nevertheless, all teachers and students used textbooks as reference.[1]

Other observations made by the writer add to our picture:

—Some 82-85 percent of districts over the United States at all levels of instruction insist on information dealing with "readability" before a science text, science program, or science "system" is accepted for consideration—a clear index that the "textbook" or "text unit," is central (ca. 1,100 districts over the U.S. investigated).

—In the period 1970-1977 some 67 percent of superintendents—not teachers—placed individualized instruction in science at the 6-10 range of importance, 1 being most important ("individualized instruction" being equated with "laboratory periods"). In the period 1954-65 some 72 percent placed it in the 2-7 range (some 975 superintendents).

The writer's observations are clear: Over 30 years of firsthand study of curriculum and instruction in the United States show that the textbook has been basic to schooling. In classrooms visited by the writer, some 95-97 percent of the students utilized a basic textbook. So too over the Western world—Europe mainly.

AT THE TURNING POINT

Nevertheless, the world seems to be at one of its strange turning points. We are about to enter the post-industrial era, and school populations of the next 50 years will undergo a change in character.

First, we shall be required to meet the needs of the greater variety of youth. All of youth. It will no longer be possible to have collegiate and noncollegiate orientations only; the full range

---

[1]As this is being written, a presentation on CBS television news (Walter Cronkite) on "education" [sic] reports that 95 percent of the time in class is spent with textbooks.

of human endeavor will require representation. Schooling and education will be lifelong. Why? Given the strictures placed upon life, it will be clear that the major business of humankind (in the post-industrial countries) will be the business of education. In other words, with expenditures in energy and resources severely curtailed, the investment will be in people. Therefore, schooling and education will flourish; and the fulfillment of all children—handicapped in whatever way, gifted in whatever way—will be the superordinate goal.

Second, we shall be required to consider a greater variation in learning styles of all learners. We have come to recognize that "education for the whole mind" requires education of both hemispheres of the brain. The left brain (in right handers) you will recall is concerned mainly, but not entirely, with linear sequencing (reading, mathematics); the right, with spontaneous processing (holistic, conceptual patterning, and with the spatio-visual).

So Bogen speaks to us:

> Since education is effective only insofar as it affects the working of the brain, we can see that an elementary-school program narrowly restricted to reading, writing, and arithmetic will educate mainly one hemisphere, leaving half of an individual's high-level potential unschooled.
>
> We are accustomed to hear, these days, of the "culturally disadvantaged," those persons whose propositional potential has remained underdeveloped for lack of relevant exposure. There is likely a parallel lack of appositional development in persons whose only education consists of the three 'F's.' That is, just as the left-hemisphere potential for propositionizing may be underdeveloped, so too should we expect that right-hemisphere capacities can suffer educational neglect (Bogen, 1975, p. 27).

So Wittrock:

> Studies with school children also usually indicate that instructions, pictures, and high-imagery words facilitate learning and recall, although the size of the effect is often less than that obtained in the laboratory. At UCLA several experiments were conducted to determine if kinetic molecular theory could be taught to kindergarteners and primary-school children using pictures, concrete examples, and simple verbal text to introduce and explain the concepts of molecules in motion, states of matter, and changes in states of matter....Several hundred original colored drawings prepared by artists were used to represent molecules, gases, liquids, solids, evaporation, and condensation. After two to four weeks of instruction, two-thirds of the children in one study successfully answered most of the questions about the comprehension and recall of the concepts. These concepts were previously thought to be too complicated for children below Piaget's symbolic (age 11) or concrete (age 7) levels of intellectual development. (Wittrock, 1975, p. 38.)

What emerges from this is the terrible thought that what we have always suspected may indeed be true: In our urgent determination to secure scientists, technicists, mathematicians, lawyers, and teachers, we have emphasized one mode, the verbal, and have neglected relatively the spatio-visual. We are beginning to suspect that many children may lead from the spatio-visual to the linear verbal and others from the linear verbal to the spatio-visual. Is this possibly the reason for the fact that 25-30 percent of our children get 75 percent of the "failing marks"? Is it possible that an approach to teaching and learning which stressed the spatio-visual as importantly as the verbal might have saved them? Is idiosyncracy in learning then more than a supposition?

The implications for instruction, for curriculum, for instructional programs of the work on the duality of the mind are significant and critical. From the perspective of these elements:

a. On-rushing post-industrialization and the consequent primary orientation towards schooling and education for <u>all</u>—whatever their ability and learning style (verbal or spatio-visual or both).

b. Changes in the administrative and supervisory cadres; younger administrators with "newer values" are replacing those who are retired.

c. An ever-increasing life-span; therefore, a longer "adolescence" and "youth."

—it seems, at least to this writer, that at last "schooling" is to become increasingly "education." All modes of teaching and instruction will find their place as we attempt to fashion an environment in which each and every child is considered to be of supreme moral worth. The vast range of instructional materials—laboratory materials, workbooks, films, filmstrips, materials stressing "investigation" and "inquiry," textbooks, computers, machine-assisted instruction used for individuation, small and large group instruction, team teaching—and the like will surely be useful in a compact delivery system of the culture. Surely Cronbach's modest request will guide us.

> In spite of the confident endorsements of teaching through discovery that we read in semi-popular discourses on improving education, there is precious little substantiated knowledge about what advantages it offers, and under what conditions these advantages accrue. We badly need research in which the right questions are asked and trustworthy answers obtained. When the research is in it will tell us, I suspect, that inductive teaching has value in nearly every area of the curriculum, and also that its function is specialized and limited. The task of research is to define that proper place and function.
>
> Honest research is hard to do, when learning by discovery is the battlecry of one side in the ardent combat between

> educational philosophies. We have, on the one hand, the view of education as cultural transmission, which hints strongly that it is the teacher's job to know the answers and to put them before the pupil. On the other, we have the view of education as growth, arguing that the only real and valuable knowledge is that formulated by the pupil out of his own experience. The second position, which appeals to liberal, humanitarian, and instrumentalist biases, has a long history. In the last 30-odd years the bias favoring do-it-yourself learning has been very strong, as educators and psychologists have united in attacks on teacher dominance and pupil conformity. Consequently, we have had almost none of the cut-and-thrust debate needed to define issues and to expose implications or falacies of the evidence.
>
> It is time to put aside the polemic question, Is teaching through discovery better than didactic teaching? (Didactic is perhaps not the ideal brief label for the pedagogy in which the teacher sets forth knowledge, but among the words that come to mind it has the advantage of being least value-loaded.) We shall have to ask subtle questions and exhibit both patience and ingenuity in unravelling them. (Cronbach, 1968, p. 76; reprinted with permission of the editor.)

Whatever is the future dictated by research and the best interpretation of its utilization for children in our schools, it is clear that the mind will seek to interpret the world as a whole. It will select from the world's clutter, it will economize on cues and connect all experiences into wholes, that is, explanatory models. The syncretic operation of author (scholar and institution), of editor (scholar and institution), of teacher (scholar and institution), of learner (scholar-to-be in society, as institution) will furnish ways (i.e., "materials of instruction") to assist the mind in its quest.

Mind makes the child and to nourish the mind is our sole objective as teachers. The goal is no longer "a healthy mind in a healthy body" but a healthy mind, in a healthy body, in a healthy environment. Schooling and education is our province—that province is the environment we fashion for the health of the mind within the body.

All instructional materials are an earnest of our interdependence with teachers of past, present, and future. All children must learn the skills of interdependence with past, present, and future. One of the great skills of interdependence is the proper utilization of the knowledge painstakingly gathered by those who have gone before us.

Like other organisms we are interdependent with our environment—and part of this environment is that described, in whatever way, in books. We disregard at our peril the cumulative record which is passed on to us in textbooks, in books, in men, women, and instructional materials of all kinds—to use and supplant by greater work. The "unknown"—that which is accessible to our search—is bound by its umbilical cord to the "known." The past—however gathered—in book, or voice—is but prologue.

POSTSCRIPT

[N.B. to the reader—As I write I sit with Dante's "Inferno" and Lucretius' "On the Nature of Things"—possibly used as textbooks. Around me in the shelves are <u>all</u>, I think all, the current programs in science at the elementary, junior high school, and high school levels. One elementary program has 162 items—each an orchestration of experience for eyes, hands, nose, ears, for reading the past and probing the future. It is incredible how far we have gone—yet so infinitestimal a distance.]

REFERENCES

Bogen, J. E. "Some Educational Aspects of Hemispheric Specialization." <u>Educator</u>, University of California at Los Angeles, Vol. 17, No. 2:27, Spring 1975.

Brandwein, Paul F. "Duality of Mind: Implications for Educational Instruction." Lecture given at the University of California-Berkeley, July 25, 1976.

Brandwein, Paul F. <u>Notes Towards a General Theory of Teaching</u>. New York: Harcourt Brace Jovanovich. Inc., 1966.

Bruner, Jerome S. "The Curriculum: Some Elements of Discovery, in Shulman and Keisler (eds.) <u>Learning by Discovery—A Critical Appraisal</u>. Chicago: Rand McNally & Company, 1968.

Bruner, Jerome S. <u>Towards a Theory of Instruction</u>. Cambridge: Belknap Press, 1966.

Cronbach, Lee J. "The Logic of Experiments on Discovery," in Shulman and Keislar (eds.) <u>Learning by Discovery—A Critical Appraisal</u>. Chicago: Rand McNally & Company, 1968.

Gagné, Robert M. <u>The Conditions of Learning</u>. New York: Holt, Rinehart & Winston, 1965.

Wittrock, M. C. "The Generative Processes of Memory." <u>Educator</u>, University of California at Los Angeles, Vol. 17, No. 2:38, Spring 1975.

As a long-time participant in the federal government's funding of science education, Howard Hausman has the historical perspective to examine events of the past several decades and bring them into fine focus. In his own words, this paper: "...is a commentary on the socio-political atmosphere of the times in which science ed became the business of Uncle Sam... I relate why and how this happened...and try to show the significance of these events for educators."

INFLUENCE OF FUNDING BY THE UNITED STATES GOVERNMENT ON THE TEACHING OF SCIENCE IN THE ELEMENTARY AND SECONDARY SCHOOLS

Howard J. Hausman

Of all the traditional academic subjects taught in the secondary schools, only in science and mathematics has the federal government initiated and sustained a long-term effort to bring about changes. Beginning in 1954, government policy had succeeded by 1970 in profoundly influencing teacher education, teaching practices, and curriculum content in probably a majority of secondary school science and mathematics classrooms. Elementary school science and particularly mathematics have also been strongly affected by federal activity, but probably to a lesser degree than in the secondary grades.

That any school subject areas should be so influenced is a startling departure from nearly a century and a half of political doctrine in our country, for a federal role has always been vigorously denied in favor of state and local government initiatives for education. Even when attempting to strengthen such restricted areas as vocational and agricultural education, federal funds were left in the control of state education agencies through a "trickle down" mechanism of channeling allocations. How this came about, and the effects of over two decades of federal activity on these disciplines, is the subject of this paper.

ORIGINS

The end of World War II left the nation with a powerful and growing scientific research and development establishment. Within the government and within colleges and universities the voice of science and technology was given respectful attention. For practical purposes government and university science acted as a single, broadly based "Establishment." Counsel of the wise men (literally so, for almost no women were involved) was sought on almost every aspect of national policy during the 1940s and 1950s. The Cold War, with its tests of strength in technology and scientific resources, appeared as a recurrent theme in arriving at decisions.

This Science Establishment led the federal government in the 1950s into an historic break with past educational policy, with a sympathetic boost from allies in Congress, by entering aggressively into the strengthening of science education in the secondary schools. The beginnings were imperceptible, and the chosen agency was an obscure newcomer to the government scene practically unknown even to academic scientists: the National Science Foundation. Reflecting our country's traditional expectations from the scientific enterprise, but with a new sophistication as to how it is nurtured, the Congress in 1950 created the National Science Foundation and directed it to "develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." Moreover, in exercising its authority, "it shall be one of the objectives of the Foundation to strengthen basic research and education in the sciences" (U.S. Congress, 1950). Much later, in 1972, the charge to the Foundation was revised to read:

> to initiate and support basic scientific research and program to strengthen scientific research potential and science education programs at all levels—(underlining added) (U.S. Congress, amended 1950).

This reflected years of frustrating conflicts between Congress and a foot-dragging Foundation on the subject of pre-college science education, reaffirming Congress' intentions in the establishment of education policies.

Institutes Program

Within four years of the enabling act, the Foundation was experimenting with a program for upgrading high school science and mathematics teachers through intensive subject matter training in summer institutes, and shortly afterward to consider academic year institutes involving full time attendance during the school year. Furthermore, in 1955 NSF funded the first of its major curriculum development projects to improve course content in the high schools. By the summer of 1957 the new federally supported institutes began to acquire visibility, and in 1958 there were 122 summer institutes, 19 academic year institutes, and 85 in-service institutes serving about 10,000 teachers!

NSF had launched an extensive operation that broke new ground in federal education policy. In doing so, it had completely bypassed the United States Office of Education, ostensibly the only federal agency with a clear legislative mandate to concern itself with elementary and secondary education. The political reasons for circumventing the Office of Education, which is now and was then part of the Department of Health, Education and Welfare, are complex. A simple explanation is the desire of one element in the power structure of Congress to have a direct impact on science (and improving the schools) without a head-on collision with the education establishment and HEW's powerful supporting lobbies.

In the background lay the interaction of the executive agencies of government, the Congress, and the Scientific Establishment. The wise men of science showed evidence to the Executive branch and the

committees of Congress that the nation was falling behind Russia in science and engineering manpower, as well as in rate of growth for certain crucial fields of research. Moreover, the state of pre-college education was such that it needed the benevolent intervention of the Establishment. So it came to pass that science education became the beneficiary of important federal money and concern.

In Congress, everything starts with the Committee. For NSF in the House of Representatives this is the Subcommittee for Independent Offices of the Appropriations Committee. In fact, for the first 18 years of NSF's existence the Appropriations Committee was the only congressional body consistently to review NSF's programs. Finally both the House and Senate provided for authorization committee hearings independent of appropriations, so that ample oversight of NSF performance and authority could be made before recommending funding levels for the year's appropriations. Rep. Albert Thomas (D, Texas) was the appropriations subcommittee chairman during NSF's early years. He, along with the other astute members of the subcommittee, steered NSF's initial funding requests into acceptable (i.e., to Congress) amounts for each important segment of the budget. As events caused NSF to grow, Rep. Thomas was usually supportive, though cautious.

In the process of setting appropriation levels, the priorities of Congress inevitably merged with those of the Foundation and, at that time of the Eisenhower administration, in determining program emphases and spending. On one point there was a difference of opinion—the place of high school science education in NSF's plans. NSF's most senior officials were oriented toward basic research, mainly in universities, and toward the graduate schools that produced the best young scientists. The National Science Board, NSF's governing body which by law sets Foundation policy, consisted of eminent scientists from research backgrounds. In their judgment there was no time to lose nor money to be wasted on anything that would detract from meeting the urgent needs of basic research and that arm of the education system that supports research, the graduate school. Emphasis was on building up modern research facilities, supporting outstanding research proposals in the various disciplines and newly appearing subdisciplines or cross-disciplines of science, and maintaining an adequate supply of top-trained young Ph.D.'s. These would all take many millions more than the government was willing to give NSF. Education in the sciences (read: undergraduate colleges) was important but of decided lower priority; as for education in the high schools, or, perish the thought—elementary schools, that was hardly the responsibility of an organization whose mission was the strengthening of basic research. This point was made by the National Science Board and reflected by the most influential members of NSF's administrative hierarchy at every opportunity, at times in public statements but consistently behind the scenes whenever Foundation priorities were being established and budgets formulated. Of course, the small staff within NSF charged with strengthening science education was deeply disappointed by the Foundation's institutional biases.

In the early years of the Eisenhower administration NSF's moguls were persuaded to divert some very modest sums to science education, because disparities with Russian efforts were seen as a threat. Reports appeared of serious inadequacies in the backgrounds of science

teachers, college teachers and particularly high school teachers. Undergraduate enrollments in science majors were declining. Even though NSF had not planned on it officially, the agency found itself supporting a few "experimental" institutes for college teachers in 1953 and, in the next year, for high school teachers.

Thomas disagreed vehemently with NSF's stand on science education. He repeatedly took the Foundation to task over its shortsighted neglect of high school science. Possessing the power of the purse, this House subcommittee established a new federal policy of large-scale support for high school teacher institutes in the spring of 1956. For the fiscal year beginning July 1, 1956 (FY 1957) both houses of Congress agreed to an unprecedented clause in NSF's appropriation that no less than $9.5 million would be spent on "tuition, grants, and allowances in connection with a program of supplementary training for high school science and mathematics teachers." This was almost three times the amount NSF wanted to spend on that program. Adding insult to injury, the money was not to be added to NSF's original request, but was to be taken from the remainder of NSF's budget. The "limitation clause" was inserted to prevent NSF from juggling funds later, thus negating Congress' intent. The same device was used in every NSF appropriation thereafter as a floor for support of teacher institutes through FY 1973.

Naturally NSF's senior structure chaffed at this restriction on their management flexibility. In practice it meant that changing needs inflation, or escalating long-term commitments for major research projects could be subject to cutback if Congress failed to appropriate all the funds requested, but high school teacher institutes could not absorb any of that reduction. The psychological block produced other effects, such as disproportionate reductions in all other aspects of the science education budget except for graduate fellowships. Congress' sympathetic sponsorship of teacher institutes was not an unmixed blessing, because it stunted development of other NSF education programs. It also resulted in deep congressional suspicion of staff initiatives in science education, as a devious plot to undercut the institutes. Coupled with resentment of the other NSF divisions, problems were thus created for science education in the larger sense. Thus, attempts to tackle the problem of elementary teacher inadequacies in science and math started and were aborted; alternative programs to help high school science were held back or discarded; undergraduate science education programs were seriously underfunded. The specter of the "limitation clause" generated hostility within NSF and boomeranged on science education.

One remark by Albert Thomas should be noted. In the FY 1957 hearings, commenting on the importance of the institute program, he said:

> My own thinking toward the Foundation in the past has been that you have been living in the past. You have been doing too much bookkeeping work to find out what has been done in the past. -
>
> Let's forget that. The past is prologue and may have some value. You are striking out on something new now. You are going right at the fundamental thing, this shortage that is

created by a lack of high school teachers. When you start doing work like that, you are really striking something that is of value to the whole nation.

But get away from evaluating past work and spending four or five hundred thousand dollars in bookkeeping, evaluating, and sifting here and there.

I think you have a fine program but I believe you can cut out some of your paperwork. Train your manpower, that is what you need. (U.S. Congress, House, 1956.)

So much for evaluation! Rep. Thomas frightened off NSF's top echelon of executives so that practically no funds were used to establish baselines and follow through on effects of the new programs before the sheer size of the institute program blanketed the profession and contaminated all measurements. This prejudice against "educationist" types of study continued within NSF into the 1960s, so that little effort was focused on estimating the impact of an entire generation of new education programs spawned in 1958 and later. In the end, this early unwillingness to evaluate worked very adversely on the institutes program itself, leaving no defense against assaults by the Nixon administration to show degree of need at that time. When the final attacks succeeded in killing off all teacher institutes, the available evidence on likely effects of the cut-off was equivocal.

Curriculum Reform

The second major element in NSF's pre-college education program was the restructuring of science, math, and social science course content. This began in the early 1950s through support of specially constituted professional groups of scientists and science educators. Curriculum reform was an early goal of the Science Establishment. They surfaced examples of physics texts that were alleged to have taken their structure from the early 1900s and merely accumulated pieces over the decades as publishers issued cosmetic revisions. New concepts were years in getting introduced to high school students; they could read about them in science columns of newspapers or school-oriented magazines, but hardly touch upon them in class for lack of systematic text treatment. Biology was largely descriptive at the beginning levels, and medically oriented in advanced courses. It was also too often "nature study" rather than science. (The reader must remember at the time the <u>environment</u> and <u>ecology</u> had not yet been "discovered.")

Academic scientists and the better prepared high school teachers were eager to introduce more modern materials into high school classrooms for the students who might continue in college as science or engineering majors. As for the academically able student who did not intend to major in science or engineering, the courses the scientist groups had in mind would prove intrinsically more interesting. If students were not led into science by these improved courses, they would at least gain a truer understanding of science and the processes by which knowledge is gained—"science literacy."

There emerged a consensus that the Science Establishment should be the core around which curriculum reform would take place. Academic scientists would have to become deeply involved, with commitments to work for protracted periods of time either on the entire project or segments suited to their expertise. A genuine sacrifice would be demanded of the scientists selected to participate; their research or other interests would have to wait until the high school course problem was handled. This attitude did make service on high school curriculum projects respectable for well known scientists, and it brought first rate science into the preparation of high school content.

These themes crystallized with the arrival of a plan by Jerrold Zacharias of MIT, a renowned physicist, for development of a modern high school physics course. In November 1956 a $300,000 grant was made to Zacharias' group for a detailed study of operating procedures and some illustrative materials. The result became the model that shaped the first wave of curriculum reform, a landmark that changed ideas on how to construct science curricula. The unifying concept was to be wave motion. The course would be developed by teams of highly qualified people, with academic scientists responsible for all phases. A coordinated package would emerge, with a text unlike any seen before (not merely another college freshman text adapted for high school), totally integrated with lab experiments, films for phenomena not readily shown in a high school classroom, paperback books for supplementary readings, examinations, and teacher education plans to enable <u>capable</u> teachers to learn the materials and how to teach the course. Noteworthy also was the intention that the course be experiment centered, with laboratory equipment designed especially for the concepts and phenomena of the course. Thus was born PSSC.

Another feature of the PSSC model was the trial of materials in classrooms, followed by revisions until the final product satisfied users as well as developers. Then there was consideration of publishing and distribution of text and other materials, with a cautious eye to the likelihood that a publisher could promote texts without due regard for non-print but basic elements—the laboratory experiments around which the course revolved, the films, paperbacks, and particularly the needs of teachers for orientation. Distribution of products was achieved by competitive bidding; thus, D. C. Heath was awarded publishing rights to the text, and other educational commercial channels handled films and supplementary books. Teacher training, however, fell upon the NSF institutes.

Well before 1960 a distinctive set of criteria for new course development had become established: (1) stress understanding of principles rather than relying on memorization of facts and definitions; (2) structure the course around powerful organizing themes that underlie the most important phenomena of the discipline; (3) introduce important new concepts to high school students in a manner meaningful to them and yet honest in adherence to scientific understanding; (4) hands-on experimentation should precede explanation, and phenomena should lead to learning whenever possible rather than be used merely for illustration; (5) teachers should refrain from telling students what will be found, but create situations that permit the student to experiment and discover governing principles for him or herself.

The Foundation showed institutional courage in funding Zacharias' daring proposal essentially as drafted. Eventually NSF contributed $5.7 million to PSSC in development costs alone, and additional funds from non-public sources helped to defray the cost of this mammoth project. There followed equally radical proposals for mathematics, biology, chemistry, earth science, and, a bit later, geography, anthropology, sociology and other subject areas. Junior high science received important boosts by a series of projects that leave a real choice to school districts. Elementary science also received major funding. A complete listing and description of NSF's course development work has been published (National Science Foundation, 1974).

Sputnik and Related Events

The role of Sputnik is frequently mentioned when discussing the beginnings of federal support of science education. This memorable event occurred on October 4, 1957, a total surprise to the American public. The national mood in the following years favored the NSF thrusts. Sputnik, however, did not create the science education program. Both Sputnik and the advice that placed NSF in the business of science education can be traced to the same source—Russian technical and scientific competence, and the doggedness of that country's efforts to excel in at least certain spheres of science and engineering. The timetable of NSF's early activities indicates that policy-makers were alert to the possibility of a demonstration of relative weakness of American activity in some aspect of science. NSF's graduate fellowships were started in 1951; institutes for high school teachers were first supported in 1954 (private industry had supported prototypes for several years before that), and by spring of 1956 the House of Representatives had escalated institutes into a large program; NSF's first large venture in course improvement, PSSC, was first funded in November, 1956.

Obviously NSF had already established its initiatives with the types of high school science improvement for which it became noteworthy well before October, 1957. What Sputnik did for NSF was to accelerate matters, dramatically increasing funding for science education and thus helping support a much greater and more diversified effort.

Sputnik also caused the passage of the National Defense Education Act (NDEA) in 1958. NDEA had a decidedly positive effect with its transfusions of funds into science materials for the schools and its bolstering of science components of state departments of education; public and school system attitudes were favorably affected, as well. The National Aeronautics and Space Administration (NASA) was also created, and one of that new agency's responsibilities was to tell the public about itself and space science. NASA organized several educational programs that reached the schools with some effectiveness. The Atomic Energy Commission was able to increase a small program it had started and promoted in collaboration with NSF, the teaching of nuclear science to high school science teachers. For a long time into the 1960s a large number of well trained science teachers were introducing nuclear-based experiments and content into their classes

as a direct result of these institutes, and today the subject matter is well diffused into the curriculum. Sputnik had in effect primarily helped to expand the base and size of a small but developing science education thrust in the federal government.

IMPACTS

Institutes

The NSF institutes were the first large-scale, national effort to upgrade a segment of the secondary school teaching staff. Estimates of the proportion of teachers who participated are inexact because of difficulties in collecting statistics and the relative expense of keeping accurate cumulative records over 15 years (recall Rep. Thomas' admonition against paper work and evaluation). A reasonable estimate has been made, from several sources, of those who participated in one or more institutes (either in summer, full-time academic year attendance, or part-time in-service attendance during the school year —or in some combination). At least 50 percent of the existing junior and senior high school science teacher population in 1972 had probably attended, to greater or lesser degree. Almost 45 percent of the math teachers in the schools in 1972 were also probable participants at some time during the past 15 years. These percentages sum up a total of over 120,000 individual teachers (Hershkowitz, 1971; Schlessinger, et al., 1973, pp. 98–100,148–9).

The peak year for institutes was 1965, when nearly $40 million supported over 37,000 high school teacher participants in 492 summer institutes and conferences, 64 academic year institutes, and 313 in-service institutes. Each was held at a college or university, with its teaching staff drawn from that institution's faculty as a general rule (often superior high school science teachers or supervisors were also on the teaching staff). Emphasis was on the subject matter of the teacher's discipline, in courses suited to the teacher's background. Participants were expected to return to their classrooms and use the material assimilated during institute attendance in appropriate ways in their own teaching. A detailed description of institutes is not warranted here; for an account of the history and workings of NSF's institutes programs up to 1965, a very readable report is available (Krieghbaum and Rawson, 1969).

Exactly how institutes actually benefited teachers, and in what ways these benefits might be measured, are exceedingly difficult questions. Many studies of institutes appear in the literature (the ERIC system catalogs such studies), offering varied approaches of different investigators to the problem. Objective data are hard to obtain, and measures of student improvement attributable to institute attendance are equivocal. Many subjective reports by participants and observers have formed the basis for positive conclusions on the effectiveness of the institute mechanism. For the most part, attempts to assess the impact of institutes on science teaching have been forced to fall back on self-reporting by teachers or observations by more-or-less experts. Even when a listing of

topics or details of topic treatment can be obtained from participating teachers as an index of institute effect, relationships to student achievement are attenuated and in the end the investigator's value judgment on "strengthening the course" must be imposed.

Despite the lack of hard, irrefutable data, the evidence for institutes as change agents for the science teaching profession is very impressive. Innumerable interactions of participants with visitors to institutes while in operation, and in high schools after return to the classroom, attest to the ferment of ideas and changes associated with institute attendance. Visitor reports filed with NSF are filled with anecdotal accounts and specific details of highly positive results. As usual, there is a small minority of dissenters among the teachers. Moreover, with so many thousands of institutes over an 18-year period, great variation in procedure and quality was encountered; not all were successful. Nevertheless, one finds it hard to discount such overwhelming testimony by participants during and after their institute experience, often given with examples of how they are using material. Subjectively, the teaching population believes that institutes have improved their knowledge and performance in the classroom.

When a significant portion of teachers in a subject area is singled out for special treatment, and that group reacts very favorably, this fact in and of itself tends to create an impact on education. School administrators are influenced by the prevailing opinion that subject matter training in the teacher's discipline benefits the school. This extends beyond the bandwagon syndrome. From the beginning of the institutes program administrators in positions to observe returning participants commented on the improved attitudes and sense of initiative of the returnees, and consequently these administrators advanced the cause within their own spheres of influence. This became apparent in the first NSF-supported follow-up study of summer institute participants in 1956, with overwhelmingly favorable reports from school principals (Bureau of Social Science Research, 1956).

The favorable opinion among school administrators became reinforced as former participants began moving into administrative ranks over the next few years. This became evident when NSF began offering opportunities to high school principals and school system curriculum directors to learn about new science curriculum developments and the costs and problems of implementation through a small program of Administrators Conferences beginning in 1967. A significant proportion of attendees were former science and math teachers, although the majority had other backgrounds. Attitudes among these groups showed the pervasive influence and positive feelings engendered by NSF programs.

Thus an inquiry into the impact of NSF's institutes programs on secondary schools must start with the vast scope and duration of the effort, together with the great preponderance of favorable reactions among participants and other parts of the educational structure. Beyond this, there were the many anecdotal and statistical accounts of better educated freshmen classes entering the

state universities in the early 1960s, a change attributed to more substantive high school science and math resulting from better prepared teachers. The inference was that NSF institutes were at least in part responsible. No accurate, systematic tracing of this phenomenon was done, to the best of this writer's information. That NSF programs were responsible is a plausible explanation, but university admission policies may not have held constant during the period 1955 to 1965, a possibility that also should be investigated. Then there were rises in Scholastic Aptitude Test (SAT) and College Board scores at that time, also coincident with the big push in NSF educational programs; other explanations can be found for these gains without invoking a direct cause-and-effect relationship with teacher institutes. There is, however, a more diffuse and all-encompassing effect that can explain these freshman gains. If NSF's education programs in their initial momentum were to be integrated with the national mood for educational improvement, together with the uncounted legion of local efforts to upgrade education at that time, the thrust of national policy was consistent with the finding of widespread student gains among college freshmen.

Curriculum Projects

The NSF-funded curriculum projects have profoundly affected content and teacher practices in at least some classrooms in most high schools and junior high schools in the country. The first project to be completed, PSSC, serves as an example of spread throughout the educational system.

From the first large-scale trials and early distribution of the original paperback PSSC text up to the present day, every physics teacher in the country has had an opportunity to become familiar with PSSC. Most of those who took advantage of these opportunities did so through one or another type of NSF institute. Many physics institutes were especially designed to assist teachers with PSSC, while others devoted a portion of time to exploring it. High school physics teachers are not an especially large group, compared to biology teachers, and covering them in institute training was relatively easy. Thus, one estimate shows that 81 percent of the full time physics teachers in 1969 had attended at least one NSF institute, and 70 percent of those who taught other subjects in addition to physics had also attended—the great majority having taken principally institute courses in physics. Even those teachers who were borrowed from other disciplines to teach at least one section of physics showed 57 percent participation in one or more institutes, though these were less frequently in physics (Hershkowitz, p. 115). For the relatively few who apparently never attended, the opportunity was there.

Usage of PSSC in the classroom is a very difficult matter to judge. A report by the American Institute of Physics showed that a teacher could state that he was using PSSC if he was using the text only—or even the text in part, the lab equipment wholly or in part, the experiments if only in part, or all of these. Similarly, a teacher might deny using PSSC if he omitted part of the integrated

package, although the rest were in use. Most classrooms visited by the study team showed significant influence of PSSC in this exploratory study performed on a non-random sample. However, PSSC is also a teaching philosophy, and this aspect is very difficult to assess without a controlled observation. The question of usage has no precise answers, only estimates based on definitions (American Institute of Physics, 1972).

