Nurturing New Scientists

A young person's decision to become a scientist opens to him one of the noblest and most rewarding paths to the future in our time

By DR. GLENN T. SEABORG

Chairman, U.S. Atomic Energy Commission and President, Science Service

Address to the International Science Fair —Dallas, Texas, May 13, 1966.

➤ IT IS A pleasure once again to attend the National Science Fair and have an opportunity to speak to the young people who, I think, truly represent "the new wave" of the future. Winston Churchill once said: "Men occasionally stumble over the truth, but most of them pick themselves up and hurry off as if nothing had happened."

Such is not the case with the young men and women here this evening. You are the ones in the new generation who will be actively seeking the truth—many truths—and when you find them I'm sure you will also be doing your share in seeing that they are directed toward serving society. We are proud of you and we are putting a great deal of faith in you.

I want to talk with you tonight in a serious way about what it means to be a scientist. I know from the fact that you are here that many of you must have given some thought to this question. The decision to become a scientist is for anyone a commitment which he ought to think about carefully.

For young people of your age there are many possible avenues into the future—many, many paths you might take toward the realization of your dreams and ambitions and science is one of the noblest and most rewarding of these in our time.

It was only a century or two ago that modern science became an organized study of natural phenomena deduced from experimental evidence. Since that time applied science and invention have influenced the life of the individual, the development of industry, the evolution of political societies and the course of history. In the past few decades we have seen a great increase in the impact of science on our society owing to a new factor which was not previously present.

This new factor is the systematic and intensive accumulation of new scientific knowledge—the result of basic or fundamental scientific research.

We now know that the search for new knowledge, if not restricted to subjects of foreseeable and immediate practical importance, results in an unexpected increase in our understanding of physical or biological phenomena.

Far-Reaching Applications

These increases, in turn, give rise to far-reaching practical applications which could not have been anticipated from the original basic research. Our scientific knowledge and technology are advancing at an explosive rate. The time lag between the discovery of a fundamentally new scientific principle and its application in engineering or medicine is now very short, and these rapid developments are changing the lives of all of us in many ways which we only dimly preceive—and perhaps in some ways which are quite obvious.

Precious Resource

Because of our inescapable dependence on modern science and technology we must regard trained brainpower as a precious natural resource. The extent to which we discover exceptional intellectual talent, encourage and develop it, and provide conditions for its effective flowering will be a measure of our success in meeting the truly challenging problems which technology and population growth are posing for us in the remainder of this troubled twentieth century.

I refer broadly to two types of trained brainpower. One is represented by the professional scientist or engineer, the other by the educated person in other fields who has mastered enough of the meaning and content of modern science to make valid judgments on the many questions raised by the influence of science on his field, whether it be law, medicine, politics, military affairs, industrial management or some other.

It is fitting, therefore, that considerable attention be paid to the early identification of intellectual talent. Tonight we are gathered to participate in one attempt at the identification of young men and women who have

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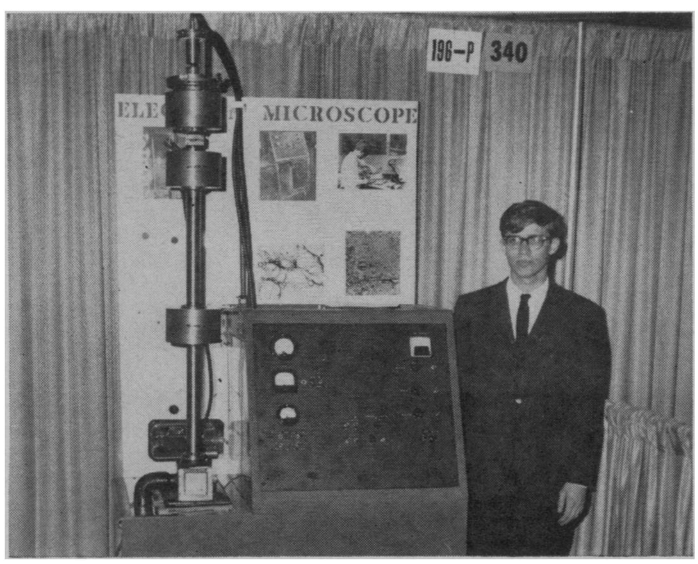
MELINDA L. WARNER



JOSEPH F. LEYKAM

New Job for Psychiatry

➤ FACED with the impact of Medicare, expanded insurance benefits and new community health centers psychiatrists are hopefully—some say desperately—reaching for new concepts to embrace this immense task.

