day, however, even less plausible than they did in the years just after the war when the first edition appeared. After such a warning, any aspirant to learn radiation biology can profit from this fine work, newly available.

**Essays on the Use of Information Theory in Biology.** Edited by Henry Quastler. 273 pp. University of Illinois Press, Urbana, Illinois, 1953. Paperbound, $4.00. *Reviewed by J. G. Hoffman, Roswell Park Memorial Institute.*

The evanescent quality that makes living cells click has been known by many different names. These names have ranged from spirit to negative entropy. It now turns out that negative entropy and information are directly related. It is said that amid the universal increase of entropy there is a temporary reversal inside living things because they can make and handle information. This book presents a new way of thinking about these matters. Of the nineteen essays twelve are devoted to a study of information in living matter.

The first seven essays outline the theory and definition as well as the measurement of information. These provide means for taking hold of the living process, and from there on it is apparent that there is much room for discussion about the ability of living things to make information. It is not altogether clear whether life is measurable by the negative entropy or whether it is the process of reeling off the information with which entropy is equivalent, or whether life is molecular organization itself. Some very stimulating answers to these questions are given in this book. The mystical thing called organization has never been adequately defined. Yet it is always well known by its presence, and it is here subjected to a thorough search and analysis.

One of the simplest experiments imaginable would be to put living cells in a calorimeter and watch for the exchange of heat. An alternative would be to make a thermal analysis by heating the cells through a range, say, from 95°F to about 105°F. Many ideas and counter ideas of what should happen in such experiments, from a theoretical standpoint as well as in the light to practical realities, are indicated in various ways throughout this book. If the cells are alive they will give off heat, and at the same time try to keep down their internal entropy. If the temperature rises the living cells may run into difficulties. Fuses may blow; some of the many different kinds of governors may jam or freeze; and enzyme systems may be completely destroyed. Or, if the cells die, and the calorimeter measures the heat of death, what are the theoretical expectations and practical limitations? In other words, what are the internal rearrangements in living matter by which we might be able to deduce its essential structure?

The data selected by the essayists to carry out their diverse discussions of information in biological systems, is in itself most instructive. There are excellent tabulations of the properties of molecules of amino acids along with pictures of molecular models and their structural formula. For example, there is a remarkable table of information about identical twining which K. S. Tweedell uses to develop the information content of germ cells.

The essays are practical in the sense that they aim directly to show where theory is applicable. One needs only to point to Information Theory and the Structure of Proteins, by H. R. Branson. This essay presents extensive calculations on the information content of amino acid residues, as well as on twenty-six of the well-known macro-molecular proteins. Or, in another field, the essay by M. R. Irwin on Genes and Antigens. goes directly to data on men, birds, and cattle, and provides, incidentally, a nice synopsis of intricate genetic relationships.

A word has to be said about the last essay called The Information Content and Error Rate of Living Things, by Dancoff and Quastler. When making animals or cells, life probably makes many mistakes; but they are quickly hidden because they die. Those that do survive seem mighty impressive because they are nearly perfect. Yet, even though they are nearly perfect, they still may be sports, or mutants, or possibly cancer cells. Taking account of the number of atoms in a human being, the authors carry out speculations on the orders of magnitude of information in the atoms, and in the molecules in germ cells. For example, the essential information for creating a new individual, which is contained in a germ cell, amounts to ten million printed pages, or the content of a library of considerable size. The authors then procede to compute the fidelity of reproduction of living cells, and the rate of mistakes probable or allowable. One basic question raised is that of data: how will we measure mistakes that cannot live? The estimates are extremely coarse; yet they are, as the authors say: "better than no estimate at all".

This volume carries the reader to profound thoughts. It is of interest to biologists and biophysicists, because of the specific kind of data which the essayists have selected for demonstrating the theory. Physicists in general will be interested because there is an attempt to nail down the ephemeral relationship between entropy and life. The text is well written and concise. The illustrations are generous and serve their purpose well. The effort of fifteen different essayists combines to make a concrete discussion of how information theory provides a new way of thinking about living things.

**Rocket Exploration of the Upper Atmosphere.** Edited by R. L. F. Boyd and M. J. Seaton, in consultation with H. S. W. Massey. 376 pp. (Pergamon Press, England) Interscience Publishers, Inc., New York, 1954. $11.00. *Reviewed by S. F. Singer, University of Maryland.*

This book published as a supplement to the well-known *Journal of Atmospheric and Terrestrial Physics* is the report of the first major international scientific conference concerned with rocket exploration of the earth's upper atmosphere, held in Oxford, England, Au-