Influence of PSSC, however, has been profound. Physics texts by competing publishing companies frequently show style and content influences. Lab equipment sales are still going on, more than 17 years after full-scale introduction of the course. The style of course development set by PSSC has remained as a point of departure for all subsequent major curriculum projects funded by NSF and also by the Office of Education—sometimes with radical departure, it is true. In answer to objections among physicists and engineers to the PSSC content, there are now alternatives in Project Physics and the Engineering Concepts Curriculum Project (ECCP), plus several new competing texts on the market that permit use of the PSSC lab materials.

As for other curriculum projects for the high schools, usage is undoubtedly high although it is very difficult to estimate precisely. At one point in the late 1960s NSF received figures indicating that almost two-thirds of the first-year biology classes were using one of the three BSCS texts. CHEMS seems to have captured a majority of the chemistry classes, if one includes the several CHEMS derivatives and close relatives that have appeared since the exclusive publication rights on the original CHEMS text expired, although precise figures are not at hand. SMSG in mathematics literally overthrew the established texts and caused a major upheaval of high school math content, with many competing texts and text series on the market, all inspired by the SMSG model. A recent estimate shows that 30 percent of all first courses in junior and senior high school science used texts from one of the NSF-supported projects or a close derivative in 1970. This includes 42 percent of all first-year biology using one of the BSCS texts, without counting competing texts that show marked BSCS influence (Schlessinger, et al., 1973, p. 125).

In the elementary schools the NSF influence is predominantly in math. SMSG totally swept away traditional elementary math texts. It is well to remember that SMSG, which developed materials for grades K-12, did not produce authorized texts but rather produced models of text materials (with accompanying teacher suggestions) that illustrated the kind of curriculum needed in today's world of computers and science. Although there were paperback copies sold by Yale University Press, publishers were encouraged to use the sample texts to develop their own series. Thus each publisher could hire his own team of experts and take an approach anywhere along the path laid out by SMSG. Texts ranged from almost full adoption of the example materials to token adoption; no publisher could afford to ignore the project.

Although criticism of SMSG has been a favorite parlor sport in recent years, it may well be that factors other than the course

materials lay behind the poor performance of many elementary school students. Reading had been in a constant decline and school discipline a growing problem during the period beginning shortly after SMSG was spreading. It must also be noted that most elementary teachers had difficulty using the "new math" in its purest form; the closer it came to traditional forms, the easier it was for most teachers to handle the material. Since, however, the unsatisfactory nature of traditional materials and the lack of success of traditional arithmetic teaching in inducing mastery had caused the public to demand reform in the 1950s, there is little comfort in the fact that traditional arithmetic teaching is still the mode.

Many attempts at in-service training were carried out by schools initiating "new math" programs. In most cases the effort was not sustained or extended widely enough to cover replacements in a high-turnover profession (i.e., beginning elementary teachers). Teachers needed more help than the typical in-service program could give them. There were successful training programs that could be used as models, of course. One of these was the Madison Project, which did not promote any text series but rather concentrated on getting subject matter across to children through activities, mathematical games, greater involvement of children in the learning process, and a liberal dose of demonstration teaching.

Science in the elementary school, unlike math, is in practice an optional subject. It is listed as part of the curriculum and awarded much lip service for its value as an intellectual discipline and for its own content. Very few teachers are evaluated on their competence in teaching science to elementary children, however. A boost was given in the wake of Sputnik, first through public demand, then through passage of NDEA with its provisions for science equipment, and finally through the advent of NSF-supported course content materials for elementary science.

When NSF was first approached on funding projects in elementary science it was very reluctant to dip so far back in the educational pipeline. The persuasive argument in the end was the undeniable power of good science teaching to encourage elementary school children and of poor teaching to cause negative attitudes. With positive attitudes toward science the goal as science literacy became an NSF objective, and with belated recognition that the pipeline to an adequate supply of creative scientists extends back to the early stages of education, the National Science Board authorized the staff to fund science curriculum development for the full range of the elementary grades.

Beginning with the early 1960s, several major projects have appeared, each with a different rationale so that schools now have genuine choices among modern science curricula that do not depend on the traditional text series. The new science programs are centered around children's experience with skillfully devised units that depend on simple materials designed for the units. The programs differ in the amount of structure or types of structure inherent in their organization, as well as specific content, yet all are admirably suited to the age level without sacrificing content and process

objectives. Under proper conditions all the new programs show gratifying results with students. The conditions, however, include appropriate teacher orientation in content and teaching technique.

In-service teacher orientation to these science projects has been an enormous undertaking. Much has been done entirely at local expense, and perhaps at least as much through shared expense of local school system and NSF support under the Cooperative College-School Science Program (CCSS). The latter program was designed to help make school systems self-sufficient with respect to their teacher training obligations for the new, inquiry-oriented science programs. Implementation of these materials is a serious problem for elementary schools. Science backgrounds of teachers are usually quite meagre. The teaching of elementary science has long been dominated by almost exclusive use of text books, with a minor proportion of time for textbook-dictated demonstration "experiments." To break this pattern schools had to establish their own capability to implement modern curricula and train their teachers. Having chosen the program most suited to its needs, the school system could approach NSF through an alliance with a neighboring college or university, proposing a plan that would ensure its continuing ability to use modern curricula. This was the design of NSF's CCSS program from 1965 to 1975, when it was terminated at congressional insistence.

NSF aid to elementary education, aside from the curriculum materials themselves, was accomplished principally through the CCSS program. From 1959 to 1966 NSF supported subject matter institutes for key persons in elementary schools, but the funding was low and the impact on well over a million elementary teachers was miniscule. The design of CCSS was such that many thousands could be reached each year by a modest investment of NSF funds, hopefully to be spread in widening circles in subsequent years. CCSS was not confined to the elementary level, and similar designs applied to junior and senior high school system improvements.

OFFICE OF EDUCATION ACTIVITIES

The Office of Education (OE) was at first bypassed by curriculum reformers in the drive to improve science and math in the schools. With Sputnik, however, the professional educators and the congressional committees overseeing programs and budgets of OE wanted a piece of the action. The National Defense Education Act of 1958 (NDEA) significantly expanded the role and influence of OE. Most visibly, NDEA provided for purchase of science teaching equipment by schools through formula allocations to the states and, via the state education agencies, to individual school districts and schools. The effects of this new equipment on local schools were decidedly varied. Where competent persons were given responsibility both for designing the curriculum and selecting the instructional materials to aid in teaching, the accomplishments met objectives—provided, of course, that the teachers were capable of handling the equipment and curriculum content. There were some abuses, and instances of equipment lying in storerooms because the current teaching staff was not using it, for good or bad reasons. Unfortunately, this seems to be a natural outgrowth of

"trickle down" allocations, if only because many officials dislike refusing an offer of funds even if they do not know how to spend them or even how to find competent help in using them constructively. However, the horror stories should not be used to smear this program, as with all such tales, they grow in the repeating, usually starting from a relatively few flagrant cases.

The science lab and/or demonstration materials purchased under NDEA, as well as audio-visual equipment purchased for more general use in the schools, have served an important teaching function. Schlessinger and Howe found that, as late as 1968-70, 69 percent of the schools in their high school sample had used NDEA funds for this purpose in those years, and 15 percent had used NDEA funds for remodeling science facilities (Schlessinger, et al., 1973, pp. 19-20). Similar percentages are reported for elementary schools in a parallel study at Ohio State University (Steiner, et al., 1974).

Another contribution of NDEA was the strengthening of state education agencies. NDEA funding helped to staff science specialists in the state agencies for a variety of functions which also attracted state funds as well. With the addition of science specialists, standards within the states became better drawn and enforced. This has not always been without strain for some of the local jurisdictions but, on balance, the move has been quite beneficial.

In 1964 OE established what is now called the Educational Resources Information Center (ERIC) in its Bureau of Research. With the establishment of the National Institute of Education (NIE), ERIC eventually was removed from OE and housed in NIE. ERIC placed one of its most successful subject matter centers, the Science, Mathematics, and Environmental Education Information Analysis Center, at Ohio State University. ERIC/SMEAC, as it is known, has become a very useful contributor in the spread of information on research and developments in science education, synthesizing findings on selected topics, and as a center for communication in the field. For example, the two science teaching studies on elementary and secondary schools in 1970-71 were performed under ERIC auspieces. The Center is a valuable asset.

The Elementary and Secondary Education Act of 1965 (ESEA) marked another turning point in the country's acceptance of the federal role in education. The Office of Education was given a genuine opportunity to affect educational policy. Title I carried the largest funding, to help overcome educational disadvantage as part of the Johnson administration's "War on Poverty." Title III authorized supplementary educational centers for local school districts or regional coalitions, with funding based on merit and subject to open competition. Funding by merit instead of formula allocation was said to be due to NSF influence. For the brief period that national competition was permitted, some real creativity appeared in locally devised projects to improve education. The strain of political pressure was apparently too much for Title III, and it was returned to the states with formula allocations and influence of state political machines. Both Title I and, especially, Title III had some interesting science and math projects that had at least a brief impact on their districts.

The Office of Education, under the Cooperative Research Act, began in 1964 to create Research and Development Centers at universities across the country. These were augmented by the Regional Education Laboratories that Congress authorized under an amendment to the Cooperative Research Act which was part of ESEA. Both types of institutions were created to perform in a long-neglected field, educational research and development (R & D). Math and science received considerable attention in these new institutions. One example is the individualized approach to school learning known as Individually Prescribed Instruction (IPI). Other curriculum and technological approaches originating in such centers have also gained wide usage. Computer-assisted instruction in all its aspects received a large boost from ESEA and Cooperative Research funding. (NSF also staked out an interest in the applications of computers to learning which is still going on. The two agencies have at times collaborated in this.)

Of interest is the acceptance of the NSF models for teacher institutes funded by ESEA (and also by NDEA) in several disciplines. Although a small number of these were in math or science, the largest proportion were in other disciplines. Major curriculum projects also were given a start under ESEA (although the Office of Education earlier had initiated curriculum projects in English, social studies and foreign languages within its general appropriation, at the beginning of the Kennedy administration). Adaptations of the NSF models were applied here. Several projects started by OE were transferred to NSF in their latter phases: Harvard Project Physics (HPP), Intermediate Science Curriculum Study (ISCS), and Conceptually Oriented Program in Elementary Science (COPES).

During the ESEA era, and the earlier NDEA years as well, OE and NSF staff remained in close touch to coordinate activities. Shared funding occurred in several important projects. Information was freely exchanged and staff members attended the other agency's meetings. At another level, the top executives of both agencies served on the Federal Interagency Committee on Education (FICE) for policy coordination. Considering the scope of the programs and pressures on working staff, the coordination between agencies was effective in channeling funds.

Still another effect of the NDEA-ESEA era was marshaling of federal moneys so as to create a new capability in a school system. Philadelphia's public schools, for example, used funds from Office of Education allocations to invest in equipment and planning in such a superior manner that they attracted NSF funding into colleges and universities of the region. In this way, through locally oriented teacher institutes and particularly through NSF's Cooperative College-School Science Program (CCSS) large numbers of teachers in the Philadelphia system received specialized science or math training and helped to implement the school system's choices of new and improved curricula in their classrooms. Other school systems, large and small, reacted in similar fashion to create a positive movement of science upgrading. Without the federal programs it is doubtful if most of these plans would have crystallized.

As part of a national effort to improve academic performance, NDEA and ESEA helped to strengthen science in the schools. These OE programs helped to affect national attitudes toward the schools and academic achievement, including that in science and math, even though many of the entitlements were in the non-science areas. As is so often the case, funds beget funds. National policy extended beyond speechmaking and impacted schools directly with dollars they could use within their own discretion for specified purposes. Perhaps one cannot draw a cause and effect analogy, but during these times local school appropriations and teacher salaries began their long overdue rises.

BACKLASH

During the late 1960s and early 1970s a gathering storm took shape. First, the institutes for teachers fell under heavy fire. Officials in the Bureau of the Budget, now Office of Management and Budget, had an often-expressed dislike for programs that were self-sustaining, whereby large numbers of people could be justified every year to receive the same benefits. Teacher institutes became the epitome of a program without end, drawing money from the federal treasury for an ever-renewing body of teachers. Their thinking reflected a desire for programs that would be problem-oriented, with a quick fix and an end to the program. As the Nixon administration took hold of the government, anathema for institutes became administration doctrine. However, Congress insisted on institutes being retained in the form they had started. The NSF top executive level, and the National Science Board, had no stomach for this fight; teacher institutes were a barely tolerated stepchild for them. A classic tug of war developed.

NSF's education staff attempted to bolster the pre-college program by expanding its Cooperative College-School Science Program (CCSS), which had an attraction to a pragmatic administration in stressing teacher training for implementation and a built-in development of local capability for continuance. For budgetary reasons, the expansion of CCSS was to come from some of the institute funds, with the intention of realigning the education program in a "balanced" fashion between teacher improvement per se and orientation for implementation. Congress rejected this approach if it involved reduction of institutes. The Nixon administration then found other tools, including impoundment of funds appropriated by Congress. This precipitated a constitutional crisis, since the same practice was being applied to a wide variety of congressionally-initiated programs all over the government. Congress weakened on many fronts for a while. One result was a progressive squeezing of institutes appropriations downward. A last desperate accommodation was made by NSF to turn institutes into implementation projects, with a hope of preserving the concept and riding out the storm. Institutes, however, apparently died with the FY 1973 budget.

More disasters loomed for the pre-college set of programs. A controversy welled up over the content of the fifth grade social studies course developed with the help of NSF funds, Man: A Course of Study. This escalated into an assault in Congress against all government-supported curriculum development. Some long-standing

weaknesses in NSF's control of curriculum development were revealed, and some wild, even scurrilous, charges that later proved false were circulated. Congress put extreme pressure on the Foundation to change the process. Emasculation of curriculum development was the result. The program was politically tarnished.

Suddenly, NSF's outstanding innovations in pre-college science improvement, institutes and curriculum development, went into eclipse. The final blow landed in 1975 with rejection by Congress of the implementation concept. Federal support for implementation of science curricula, whether or not they were federally funded projects and notwithstanding the fact that the projects selected were the choices of the schools themselves, raised the specter of federal control. As long as teacher institutes co-existed with the CCSS program, there was no real objection, but when implementation stood alone as the only justification permitted by the administration for teacher instruction, it was too much. Combined with the cloud over all course development, the last vestige of NSF's pre-college science improvement program was ended. To signal the end, NSF reorganized its Division of Pre-College Education in Science out of existence.

An excellent history of the origins, growth, maintenance, and apparent demise of pre-college education in NSF will be found in a congressional report (U.S. Congress, House, 1976). Before writing finis to 20-plus years of NSF involvement, however, we must note that Congress is resolved to have the last word. As will be seen below, an institute-like program has re-emerged.

NSF AND THE CURRENT STATE OF SCIENCE EDUCATION

Reflecting on the influence of NSF programs for science education, it is necessary to lump the entire effort rather than trace each program's individual impact. Curriculum improvement took place in both the curriculum development efforts and through teacher education. Teacher improvement was a complex function of institutes, new course content, and implementation efforts. The supportive feelings of public and local governments helped create an atmosphere for acceptance of the new programs, and the new programs helped create a supportive feeling because they made sense at those times.

It is instructive to stroll through the exhibit areas at a National Science Teachers Association meeting, browsing among the book and laboratory equipment displays. Whether in original form or in an evolved state, books and materials are now dominated by the NSF-supported curricula that were successfully spread through teacher improvement techniques and the efforts of private enterprise. For example, competition has introduced modifications of the once-innovative materials of the elementary science projects. Price competition is also featured.

The texts on display are unmistakably of a new generation. At the high school level one finds the texts written by the project teams but by now in their second or third revisions. Publishers

not possessing these texts have their own, often with preface acknowledgments in the projects but with topics and treatments clearly showing project influence. Members of the original projects have authored, or heavily contributed to, new departures that use the project approach in part but modify it in light of classroom experience with the materials. This phenomenon appears in all fields: physics, earth science, chemistry, biology, and the junior high levels.

Most fascinating is the change in elementary texts and materials. Not only are the NSF-supported projects very prominently displayed, but their derivatives and offshoots are now appearing. Responding to some demands for hard covered texts in place of sole reliance on the teacher-centered materials featured by the projects, a number of publishers have in part put the projects in book form. This is not entirely possible, so the adaptations have been ingenious; however, at times these radical changes have not been true to the original intent of the material. There are both advantages and disadvantages to those newer texts, and they are worth close inspection. When properly used in the classroom, this approach may become a true merger of materials-centered inquiry and textual structure.

The recent elementary texts show many familiar units extracted from one or more of the best-known curriculum projects, with suggestions on their use in the new context. Not all the content is borrowed, however. In at least a couple of cases publishers have given creative text authors freedom to organize the science text series around units and materials not obviously derived from the projects, but very much in their spirit. The promises and possible drawbacks of the new elementary science texts have been discussed elsewhere.

The publishing industry seems to have accepted the changes associated with NSF intervention, after a few fearful years of opposition and an unsettling realignment of resources so as to include more than printing of hard covered texts among instructional materials. A review of the publishing industry's relationship with NSF and other government agencies has been made as part of NSF's inhouse review of its curriculum development efforts. The conclusion of the study states: "To summarize, the federally-funded research and development that was launched in 1958 with many misgivings on the part of many educational publishers has now become an integral part of the el-hi publishing process" (National Science Foundation, 1975, p. 167). Among the important points made is that one of the major aims of federally-funded curriculum efforts has been stimulation of creative commercially-funded materials as competition.

That curriculum materials now appear different is obvious. The leadership of science education is also very different from the previous generation of the 1950s. In one way or another, today's leaders in local school systems, state agencies, college or university science and science education departments share a common experience of involvement with the NSF education improvement grants. The great majority of state and local science supervisors have had at least some contact with NSF-supported institutes or conferences.

While no physical count has been taken, it would appear from partial surveys that a large number of these leaders are graduates of NSF-supported academic year or sequential summer institutes. Science educators in colleges and universities have inevitably been deeply involved, either in the direction of institutes and other projects, teaching staff in such projects, or as former participants. It is gratifying to identify the many former high school teachers who attended institutes, strengthened their ties with higher education and eventually became senior members of college and university science education staffs. A large number of institute and CCSS directors have had such a history. Moreover, service of teachers and supervisors from the elementary and secondary schools as institute or CCSS staff members has been widespread. Thousands of science educators from all levels of education have served as consultants to the Foundation in evaluation panels during proposal review time.

The shared experiences, the innumerable contacts between NSF and the community of science educators, the influencing of NSF policies and practices that resulted from all these exchanges may be summarized as both the end product and the process of the federal impact on science education.

INDIVIDUAL OPPORTUNITIES TO PARTICIPATE IN FEDERALLY FUNDED PROGRAMS (1978)

In the past, members of the science teaching profession have had excellent access to NSF-supported activities by virtue of the large numbers of "stipend" vacancies in institutes and a variety of other conferences. Opportunities began to diminish after 1972, almost reaching a vanishing point in 1976. Congress reversed this trend by mandating NSF to spend in FY 1977 and 1978 funds for a Pre-College Teacher Development in Science Program (PTDS). With this move, Congress reasserted its initiative in forcing NSF to retain a position in pre-college education, and it showed again its belief in the value of subject matter training for teachers at both elementary and secondary levels.

In announcing the first wave of grants NSF's press release of July 11, 1977 states:

> The primary objective of the PTDS program is to provide pre-college teachers with opportunities to participate in seminars and workshops designed to improve their subject-matter knowledge of science and to enable them to develop a continuing association with university scientists. The seminars and workshops will generally take place on a part-time basis during the 1977-78 academic year or on a full-time basis for one to four weeks during Summer, 1978.

Ground rules for attendance at these projects are somewhat different from those of the old institutes. Once a teacher participates, he must wait three years before being eligible to participate

again. The content tends to be important topics of current interest that will benefit teachers in carrying out their classroom responsibilities, rather than college-catalog types of courses. Projects will not devote time to the problems of implementing a specific curriculum project. While expenses for commuter travel during the school year may be reimbursed, for the summer projects (aside from travel expenses) a participant may receive only a portion of actual subsistence expenses if he or she is housed away from home. This may be supplemented, however, by the school.

For the first year, slightly less than half the projects take place only during the school year, operating in the same fashion as did the old in-service institutes. About one-fourth operate only during the summer, and the remaining fourth have both summer and school-year components. Summer projects permit application from a broader geographic region than do the commuting school-year projects. There must be sound reason for the project to operate in the summer, however, such as a smaller target group within a limited commuting area (e.g., chemistry or physics teachers as opposed to elementary school teachers) or content of such nature that it requires intensive study within a concentrated period of time. A directory of summer opportunities will be distributed in the spring of 1978.

Of the 187 awards for the first year, about 60 percent were directed to the natural sciences, either in a single discipline or a mix that might include true interdisciplinary approaches. The remaining projects were in math or social sciences. A few encourage mixes of secondary school teachers from both natural and social sciences, or the social/natural sciences and math.

Unlike the old institutes, there is a conscious effort to involve elementary school teachers in PTDS. Of the projects in natural science, one-fifth are exclusively for elementary teachers and another fifth are designed for them plus middle school or junior high teachers. In fact, only about one-third aimed exclusively at teachers in senior high schools, with the remaining projects accommodating all secondary grade level teachers.

For grants announced in 1977, covering the 1977-78 school year and the summer of 1978, $4,710,000 was available, enough to fund 187 grants. About 11,000 participants can thus be included. Recent congressional appropriations will make $6 million available to the program in 1978, which should fund about 238 projects for 14,000 participants.

The probability of continued, if modest, growth for this program is good, provided evaluation supports the program and politics permit it. Let not the science educator or teacher rest complacently, however. Every federal program must justify itself annually. It is the reader's responsibility to support this program politically with NSF, the current administration, and Congress, if he believes in it. The history of the early 1970s should not be forgotten, and educators involved with pre-college education must not assume that they have enduring friends in high places.

Another NSF program for science educators is Information Dissemination for Science Education. This is intended to let the educational community know important details about new and alternative instructional materials and practices. Target audiences are education decision-makers such as principals, supervisors, teacher-leaders, school board members, and representatives of parent groups. Although most of the openings will be for subject matter specialists, the program will not train teachers or provide technical assistance in implementing specific materials or practices. In a nutshell, the program is designed to help those responsible for decisions to make more informed choices.

About 2,000 openings will be available in the 17 projects announced for 1977-78 and the summer of 1978, funded by an allocation of $400,000. However, $800,000 will be allocated in FY 1978, with approximately double the number of grants and individual openings. Projects are local or regional in nature, designed for a specified geographic area. They may take place at any convenient times during the calendar year. Publicity will be circulated by the grantees in their target regions. Expenses for travel and for subsistence in the case of residential projects may be allowed, but school districts are encouraged to offset these as much as possible. All pre-college disciplines in the natural, social and mathematical sciences are included.

Science educators teaching in community colleges, four-year colleges, and universities are eligible to participate in NSF-supported Chautauqua-type Short Courses. These are discipline-oriented sessions meeting for two days in the fall and two days in the spring, with provisions for participants to work on individual projects related to the course between sessions. Scholars at the frontiers of their disciplines communicate recent advances in their fields directly to the college instructors so that these in turn may keep their teaching current.

During the year 1977-78 Chautauqua Courses will be offered in 15 field centers scattered across the country, with 52 courses and 3,400 openings available. The usual broad range of scientific disciplines is covered. About $1 million is budgeted for this program, both in FY 1977 and FY 1978. Participants bear the cost of transportation, meals, and incidental expenses, but NSF funds provide at least partial costs of room rent and instructional materials. The American Association for the Advancement of Science (AAAS) is responsible for selection of topics and instructional staff, and AAAS has corralled a collection of outstanding figures for these courses. One may obtain information about course dates and locations from any of the 15 field centers.

The College Science Faculty Professional Development Program is a small but helpful NSF program. It enables college science faculty members to undertake activities that will enhance their effectiveness as science teachers through an affiliation of from 3 to 12 months with an academic or non-academic institution. Participants may receive their normal salaries for the period of the award. In FY 1977 NSF made 119 awards, for a total of about $2.1 million, one for every ten applicants. A similar amount will be available in FY 1978.

Those who wish to submit proposals to operate teacher development projects should obtain the current annual announcement from NSF to ensure accurate information on eligibility requirements, specific program objectives (which can change in large or small degree from year to year), proposal deadline dates, and anticipated grant announcement dates. Programs listed above generally will have grant announcements in the spring of each year, unless they change. As an example of shifts in program emphasis, for Pre-College Teacher Development in FY 1978, Congress has expressed a wish that: "--the Foundation--use not less than 25 percent of the funds available to train teachers in methods to encourage students to explore the interaction between science and society."

The Foundation has also started to announce on a regular basis its program for Research and Development in Science Education. Some of the money will go to pre-college education. There are, however, many boundary conditions on funding, and generalizations this year can be rapidly overturned in the near future.

A NOTE OF CAUTION

A reservation is hereby entered on the practices for in-service education of elementary school teachers apparently mandated in NSF's new Pre-College Teacher Development in Science Program (PTDS). As PTDS seems to be heading, the elementary teacher enrolled in one of these grants will be studying the subject matter of physical science, life science, earth science, or environmental science (or some combination). The object is to give the teacher enough background so that he or she can teach a more substantive course and hopefully a more interesting one. Every elementary school's curriculum guide includes content from all of these sciences, however. If the teacher is to understand the background of the subjects called for in the curriculum, then he needs education in all these fields, presumably having omitted them as an undergraduate. That, however, requires a schedule involving three or probably four calendar years for a fully employed adult to acquire a smattering of knowledge in after-school instruction for the major disciplines. Aside from the barrier against participating more than once in four years, how many elementary teachers will face up to such a schedule? Is this proportional to the pressures on them to teach reading, and hopefully math? How will the subject matter newly acquired be useful to the teacher when attempting to apply it in the classroom? Will it correlate at all with the science curriculum specified in the school and with the science equipment available in the school?

Well intentioned as it is, the PTDS model of subject matter training for teachers is derived from the secondary school teacher's responsibilities. It is not geared to the elementary teacher, whose responsibilities and talents are quite different. Moreover, an appropriate model for in-service training for science in the elementary school is not the same as one for math, and social science may differ from both. NSF should think this through again but take care that

consultants called upon represent the targeted population—elementary science specialists and classroom teachers—and not the people who normally apply for grants to teach them. Similar but entirely separate consultations should be held for elementary math and social science/ social studies.

In this observer's opinion, elementary teachers need a great deal of help in teaching science, no matter what the curriculum in their schools. Hopefully an effect of NSF activity will be for schools to select and maintain one of the substantive, modern, activity-centered science curricula rather than the text-reading science curricula. Regardless of that, however, it is the schools that have the responsibility for choosing their curricula and making them work. What the teachers need is enough content on the topics covered, plus much demonstration and practice in how to conduct the science class activities, so that they can do a decent job of getting across the existing (or newly selected) school curriculum. Ideally, if they knew far more about the topics covered and those omitted, they could construct their own course and suitable labs—which probably would be totally uncoordinated and non-sequential for the six grades. A tiny fraction of the teacher population will respond to the subject-matter treatment, but the enormous mass will be left untouched. Experience shows that elementary teachers are eager to learn to do their jobs, but cannot be thrown in over their heads.

The present guidelines seem to encourage the colleges and universities that obtain grants in elementary science to prescribe the content for the schools served. It does not have to operate in that way, but without adequate safeguards for school system input into the design of the content and objectives of teacher instruction, plus school collaboration in selection of teachers, the possibility of operating at cross purposes is not negligible.

Congress' legislative intent is seen by NSF to lie behind this treatment of elementary school science teaching. The Foundation has a responsibility to ascertain, without bias, which of their elementary science grants are most likely to result in visible increments of improvement in classroom science as the schools are actually constituted rather than against an ideal that is not attainable. Careful selection of field observers from among professionals with a profound working knowledge of current teaching problems within elementary schools is essential. The same kinds of field studies are needed in elementary math and social science.

With results in hand, NSF can then tailor its elementary phase of the PTDS to realistic approaches toward improvement of the targeted elementary subjects. If necessary, the Foundation must petition Congress for clarification of its expressed intent so that the essential differences between high school, elementary school, and probably junior high school teaching can be recognized without putting all into a framework that is most easily suited to the senior high school. Judiciously applied assistance from the science education community is undoubtedly called for.

REFERENCES

American Institute of Physics. High School Physics Teaching: A Report on Current Practices. New York, 1972.

Bureau of Social Science Research. The NSF Summer Institutes of 1955: Forty-one Participants Express Their Views a Year Later. Washington, DC, December 1956.

Dyrli, O. E. "Is There Anything New About the New Science Textbooks?" Learning, Vol. 4, No. 5:30-36, January 1976.

Hausman, H. J. Choosing a Science Program for the Elementary School. Occasional Paper Number Twenty-four. Washington, DC: Council for Basic Education, October 1976.

Hershkowitz, M. National Science Foundation Program Participation and Secondary School Science Teaching, 1969. Technical Report No. 01024.01-2. Silver Spring, MD: Vitro Laboratories, 1971. (Available from National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161 as document PB-202918.)

Krieghbaum, H. and H. Rawson. An Investment in Knowledge. New York: New York University Press, 1969.

National Science Foundation. Course and Curriculum Improvement Projects, Mathematics, Science, Social Sciences. Washington, DC: National Science Foundation, 1974.

National Science Foundation. Pre-College Science Curriculum Activities of the National Science Foundation. Report of Science Curriculum Review Team, Vol. II-Appendix. Washington, DC: National Science Foundation, May 1975.

Schlessinger, F. E.; R. W. Howe, et al. A Survey of Science Teaching in Public Schools of the United States (1971) Volume 1—Secondary Schools. Columbus, OH: ERIC Center for Science and Mathematics Education, The Ohio State University, 1973.

Steiner, R. L., et al. A Survey of Scie[illegible] Teaching in Public Schools of the United States (1971) Volume —Elementary Schools. Columbus, OH: ERIC Information Analysis Center for Science, Mathematics, and Environmental Education, The Ohio State University, 1974.

U.S. Congress, House. Subcommittee of the Committee on Appropriations. Hearings. Independent Offices appropriations for 1957. Washington, DC: U.S. Government Printing Office, 1956, pp. 522-3.

U.S. Congress, House. The National Science Foundation and Pre-College Science Education: 1950-1975. Report prepared for the subcommittee on Science, Research, and Technology of the Committee on Science and Technology, U.S. House of Representatives, Ninety-fourth Congress, January, 1976.

U.S. Congress, Public Law 81-507. The National Science Foundation Act of 1950 (Public Law 81-507, 64 Stat. 149).

U.S. Congress, Public Law 81-507, Amended. The National Science Foundation Act of 1950 (Public Law 507-81st Congress; 64 Stat 149; as amended).

Albert Medvitz and Fletcher Watson use models of social influence and professional occupations to explore the effects of professional associations on science education. They present science education as a hybrid occupation and analyze the science and education parents as well as the science education offspring. Because of the compromise of the "professional" science component and relative weakness of the "semi-professional" education component, the effects of professional associations on science education are moderated by occupation strain. They offer suggestions for future action.

THE INFLUENCE OF PROFESSIONAL ASSOCIATIONS ON SCIENCE TEACHING

Albert G. Medvitz and Fletcher G. Watson

CURRENT CONDITIONS

A diversity of professional associations influences science teachers on at least two levels. One level is that of direct personal influence through acquaintanceship, admiration, and role modeling. The other level is organizational: each professional association acts as the collective agent for a purpose shared by the membership. Examples of this second level would be encouraging and offering institutes for in-service teachers, or becoming involved in a course development project intended for wide usage, or establishing criteria of training. Our brief review of the direct influence of associations lays the foundation for the subsequent discussion of the less direct, but more important, organizational mechanisms of influence. Note at the start that the second level of influence is immersed in and effective through political action.

