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Literature, Science, and the Manpower Crisis

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Before me is the revised edition of the *Cyclopedia of English Literature,* edited by Robert Chambers in 1843 and republished in 1858, which claims "to provide a systematized series of extracts from the best productions of English intellect from Anglo-Saxon to the present times in the various departments headed by Chaucer, Shakespeare, Milton—by More, Bacon, Locke—by Hooker, Taylor, Barrow—by Addison, Johnson, Goldsmith—by Hume, Robertson, Gibbon—set in a biographical and critical history of the literature itself."

Observe the comprehensiveness of the implied definition of literature. Included are theologians, historians, and philosophers. The actual contents confirm this universality. In the section on prose of the "Third period—reigns of Elizabeth, James I and Charles I" we find, among many other similar items, a discussion of "The languages of ancient Britain" taken from Holinshed's *Chronicles*; a eulogy of "The sea" by Samuel Purchase, which has a Rachel Carson flavor; a bit of natural history on "The chameleon," in Scottish, by George Buchanan; and a bit of unnatural history on "How witches travel," by King James I.

In "The fourth period—the Commonwealth," the *Cyclopedia* uses systematic subdivisions (which set the pattern for later historic periods) for "theologians," "historians," "essayists," and "metaphysical and scientific writers." In the last category are included Sir Isaac Newton, Robert Boyle, and even such a technical discussion as "Proportionate lengths of necks and legs of animals," by John Ray, which ends with this aphorism: ". . . for nature makes not a long neck to no purpose."

The *Cyclopedia* was not an aberrant critical or anthological work. It was a standard work of reference. It was reprinted in this country by Lippincott in 1869, in a handsome leather binding, and apparently had a wide circulation.

What I am concerned with here is the presupposition, which this work demonstrates, that literature, in the early 19th-century view, comprehended writings other than belles-lettres. This was traditional. Samuel Johnson, in the 18th century, included theologians and philosophers among the poets. All insights into the nature of the universe, of man, of society, were the proper province of literature. Similarly, in ancient times, sacred literature included allegory, apocalyptic vision, moral disquisition, but also history and legal compilations. Latin literature included a tract on farm management by Cato the Censor, works on architecture by Vitruvius, Pliny's *Natural History,* and Lucretius' poem *De Rerum Natura,* dealing with physics, cosmology, and ethics.

Literature Grows Narrower

It was only in the course of the 19th century, and particularly toward the end of Victorian times, that the domain of literature was truncated. This occurred for two reasons.

As various sciences and disciplines matured, their subject matter became ever less speculative and philosophic, ever less the projection of personal sensitivity and insight. Rather, this subject matter became ever more technical, rigidly systematic, mathematical, and either experimental or clinical. The earlier analyses and reflections were, therefore, personal and imaginative. The later developments became more impersonal and generalized. Adam Smith, John Stuart Mill, or even William Graham Sumner may be said to have written literature. The works of later social scientists, in parallel fields, are technical science. William James wrote what might still be called literature; contemporaries write psychology. Boyle's or Newton's revelations might have been literary. A contemporary report in nuclear physics, or a doctoral paper on semiconductors, is not; it is a specialized technical report. It is incomprehensibe to the literate and educated layman, not trained in the symbols, language, methods, and customary thought processes of the specialists in the field.

This is our cue to differentia. Literature may be said to include the pristine evaluations of experience in some new areas, the intuitions which are personal and fresh and usually weighted with emotion and lyric delight of discovery which can be transmitted to the reader. It can be apprehended by the intelligent nonspecialist. As the body of knowledge in the area grows, as its special terms of reference evolve and crystallize, as it makes more and harsher demands upon the reader in the way of manipulative intellectual techniques, an area secedes from the field of literature and becomes a separate discipline. This evolution occurred early in medicine, in metaphysics, in theology, and in ethics; then in the natural sciences, throughout the 19th century; then in linguistics, sociology, economics, archeology, and history; and finally, within the memory of living man, in anthropology, psychology, and esthetics.