Traditional analytical therapy obviously cannot do the job. Large numbers of people—the aged, the poor, the deprived—will be seeking help until now denied them. There simply will not be enough time or enough psychiatrists.

Freudian theory is not obsolete, psychiatrists were quick to interpose in any discussion of new approaches, but throughout their annual convention in Atlantic City, ran the terms: computer, general systems theory, transactional analysis, social psychiatry, interdisciplinary services.

For the first time in its history, the American Psychiatric Association staged a session called General Systems Theory (GST).

Systems theory has been used with considerable success to plot business and industrial operations. But can it be applied to alleviate the complexity of human suffering?

The concept of systems theory is a slippery one when it comes to human behavior, but, as one psychiatrist said, perhaps its appeal is that "it is so beautifully vague."

Vague or not, systems theory has an impressive list of pioneers to its name such as Drs. Karl Menninger and Roy Grinker, and the movement is gaining considerable momentum.

As it applies to society, GST is basically a change of focus, said Dr. William Gray of the Massachusetts General Hospital. Rather than focusing on one thing, as on an individual in psychoanalysis, it focuses on many things, particularly on the confrontation between those things.

Each unit, whether it be a human being, a family, a newspaper, a chain of newspapers, a city, a nation, is a system (with subsystems). How these units interact when they come face to face is a test of how well or ill the system is. Therefore, the confrontation (or interface), if it is out of whack, is the thing needing adjustment.

In a community center run with GST, said Dr. Frederick Duhl of Brookline, Mass., a man on his first visit would be questioned for medical, social, psychological and family data. The goal would be to discover all of his disrupted interfaces then arrange integrated treatment. Perhaps the man would have to change his attitude to live in the society; perhaps the best solution would be to change the society.

The dangers of community health centers, said Dr. Duhl, are that they may become fossilized, that treatment will not truly be transdisciplinary, and that psychiatrists, social workers, medical specialists, sociologists, will remain specialists, as they have been for the past century, resulting in fragmented services and sliced up citizens.

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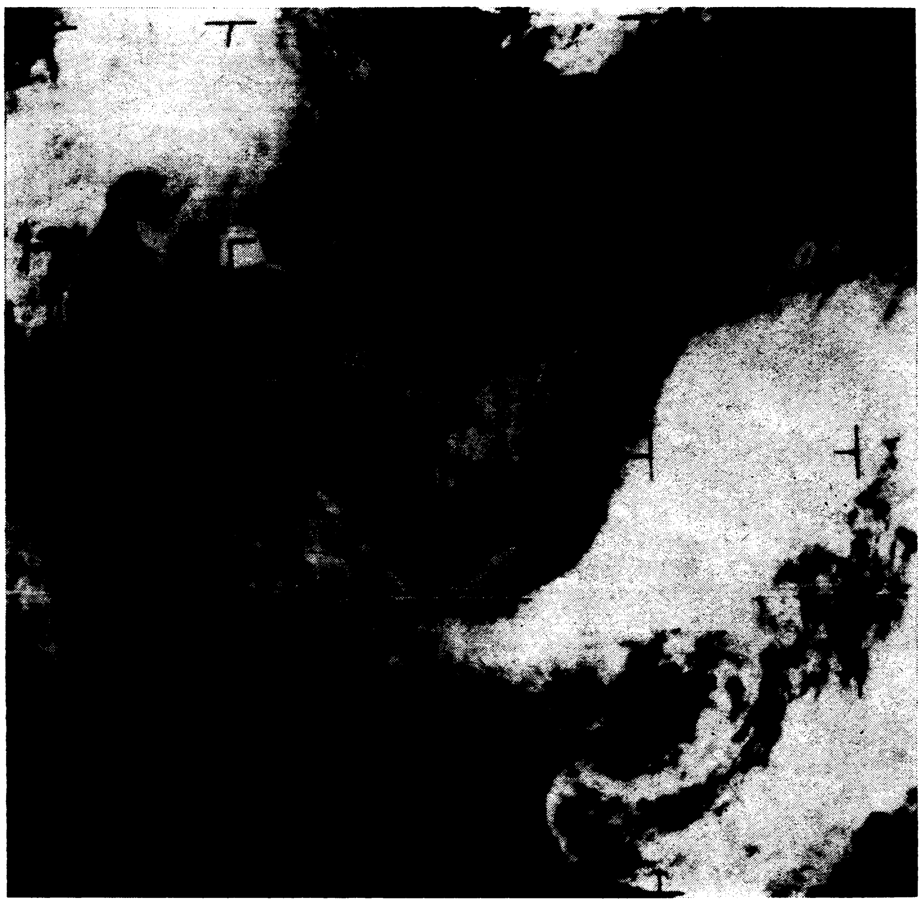