Professional associations, both scientific and educational, influence science teachers directly through publications and conferences. These are the major means which the association uses to communicate with its members about science, its teaching, and the development of teachers. Also, publications and conferences provide opportunities for the chosen leaders of the group to "sense the pulse" of the body politic so that associational efforts will be based on wide support of the membership. Since science teachers may attend the meetings or read association journals, they can be influenced directly by the public associational activities.

While superficially most of the actions of associations appear to be concerned with particular knowledge of or about science, that which is discussed in the media of these associations also carries other clear but implicit messages. These messages are about values, appropriate normative behavior, and the role of science and education in the political and social structure of the society. Professional associations attempt to continuously acculturate teachers to the norms

and expectations of scientists, promulgate notions of what is important to teach, and continually inform teachers of their place in the scientific community. These associations attempt to exercise social influence on the way teachers act and use their knowledge of science.

Studies in social influence (for example those by Kelman (1961), Asch (1940), Milgram (1974), etc.) indicate that influence is an interactive process. The extent and direction of the interactions depend upon the characteristics of the two groups or parties involved in the interaction. Some of the important characteristics are perceived authority (Milgram, 1940, pp. 1-12; Kelman and Hovland, 1953), relative status (Hollander and Willis, 1967), control of important rewards or sanctions (Kelman, 1961; Schein, 1971), and extent of agreement in a group (Asch, 1958). Also, the degree to which interactive messages are received depends upon the previously held values, beliefs, self-imagery, etc., of the receiver. We believe that these attributes, isolated from studies of the interactions of individuals, apply also to the interactions between groups or associations—which are necessarily represented by individuals. As an example of these proposed generalizations, consider one's approach and likely behavior if a stranger were introduced as a Nobel laureate or as a beginning lab technician. Similarly, consider representatives of the AETS approaching the National Academy of Science or the local PTA.

Within the science education community are many receivers of influence who have a diversity of roles and careers. Among the subgroups are elementary and secondary school teachers, college and university teachers, curriculum coordinators and supervisors, and science teacher trainers and researchers. While they differ at the species level, we shall consider them as essentially one family. The question becomes: what characteristics of this group are relevant to an increased understanding of their being influenced by professional associations?

Initially we must recognize that each individual within any defined group is simultaneously a member of many other groups: home, social, religious, political, and educational. Also, each individual has his or her own personal history of experience, knowledge, values and beliefs. With this diversity, what shared attributes will cause members of the science education community to resonate with messages from professional associations? To what are they commonly atune?

Like Janus, science teachers are necessarily two-faced, with one face towards the sciences and the other towards the schools, students and educational systems. The maintenance of such dual allegiancies generates tensions, sometimes creative and sometimes not. Commonly, as Cooley (1963) has pointed out, entry into science teaching, educational research, and teacher training comes after an extended prior of training and career orientation towards the sciences themselves. During this period, teachers and their mentors have undergone extensive socialization and acculturation into the idealized norms of science and the scientific community: teachers are encouraged to form a lasting allegiance to the non-political, impersonal, objective, and often private search for scientific knowledge for its own sake.

They are steeped in the mythology and ideology of science and develop an awareness of the past and present heroes and of the general status distinctions within the scientific community. Sometimes, for any number of reasons, the individual concludes that the life of science is not personally appropriate and moves into the school as a science teacher.

As Edgar Schein (no date) had noted, during a period of acculturation and socialization such as that just described, an individual develops a concept of him or herself in an occupation. Schein calls this self concept an "internal career." It is complete with occupational goals, anticipated steps necessary to achieve those goals, notions of the times when various steps are to be taken, imagery of behavior at various career stages, etc. The internal career is distinguished from the "external career" in that the external career is the individual's occupational behavior and position in society. It consists of actual decisions made, positions held, and socially possible future steps towards socially recognized occupational positions. During the course of an individual's life there is a constant interplay between internal and external careers. It is not uncommon that personal preferences in work evolve and change over time and generate a work change. Nor is it uncommon that social and economic conditions force career choices not in keeping with individual expectations or wants. In these instances where internal and external career no longer match, the individual must change his or her internal career or persist in a state of dissatisfaction with work. We note some of the problems of transition for those who leave the world of "science" for the world of "science teacher."

From the primarily thing and knowledge-oriented, non-political world of science the individual enters the interpersonal, client-oriented, and to some degree custodial world of schooling. Here work does not occur in the privacy of the laboratory or with ordered debate in academic settings, but rather in the highly social and political arena of schools, parents, and the public. To some degree the transition is eased by public pronouncements by members in the scientific community on the high importance of science teaching by which the next generation of scientists is brought along. Weller's (1965) study of the role orientation of science teachers supports this description.

Science teachers often see themselves as the representatives of the scientific community in the classroom and indeed are encouraged to do so by that community and the professional associations of science education. This has been particularly true in recent years when science education received considerable attention. The NSF encouraged the image of "the scientist teaching." Also, the recent AAAS booklet Scientific Freedom and Responsibility (Edsall, 1975) explicitly includes secondary school science teachers within the scientific community.

The teacher's strong identification with the scientific community rather than to the educational community (made most symbolic by the recent total separation of NSTA from the NEA) is accentuated by the ambiguous professional status of teachers in general.

The occupational problems and professional limits of teaching have been discussed elsewhere [Brenton (1970); Goode (1969); Friedson (1973); Lortie (1975); Marcus (1973); Stub (1968); Gross (1960); Waller (1932); Lieberman (1956); Musgrave (1972); Wilensky (1964); and others.] In general, these discussions contend that teachers lack the extensive knowledge-base, career lines, and normative characteristics to realistically make the same claim for professional recognition and status that is accredited to, for example, attorneys and physicians. However, in some ways teaching as an occupation does bear some resemblances to other professions. Teachers do have autonomy in the classroom, but it is limited. They do have some authority but while it is partly based on knowledge, much of it is organizational. Teachers exhibit fewer of the collegial norms characteristic of the "high" or "free" professions, and they do not as a group show strong commitment to the spread of knowledge about teaching, or to the notion of teaching as a lifelong career. We should emphasize that we are here describing an occupational group. Within any group there are individuals who, to more or less degrees, exhibit strong characteristics of professionalism (Ritzer, 1973; Gold, 1952).

In the above-mentioned characterizations of the professions, a heavy emphasis is placed on the importance of a special and even esoteric knowledge base to the claim of professionalism. The knowledge base is important both to the individual's sense of legitimacy in making the claim to professionalism and to the acceptance of that claim by others. For example, the knowledge base of scientists is given high status in the society and is regarded as difficult to obtain by the public at large. Furthermore, science involves a language and jargon accepted as legitimate, if mysterious, by the general public. Science is special.

The knowledge base of science teachers has two components. A familiarity with science and its terminology is one component. Yet, the degree to which the science teacher has these is not really unique, for others have or may have access to the same level of knowledge. Because science teachers possess scientific knowledge, they can maintain a psychological link to the scientific community. Because their scientific knowledge is limited, however, their professional links to the community are tenuous and their status peripheral in nature.

The second component of the knowledge base of science teachers lies in a hybrid collection of theories and terminology from the behavioral sciences and professional practice dealing with principles of learning and of teaching. But this component of the knowledge base is ill-defined, complex, probabilistic and lacks the sense of importance, specialness, and the mystery associated with science. Furthermore, the public is quick to regard the jargon of teaching as patent obfuscation. Therefore, for many science teachers identification with science and its professional norms is preferable to identification with education, teaching, and students.

This orientation has an obvious effect on a teacher's perception of and response to communications from professional associations and on the general character of science teachers' professional

behavior. Science teachers accept science, scientists, and scientific associations as their sources of authority and have failed to create a necessary but distinct collegial authority based on a combination of expertise in science and in pedagogy. This lack of independent authority persists despite the relatively low place given the economic and social needs of science education among the concerns of the professional associations of science. In keeping with this lack of relative authority, significant rewards and sanctions and much power and control over resources (money!) are vested in well-meaning but relatively uninformed segments of the scientific community. This is not to say that there is no professional organization of science education, but rather that only modest agreement exists within science education about professional goals and the possibilities of taking collective action vis-a-vis the associations and societies of science to achieve those goals. Those in science education accept the largess of others, but take little initiative to shape their own political and social position.

PROFESSIONAL POSSIBILITIES

If science educators were to seek greater public effectiveness as a profession in America, what would need to be done? A necessary starting point is a clarification of our understanding of professionalism and legitimate professional action. While no single set of criteria seems to be universally accepted for the definition of a profession or of professionalism, we can extract, from writings on the subject (see references cited earlier), criteria about which there would be considerable agreement. These are:

1. A unique knowledge base and allied skills based on extensive training and which are applied to important areas of social concern.

2. A commitment to the profession as a career and to the culture of the profession as a way of life.

3. A professional ethic emphasizing the good of the client, the public, and the profession over personal pecuniary or political gain. The ethic also defines relations between professionals.

4. Jurisdictional control or a significant voice in the state of the profession by members of the profession themselves. This may be in addition to or instead of state or civilian control. The controls apply to training, entry, licensing, discipline of malpractice, etc., of the profession.

5. Public acceptance of the claims to professional status as evidenced by at least some control over the occupation, as in #4, but also by respect, authority, trust, and autonomy being invested in the professionals in the practice of their occupation.

If we consider the state of science education on these five criteria, we have:

1. The possibilities for a unique hybrid knowledge base arrived at by combining science with pedagogy; but at present the pedagogical component is weak and not highly valued by teachers or the public.

2. Commitment to the teaching of science as a lifelong career is unsure; some teach for a time then move to other occupations, even as some having had other careers are accepted as teachers. Strong commitment is not evident.

3. Client (student)-orientation exists and is emotionally rewarding, but ethical relationships with regard to students is unclear, as are relationships with colleagues.

4. Teachers, including science teachers, have done little to set the conditions by which newcomers may enter the group or to monitor and reward those already teaching.

5. Despite the mildly positive orientations described under 1 and 3 above, to the public the negative aspects under 2 and 4 appear to limit the role of teachers to what Glazer (1974) has termed "minor professions" and Etzioni (1969) called the "semi-professions." Perhaps that is as it should be when thousands of teachers are involved and children have little or no choice about who their teachers are. Using these criteria, science education is not a profession.

Each of those summary statements requires elaboration. As noted before, the knowledge-base of science education could be expanded to include comparable concern for students and learning. This would require significant changes in the academic programs by which future teachers are developed, as well as of the knowledge and values of those who train teachers. Initially this seems shocking, difficult, and improper. However, a look to the future and the growing concern for the social utilization of science and technology, indicates that a shift in emphasis from "knowing that" in science to "knowing how to decide" may be inevitable. The social and political role of science will receive more stress. Teachers must be qualified to consider such social problems even those involving criticisms of traditional science. A major transformation in the justification and emphasis of science instruction is brewing, and we should get prepared for it.

Commitment to a lifetime career as a science teacher or educator is not commonly expressed or expected. Access into or out of the role of science teacher seems relatively easy. Therefore, the public does not see the degree of commitment it finds among the "established" professionals.

Those contemplating a career in science education should, from the earliest possible time, have involvement with students and explore in depth their observations, interpretations, and alternate consequences of various classroom strategies. Increasingly, teacher training

programs are requiring such early involvements which enable students to decide whether a teaching career fits their interests. Alternate career lines within education need to be made more visible and explicit; e.g., positions with state and local governments, publishers, R & D groups, etc., need to be defined as career steps for science teachers. Visible work opportunities in associations themselves can also provide career steps important to teachers.

Becoming responsible for the conditions of entry into a profession of science education would be essential in establishing public recognition that this is a professional group. Science educators have not taken either the academic or political actions necessary to ensure that future science teachers have appropriate competencies. In the past, groups convened by the AAAS, including some teachers and teacher trainers but mainly composed of academic scientists, have proposed requirements and guidelines for teacher training. Through thoughtful analysis and concerted planning, teachers themselves could set and guarantee standards for state certification and the approval of academic training programs. This would indeed be a revolution, for teachers have been relatively negative about involvement in describing even the criteria for "competency-based" teacher education programs. Experience and academic criteria for posts as supervisors, etc., could also be set.

What has been distinctly lacking in science education is the realization of the political nature of the structure and function of a professional association, and particularly the political function of the claim to adherence to professional norms as ideology.

As Eliot Friedson (1969, p. 29), another student of the professions, observed:

> No matter how disinterested its concern for knowledge, humanity, art, or whatever, the profession must become an interest group to once advance its aims and to protect itself from those with competing aims. On the formal associational level, professions are inextricably and deeply involved in politics (emphasis added).

Our claim is that science teachers and science educators and their professional associations have followed the ideology of professionalism in science without a realization of the political purpose of that ideology. Associations in science education have modeled themselves after those in the sciences without examining the very real differences in institutional setting and socio-political function between scientists and teachers of science. Science educators possess a very different knowledge base than that of scientists. It may not be as formalized or systematic as that of the sciences, but it is real and it is about schools, children, teachers, educational systems and communities. But, it is up to us to establish in the mind of the public the relevance and necessity of our having control of the directions that science education should take, what the training of science teachers should be, their conditions of work, and the institutional connections to translate research knowledge into practice. To achieve this we must define the boundaries of the territory of our expertise,

demand a say in the allocation of resources appropriate to our occupation, and defend those boundaries against those in the scientific and educational communities who would not recognize the necessity of deference to the expertise we carry.

Public acknowledgment of professional stance and action by science teachers must be earned through political actions. To us it seems that educators in general and science educators in particular have been remarkably timid in taking action in their own behalf. Pre-service training programs are not appraised. Curricular reforms were initiated from outside the group. Training programs for refurbishing teachers did not originate with us, nor have we evaluated their effects. If we decide what needs to be done, we must work diligently through political action to achieve our purposes. If we continue to be unwilling or impotent to speak in our own behalf, we shall continue to acquiesce to decisions made for us by others.

A conclusion typical of an article such as this is to suggest that the problems and issues discussed are important, that there is little formal knowledge about these issues and problems and therefore further research should be undertaken. We eschew this notion and rather urge deliberate programs of action intended to strengthen the political and social voice of the associations of science education. In this instance research is not to be regarded as the primary mode of obtaining relevant knowledge. Associational action intended to achieve well-defined goals (safety legislation, criteria for the accreditation of schools which train science teachers and educators, etc.) is a preferred means of answering important but difficult questions. Some of these are:

1. What role should professional associations of science teachers play in the certification of science teachers, and the accreditation of schools of education to train science teachers?

2. What is the appropriate relationship between professional associations and unions of teachers to provide unions much needed advice on the special conditions associated with science teachers? What are appropriate ways to approach unions to maintain professional autonomy but still gain consultative status?

3. What are appropriate relationships for professional associations to have with legislative and administrative bodies of government at the local, state, and national level? Where can professional associations of science teachers and educators get advice on how to approach government?

4. Are social conditions in America well beyond the point where the primary role of science instruction is to provide initial professional training for future scientists? Can science teachers be critics (in the best sense of the word) of science and the scientific establishment? How can we proceed to redefine our position vis-a-vis the scientific community and the educational community?

RESOURCES

In this article we have suggested the need for science teachers, teacher trainers and researchers to assess the state of their occupations, to gauge the effectiveness of their professional organizations in voicing the concern of their occupations, and to take appropriate but assertive action in these associations. We have urged this course of action to ensure that the voices of the associations are heard among many, many competing voices. To this end we are providing a brief annotated list of readings to assist the reader in further understanding the processes of professional development in occupations. There are few published works about science teaching or science education as an occupation. Therefore much of what is to be learned must be inferences drawn from the literature on teaching and other professions.

We have also provided a brief list, with descriptions, of some of the major associations in which teachers and educators in science might be interested. We are doing this for two reasons. The first is to provide a resource for those who would like to extend their association activities. The second is to provide an overview of the gross associational structure of the science-related educational occupations. In no way should this overview be regarded as complete. It consists primarily of the national associations of science education, science, and education. Space simply does not allow the inclusion of local and state science teacher associations, academies of science, chapters of the NEA, etc. This is unfortunate because it is at the local level, particularly with the state organizations of science supervisors, that science educators are beginning to fulfill the political responsibilities of professionalism. Where appropriate, we have included information about where further information of activities at the local level can be obtained.

BIBLIOGRAPHY

Readings

Complete citations can be found in the References section.

Kelman, Herbert C. (1961). "Three Processes of Social Influence"
Kelman provides a convenient scheme which can be put to use for understanding the potential influence of associations on teachers. Of particular interest to professional associations is Kelman's notion of identification—a process of influence dependent upon the provision of role relationships with admired or important individuals.

Milgram, S. E. (1974). Obedience to Authority
The authority Milgram refers to is specifically "scientific" authority. A clear understanding of the psychological power of scientific authority in current culture is imperative to understanding science teachers and others who interact with scientists.

Schein, Edgar (1975). "Career Development: Theoretical and Practical Issues for Organizations"

Schein explores the notion of "career" and its relationship to both the individual and the organization. Little study has been devoted to the career of the science teacher. The application of Schein's analysis to science teachers and their professional associations provides one approach to the development of the professional organization of teachers.

Cooley, William (1963). Career Development of Scientists

Only available as a report, this document has been widely circulated and is in many university libraries. It is an important study of why some people persist in science careers and why others drop out or shift to alternatives. It is important for understanding some of the underlying dynamics and tensions in science education. (If there is difficulty in locating this document, write to Dr. William Cooley, School of Education, University of Pittsburgh, Pittsburgh, Pennsylvania 15260.)

Glazer, Nathan (1974). "The Schools of the Minor Professions"

The dilemmas and strains of professional identification affect teacher trainers and those who do academic research in schools of education as well as teachers. Glazer's article allows one to infer the manner in which the professional conditions of academics in science education are likely to influence their participation in professional organizations and hence the orientation of their association.

Wilensky, Harold L. (1964). "The Professionalisation of Everyone"

An analytical exploration into professionalism and its origins. Wilensky places a heavy emphasis on the acceptance of the knowledge base of the occupation by the public as the origin of professional status. Among the functions of the professional association are the definition of the occupation, the formalization of collegial behavior, and the activities to gain the public acceptance of the claim of the members of the occupation to professional status.

Etzioni, Amitai (1969). "Preface" in the Semi-Professions and their Organization

Summarizes the points of strain in some occupations: viz. those which require a (albeit limited) knowledge base similar to those of the professions and in which there are constraints on autonomy and authority. Etzioni traces the origins of professionalism to the generation and control of knowledge.

Friedson, Elio (1973). "The Professions and the Occupational Principle"

Friedson claims the origins of professionalism are in the political and social control of work. The claim to special expertise and knowledge can be regarded as an ideology to justify such control (control here taken to include authority and autonomy).

A major function of the professional association is to act on behalf of the members of the occupation to achieve this control. Hence, political action is an important aspect of professional behavior.

Goode, William J. (1969). "The Theoretical Limits of Professionalism"

Goode attempts to show that there are limits to the degree to which an occupation can become "professional." These limits are imposed by the character of the knowledge base and the degree to which sensitive or potentially dangerous knowledge about the client is necessary for the professional to carry out his task.

Ritzer, George (1974). "Professionalism and the Individual"

Individuals may behave in a professional way, but this does not necessarily mean that they are members of "professional" occupations. Ritzer distinguishes between professional behavior in individuals and membership in professional occupations. By implication, professional activity on the part of teachers makes sense despite limits to the professional status of the occupation

Marcus, Philip M. (1974). "Schoolteachers and Militant Conservatism"

The growth of large bureaucratized school systems and the simultaneous specialization within the teaching occupation are providing increased autonomy and authority to teachers individually and as a group (a point often missed by the functionalist sociologists who concentrate on stability in an occupation). Teachers have responded with demands reflecting a traditional conservative orientation toward professionalism. Professional associations of science educators may be alternative sources of progressive professional action.

Lortie, Dan (1975). Schoolteacher

A comprehensive look at the occupation of teaching including career lines, reward systems, authority and collegial relationships; very functionalistic, emphasizing stability in the occupation and not change. Lortie notes that teachers have been content to accept authority structure in the school and in recent times to shape that structure rather than to assume more control. This book is a necessity for those attempting to understand many of the dynamics of the teaching occupation.

Waller, Willard (1932). The Sociology of Teaching

This is an early work on teaching as an occupation, worthwhile for pinpointing patterns of stability in the occupation as well as direction of change. It provides an important historical perspective.

Brenton, Myron (1970). What's Happened to Teacher?

A more journalistic (and somewhat muckraking) account of the tensions and strains that characterize teaching in the large urban school districts. Subject teachers associations may be an important means of helping to ease these strains. But, the origins and

consequences of the strains must be thoroughly understood if professional associations are to be effective.

Organizations

There are many levels of action for those who wish to influence the further development of science teaching through associational activity. Associations exist on the national, state, and local levels. On these levels there are associations of science teaching and science education, associations of science to which teachers may belong, and of course associations of teachers and other educators. If the actions of the various communities that these associations represent effect the course of science teaching, then it is important that at least informal associational links between the science education community and the other communities be established. Membership in several kinds as well as levels of associations should be encouraged. (If association membership dues are taken as $20.00 per annum per association, then membership in four associations would cost less than 1 percent of a beginning teacher's annual salary.)

The following descriptive list gives information on the national associations of science education, the scientific societies that have sections concerned with the teaching of disciplines, and some relevant associations of education.

National Associations of Science Education:

<u>National Science Teachers Association</u> (NSTA)
1742 Connecticut Avenue, N.W.
Washington, DC 20009

Executive Director: Dr. Robert L. Silber

The largest science teachers association with several affiliates and sections concerned with different aspects of science teaching and science education. Publishes journals on elementary, secondary, and college levels of teaching. Sponsors national and regional conferences and other professional activities. Potentially a strong voice of the occupation in Washington. NSTA has a list of state chapters and associated groups at the local level.

<u>Council for Elementary Science International</u>
c/o NSTA
1742 Connecticut Avenue, N.W.
Washington, DC 20009

President: Beth Schultz

A section of NSTA which devotes its efforts to the concerns of elementary school science.

School Science and Mathematics Association (SSMA)
P.O. Box 1614
Indiana University of Pennsylvania
Indiana, PA 15701

Another national association, also incorporating mathematics teachers. Smaller than NSTA, SSMA also publishes a journal and sponsors an annual conference. In its earlier years the association took part in the certification criteria in several mid-western states.

National Science Supervisors Association (NSSA)
c/o Charles Butterfield
Science Chairman
Ramsey High School
Ramsey, NJ 07446

President: Charles Butterfield

An association for science teachers and others who hold administrative and supervisory positions in schools, local systems, or state departments of education. Local science supervisor associations are increasingly aware of their potential of bringing about change and improvement through legislative and administrative action. For more information about local and state activities contact the association.

Association for the Education of Teachers in Science (AETS)
c/o Joyce Swartney
State University College
1300 Elmwood Avenue
Buffalo, NY 14222

Secretary/Treasurer: Joyce Swartney

Professional association for teacher educators and college teachers with a special interest in teacher education in the sciences as well as science supervisors and administrators with training responsibility. Publishes in the journal Science Education as well as yearbooks and an occasional newsletter.

National Association for Research in Science Teaching (NARST)
College of Education
206 Memorial Hall
Drake University
Des Moines, IO 50311

Secretary/Treasurer: Paul H. Joslin

Perhaps the most "academic" of the associations of science education, NARST is comprised mostly of researchers in universities. Major political concerns are the priorities and funding allocations of research in science education.

National Associations for the Teaching of Scientific Disciplines:

Some of these associations are in fact sections of scientific societies. The following organizations are oriented towards specific disciplines in science. Their orientation, therefore, is more towards high school and college teaching. Because of the larger numbers of university and college teachers, these organizations exhibit a concern for the integrity of their respective disciplines. They also appear to adhere more closely to the well defined status patterns in the scientific community.

Their names are self-explanatory and they will be listed without further comment.

<u>National Association of Biology Teachers</u>
11250 Roger Bacon Drive
Reston, Virginia 22090

Executive Director: Dr. Jerry P. Lightner

<u>American Chemical Society</u>
Division of Chemical Education
1155 16th Street, N.W.
Washington, DC 20036

<u>American Association of Physics Teachers</u>
Graduate Physics Building
SUNY-Stony Brook
Stony Brook, NY 11794

Executive Officer: John C. Muster

<u>National Association of Geology Teachers</u>
Department of Geology
University of Arizona
Tucson, AR 85721

Secretary/Treasurer: Edgar J. McCullough

<u>National Council of Teachers of Mathematics</u>
1906 Association Drive
Reston, VA 22091

Executive Director: James D. Gates

<u>Middle Atlantic Planetarium Society</u>
c/o Peter F. Connors
Half Hollow Hills Planetarium
50 Vanderbilt Parkway
Dix Hills, NY 11746

President: P. F. Connors

<u>National Association for Environmental Education</u> (NAEE)
5940 S.W. 73rd Street
Miami, FL 33143

Secretary: Bonnie McCabe

(This Association is least likely of this group to adhere to the academic orientation described earlier.)

Associations of Science:

The American Association for the Advancement of Science (AAAS)
1515 Massachusetts Avenue, N.W.
Washington, DC 20005

Director of Education: Dr. Arthur Livermore

Strictly speaking, the AAAS is not a professional association or society. Increasingly, however, it is taking on many of the characteristics of such an association. The AAAS as a section devoted to education and an office responsible for coordinating AAAS education activities and disseminating information about science education. It publishes Science Education News (a free newsletter) and the authoritative journal Science. AAAS membership is an important one for educators and teachers. Write to the AAAS about activities at local academies of science.

Federation of American Scientists (FAS)
307 Massachusetts Avenue, N.E.
Washington, DC 20002

Director: Jeremy J. Stone

The FAS, originally the Federation of Atomic Scientists, grew out of concern over the use of atomic weaponry after the second World War. It is registered as a lobbying organization to promote the peaceful and humane use of scientific knowledge. Publishes the FAS Public Interest Report. Very important for those concerned with science-related social issues.

Associations of Education:

National Education Association (NEA)
1201 16th Street, N.W.
Washington, DC 20036

Executive Director: Jerry Hendon

Under competition from the American Federation of Teachers, the NEA has undertaken to represent teachers in collective bargaining. As such, its voice is very important in the allocation of local resources and conditions of education. Many of the concerns of the NEA are professional in nature and not simply concerns over salaries. Write to the NEA for information about local and state organizations.

American Federation of Teachers
11 DuPont Circle, N.W.
Washington, DC 20036

More explicitly a union than is the NEA. Where the AFT represents teachers, it is an important means of influence in the schools. Write to the AFT for information about local activities.

<u>Association of Teacher Educators</u> (ATE)
1701 K Street, N.W., Suite 1201
Washington, DC 20006

Executive Secretary: Melvin C. Buller

National association of those responsible for pre- and in-service teachers education.

<u>American Educational Research Association</u> (AERA)
1126 16th Street, N.W.
Washington, DC 20036

The AERA is a national association of educational researchers. Its orientation is primarily academic.

<u>Association for Supervision and Curriculum Development</u> (ASCD)
1701 K Street, N.W., Suite 1100
Washington, DC 20006

Executive Director: Gordon Cawelti

An association of teachers, administrators, supervisors, and university teachers and researchers concerned with the development, implementation, and evaluation of curricula.

REFERENCES

Asch, S. E. "Studies in the Principles of Judgments and Attitudes: II. Determination of Judgments by Group and by Ego Standards." <u>Journal of Social Psychology</u>, Vol. 12:433-465, 1940.

Asch, S. E. "Effects of Group Pressure Upon the Modification and Distortion of Judgments" in E. E. Maccoby, T. M. Newcomb, and E. L. Hartley (eds.) <u>Readings in Social Psychology</u> (3rd edition). New York: Holt, 174-183. 1958.

Brenton, Myron. <u>What's Happened to Teacher?</u> New York: Avon, 1970.

Cooley, William. <u>Career Development of Scientists</u>. Unpublished report. Cambridge, MA: Cooperative Research Project #436, Office of Education, Department of Health, Education and Welfare, 1963.

Etzioni, Amitai. "Preface" in Etzioni, Amitai (ed.) <u>The Semi-Professions and Their Organization</u>. New York: Free Press, v-xvii, 1969.

Edsall, John. <u>Scientific Freedom and Responsibility</u>. (A report of the AAAS Committee on Scientific Freedom and Responsibility.) Washington, DC: AAAS, 1975.

Friedson, Eliot. "Professions and the Occupational Principle" in Eliot Friedson (ed.) The Professions and Their Prospects. Beverly Hills: Sage, 19-38, 1973.

Glazer, Nathan. "The Schools of the Minor Professions." Minerva, Vol. XII, No. 3:347-364, July 1974.

Gold, Ra . "Janitors Versus Tenants: A Status Income Dilemma." The American Journal of Sociology, Vol. LVII:486-493, March 1952.

Goode, William J. "The Theoretical Limits of Professionalism" in Amitai Etzioni (ed.) The Semi-Professions and Their Organization. New York: Free Press, 266-308, 1969.

Gross, Edward. "Sociological Aspects of Professional Salaries in Education" in Robert R. Bell and Holger R. Stubb (eds.) Sociology of Education (revised edition). Homewood, IL: The Dorsey Press, 1968.

Hollander, E. P. and R. H. Willis (1967). "Some Current Issues in the Psychology of Conformity and Non-Conformity" in E. P. Hollander and R. C. Hunt (eds.) Current Perspectives in Social Psychology (3rd edition). New York: Oxford University Press, 435-450, 1971.

Kelman, Herbert C. "Three Processes of Social Influence" in E. P. Hollander and R. G. Hunt (eds.) Current Perspectives in Social Psychology (3rd edition). New York: Oxford University Press, 421-434, 1971.

Kelman, Herbert C. and Carl I. Hovland. " 'Reinstatement' of the Communicator in Delayed Measurement of Opinion Change" in Samuel Himmelfarb and Alice H. Eagly (eds.) Readings in Attitude Change. New York: Wiley and Sons, 138-149, 1974.

Lieberman, Myron. Education as a Profession. Englewood Cliffs: Prentice Hall, 1956.

Lortie, Dan. Schoolteacher. Chicago: University of Chicago Press, 1975.

Marcus, Philip M. "Schoolteachers and Militant Conservatism" in Eliot Friedson (ed.) The Professions and Their Prospects. New York: Sage, 191-216, 1973.

Milgram, S. E. Obedience to Authority. New York: Harper and Row, 1974.

Musgrove, P. W. The Sociology of Education (2nd edition). London: Methuen and Co., 1972.

Ritzer, George. "Professionalism and the Individual" in Eliot Friedson (ed.) The Professions and Their Prospects. Beverly Hills: Sage, 1973.

Schein, Edgar. Career Development: Theoretical and Practical Issues for Organizations. (Also published in Career Planning and Development Management Series, #12, of the International Labor Organization.) Offprints available from Professor Edgar Schein, Sloan School of Management, MIT, Cambridge MA 02139, at a cost of $1.80. [Schein explores the idea of "career" and its relationship to both the individual and the organization.]

Schein, Edgar. Coercive Persuasion. New York: Norton, 1971.

Stubb, Holger R. "The Professional Prestige of the Classroom Teacher: A Consequence of Organizational and Community Status" in Robert R. Bell and Holger R. Stubb (eds.) Sociology of Education (revised edition). Homewood, IL: The Dorsey Press, 251-272, 1968.