The second factor in narrowing the province of literature was the emergence, at the close of the 19th century, of the doctrine of the autonomy of the arts. The heightened self-consciousness of artists in the use of their tools (for whatever historic and social reasons) gave rise to "art for art's sake." This tended to alienate the artist from subject matter and content and made him concentrate on the technique of his craft, in various modes and degrees—from Edgar Allan Poe and Flaubert through the symbolists, the "mauve

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decade," the impressionists, the post-impressionists, the imagists, the cubists, and even the dadaists. Art became "pure," content became inconsequential, pretendedly. One no longer dared ask what a poem had to say; one could only speculate on how poorly or how well it expressed the ineffable. "A poem should not mean, but be," said Archibald MacLeish, about 30 years ago.

Reading Syllabus Impoverished

This would appear to apply only to the *avant-garde,* to the cliques and schools of the arts. Mass art may be said to have continued to be sententious and sentimental. However, the impact of the esthetic schools ultimately was felt in the academic world in the first quarter of our century. University English departments ultimately conditioned the literary values in teacher-training institutions and among teachers, textbook writers, and school administrators. The result was an ironic cultural lag.

"Art for art's sake" was manifest in what the schools taught as literature a quarter of a century after it had ceased to be a battle call among writers, while, in today's adult population, the cultural lag is perhaps as much as a half-century, and, to the popular mind, an expository work in history, science, or philosophy no longer carries the cachet of literature.

Now this is not a question of lexicography, nor one of purely academic definition. The consequences are felt in our cultural life. They are shown in the curriculums of our schools. Thus, in the 19th century, certain political orations became commonplace works, studied as literature—for example, Burke's speech on conciliation with the Colonies, Washington's farewell address, and Daniel Webster's orations. These survived in the syllabus of the high-school English class as established classics well into our own time and are still taught, if rather apologetically, where modernization has not been seriously stressed. However, equivalent forensic works of our own or of recent times would receive scant consideration by present-day curriculum planners in the field of English and literature. The works cited are on political themes, but writings and speeches in the fields of history and science are equally neglected.

Cultural Lag in the Humanities

The most conspicuous aspect of our civilization, today, is the pervasive and ramifying impact of science in every department of life, from household management to warfare. Yet it is curious to observe how little, relatively, the scientific outlook has permeated our cultural life. I use the term *culture* not in the anthropologist's sense but in the more familiar way, to cover the arts, the humanities, entertainment, and the communication media. The case is most conspicuous in literature. Again, comparisons with other ages are revealing.

Slight, comparatively, as were the general or practical consequences of physics or astronomy in the early 18th century, Alexander Pope's great didactic poems reflected the teachings of Newton, to mention only the outstanding instance. In the 19th century, the work of so dreamy a romantic as Shelley is interlaced with the new scientific perspectives of his age. Tennyson and Arnold showed the surge of new scientific concepts. So did Whitman in America. Emerson made abundant use of the new ideas in geology and biology, which stirred the imagination. In the narrower field of poetry of the machine, Carl Sandburg and Hart Crane exploited new possibilities almost 50 years ago.

Now consider the overwhelming new concepts and insights provided by science in the last 30 years: galaxies beyond, the expanding universe, subatomic particles, entropy, genes, the immortality of chromosomes, atomic energy, Hoyle's continuous creation, matter as wave motion, the various implications of relativity, the original ylem of creation, the succession of species, the life and death of stars. All these challenge the imagination. How little they have been exploited by poets! Robinson Jeffers has employed one phase of biological perspective to extend into our time some of the stunned and perhaps naive disillusionment of the Victorian reaction to Darwin. Archibald MacLeish wrote a moving poem, "An epistle to be left in the earth," and Mark Van Doren wrote an exalted "God of the galaxies." Beyond these—nothing. Not quite; several dozen glib satirical pieces have appeared in magazines, chiding science for man's interference with God's ways. These do not absorb and poetically reintegrate the new outlook, the new constellations of ideas forged by the science of our time. The revelations and the moods presented are trivial variations on themes already centuries old.

