GENERAL SCIENCE

Spirit of Scientific Inquiry

To maintain spirit and competence of scientific endeavor, the excitement and spiritual satisfaction of the investigator must remain the overriding goal.

By CARYL P. HASKINS

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An address at the awards banquet of the Fifteenth Annual Science Talent Search, in Washington, March 5.

➤ I COUNT it a great honor to be with you this evening, at the climax of a most extraordinary occasion. And it is not only an honor—it is an immense surprise, and it just shows what years can do for you, without any effort at all.

For I have been doing my homework, a little. Specifically, I have been trying to answer that questionnaire that was left at my plate.

Now, I hope that I never had a very inflated idea about my intelligence. But after going through *that* ordeal I am convinced either that it is even lower than I thought or that the differences between your generation and mine are even greater than I thought.

Sign of Progress

I suppose I ought to be glad about that, for it is a vivid illustration of progress, scientific and otherwise. But the whole thing is a very disquieting experience, and it adds poignancy to my congratulations to you as winners, and to all those who have made this wonderful occasion possible.

It is a humbling and a very inspiring thing to stand before you. For in a very real sense you represent the constancy, the invariance, of a most precious thing, needed more in our national life now, perhaps, than ever before in our history—the spirit of scientific inquiry, the creed of the pioneer investigator.

It represents no rhetoric, but the most sober truth, to point out the obvious fact that you really are the heritors of Galileo and Pasteur, Faraday and Darwin, Fermi and Einstein and T. H. Morgan.

You really do represent the continuity into the future of one of the most noble traditions of human endeavor since the Renaissance. It does not obscure that continuity in the slightest nor blunt the essential nobility of spirit inherent in it that you are carrying that tradition forward into an age in which scientific research has become a dominant activity in our country and indeed in the whole world.

It does not matter that you are projecting that tradition into a period in which the pragmatic aspects of science are those which may be picked out and overwhelmingly emphasized by the lay observer—may indeed, in many quarters, be taken to *be* the scientific effort.

Today you are the representatives, no less than Newton and Faraday and Einstein and so many other men and women who missed or managed to avoid the incident of fame, of one of the purest and the finest modes of expression of the human intellect and spirit.

This aspect of the profession of the scientific investigator seems to me so overwhelmingly important, so overwhelmingly the "nub of the matter," that I want to return to it for the greater part of my talk.

Pragmatic Relationships

But first I would like to speak for a moment about some of the other and more pragmatic relationships of science to the national scene—relationships which are evident, to which you all will have given much thought—and yet which practically are so terribly important today.

In a way I detest looking back, for the really important questions lie all in the future. And yet it is instructive—and almost frightening too—to think of the changes that have occurred in our notions of security, both personal and national, in this country in the last generation or two, over a span, say, of fifty years.

Fifty years ago, in this country, we lived in the security and under the shield of a "Pax Britannica" whose nature and power earlier Americans had well understood and even feared, but which the generation of 1906 had largely come to take for granted. In a way it was a curious period, judged scientifically, and in some ways it was smug and stuffy.

Physics Thought Dead

Those were the years when a misunderstood Darwinism looked like an easy, fairly effortless road to social understanding, and to ideas of the inevitability of progress.

Those were the decades when some classical physicists widely proclaimed that there were no more real frontiers in phyiscs—the orderly universe had essentially been explained; the placing of the decimal points was the principal job. But those were also the years of Crookes and Becquerel and Roentgen and the first stirrings of a revived Mendelian genetics, of the early work of the Curies and of Ernest Rutherford.

I suppose that anyone who questioned the essential security of the United States and of Americans in the world in that day would have been thought unpatriotic and defeatist, if not worse.

This was the atmosphere in which we were struck by the fact of the first World War, and I imagine it would be difficult to reconstruct, at this late day, the profound shock that it gave to our easy sense of national and individual security—a fleshy, sappy plant that had not been really toughened to the winds of the world for a full generation.