Waller, Willard. The Sociology of Teaching. New York: John Wiley and Sons. (Undated reprint of 1932 edition.)

Weller, Charles M. The Role Orientation of the Secondary School Science Teacher. Unpublished Doctoral dissertation. Cambridge, MA: Harvard University, Graduate School of Education, 1965.

Wilensky, Harold L. "The Professionalization of Everyone?" American Journal of Sociology, Vol. LXX, No. 2:137-157, September 1964.

Groups with special needs lobby or pressure government to try to influence changes. Groups also lobby education. They do this directly through contact with the schools or indirectly through government or other social agencies. Handicapped students are one such group. Present trends are to put handicapped students in public schools rather than in separate institutions. This requires that the schools make physical modifications and programs which are compatible with handicapped students. George Mallinson discusses the issues associated with providing science education for blind, deaf, and orthopedically handicapped students.

SPECIAL STUDENT NEEDS: SCIENCE FOR THE HANDICAPPED

George G. Mallinson

INTRODUCTION

When this author was first invited to prepare a chapter for this Yearbook of the Association for the Education of Teachers in Science, he planned to deal with four groups: the intellectually talented; the visually impaired; those with hearing disabilities; and the orthopedically handicapped. After some thought, and because of the involvement of the National Science Foundation with the Science for the Handicapped Program, he decided to eliminate the intellectually talented from consideration and limit the "special students" to those in the three handicapped groups. It is worthy of mention that proposals targeted on these three groups were the ones funded with grants from the National Science Foundation in 1977.

The part of the legislation leading to the Science for the Handicapped Program is nebulous with respect to its objectives. Apparently the concern arose when a group of persons from handicapped organizations went to the Senate Committee dealing with the FY 77 appropriation for the National Science Foundation and suggested that some funds should be included to provide opportunities for entry or reentry of handicapped persons in scientific careers. The legislation included only a brief statement about the $500,000 that was included for the program. It did little more than tell the National Science Foundation to "do something." The $500,000 was "sealed" in Mandation Section 7, P.L. 94-747, National Science Foundation Authorization Act FY 1977 and signed on October 11, 1976. On page 21 of Report #95-93 which accompanies S-855, there is a recommendation for $3 million for FY 78 and FY 79 for programs for minorities, women and the handicapped in science. It seems to be the opinion of personnel in the National Science Foundation that the program will be permanent insofar as anything is permanent in the federal government.

Without question, the aims of the program are laudatory, particularly with the idea of "mainstreaming" the handicapped into scientific

careers. The writer wishes to point out, however, that funds from the National Science Foundation and other federal agencies have deluged educational institutions in the hope of improving scientific literacy, increasing the numbers of students electing sciences, particularly high school physics; raising levels of verbal and quantitative achievement of students; and, in general, making sure that all good intellectual things are disseminated to everybody. The flow of money into these enterprises has, if the results of research studies are any criterion, resulted, at best, in only a trickle of accomplishment. Indeed, if the scores of SAT and similar tests are any criterion, there has been a retrogression in achievement. There is much evidence to suggest that the United States and other nations have had less than reasonable success in "mainstreaming" the nonhandicapped. If anyone thinks that this can be accomplished easily with the handicapped, he/she is "whistling into the wind." In fact, many efforts to "mainstream" the handicapped in the past have ended up with drowning the victim of all the good will. Probably, the major deterrent factor has been the low population of hybrid personnel who understand the scientific enterprise and also field of the handicapped. Those who had expertise in the scientific enterprise had good intentions for dealing with the handicapped but little expertise and vice versa. Also, even among those with expertise in dealing with "special students" with these handicaps, there is frequently a lack of understanding of the implications of the dimensions and configurations of these handicaps.

SOME DEFINITIONS

Before dealing with activities that lead to mainstreaming, it is appropriate to "define" what the three handicaps are. That task is difficult, if indeed it can be done at all.

Blindness or Visual Impairments

Blindness is often construed as the complete lack of any light perception. However, few of the persons who are classified as being blind are that severely handicapped. A much better term is "visual impairment" since the handicap is a matter of degree, not an all-or-nothing characteristic. A person is considered to be "legally blind" if his visual acuity in the better eye is 20/200 or less with ordinary corrective lenses and/or if he has a visual field that extends no greater than 20 degrees at its widest diameter. There are, however, many legally blind persons who have passed the test for a driver's license and some who drive without such legalities. In fact, the classic case is that of the legally blind person who drove his car alone from Washington, DC to the Veteran's Administration Hospital at Hines, Illinois, just west of Chicago, to enter the training program for orientation and mobility for blind veterans.

One must also recognize the difference between those who are congenitally blind and those who are adventitiously blind. Both forms of blindness may occur because of endogenous or exogenous factors. Endogenous factors are genetic in nature. Exogenous are those that arise

from disease, toxicity, injury and other external forms of damage. But those who are born blind (congenital) never have any visual reference and the same is true for those whose onset of blindness (adventitious) is prior to five years of age. Those whose onset of blindness is after five years of age retain some visual reference, the amount depending on the age of onset. Consequently, persons with the same degree of blindness may have quite different functional capabilities. Also, persons who are classified as legally blind may differ greatly. The deterioration of vision may be generalized over the entire visual field or it may be total for a large portion of the visual field with normal vision in the small remaining portion. The reader is referred to Harley (1973) for a more extensive discussion.

Deafness or Hearing Impairment

The classification of hearing impairment is not so well defined as that for visual impairment. They are alike in that the impairments may be congenital or adventitious and endogenous or exogenous (McConnell 1973). But, there is no "legal" definition for deafness as there is with blindness. However, a deaf person is considered, by professionals, to be one with a 50-70 decibel bilateral hearing loss with maximal correction on the basis that normal language is produced at about a 60 decibel level. Stated in more practical terms a "deaf" person is one whose hearing loss at birth or before two or three years of age is so severe that the normal spontaneous development of spoken language does not occur. Those classified as "partial hearing" have a hearing loss in the prelingual period that is not so severe as to prevent the development of some spoken language, or who have normal hearing during the prelingual period but develop a hearing loss later.

Hearing impairment is classified at a number of levels but the three greatest are referred to as (1) marked with a 56-70 decibel loss in which the person encounters frequent difficulty with loud speech; (2) severe with a 71 to 90 decibel loss in which the person can understand only shouted or amplified speech; and (3) extreme with a loss of 91 decibels or more in which even amplified speech cannot be understood. In addition, hearing loss may be selective in terms of frequency with a person having low auditory acuity with high frequencies and normal with low or vice versa.

Orthopedic Impairment

It is clear from the report by Wilson (1973) that the definition of "orthopedically handicapped" is even more nebulous. According to the Veteran's Administration, the loss of one leg usually represents a 40 percent disability and the loss of both legs, a 100 percent disability. However, these "ratings" are mainly criteria for awarding compensation, not for measuring disability. Many who have lost both legs and have been fitted with prosthetic limbs are highly mobile and productive individuals. The assignment of a 100 percent disability rating in terms of functional capabilities is grossly incorrect. The

same is true for the assessment of disability of a person who has lost one or both arms, or who has lost functional capabilities in the extremities because of disease or injury. A person who has cerebral palsy may have mild to severe spastic involvement on one or both sides but yet is able to walk, talk and think.

It is obvious, therefore, that stereotypic assumptions about the discrete configuration of the characteristics of a handicap are totally invalid. This does not suggest, as many zealots do, that the handicap can be dismissed merely as an irrelevant characteristic, such as hair color or skin color. Many "mainstreaming" efforts have gone "down the tube" because of such casual dismissal. It does suggest, however, that the approach must be positive in terms of assessing what the individual can do and not in terms of the limiting effects of the handicap.

JOB ASSESSMENT AND INDIVIDUAL ASSESSMENT: AN IMPEDANCE MATCH

This paper deals mainly with issues related to expanding opportunities for the handicapped in science. Consequently, the factor of job assessment will be dealt with only briefly. It should be emphasized, however, that assessments of the knowledges and skills needed to perform successfully in scientific jobs must be made and must be available to vocational counselors who deal with the handicapped. These are available from sources within the U.S. Department of Labor, particularly on a "thumbnail" basis in the Dictionary of Occupational Titles (1965). Obviously, the qualifications needed to perform in a job will vary with the industry or organization in which the opportunity exists. Thus, it should be kept in mind that the configurations of knowledges and skills needed for jobs are not discrete any more than the configurations of characteristics of handicaps are discrete. In effect, the essential parameters, not the specific activities, of the job must be identified and the vocational counselor must have "psychological ownership" of them.

Parenthetically, it must be recognized that the qualifications of many vocational counselors, including those of some who are involved in rehabilitation counseling, are less than adequate. This should not be construed as a blanket indictment or even an indictment of the majority. One must face the situation, however, in accord with Murphy's Law, that if it is possible for things to go wrong, they will.

The assessment of individuals must be the responsibility of professionals who are perceptive of capabilities, both existent and potential, of the handicapped, rather than being experts in the limitations. Obviously, the latter must be considered, but it should be secondary to the former. The data from the assessment of individual capabilities must be transmitted to the vocational counselor, and as with the assessment of job knowledges and skills the counselor must have psychological ownership of the implications of the data.

The match of qualifications for the job and capabilities of the individual should not be prescriptive since there are many variables that must be considered, including, among many others: age, general physical condition of the individual, prognosis of the trend of the handicap, mobility requirements of the job, and demands for preservice and continued inservice education. Any effort to make the match, therefore, should be suggestive.

Expertise for suggesting possible matches should be sought from individuals who have been successful in entering scientific careers as well as from those who have not been successful. The types of information that should be sought will be discussed in another section.

MOBILITY

Opportunities for entering or extending scientific careers depend greatly on the mobility demands of the job, the mobility capabilities of the handicapped, and the extent to which it is feasible to remove barriers that limit mobility. Mobility of those with severe visual impairments began with the sighted guide and successively involved the cane, the guide dog, the long cane and more recently the laser cane, sonic guide, and Lindsay-Russell Pathsounder. Within the past few years there have been many developments with low-vision aids of various types such as special eye glasses that improve visual perception markedly. All these increase the accessibility of the environment to the handicapped individual. Since World War II, the numbers of programs for training rehabilitation teachers for the blind, orientation and mobility specialists, and low vision specialists have increased greatly and so opportunities for increasing the mobility of the visually impaired have increased greatly. This does not mean that the needs have been met adequately since they have not. However, the situation has definitely improved.

About the only devices used to increase the mobility of the deaf involve amplified speech and the use of air and bone conduction hearing aids. These have become increasingly smaller, and more efficient as microelectronics have developed. Without regard for the affective advantages of the cosmetic improvements in these devices, they have enabled those with hearing impairments to respond to environmental stimuli to which they formerly could not. It is important to note that mobility, other than by constant visual scanning of the surroundings, depends on these responses. For those with marked, severe or extreme hearing impairments, lip-reading may be the most efficient alternative to speech communication. However, the percentage of those with hearing impairments who can lip read is relatively small and this skill does not enable the handicapped person to respond to environmental stimuli that have auditory dimensions and to which he is not directing his eyes. The feasibility of using a sign-language interpreter on-the-job is quite questionable.

Prosthetic devices for the orthopedically handicapped have become increasingly more sophisticated in terms of increasing mobility. The

use of lightweight alloys have made it possible to develop more efficient canes and crutches. It is also evident that prosthetic limbs, motorized wheelchairs and other mobility aids increase capabilities far beyond th of the earlier ones. It would not be appropriate to discuss their characteristics at length in this section since the theme is "mobility" not "hardware." One should mention, however, the development of barrier-free environments with the construction of ramps instead of curbs at street corners, the modification of lavatory stalls to accommodate wheelchairs, and the adaptation of vans to admit the orthopedically handicapped.

In summary, although it may seem that this section has dealt with what might be generally referred to as prosthetic devices, the emphasis is on using the devices to increase the mobility of the handicapped without which entry into, or extending, scientific career opportunities would be relatively impossible. But, there are four facets that must be considered in using devices to increase mobility: (1) developing and improving the devices; (2) making the devices available to the handicapped; (3) training personnel to teach the handicapped to use the devices; and (4) training the handicapped to use them. Realistically, cost is a major consideration since the market for the devices cannot be compared with the demand for automobiles, shirts or canned beer and consequently, the unit cost is high. In most cases, much of the training of personnel to teach mobility to the handicapped, and teaching the handicapped is on a one-to-one basis. Also, the handicapped are among those whose monetary resources are least affluent. Consequently, the extension of mobility of the handicapped and their subsequent increased entry into scientific careers must be accepted initially as a social cost. But, the cost of maintaining a handicapped person on welfare during his productive life is at least ten times greater than the cost of making him self-sustaining. The economic advantages of the initial cost of providing mobility are obvious.

BASELINE DATA NEEDED FOR IMPLEMENTING OPPORTUNITIES IN SCIENCE FOR THE HANDICAPPED

Currently, other than for the visually impaired in the field of data processing, there are no complete lists or assessments identifying handicapped persons in the scientific community, or the competence with which they function in their jobs. The American Association for the Advancement of Science (AAAS) has initiated a Project on the Handicapped in Science and has a number of publications, one in particular that was edited by Redden and Schwandt (1976) that seeks to gather such information. Also, the grants under the Science for the Handicapped Program of the National Science Foundation support several projects that have that intent. However, these efforts so far have only scratched the surface.

Perhaps even more important, there has been no definitive study that identifies the problems the handicapped have had with obtaining education for their present jobs, or the problems they encountered in placement and on-the-job activities. It would seem, therefore,

that the following must be accomplished if improved entry into, and extension of, job opportunities into scientific careers are to be implemented.

1. a. Identification of the problems the handicapped encountered in selecting an educational program that led to current employment.

   b. Identification of the types of professional support the handicapped received in selecting an educational program that lead to current employment.

2. a. Identification of the problems the handicapped encountered in entering and completing the educational program.

   b. Identification of the types of professional support the handicapped received in entering and completing the educational program.

3. Identification of the types of vocational rehabilitation the handicapped received, including training and fiscal support.

4. a. Identification of the problems the handicapped encountered on job placement. These problems would consider both personal and external factors.

   b. Identification of the types of professional support the handicapped received in job placement.

5. Identification of the problems the handicapped encountered since job placement.

   a. Attitudes of colleagues.
   b. Job requirements.
   c. Adaptations of job environment.

6. Identification of the successes and failures the handicapped encountered in advancement on the job.

7. Identification of the types of common problems that are encountered by all handicapped groups and the types of problems encountered that are unique to the different handicapped groups.

Unless such information is obtained and used, there will be much "spinning of wheels."

AN EPILOGUE

Those members who express concern for the handicapped must be lauded for their attitudes. However, several cautions must be observed.

1. The problems with general and specialized education of the handicapped are greater than those with the non-handicapped as is attested to by veterans in the field. More efforts and dedication are needed than with the nonhandicapped although accomplishments are much more rewarding.

2. There are few handicapped persons who do not also have some corollary physical, psychological or social problem that needs attention. Thus, one must not dismiss a visually-impaired person as being only visually impaired. However, the author hastens to add that those who do become involved should not become wary and start searching for other problems.

3. Much time and effort are required, as with all education, to produce and particularly to observe results. They do not occur overnight. There is much evidence, an example being the environmental movement, that disenchantment sets in when "instant" success is not evident. If such does happen the fresh ideas of newcomers will be unfortunately lost. In other words, "If you do get involved, stick with it."

4. Finally, and this probably should have been the first paragraph of the paper, the handicapped should not be considered benefactors of charity. They are taxpayers, have egos, and display the spectrum of personality traits that are found in the "non-handicapped." No one is perfect and so everyone is handicapped to a degree in one or more ways, probably more. As taxpayers, the handicapped have a right to access to the environment and to job opportunities in every area in which they have capabilities. The obligation is to help them exercise that right.

REFERENCES

Harley, R. R. "Children with Visual Disabilities" in L. D. Dunn (ed.) Exceptional Children in the Schools: Special Education in Transition: Second Edition. New York: Holt, Rinehart and Winston, 411-464, 1973.

McConnell, F. "Children with Hearing Disabilities" in L. D. Dunn (ed.) Exceptional Children in the Schools: Special Education in Transition: Second Edition. New York: Holt, Rinehart and Winston, 349-410, 1973.

Redden, M. R. and W. Schwandt (eds.). Science, Technology and the Handicapped. American Association for the Advancement of Science, Report No. 76-R-11, August, 1976.

Wilson, M. I. "Children with Crippling and Health Disabilities" in L. D. Dunn (ed.) Exceptional Children in the Schools: Special Education in Transition: Second Edition. New York: Holt, Rinehart and Winston, 465-530, 1973.

U.S. Department of Labor. Dictionary of Occupational Titles: Third Edition: Volume I: Definition of Titles. U.S. Government Printing Office, 1965 and Volume II-Occupational Classification. U.S. Government Printing Office, 1965.

One of the biggest pressures which students feel from society is the pressure to be employable. Although technical and scientific employment is available, students feel immense pressure to do well so that they can eventually get a "good job." Career education is the schools' response. What career education is and how it is related to science education is the subject of Michael Leyden's paper.

CAREER EDUCATION

Michael B. Leyden

A NEW CAREER: CAREER GUIDANCE PERSONNEL

The Family of Man—In Search of Employment

Jimmy Carter campaigned on the issue of a 7.9 percent unemployment rate, and a promise that he would attempt to reduce that figure to 6.4 percent within one year. And when Carter became President, he forced Gerald R. Ford to be unemployed. The issue of employment is important for people at all levels of society--from presidents to paupers. When people cannot find work, they wallow in depression and poverty, and question their self-worth. When they retire, people often become despondent because of their inability to constructively use their sudden wealth of leisure time.

What we "do" in life is of great importance to ourselves and others. What we "do" can be called many things: employment, a job, career, vocation, profession, business, or work. No matter what the title, the search for something that is enjoyable, profitable, and stimulating to "do" is almost a built-in drive of people.

Career education is concerned with human and economic survival. Parents, relatives, friends, the teaching community, and of course, the media, all have roles in helping a person select a career. Many careers have been created in the career guidance field—constructing, administering, and evaluating the results of interest and ability tests. The public often points toward our educational institutions as bearing the sole responsibility for career training. There are two polarized thoughts on the concept of formal education as the vehicle for career training.

First, there is the school of thought which springs from the pure vocational education programs. They believe that there are certain basic skills for many types of jobs that can be taught and will never be outdated by technological advances. Once students learn these task skills they'll be able to adapt to future changes in the field of expertise. This concept of career training is esoteric.

Others see the role of formal education as being that of career awareness—not career training. Anchored in a broad base of liberal arts, this form of teaching believes that students should learn more than just task and job analysis techniques. Those who favor career awareness hope to teach young people about problem solving and decision making, the values of work, to seek understanding of oneself in relationship to work, and to realize the interdependence that exists in the labor community. Such goals cannot be met with a narrow, specialized vocational program.

One of the most ironic problems of employment is the vast amount of leisure time that is left each week after a person has worked for 35-40 hours. Four-day work weeks are not uncommon. Some corporations are even trying a three day, 12-hour work shift! That would leave four days of leisure time. Time to do what? Those trained exclusively for the world of work find there is more to life than a job.

"But," the cry goes up, "I have a niece who got a BA degree in history and is a clerk! What good did all that schooling do her?" Only the niece knows for sure. When she isn't clerking, maybe she reads, visits art, historical and science museums works with the League of Woman Voters, and realizes that she is living a productive 24-hour-a-day life. When she punches out of the store in the afternoon, her mind is still active. Charley Johnson, a Ph.D. in chemical engineering, was a quarterback in the NFL and now works in sales and public relations for a large company. Charley Johnson is a total person, at work and play. It is important to remember that a person's education should not be limited by the work he/she does.

Work Issues—More Than Just Labor[9]

If unemployment is the major problem facing economic America, it is closely followed by the second most pressing issue: job dissatisfaction by those who are employed. Listen to these employees... "I'm a machine," says the spot welder. "I'm caged," says the bank teller, and echoes the hotel clerk. "I'm a mule," says the steelworker. "A monkey can do what I do," says the receptionist. "I'm less than a farm implement," says the migrant worker. "I'm an object," says the high fashion model... This is America at work. This is a depressed America—the shame of the GNP.

A career is more than just a job; it becomes part of the person. Like a marriage, the person and the job must meld—and like the many marriages that are dissolving at a rapid pace, job dissatisfaction waxes alarmingly.

No one can say that there is a shortage of jobs. Every day newspapers list jobs that go wanting because they are jobs that nobody wants.

I was eating breakfast in a restaurant. A man dressed in a suit sat next to me and ordered coffee. A few minutes later he was spotted by a waitress who greeted him cheerfully and exclaimed: "Gosh, Barney, where are you going all dressed up like that on a Saturday?"

He sipped the black brew, put down his cup and replied: "I've got to work this afternoon. I have a job, too." The tall, thin red-headed lady put her hands on her hips and sighed: "Listen, Barney, I have a JOB. Anyone dressed up like you has a POSITION."

People don't want "any old job," they want a position! The janitor becomes a "Building Engineer," salespersons are "Account Executives," secretaries are "Offi- nagers," and the list of euphemisms grows.

On one hand we have unemploy e, and on the other we have unemployed people who won't accept any job. Ironically, it is often the most ill-prepared worker who is the most particular when it comes to selecting a job. A well-defined career awareness program may allow students to assess their abilities and goals with the vast number of available occupations and to select a position that is neither too high nor too low. Let us examine some of the problems of establishing such a program.

THE VAST TASK: CAREER AWARENESS

Defining Terms

There is not only a problem of defining terms used in career education, but there is the task of defining what terms one wants to define. The most critical term is career education itself. Most states and schools have formed definitions to meet their own needs.

Kenneth B. Hoyt, Head of the Office of Career Education of USOE, has defined career education this way:

> Career education is the total effort of public education and the community to help all individuals become familiar with the values of a work-oriented society, to integrate those val [illegible] their personal value system, and to implement thos [illegible]es into their lives in such a way that work becomes [illegible]ible, meaningful, and satisfying to each individual (Heyden and Peterson, 1975, p. 15).

There are also other terms to define: work, career, education and leisure. The person-in-the-street definitions of these words is fairly restrictive. Work is more than what you do for pay—it should be thought of as a conscious effort at producing benefits (materials or services) for one's self and others. A career is not just a list of jobs a person has had but is the totality of work experiences he/she has encountered. Often as person changes jobs, he/she moves to another with a similar theme. For example, sales could be in automobiles or television sets. The job may change, but the career theme of sales lingers. The term education is not restricted to schooling but should be thought of as the totality of formal, informal and incidental experiences through which a person learns. Leisure is more than play; it is all those activities which person pursues when not engaged in his/her vocation.

But what is a vocation? Defining career education terms is somewhat like science teachers who get bogged down trying to distinguish between inquiry teaching, guided discovery, and discovery learning; the differences are often blurry. (For a more elaborate discussion of career development theory and associated terms, see Herr (1972), Osipow (1968) and Peterson and Peterson (1975).)

Implementation Patterns

Inviting the butcher, the baker, and the candlestick maker to visit your classes is not exactly all that is involved in a career education program. It is important but such resource persons must fit into a program which has a strategy and a long-term goal. Eastern Illinois University has developed a list of career development concepts (cdc), and it is such a rationale which separates a hit-or-miss program from a sequentially based one.

Career awareness is a blend of career development concepts (cdc), subject matter concepts (smc), and occupations available (occ). To which extent should any of these three be stressed, omitted, or integrated with the others? The degree of emphasis provides for several possible models of implementation:

Pattern One: Some schools start with cdc and then look for ways that these can be reinforced in various subject matter areas with smc. Although occ are not stressed, they are inherently present to some degree.

Pattern Two: Another approach is that which stresses a subject matter model. The smc might be selected, and then the application of idea to people with specific occupations is suggested. In this framework, cdc are omitted.

Pattern Three: Here specific occupations serve as the organizing force around which smc are aimed. The cdc are treated as a separate subject rather than integrated with the smc and occ.

Pattern Four: The Enrichment of Teacher and Counselor Competencies in Career Education Projects (ETC) at Eastern Illinois University (1974) produced a program which gives equal emphasis to smc/cdc/occ. Sponsored by the USOE, the ETC produced 11 major concepts essential for career development and then cited 76 subconcepts.

It does not take much imagination to envision how these cdc could be integrated into a science program without any drastic deviation from the normal lesson plan. The use of career information should actually enhance the attainment of the science objective for any lesson.

Fig. 1: Career Development Major Concepts[1]

Attitudes and Appreciations

Society is dependent upon the productive work of individuals.

Career Information

Basic career information will aid in making career-related decisions.

Coping Behaviors

Certain identifiable attitudes, values, and behaviors enable one to obtain, hold, and advance in a career.

Individuals can learn to perform adequately in a variety of occupations and occupational environments.

Decision Making

Life involves a series of choices leading to career commitments.

Basic components of the decision-making process can be applied to the establishing of personal goals and the making of career-related decisions.

Educational Awareness

Educational skills and experiences are related to the achievement of career goals.

Lifestyle

Work affects an individual's way of life, in that a person is a social being, an economic being, a family being, a leisure being, and a moral being.

Self-Development

An understanding and acceptance of self is important.

Social, economic, educational, and cultural forces influence self-development.

Individuals differ in their interests, aptitudes, values, and achievements.

---

[1] The "Career Development Major Concepts" were compiled by the Enrichment of Teacher and Counselor Competencies in Career Education (K-6) Project, Eastern Illinois University, Charleston, Illinois. This chart was developed by taking parts of the tables in Leyden (1976, pp. 88-92) and is printed here with the permission of School Science and Mathematics.

What Is A Scientist?

If you were to ask the public to describe a scientist, they would begin talking about a male who wears a long white lab coat, and then go on to list other misconceptions. Most of the scientists I see in the labor community are male, but very few have a college degree or wear a long white lab coat. I'm talking about electricians, auto mechanics, photographers, television repairpersons, and many others. They are all scientists because of the way they attack problems. It is the thought processes they use which classifies them as scientists. In the Piagetian sense, they are "if-theners," using the logical construct: "if-then, therefore." While millions of housewives are not in the "paid" laboring force, many of their daily decisions call for formal thought. In fact, survival in our society calls for people to make daily decisions on the basis of "if-then"-ing.

Because of the technological nature of our society, the chances for students ending up in a science-oriented career are much higher than you think. A college graduate with a BA in English might be the science editor for a radio/television station or magazine. The students with an art background could be a science museum curator. A major in social studies becomes the city planner.

Conceptual Models

Elementary School: Shown in Figure 1 were the seven areas and 11 major concepts that were considered by the ETC Project. Figure 2 is an elaboration of two areas, Coping Behaviors, and Decision Making. In this chart and the complete list which can be seen in Leyden (1976), each of the concepts has a sub-concept suggested for each grade level. It is important to realize that because some statement falls into the Second Level, does not mean that it should be omitted at higher levels. Here is the First Level statement from Coping Behaviors: "An individual should learn to cope with the rights and feelings of others." There are many adults walking through life who still haven't internalized that concept. How many of the statements listed has the reader assimilated? The complete list of 76 statements might serve as an "OK Index" for the reader—a barometer of OK-ness with themselves and with others.

But what does all this mean? How do I go about getting this "stuff" into my lesson plan? It is really quite easy, as this example might illustrate. Let us examine the second level Coping Behavior statement: "An individual should learn how to give and take criticism." Certainly, this is another guideline that many adults cannot handle. By making children aware of these ideas early in the elementary school, it will not only be an aid in career awareness but will also serve to produce more people who are able to cope with the problems of life on the job and off the job.

Science has a history that is filled with controversial issues and debate! Is light a wave, Mr. Huygens, or is it a particle, Mr. Newton?

DIMENSION	MAJOR CONCEPT	READINESS LEVEL	SUBCONCEPTS FOR EXPERIENCE LEVELS READINESS THROUGH SIXTH					
			FIRST LEVEL	SECOND LEVEL	THIRD LEVEL	FOURTH LEVEL	FIFTH LEVEL	SIXTH LEVEL
COPING BEHAVIORS	Certain identifiable attitudes, values, and behaviors enable one to obtain, hold, and advance in a career.	An individual should learn to cope with authority exercised by others	An individual should learn to cope with the rights and feelings of others.	An individual should learn how to give and take criticism.	A contribution to group effort can be made by demonstrating ability to both compromise and exercise influence in achievement of group goals.	Certain behaviors are appropriate to specific job settings.	There is a universality of feelings and aspirations of all people—regardless of physical appearance, nationality, creed, sex, or ethnic background.	There are effective interpersonal relations skills for giving or evaluating instructions.
	Individuals can learn to perform adequately in a variety of occupations and occupational environments.	Different skills are required for different tasks.	Several skills are required for different tasks.	Some skills can be transferred from one job to another.	Performance requirements for a job vary with the work setting.	Performance requirements for a job may change with time.	It is important for a person to be able to make the transition from one job to another.	There are characteristics which differentiate between occupations—both within and between job families.
DECISION MAKING	Life involves a series of choices leading to career commitments.	Choice means "making up one's mind" and there are certain situations where one can make choices.	Things change and these changes influence the choices and decisions one makes.	An individual's decisions affect himself and others.	People change and these changes influence the choices and decisions one makes.	Decision making involves risks.	Decision making can precipitate chain reactions.	Previous decisions, peers, gratifications, needs, interests, and career information influence present and future decisions.
	Basic components of the decision-making process can be applied to the establishing of personal goals and the making of career-related decisions.	An individual should recognize what "a goal" is and learn how to set one's own goals.	Problems which conflict with one's goals can be identified and assessed.	An individual should consider alternative ways to reach a given goal.	Decision making plays a role in the setting of immediate and long-range goals.	The decision-making process can be used to set priorities in developing personal goals.	Setting goals can be enhanced by analyzing decision-making processes.	The decision-making process can be used to determine one's preferences, at that point in time, between various job families.

Fig. 2.--Developmental Dimensions Scope and Sequence

[1]This chart is taken from Leyden (1976, pp. 288-289) and is printed with the permission of School Science and Mathematics.

Older students could research this issue, and perhaps even put on a debate dressed in 17th century apparel. Ask the children how they feel when criticized for something they believe in. How do they think Newton and Huygens felt? Why do people criticize? And by the way, which scientist was correct: Newton or Huygens?

It takes a lifetime to achieve equilibrium with all of the statements in the ETC scope and sequence chart, but by using it in the elementary school, many children will get a six-year head start in reaching this goal. There is more to a career than getting paid. The key to success in any job is not the financial reward or the number of college degrees held, but the inner peace that is secured as the person whistles while he/she works. One of the prime goals of a career awareness program is to help people be content with themselves, their job, and their working peers.

Junior and Senior High School: Once a child walks away from the elementary school, the concept of career education begins to emerge from the fantasy stage to the onset of reality. Students begin to obtain after school and vacation jobs. Some of the money that is earned is spent on clothes, records and good times. Part of it may be saved for a college education and in the traditional sense, a time that will train them for a life of work. If an active, exciting science program was not provided for in the elementary school, then it will be difficult for the junior high school teacher to focus the child's energies on this discipline. Since most of the science courses at the high school level are electives, the child with a negative perception of the sciences will have his/her last course at the ninth grade. That would put a damper on the child's chances of working toward a science career that would require a college degree, but still many chances for him/her to get a science-oriented career would exist.

One of the basic problems facing junior high school teachers is that the logical development of the child does not meet the traditional syllabi of our schools. In the Piagetian sense, most students are concrete operational throughout high school, and the types of science studied in these grades calls for formal operational logic. Understanding subject matter concepts calls for rational thought processes that are not present. Because of the student's inability to handle abstractions within the discipline, it is almost hopeless at times to talk about the most abstract concept of all: a career ten years from now. But, a success oriented, activity-centered approach to science lessons is a vehicle that could change the student's ability to handle the discipline as well as to project future career plans into his thinking. Leyden has discussed this issue in the writings noted in the bibliography.