NASA

NIMBUS II—The Eastern Seaboard, Cheasapeake Bay, Great Lakes, Gulf of Mexico and Florida Peninsula (bottom center) are shown in this photograph from Nimbus II, the newest U.S. weather satellite. The picture, covering an area of some one and a half million square miles, was taken at 12:22 p.m., May 15, about nine hours after the satellite was launched from the Pacific Coast. Developed by the National Aeronautics and Space Administration's Goddard Space Flight Center, Greenbelt, Md., the craft orbits the earth at an altitude of some 700 miles.

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exceptional aptitude for a creative and productive career in science.

We are here to honor young men and women who have demonstrated by their conception and execution of some science project that they have a strong motivation and exceptional promise for a scientific education. I think it is quite proper that we pause on regular occasions to acknowledge the intellectual, esthetic and idealistic aspirations of our young people and encourage them by recognizing their academic excellence. Not unnaturally, a young person is influenced to seek goals which are recognized and respected.

If praise is reserved only for athletic prowess or monetary success. who can blame him if he seeks these even if it means sacrificing a great potential in some other field.

Limelight for Scientists

Actually, scientists are more in the limelight today although we have yet to achieve the status of the medical profession on nighttime television. However, I believe the day is almost at hand when one of us—though certainly unrecognizable—will be replacing a Ben Casey or Dr. Kildare.

Of course television is not the only measure of a profession's prestige. Certain scientists have received the well-earned acclaim of the general public even though that public understands little of their work. One example that comes to mind is that of Albert Einstein, who once said: "Isn't it strange that I who have written only unpopular books should be such a popular fellow?"

But the glamour of today's science notwithstanding, I am most happy to extend my personal congratulations to you young men and women. It would be extraordinary indeed if all of you should develop into brilliant scientists of international reputation.

I would be the last to lay the heavy burden of such an expectation on your shoulders. It would also be extraordinary if any of you failed to contribute in some way and in some pursuit, which none of us can predict here tonight, much more than an average share of intellectual achievement.

I would like now to mention briefly a few important steps in the education of a scientist, and a few attractive features of the life of a research scientist.

The work of a research scientist is of great interest and importance. Often it is difficult to relate his work to matters of dollars and cents but in the value system of the scientist the subject he has under study—whether this be the origin of the solar system, the biochemical basis of heredity, or the nature of a meson—is of great significance.

I believe that most people have a deep psychological need to feel that what they are doing is of some importance. The scientist feels the satisfaction of this need, and this gives drive and zest to his efforts. This is particularly true if, from time to time, his efforts are rewarded by the thrill of discovery. In his search he knows that in the final analysis his success as a scientist is measured against the criteria of nature rather than the judgments of persons. Science is self-correcting in that spurious results will sooner or later be unmasked by new experiments or the attempted verification of previous conclusions.