Recently, Helen Plotz edited *Imagination's Other Place,* a thin compilation of poems of science and mathematics. The anthology shows exhaustive and painstaking research. The editor has to lean heavily on Emerson, Masefield, Hardy, and Shelley. She culled her most deeply felt lyric passages from Lucretius and the Book of Job. Where are the contemporaries? John Ciardi is represented by a warning against scientific disaster, reminiscent of the sermons against the "iron horse." The other living poets are flippant about flying saucers and the like.

It is instructive to examine such a lexicon as the *Reader's Encyclopedia,* compiled by William Rose Benét, a literary scholar of scope and judgment. In it may be found listed the unicorn and the music of the spheres, but not the awe-inspiring new elements in today's cosmology, or the hair-raising imaginative ideas of the other sciences of our time.

What is true of poetry and of literary reference is equally true of the drama, the novel, and the humanities in our schools. College presidents and professional societies issue dicta about the urgency of spicing technical training with "the rich leaven of the arts." Professors of science apologetically admit the straitened confines of technologic studies and defer to the deeper wisdom of the humanities. But the humanities sweepingly ignore the role played by scientific insight and thinking in the ideology of our times and disdainfully march on their archaic way as though the atomic and electronic age had not yet arrived.

Scientific Manpower Shortage

At the same time the *New York Times* reported, in a review of the year in education, on 1 Jan. 1956: "The National Manpower Council has drawn attention to the great shortage of teachers, scientists, engineers, and technicians of various kinds." Lewis L. Strauss, chairman of the Atomic Energy Commission, pointed out at the Thomas Alva Edison Institute, in 1955, that in 1956 the United States was graduating about half as many engineers and scientists as the nation's industry and research programs needed, and that in the decade 1950–60, the Soviet Union is expected to produce 1.2 million trained engineers and scientists to our 900,000.

"The new thing," said James Reston in the *New York Times* on 5 Dec. 1955, "is that education is now being argued out in the National Security Council where the views of men like Mr. Dulles and Mr. Strauss can have some effect."

Public and private agencies concerned with scientific manpower have focused their attention on recruiting students for science and engineering courses in the colleges and on improving the quality of science teaching in the high schools. Strauss has even proposed that the study of physics and chemistry be made obligatory, in high schools, for college candidates.

But to solve our scientific manpower shortage, we cannot, in the long run, depend on coercive syllabi. The Soviet Union is said to enforce fixed curriculums heavily weighted with technical studies. But the Soviets are also reported to pay the highest emoluments to engi-

neers and technicians and to make a veritable cult of science, so that scientists constitute a venerated elite. It is doubtful whether, in this country, the lure of higher pay for scientists will succeed, in the absence of other influences, in attracting a sufficient number of recruits into scientific professions, for, in our society, there will remain the countervailing attraction of rival fields of enterprise. The scientist is generally a salaried employee, while the free entrepreneur, if he has initiative, and the executive, if he has ability, will command greater authority, greater economic opportunity, and greater social prestige. It is reasonable to believe that increased remuneration will draw more qualified young men and women into scientific fields, but it is equally reasonable to seek to create additional and perhaps deeper and more sustained incentives.

The many organizations concerned with our present and prospective shortage of scientists, engineers, and technicians are now engaged in campaigns to improve teaching methods in the sciences on various educational levels, in the colleges and in the secondary schools. Similarly, they seek to improve the facilities and equipment in the schools. They have mobilized a massive program of public education to secure financial support from both governmental and private sources for scholarships, endowments, and appropriations, to expand and strengthen science teaching. They have succeeded in arousing our citizenry to an awareness of the urgency of the problem.

Arousing Youth's Imagination

However, a serious shortcoming of this campaign lies in this fact: students must be attracted to the study of sciences, not *after* they are enrolled in science courses in the colleges, but *before;* not after they have elected physics and chemistry in the secondary schools, but before they do so. Moreover, while they are engaged in what, to them, is the exacting and arduous work of science and mathematics classes on the high-school level, they must be endowed with a perspective that will provide them with a profound and continuing motivation to apply themselves.