Earlier, the ETC model for career education was illustrated. The Educational Properties, Inc. planners have developed another model for secondary school students. Their categories include: Self Awareness, Appreciations and Attitudes; Decision Making; Educational Awarnesss; Career Awareness; Economic Awareness; Skills Awareness; and Employability Skills. A complete list of the concepts to be developed at each grade level are noted in Leyden and Peterson (1975).

Under tenth grade Appreciations and Attitudes is listed this concept: "Understand the importance of all careers and their contribution to society." What is one way to implement this idea for students?

Career awareness develops many odd-couple relationships in the curriculum. It has been said that science is the art of looking at nature. This might or might not be true, but there is certainly a lot of art in science. A student with low ability, but interest in the sciences and high ability in art, might combine a career in both. This person could construct posters, make dioramas, and take photographs of various science-related things. People with art and science backgrounds become museum curators, media people for scientific supply houses, or scientific photographers. An art and science combination might not seem to be a possible career outlet but, with a little imagination, the two fit together perfectly.

Some Closing Thoughts

Why are you reading this paper? How did you, the reader, ever get into the position of reading an AETS yearbook? How did you ever choose your career? What were the important factors? Fifteen years ago I was content to be a junior high school science teacher and that was the extent of my career. Through some people who really turned me on to science education and luck of being at the right place at the right time, here I am at the keyboard. There is a lot of "luck" involved in anyone's career success, but there is a lot of hard work, too. If students receive a solidly basic, sequential career awareness program, they will realize that they can make their own breaks through hard work and rational decision-making processes. They won't leave their life's work up to chance.

RESOURCES[1]

BIBLIOGRAPHY

General:

Can I Be a Scientist? Public Relations Staff, General Motors Corporation. Considerations of a scientific career, background required, and opportunities.

Careers and Opportunities in Science. Philip Pollack, E. P. Dutton & Company, Inc. Opening with a broad survey of the impact of science upon our lives, the author shows the career opportunities in many fields of science. $4.95.

[1]This section is taken from Leyden and Peterson (1975) and is printed with the permission of Houghton Mifflin.

Careers in Science and Engineering. Civil Service Commission. Basic information for people desiring jobs in these fields with the federal government. 8 pp.

Engineers, Scientists, and Related Professions in Mathematics and Statistics. Civil Service Commission. Information about entrance levels GS-5 and GS-7. Briefly describes the careers and requirements for these professions.

Jobs in Science. Science Research Associates, Inc. Physics, chemistry, biological sciences, earth sciences—a variety of jobs in each of these fields is covered in this booklet. 48 pp. $1.50 ea., net.

Jobs in Technical Work. Science Research Associates, Inc. This booklet describes careers for technicians working in chemistry, physics, metallurgy, and other areas. 48 pp. $1.50 ea., net.

Occupational Goals for College Students, Part I: Architecture, Engineering, and the Physical Sciences and Part II: Agricultural and Related Sciences. The Ohio State University, Publications Sales Office. Facts about career prospects in these fields. Part I: 96 pp. 75c. Part II: $1.50.

Science and Engineering. International Business Machines Corporation. Outlines career opportunities for engineers, scientists, mathematicians, physicists, programmers, chemists, and metallurgists. Includes sections relating to IBM company products, benefits, and working environment.

Search—Science, Engineering and Related Career Hints. Scientific Manpower Commission. The sixth edition of this bibliography of science career pamphlets. April 1971. 48 pp. $1.

Sources of Career Information in Scientific Fields. Manufacturing Chemists Association. Specific sources of information from astronomy through veterinary medicine. 1971-72. 20 pp.

Astronomy and Meteorology:

A Career in Astronomy. Gives information on the nature of work involved in contemporary astronomy, the schools having training in this area, and employment opportunities.

Career Guidance and Educational Materials on Meteorology. American Meteorological Society. Literature on careers in meteorology as the science of the atmosphere. Material includes career booklet *The Challenge of Meteorology,* and a listing of colleges having degree programs in meteorology. A book, *Opportunities in Meteorology,* is also available. 1972. $5.75.

What Astronomy Is About. American Astronomical Society. What astronomers explore, new finds in astronomy, experimenting in astronomy, astronomer's duties, and how to become an astronomer.

Atomic Energy:

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering. Oak Ridge Associated Universities. Describes AEC program designed to encourage promising students to undertake graduate studies in these fields and to strengthen nuclear programs at 42 participating universities. Includes outline of graduate programs at these institutions.

Careers in Atomic Energy. U.S. Atomic Energy Commission. The various fields of the atomic scientist. Also contains a selected reading list on sources of financial aid to the student. 27 pp.

Employment Opportunities in the Atomic Energy Field. Bureau of Labor Statistics, U.S. Department of Labor. The bulletin, designed for the use of young persons interested in the field of atomic energy, provides information about the major scientific, engineering, technical, and skilled occupations in this field. 48 pp. 50c. Order from Government Printing Office.

Chemistry:

Career Opportunities in Chemistry. American Chemical Society. This reprint from the March 1971 issue of *Chemistry* gives a profile of chemistry today, the education required, and information about selecting a college. 1-5 copies, no charge; multiple copies, 5c each.

Careers in Biochemistry. Educational Affairs Committee, American Society of Biological Chemists, Inc. Fields of investigation, the scope of research career planning, education and training costs, salaries, and sources of further information in biochemistry. 1972. 6 pp.

Careers in Chemistry. Department of Chemistry, State University of New York. Curriculum guide for chemistry detailing the biochemistry and natural products option, and the wood and polymer option of the College of Forestry, State University of New York. 11 pp.

Careers in Chemistry: Questions and Answers. American Chemical Society. Seventeen questions and answers about how to become a chemist and what it is like to be a chemist.

Is Chemical Technology the Career for You? American Chemical Society. Describes the preparation necessary for chemical technicians, the various duties they perform, and the industries that employ them. More than 5 copies, 15c each.

Probe Tomorrow as a Chemical Technician. Manufacturing Chemistry Association. Describes the opportunities for young people in this field and the training and other qualifications desirable for entering it. 12 pp.

Accredited Curricula Leading to Degrees in Engineering. Engineer Council for Professional Development. Annual listing of accredited curricula in engineering. 1973. 8 pp.

Can I Be an Engineer? Public Relations Staff, General Motors Corporation. An outline of what engineers do, precollege courses, and the opportunities for engineering graduates. 19 pp.

Civilian Careers with the Corps of Engineers. Corps of Engineers, Department of the Army. Describes opportunities in resources planning and management; engineering and architectural design; topography, geodesy, mapping, and charting; hydroelectric power production; nuclear power production; engineering and scientific research and development; indicates how to turn interest to action. Order from Government Printing Office. 1972. 33 pp.

Engineering. . .A Career of Opportunity. National Society of Professional Engineers. Booklet explains engineering and the preparation and educational requirements of engineers. Revised 1972. 12 pp.

The Engineering Technician. American Society for Engineering Education. Gives information on the technician's place in society, opportunities, qualifications, cost of education, and fields of study. 1970. 21 pp. 50c.

The Future Outlook for Engineers. Engineers Joint Council. A projection of the prospective output of new engineering graduates showing a growing gap between supply and demand, plus the latest outlook figures released by the U.S. Department of Labor. Bulk prices on request. 4 pp. $1.

The Industrial Engineer: One-time Black Sheep Becomes Glamorous. American Institute of Industrial Engineers. Reprint from *The New York Times* tracing the transformation from the "seat of the pants" approach to the sophisticated functions of today's industrial engineer. 1971.

Is Civil Engineering for You? American Society of Civil Engineers. What civil engineering produces, the variety of alternative careers in civil engineering, personal requirements for a civil engineer, studies required for a civil engineering degree, the role of civil engineering in constructing a better world. A list of supplementary reading is also included.

Mechanical Engineering at Dow. Dow Chemical Company. Opportunities in the mechanical engineering field, with samples of tasks one might encounter at this company. 16 pp. Single copy free to teachers.

Nuclear Engineering in Your Future. American Society for Engineering Education. Lists the challenges of consumer and industrial power, space exploration, water supply, and prevention of environmental pollution in the field of nuclear engineering. 1969. 20 pp. 50c.

Women in Engineering. Engineers of Joint Council. A compilation of data and expert opinion on the role of women in the engineering profession. 1972. 6 pp. $1.50.

Geological Sciences and Oceanography:

Careers in Exploration Geophysics. Society of Exploration Geophysicists. Job opportunities combining interests in geophysics, geology, geomagnetics, hydrology, oceanography, seismology, and other related earth sciences. 1-10 copies free; 11 or more, 25¢ each.

Geology: Science and Profession. American Geological Institute. Revised 1972. 28 pp. Tells how geologists work and live, where the jobs are, and what it takes to become a geologist. 1-49 copies, 35¢ each; 50 or more copies, 25¢ each. Orders under $5 must be prepaid.

The Oceans and You. Marine Technology Society. Career prospects in oceanography; employment possibilities with the federal government, private industry, and universities; oceanography curricula, information on marine technicians, a reading list, and further sources of information. 1973. [illegible] pp.

Publications of Value in Planning an Earth Science Career. American Geological Institute. Bibliography of 25 publications on earth science careers.

Mining and Metallurgy:

A Career in Metallurgy Will Extend Your Reach. American Society for Metals. Illustrated booklet discusses the opportunities and educational requirements in metallurgy and related occupations. 25¢ each in quantity.

Career Opportunities in Metallurgy. American Society for Metals. The different types of careers that are available in the field of metallurgy. 20¢ each in quantity.

Careers in Metallurgy, Materials Science, and Metallurgical Engineering. The Metallurgical Society. The metallurgical engineer, his personal qualifications, educational requirements, salaries and working conditions, employment opportunities, future outlook, and a list of accredited universities and colleges.

The Metallurgical Engineering Technician. American Society for Metals. A short brochure providing information on metals/materials technology. 15¢ each in quantity.

Physics:

Careers in Physics. B'nai B'rith Career and Counseling Services. Details nature of work, educational requirements, financial assistance, working conditions, earnings, practical hints for seeking a job, and employment outlook. 1972. $1.

Physics as a Career. American Institute of Physics. Discusses physics as science and as a profession: physicists in industry, teaching, and the federal government; the training of the physicist, and physics organizations and publications. 1970. 20 pp. Single copy free; 2 or more copies 35¢ each.

The Wise Use of Science. American Institute of Physics. Some paths to explore in the career of physics, how greater awareness on the part of the general public of new technological problems can lead to increased opportunities for research scientists, teachers of science at all levels, and technicians in research or industrial laboratories.

ORGANIZATIONS

American Association for the Advancement of Science Education
1776 Massachusetts Avenue, NW
Washington, DC 20036

American Association of Clinical Chemists
P.O. Box 15053
Winston-Salem, NC 27103

American Association of Textile Chemists and Colorists
AATCC Technical Center
P.O. Box 12215
Research Triangle Park, NC 27709

American Astronomical Society
211 FitzRandolph Road
Princeton, NJ 08540

American Chemical Society
Education Office
1155 G 16th Street, NW
Washington, DC 20036

American Gas Association
Personnel Committee
1515 Wilson Boulevard
Arlington, VA 22209

American Geological Institute
2201 M Street, NW
Washington, DC 20037

American Geophysical Union
2100 Pennsylvania Avenue, NW
Washington, DC 20037

American Institute of Aeronautics and Astronautics
1290 Avenue of the Americas
New York, NY 10019

American Institute of Industrial Engineers, Inc.
25 Technology Park
Atlanta, GA 30071

American Institute of Physics
335 East 45th Street
New York, NY 10017

American Meteorological Society
45 Beacon Street
Boston, MA 02108

American Paper Institute
260 Madison Avenue
New York, NY 10016

American Society for Engineering Education
Suite 400
One Dupont Circle
Washington, DC 20036

American Society for Metals
Metals Park, OH 44073

American Society of Civil Engineers
345 East 47th Street
New York, NY 10017

The American Society of Photogrammetry
105 N. Virginia Avenue
Falls Church, VA 22046

The American Society of
Radiologic Technologists
645 North Michigan Avenue,
Room 620
Chicago, IL 60611

American Technical Society
848 E. 58th Street
Chicago, IL 60637

Association of Official Analytical
Chemists
Box 540
Benjamin Franklin Station
Washington, DC 20044

Bausch & Lomb
Science Award Committee
Rochester, NY 14602

Dow Chemical Company
Barstow Building
2020 Dow Center
Midland, MI 48640

E. I. du Pont De Nemours & Co.,
Inc.
Public Relations Office
Photo Products Division
Wilmington, DE 19898

Eastman Kodak Company
343 State Street
Rochester, NY 14612

Education Council of the Graphic
Arts Industry, Inc.
4615 Forbes Avenue
Pittsburgh, PA 15213

Educational Affairs Committee
American Society of Biological
Chemists, Inc.
9650 Rockville Pike
Bethesda, MD 20014

Electronic Industries Association
2001 Eye Street, NW
Washington, DC 20006

Engineers' Council for Professional
Development
345 East 47th Street
New York, NY 10017

Engineers Joint Council
345 East 47th Street
New York, NY 10017

Gemological Institute of America
11940 San Vicente Boulevard
Los Angeles, CA 90049

General Motors Corporation
Public Relations Staff
Room 1-101, General Motors
Building
Detroit, MI 48202

Health Physics Society
P.O. Box 156
E. Weymouth, MA 02189

Institute of Gas Technology
3424 South State Street
IIT Center
Chicago, IL 60616

Manufacturing Chemists Association
1825 Connecticut Avenue, NW
Washington, DC 20009

Marine Technology Society
1730 M Street, NW
Washington, DC 20036

Mathematics & Science Center
2200 Mountain Road
Glen Allen, VA 23060

The Metallurgical Society of AIME
345 East 47th Street
New York, NY 10017

National Aerospace Education
Association
806 15th Street, NW
Washington, DC 20005

National Center for Information
on Careers in Education
1607 New Hampshire Avenue, NW
Washington, DC 20009

National Council of Teachers
of Mathematics
1906 Association Drive
Reston, VA 22091

National Education Association
Customer Service Section 81
1201 16th Street, NW
Washington, DC 20036

Committee on International Relations
National Education Association
1201 16th Street, NW
Washington, DC 20036

National Science Foundation
1800 G Street, NW
Washington, DC 20550

National Speleological Society
Committee on Educational Opportunities in Speleology
George Pshenay, Jr., Chairman
178 Walker Road
West Orange, NJ 07052

National Speleological Society
Dr. John R. Holsinger
Research Advisory Committee
Department of Biology
Old Dominion University
Norfolk, VA 23508

Oak Ridge Associated Universities
Box 117
Oak Ridge, TN 37830

Opticians Association of America
1250 Connecticut Avenue, NW
Washington, DC 20036

Plastics Education Foundation
Maurice Keroack, Education Director
Four Lorna Lane
Loudonville, NY 12211

Science Research Associates, Inc.
Guidance Services Department
259 E. Eric Street
Chicago, IL 60611

Science Service
1719 N Street, NW
Washington, DC 20036

Scientific Apparatus Makers Association
370 Lexington Avenue
New York, NY 10017

Scientific Manpower Commission
2100 Pennsylvania Avenue, NW
Washington, DC 20037

Shell Oil Company
One Shell Plaza
P.O. Box 2463
Houston, TX 77001

Society for Industrial and Applied Mathematics
33 South 17th Street
Philadelphia, PA 19103

The Society of Exploration Geophysicists
Howard Breck, Executive Secretary
Box 3098
Tulsa, OK 74101

The Society of Mining Engineers of AIME
345 East 47th Street
New York, NY 10017

The Society of Naval Architects and Marine Engineers
74 Trinity Place
New York, NY 10006

Society of Wood Science and Technology
P.O. Box 5062
Madison, WI 53705

State University of New York
Department of Chemistry
College of Forestry
Syracuse, NY 13210

Syracuse Pulp and Paper Foundation, Inc.
State University of New York
College of Environmental Science and Forestry
Syracuse, NY 13210

Technical Education Research Centers
44 Brattle Street
Cambridge, MA 02138

The Upjohn Company
Kalamazoo, MI 49001

Water Pollution Control Federation
3900 Wisconsin Avenue, NW
Washington, DC 20016

Woods Hole Oceanographic Institution
Woods Hole, MA 02543

National Aeronautics and Space Administration
Counseling and Career Guidance Officer Code FE, Educational Programs Division
Office of Public Affairs
Washington, DC 20546

U.S. Atomic Energy Commission
Division of Technical Information
Box 62
Oak Ridge, TN 37830

U.S. Civil Service Commission
Washington Area Office
Washington, DC 20415

U.S. Department of Labor
Bureau of Labor Statistics
Washington, DC 20212

Teacher Exchange Division
Division of International Exchange and Training
Institute of International Studies
U.S. Office of Education
Washington, DC 20202

U.S. Office of Education and Training
Smithsonian Institution
Washington, DC 20560

REFERENCES

Feynman, R. P. "What is Science?" The Physics Teacher, Vol 7, No. 6: 313-320, 1968.

Herr, E. L. and S. H. Cramer. Vocational Guidance and Career Development in the Schools: Toward a Systems Approach. Boston: Houghton Mifflin, 1972.

Hoyt, K. B., et al. Career Education: What It Is and How To Do It. Salt Lake City: Olympus Publishing Company, 1974.

Leyden, M. B. "Piaget and the National Clay Boat Contest." Science Activities, Vol 8:10-14,46,/January 1973.

Leyden, M. B. "Science, Careers and the Elementary School." School Science and Mathematics, Vol. LXXVI, No. 4:285-297, 1976.

Leyden, M. B. and M. P. Peterson. Career Education and Physical Sciences. Guidance Monograph Series (Set IX). Boston: Houghton Mifflin, 1975.

Margenau, H.; D. Bergamini; and the Editors of Life. The Scientist. New York: Time Incorporated, 1964.

Mogill, A. T. "Laws of Nature: Created or Discovered?" The Physics Teacher, Vol. 11, No. 3:174-175, 1973.

National Standard Career Education Model: K through Adult. Educational Properties Incorporated, P.O. Box DX, Irvine, CA 92664.

Osipow, S. H. Theories of Career Development. New York: Appleton-Century-Crofts, 1968.

Peterson, J. C. and M. P. Peterson. Career Education and Mathematics. Guidance Monograph Series (Set IX). Boxton: Houghton Mifflin, 1975.

Peterson, M. P., et al. "Enrichment of Teacher and Counselor Competencies in Career Education K-6, Final Report." Charleston, IL: Enrichment of Teacher and Counselor Competencies in Career Education Project, Eastern Illinois University, 1974.

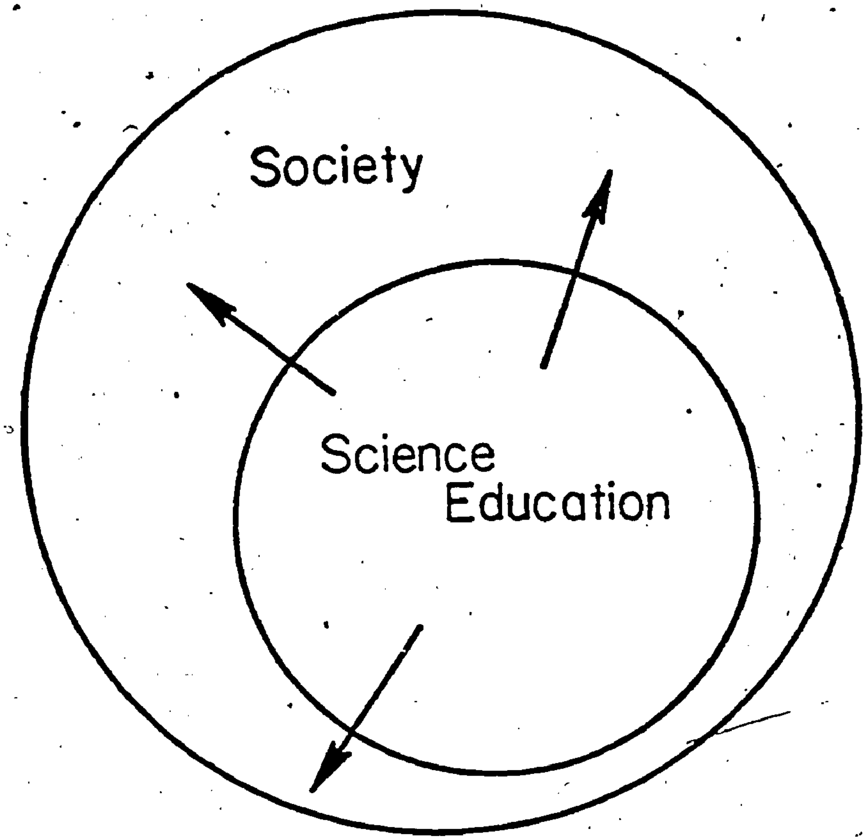
Smith, E. "An Operational Definition of Science." Science and Children, Vol. 11, No. 6:34-35, 1974.

Smith, N. F. "The Challenge of Scientific Literacy." The Science Teacher, Vol. 41, No. 6:34-35, September 1974.

Schmidt, D. J. "The Long White Lab Coat and Other Misconceptions." Science and Children, Vol. 8, No. 7:28-29, April 1971.

"Women in Science." The Science Teacher, Vol. 40, No. 9:14-18, 1973.

PART III: INFLUENCE AND INTERACTION BETWEEN SCIENCE EDUCATION AND SOCIETY



In Parts I and II of this Yearbook, the Venn diagrams which have served as a logo for this Yearbook, have indicated a directional flow from Science Education to Society or from Society to Science Education. The double-pointed arrows of the diagram for this part illustrate its emphasis. In a sense the emphasis is on the arrows; the nature of interaction and influence. Some of these papers are more philosophical than those in other parts of the Yearbook. Nevertheless, in some sense they define the parameters of the practical suggestions in earlier parts.

Many of the papers in earlier parts of this yearbook point to the affective, value-oriented nature of science/society problems. Some suggested using value-clarification techniques for exploring the science/society issues in classrooms. The emphasis of Gene Gennaro's and Allen Glenn's paper is on the treatment of values in a science classroom.

EXPLORING VALUE ISSUES IN SCIENCE TEACHING

Gene Gennaro and Allen D. Glenn

INTRODUCTION

A commonly held belief among scientists and science educators in the past was that the science curriculum as taught in the schools was to be value-free. Science teachers helped students understand the basic concepts and the relationships of a particular discipline of science and taught students the various skills of problem solving and scientific inquiry. It was not that science didn't have topics that raised important value questions nor that scientific inquiry did not involve a particular value system, but simply the fact that both the teacher and the curriculum developers simply chose to avoid issues which might raise questions about the "rightness" or "wrongness" of a specific topic. Science was to be objective in the pursuit of truth. The interrelationships between various scientific findings and their societal impact was given little consideration in the curriculum.

During the past decade the impact of scientific research and technology and its effect on society has come into sharper focus. For example, as a result of research work in recombinant DNA, a fundamental question for society has been raised: should scientists have complete freedom of inquiry or should, in the final analysis, the public decide what areas of research are permissible?

The questions pertaining to recombinant DNA and other science-related issues such as those concerning the environment have led to an increasing awareness on the part of the scientist, the teacher, and the student that scientific advances may solve some problems while creating new problem areas. An increasing number of individuals are interested not only in the basic scientific principles involved in the study of ecology, for instance, but also in what should be done about various environmental problems and the alternatives available in their solution. An individual's values have a significant impact on how the individual believes a problem should be resolved.

As a result of this increased awareness of scientific-societal issues, science teachers are becoming aware of the need for dealing with value-related topics in the science classroom. If science teaching is to be relevant to today's student, it must deal openly with important issues of a scientific-societal nature. Science teachers,

therefore, need to incorporate, along with their treatment of both the "process" and "product" aspects of science, the value issues associated with a particular scientific topic. Failing to do so would produce students who are scientifically illiterate. Failure to make students aware of the issues associated with the science being taught will mean that the students may not be in a position to understand, let alone vote on issues which have a scientific basis. Shortly after graduation, students will be asked to make choices on issues which may require trade-offs. If, as an example, the United States moves from the use of oil to coal as a source of energy in society, pollution standards may have to be relaxed—or life styles changed. In the past, controversial issues were primarily left for social studies teachers to handle, but since social studies teachers often do not have the science background for knowledgeable treatment of some issues, science teachers will need to treat such issues in their classes. No longer can science teachers simply choose to avoid such areas or leave them for special sections.

VALUE RELATED ISSUES IN THE SCIENCE CLASSROOM

Dealing with value topics in the classroom is a matter a science teacher should not do without some forethought. A teacher cannot anticipate all the various outcomes from a discussion or treatment of an issue; however, thinking about several key issues related to dealing with values in the classroom may enhance the learning experience for both the teacher and the student. These factors will be treated in two general sections in this chapter. The first focuses on considerations before dealing with value-oriented topics and the second presents two strategies for teachers to deal with such issues during the class.

CONSIDERATIONS BEFORE DEALING WITH VALUE-ORIENTED TOPICS

What Are Values?

There are a variety of definitions for the term values. Using the work of James Shaver and his colleagues as a basis, the following definition seems to be useful:

> Values are our standards and principles for judging worth. They are criteria by which we judge people, objects, ideas, actions and situations to be good, worthwhile, desirable; or, on the other hand, bad, worthless, despicable; or, of course, somewhere in between these extremes (Shaver and Strong, 1976, p. 51).

As we interact with people in various situations, we may apply our values consciously in making various decisions or we may be unaware of them in the decision-making process.

Personal values assist the individual making value judgments about various issues. For example, "I feel abortions should not be permitted" is a value judgment. It is based on a value that may be expressed as the "sanctity of life." As individuals, we sometimes use these values as a basis for making decisions about a particular issue. Values are both affective and cognitive in nature in that they embody and convey feelings which may be refined and clarified, but often they are also based on well thought-out concepts and informational data.

Value conflicts arise because of differing value stances held by individuals (interpersonal value conflict) but can also arise as a result of differing values held by the same individuals (intrapersonal value conflict). Teachers need to realize that people are inconsistent at times due to their compartmentalizing of situations. It is important for students, then, to realize that these inconsistencies exist. Students need to deal rationally with these discrepancies. For example, polluting the air by smoking may be thought of by some individuals as quite different from industry's polluting the air with their smokestacks (Shaver and Strong, 1976).

The number of value areas having a scientific basis which raises issues for the individual and society are varied. They may be divided into categories associated with: (1) the environment (e.g., energy, population, pollution, land use, natural resources, weather control, quality of life); (2) genetics and biomedicine (e.g., genetic engineering, genetic screening and counseling, race and I.Q., organ transplants, life-death issues, medical priorities); (3) theology and religion (evolution, birth control, amniocentesis, abortion, behavior modification, human experimentation, hunger); (4) developing technological, scientific and pseudoscientific fields (nuclear energy, recombinant DNA research, biosociology, parapsychology, acupuncture, astrology).

There is an obvious overlap among these categories of issues. For example, one cannot consider certain environmental problems without considering their impact on the health of individuals within society. Methods such as abortion clearly get into discussions of both theology and population control. Recombinant DNA research could be considered as well under the category of genetics and biomedicine.

Determining the Significance of an Issue

The importance of issues will need to be assessed, issues should not be included in a course solely because they are controversial. If they affect or will affect the life of the student in the future, and he has to or will have to make a personal decision about a particular issue, it is "fair game" for treatment in the classroom. Some issues, although not urgent or even seemingly important, might be included solely for the sake of interest. Presently cloning and some other esoteric forms of genetic engineering are not really urgent problems facing society, but students may be interested in reaching tentative conclusions about these and other similar issues. If one looks carefully, however, at some of these issues, they do get at some fundamental rights and responsibilities. For example: What

traits in humans are desirable? Should we seek optimum man or unique men? Is there a difference between genetic therapy to correct genetic anomalies and other genetic manipulations? If the quest for genetic improvement is continuous, would it invariably make children "superior" to their parents and hence, institutionalize generation gaps? (Tunny and Levine, 1972).

It is not possible to include all the various value topics in any particular science course. As a professional, the teacher must constantly choose among the topics available in selecting what should and what should not be included in a particular science unit. Before selecting a topic, a teacher needs to ask himself or herself several key questions. The first set of three questions is related to student interest in an issue. These questions are:

1. Is this an area of wide social concern, an area generating problems for large numbers of people?

2. Is this an area which, in addition to widespread concern, is also of concern to the students I teach?

3. If it is not of concern to the students I teach, am I likely to have reasonably good luck in getting them concerned?

If the topic is one in which people have an interest and specific opinions, there is a greater possibility that students will be more interested in exploring the issue or that the teacher will be capable of generating student interest.

Ability of the Teacher and Students to Handle the Topic

The second set of questions focus on the teachers' ability to competently handle the topic. These questions are:

4. Is this an area which I am capable of handling competently?

    a. What are my values related to the topic?
    b. Am I willing to accept different value positions?
    c. Do I have enough knowledge to deal with the topic?

5. Are the students mature enough to handle the issue?

6. Can I deal adequately with the topic?

It is important that after reading about the various sides of a topic that teachers consider their own position on the issue. A strategy that may be useful is to rank the criteria as to their relevance and importance to the issue before presenting material to the class. After examining the issues related to the value dilemma, students may ask what the position of the teacher is on this particular topic. The teacher should be prepared to respond honestly and give reasons for his/her position.

Is the issue one which would give the teacher great difficulty in allowing students to accept a point of view different from the teacher's? Can the teacher assist the students in the exploration of the topic without leading them to the "right" conclusion—the teacher's? If the answer is "yes" to the first question and "no" to the second, the topic should be avoided. Since we live in a pluralistic society, students need to examine as many sides of an issue as possible so to avoid a biased point of view. Students should be encouraged to come to a conclusion after all sides have been presented and discussed. Being open-minded and willing to change one's point of view on the basis of new evidence needs to be recognized as an essential part of critical thinking. In attempting to treat an issue fairly without indoctrination, the teacher needs to be careful in presenting the materials so that the teacher's stance will not be given away before students have a chance to make their choices.

Materials are selected and instructional activities are developed to maximize student learning. The same care needs to be used in the classroom. Teachers will need to consult general reading materials such as the newspapers, popular magazines like Time and Newsweek to be able to incorporate the materials into the plans for a unit. Magazines such as Science Newsletter, National Wildlife, Nature, Scientific American, Science, Bulletin for the Atomic Scientists, to mention only a few, contain articles and editorials which deal with controversial issues having a scientific basis. A booklet prepared annually by the American Association for the Advancement of Science is particularly good for identifying issues and sources of information on the issues (Dambach, 1976).

After working with a group of students over a period of time, a teacher can judge the emotional and intellectual maturity of the class and their ability to deal with various topics and with each other. Before introducing a topic for study and exploration, a teacher needs to ask, "Is this particular class mature enough to handle the issue?" For example, the introduction of materials raising issues related to sexual reproduction may be inappropriate for students at a certain grade level or age. The students may lack both the emotional maturity and knowledge to deal with the value questions raised by such material.

It is wise, therefore, to think about the ability of the students to handle value-laden topics. Unfortunately, most teachers underestimate the ability of their students to emotionally and cognitively deal with such topics. Teachers too often believe their students to be too young, too immature and too lacking in background to explore a topic. In fact, it may be the teacher, not the students, who cannot handle the issue comfortably.

