Responsibility and Science Writing

What standards should we expect of educational groups that sponsor or publish science books for young readers?

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In this review we are considering three paperbacks that a benevolent citizen might give to the local high school library—or that an exasperated school boy might offer to his un-rocket-minded uncle. I shall call them α, Γ, and Ω. α is **Spacecraft** by James L. Haggerty, Jr. (*National Science Teachers Association, Vistas of Science*, No. 1. Published for the Association by Scholastic Book Services, New York, 1962. 159 pp. $0.50). Γ is **Gravity** by George Gamow (*Science Study Series*, No. 22. Published for the Physical Science Study Committee by Doubleday, New York, 1962. 157 pp. $0.95). Ω is **Artificial Satellites** by Michael W. Ovenden (Penguin Books, Baltimore Md., 1961. 128 pp. $1.25). All three discuss, for young students and other laymen, satellites and their orbits, rocket propulsion, weightlessness, and related topics, in different ways and with different appeals to the underlying physics. After reading them I advise, "Give all three to the high school library, or to an individual student; *but do not give only one*." I am still not sure what to suggest for uncle: certainly not α, probably Ω, though Γ would do more for his blood pressure and might lead to richer support for high school science. None of the three will make the physics of satellite motion quite clear to a beginner. Reason: all are confusing—and one of them confused—regarding centripetal and centrifugal force. Even Gamow switches from one scheme to the other, without warning or explanation; and it is that *mixture* which drives a young scientist crazy and which may even convince a young layman that scientists are crazy. In other matters—the working details of rockets, the underlying descriptions of Newtonian theory, the present types of and future plans for satellites—the three books supplement each other.

Which of these books will produce the most active talk about satellites and the greatest number of science-prize essays? α. Which will give most help in making more young scientists? Ω. Which will produce the most enthusiasm for a good physics course? Γ.

α rolls along with great enthusiasm —or, to approximate its own language, blasts away and orbits successfully. It is an account of rockets and satellites—their design, achievements, and prospects—written with an enthusiastic vocabulary of spacetalk that will certainly catch the youngsters' fancy. It has fanciful sketches, good photographs, and a skill to its story that comes from experienced writing. For those of the school population who want thrilling descriptions—reasonably accurate ones but without very clear science—in the jargon of today (where theorize, orbit, and impact are current verbs), this is the book. As a sincere attempt to put a story of satellites and space travel fairly before young readers, and to get rid of some of the rumored nonsense, this is a good book. But as a means of encouraging more science and better science in schools it is quite poor. It never comes to grips with the physics of satellites clearly enough to help; in fact it will hinder a good physics course like that of the Physical Science Study Committee. Its style may even give a wrong impression of science and scientists; science, as I see it, is romantic without having to be romanced-about. Young people who want to be informed about rockets and to talk enthusiastically about space travel will welcome this book. For myself, as a physicist interested in persuading nonscientists to enjoy and understand science, and on behalf of thousands of physics teachers across the country with similar aims, I am disappointed because this book, whose physics is thin and even confusing, comes out with endorsement by a distinguished board of educators. But that raises questions of editing as well as of writing, so I leave it to a later discussion of editors.

The book offers some simple experiments that should interest a young scientist and may puzzle as well as help him. And in that puzzling I see great hope of benefit. The book finishes with a healthy reading list of a dozen books which includes DuBridge's *Introduction to Space*.

In Γ Gamow writes with his usual gay style, which will catch many a young reader—and many an older one too—and give him a sane enthusiasm for science. He writes about falling bodies, acceleration, vectors, and projectile motion with great speed and gusto; then he skips to the moon and links orbital motion to simpler accelerated motion by a geometrical analysis that the tougher nonscientist may follow; then to universal gravitation, with Newton, Cavendish, Kepler, and Newton again; then to precession and tides. He interpolates a chapter on calculus—full of promise—to show how it can be learned, but then seems to make little use of it. He ends with chapters on gravity and general relativity (following the style of his *Scientific American* article) and a stirring but all-too-short chapter on the unsolved problems of gravity. I feel that these last talk too fast and run too far away from the reader's general coordinate system of knowledge to be a good ending for the book, unless they are expanded. ("Now, after your two weeks' tour of France, let me show you a few color photos of Istanbul and give you a quick look at the back of the Moon by TV" is the feeling these chapters give me.) This book gives readers genuine contact with a very able, imaginative physicist and his understanding of physics, and for that it is well worth giving to any reader. For providing information and building scientific knowledge, it is too hurried to finish the job alone; other books, such as the PSSC textbook and

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Ω, should go with it. Sometimes where he offers historical comments I suspect the author, just as I suspect myself, of writing unreliable, secondhand history that would make the professional historians of science draw their skirts around them and look down on amateur mistakes. Never mind, the *physics* in the book is alive, and its physicist-author is a scientist who is very much alive. This book should be read as an antidote to α, and then Ω will be needed to set a welcome, serious note.