Science Confounds Error

Hence it can more readily establish truth and confound error than other more abstract fields of study. A scientist who is correct can prove he is correct, and by a proper marshaling of experimental evidence can convince his colleagues regardless of their superior reputation, seniority or rank.

Scientific research is a stimulating activity requiring constant assimilation of new facts, theories and techniques. This feature appeals to many gifted persons who would be stifled by the repetitive, dulling routine of many other occupations. A career in scientific research has many deep intellectual satisfactions which appeal strongly to the person of superior natural abilities.

For many scientists and especially perhaps for those whose work lies in theoretical fields bordering on mathematics, there may also be an aesthetic satisfaction comparable to that enjoyed by the artist, the musician, the painter or the poet.

Certainly scientists like Einstein and mathematicians like Whitehead and Russell have found in their completed work the satisfaction of observing structures of great elegance, order and beauty. And for the scientist with a strong feeling of social responsibility there is certain to be great satisfaction in seeing his work applied for the betterment of society.

Let us turn now to a consideration of how an interested young person may make a career in this exciting field.

Two-Step Process

Science is an organized body of knowledge and a method of extending or revising that body of knowledge by observation, hypothesis formation, and experiment. The training of a scientist is a two-step process—the mastery of a body of knowledge developed by previous workers and the mastery of a technique for extending that knowledge.

I sometimes liken the role of the scientist to that of a mountain climber who with great care and exertion achieves some great prominence from which he is able to perceive immediately and clearly new vistas which are hidden from the sight of those down in the valley below even though many of those in the valley may have better eyesight. New science builds on the work of the past. The scientist of today stands on the shoulders of the giants of yesterday. Therefore, the first task of any serious aspirant toward a career in science is to master the recorded history of the past. The task of the effective teacher is to organize and present that history concisely and effectively.

Our libraries are so filled with an enormous accumulation of facts, hypotheses and theories that the complete mastery of any science or even one major branch of a single science is a quite impossible task. Hence there must be a judicious selection of material—a judgment concerning the relative importance of various fields of study at various stages of the educational ladder, and a continuing judgment concerning the relative importance of facts, laws and correlations.

We are greatly helped in this effort by the great unity of much of science because of the fundamental laws or generalizations underlying all natural phenomena. In physics and chemistry, for example, we are enormously aided by the laws of thermodynamics, the laws of conservation of momentum and energy. We are also aided by the circumstance that many decades of past work in science may become logical and clear once some satisfactory organizing law or theory is evolved. By intensive study of the organizing law the new scientist may understand immediately many hundreds of individual facts which were quite mysterious to the past generation of scientists.

New mathematical techniques may also make it possible to explain or quickly derive numerous experimental facts which could only be understood at the expense of great labor by previous students. Therefore, it is the purpose of high school and undergraduate education in science to teach with the utmost economy of effort the organizing principles which may unlock for the student the important heritage of the past. Because the relative importance of facts is subject to rapid obsolescence, the goal is not to teach facts alone, but a system of understanding facts so that the new knowledge can later be absorbed.

There is no ideal way to teach high school or college science courses and we may expect a variety of approaches without a clear choice among them as to effectiveness. Nevertheless, whatever approach is tried must be subject to change in content to accommodate the material to new advances in science, particularly advances occasioned by important discoveries.

One encouraging development of the past few years is the renewed interest of the universities, the professional scientific societies, the private foundations and many governmental agencies—particularly the National Science Foundation—in the high schools. This interest has taken the form of summer institutes for the retraining of teachers, writing projects to revise outdated course outlines, textbooks and laboratory manuals, the preparation of films, TV programs and TV courses and the publication of a wealth of new explanatory and authoritative scientific material in paperback form.

School board members, school administrators, and interested citizens who are acquainted with these programs find them a new and very effective means of developing adequate science teaching in their school systems.

One of the chief purposes of high school science and undergraduate college science is to present the huge output of previous scientists to the student in a compressed form. They must give the student a meaningful, accurate, unified body of knowledge so that the general features of the sciences may be correctly perceived, so that new information to be acquired in the future can be related to the old and so that important features requiring further study can be recognized.