The last issue to consider when thinking about reactions is the individual teacher's ability to deal with various student points of view. It is, of course, impossible to anticipate how all the students will react. However, it would serve the teacher well to ask, "What are the possible reactions students might have to this topic and how might I deal with them?" It may happen that a particular student may have had a personal experience that has influenced his/her value

position and may react strongly to a topic. For example, a student who has had a parent die of cancer recently may have great difficulty discussing the Laetrile issue. Forethought on the teacher's part may enable the teacher to deal with various student reactions.

Some issues may be too complex for students at a certain grade level to handle. For instance, if students are not able to handle arguments for evolution versus special creation, it is fruitless to discuss the issue and attempt to give the pro and con arguments. If students do not understand what recombinant DNA is or why sociobiology is controversial, the topics ought to be delayed until a time when they can understand the topic. More research needs to be done in determining when children and adolescents can deal intelligently with specific value-laden issues. It would appear, however, that even elementary school children can deal intelligently with many environmental issues. Kohlberg has shown that children and adolescents go through developmental phases in their ability to move from more egocentric decisions to ones that are more altruistic (Kohlberg, 1966).

The Classroom Environment

Another question related to the issues discussed previously focuses on the overall classroom climate in which an analysis and discussion are to occur. The question is:

7. Has a classroom climate been developed that is conducive to the exploration of a value-related topic?

In essence this question asks, "Do the students feel that they can explore a topic and disagree with the teacher and other students without fear of ridicule or pressure to say the right thing or reach the right conclusion?" The creation of such an environment is not an easy task. Students learn very quickly to be aware of "what the teacher wants" and to give back the desired answers at the appropriate time. If discussion is to occur in an open manner, where the student feels as free as possible to say what he or she has found and believes, an appropriate classroom climate must be developed over time. A teacher must build into the various interactions that occur within the room a respect for another's opinion and the right to disagree. If students are accustomed to open discussions and are not afraid to express their opinions on other topics, they will be comfortable when touchy subjects are handled.

Teachers also need to be conscious of non-verbal communication patterns such as body language, eye contact, smiling and nodding, and their impact on student's openness in communication. Teachers need to be aware of verbal patterns as well. Reinforcements such as "good" may be detrimental since students who do not share the opinion of the student who is being reinforced may feel the teacher's response is showing agreement with the reinforced student. Students should not be graded on their value stances, and the teacher must respect the individual's choice to participate or not to participate in a value discussion. "Active listening" in this kind of setting may be fact be a good method of use since it is self-corrective and says to the student, "I have heard you so well I can repeat what you have said." Teachers need to be aware that intonation can also give away feelings.

It may be well to involve students in establishing rules for class study of controversial topics. Examples of such rules are: when presenting facts, sources should be cited; and no one person should be allowed to dominate the discussion. If feelings run high, the discussion should be stopped and continued at another time.

Before proceeding the teacher needs to examine the classroom environment. The type of environment will have implications for deciding whether to use a particular topic for discussion and which type of strategy to employ.

Curriculum and the Community

Two final questions need to be considered before a decision may be made. These are:

8. Are there materials in the school and community to assist in the exploration of a selected issue?

9. How does the community feel about the topic?

The first question is instructional in nature: can the teacher find enough information to deal with the various issues involved? Are materials exploring both sides of the issue available? The type of materials can and does influence the student's understanding of an issue. For example, if only materials representing the arguments for SST manufacture are available, students cannot explore the issue in a reflective, objective manner. The teacher's selection—or lack of selection—has predetermined the conclusions students may reach and may greater inhibit classroom discussion.

The second question is more of a political nature. A teacher who enters into a topic of potential value conflict should first look at the broader community in which this discussion is to take place. Is this topic one in which various groups within the community have strong feelings? If so, what are these feelings and what might be the consequences of introducing a discussion of this nature in the classroom?

A teacher needs to consider the potential repercussions. This does not mean that a teacher only chooses "safe" issues—topics that have little likelihood of creating problems—for discussion, but only that the teacher is sensitive to community feelings. For example, if a teacher teaches in a community where certain religious groups believe in the literal interpretation of the Bible, the discussion of evolution should be considered carefully to ensure that a balanced view is presented. Some other topics which might be considered "hot" would be abortion, certain aspects of sex education, and certain environmental issues which may be tied to jobs of parents in the community. The problem of the dumping of asbestos fibers into Lake Superior by Reserve Mining may be handled quite differently by the children of Reserve Mining's employees than by other groups of students. In many cases, however, certain topics would be less controversial in a community if parents were shown the materials beforehand and asked for input.

After considering the questions posed above, a teacher may be tempted to say, "Forget it" because dealing with a certain value topic may be too much trouble. What is suggested is that the teacher make the same carefully considered decisions when deciding about the inclusion of value-related issues as he/she does when considering other topics to be included.

After making a decision that a specific topic should be included in an instructional unit, the teacher is then faced with the question, "What instructional model should I use?" Like any teaching strategy, there are numerous variations of any proposed mode and the field of and the field of values education has many models and accompanying strategies. Two general models will be suggested.

TWO MODELS FOR DEALING WITH VALUE TOPICS

Two models for dealing with values have received widespread attention among educators. One is the affective clarification model and the second in the analytical decision-making approach.

Affective Clarification Model

The affective clarification model or values clarification approach was developed by Louis Raths and Sidney Simon (Raths, Harmin and Simon, 1966). This approach is concerned with developing techniques for assisting students to think about and clarify their own values and has been modified over the past few years. Essentially the values clarification model suggests that the teacher provide stimuli to elicit student responses which call for the student to state a value position, for the teacher to accept this position, and then to assist the student in clarifying his/her position. The role of the teacher is not to carefully explore each student's position but to "gently nudge" the student to think about his or her own values.

Affective clarification proponents suggest a variety of methods to assist students. Value sheets, role playing, contrived incidents, values clarification exercises, and clarifying responses are all suggested methods (Simon, Howe, and Kirschenbaum, 1972). Below is an example illustrating the values clarification technique.

A Value Clarification Exercise in the Use of Transplants: A total of 55,000 persons die each year in the United States of kidney disease. About 10,000 of these people are suitable for transplants or dialysis treatment, but only 1,500 to 2,000 undergo dialysis or transplants.

At the present time, the cost for a kidney transplant is approximately $15,000 and following surgery, up to $1,000 per year is needed to cover the costs of examinations.

Hospital dialysis costs $35,000 to $50,000 per year.

Dialysis in an ambulatory care facility generally is between $14,000 and $20,000 or more per year.

Home dialysis costs between $12,000 and $20,000 the first year for the purchase of equipment, training and other facilities, and $4,000 to $6,000 per year after the first year.

Seventy percent of the kidney transplants using cadaver donors are successful and 90 percent of the transplants using closely related, live donors are successful.

In many states, under existing laws, the consignment of a body or its parts to science can be denied by the next-of-kin, even though the deceased may have wished it.

Who should have the final say so as to whether organs should be taken for transplantation?

_____ The patient before he has died
_____ The next-of-kin
_____ I don't know

What questions does this raise?

Do you agree with the following statement: Only those who are able to pay the large fees necessary for transplants and dialysis should be eligible for kidney transplants or dialysis.

_____ Yes
_____ No
_____ I don't know

What questions does this raise?

Do you agree with the following statement: The government should "foot the bill" for kidney transplants and dialysis.

_____ Yes
_____ No
_____ I don't know

What questions does this raise?

If this were to become available to all persons living in the U.S., there would most certainly be a shortage of available kidneys for transplants and doctors for doing them. Also, we would not have enough dialysis machines. Who should make decisions as to who receives a transplant or undergoes dialysis?

_____ A group of specialists such as urologists
_____ A group of people, chosen at random from a list of college-educated individuals
_____ A group of people chosen at random from the general population
_____ A group selected from priests, ministers, and rabbis.

What questions does this raise?

If you were a member of such a board, and you could only select one of the following for a transplant, to whom would you decide to give a transplant?

____ A father with a wife and two children
____ A mother with a husband and two children
____ An unwed mother with two children
____ A widower with two children

What questions does this raise?

If you were a member of such a board and you could only save one of the following, to whom would you decide to give a transplant?

____ A politician
____ A scientist
____ A doctor
____ A teacher

What questions does this raise?

So as to eliminate decisions of this type from having to be made, how would you go about changing the decision-making process?

A teacher who selects the values clarification approach should be aware of several factors related to this technique. First, the focus is on the individual, not on developing decision-making skills related to a particular issue. Simon and others do not suggest the teacher discuss an issue in-depth so as to arrive at a solution to a particular issue. In essence, this approach can be used quite effectively by the teacher who does not want to spend a lot of class time in dealing with the value aspects of a topic but who wants to get students to think about their own personal value positions. Using this approach is not meant to help students either individually or as a group to analytically study an issue or to develop the accompanying decision-making skills but to get the student to think about the value issues raised by the topic.

Second, a teacher needs to be aware that probing a student's value belief system is something that needs to be done with sensitivity and respect. Simon and others provide several guidelines in this area (Simon, Howe, and Kirschenbaum, 1972). A practical question a teacher might ask is "Would I be willing to share my opinions on this issue with my students?" If the answer is "no," maybe the teacher has no business asking a student the question.

Analytical Decision-making-Models

As students are confronted by issues that cause them to think about their own values and the values of others, they quickly realize that their own values may conflict with those held by other students. Also, as attempts are made to resolve scientific-societal issues such as pollution, students find there are few simple answers. In fact, there

may be considerable conflict in attempting to resolve a particular pollution problem. To assist both the teacher and the students in dealing with value conflict and developing decision-making skills, more systematic, rational models may be used.

A variety of analytical decision-making models exists in the educational literature, especially in the area of social studies education (National Council for the Social Studies, 1971). Each model varies to meet the unique approach of its developers. However, each model suggests that the students follow a process that includes: (1) identifying and clarifying the basic question; (2) assembling facts about the basic issues involved; (3) assessing the factual assertions; (4) examining the relevance of the facts; (5) arriving at a tentative decision; and (6) determining whether or not the solution is acceptable. In this model the effort is made not only to examine an issue that has value conflict on an individual basis but to assist the student in a structured learning experience to study the issue and make a decision on the issue.

Such models have direct implications for the classroom. First, utilizing an analytical model to explore a value topic entails the expenditure of more class time. Whereas the affective clarification strategies may be inserted into an instructional unit without the cost of much class time, analyzing a value conflict issue in-depth requires more class, student and teacher time. Secondly, the analytical models call for the teacher to play a more involved role in the areas of discussion, data collection and hypothesis testing. The use of an analytical model requires a stronger commitment on the part of the teacher. Below is an example of an approach using the analytical model.

Recombinant DNA Using the Oliver-Newman Model

Students would be given an issue to discuss such as: Should recombinant DNA research be allowed? Students would be allowed enough time to read arguments pro and con on the issue and then given enough time to discuss it.

In discussing issues of this type, people generally get involved in several sub-issues such as (a) moral or value issues (Should scientists have complete freedom of inquiry?); (b) definitional issues (What is recombinant DNA? What is "shotgun experimentation" in DNA research? What are P-4 facilities?); and (c) issues involving facts and explanations (Would following the National Institute of Health guidelines for recombinant DNA research help prevent the escape of newly created organisms?) (Oliver and Newman, 1967).

After the discussion in which the teacher serves as moderator, an analysis of the discussion can take place which might include the following questions:

1. What were the basic issues discussed? Which of these were moral, value issues? Which were issues requiring facts or information?

2. Was agreement reached on any issues? Which ones?

3. How did most students support their statements? Did they primarily rely on (a) common sense, (b) reference to authorities, or (c) other well established claims?

4. What was the biggest stumbling block to your discussion?

5. How effective was this model in helping your group reach a decision?

Very effective	Effective
Somewhat Effective	Not at all Effective

This type of discussion might be carried out by small groups if it appears that within the small groups, there is diversity of opinion. In that case the teacher would move from group to group as a listener, not as a participant. Afterward, students could share what happened within each small group with the whole group.

One of the ways that value topics could be handled in the schools would be in science and social studies inter-disciplinary classes. In such cases, students would profit by the expertise in subject matter of the science teacher and the knowledge of social studies teacher in the handling of associated value-related topics. The teaching of such inter-disciplinary classes would insure that the data related to scientific topics would be presented and decision-making skills would be taught. Until interdisciplinary teaching becomes a more common practice in the schools, science teachers will need to learn models and strategies for dealing with values associated with the topics they are teaching.

ADDITIONAL COMMENTS ABOUT THE TREATMENT OF SCIENTIFIC-SOCIETAL ISSUES IN THE SCIENCE CURRICULUM

A democratic society has as one of its cornerstones a belief in the worth and dignity of the individual. A goal of the school is to assist the student in the development of his or her abilities in a humane manner. Included in this growth is the development of a value system that is based on an intelligent, rational foundation.

If these factors are indeed a part of the school's function, the teacher's role is to assist the student in development of his or her intellectual abilities and value system. This means that the teacher must not only be concerned that the student learn the basic information associated with the discipline but also allow and assist students to discuss issues that concern them and society and help develop the skills to enable them to make decisions as adults.

The teacher must be willing to attempt to present a balanced view which attempts not to indoctrinate students to a particular point of view but instead seeks to present various positions and to permit the

student to make a final decision. In some cases, this may mean permitting a diverse number of value positions within the classroom.

In order to achieve this goal, in summary, teachers must be willing to:

1. Include topics that raise value issues and questions.

2. Develop instructional strategies to explore value-related issues.

3. Develop a classroom atmosphere that is conducive to discussion and the sharing of opinions.

RESOURCES

During the last several years a wide variety of educational materials has been published focusing on values and value education in the public schools. It is not the purpose of this section to list all these sources, but simply to point the interested reader in the proper direction. An excellent book that discusses various approaches to values education and related materials is the Value Education Sourcebook: Conceptual Approaches, Materials Analyses, and an Annotated Bibliography by Douglas Superka, Christine Ahrens, Judith Hedstrom with Luther Ford and Patricia Johnson. The book is available from: Social Science Education Consortium, Inc., 855 Broadway, Boulder, Colorado 80302. Any teacher interested in a comprehensive overview of values education and student and teacher materials should examine this book.

The readings presented below are exemplars of materials that a teacher might examine to gain additional insights into a particular approach. From these general sources a teacher could then explore other publications.

Rational Analysis

Metcalf, Lawrence E. (ed.). Values Education: Rationale, Strategies, and Procedures. Washington, DC: National Council for the Social Studies, 1971.

Newman, Fred M. and Donald W. Oliver. Clarifying Public Controversy: An Approach to Teaching Social Studies. Boston: Little, Brown 1970.

Shaver, James P. and William Strong. Facing Value Decisions: Rationale-building for Teachers. Belmont, CA: Wadsworth Publishing Company, Inc., 1976.

Values Clarification

Casteel, J. Doyle and Robert J. Stahl. Value Clarification in the Classroom: A Primer. Pacific Palisades, CA: Goodyear Publishing Co., Inc., 1975.

Harmin, Merrill; Howard Kirschenbaum; and Sidney B. Simon. Clarifying Values Through Subject Matter. Minneapolis: Winston PRess, 1973.

Rath, Louis E.; Merrill Harmin; and Sidney B. Simon. Values and Teaching: Working with Values in the Classroom. Columbus, OH: Charles E. Merrill Publishing Co., 1966.

Moral Development

Fenton, Edwin (ed.). Holt Social Studies Curriculum. New York: Holt, Rinehart and Winston, 1969-75.

Kohlberg, Lawrence. "Moral Education in the Schools: A Developmental View." School Review, Vol. 74:1-30, 1966.

Rest, James. "Developmental Psychology as a Guide to Value Education: A Review of Kohlbergian Programs." Review of Educational Research, Vol. 44:241-259, 1974.

REFERENCES

Dasbach, Joseph M. Science and Society—A Bibliography, 6th Edition. Washington, DC: American Association for the Advancement of Science, 1776 Massachusetts Avenue, NW, 20036.

This is a yearly publication which lists topics and articles which treat social issues having a scientific basis. It is an excellent bibliography, obtained for a nominal amount.

Harmin, M.; H. Kirschenbaum; and S. B. Simon. Clarifying Values Through Subject Matter. Minneapolis: Winston Press, Inc., 1973.

This book describes techniques and strategies to be used in different subject matter areas. There are representative examples for earth science, biology, chemistry, and physics. There is a particularly good chapter, "Using the Values Strategies with Subject Matter," which deals with environmental education and which would be useful to examine diverse techniques in value clarification.

Kohlberg, Lawrence. "Moral Education in the Schools: A Developmental View." School Review, Vol. 74:1-30, 1966.

A treatment of the moral-development point of view from the leading proponent of that view.

Metcalf, L. E. (ed.). Values Education. Washington, DC: National Council for the Social Studies, 1971.

This is the 41st yearbook of the National Council for the Social Studies. It is particularly good for looking at objectives, strategies, procedures, and resolution of value conflicts using a cognitive, rational approach to value education.

Oliver, D. W. and F. M. Newmann. Taking A Stand. Middletown, CN: Xerox Corporation, 1967.

This is an American Education Publications Unit Book adapted from the Harvard Social Studies Project. The approach is a cognitive, rational one for dealing with public issues in the classroom.

Rath, Louis; Merrill Harmin; and Sidney B. Simon. Values and Teaching. Columbus, OH: Charles E. Merrill Publishing Co., 1966.

This book outlines the basic philosophy underlying the Raths et al values clarification approach and presents selected strategies for use in classroom.

Shaver, James P. and William Strong. Facing Value Decisions: Rationale-building for Teachers. Belmont, CA: Wadsworth Publishing Company, Inc., 1976.

This paperback book deals primarily with a rational cognitive approach within a democratic context. There is also a chapter on the values clarification model and the cognitive developmental model of Kohlberg's.

Simon, S. B.; L. W. Howe; and H. Kirschenbaum. Values Clarification. New York: Hart Publishing Co., Inc., 1972.

This is a handbook of 79 strategies for teachers which show the many diverse ways of handling value topics in the classroom, using a humanistic approach.

Tunney, John and Meldon E. Levine. "Genetic Engineering." Saturday Review, Vol. LV, No. 32:23-28, August 5, 1972.

This article deals with the political and moral issues of genetic engineering.

The culture of Western civilization has become more and more scientific. The use of science has at the same time modified one way at looking at science itself. There are essential differences between ancient and modern science. These differences include: (1) What is a proper question or problem and (2) How to study these problems. Science/society issues must be studied from an interdisciplinary point of view. A synthesis of ways of knowing, a more wholistic approach is needed. Bob Samples looks at Western culture and sees science transforming itself in this direction.

SCIENCE, MIND, AND EDUCATION

Bob Samples

LOOKING BACK

Throughout the history of Western thought there have been worldly philosophers reflecting upon science. At different times, several have described science as being a context of inquiry, based upon three assumptions. The assumptions are:

1. The universe contains order,
2. That order can be discovered; and
3. It is important to understand this order.

It is popular to think of science as the study of order in the universe. For centuries, the geometry of snowflakes, spiderwebs, and the motion of heavenly bodies have driven the human mind away from myth and superstition toward order. On this journey there emerged abundant evidence to convince the seeker that order was its own reward.

The substances of the earth were early-on ordered in the alchemists' vision of fire, earth, air, and water. From there, hundreds of minds took these substances and wove them into intricate, though badly loomed, testimonies of order. It took Democritus to venture the claim that there were more than just these four basic elements. In fact, there were dozens. Further, Democritus argued that matter was comprised of tiny particles of the substance it represented. These tiny particles he called atoms.

At the same time the human mind searched for order in the miniscule world of the atom, it turned outward into the heavens. Relying on the rich observations made by the Sumerians, the Greeks took up the tasks and tried to fix the relationship between earth and other heavenly bodies. Order was to be had at both ends of the physical world's extremes. In the centuries that followed, the skies were looked upon for data rather than just for "signs." Science became more important than astrology as the sky was searched.

The elaborate geometrical gadgets used to make observations by Tycho Brahe and, later, Johannes Kepler gave a refinement to the conclusions of Copernicus. In a sense the instruments provided not only astronomical data but also created a climate of favor for mathematical methods. With the advent of the telescope a whole new domain was made available by wedding instrumentation with mathematics. A new kind of methodology was born . . . the extension and amplification of human senses.

It took the work of Newton and Descartes to provide the philosophical energy to insure that mathematics would become the primary medium for the emerging art of science. It was they who guaranteed that if something could be counted, measured, or expressed mathematically, it was capable of being scientific. Simultaneously, theoretical models of electricity, magnetism, and the structure of matter began to be created through the application of mathematics to physical study.

Finally the new medium of inquiry, mathematics, added strength to the quality of science that would guide it for the next three centuries—reductivism. Some credit Descartes with this, claiming he sponsored the reduction of problems into more discrete, manageable parts. His belief that there was universal order created another premise: science must be studied from qualities of simplicity toward the more complex. These two ideas plus his creation of methods to apply algebra to geometry created a veritable explosion in the perceptions of science that were woven on the loom of mathematics. It would be centuries before Marshall McLuhan would claim "the medium is the message" and for this great age of order-making in science, the laws that spewed forth were considered to be true rather than what they were—statements that follow from that list of a priori assumptions regarding the order of the universe in the medium of mathematics.

Strangely enough at the scale of the earth-sized and human-sized domains, the tapestry held together. So elegant were the interwoven threads of assumptions and evidence that finally the belief that order was discovered became accepted. Yet there were difficult times ahead in the inquiry that was to lead into the world scaled toward the atom and toward the universe.

The nineteenth and twentieth centuries gave rise to periods of study of atomic structure and galactic "order" that witnessed a nearly continuous abandonment of the described "Newtonian" order of earth-sized science-mathematics. New kinds of order began to be assumed and then tested. There were times that perception of models and presumption of models became so intricately interwoven that it was difficult to determine if the investigators had proof of order or had presumed order and were mathematically exploring it. Telescopes and cyclotrons became the technological arenas of this exploration of the material and hypothetical. They too were inadequate and their nerve center was created: The computer.

The computer became central to science. It was after all an awesomely efficient storehouse and analyzer of data. Information could be inserted, compared, retained, or discarded, or any

combination of these. Whereas the instrumentation of the past had been sensory amplifiers, the computer became a ratiocinative amplifier, an extension of human capacity to reason. This manifestation of mathematics' role in science stands as a cathedral to the original Cartesian catechism. The computer has become a veritable altar on which the religion of rationality is consecrated.

LOOKING AT NOW

The decade within which now is the terminal interface is perhaps the most tumultuous in the history of science. This tumult is not the result of amazing new discoveries such as DNA, neutron stars, or any of a variety of new particles. Instead, it is linked to what science is not, rather than what it is. We are beginning to see the growing edges of uncertainty about the very premises upon which science is based.

Instrumentation and theory have progressed to the point that we are clearly seeing that mathematics as a medium has within itself the capacities of the mystical. Both the world of the atom and of celestial objects possess this same quality. Scientists are speaking freely about how those droves of mathematically expressed data regarding the order in the universe are held together by highly tentative assumptions. Just as Descartes questioned all evidence derived by the senses and warned us to suspect evidence gained through mathematics, today's computers with their subtle souls seem to follow.

A most eloquent spokesperson for the emerging awareness of the limits in subatomic physics is Fritjof Capra. Capra's work portrays the knowledge about subatomic particles as a series of overlapping circles like so many drops of rain on a pond. Each circle is a field of data which, true to its unique assumptions, describes the characteristics of a specific quality of matter in terms of mathematics or instrumentation. Each of these areas of knowing is internally consistent, yet some overlap. This overlap provides mutually validating qualities derived from different kinds of exploration. Such overlap is taken as having a higher probability of accuracy. Yet at a larger scale, precious little of what is known about matter has this mutually validating evidence. Instead, what is known is based on evidence of overlaps several links down this chain of data.

Capra's thesis, which has been emerging in one form or another through the works of all the major theoretical physicists in this century, is that uncertainty is upon us. Capra points out that our modes of reductive, analytic thought which are the modes of science and mathematics, have led us to the limits of their applicability. (It is important to note that there is no anti-rationality in such claims. Rather there is such a complete honoring of the rational process that such modes of knowing are considered for that which they can do and not denigrated for that which they cannot do.)

The Western discovery of these limits has brought us, through the media we have chosen, the rational thought modes of science and mathematics, to levels of awareness manifested in Taoistic thought. It is

comfortable for the Western mind to deal in dichotomies and thus the infatuation with Eastern and Western world views is popular. Zen Buddhism or Taoism as a philosophy is well documented throughout human history and is easily labeled Eastern in this dichotomy. Yet Taoism is paralleled by Hinduism, Brahmanism, and dozens of spiritual views held by cultures throughout the world that have not invested in the symbolic record keeping of writing, including Native American.

Basic to this alternative world view is a simultaneous acceptance of the mystical as well as the rational. Whereas Western thought strives to pursue and eliminate the mystical, the Eastern forms of thought acknowledges and honors both. The honoring of the rational appears to be done with more of a sense of humor as it is clear that, to Eastern thinkers, rationality is a game. Conversely, a sense of the mystical is considered more normal in Eastern thought, as is the ambiguity that accompanies it. When one considers ambiguity to be the appropriate condition of thinking, then attempts at the reductive elimination of ambiguity appear to be exercises in futility.

It is at this meeting point that the major departure between Eastern and Western thought takes place. Just as the choice of words in the previous sentence suggests (meeting/departure), it is not a comfortable place to be. The Western thinker strives to eliminate ambiguity and thus must stand mildly bewildered as it contemplates the rhetoric emerging from modern physics. Uncertainty is the only certainty. Matter is pattern and not substance, and it can apparently be created and destroyed.

The mystical vision is returning to Western thought through the very instruments of logic that were first marshalled to drive it out. We are perhaps discovering that we can extend our consciousness as surely as we have perfected our ability to extend our reason. Einstein said it best when he claimed a sense of the mystical was a most profound and beautiful emotion. It was, he claimed, the dower of all true science.

LOOKING AHEAD

Modern neurophysiologists have determined that the cerebral cortex in humans is lateralized. At least this seems to be true in most technologically dominant cultures. One side of the cortical brain is specialized in performing those mind functions that are logical, linear, sequential, and time-ordered. This is the left cerebral hemisphere in most persons. On the opposite side (the right) the mind function is specialized that handles analogic, metaphoric, and wholistic thought.

It is easy, with our Western tendency (or is it compulsion?) to dichotomize, to call these the Western and Eastern hemispheres. But neither the data nor the moral necessity exists for such folly. Instead, let us proceed with the mind functions being as dualistic and complementary rather than dichotomous and opposite. It is in the synchronous use of these modes that the promise for the future resides.

Strangely, it may well be modern physics that gives us permission for this wholism at another level. Karl Pribram in neuroscience and David Bohm in physics have complemented each other's work in regard to applying concepts of holography to brain function. There is a growing body of research that suggests that thoughts are encoded in the brain in a holonomic way. That is, a thought is a pattern of activity in the brain rather than the linear circuit proposed most consistently by neuroscientists during that last century. These patterns provide an intrinsic structure within the brain/mind field, a structure that interacts with the extrinsic structures connoted by science and mathematics.

The concept of the holonomic brain is compatible with not only neurophysiological theory but physical theory as well. In terms of the neurosciences, it helps explain why massive brain damage can result and the brain will continue to function in a reasonably normal manner—a circumstance completely untenable in the linear model of the brain. The concept of the holonomic brain also can easily incorporate lateralized brain data as well as supporting far more wholistic vision in regard to psychology.

The holonomic concepts create a model of brain function far more consistent with models of physical interaction inherent in quantum mechanics. Evidence is persistently growing that matter is a pattern of energy and that no specific model, whether wave or particle-based, can suffice to explain what is observed. New mathematics, called curiously "catastrope theory," have emerged to cope with the processing of the data derived from the subatomic ambiguity. Such mathematics provide a more dynamic vision of the physical and the neurophysical. In a crious way, the brain in its Western context may have invented physics as a medium to reason itself into an acceptance of the mysticism that Eastern cultures have acknowledged all along.

That we at this interface with tomorrow recognize that there are varying world views, that there are different modes of thinking, and that science and mysticism are in fact as inseparable as parent and child, then the hope for a clearer vision emerges. In celebrating this vision, it is necessary to treat the preceding with neither defensiveness nor aggression. This essay, though spending most space on vignettes from Western thought and precious too little on Taoistic thought, is to culminate in a series of propositions to be mindful of in education for the future. But to go on, it must be clear that science and mathematics are not testifying to their own demise. They instead testify to the transformation of the assumptions on which they as world-view and intellectual methodology rest.

But in pragmatic terms, what is this transformation of assumptions? To return to the list at the beginning of this essay, one might rewrite it as follows:

1. Humans have the capacity to perceive order in the universe.

2. Humans can also invent methods to verify their perceptions.

3. It is sometimes interesting and useful to do this.

In addition, the list could well be expanded to include these possibilities:

4. Humans have the capacity to perceive unity in the universe (which requires no precepts of order),

5. They can invent methods to experience this perceived unity; and

6. It is sometimes interesting and useful to do <u>all of these</u>.

What all this means is that Descartes' gifts were exquisite for using reductive methods to fragment wholistic thought into contexts of higher specificity and precision. However, they were limiting met methods for developing a complete world view. The contrary argument, that reductive methods have led us to the "proof" of this premise, are pointless to one who may have embraced Zen or certain Native American philosophies. Such persons, it would be claimed, "knew it all along."

Now where does this take us in education? Here I will propose a series of recommendations that are intended to provide a more wholistic possibility for instructional practices in education, curriculum and research and evaluation.

INSTRUCTIONAL PRACTICES

Most instructional methodology has a predetermined linearity in both content and in process. That is, both the conceptual material to be taught and the way it is to be taught are pre-planned. Flexibility generally exists only in the utilization of a narrow range of alternatives that are designed to get deviating students back on the path. The establishment of linearities in process was the primary contribution of the revision of instructional strategies during the past two decades.

The whole realm of learning disabilities and learning d[illegible]nction is established in regard to a narrow range of expectations. These expectations are the historical "basics" in both skill and content areas. That is, they are the three R's and the basic concepts in science, math, and social studies and, of late, the humanities. The basic disadvantage of such approaches is that even in the simplistic, lateralized mind model they nurture only the reductive functions of half the brain—the left hemisphere.

Instruction must become whole-minded or, more precisely, holonomically minded. To facilitate this it might be well to extend instructional concern in the domain of the following recommendations:

*<u>A more pluralistic vision of "appropriate" content</u>. Arguments may no longer be maintained that separate the content of any discipline from another.

*An honoring of the non-rational skills of exploration in ideas and communication. Movement, visual and auditory expression must be established as valid media of expression—media as legitimate as the more abstract, symbolic systems of logic represented by the three R's.

*Planning that honors spontaneity on an individual level. Recent trends in individualized instruction seldom relate to spontaneity. Instead they focus on students doing the same linear thing at different rates. The synergic context of instruction (that is, the blend of ideas, skills, teachers, and students) should establish what is taught and the ways in which it is taught.

*A higher level of honesty between teachers and students. Teachers are not the harbingers of knowledge. They are the knowledge. Dishonest teachers create a charade around this point. They become the primary medium through which the curriculum is transmitted. Teachers should accept and admit this role.

*More humor in instruction. Even as staid a thinker as Arthur Koestler has acknowledged humor as the primary medium of commonplace creativity. Humor can and does celebrate proliferated forms of knowing.

*Alternatives to lesson planning. Many teachers have transformed their teaching (and life) styles by compiling diaries of the previous week's experience rather than writing lesson plans each Friday.

CURRICULUM

Because curriculum has been primarily a recounting of history, it has been dominantly reductive in the modes of thought required. Only the arts and language arts have held any real promise to counter this tendency and seldom are they used to do so. The arts have within them an inherent energy for transformation. A drive for invention and the nutrients for creativity all abound in the arts. Yet the past decades have seen inordinate funding and developmental focus in the sciences and not the arts. This tendency entrenched the reductivism of thought so consistent with history.