It is a commonplace that European students are subjected to a rigorous course of study in *lycée* and *gymnasium,* and that they study with single-minded assiduity. Their *continuing* motivation is to be found in the traditional prestige attached, in their cultures, to the baccalaureate and doctoral degrees and to the code among students which puts a high value on scholastic achievement. Thus, a German or Scandinavian business executive not uncommonly has a doctorate. In France, it is notorious that suicide rates are high among young people who have failed in their baccalaureate examinations.

Our culture, and the codes prevalent among our students, do not prize scholastic achievement so highly. Strong motivation for young people to persist in difficult studies must be found in the intrinsic appeal of the areas of study as well as in the pecuniary rewards offered by the goal—the profession for which their studies prepare them. The intrinsic appeal of the sciences can be found in the emotionally satisfying, dynamic concepts which modern science employs—the very list referred to in a preceding paragraph as stimulating to the imagination. The intrinsic appeal of science can be found in the splendor and the magnitude of the ideas which it handles, in the feeling of awe which its universalized observations provide, and in the sense of workmanship, order, and organization which is satisfied in the pursuit of one of its topics or objects of investigation.

Now it is in the very nature of the process of specialized study in a specific science that some of these appeals should be attenuated. The pursuit of technical details in the laboratory often militates against the sweep and majesty of basic theories and emotion-laden hypotheses.

Where, then, can the emotional and imaginative appeal of modern science be conveyed to the student? Obviously, in the humanities and the arts, generally, and, most specifically, in the study of literature. Literature always pinpoints individual sensibility and the relationship of the individual, the writer, the reader, or the character examined, to the world around him. It is literature which can most appropriately project the emotional impact of the scientific outlook on the individual.

It is in literature, in the arts, and in social studies that students may learn to recognize the scientific outlook and to be aroused to the romance, the wonder, the reverence, the adventure of modern science. They may learn enough about what science is to be able to elect science courses intelligently. The appeal of science to the student has usually been in the nature of a calling, a mission. Teachers have found some students who were enamored of science before they began to study physics or chemistry or biology. The number can be increased by offering young students insight into what science offers to mankind in general, and to the private imagination as well, before they begin their regular scientific and technical study.

Observe the opportunities in high-school English classes. High schools do not offer, and are not geared to offer, such subjects as astronomy, cosmology, oceanography, geology, paleontology, archeology, or anthropology. But consider the vast number of imaginative and well-written books which have been put out since World War II, alone, dealing with these subjects at the level of the intelligent layman. I list only the most conspicuous of the best sellers which, by their sales, reveal that they contain no technical hurdles and that their attractiveness for the literate, adult layman is great: Rachel Carson's *The Sea Around Us,* George Gamow's *Life and Death of the Sun,* Fred Hoyle's *Nature of the Universe,* Patrick Moore's *Guide to the Planets,* Roy Chapman Andrews' *Meet Your Ancestors,* William White Howell's *Back of History,* C. W. Ceram's *Gods, Graves, and Scholars,* Ruth Moore's *Man, Time, and Fossils.* That scientific writing on a nontechnical level holds the interest of the lay public is revealed by the increasing space given to such material in periodicals such as *Harper's* and the *New York Times Magazine. Life* ran a series, in 1952–54, entitled "The world we live in," and is currently publishing a series on anthropology. The man on the street definitely has an appetite for scientific revelation. *The Scientific American,* a monthly magazine, has increased its circulation in the last 8 years to the hundreds of thousands, despite the fact that it is quite technical and makes few concessions to the ignorance of the layman.