Several popular reactions occurred which are historically significant, I think, because they indicate the extent of the shock and the empirical, impulsive, defensive kind of grasping at intellectual straws that took place and because they set certain national attitudes that have not wholly vanished today.

This was the "war to end war"—a statement of our unwillingness to believe in the realities of that war at all, or to face the continuing world responsibilities, over and beyond the mere call of arms, which it implied.

Peace Brought Isolationism

With peace there came the isolationism that was so prominent a feature of our world view throughout the interwar period—our national creed that this war and the major power shifts that it brought to the world were unreal, nightmarish things and none of our affair, things which, if we retreated from them and ignored them long enough, might go away. And there was one more event which is worth recalling, though the connection, for the moment, is indirect.

This was also the first war of ours in which science emerged in its own right, however modest and primitive the effort may look in restrospect, as a vital agent of national defense.

The second World War was a very different thing, as you all know. It was fought, in some ways, in a more sophisticated fashion and in a more realistic spirit. And this time science became one of the very great, even decisive, factors in warfare and in national defense. And yet I think, in many ways, the underlying political and strategic concepts which many of us held had not advanced so much since the days of World War I.

There were still important segments of opinion in our nation who held that this was the "war to end war." We still had powerful voices raised in 1946 to advocate a renewed isolationism. Perhaps it was not until after Korea that we really toughened and hardened and, in some degree, matured.

Then came the "atomic era"—if that is not too simple a name for it—which is peculiarly your own. My own generation will probably long since have gone before you

will have fully developed its astonishing potentialities for good or fully learned to cope with its equally absorbing liabilities. But it brings with it its own kinds of wishful thinking and of total paralysis of thinking, which are the grown-up—the very grown-up—cousins of the versions of all the generations of the last fifty years.

They cluster about the gigantic and the terribly real world-facts with which you must deal and which you will be in particularly strategic positions to consider effectively. The holocaust that all-out atomic war would bring; the constancy and the steady malignity of the Communist menace; the inherent perilous instability of a bipolar world.

World Perils Real

They are all real—frightfully so. But they are all capable, too, of being made the vehicles of wooden or paralyzed or unadaptive thinking—as wooden or paralyzed or unadapted as much of the thinking of World War I. And that particular peril you, as thoughtful people trained in science, will be peculiarly well fitted to mitigate—and it will be an important part of your task to do so.

The world perils that we come to at maturity never seem overwhelming to us. Those that crowd upon us after maturity often seem much worse, and the difference, in part, lies in our own biology. And so, I suspect, this kind of world will not seem nearly as serious to you as it may to me. And you are probably right.

Perilous bipolar narrows in world power that looked something like this have been negotiated to safe waters before in the history of the world. And there is the overwhelming bright possibility of a peace in the years to come under whose shield cultural progress could advance further than the world has ever known.

But it is well to recall soberly that achievements of this sort are basically the achievements of power, rightly used. They can never be attained in the absence of that power, whether we like it or not. And if we look at the present hostile bipolarity of the world, the first fact that strikes us is that at the eastern pole potential for action has resided for uncounted aeons in superior manpower, wielding tools of a relatively limited character, but frightening because of its very mass. And at the western pole the situation has been opposite—a manpower relatively slight in numbers.

Survival and growth have been possible there because of other sources of power—because, in sum, of the decisive advantage of a markedly superior technology. And now we are entering an era—peculiarly your era—in which a sector of that eastern pole which is and which for years to come will be malignantly hostile, still relying on its tremendous manpower and the mass of the relatively crude conventional weapon-tools with which it has been traditionally equipped, has taken a leaf from the book of the west and is adding to that arsenal our own power of technology.

There is no blinking the problem that faces you.

Technology *is* a most crucial—perhaps *the* most crucial—single factor in this perilous balance of power upon the maintenance of which all our peace depends—technology and the science that feeds it. There is no getting around it.

Science *does* have a pragmatic task to do in the service of our country of unprecedented character. And you, as scientists, are entering the ranks of one of the outstanding "warrior" groups in our nation.