To repeat, the arts contain the capability within the curriculum for transformation, but seldom have they been used toward such ends. In most places the arts are presented in as reductive modes as is science. Taxonomy appears as an emphasis in "schools" of art, dance, and music. Evolution and history dominate curriculum presentations in regard to the varieties of artistic experience. Art generally is reduced to an ornament to the progression of reason, rather than as central to it.

An artistic vision must be added to the scientific vision for wholistic curriculum. As surely as mystical vision created science,

science is at the dawnpoint of a reinstatement of a new, mystical vision. The arts will be the primary media of this enterprise.

On these bases, I see the necessity for the following:

*An honoring of the non-rational modes of exploration in the basic, linear content areas of traditional curricula. (That is, movement, music, and visual expression in science, math, social studies, etc.)

*A creation of methodologies in metaphoric and proliferative thought in order to balance the reductive methodologies central to the federally-funded and publisher produced science, math, and social studies curricula created during the past two decades.

*A wedding of the practices of affirmation of knowledge with the possibilities of invention of "new" knowledge. This differs from "discovery" approaches in that neither teacher nor student knows the actual results of the inquiry ahead of time.

*Wider use of spontaneity in curriculum as contrasted with "programs" and highly organized courses of study.

RESEARCH AND EVALUATION

Though in theory research and evaluation are different, in practice they are usually the same. Both in practice are dominantly reductive. The methodology of research is more openly reductive as it sets up elaborate game-plans that result in a supposed kind of objectivity in whatever study is chosen. The most common outcome is a bland kind of objectivity that is displayed in predictably trivial results. It is this quality of trivia that renders most research superficial to the real issues in education. It remains therefore as the rites of passage into a possible mindset of mediocrity.

Evaluation is in danger of conveying the same mindset in classrooms. Its reductive components tend to excise major qualities of thought that represent the whole mind context spoken to earlier. Most evaluation is focused in a summative philosophy rather than on formative criteria. Though few evaluators would agree in theory that summative evaluation is reductive, in practice it nearly always is. Thus at the risk of being accused of over-simplicity, I will equate evaluation and research in the following recommendations:

*Research and evaluation models should accept the legitimacy of divergence in results as well as convergence.

*Research and evaluation should include strategies of synthesis and union of disparate ideas as well as strategies of analysis and separation of ideas.

*Research and evaluation strategies should explore the qualities of positive entropy as well as the qualities of reduced or negative entropy.

*Research and evaluation models should realign with strategies of description more likened to natural history than the analytic reductionism of controlled manipulation.

*Research and evaluation should expand from solely counting responses to extrinsic manipulations, to the counting of options intrinsically chosen by students.

*Research and evaluation should shift from digital to analogic modes of analysis.

Bill Romey has written a very personal paper about values, growth, self-actualization and how these qualities can be nurtured in a science classroom.

THE ESSENCE OF LIFE

Bill Romey

INTRODUCTORY VIGNETTES

I.

"Are you busy, or can I come in and talk for a while?"

After standing hesitantly in the open doorway to my office, Kathy came in and jumped onto a stool beside the table where I had been writing. After a few moments of just looking at me, her brow furrowed, she spoke, her words pouring out in a regular torrent.

"I just can't deal with it any more. I've worked and worked. I really want to do well. And now I've just flunked my science final. I know the grades don't mean anything about me and what I'm really worth, but I feel so awful. I worked so hard all term. I'm afraid I'll never make it."

Tears of frustration and disappointment poured down her cheeks. It seemed that the people running her courses just didn't care about her at all. All they cared about was the subject matter of their courses.

II.

Sue came in to talk about her work in an "open" science class we had conducted. Her credit came almost automatically, whether she did anything or not. We had tried to nourish her, to let her sense out interest in her personal growth and learning, and to invite her participation in as many ways as we could. A wide range of opportunities had been presented to her. Yet her course feedback sheet said she wished we had forced her to work. She felt guilty that she had not done what she "should." Her guilt feelings led her to blame us for not making her work on her geology, the subject she really wanted to study, she said. ("But I couldn't study what I wanted to because I had to work for my exams in other courses.")

Both Kathy and Sue are faced with important personal conflicts, Kathy in a situation where she feels no one cares about her and her real learning, and Sue in an open and caring environment where she knows people care about her but has not yet learned to take

responsibility for herself. Both people externalize the responsibility for their failure to achieve. For Kathy it is failure to achieve in someone else's eyes. For Sue, it is failure to achieve in her own eyes. Both are involved in one of the most important growth experiences in their lives: learning to cope.

III.

Don was preparing to teach earth science. During his student teaching he tried many ways of getting students more in touch with themselves and with each other as well as getting excited about their subject matter. He had a constant battle with a master teacher who wanted him to do conventional lecture and lab work. Although Don received only lukewarm evaluations from the master teacher, a number of parents communicated with our offices that Don was having extraordinary success in helping their children grow and learn. At one time, Don decided he could never really make it as a conventional teacher. Now, he has a job working with disturbed children in a special school. He got through the callous, non-empathic treatment he received from many school officials, perhaps because his university program was a caring one.

IV.

Dan thought he had developed a good rapport with his master teacher. Dan is a loose, student-oriented person full of contagious vitality. He has all sorts of games and tricks to keep his students interested. He is also delightfully human, such as the time when he accidentally sat down in the middle of the model glacier made out of apple jelly. Another time, just after warning his class to be especially careful of the open ether bottle, he swept the bottle onto the floor himself, in the middle of some grand gesture. Dan is able to make mistakes and to use them as a source of humor and enlightenment. His students were learning lots and felt good about science and science-related issues. Then, at the end of a grade period, the master teacher substantially lowered many grades Dan had given. Dan protested, and the students got a petition going to express their resentment for this unfair interference. The principal hauled Dan into his office, shouted at him, berated him as a trouble-maker, and ordered him to leave the school immediately, without being allowed even to go say goodbye to his students. This occurred three days before his student-teaching was to end. Dan survived this assault and is convinced he did the right thing, defending major principles concerning his responsibilities toward his students and his duty to protect them against toxic wrongs he sensed. Dan is now in a full-time teaching job in a private school, still wrestling with institutional rules, but surviving and growing.

V.

Rich teaches science in junior high school. He is devoted to working personally and individually with students, but he has a principal who demands rigid lesson plans daily (180 pages of them

last year alone), tightly conceived behavioral objectives, formality in the classroom, punishment, control, accountability. This administrator applies coercion by means of manipulation of salaries, teacher evaluations, extensive files on each teacher, and other means of keeping people in line. During the period of pre-tenure evaluation, he clearly intends to try to shape Rich into his own image. But Rich has decided that he has a simple existential choice: to cower and be automatized or to let his administrators think they have him in line, but to do what he must to show his caring for students in quiet ways in his own classroom and to wait. Rich loves "these people that pose as students." He is caught in constant conflicts but resolves these in favor of the individual students rather than in favor of the rules established in the school as a whole.

SEEKING THE ESSENCE

Centeredness, change, balance, growth, self-actualization, dynamic equilibrium, conflict resolution, caring. These are ideas that come first to mind as I think about an "essence" of life. What relationship, if any, should science teaching have to these kinds of things? These represent to me what make human beings special and different from other creatures. Animals don't appear to look back or ahead in time or to show much evidence of inner conflict. They don't stop to think or plan. Their behavior seems largely automatic, given certain contexts, or "autistic" as Pierce (1973, 1975) labels it.

These ideas seem to relate more to individual human beings than to society at large. Since such concepts lend themselves to introspection, self-analysis, and contemplation, don't they represent a narcissistic and selfish kind of focus? Shouldn't we be more concerned with wider kinds of societal problems? Can we afford, as some have put it, to wallow in person-oriented aspects of learning and growth?

As a species, we have made rather a mess of our world. Laing (1967) points up the alienation from which we all suffer in a society where fantasy, "magic," mystical experiences, and other "abnormal" personal experiences are not valued.

> The condition of alienation, of being asleep, of being unconscious, of being out of one's mind, is the condition of the normal man. Society highly values its normal man. It educates children to lose themselves and to become absurd, and thus to be normal. Normal men have killed perhaps 100 million of their fellow normal men in the past 50 years (Laing, 1967, p. 28).

In the U.S., we have barely gotten out of a vicious, self-serving involvement in Viet Nam. In the Watergate affair, rottenness in political structures broke through what looked like a shiny, healthy, democratic skin. Scientists supposedly in search of "truth" have participated in the creation of weapons capable of destroying the whole of mankind. Leading scientists have recently been caught cheating in various ways to enhance their reputations and win prizes. Shouldn't

we therefore be concentrating in our educational system on developing new sets of more humane societal values rather than on individual growth and introspection? Shouldn't science teaching be concerned more with issues of science and society than on the personal potential of individual students? Isn't the problem more one of changing the content of science programs to focus on more social issues rather than worrying about personal problems of people like Kathy, Sue, Don, Dan, Rich and how they feel about themselves and their associates, students, teachers, or administrators?

I believe that societal consciousness and conscience can only develop in people who have a strong sense of self. Maslow (see Goble, 1971) points out that self-actualizing people such as the "greats" we all desire to emulate have both a strong sense of themselves as people and of their responsibility to larger societal causes. Albert Einstein, Linus Pauling, Benjamin Spock and other scientists who have become strongly oriented toward political and societal causes provide models. Scientific activists like Barry Commoner, contributors to the Journal of the Atomic Physicists, and many others commit significant amounts of their time to societal value questions. Ralph Nader and others like him plunge into issues concerning how science and technology affect the lives of individual citizens.

One might disagree with the positions taken by many of these people, but are people of action, often fine scientists who have dared to become involved in wider political arenas that affect the lives of each of us in profound ways. These are people who had a strong sense of themselves to begin with. They are able to face criticism, controversy, and often rejection and still continue to function actively and joyfully in their personal, scientific, social, and political activities. They are people of principle who have taken humane, life-supporting value positions.

Theodore Roszak (1969, 1973) is among the more articulate critics of big science that seems unconcerned with human values. He blames much that is shabby about our society on the dehumanization and narrowness he sees in a science and society oriented toward objectivity has infected more than just scientists, too. Many people whose disciplines are labeled humanities and social sciences show little evidence of real concern for other human beings either. Charles Reich (1971) also criticizes cold and impersonal institutionalism that fails to recognize the sacredness of the individual and his or her feelings and psychological and moral health as prerequisites to societal health. Many people in the so-called humanities express their desire to deal with what it means to be human. But their means of doing this is to study what poets, artists, and philosophers indicated about it in the past rather than to deal with the problem in any experiential way that might have personal relevance to students. Specialists in the humanities and social sciences and their textbooks and research show the same preoccupation with analytical scholarship, "objectivity," and descriptions of past glories of humans of which we in the sciences stand accused. In many instances, biographies, literature, and history dress up individual humans in heroic clothes that hide the conflict and uncertainty, the mistakes and the baser sides of even our "greatest" people, as Kozol (1975) points out.

In a recent panel discussion on humanities and sciences, I expressed active concern and involvement with many values related to the quality of our emotional and intellectual lives as well as with the physical and biological factors usually consigned to "science." A fiction writer on the panel said that people shouldn't listen to me as a representative of "science"—that I was really just a humanist in disguise. Unfortunately, the image we project in science teaching has earned us the reputation of not really being concerned about the nature of being human. Those of us who go on to do science know that we are as concerned about uncaringness and stupidity we see rampant as any humanities scholar, social worker, minister, poet, or therapist.

The problem throughout is a lack of <u>caringness</u>. Such caring begins on a very personal level. Children are affected by it at the earliest stage of their development when the conflict that Eric Erikson (1963) has identified as basic trust versus basic mistrust arises within them. To the extent that children are with truly caring adults, they are able to resolve the conflict in such a way that they may progress to a higher stage of development. Just as Piaget (1968) suggests that people progress through a series of psychological and intellectual stages, Erikson deals with even more basic kinds of growth as humans pass through several stages of conflicts: basic trust versus basic mistrust; autonomy versus shame and doubt; initiative versus guilt; industry versus inferiority; identity versus role confusion; intimacy versus isolation; generativity versus stagnation; and ego integrity versus despair. Each person must deal with each of these stages of conflict in order to maintain emotional and psychological health and the ability to lead a productive and satisfying life in science, business, or any other area of interest. One can never avoid conflict. Each stage of life brings with it new conflicts to be resolved, and the old conflicts remain, too, demanding further energy for their on-going resolution. Growth and learning in the long run mean becoming able to deal with more and more levels of conflict on a continuing and simultaneous basis rather than with any final resolution of any single conflict. The only permanent resolution comes with death, just as the only self-actualized person is a dead one. Conflict-resolving, self-actualizing, centering, balancing, growing all lie within the realm of processes rather than the realm of products.

Individual personal growth occurs through conflict and the reaching of various stages of dynamic equilibrium. We arrive at a metaphor which connects us on a larger scale with the broad domains of ecology and social ecology. As science teachers we have all applied the concept of dynamic equilibrium in chemistry, physics, biology, and the earth sciences. Natural phenomena exist in a kind of homeostatic balance. When the system or organism becomes unbalanced, changes must occur to bring forth a new balance or else the system will disintegrate or the organism will die.

Dynamic equilibrium requires centeredness. Each person must ultimately resolve her or his own conflicts. A highly caring human environment helps people find their balance in conflict situations, if we are to believe the data provided by psychologists such as Rogers (1969), Perls (1972), Maslow (1966), also see Goble (1970) and others.

Two initial conditions must be satisfied in order for people to play an active role in dealing on a personal level with problems of science and society. First, a person must maintain the kind of personal centeredness that enables her or him to assign high priority to societal problems and to adopt causes. Second, she or he must successfully resolve the many personal conflicts that precede the learning of science content as such. I believe that the <u>way</u> in which science is presented in the schools and the environment in which it is learned have a great deal to do with whether or not we begin to realize the potential science might have for affecting society in positive ways. Above all, science must be set in a caring context, if we wish for it to contribute to a more caring and humane world.

The essence of life as I have tried to characterize it here lies in centeredness, dynamic equilibrium, and caring. It is fundamental in every human activity. Roszak (1973) wants us to return to a wholistic, non-reductionist world view. For this to happen, science must be removed from its pedestal as any ultimate route to solving human and societal problems and put back as a person-oriented, psychically reconstituted set of interesting human activities. It becomes essential to put all of our science and science teaching at all levels, elementary, secondary, collegiate, and professional, back into a humane, person-oriented, wholistic, non-reductionist context. I mean here both the way in which we act in science classrooms and other educational settings and the science content we deal with. Questions of human values need to be at the center of every scientific investigation, lesson, or activity.

MODELS FOR DEALING IN TEACHING SITUATIONS WITH THE ESSENCE OF LIFE

The essence of life as I have treated it includes its process and values aspects. This essence represents a pervasive element that permeates every part of science teaching environments whether we want it to or not. The only choice we have is whether we want to recognize its presence and do something about it consciously or whether we take it for granted and pretend that we won't have to deal with it. In the latter instance the values conveyed and the processes represented will be a reflection of the overall society and institutions of which the school is a part. This approach is what allows many scientists to lay the blame for any misuses of their discoveries on the state, on society, or on anyone but themselves. We weave a weft of science content over a warp of values, configurations, and concepts of society. There is no weaving, no tapestry without both warp and weft. The warp is placed upon the loom first, as the underlying control of the fabric we will achieve. The quality of the material we end up with depends upon the underlying color, texture, strength, and spacing of elements in the warp of values and processes.

The issue as a whole is handled in teaching situations by the configuration of these situations. In an authority-based situation (lecture, lab, discussion, or project-oriented) we reinforce the idea of reliance upon authority as a value. In a situation where teachers

grade students "impartially" and "objectively," we reinforce ideas of reductionism and dependence upon extrinsic evaluation rather than upon a more intrinsic, wholistic, intuitive kind of self-evaluation. (Incidentally, the highest level of evaluation identified by Bloom (1956) in his taxonomy of educational objectives is self-evaluation. Yet how seldom do we allow learners to evaluate their own work.) In situations where we suffer from the delusion that we, as teachers, can motivate students extrinsically, we reinforce the idea that motivation comes from outside. All of our hidden assumptions about life, all of our true values, the things we really believe enough to act upon them, the things that determine our own behavior, come forth in the learning environments we maintain. Would that we could all stand back and see the gap between our rhetoric and our behavior.

For my part, I want to develop learning environments that come as close as possible to reflecting the set of values I feel intuitively and wholistically good about at any point in time. As I get reflections and feedback from learners, colleagues, friends, enemies, and anyone who reacts to what I do, I want to become more aware of what values my behavior seems to express. In that way, my life becomes a continual examination and appraisal of my values, accompanied by changes that help me come closer to the positions I seek. I become a spaceship making mid-course corrections as I move toward what I perceive my goals to be at any point in time. My goals will keep changing, too, as I see more of the universe I am exploring and perceive other levels of goals that I had not even suspected were out there. A given set of goals can only be seen from certain perspectives. As my perspectives change, so must my goals, and so, too, must the course of my spaceship. The ultimate goal is the seeking, the vehicle is my awareness, and the skill is my ability to be open to new possibilities and to make mid-course corrections.

The model I present has to be a personal one. I offer it and the accompanying resource list as an invitation for each reader to look deeply at her or his own values. This also becomes a call to action in the sense that all of us will be acting within these value dimensions whether we choose to or not. No action is also action, in that it represents tacit acceptance of the value set of the institutions we work in. Changes in institutions and in society arise only through actions of individuals and changes in their sets of values as expressed in overt behavior.

In my present approach to science teaching and to teacher education I want the individual person and her or his personal quests for growth always to come first. I ought to be able to exercise this approach in virtually any institutional setting. By being attentive to each learner and making each decision in favor of what the learner and I agree will facilitate the learner's personal quest, we probably have a good basis for mid-course corrections as these become necessary. If I am strong and sure of myself I ought to be able to do this in anything from the freest to the most coercive overall school situation.

In fact, however, many school situations that favor control, authority, and coercion tend to punish teachers who center their concern

around learners as individuals rather than around narrowly defined transmission of subject matter. This is certainly true of the situation Rich, whom I introduced in a vignette at the beginning of this paper, is in. He is in full conflict, and yet he has kept himself more or less centered and able to bounce back. He understands the necessity of conflict for growth. I consider Rich's position about average for most public schools—a little better than in some schools, a little worse than in others.

Other school situations appear from the outside to provide a much more favorable climate for a person-oriented, value-related, process-oriented kind of schooling in science. In such places, however, there is just a different level of conflicts. Many open schools have moved a long way in the directions I value. However, the more recent works of Herb Kohl (1974), John Holt (1974) and other reformers who have tried to change the institutions called "schools" suggest that the only solution is to destroy the existing approach to schooling almost completely. In spite of their call for a whole new approach, whatever we would create in their place would still be in part a mirror, reflecting the nature of our society. The question returns—is the goal of schools to train people to fit into our existing society or is it to let people learn ways to change society? If their goal is ultimately to bring about change, then those of us who believe this necessarily commit ourselves to lives of intense conflict.

In my own present school situation I managed to "get control" of a moderate-sized academic department in a small private university. Note the incongruity at once of the term "get control." It does not fit the model I shall describe, in that it derives from a hierarchically control-oriented context. Yet it provided a platform for larger action than I as an individual might have attempted. We set up, on the spot and all at once, what looked like a model for a science learning environment that could be largely person-centered. The goal was to provide more or less unlimited chances for all students to pursue studies either on their own or in groups in any areas of their choice (far exceeding any conventional notion of what could be included in "geology and geography"). We removedconventional grade pressures. We established an open style of operation where any faculty or students had substantial access to the departmental budget in support of their activities. Many faculty offices and all other labs and spaces stayed open at all times and served as student study spaces. We used encounter groups and other counselling mechanisms to help ourselves and our students confront and deal with questions of values both within and beyond their "academic" work. Details of the model have been described at length in a number of publications (see Romey, 1972, 1975, 1976 and numerous articles to which I shall be happy to direct any interested readers who wish to write me), and I do not wish to burden the reader with their description here.

Learners, we found, seemed to go through a more or less definite set of stages. We've come to label the first of these the "do-nothing stage." In extreme cases we may not see these people at all for extended periods. People who do come often respond poorly to "challenges" we may make as optional assignments and suggestions. They come in ill-prepared for discussions we try to schedule. They

rarely read materials we suggest. They would do these things, they say, if only they didn't have an exam in another course. They'd rather do their science with us, but they just don't have the time, since we refuse to coerce or direct them. We want them to deal personally with the conflict they sense rather than removing the conflict for them by making just another set of requirements.

In a second stage of their development, students externalize the blame for their own inactivity, as Sue did in the vignette. Still suffering from their belief in the myth that motivation can come from outside, they blame us for not requiring them to work. Of course, if we did require them to work, then they would blame us for that, too —for keeping them from working on some other imaginary things they would work on "if only I didn't have to do this first."

Finally, in a third stage, they realize that they are responsible for their own learning and for their own lives, and eventually for at least part of the society they live in. They begin to resolve their own conflicts in an environment that is as caring as we can make it. At this point, they begin to work effectively as independent learners who seek guidance, contribute to groups, write papers, do lab work, and perform from a basis of a truly intrinsic motivation. They even become able to deal effectively in other areas with conventional course requirements and what might have before seemed trivial expectations, without anger or fear.

For the first two years, our particular group tried to think of itself as somewhat unified around a person-centered theme. Then, to varying degrees, both faculty members and students began to drift back into the safe old behaviors that still filled their lives outside our department. Now, five years after we began trying to set up an "open" department surrounded by a conventional institution, our group has developed into several alternative communities. One group, involving perhaps a third of the students and faculty members, continues to operate in the open, person-centered style we began with in 1971. A second group involving another third of the students and three faculty members operates in a conventional, content-centered, exam-based, grade-oriented mode similar to that of the rest of the university. Even among this group, however, the climate for learning seems vastly better and more oriented toward the students than in many departments. Generally this group, too, is committed to the students as people, but the focus is more on subject matter and on certification of students. A third group of students is not particularly committed to one group or the other, but occupies an intermediate position. All three groups are reasonably acceptant of each others' differences. Probably, for the particular overall context involved, this represents an optimum, decentralized arrangement in which the various groups do not try very actively to control each other by "majority-rule" tactics. All segments are reasonably supportive of each other, and no part of the environment suffers from too much of a "red-line" mentality of criticism, correction, reductionism, and coercive accountability that inhibits human growth and learning in many groups. Each faculty member decides what and how much he or she will teach each term, and students often teach and get paid for it,

too. All meetings are totally open, and students have essentially equal votes with the faculty to the extent that they choose to participate in departmental business.

For my part, I have been able to work in widely diverse areas of my interests. I have felt little effective interference, even though many other faculty and administrators in the university at large may protest verbally a great deal. One problem is the human overload and difficulty the faculty have in focusing our interests once we commit ourselves to several hundred individual people instead of to three or four courses." During the past term, for example, I conducted four-week mini-courses in field geology, earth science from the newspapers, and earth-science aspects of energy problems. In addition I led an advanced regional field geology group working on special projects related to an on-going research project. Other students were working with me as their sponsor in stratigraphy, mineralogy, geomorphology, and several areas of both cultural and physical geography. A non-departmental seminar I'll lead next term will be on reality and perception in science. In other terms I've recently worked jointly with people in the departments of government, religious studies, English, and modern languages on problems of developing non-western countries. I've worked with our science "methods" students during their professional semester. In some terms I've had no formal "courses" at all, only project students. This open diversity has provided a rich environment in which I feel high personal enthusiasm. I believe I can see this reflected in high enthusiasm among learners as they work through stages of their own growth. In all of these experiences the students receive no grades—only the designation "credit," even though the university as a whole maintains a conventional grading system throughout.

As we begin to make contact as human beings, much time is spent in counseling and, virtually, psychotherapy. To a large extent some of us help students pick up the pieces after, like Kathy, they get smashed psychologically in some other department and come in, down on themselves, feeling emasculated, and far from any mood that could lead to learning of content or to psychological growth.

The open parts of our program, and the programs being used in many schools, individual classrooms, and alternative learning environments, are those where learners and facilitators can work together freely, identify and work through conflicts, and seek experiences that lead to intellectual, emotional, physical, and moral growth. These are environments where values are constantly re-examined and tested, where people can try things, can take risks with a maximum chance of finding human support when they need it. Learners need to have their personhood recognized and validated whenever possible. In programs where rules and roles form a primary focus, the human beings get lost. Principals, supervisors, teachers, and students all suffer in impersonal contexts and we get caught in a vicious circle in which "the institution" seems to take on a life of its own, controlling people and often thwarting their best hopes and chances for growth.

Ledon Sheets, a radical religious and political activist who has helped burn draft records, pour blood on military aircraft, and dig

graves on the White House lawn in protest against injustice and inhumanity has spoken to me about the importance of expressing one's values openly and without hesitation or wondering whether or not one's actions will have some definite effect. I hear many educators agreeing "in principle" with ideas of human concern and of the importance of being responsible and active where issues related to science and society are concerned. But when it comes to action they too frequently claim that, "It wouldn't do any good anyway; it would have no effect." Sheets' point is that, if we stop to weigh consequences and wonder much about results, we are apt not to act. In order to express values, we must learn to act upon them without particular thought of having our actions "work." What is important is expressing our values through some concrete action. Oddly, I begin to discover, the more often I act directly in support of my values and principles, without being concerned about whether or not my actions will produce any results, the more things seem to work better. Learners who spend time with people who are willing to stand-up and act on their beliefs also will have models to observe and may themselves learn to act positively and firmly in expressing their own values. They will, I believe, have a maximum chance of becoming process-oriented people who recognize their own power and potential. As such they can become scientifically literate and active citizens. Those who go on to become professional scientists will also be more likely to help place science back into the firmly human context where it has always really belonged.

RESOURCES

The materials described below, listed alphabetically, represent only a few of the resources available in this area. I should issue a word of warning about what may happen if you become seriously involved with these materials or the approaches they suggest. Getting involved is like going through a one-way door into another world. There is no easy retreat back to the safety of a conventional viewpoint. Growth is always painful. The rewards, on the other hand, far outweigh the pain, I believe. With our society in its present circumstances, we have little hope of dealing effectively with the conflicts referred to in the other chapters in this book until we actively deal with the issues I have treated in this chapter on the essence of life. The list below includes all of the references cited in the chapter and a number of additional sources as well.

Bibliography

Abruscato, J. and J. Hassard. Loving and Beyond: Science Teaching for the Humanistic Classroom. Santa Monica, CA: Goodyear, 1976.

This book describing various humanistic "methods" as applied to science teaching contains extensive references and resource lists that will be helpful to pre-service and in-service teachers at all levels.

Bloom, B. (ed.). Taxonomy of Educational Objectives, I: Cognitive Domain. New York: Longmans, Green, and Co., 1956.

This is a basic attempt to classify educational objectives. A quick reading shows that most of our objectives are very low level.

Coombs, A. (ed.). Perceiving, Behaving, Becoming. Washington, DC: Yearbook, Association for Supervision and Curriculum Development, 1962.

This classic volume dealing with the truly adequate, fully functioning, self-actualizing person contains articles by Earl Kelly, Carl Rogers, Abraham Maslow, and Arthur Coombs as well as detailed notations and chapters prepared by a committee of ASCD members.

Erikson, Eric. Childhood and Society, 2nd Edition. New York: W. W. Norton, 1963.

Chapter 7, "Eight Ages of Man," presents Erikson's ideas about conflict and maturation. How personal identify evolves through various stages of life is a primary focus. Erikson's eight ages were the subject of a major prime-time television program in late 1976 entitled "The Carousel of Life."

Freire, Paolo. The Pedagogy of the Oppressed. New York: Seabury, 1970. (Original Portuguese ms in 1968.)

Freire deals with the "banking" concept of education (in which teachers try to "fill" students with intellectual "wealth") as an instrument of oppression which inhibits societal change. Problem-solving approaches, on the other hand, provide an instrument for liberation of all classes of people, both the oppressed and the oppressors. Political revolution led by a conscious and dedicated few, who see through the tactics of opponents of change, may be the only way to achieve personal liberation for all.

Goble, R. The Third Force: The Psychology of Abraham Maslow. New York: Grossman, Pocket Books edition, 1971.

Goble provides a detailed summary of Maslow's ideas, with references to all of his major works. Maslow himself reviewed and approved the manuscript just before his death. The book lacks the charm and readability of Maslow's own writing, but it contains a wealth of information and presents a detailed overview and historical perspective that Maslow himself could not have achieved, tied up as he always was with his latest ideas.

Holt, J. Escape from Childhood. New York: Dutton, 1974.

John Holt presents the whole world of the child and young person as a virtually untenable one. Parents are urged to keep their children out of regular schools completely unless they want to risk permanent psychological damage to them.

Jerome, Judson. Culture Out of Anarchy: The Reconstruction of American Higher Learning. New York: Herder and Herder, 1971.

Jerome reviews a number of experimental programs at both higher and lower levels. He describes numerous attempts to arrive at truly democratic values and the generation and spin-off of alternatives. He challenges degree, diploma, and credit systems as inimical to the very essence to which many give lip service. The book is full of specifics as well as presenting a challenging and stimulating political and social viewpoint.

Kohl, H. Half the House. New York: Dutton, 1974.

After years of criticism of public schooling and books such as The Open Classroom, which suggested classroom reforms, Kohl gives a personal look at his own feelings about education and values. He proposes that a large part of the present school establishment may literally have to be destroyed before truly humane and effective schools that deal with the essence of life, as I have identified it, can grow. He describes the pain and difficulty that people interested in change must commit themselves to.

Kozol, J. The Night is Dark and I am Far From Home. Boston: Houghton Mifflin Co., 1975.

In a part of this book reproduced in Learning, December 1975, pp. 16-20, Kozol shows how the images of people like Thoreau, Helen Keller, Martin Luther King, Malcolm X, and others are "sterilized" and glorified in textbooks and literature, tailored for school use. We lose the real humanness of people in such portrayals.

Kuhn, T. S. The Structure of Scientific Revolutions, 2nd Edition. Chicago: University of Chicago Press, 1970.

Science progresses by discontinuous, intuitive leaps rather than in a smoothly incremental fashion. Ruling paradigms guide scientific thought for extended periods during which "normal" science goes about its orderly and controlled explanations. As anomalies arise that do not fit the paradigm, the stage is set for a new leap forward and the creation of new ruling concepts. Normal scientists often fight such changes in ruling concepts, which require changes in basic beliefs. Abrupt changes in beliefs and values, regular conversions in an almost religious sense, are the main mechanism for ultimate progress. Textbooks strongly hinder the progress.

Laing, R. D. The Politics of Experience. New York: Ballantine Books, 1967.

Laing points out the destructive qualities of education based on limited, "objective," standard, "scientific" views of reality. These lead to interpersonal and intrapersonal alienation and the denial by outsiders ("Them") of personal experiences in which no one but ourselves can participate. Natural scientism based on objectification denies access to those aspects of us that are most human and special.

Mao Tse-Tung. Selected Works of Mao Tse-Tung. Hazelwood, MO: Great Wall Press, 1972.

Mao began with an underequipped and vastly out-classed minority army. He learned to wait patiently, playing the red tape and administrative blundering of the Nationalist State against itself. Through patience and discipline he prevailed eventually over the established powers to initiate a new order. Whether or not one agrees with the outcomes in Red China, Mao's example at least suggests that by patience and adherence to principles one can institute new kinds of social order even over great odds. I'm not sure how life-supporting they are or can be in a vast state oriented around the military, however.