We turn now to the next step in the making of a scientist, namely, his training in the methods of carrying on scientific investigation. The principal centers for this type of instruction are the graduate schools of our great universities. The graduate holding a bachelor's degree in science has a good knowledge of his field, is able to perform a variety of laboratory tasks and may, with on-the-job training, develop into a creative research scientist.

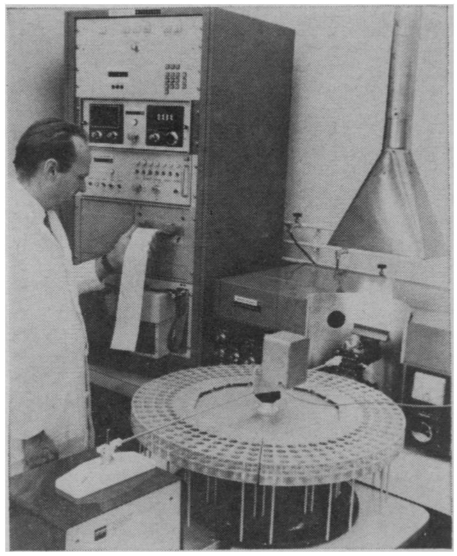
But as a general rule we rely on the rigorous training of our graduate schools to convert the trained intelligence of the holder of a bachelor's degree into the creative intelligence of the research scientist. The Ph.D. degree is the symbol of this creative intelligence.

The chief instructional technique of the graduate school is to put the student in the laboratory under the supervision of a master scientist to do a piece of original scientific investigation on a problem of considerable importance and difficulty. Here he learns a variety of experimental techniques. He learns the importance of asking big questions. He learns how to set up a meaningful experiment and how to extract correct answers from the data he collects. He learns the importance of letting the unexpected result lead him to new conclusions or at least to new experiments. Graduate research is a rigorous, demanding experience which makes an enormous change in the scientific effectiveness of the candidate.

Research Interests Advanced

At the better institutions the research interests of the professor are very advanced and are likely to be in a frontier area far beyond the material currently appearing in undergraduate textbooks. The professor is also greatly stimulated by the student. The student is usually brilliant, comes to the problem with a rather different educational background from that of his professor, and is eager to work hard to find out what the experiments will reveal. With this fresh outlook it frequently happens that he contributes greatly to the success of the research and may transform it into an advance far greater than might reasonably have been expected at the initial stages of the work.

The American people can regard with great pride the graduate schools of our great universities. They meet all the qualifications of excellence. They train virtually all of our great creative scientists. The scientific research done under the student-professor symbolic working arrangement adds a major fraction to our truly important new knowledge.



Perkin-Elmer Corporation

ABSORPTION SYSTEM—Blood serum can be analyzed for metals content with this automatic atomic absorption system designed by Perkin-Elmer Corporation, Norwalk, Conn., for the Kaiser Foundation Research Institute in Oakland, Calif.

I could cite many, many examples of this. The selection of any scientific problem involves a judgment concerning what is worth investigation. In the first rank graduate schools it is the big problems which are attacked. It is free research. The fact that over 50 living Americans hold the Nobel Prize in chemistry, physics or medicine attests to the excellence of our graduate schools of science. Unfortunately, there is not a sufficient number of such schools. But we are taking action to remedy this situation. Only last fall President Johnson issued a directive to all Federal departments and agencies to take measures which would strengthen scientific research in those universities where it exists and also help produce more centers of excellence.

It is important that the standard of excellence of our top-rate universities be maintained and extended to more institutions. In the extension of scientific knowledge excellence is crucial. There is an enormous difference between pretty good and the very best. A system of scientific training and research institutions which can produce and support a few Enrico Fermis or John Von Neumanns or Ernest Lawrences will be profoundly more effective than one which fails to do so.