English Syllabus Neglects Science

We must now return to our initial discussion. Up until 70 or 80 years ago there would have been little question that such books as those listed in the preceding paragraph belonged properly in the jurisdiction of literature. They are neither textbooks nor technical reports for specialists. They serve the purpose of communication to a general public. It is, perhaps, time that we returned to this pristine notion of what is literary. I am not quarreling with library classification practices, though, in passing, we might note two pertinent anomalies—the result of our present adoration of specialization. *Great American Nature Writing,* assembled and edited by Joseph Wood Krutch, is assigned by our libraries, under the Dewey decimal system, to the area of biology, although Krutch, certainly eminent as a literary critic, essayist, and historian, spends his 80 pages of lucid prologue discussing nature-writing as literature. Similarly, Roy Chapman Andrews' *My Favorite Stories of the Outdoors,* which consists predominantly of fiction—of short stories—is classified under biology. I have no quarrel with librarians; let them have it as they will.

But those responsible for the syllabi in English must learn to look for material on the nonliterary shelves.

The American Association for the Advancement of Science has organized a library of 200 books dealing with general and broad aspects of science, from archeology to engineering. This library is circulated to small high schools to stimulate interest in science among students in out-of-the-way districts. The books listed were recommended by professional scientists and educators and were subjected to scrupulous counterchecking, for readability, by experienced teachers. Of the 200 books, 112 have proved to be of interest to high-school students in 66 program schools, during 1955–56. Observe, in contrast, the treatment of science reading in an official publication of the National Council of Teachers of English, the *Combined Book Exhibit* of recommended, supplementary reading. The exhibit was held by the National Council of Teachers of English at its New York convention in 1955. The books exhibited were listed in a graded, and annotated, printed bibliography, published by the council, which, in practical effect, will become an official guide to teachers on books to recommend. Under the heading "Seeking to understand the universe," this bibliography lists only one book on the high-school level. The annotation for this book is: "A selection of 365 readings from the main stream of devotional writing, one for each day of the year." Science is not regarded as even having any relevancy in "seeking to understand the universe."

Under the general heading "Seeking to understand the world around you," the *Combined Book Exhibit* contains subdivisions on living things, on the physical world, on material things and inventions, and on space and ocean depths. Under the first subdivision there are 72 items of natural history for the elementary-school level, but only seven books are listed as suitable for grade 9, and above. None of these deals with basic biological concepts, and none is on the higher intellectual level suitable for the high school proper, as distinguished from the junior high school, although the traveling library of the American Association for the Advancement of Science lists at least 75 items in the biological sciences, including medicine and paleontology. Under "material things and inventions" there are several elementary-school listings but only two for the "ninth grade and above," one a gazetteer and one the story of gold. Again, nothing is listed on a more challenging level for the upper grades of the high school. Under "the conquest of space and ocean depths," only three books for the tenth grade, and above, are listed, and these, while worthy, do not touch the profound, evocative ideas of modern science. One is an account of wartime torpedoes; one, an account of "man under water"; and one, a discussion of unaccomplished engineering fantasies! Under the more comprehensive heading, "the physical world," there are nine listings for "grade nine and above," none specifically for the higher grades or higher intellectual levels. One, only, of the nine, *Design of the Universe,* by Fritz Kahn, presents a comprehensive overview of the hypotheses and speculations of today's science. Another, an excellent, reputable, and adult book, Waldemar Kaempffert's *Explorations in Science,* is focused chiefly on new processes and inventions—on the laboratory, not on general perspective. *Atoms Today and Tomorrow,* by M. O. Hyde, is concerned with a narrow treatment of atomic energy from a utilitarian standpoint. The others, while worthy, deal with such restricted areas as science in the service of the police, mountaineering, and practical meteorology. Observe that these few recommendations for science reading occur in a total bibliography of more than 900 books.

Contrast the listing with that of the American Association for the Advancement of Science. It is almost as though the English teachers' association had planned to misdirect student attention; to guide it into arid and narrow channels dealing with gadgetry, pet-care, and the trivial curiosities of science; to divert student attention from the breath-taking vistas presented by literally hundreds of contemporary expository works for the layman. A sinister group, determined to inhibit the growth of an interest in science reading among high-school youth and to forestall development of a passion for scientific studies, could hardly have planned better.