There is no blinking, today, the importance of the pragmatic function that you are assuming. And we *are* still blinking it—far too much. Witness the belatedness of alarm about our rate of production of scientists in this country compared with Russia and our comparative rate of development in key technologies, and a dozen other avenues of concern that are as deadly real and serious as anything could be, and that you, I am sure, have heard often in recent days.

Democratic Way Superior

A belief in the superiority of the democratic way is a religion with us, and lies at the very foundation of our national creed. It is based upon our faith that, over the long pull and in the major aspects of the major issues, the collective wisdom of our people will be superior to what any one of us, or any limited group among us, may think or say. I think we have a splendid illustration of that belief in this very area.

The public interest in science, the public demand for scientists, even some of the public fear of science, reflect a real understanding of the key position which science occupies in our national safety and welfare today.

But it is a corollary of this ultimate public accuracy in assessing the overall aspects of a position that features—and often key

features—of the picture are likely, over the short term, to be neglected or distorted.

If the real nature and the real purpose of science were merely to provide us with protection, with mere instruments of power, with mere material gains, as some less wise individuals have thought and openly proclaimed, there would be no such thing as science.

There would only be a kind of pseudo-technical activity so mean, so uninspiring, so devoid of roots that it would be unworthy of your allegiance and could not even long survive.

It is the essence of my thesis that there is a deep and important paradox at the root of the scientific effort which every real scientist feels instinctively but which has been made far too little known publicly.

The control and the fashioning of the tools of power are powerful pragmatic attributes of science in our immediate world today. But they are not the reasons for the deep intellectual ferment from which modern science was born in seventeenth-century Europe, or by which it lives today.

It was not for considerations of practicality or power that Kepler remained absorbed for so many years in those studies of conic sections which fascinated him deeply and in which he excelled all his contemporaries, but which no contemporary would have

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Books of the Week

For the editorial information of our readers, books received for review since last week's issue are listed. For convenient purchase of any U. S. book in print, send a remittance to cover retail price (postage will be paid) to Book Department, Science Service, 1719 N Street, N.W., Washington 6, D. C. Request free publications direct from publisher, not from Science Service.

BUILDING HEALTH—Dorothea M. Williams—*Lippincott*, 2d ed., 431 p., illus., $3.20. A junior high school text intended to enliven the interest of students by providing interesting things for them to do.

DICTIONARY OF ARTS AND CRAFTS—John L. Stoutenburgh, Jr.—*Philosophical Library*, 259 p., $6.00. Defining new and old terms, materials and techniques.

EDUCATORS GUIDE TO FREE TAPES, SCRIPTS, AND TRANSCRIPTIONS—Walter A. Wittich and Gertie L. Hanson, Eds.—*Educators Progress Service*, 2d ed., 161 p., paper, $5.75. A reference book for educators.

ELECTRONS, WAVES AND MESSAGES—John R. Pierce—*Hanover House*, 318 p., illus., $5.00. To help you understand the world of radar, television and other electronic gadgets.

ELEMENTARY THEORY OF NUCLEAR SHELL STRUCTURE—Maria Goeppert Mayer and J. Hans D. Jensen—*Wiley*, 269 p., illus., $7.75. The state of nuclear physics today, the authors comment, is somewhat analogous to that of the concepts of the structure of matter before quantum mechanics.

ENJOYING HEALTH—Evelyn G. Jones—*Lippincott*, 2d ed., 434 p., illus., $3.40. A senior high school text based on findings of the Denver study on health interests of children, such as how to promote attractive appearance and physical fitness.

GRADUATE EDUCATION FOR WOMEN: The Radcliffe Ph.D.—Faculty-Trustee Committee—*Harvard University Press*, 135 p., illus., $3.50. This book, centered on those with a doctor's degree from Radcliffe College, attempts to answer two questions: what service to society may be expected of women with a Ph.D. and how graduate education can most effectively increase the value of that service.

GUIDED MISSILES IN WAR AND PEACE—Nels A. Parson, Jr.—*Harvard University Press*, 161 p., illus., $3.50. For military men and those who wish to keep abreast of our fast-moving world.