Maslow, A. The Psychology of Science. New York: Harper and Row, 1966.

Maslow challenges the validity of largely mechanistic science, suggesting that the obligation of science is to look at all aspects of reality as we experience it, describing, understanding, and accepting it. He pleads for a transcendent, all-encompassing approach to science as opposed to narrower views. Maslow affirms the role of values in science.

Perls, F. In and Out the Garbage Pail. New York: Bantam Books edition, 1972.

This is an autobiographical account by one of the founders of gestalt psychology and therapy. Perls stresses the importance of the individual observer and his psychological conditioning on the observations he makes. Here is a person who has centered his own life and processes and developed a system of therapy to help remove the blocks we have formed that prevent us from tuning in on the world around us.

Piaget, J. Six Psychological Studies. New York: Vintage Books edition, 1968.

This is an activity aimed at bringing about a balance of the effects of social and physical environments with our need to conserve our structural systems governmental growth in human beings. Piaget provides an extraordinary example of leaping across established boundaries (biology, physics, logic, philosophy, psychology, education) in search of new points of view about how children learn and behave. In many of his writings he explores the new field of genetic epistemology: the study of how knowledge is acquired.

Pierce, J. C. The Crack in the Cosmic Egg. New York: Pocket Books edition, 1973.

We exist within a social-scientific-philosophical-psychological context—our "cosmic egg." Moral, intellectual, and physical progress occur when a crack forms in that cosmic egg and we are able to see outward to new levels.

Pierce, J. C. Exploring the Crack in the Cosmic Egg. New York: Pocket Books edition, 1975.

This book carries the "cosmic egg" discussion further.

Reich, C. The Greening of America. New York: Bantam edition, 1971.

Our society progresses through stages of consciousness. Consciousness III, emerging over the past few years, involves liberation. Individuals free themselves from automatically accepting personal goals proposed by society. Each individual becomes free to build his or her own values, philosophy, life style, and culture from the beginning. Con III begins with the self. This doesn't mean selfishness, but rather the starting from premises based on nature and human life rather than artificial ideas of power, status, the corporate state, "science," etc.

Rogers, C. Freedom to Learn. Columbus, OH: Charles Merrill Co., 1969.

Rogers discusses the importance of interpersonal aspects of learning and how the growth of the individual and the group proceeds simultaneously. Concentration must be on the development of a fully functioning person in order for significant changes or learning to happen on any level.

Romey, B. Risk-Trust-Love: Learning in a Humane Environment. Columbus, OH: Charles Merrill Co., 1972.

Romey, B. Consciousness and Creativity: Transcending Science, Humanities and the Arts. Canton, NY: Ash Lad Press, 1975.

Romey B. Confluent Education in Science. Canton, NY: Ash Lad Press, 1976.

The three previous books summarize in detail my own philosophy of education as it has developed over the past several years. They contain examples, philosophical commentary and practical suggestions about creating an environment where conventional boundaries are transcended, where concentration is on the development of autonomous, powerfully functioning people, and where a value orientation can be "safely" pursued.

Stevens, J. Awareness: Exploring, Experimenting, Experiencing. Moob, UT: Real People Press, 1971.

Stevens provides a whole manual full of awareness exercises for individuals, pairs, and groups. Many are directly useful in school situations and generally enhance people's capabilities to explore openly, to cooperate, and to develop aspects of their humanness that are generally neglected in schools.

Roszak, T. The Making of a Counter Culture. New York: Anchor edition, 1969.

Roszak presents his view of the myth of objective consciousness as a destructively anti-human trait of science.

Roszak, T. Where the Wasteland Ends: Politics and Transcendence in Postindustrial Society. Garden City, NJ: Anchor edition, 1973.

Roszak challenges the religion of science as antithetical to many values and qualities that are most important in humanness.

Samples, B. The Metaphoric Mind. Reading, MA: Addison-Wesley, 1976.

This book deals with the processes of using metaphors to expand consciousness and with developing the capabilities of the right cerebral hemisphere as well as the left.

Samples, B. and B. Wohlford. Opening: A Primer for Self-Actualization. Reading, MA: Addison-Wesley, 1973.

The authors provide a wide range of suggestions for helping people become more aware of their potential. This gives blueprints for trying new things. Many of the ideas are directly applicable in schools. Some of the materials are related to the Essence materials described in the curriculum materials section which follows.

Schumacher, E. F. Small is Beautiful: Economics as if People Mattered. New York: Harper and Row, Colophon edition, 1975.

Size, institutionalism, oversized technology, and impersonality are seen as primary factors leading to human misery in both developing and developed countries. Schumacher issues a call to reorient our institutions, schools included, so that they are more oriented toward the individual person and his feelings of autonomy and power.

Simon, S. and J. Clark. Beginning Values Clarification: A Guide for the Use of Values Clarification in the Classroom. San Diego, CA: Pennant Press, 1975.

The authors provide many practical suggestions that can be used to encourage the expression and integration of values considerations in organizations and in schools.

Curriculum Materials

Earth Science Teacher Preparation Project. Gift Garden of Fantaseeds. Leesburg, VA: American Geological Institute, 1974.

This kit of methods materials stresses clarification of values, interpersonal and intrapersonal growth, creative behavior, learning facilitation. For both pre-service and in-service teachers, administrators, and any group-training activities.

Essentia. Essence I and Essence II. Reading, MA: Addison-Wesley, 1975. (Preliminary editions from American Geological Institute, Leesburg, VA, 1972.)

These kits, for use at any grade level or also for adult groups, provide a basis for group activities that trigger divergence and openness. Questions of values emerge constantly as one uses these.

Stone, A. H.; F. Geis; and L. Kuslan. Experiences for Teaching Children Science. Belmont, CA: Wadsworth Publishing Co., 1971.

This is a "methods" book full of activities and games that bring forth good humor, playfulness, and joy in the classroom. Activities are oriented toward providing a nourishing environment in

which to learn science and to develop children's sense of self, confidence, and autonomy.

Organizations

Association of Humanistic Psychology, 325 Ninth Street, San Francisco, CA 94103.

The association publishes the monthly newsletter, quarterly Journal of Humanistic Psychology, and various monographs. It also has regional and national meetings, special interest networks to facilitate communication among people with similar interests and provides other services as well. Membership is $35 per year.

Biological Sciences Curriculum Study (BSCS), 8383 S. Boulder Road, P.O. Box 930, Boulder, CO 80306.

This group is now producing the Human Sciences Program out of its offices in Boulder, Colorado. Aimed at middle-school children, the program provides a value-oriented, integrative set of curriculum materials in the form of activities cards which students choose among each day. The cards cover a wide range of areas in science, social science, humanities, and arts. Divergent thinking, personal responsibility, decision-making, personal growth, and interpersonal cooperation are encouraged.

Zephyros Education Exchange, 1201 Stanyan Street, San Francisco, CA 94117.

This is a small, non-profit group that collects, prints, and distributes practical lesson plans, activities, and games that have a heavy value orientation in directions I have favored in this article. The group is oriented toward creating a more humane society and includes many activities relevant to people in the sciences.

If science/society issues are to be absorbed effectively into schools, then change must occur. Change is both a process and a product. Understanding the nature of change and its relationship with science education is the subject of Thomas Evans' paper.

BRINGING ABOUT CHANGE IN SCIENCE EDUCATION

Thomas P. Evans

Millions of dollars and enormous amounts of effort have been directed toward change in science education over the past 20 years. The fruits of these labors and resources have resulted in a myriad of new instructional materials. Textbooks reflect an updating of content. More attention has been placed on the structure of science, and at least at the verbal and written levels, greater emphasis has been placed on discovery, inquiry, and scientific processes. As a result of federally funded programs, science teachers have experienced an increased number of basic science courses. Yet, observations of science classes reveal that little change has actually occurred in the teaching-learning of science. Lecture is still the predominant teaching method, and teachers remain the dominant figure in the classroom. Most classroom interactions are between teacher and student, and nearly all are initiated by the teacher. Textbooks, chalk, and chalkboards remain the most frequently used teaching aids. Students are still being evaluated on their ability to recall content, and the content is often not related to the lives of the students. Why has there been so little change in classroom practices? This chapter is devoted to an analysis and discussion of this question. Suggestions that should facilitate change are offered. The chapter specifically deals with resistance to change, facilitators of change, planning for change, and guidelines and requisites for change.

RESISTANCE TO CHANGE

Resistance to change derives from a variety of sources and manifests itself in numerous ways. It includes all factors and forces that contribute to the stability of individual personality and social systems. Resistance to change is the natural order of things and should be expected. Harris (1964) elucidates this position in his analogy between on-going educational programs and a body in motion. Any attempt to speed up, slow down or change the direction of the body results in friction. The fact is that all persons interested in bringing about change in science education must realize that there is no such thing as a peaceful change.

One source of resistance in science education is related to the use of a model for change described by Mann (1976) as an influence model. For example, in the science content improvement projects of the past two decades, changes have been designed and disseminated at the national level. Then attempts have been made to implement these changes at the regional, district, or local levels. Inherent in this model is the assumption that either the change agent (project developers) and target population (classroom teachers) are in agreement with respect to values concerning the need for change, objectives for students, and method of instruction or that the target population's values can be influenced and brought into agreement. Bennis, Benne, and Chin (1969) have identified empirical-rational, normative-re-educative, and power-coercive as being general groups of strategies for effecting changes in human systems. Empirical-rational and power-coercive strategies were applied to the target population in an attempt to implement the course content improvement projects. The empirical-rational strategies used included the following: (1) providing research results, (2) participating in institutes and leadership conferences, (3) enrolling in basic science courses, (4) attending inservice workshops, (5) observing teachers using new materials, and/or (6) going through the materials and doing the student activities. In these strategies, the target population is assumed to be rational and to accept the proposed values if it could be rationally shown or justified that teachers or their students would gain as a result of the change. In power-coercive strategies, a principal or science supervisor acquired a new program and simply applied pressure on the target population to accept the project values. Normative-re-educative strategies were rarely, if ever, used in project implementation. They involve value clarification, i.e., getting values of change agent and target population out into the open and working through the value conflicts. Superficially the model, assumptions, and strategies used appear to be both logical and acceptable, but their application has not resulted in the expected changes. Perhaps the model and/or strategies were inappropriate or the inherent assumption may have been false. Regardless, failure to obtain value consensus was, and remains, a major source of resistance to change.

Attempts by individuals to stabilize or cope with cultural conflicts represent a second source of resistance to change. In a conversation between Toffler and Morisseau (1973), Toffler explains that cultural conflicts arise when an individual is subjected to unusual conditions or unpredictable situations and is forced into making nonroutine responses. The number and intensity of conflicts become greater as the number, intensity, and rate of change increase.

Lack of research provides a further source of resistance (Stiles, 1973). In the absence of consistent and conclusive research findings, one person's opinion concerning objectives for students and associated classroom methodology can be argued for as effectively as another's.

An additional source of resistance is related to divisions within the teaching profession. The growing "us versus them" attitude between administrators and classroom teachers and between school personnel and members of society is not a favorable environment for the implementation of change. All four groups have the ability and power to virtually

neutralize the change efforts of the other. Divisions also exist among specialists, between specialists and generalists, and between elementary and secondary school levels. Such attitudes and divisions make it difficult, if not impossible, to amass an adequate support system and the driving force necessary for change.

The public's perception of schools is also a source of resistance to change. Goodlad (1976) points out that schools are viewed by the public as factories and are expected to give up quality of education in favor of efficiency. They are also expected to solve all of the problems of society. This perception results in a diversity of demands and expectations being placed on the schools and contributes to the existing lack of a majority viewpoint and articulated set of priorities for our schools.

Additional sources of resistance to change include the following: (1) loss of autonomy, (2) fear of manipulation, (3) lack of planning and adequate preparation, (4) complexity of educational system, (5) promotion and status gained by adhering to status quo, (6) lack of demand for change, (7) sacrosanct rituals held by school personnel and community, (8) intolerance for ambiguity and complexity on part of decision makers, (9) standardization of teacher preparation, (10) limitations of physical environment, (11) lack of clarity about focus of change, (12) vested interests and conflicts of interest, (13) lack of skill and understanding, (14) fear of failure, (15) threat to self-esteem, (16) isolation of teachers, (17) inadequate communication, (18) lack of resources, (19) mental set of individuals involved in change process, (20) progressive unionization of educational labor, (21) amount of time and effort involved in change process, (22) lack of involvement of persons affected by change, (23) inconsistency of reform with social reality, (24) inadequacy of evaluation processes, (25) complacency of individuals, (26) lack of sensitivity and ability among school personnel, (27) rejection of outsiders, (28) lack of trial before adoption, (29) feeling of self-distrust, (30) insecurity of teachers, (31) lack of community support, and (32) conservatism of school boards.

Simply listing these sources of resistance does not mean that they are unimportant concerns for science educators who desire to implement changes. Space precludes an indepth discussion of each item. A lengthy and more detailed treatment of each identified source of resistance can be obtained by consulting the writings of Harris (1964), Neagley and Evans (1970), Engel (1974), Bennis, Benne, and Chin (1969), Buchan (1971), Wolf and Florino (1973), Goodlad (1976), Brubaker and Nelson (1975), Morin (1975), Sergiovanni and Strratt (1971), Stotler, Richardson, and Williamson (1967), Ost (1976), and King (1975).

Any discussion of resistance to change would be incomplete without consideration of its beneficial contributions. The conflicts that arise as a result of resistance provide stimulation for many innovative ideas and practices. Resistance to change contributes to stability by slowing down change that may be occurring too rapidly. Changes are often far reaching and irreversible, and it is difficult, if not

impossible, to change one aspect of the educational establishment without affecting others. A change may be an improvement in one area while producing harmful side effects in related areas. Resistance provides time and the opportunity for an indepth consideration of changes and allows for the elimination or modification of those that may be in error and that pose real threats to individuals and social systems.

Facilitators of Change

A few of the previously mentioned sources of resistance, such as cultural conflict, public perception of schools, complexity of educational system, and mental set of individuals involved in change, could under a particular set of conditions serve as facilitators of change. And it seems reasonable to suggest that the opposite forms of the remaining sources of resistance could also be facilitators of change. For example, attempts to bring about change would receive an impetus by changing lack of cooperation to cooperation between teachers and administrators and by providing adequate instead of inadequate resources. Recognizing the need for change, sharing ideas, listening to critics of education, developing positive attitude toward change, keeping public and students informed, participating in professional association activities, writing journal articles, attending workshops, and reading professional literature are possible facilitators.

Observations by Rogers (Van Til, 1969) suggest that successful participation in the change process may also serve as a facilitator of change. He found that individuals were more willing to participate in further change efforts once they had experienced the growth, fulfillment, and excitement associated with changing.

Adequate attention has not been directed toward the where, when, and how of implementing change in science education. The situation is not much better in education in general, although Hearn (1972) has made some recommendations based on his reading, observation, and study of variables affecting adoption rates of ESEA Title III innovations. These recommendations appear to be logical and are suggested as probable facilitators of change in science education. The most likely place for change to be successful is in liberal communities where parental income and educational level are high and whose members are ethnically, religiously, and economically homogeneous. Youthful staff members are desirable, especially the administrative staff members. Change is facilitated by a staff who has traveled widely, taught in other school systems, and attended numerous professional meetings outside the state. The most opportune time to initiate change is during periods of rapid growth, changes in administration, media crusades against supposed school neglects, and periods of social crisis. According to Hearn, the how-to-implement-change depends upon the talent, energy, personal qualities and status of the change agent and conditions that currently exist in the school system and society.

The personal qualities of change agents are important factors in facilitating or prohibiting change. One of the personal qualities that facilitates change is a tolerance for turbulence (Harris, 1964). This quality, along with tolerance for ambiguity and complexity, contributes to objectivity in decision making. These allow change agents to remain calm and avoid hasty decisions during periods of conflict and increasing pressure that accompany change processes. Other desirable personal qualities include good self-esteem, faith in the ability of others, and openness to change. Effective change agents must acquire these and any other personal qualities that are requisites for shared decision making, shared responsibility, maximum utilization of the abilities of others, and establishment of two-way communication. Change should be a cooperative endeavor, and it will be facilitated when change agents have the personal qualities that enable them to work with educators and teachers in the way in which they would have teachers work with students (Stotler, Richardson, and Williamson, 1967).

A number of individuals and groups of individuals both within and outside the educational field have been identified as potential change agents. These include science supervisors, science teachers, department chairpersons, principals, consultants, and persons representing federal agencies, scientific and professional societies, industrial and commercial agencies, independent educational agencies, and special interest groups. The question arises as to which of these individuals or groups of individuals would be the most effective change agents. A conclusive answer does not exist, but a study by Orlosky and Smith (1972) provides guidance regarding two aspects of the question. After reviewing major educational changes over a 75-year period, they reported that the support a change received had a greater effect on the probability of success than did who had initiated the change. They found that it was extremely important to have support both within and outside the school system. For example, efforts to add new courses or change the substance of subjects were increased with support from legislation or organized interest groups. In the change attempts studied by Orlosky and Smith, no successful change in teaching methods was initiated outside the educational field.

Orlosky and Smith reported additional findings that were not specifically related to change agents but should be of interest to them. First, changes in methods of teaching were more difficult to achieve than were curriculum and administrative changes. Second, a change had a high probability of success if the cognitive burden was light and if teachers did not have to displace existing practices with new practices. Third, a change was not likely to become widespread or permanently entrenched without a definite plan for diffusion.

Further evidence of how difficult it is to bring about changes in classroom methodology was illustrated in a review by Evans (Balzer, Evans, and Blosser, 1973). Systematic observation was used in approximately 232 investigations to measure changes in teacher classroom behavior. Seventy-three of the investigations dealt exclusively with science teachers. Of ten variables studied, only training in systematic observation of classroom behavior was found to be a consistent

facilitator of change in selected aspects of classroom behavior. The direction of change was toward the positive categories of the observation instrument used in the training program.

Planning for Change

Any serious attempt to implement substantial changes in science education must be preceded by a comprehensive plan, and the plan should be viewed as an integral part of a delineated model for change. Figure 1 presents a suggested model for change. In addition to planning, the major components of the model include assessment, trial or pilot program, evaluation, rejection, modification, adoption, teacher preparation, and implementation and dissemination. Lines are drawn between the components, representing a two-way flow of information. They also illustrate that the model is cyclic; i.e., the capacity for continuing change is built into the model. Although each component is essential, planning is proposed as the most important aspect of the model. Planning must be continuous throughout any effort to bring about change even though it occupies only one portion of the model. The time, energy, and resources available for planning should be equal to or greater than the combined amounts given to the other components of the change process.

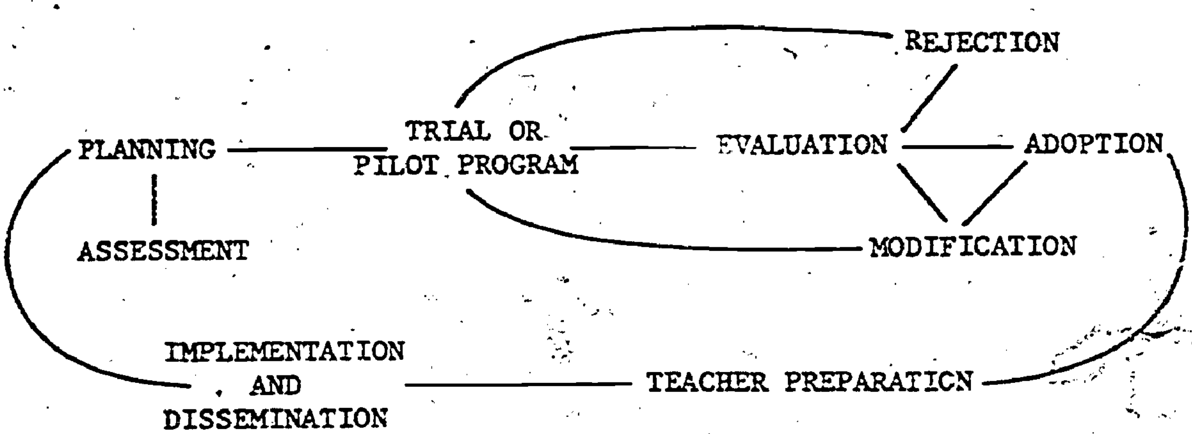


Fig. 1.—Model for Change

Before examining the tasks involved in the planning component of the change model, a brief discussion of how planning relates to the future seems appropriate. Although immediate problems and crises cannot be ignored, science educators must plan with an eye to the future. Efforts should be directed toward future-planning rather than planning to meet the future (Shane and Shane, 1968; Evans, 1977). Future-planning is active as far as the future is concerned. It

involves the following steps: (1) identifying systematic conjectures of what society will be like in the future based on logical analysis and extensions of data and trends by experts in such fields as sociology, political science, psychology, anthropology, science, demography, and technology; (2) identifying educational alternatives that are possible within the framework of the systematic conjectures; and (3) selecting from among the alternatives based on long-range objectives. Such a plan of action assumes that many futures are possible and that the decisions made today will determine the nature of science teaching in the future (Cornish, 1969; Williamson and others, 1973). It enables the future to be consciously influenced in selected directions.

Identification and clarification of the objectives for science teaching are among the first tasks of individuals who participate in the planning component of the model for change. It is essential that the objectives be clearly stated, thoroughly understood, and eventually accepted by all who participate in the change process. A related task is the establishment of specific criteria and levels of acceptance for determining when the objectives have been attained. Objectives serve as the central focus around which the remaining components of the model are planned and carried out. Additional tasks that must be considered during the planning component follow: (1) identifying sources of resistance, (2) establishing strategies to minimize resistance, (3) determining area of involvement as well as rate and direction of change, (4) including available research results into a plan of action, (5) developing a commitment to change, (6) establishing guidelines for conflict resolution, (7) identifying all available resources and forces that augment change process, (9) establishing programs of public information, (10) obtaining public support, (11) involving representatives of all groups affected in the change process, (12) determining what individuals, and how each, will be affected by the change, (13) identifying mechanisms used for maintaining status quo, (14) establishing a support system for those who participate in change process, (15) considering possible effects of change on other aspects of educational program, and (16) making results of attempted change known to others.

A detailed description of each component in Figure 1 is beyond the limitations of space, but several caveats seem necessary. None of the components should be omitted or seen as having less importance than the others. Each is essential and makes its unique contribution to the overall success or failure of ange attempts. Data from assessment are indispensable for adequat planning and implementing the trial component. After questioning 600 educators, Wolf and Fiorino (1973) reported that nearly one-half of the subjects who adopted innovations did so without any kind of trial or consideration of scientifically gathered information. Such a situation is untenable; adoption cannot be accomplished in an objective manner in the absence of information provided by the trial and evaluation components. Successful implementation and dissemination follow and are dependent upon a teacher education program that makes provisions for understanding and accepting the objectives and methodology involved in the change process and for establishing a commitment to the necessity of change.

Proper dissemination is also dependent upon accuracy and timeliness of reporting. Ohme (1972) pointed out that many innovation projects reported in the literature reflect what was hoped for rather than what was real, reflecting premature reporting and/or desire for national recognition and financial gain. The report should be delayed until the trial and evaluation components are completed, and it should include an accurate description of the project, including specific details of planning, rationale, objectives, operational details, and special resources as well as the method, techniques, and results of the evaluation component.

Guidelines and Requisites for Change

Figure 2 is presented as a summary of the major ideas discussed in this chapter. It is a checklist of guidelines and requisites for bringing about change. The checklist contains 71 items arranged into four categories including personal qualities of change agent(s), facilitating communication, relating to society, and planning and implementing plans. The categories are not completely mutually exclusive, nor are the items inclusive of all possible guidelines and requisites for change. The items were selected on a priori grounds as being among the most essential. The order of the items and categories does not suggest an hierarchial arrangement. The instrument simply represents a first attempt to organize and develop a checklist that should provide change agents with assistance in planning, implementing, and evaluating change in science education.

CHANGE PROCESS CHECKLIST

DIRECTIONS: Below is a list of guidelines and requisites for attempting to bring about change. Indicate which ones you have completed or provided for by checking the blank at the left.

Personal Qualities of Change Agents

( ) 1. established and maintained a high degree of faith in self and others

( ) 2. exhibited tolerance for turbulence, complexity, and ambiquity

( ) 3. provided psychological support for participants during risky phases of change process

( ) 4. accepted others as equal participants in change process

( ) 36. made participation in change process as voluntary as possible

( ) 37. established level of change within competence of teachers

( ) 38. secured support of active opinion leaders

( ) 39. identified available resources

( ) 40. established adequate support system for those who took part in change process

( ) 5. exhibited an oppenness for self-change

( ) 6. conducted periodic self-evaluations

( ) 7. respected other ideas and points of view

( ) 8. consciously utilized the abilities of others

( ) 9. displayed a consistent pattern of behavior

Facilitating Communication

( ) 10. provided opportunity for sharing beliefs and feelings

( ) 11. actively sought feedback from others to compare perceptions concerning various aspects of change process

( ) 12. established atmosphere free of censorship

( ) 13. viewed change as a cooperative endeavor

( ) 14. encouraged attitude of cooperation between teachers and administrators

( ) 15. delayed reporting until pilot and evaluation data were completed

( ) 16. accurately described project in the report

( ) 17. treated ideas as property of group rather than of individuals

( ) 18. dealt with interpersonal relations problems that arose during group work

( ) 19. established and maintained two-way communication

( ) 41. based change on available research results

( ) 42. started with concerns and problems teachers faced

( ) 43. involved individuals who were affected in determining if and what change should occur

( ) 44. secured adequate fiscal power

( ) 45. stated purposes clearly and precisely

( ) 46. reached consensus regarding need for change

( ) 47. secured commitment to change early in process to sustain morale

( ) 48. made decisions by seeking consensus

( ) 49. considered rate as well as direction of change

( ) 50. dealt with participants in a manner congruent with principles of change process

( ) 51. determined what and how individuals would be affected by change

( ) 52. ascertained effects of change on other aspects of educational system

( ) 53. planned for experience satisfaction and success at various intervals throughout the change process

( ) 54. provided opportunity for participants to understand nature of change and its consequences

( ) 55. included strategies for value clarification

( ) 20. provided democratic leadership where participants shared in decision making

( ) 21. made provisions for sharing ideas

( ) 22. encouraged and provided for social interaction among participants

( ) 23. promoted feelings of mutual trust

Relating to Society

( ) 24. utilized representatives of public as active participants throughout the process

( ) 25. responded to felt needs of society

( ) 26. enlisted public support

( ) 27. established program of public information

( ) 28. considered social implications of planned change

Planning and Implementing Plans

( ) 29. developed a comprehensive plan of action

( ) 30. identified a delineated model of change

( ) 31. promoted efforts toward future-planning

( ) 32. placed equal amounts of time, energy, and resources on planning as other aspects of change model

( ) 33. identified common sources of resistance

( ) 56. realized that change requires considerable time and energy

( ) 57. implemented various strategies to obtain value consensus regarding objectives and method of instruction

( ) 58. held some aspects of program constant while attempting to change others

( ) 59. built-in program for self-renewal into plan for change

( ) 60. developed guidelines for conflict resolution

( ) 61. made provisions for complete understanding of tasks by individuals involved in process

( ) 62. coordinated change with rest of educational program

( ) 63. realized that implementing change required mutual adaption on part of change agent and target for change

( ) 64. used assessment data in planning and implementing pilot or trial program

( ) 65. planned evaluation that included techniques, methods, criteria, and levels of acceptance

( ) 66. established a comprehensive teacher preparation program

( ) 67. conducted teacher preparation program on change site

( ) 68. established a plan for dissemination

( ) 69. based adoption on data from pilot and evaluation programs

( ) 70. secured participation in planning when possible of those who provided resistance

( ) 34. designed strategies to minimize resistance

( ) 35. utilized potential contributions of resistance

( ) 71. shared responsibility for decisions to reduce risk of experimentation

( ) 72. identified and utilized forces that promote change

Fig. 2.--Checklist for assisting change agent(s) in planning and implementing change in science education.

REFERENCES

Balzer, A. L.; T. P. Evans; and P. E. Blosser. "A Review of Research on Teacher Behavior." Columbus, OH: Association for the Education of Teachers in Science and ERIC Information Analysis Center for Science, Mathematics and Environmental Education, 1973.

Bennis, W. G.; K. D. Benne; and R. Chin. "The Planning of Change." New York: Holt, Rinehart and Winston, Inc., 1969.

Brubaker, D. L. and R. H. Nelson. "Pitfalls in the Educational Change Process." Journal of Teacher Education, Vol. 26:63-66, 1975.

Buchan, W. J. "A Design for Introducing Educational Change." Education, Vol. 91:298-300, 1971.

Cornish, E. "The Science Teacher as a Futurist." The Science Teacher, Vol. 36:21-24, 1969.

Engel, M. "Politics and Prerequisites in Educational Change." Phi Delta Kappan, Vol. 55:457-459, 1974.

Evans, T. P. "Choosing Science Teaching-Learning for the 21st Century." Paper presented at Annual Meeting of Association for the Education of Teachers in Science, Cincinnati, OH, March, 1977.

Goodlad, J. I. "Principals are the Key to Change. In J. Chaffee (ed.) New Dimensions for Educating Youth. Denver: U.S. Department of Health, Education, and Welfare and National Association of Secondary School Principals, 1976.

Harris, B. M. Supervisory Behavior in Education. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1964.

Hearn, E. H. "The Where, When, and How of Trying Innovations." Phi Delta Kappan, Vol. 53:358-361ff, 1972.

King, J. P. "An American Perspective on Education and Change in a Technological Society." Education, Vol. 104:114-118, 1975.

Mann, D. "Making Change Happen." Teachers College Record, Vol. 77: 313-322, 1976.

Morin, A. "An Innovator's Odyssey: How to Become a Thoughtful Change Agent." Educational Technology, Vol. 15:42-45, 1975.

Morrisseau, J. J. "A Conversation with Alvin Toffler." National Elementary Principal, Vol. 52:8-18, 1973.

Neagley, R. L. and N. D. Evans. Handbook for Effective Supervision of Instruction. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1970.

Ohme, H. "Needed: Exportable Models of Significant Change in Education." Phi Delta Kappan, Vol. 53:655-658, 1972.

Orlosky, D. and B. O. Smith. "Educational Change: Its Origins and Characteristics." Phi Delta Kappan, Vol. 53:412-414, 1972.

Ost, D. H. A Report of a Study of the Effects of Several Projects to Assist Kern County Schools Implemented Science Curricula. Research Report, The California State College, Bakersfield, 1976. (Mimeographed.)

Sergiovanni, T. J. and R. J. Starratt. Emerging Patterns of Supervision: Human Perspectives. New York: McGraw-Hill Book Co., 1971.

Shane, H. G. and J. G. Shane. "Future-Planning and the Curriculum." Phi Delta Kappan, Vol. 49:372-377, 1968.

Stiles, L. J. "Policy and Perspective: A False Assumption About Educational Change." Journal of Educational Research, Vol. 66: inside cover, 1973.

Stotler, D. W.; J. S. Richardson; and S. E. Williamson. The Supervision of School Science Programs. Columbus, OH: Charles E. Merrill Books, Inc., 1967.

Van Til, W. (ed.). Curriculum: Quest for Relevance. Boston: Houghton Mifflin Co., 1974.

S. E. Williamson; T. P. Evans; F. W. Fox; and K. J. Nice. "Science Education." In W. Ellena (ed.), Curriculum Handbook for School Executives. Arlington, VA: American Association of School Administrators, 1973.

Wolf, W. C. and W. C. Fiorino. "Some Perspectives of Educational Change." Educational Forum, Vol. 38:79-84, 1973.