No Dichotomy—Science Belongs with the Humanities

Now I am not suggesting that a foreign power has a cell operating in the National Council of Teachers of English. What is apparent is the dichotomy in our culture. On the one hand, science is respected, but, perhaps, among nonscientists (and this includes teachers and writers), with the same mixed fear and regard that are felt for the medicine man among primitive groups. On the other hand, in our everyday attitudes and dealings, science is left out of account. So, also, science is left out of account in our view of our relationships to ourselves, to one another, and to the universe. Consequently, it is left out of our fine arts and our literature—which, to that extent, are still prescientific. And with this goes the prescientific attitude which a legendary Moslem might have had toward a magic jinnee: that it was a handy, servile monster, ready to be ordered to produce conveniences, gadgets, and occasional miracles. It is this dichotomy which opposes science to the arts and the humanities in conferences of university administrators and curriculum builders.

There need be no dichotomy. It was not inconsistent for Einstein to love the violin. The physicist's recognition of the nature of musical pitch, overtones, and timbre need not militate against his having a deep-felt appreciation of melodic line, harmony, and orchestration. Nor does the musician's sensitivity forbid him to contemplate sound as a phenomenon of nature. The emotions of awe, reverence, love, self-identification, or joy-in-life are not muted by an understanding of mathematical relationship, of atomic structure, or of the chemistry of enzymes. These are not opposites. They are complementary aspects of reality.

The aspect of Western society which has differentiated it from the rest of the world in the last few centuries has been its concern with science. Science is the bedrock of the contemporary world. Without the *Weltanschauung* of modern science, no form of thinking, feeling, or reacting has validity today. No man can see the world except through his modern eyes, and these, in a large measure, are conditioned by the scientific outlook, whether or not he is conscious of it. Not to apprehend this world from the standpoint of science is, therefore, to belie the very process of seeing. To speak in any idiom other than that which incorporates the scientific outlook is to speak the language of the dead—a feat which usually falsifies the meanings and the nuances which that language had for those who lived in the past.

The writer has no choice. The cultural gap which leads him to stand with one foot in the present and one in a prescientific past must be closed, if his message is not to consist of arbitrary and falsified symbols. The poetry of nature is not dead. It has been transmuted into the staggering images of science. When the writer discovers the poetry of the scientific outlook, as Whitman, for example, hoped he would, his work will arouse the young to exaltation. It is this exaltation, alone, that can provide the incentive for hundreds of thousands to devote themselves to scientific careers.

Meanwhile, the courses in the humanities, on the secondary-school level, hold the key to the future of our country and of our society. They can do a twofold job. They can predispose many students, who have the right potentialities, to elect scientific studies voluntarily and eagerly, by showing them the wonder, the vision,

and the excitement of science. And these courses can prepare those who will not be scientists—the writers, the artists, the journalists, the lawyers, the historians, the merchants, the ministers of tomorrow—to share in the scientific outlook and, through it, to enrich the arts and the literature of the future.

What Literature Classes Can Do

Where may our schools begin? They may begin, as literary man in general should begin, by revitalizing the definition of literature to make it conform to its age-old traditional meaning and include all that is profoundly revealing in what is written. In our time, this means such books on science as were listed earlier in this article. We might include some titles that the *Combined Book Exhibit* of the English teachers overlooked: *The Scientific American Reader; The Time Book of Science,* by Jonathan Leonard; *Atoms, Rocks, and Galaxies,* by J. S. Allen; *The Common Sense of Science,* by J. Bronowski; *One, Two, Three—Infinity,* by George Gamow; *Modern Man Is Obsolete,* by Norman Cousins; *Mathematics for the Million,* by Lancelot Hogben; *The Story of Man,* by Carleton S. Coon; *Back of History,* by William White Howells; *Water, Miracle of Nature,* by Thompson King; *A Treasury of Science,* by Harlow Shapley; *The Tree of Culture,* by Ralph Linton; *Magic in a Bottle,* by Milton Silverman; *The Creation of the Universe,* by George Gamow; *Life on Other Worlds,* by Spencer H. Jones; *Our Sun,* by D. H. Menzel; *The Story of Man and the Stars,* by Patrick Moore; *The World We Live In,* by Lincoln Barnett; *Man's First Million Years,* by Jeannette M. Lewis; *Flight into Space,* by Jonathan Leonard; *Unresting Cells,* by R. W. Gerard; *Road to Survival,* by William Vogt; *Nature's Ways,* by C. Andrews; *The Living Tide,* by N. J. Berrill; *Science, the Servant of Man,* by J. Bernard Cohen; *Eleven Blue Men,* by Berton Roueche; *Crucibles,* by Bernard Jaffe; *Rats, Lice, and History,* by Hans Zinsser; *The Next Million Years,* by Charles Galton Darwin; *Mr. Tompkins Explores the Atom,* by George Gamow; *Devils, Drugs, and Doctors,* by Howard W. Haggard; *Men, Microscopes, and Living Things,* by K. B. Shippen.