HOW TIME IS MEASURED—Peter Hood—*Oxford University Press*, 64 p., illus., $2.75. A history of timekeeping, from the early water clocks and sandglasses to the voice that gives you the correct time over the telephone.

HOW TO MAKE A MINIATURE ZOO—Vinson Brown—*Little Brown*, 212 p., illus., $2.75. Telling just what you need to know in order to keep small wild creatures in your home or backyard.

LANGUAGE, THOUGHT AND REALITY: Selected writings—Benjamin Lee Whorf, edited and with an introduction by John B. Carroll, foreword by Stuart Chase—*Technology Press of MIT* and *Wiley*, 278 p., illus., $7.00. Including nearly all of the author's writings on the hypothesis that the structure of language influences thought processes and our perception of the world about us.

A MODERN INTRODUCTION TO MATHEMATICS—John E. Freund—*Prentice-Hall*, 543 p., illus., $8.00. A college text with emphasis on basic concepts and ideas and the abstract nature of mathematics.

MORE PLEASE—*American Dietetic Association*, 6 p., illus., paper, 3 cents. What children should eat and what they will enjoy eating.

PRESENT KNOWLEDGE IN NUTRITION: Prepared from articles published in the journal, "Nutrition Reviews"—Editorial Staff and Advisory Board—*Nutrition Foundation*, 2d ed., 130 p., paper, $2.00. Here you can find the latest information about vitamins, calories, minerals, proteins and other dietary essentials.

A QUEST INTO THE ENVIRONMENTAL CAUSES OF CANCER OF THE LUNG—W. C. Hueper—*Govt. Printing Office*, U. S. Public Health Service, Public Health Monograph No. 36, 54 p., illus., paper, 45 cents. Showing the relation between various chemicals, including such air pollutants as soot, petroleum oils, gasoline and diesel engine exhaust, and lung cancer, but indicating that the evidence is insufficient to blame smoking.

THE UNITED STATES PATENT SYSTEM: Legal and Economic Conflicts in American Patent History — Floyd L. Vaughan — *University of Oklahoma Press*, 355 p., $8.50. The judicial concept of patentability differs from that of the Patent Office, the author indicates, to such an extent that a high proportion of the adjudicated patents are held invalid.

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supposed could lead to the discovery of the laws that bear his name.

It was not practically directed thinking that inspired the vast amount of experimental work of Robert Boyle, so much vaster than would have been required for the mere discovery of his gas law; or that kept a fascinated, ailing Darwin at work at Down House on the mechanisms of the fertilization of orchids.

It was not this, nor any thought of this, that held Einstein to his task.

It is not this, nor anything like it, I submit, that inspires the best and most enduring accomplishments of any contemporary scientific investigator among us. The pragmatic aspect of scientific research is an overwhelmingly important one to us in its immediate context. But it is not an invariant.

It is a transient result of the real invariant, upon which the life of all true science depends.

The real motivations of the true scientific investigator have varied little from the beginning of the Renaissance—perhaps little since long before that, though the method of expression has changed so much.

They are the motives of discovery, of increasing our knowledge of the world, of elucidating truth and beauty as we find it, of making that truth and that beauty known to others. They are no different, it seems to me, from the motives of the great religious leader or the great poet or the writer of fine prose. And there are no more important motives in the world.

I have spoken of these things at great length. But I do think it is very important to emphasize them. For you will have to live this paradox of the scientific way more intensively than any of your predecessors. Your practical services will be more important to our nation, and to the western world, perhaps, than they have ever been before, and you may be called on to give more thought to that aspect of your profession than any before you have had to do. And yet you must *never* lose sight of the essential nature and purpose of what you do and of the spiritual and intellectual values for which it stands.

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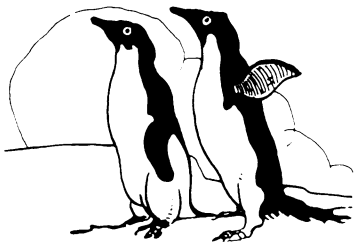
BIOLOGY

NATURE RAMBLINGS

by Horace Loftin



Penguins

➤ WITH NOT MUCH else to look at except ice, snow and each other, the men of Admiral Byrd's new expedition to Little America will undoubtedly pay a lot of attention to those dapper permanent residens of the Antarctic, the penguins.

