GENERAL SCIENCE

What It Means to Be a Scientist

Biologists stand on the brink of magnificent achievements now just as physicists did some 300 years ago when Newton discovered the laws of motion.

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Excerpts from remarks at the 15th National Science Fair-International, Baltimore, Md., May 5.

➤ SOME OF THE BEST scientists would agree that just being well fed, watching a good program on television, and having the sharpest clothes money can buy are not enough in themselves to bring happiness.

It's not that scientists don't appreciate the good things of life. Not many of them of my acquaintance would volunteer for a life of cheerless poverty.

But most of them need something more in order to achieve what a scientist would consider happiness. And to obtain this something more the scientist might be willing to endure a great deal that other people would find burdensome and at times downright unpleasant.

Any of you who have read Charles Darwin's "Voyage of the Beagle" must have been struck by the tremendous labors of the young Darwin in his tireless observation of all forms of plant and animal life in the neighborhood of South America, the geographical and geological features of the lands he visited, and even the political and social character of the people in these lands.

Add to this the problems of gathering and preserving a multitude of specimens and recording in notes his detailed observations and you will find it almost past belief that one man could accomplish so much. Yet this is the same man to whom his father had said earlier in his life, "You care for nothing but shooting dogs and rat catching and will be a disgrace to your family." . . .

Exciting Experience

As everyone of you Science Fair winners knows, hard work can be the most exciting kind of experience if it absorbs your interest so completely you almost forget when mealtime comes, or it can be boring and distasteful if the chore is one which you would never have undertaken voluntarily.

Sometimes the chores imposed by hard necessity conflict with the basic curiosity of the budding scientist. Thomas Edison owed his deafness to such a conflict.

To earn his living, Edison as a boy sold candy on a train. He was deafened for life after an angry railroad conductor boxed his ears for loafing his time away on experiments when he should have been selling candy.

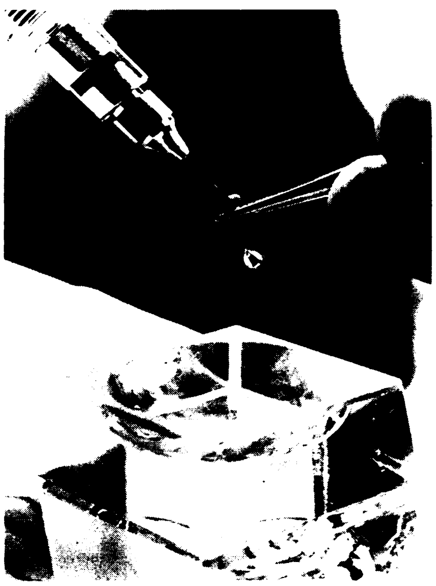
Certainly it was not laziness in Edison's case. For this great inventor who defined genius as "one percent inspiration and ninety-nine percent perspiration" could not have been called lazy. He tried out thousands of materials in his experiments to find a suitable filament for the incandescent lamp before he succeeded.

Let us take another example of this willingness to work beyond the limits of ordinary human endurance and to persevere despite the most discouraging circumstances.

Owe Much to Boole

Bertrand Russell may have exaggerated silghtly when he said "pure mathematics was discovered by Boole in a work which he called 'The Laws of Thought.'" But we nevertheless are indebted to George Boole for laying the foundations for Whitehead's and Russell's monumental work on symbolic logic, the "Principia Mathematica." This is on the pure side.

On the practical side, our rapidly developing technology based on automated production and the extensive employment of modern high-speed computers owes so much to Boolean algebra, the algebra of logic invented by George Boole, that he may be said to have written the language of this new technology. . . .



U.S. Atomic Energy Commission

BONE MARROW TRANSPLANT —Bone marrow from a mouse femur is being removed for transplantation at Oak Ridge (Tenn.) National Laboratory in a study of the treatment of whole-body radiation injury. The research is sponsored by the U. S. Atomic Energy Commission.

Seldom do scientists or mathematicians in our day find it necessary to undergo much privation in order to pursue their work, but the need for hard work as a basis for achievement is no less now than it ever was and only the rarest genius will reach the highest goals in science without expending his utmost effort. We want to know, then, what kinds of satisfaction can inspire a scientist to such efforts. What causes this satisfaction?

A factor of great importance is that the knowledge a scientist gains makes him feel more at home in the world whose laws he is able to fathom. With each new discovery, large or small, he understands the nature of his environment more clearly and achieves a more rewarding relationship to the things around him. In short, the more he knows, the more interesting his life becomes.

Satisfaction in Achievement

In the search for new knowledge there may be some modern counterpart of the age-old excitement of the chase, the satisfaction of overcoming great obstacles, not just the easy, trivial problems but the very difficult and complex barriers to greater knowledge.