A potential young scientist listening to these words may be hesitant to embark on such a foreboding and rigorous course of training. A few words of comfort may therefore be in order. Your decision whether or not to consider graduate training in science can be deferred to the middle or later undergraduate college years. By then your decision will be based on a clearer knowledge of your abilities, interests and intellectual performance. Should you then decide that your talents and interests lie in other directions there is a strong likelihood that the science courses which you studied will, nevertheless, form a significant part of your total education.

Fellowships Available

While graduate training usually takes from three to five years, the extra expense attached to this period can be greatly lessened by the many teaching and research appointments and fellowships which are available. In many fields the student can expect to pay *all* his living and school expenses from such appointments.

I believe the young women in this audience can take a great deal of satisfaction in the fact that there is now greater opportunity and encouragement for women in today's world of science. Lise Meitner's significant contributions to our nuclear age—in particular her role in the identification of nuclear fission—should dispel for all time the old chestnut that only boys are capable of scientific work and girls should always aspire to become English teachers.

Three years ago we in America had our first woman Nobel Prize winner in physics—Maria Goeppert Mayer—who shared the physics prize with Professor J. Hans D. Jensen of Heidelberg for work revealing the onion-like structuring of atomic nuclei.

Even closer to home for those of us who work in the Atomic Energy Commission is the fact that a woman microbiologist and college president, Dr. Mary Ingraham Bunting, has served as a Commissioner of the Atomic Energy Commission.

A further comment that I should make is that there is plenty of room in scientific research for those who are not in the genius category. All Ph.D.'s are better than average in intelligence, but few of them indeed approach the manifestly superior intelligence of Enrico Fermi or John Von Neumann. There is a large volume of work which needs to be done very well by the trained scientist of more modest endowments. Further, much of the potential of a Fermi or a Von Neumann would be lost were there not many other scientists to try out their suggestions or to turn up new phenomena and new data for them to study and consider.

Creative research calls for a combination of qualities only one of which is superior intelligence. It is difficult to specify the combination of characteristics which may be of crucial importance for success in solving a specified scientific problem. Perhaps an intuition or a "feel" derived from lengthy experience with certain types of phenomena, perhaps special knowledge of a new instrumental technique, perhaps a natural manual dexterity in some important type of laboratory manipulation, perhaps an unreasonable stubbornness in seeking a better explanation of some phenomena which others have passed by as "explained" may be the key to a fruitful series of developments.

I should find it difficult to explain the secret of the effectiveness of the many able scientists I know or the relative ineffectiveness of others who seemed to hold out great promise. Maybe it's just plain hard work, because, without downright hard work, there can be no success in a scientific career. All the productive scientists have been "smart" it is true, but the ways in which they have been "smart" have differed greatly. And they are all dedicated hard workers.

Let me repeat a few points that I believe the beginning scientists should remember. First, very little is accomplished in science without a great deal of hard work. I put hard work first because the ability to think creatively must be taken for granted. Second, creative ability even when it is present in a large degree has to be nourished and developed through the education process. And the scientists must have the courage to question accepted ideas and offer his own new ones in their place when he has the evidence to back up his original concepts. Third, he must have a strong sense of curiosity about the world he lives in so that he wants to know more about it. If he has these qualities and makes good use of them he will find there is plenty to be accomplished even in the fast-moving world of science he is entering today.

But no one can really tell you what it means to be a scientist. There are almost as many different kinds of scientists as there are different kinds of people, but even apart from that, no one can tell you. You can only find out what being a scientist means from the intensely satisfying experience of your own efforts.

We live in an age in which, for better or worse, the influence of science is pervasive and revolutionary. It is a part of our culture which is shaping nearly every aspect of our lives and our institutions. We can no more ignore it than the man of the middle ages could ignore the Christian church or the feudal system. Properly nurtured and employed, science can provide us with marvelous tools for the solution of many of the weighty problems of our physical and social world.

The promise of the future lies in the hands of the dedicated and the educated. A most significant part of that promise lies in the field of science. I would invite the earnest young men and women who are prepared to study and work hard to join in the exciting and rewarding profession of science and the scientists.

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