in the third. Accounts of the first probings and fingerings of elementary particles, neutrons, are given in the next two papers by Havens, Rabi, and Rainwater, and by Fermi and Marshall. From this point the story proceeds apace as blind men excitedly feel and describe (in measured terms) what they find inside the "elementary" particles called nucleons. Theoreticians (fingerless men with great imaginations) quickly join the expedition into these vast infinitesimal regions. Fitch and Rainwater build new fingers from muons, while Hofstadter and his colleagues steadily make their electronic fingers more sensitive and finally in 1955, feel inside the proton.

Through some 83 papers, the story is told by the men who led the expedition and cheered it on. The last in the sequence is a paper by Frati and Rainwater written in 1962. Taken together in this unified set, these 83 papers, with comments on each by the man who led the assault on the summit where storms of pion resonances rage and electric and magnetic fields swirl about one's ears, form a fascinating story that will live in the annals of science as long as those annals are kept by men.

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Bacterial Viruses

Molecular Biology of Bacterial Viruses. Gunther S. Stent. Freeman, San Francisco, 1963. xvi + 474 pp. Illus. $9.50.

This brilliantly written book is by Gunther Stent, one of the few people who could conceivably have done the job. Stent combines the qualities of an outstanding scientist with those of an outstanding teacher, and he has put into some 470 pages a distilled essence of molecular biology as it is approached through bacterial viruses. Any undergraduate, graduate, or postdoctoral student with even a sketchy background in biochemistry and cellular biology can use this book to tremendous advantage.

To me, the term *molecular biology* denotes a branch of science that seeks to explain biological phenomena in terms of the structure and properties of molecules, particularly of the macromolecules. Not everything that Stent has to say about bacterial viruses is molecular biology, by this or any other definition, but then not everyone takes the term that seriously. What Stent does present is a series of chapters that cover the following topics: the discovery of bacterial viruses (bacteriophages) by Twort and d'Herelle; the bacterial host cell; the nature of the infective virus particle; the various stages in viral infection, replication, and maturation; viral genetics, both with respect to mutation and recombination; and the radiobiology of bacteriophage. All of these topics, with the exception of the bacterial host cell, are covered with enough detail to give the student a good idea of the experimental basis for each and every significant conclusion.

The only weak chapter is the one in which the bacterial host is described. The 14 pages alloted to this subject do not provide an adequate background; a student who, for example, enters the field of molecular biology from a background in pure physics and mathematics will simply have to go elsewhere to learn about the fundamental architecture and function of bacterial cells.

I have only one other criticism, and that has to do with the author's treatment of the complementation test. To perform this test, two mutant genomes are brought together in a common cytoplasm; if the wild phenotype is produced, the genomes have complemented each other and are inferred to be deficient in different functions; if the mutant phenotype is produced, the genomes are unable to complement each other and are inferred to be deficient in the same function. Benzer adapted the complementation test to the identification of functional units in viral DNA. He coined the term *cistron* for such a unit, since the test, if properly carried out, demands that the same phenotype be produced when two defective *cistrons* are in the *trans* position as in the *cis* position.

The foregoing account is similar to the one that Stent presents in an expanded form. Unfortunately, he does not tell the reader that recent work with *Escherichia coli* and *Neurospora* systems has greatly weakened the complementation test as a means of identifying the functional unit. Work by Giles, Fincham, Levinthal, Garen, and others shows that complementation occurs extensively at the protein level: two genomes, each producing the same polypeptide in defective form, will complement each other if the defects are suitably spaced. The defective polypeptides associate to form functional polymeric enzymes. Thus, the rigorous identification of a functional unit requires direct knowledge of the polypeptide produced. Strictly genetic data that utilize gross phenotype as a test of complementation can only provide a tentative identification, and then only if very large numbers of mutants are studied. Groups of noncomplementing mutants can safely be inferred to be affected in the same functional unit; a positive complementation test, on the other hand, does not necessarily mean that two different functional units are involved. A book that is as thorough as this one owes the reader a discussion of this important development.

These criticisms should not be allowed to detract from the overall impression of excellence which I wish to convey. As a final item of praise, I must record the fact that the book is handsomely composed and illustrated and that the bibliography is handled in a manner which every author would do well to imitate. The 700 references are grouped alphabetically by author at the end of the book, and are also numbered serially. References are made in the text by number, but any author's work can be located in the bibliography directly. Finally, after each entry there is a list of numbers that denotes the pages on which the reference is cited. This last courtesy is one of the many touches that make this book a pleasure to read.

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Cryogenics

Cryogenic Technology. Robert W. Vance, Ed. Wiley, New York, 1963. xviii + 585 pp. Illus. $19.50.

This book is a collection of lectures given in a graduate course on cryogenic engineering at the University of California. Each of the 15 chapters was prepared by a prominent engineer or scientist. The stated goal of the treatise is to provide a reference source for those engaged in the application of, or in basic, theoretical cryogenic studies. If we consider the diversity of the disciplines involved in cryogenic studies and the wide range of technological applications, the book must be considered a success.