For many great 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.

Conversely he may sometimes be deeply disturbed when the results of his work are applied to ends that turn out to be highly destructive and antisocial.

There is a place for almost every talent in the great democracy of science and no one need be discouraged if he does not have all the attributes we have been talking about. It is perhaps a rare scientist who has all of them in a strong measure.

Carl Frederich Gauss, who has been called the Prince of Mathematics, but who also made fundamentally important contributions to astronomy, geodesy and mathematical physics, may have most nearly approached the ideal of universality. . . .

Scientists of Today

At this point you are entitled to raise the objection that I have been talking about scientists of other generations—science as it existed before the 20th century. How have things changed? Do the scientists of today and tomorrow face the same kinds of problems and need the same qualities that made for greatness in previous centuries?

I need not tell you that today's scientist works in a world far different from that of Gauss and even the later worlds of Boole or Darwin.

The scientist in Gauss' time belonged to a rather small group of individuals whose work was not of great interest to society as a whole. Today the scientist lives in a predominantly scientific and technological society.

There are advantages for the modern scientist, of course. Scientific work is better supported now than ever before, not only in terms of financial support for young scientists and salaries for working scientists but in terms of the great sums now expended for laboratories, libraries and enormous pieces of complex equipment.

Education Assured

Today the promising student who works hard can be assured of an education. When he has finished his schooling, he can be assured also of a respectable income and of a working situation conducive to accomplishment.

For another thing, the public's attitude toward scientists has changed in the main from the one of distrust and hostility which existed in earlier days to approval or even admiration in the case of outstanding scientific achievement.

Even in our own century scientists have occasionally worked under very difficult conditions to achieve great results. In the early 1900's when Lise Meitner began her career, the German schools and some of their professors were not kindly disposed toward women scientists. . . .

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.

First U. S. Woman Nobelist

Last year 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 only recently a woman microbiologist and college president, Dr. Mary Ingraham Bunting, was named a Commissioner of the Atomic Energy Commission by President Johnson.

Today science has become an operation on a very large scale. Because science is so fundamental to modern society and so highly organized, the scientist is much more likely now than in the past to be working as a member of a team or to be one of a staff of a large organization. . . .

While team work may appear to be unpromising for the ambitious individual, there are, nevertheless, rewarding experiences to be gained in working with a group of eminent scientists. Who would not have been proud to work with Watson and Crick when they made their great breakthrough of 1953 arriving at a chemical interpretation of the process of replication of genetic material?

Increasing Science Literature

Naturally because of the very great amount of work that has been done in recent years—this large-scale effort that continues to grow at an ever-increasing rate—the literature of science has become complex and voluminous in almost every field.

We are told that the amount of scientific information published around the world every 24 hours would fill seven complete 24-volume sets of the Encyclopedia Britannica. Reading around the clock, day after day, one man would need about 450 years to cover one year's output.

Though new techniques, including automatic data processing, are also making rapid progress, it is obvious that advanced education and a thorough knowledge of the scope of his field is essential for today's scientist. He must have this kind of preparation if only to know what has been done so that he will be able to define the next problems waiting to be solved.

High Degree of Specialization

It is to be expected also that in this great burgeoning of scientific and technological development there would be a high degree of specialization. The chemist today is much more likely to be known as a biochemist or a radiation chemist than simply as a chemist.

Perhaps the scientist is less likely, in view of these circumstances, to accomplish the broad sweep of achievements characteristic of Darwin's work in biology or Maxwell's very broad formulations in electromagnetic theory.

Nevertheless, even in this century we have had a man like Einstein whose work produced a revolution in physics so fundamental as to have affected the whole range of modern philosophy.

In view of these changed and changing circumstances, how different are the requirements placed on the scientist today from what they have been in the past? I have already stressed the need existing now as always for hard work and stick-to-itiveness.

Hard Work Necessary

There are many labor-saving devices such as the high speed computer and it might be pointed out that laboratories and libraries are wonderfully equipped and everything is done for the comfort of the scientist, or almost everything. But not even the most wonderful environment will produce a scientist from a man or woman who is fundamentally allergic to hard work.

A creative turn, of course, is still important in a scientist and will continue to be. The scientist who hopes for significant achievements must learn to recognize and nurture his creative abilities to the utmost. . . .

The creative mind often finds itself at odds with ideas that have long been accepted as true. Some of these conflicts during the early history of science were spectacular and dangerous for the scientist—as in the case of Galileo.

Today the influence of convention and conformity is more subtle but often no less potent. The word "authoritative" is one that should be examined skeptically by the young scientist wherever he finds it.