For the younger student, adventure is the *sine qua non* of vicarious experience through reading. Real adventures in science should be offered to him. The available material is abundant: Roy Chapman Andrews in search of dinosaur eggs in the Gobi Desert; William Beebe in his bathysphere, or considering the natural history of New York; Admiral Byrd taking meteorological readings in the Antarctic; Edwin Way Teale on his naturalistic tours of America; Carl Akeley collecting African wild life; Ernest Thompson Seton drawing the animals of the Canadian and the Arctic wilderness; Thor Heyerdahl on his balsa raft in the Pacific; Gilbert Klingel gathering marine specimens under the Caribbean; the Kelley brothers blowing air into steel crucibles; Ross Allen and Raymond Ditmars hunting snakes; Commander Rosen trying out his Viking rockets; Captain Cousteau with his aqualung; Haroun Tazieff treading volcanic craters and sliding through measureless caves; Louis Slotin testing the critical mass of uranium batches until he died of radiation anemia; and the Burdens in search of surviving prehistoric monsters.

Nor should science fiction be overlooked, even though it is generally derided by schoolmasters. Much in this medium is worthless, but the best specimens are catalysts to the imagination, not to crude and easy fantasies, but to disciplined and orderly marshaling, imaginatively, of the *possible* by extension from the known. Note what a committee of secondary-school principals and professors of education reported about science fiction in the December 1955 issue of *The Bulletin of the National Association of Secondary School Principals,* an issue devoted to "Teaching reading for the gifted in secondary schools."

"If we are to gain a wider appreciation for science, then we must take the opportunity to explore the various areas of science from the purely factual to the fanciful. Scarcely a major technological advance exists that was not at one time a projected image in someone's mind. New discoveries and inventions are outgrowths of man's imagination, thinking, and reasoning integrated with his factual knowledge to produce usable ideas and devices. Effective intellectual growth is achieved when individuals can exchange freely their thoughts and ideas, interpreting and modifying the ideas in the process. For this reason, the gifted should be encouraged to read science fiction in its place. It is through the spark of an imaginative idea that man has been able to improve his environment and himself."

Where science fiction and fantasy are concerned, the function of schooling is to train the student to discriminate between what is significant and revealing, on the one hand, and what, on the other hand, is trivial, absurd, hallucinatory, or vulgar. But education should develop just such ability and sensitivity in regard to all other literary genres as well. Romance or biography may, similarly, be either ennobling or degrading. It is not the genre that is worthy or contemptible but the performance, the content, or the theme.

An Intellectual Reorientation

What applies to the study of literature applies, with equal force, to other subjects. There are art forms that are correlated to science in various ways, through the products of modern industry, through the equipment and processes of the modern factory, the laboratory, and the highway network, and through the functional outlook of modern technology and engineering. History can mold and reenforce the scientific outlook of students. It may attract them to science as a way of life or as a prospective career. It can give greater emphasis to the creative and shaping role of science in our civilization. History can pinpoint the influence of specific sciences and particular theories upon both intellectual and material development.

In sum, what is needed is a reorientation in our intellectual outlook and in our literary and artistic output, accompanied by a reorientation in the teaching of the arts and of the humanities, generally, to gear them to a scientific outlook as part of our effort for preparedness in world competition.