It will not take a great stretch of imagination for the explorers to think of these birds as almost human companions. In the first place, the penguin's peculiar upright position and waddling gait bring to mind a tiny man.

This idea gains weight and color by the bird's close-fitting plumage: dark on the back, resembling a formal jacket; and a bright white "shirt" at his breast.

Structurally, the penguin is a bird. Yet by habit he might seem more fish than fowl, since he is flightless and can swim on and beneath the water with great speed. His food consists chiefly of fish caught as he "flies" through the frigid water by beating with his fin-like wings.

In still another sense, the penguin is something of a reptile beneath his fine feathers.

Scientists often consider all birds as a sort of "modified reptile," very closely allied to those cold-blooded animals in the evolutionary picture. Also, there is a generally accepted "law" in biology that the embryonic development of an individual follows in "shorthand" form the evolutionary history of the species. Thus, bird embryos should resemble those of reptiles in many respects—and they do. Furthermore, the closer the resemblance, probably the closer the relationship.

In an experiment, a series of 16 Emperor penguin embryos studied indicated that the early stages of penguin development resemble reptilian embryos of similar age more than chick embryos do. Thus, it seems that the penguin is more primitive and closer to the reptiles than his less elegantly-dressed cousin, the chick.

Incidentally, if you see pictures of penguins and Santa Claus together, something is wrong: Santa lives in the north; penguins are found only in the Southern Hemisphere.

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For if you once do this the lights will go out, and the joy of the work, as well as its ultimate value, will be seriously impaired. And if you ever need to argue against those who claim that it is not possible to be a detached investigator and still have your work of practical value, you can always take comfort in the fact that though the paradox is of unrivaled intensity today, it is far from new.

There are precedents to cite from the most ancient and honorable times, as well as from our own immediate day.

There was a school of philosophers in Europe, once, in the fourteenth century, which included two famous writers, Jean Buridan, and Nicholas of Oresme. They taught some strange, new and outlandish doctrines concerning the nature of impetus, and established a school at the University of Paris. Erasmus laughed their Parisian disciples to scorn for their notions of "uniform motion" and "difform motion" and even—to Erasmus' extreme amusement—"uniform difform motion." But it happened that when the more scientific world of a later day was looking for a formula to represent the acceleration of falling bodies, the solution was already at hand in that much-ridiculed mediaeval formula for "uniform difform motion."

The gap between investigation and use was shorter in the case of the mathematics of matrices which, as you recall, were well developed, for no practical purpose at all, in the nineteenth century, to be ready at hand in the twentieth to make possible those modern concepts of the physical world that dominate our thinking today.

And it is not to be forgotten that essentially every new technical principle that gave rise to decisive armaments in World War II, including nuclear weapons, was originally conceived in research directed to non-practical investigational ends.

Perhaps you will bear with me if I sum up this message once again, reiterative as it seems, because I am so sure that it is important.

You will have to live—and live earnestly—one of the greatest paradoxes that any profession has been called on to surmount. Your practical services will be immensely important, and you must give great attention to them. But you must never forget than the real roots, the real life and joy and reason for being of the scientific profession lie in quite a different sphere.

Unless the excitement and the spiritual satisfaction of the investigator remain the overriding goal, unless they are nurtured and watered and cultivated at every turn, neither the spirit nor the practical competence of the scientific endeavor can be maintained.

This is the real invariant.

It is today still as it was phrased by a Japanese sage half a world away in space and centuries removed in time, when he wrote in paraphrase, "Do not try to *do* what your predescessors did; rather, *seek what they sought.*"

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Questions

BIOLOGY—How can an earthworm be taught to turn? p. 150.

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MEDICINE—What are "sleeping cancer cells?" p. 147.

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PHYSICS—How rare are negatively charged atoms? p. 150.

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