Even Kepler found his difficulty not so much in opposition from society as from his struggle to throw off his own reverence for the traditional idea of philosophers that the circle was the perfect figure and therefore must necessarily describe the orbit of the planets.

Most important perhaps for the embryonic scientist is unflagging curiosity about what makes things tick and a desire to explore new fields. This quality is the rock-bottom indispensable trait of the real scientist. Though not every scientist can achieve greatness at the highest level of creativity, there are many contributions to be made by hard-working and intelligent scientists with an enlarged bump of curiosity.

Plenitude of Challenges

As we approach a conclusion, let me emphasize the fact that there remain many worlds to be conquered in science. I will illustrate this plenitude of challenges by taking only one area, the rapidly developing area of work on the genetic code.

Many of us believe that a situation has now arisen in the life sciences similar to that which arose in the physical sciences when, according to legend, Newton found in the falling of an apple the secret of the motions of the heavenly bodies.

For we believe that the physico-chemically oriented geneticists have recently discovered in the ultimate constitution of the gene or virus the clue to the means by which all life's diverse forms are constructed and controlled. Their work on the giant DNA molecules has revealed a great deal about the significant role of these molecules in controlling the process of growth and reproduction.

Yet however magnificent and all-pervading these recent achievements are, they set us in a sense only on the threshold of life and biological evolution. The achievements in this field to the present explain only a small fraction of the form and the course of development of the stupendous structures that have been built by the automated tools the genes provide.

In this house that Jack the Gene built (or should we call him Rube Goldberg?) many very complicated interactions have already been unraveled by the biochemists such as how this or that important substance is built up or broken down through a long succession of stages.

Genetic Code

Still, each of these operations hangs pretty much in the air until we can set it

(Continued on p. 317)

To Be a Scientist

(Continued from p. 315)

on its gene bases or tie it to the other operations and to the cellular architecture revealed by the electron microscope.

...A few of the code words in the genetic dictionary have surrendered their meaning to us but this is the barest beginning. The great dictionary of the genetic code is still to be compiled and the meaning of its code words accurately defined.

We know already that there is a safety factor of redundancy built into this system to insure survival—that there is more than one way of saying the same thing. This factor of redundancy raises a question as to how greatly the established patterns can be altered without seriously affecting the organism.

Only at Beginning

Those of us who want to establish safety factors for exposure to radiation would like to know the answer to this question. Very interesting also is the question as to what kind of physics and chemistry these macromolecules possess that enable them to reproduce themselves without the aid of enzymes.

We have just begun to explore the physics and chemistry associated with big molecules and have learned many unexpected things about viscosity and other characteristics but again this is only the beginning.

There is much more that we would like to know about how the macromolecules of DNA began to operate this way in the first place, thereby enabling the life process to originate and evolve, and how we can use their unique characteristics for developing new forms of life in a beneficial way.

Many Problems in Science

These are only a few of the many problems in this very inviting field of modern science. Certainly one could take each major field of science today and list questions of this kind which are awaiting the best efforts of young people who plan to find their future in science. The giant machines by means of which high energy physics hopes to penetrate further into the constitution of the nucleus beckon to many. Many others will be intrigued by cryogenics and the potentialities of lasers or by the intricate problems associated with information theory and computers. The barest summary of opportunities for research would take us far into the night....

I must say in closing that 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.

I cannot help feeling tonight as I look around this audience of young people who have already made brilliant beginnings that there will be notable and rewarding achievements for you in the years that lie ahead.

• Science News Letter, 85:314 May 16, 1964

BIOTECHNOLOGY

Brain Tumors Detected By New Complex Camera

➤ FAST PICTURES of radioactive substances injected to detect brain tumors and defects in internal organs are being made by a new complex camera so recently developed that there are only four in existence.

Labeled isotopic compounds can be seen more accurately in suspected organs ten times faster than with previously used scanning-type apparatus.

Research teams from the Veterans Administration Research Hospital and Northwestern University Medical School, Chicago, are investigating additional uses of the equipment on animals.

The scintillation camera is capable of picturing on Polaroid film two-dimensional distribution of radioisotopes and then following the rate at which these isotopes may move into and out of such organs as the liver, thyroid and kidney. Actual photographs of brain tumors provide additional valuable data as to their size and location, explained Dr. George C. Henegar, who is on the staffs of both Northwestern and the VA Hospital.

The original model of the camera, which is manufactured by Nuclear-Chicago Corporation, was developed at the University of California. The VA Hospital in Iowa City, Iowa, has one of the cameras, and Ohio State University, Columbus, has a smaller version.

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