Ω seems to me outstandingly the best of the three. The author is a serious British enthusiast, lecturer in astronomy at Glasgow University and joint secretary of the Royal Astronomical Society: he writes well and presents sound science without being dull: history, planets as satellites, orbits, rockets, satellites as scientific instruments, moon probes. . . . The book has good photographs, sensible diagrams, and a fine table of artificial satellites that have been launched, with details of shape, size, orbit, and so forth. (In describing our progress, the author often says, "The Americans . . ."; some readers may find that irritating until they reflect that we freely say, "The French take wine with their dinner.")

Ω is the book I shall give to *my* nephew, to answer his questions about rockets and to encourage his interest in science.

Editorial Responsibility

The function of a reviewer, as I see it, is to act as minister between the book and *potential* readers. He should state the book's scope, certify the reliability of its information, comment on its skill in conveying knowledge, and even try to assess its wisdom in conveying understanding. He should not spend ink and paper cavilling at spelling, wailing over an author's style, or picking a dozen minor errors for disdainful notice. (These things happen, as every author knows, except in journals with a first class review-editor.) And yet, despite this view I feel compelled, by the public interest in providing good reading in science, to add a severe note of criticism, not directly of books or authors, but of editors.

In the field of science, particularly science for young readers and other nonprofessionals, publishers have editorial responsibilities for accuracy and wisdom over and above those of the author. Two of the books under review force me to appeal for more careful editing, *by scientists.*

α fails to give the scientific account we should expect; and it is misleading, if not incorrect, in some of the science it does give. That would be forgivable in the work of an individual author who makes his choice of material and style and gives his own views. But here is a volume in the Vistas of Science Series whose preface explains:

> . . . there is an insatiable demand for current, accurate information. To fill this pressing need, the National Science Teachers Association has conceived and developed the VISTAS OF SCIENCE series. . . . produced under the guidance of an experienced Advisory Board. . . . Three types of information characterize VISTAS OF SCIENCE books: presentation of subject matter, research frontiers and methods, and student activities. VISTAS are science resource and enrichment literature that is sound and challenging. Written for junior and senior high school students. . . .

The preface continues with assurances of experienced writers, and it expresses hopes of uses in schools and science clubs. Since that statement emphasizes information, the author and sponsors may feel they are justified in giving a descriptive story rather than a more severe scientific study. But, even so, if the book is to live up to their general high standards, it should have been read by an outside physicist, acting as revising editor. The following quotations will serve to show why I say that:

> Since the sun pulls on the Earth with a constant force, the path followed by the Earth becomes circular. It is the result of two equal forces acting at right angles. When an object is moving in a circular path (as the Earth is moving around the sun), the force pulling the object towards the center of the circle is called "centripetal force". The Earth *seems* to exert an equal, but opposite, force against the sun's gravitational force. This reaction is called "centrifugal force". It is extremely useful in explaining circular motion.

The right-angle remark is aggravated by a sketch, which shows three vectors (in, out, and tangential), with an equally misleading legend. A physicist will know what the author means to say—there is a strong hint of that discredited word *tendency* of biological explanations—but a young reader will be confused. And, with regard to centrifugal force, neither the remark quoted nor the ensuing discussion of a stone whirled on a string will clear up the confusion between a force on the other body (Newton's third law) and an inertial force appearing with a change of frame-of-reference.

> At exactly the right speed the satellite will orbit. Scientists can compute this speed mathematically.

The second sentence may earn science a bad name—mysterious mathematics by computers. And the first suggests that starting an orbit is like pitching a horseshoe to land on a distant peg. Starting the *right* orbit is just like that, very difficult. But any velocity will start *an* orbit, though some elliptical orbits will intersect the Earth and hyperbolic ones never return. Only the special case of a circle needs a special velocity.

The notion of gravity as a long arm that can latch on or let go abruptly is likely to be fostered by wording such as the following:

> When the satellite slows, its speed can no longer cancel out the centripetal force of Earth's gravity. Gravity takes over and draws the satellite back toward Earth.
>
> . . . .
>
> At this speed, the outward push was greater than the pull of Earth's gravity, so *Pioneer* V left Earth forever. As it escaped Earth, it came under the influence of the sun's gravity.

The Earth's pull is always there, falling off smoothly (with inverse square law) as distance grows—though at very big distances it may be trivial compared with other pulls. And that pull always produces a proportional acceleration. The Sun's pull is always there too—Earth, Moon, *Pioneer*, *Explorer*, and even a baseball in flight, are all held to yearly orbits by the Sun's pull.

> Propellant performance is measured by the number of pounds of thrust produced by each pound of propellant in a single second. This is called "specific impulse" and it is listed in seconds.

There is nothing wrong here, if we accept the horrible units of modern practice in rocketry: but my fingers itch to change the wording to "pounds-weight of thrust for each pound of propellant used in a single second." Even then I wonder how much trouble the young scientist will have in linking this statement to his physics course. In the discussion of multistage rockets, the advantage of leaving some of the rocket behind seems to be obscured by a confusion between weight and mass.

> The phenomenon of weightlessness which occurs during space flight is still an enigma to space scientists.