The text begins with a brief history of cryogenic technology. The contributors of the next seven chapters discuss the basic theory utilized in cryogenic engineering—methods of producing low temperatures, the properties of solids and liquids, phase equilibria, heat transfer, the measurement of low temperatures, insulation technology, and the fundamentals of superconductivity. The concluding seven chapters cover developments which utilize superconductivity, optical masers, cryogenic pumping and space simulation chambers, nuclear propulsion, explosion hazards in propellants, cryogenic problems in space, and cryobiology. It is not possible to review here the merits of the individual chapters.

In this book, as in any book prepared by a large number of authors, there is a lack of continuity from chapter to chapter and a certain amount of duplication. In particular, the chapters "Cryogenic problems in space" and "Cryogenic aspects of deep space probes" should have been combined. On the other hand, the fact that each chapter is reasonably self-contained is an asset to those who seek a background in a specific area of cryogenic engineering. The extensive lists of references that follow each chapter will prove useful to those who desire further information.

On the whole, the book should be useful both as an advanced introduction to cryogenics and as a convenient source of the information necessary in designing cryogenic systems and components. It will be welcomed by workers in the field.

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A Teacher by Preference

George Hoyt Whipple and His Friends. The life-story of a Nobel prize pathologist. George W. Corner. Lippincott, Philadelphia, 1963. xii + 355 pp. $5.50.

This "life-story" of George Hoyt Whipple, written by one of his most distinguished junior colleagues, has both the self-revealing qualities of a personal narrative and the assessments of an objective biography. It is a remarkable book about a remarkable man. It is all the more unusual because it is a delightfully loquacious description of the character, interests, activities, achievements, hobbies, and friendships of a reticent man. Whipple seems to have been hewn from the granite of his native state of New Hampshire, where he was born at Ashland on 28 August 1878. Essentially, however, he has been as gentle, understanding, inspiring, helpful, and esthetic as he has been constant in adherence to his ideals, principles, and plan of his own life.

How this biography came to be written during Whipple's lifetime is told in the preface. In 1959, Whipple, "not a man who talks much about himself," wrote a brief autobiography in response to the request of some friends. Although he described many events of his life he told "far too little of the personal history his friends and students wanted to read. After his retirement from the deanship of the University of Rochester School of Medicine and Dentistry [in 1953 when he was 75 years old] the medical alumni began to plan a full-length biography." This book is the fruit of that planning.

The story is composed from the recollections of an association of the past 50 years between the author and his subject, supplemented by material from many sources—personal talks with Mrs. Whipple and with many of Whipple's friends, former pupils, and scientific teammates. To these sources were added files and records from Yale, Johns Hopkins, the Hooper Foundation, the University of California, the University of Rochester, the Rockefeller Foundation and the Rockefeller Institute for Medical Research, the National Academy of Sciences, the Nobel Prize Foundation, and Whipple's scientific and general publications from 1902 to 1961, a complete bibliography of which, numbering some 350 titles, is included in this volume.

For Corner, the scientific, humanistic, and literary author of this book, it was "an unalloyed pleasure" to revive memories, to study records, and to tell a story "to give readers who do not know Dr. Whipple personally some idea of what he has contributed to medical science and medical education." These pleasures will be shared by the readers of this biography.

Whipple's life has been of such consistency that to divide his activities into parts tends toward some distortion. It is, however, easy and natural to consider Whipple as (i) a teacher in the broad field of pathology and as a medical educator in general; (ii) an administrator of medical research institutes, medical schools, and medical foundations; (iii) a human being arousing and enjoying warm friendships; and (iv) a modest recipient of many honors. The author of this biography has done this with great skill, combining a technical analysis and evaluation of Whipple's researches with a running narrative of his other simultaneous activities.

George Hoyt Whipple began to teach about 1898 while he was still an undergraduate at Yale University. He became a teacher of pathology under his great preceptor, William H. Welch, as soon as he graduated from the Johns Hopkins Medical School (1905), and he continued to be a teacher "elbow to elbow" with students, who numbered several hundred over the years, and of whom many became new leaders in medical teaching, research, and administration. In his autobiographical sketch in 1959 he wrote: "I would be remembered as a teacher." Corner's comment is: "This wish was granted long years before he ever put it on paper, for the men and women he has taught—many hundreds of them—during more than half a century in three medical schools, can never forget his wise and clear instruction, nor the ideals of the good physician and scientist which he set before them."

Whipple's lifelong research, which he began working on at the Johns Hopkins Medical School in 1905, has been concerned with bile pigments, hemoglobin, and proteins of the blood and plasma. It has been an enormous undertaking, carried forward by him and his associates (among whom notably has been Frieda Robscheit-Robbins), with teams working under capable leaders; despite difficulties, these researchers meticulously performed intricate chemical and dietary experiments on dogs and human beings. Much basic knowledge was gained. The experiments on the formation of hemoglobin laid the basis for the discovery of the nature and cure of pernicious anemia. In recognition of this, and of his basic research, the Nobel prize in physiology or medicine was awarded jointly to George Hoyt Whipple, George Minot, and William P. Murphy in 1934.

In August 1914, Whipple became director of the George Williams Hooper Foundation for Medical Research, with the rank of professor, at the University of California in San Francisco. He remained there, deeply engaged in re-