This is a true statement that may do damage. Without this startling beginning the paragraph on weightlessness gives a sensible picture of practical troubles. No "explanation" of weightlessness is offered there, but an earlier chapter says "Gravity has been cancelled out by the satellite's speed, so the satellite has no weight." (Physicists must cry aloud for a simple experiment: let the children throw two stones out together, with the same velocity. "Watch them move together, on the same orbit. Now imagine the big stone is a satellite and the small stone some object inside the satellite. Things inside—rocks, lumps of metal, balloons, scientists themselves—all just hover there, as seen by an observer inside. They seem to be weightless.")

Γ raises a different issue of editing. It is one of the Science Study Series that is part of the PSSC program, though the series has spread beyond that program in a most gratifying expansion. As such, this book, too, deserved, and seems to have missed, a careful review by an outside physicist to ensure accuracy and consistency with the PSSC program that it supplements. Such review would have saved some minor mistakes: for example, Poynting's "weighing of the Earth" experiment is attributed to Boys, who made a different and more famous measurement of "*G*." The explanation of tides contains a familiar mistake that would make the lunar tide 90 feet high on the Earth instead of a few feet. But, far more important, a reviewer would have urged the author to reduce the conflict between his occasional use of centrifugal force and the position of the PSSC text, which takes a stern view against it. Gamow starts with centripetal acceleration v^2/r for moon and planets and then switches to a centrifugal force that balances gravitational pull. We are all tempted to make such switches—all three books under review seem to make them—and here all would be well if a few words were added to explain the change of frame of reference. For a book that is part of the PSSC system, with all the care for consistent and reliable science teaching that that title implies, I plead for an editor to add the necessary bridge.

Where science books are sponsored by educational groups, I think advisory boards are not enough: a final revision by an independent scientist is a duty to young scientist readers.

Inglis and Burton Lectures

The Teaching of Science. Two essays. Joseph Schwab and Paul Brandwein. Harvard University Press, Cambridge, Mass., 1962. 152 pp. $3.25.

This small book contains two essays on science teaching in secondary and elementary schools, presented as the Inglis and Burton lectures, respectively, at Harvard University in 1961. The first, by Joseph Schwab of the University of Chicago, is entitled *The Teaching of Science as Enquiry*. The second, entitled *Elements in a Strategy for Teaching Science in the Elementary School*, is by Paul Brandwein of Harcourt, Brace and World.

Schwab makes a plea for teaching science in the spirit of enquiry rather than as rhetoric or a collection of dogma. He usefully defines both *stable* and *fluid* enquiry, the latter being fundamental to the invention and creation of new scientific knowledge while the former provides the fruits for technological development. The author points out three reasons for converting school science "from the dogmatic to the enquiring mode." The reasons are our need for scientists, the competences required for our political leaders, and our need for a public that is cognizant of the nature of scientific enquiry.

Specific suggestions for achieving such a curriculum are offered, including the following unusual boundary conditions: that the laboratory lead, at least in part, rather than lag the classroom; that the classroom concern itself with an exhibition of the course of enquiry rather than with a rhetoric of conclusions; that doubt be specifically injected; that appropriately selected, original papers be included to provide experiences in depth as well as familiarity with true enquiry; that we include "invitations to enquiry" by providing suitable problems.

Every enlightened science teacher will recognize many of Schwab's observations and suggestions as being similar to his own. However, this essay is an unusually perceptive and concise statement which clearly identifies the contrast between two types of enquiry and which convincingly delineates the steps that can be taken to orient the teaching of science toward science itself as a living intellectual adventure. Its pertinence goes far beyond the secondary school to both the undergraduate and graduate curriculum. The author emphasizes that only by positive changes throughout the years of formal scientific education can we revise a situation in which we find our fluid enquirers by identifying them as the men "who run the obstacle course of an indoctrinational curriculum and emerge at the other end not yet wholly indoctrinated."

The second essay, by Paul Brandwein, is concerned with the role of the science teacher at the elementary level. Brandwein dwells primarily on the importance of each child's creativity, on concept forming, and on "teaching rather than telling." He stresses the importance of understanding to what extent children of different ages and abilities can comprehend specific concepts. As in the previous essay, emphasis is on the individual child's intellectual growth through realistic scientific experiences. While this essay makes a contribution to the general problem, it does not strike as boldly at the heart of the matter as the other. As its title implies, however, it provides a strategy for teaching science at the elementary school level, a strategy based upon conceptualization and "a mix of learning in which enquiry plays its appropriate part."

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Needed: More Scholars

Great Chemists. Eduard Färber, Ed. Interscience, New York, 1961. xxvi + 1642 pp. Illus. $29.50.

This is a large and impressive work. In its more than 1600 pages it contains the biographies of over 100 scientists who have contributed to the evolution of chemistry. It ranges in time from the era of the chemical technologists in ancient Mesopotamia to 1937 when the subject of the last biography, Wallace Hume Carothers, died. It can be safely stated that there is no other volume quite like it. Its nearest competitor, Günther Bugge's *Das Buch der Grossen Chemiker*, does not range so widely either in number, time, or space; but it should be pointed out that the present volume does not entirely displace Bugge from its honorable position in the history of chemistry.