who exemplify, in medicine, particular aspects of intellectual history" rather than on discoverers or medical innovators. Lazar Riverius provides a baseline in Aristotelian metaphysics and Galenic medicine. The Neoplatonic and atomistic viewpoints are represented by Van Helmont and Robert Boyle, respectively. With respect to methodology, Sylvius is the iatrochemist and rationalist, Sydenham the empirically oriented clinician. "A number of minor figures reveal various degrees of critical acumen"—an attribute for which the key figures, too, are assessed. By the end of the 17th century "a synthesis began to occur and the best example of this is a little known work, of 1695, written by Friedrich Hoffmann, and embodying a new and 'modern' system," the *Fundamenta Medicinae*, King's translation of which has just appeared. A persuasive case is made for Hoffmann and the *Fundamenta* as precursors of Boerhaave and the *Institutiones*. Hoffmann, by the way, is not at all pictured as one of the rigid systematics.

A number of interesting links are developed, and some (like the juxtaposition of Van Helmont and Boyle) are unexpected. King recounts how Riverius found the moon inadequate to account for "critical days" and turned, instead, to the complex influence of the signs of the zodiac, and calls this "an interesting example of scientific method." This designation is an interesting example of King's procedure. We encounter references to such entities as "what we would call tissues" and "what we would call metabolism" more often than I would call the equivalence apparent. The lucidity of King's exposition sometimes owes more, indeed, to King himself than to the lambency of his authors' opinions. At the same time, King is a learned, well-balanced, and refreshing guide through a landscape that is not tiresomely familiar.

The "enlightenment" of the title ("it indicates a new critical acumen, a new regard for empiricism, a new approach to evidence and a new concept of validity") is at last defined as looking at things in a different light. Now and again, on *The Road to Medical Enlightenment*, a new tautology may be discerned. The development of a certain kind of empiricism is documented, however, as the central change that took place in the last half of the 17th century.

LLOYD G. STEVENSON
Institute of the History of Medicine, Johns Hopkins University, Baltimore, Maryland

Invertebrate Immunology

The Cellular Defence Reactions of Insects. GEORGE SALT. Cambridge University Press, New York, 1970. viii, 118 pp. + plates. $7.50. Cambridge Monographs in Experimental Biology, No. 16.

Salt's monograph is an elegant model of scientific writing, especially welcome in this heyday of the multiauthored treatise. Clearly, compactly, and discerningly the author discusses the response of insect cells to the stimuli presented by infectious and noninfectious foreign elements.

Following an introduction that defines the terms used and the scope of the volume, the major cellular reactions—phagocytosis, encapsulation, and nodule formation—are presented in three chapters. In the next two chapters Salt discusses the types of objects that incite reaction and the differing responses of the blood cells, which constitute the major group of cells involved. The last two chapters inform the reader of how these cellular reactions form a part of the immune system of insects and how they differ from or approximate defense reactions in vertebrates. There is a list of over 200 carefully selected references, followed by indexes of the organisms and subjects discussed.

The author is the long-time head of a productive laboratory which leads in the study of reactions of insects to macroparasites. The information and interpretations of data found in this book are the thoughtful distillation of many years' observations made by Salt and his coworkers at Cambridge.

The immediate practical worth of this volume will be in its contribution to studies of the biological control of pest insects through the use of parasites. As Salt points out, the better our understanding of the cellular reactions mustered by a pest insect for its own protection, the greater the chance that we will find methods by which they can be manipulated to human advantage. He proposes, for example, that methods might be devised "to develop new strains of parasites able to avoid or overcome the defence reactions of particular noxious insects."

Perhaps not so immediate as the application to biological control, but fully as important, is the contribution Salt makes to our knowledge of general defense reactions of invertebrates and thus to cellular defense as it occurs throughout the animal kingdom. Basic recognition of "self-nonself" occurs in cells of all members of all the animal phyla. Even now, the immune reactions of insects and other invertebrates serve as simple and convenient models for study of, for example, acceptance or rejection of tissue and organ transplants.

Every student of biological control, invertebrate pathology, and transplantation immunity (no matter how impecunious) should purchase this pleasingly turned-out little book and keep it close at hand. The price is small, and the book is surely destined to be a classic.

PHYLLIS T. JOHNSON
Center for Pathobiology, University of California, Irvine

Stasis and Coagulation

The Haemostatic Mechanism in Man and Other Animals. Zoological Society of London Symposium No. 27, London, Dec. 1969. R. G. MACFARLANE, Ed. Published for the Society by Academic Press, New York, 1970. xviii, 248 pp., illus. $13.50.

When animals became so large that diffusion was no longer sufficient for molecular exchange, body cavities containing fluid media were necessarily developed. In these, exchange is facilitated in simple systems by convection and flow (due to body motion and contraction) and in the most complex systems by pumped flow through closed vessels. The necessity for economizing the fluid media led to important requirements. The appearance of a wound, or opening, through which media might escape to the external environment had to trigger a mechanism which recognized the abnormal character of the opening and closed it with sufficient promptness, but which limited its effects internally to the immediate environment of the opening. In systems having a closed circulation, it became necessary also to cope with escape to the interior tissue spaces. An examination of the processes by which these fundamental requirements are met should appeal to all who have interests in regulatory mechanisms.

In all animals the means for producing stasis appear to be some combination of a few effects, which make widely different contributions in particular instances. Generally, the opening is either reduced by muscular contraction or, more frequently, closed by an adherent plug or cover. Closure may be due to the interaction of customarily free hemostatic cells or cell fragments. These may associate without obvious alteration in physical structure,

or they may produce filamentous projections which interact and entangle. The acellular portion of the medium (plasma) may coagulate by association into cross-linked fibrils of solution components (coagulogens). The coagulogens may initially be sequestered, possibly in active form, in free cells and released rapidly in stimulation. In other systems, coagulogens may be free in plasma, and some component required to alter coagulogens so that they associate, or to initiate a chain of events which leads to coagulogen alteration, may be sequestered and released on stimulation.

In this brief book, introduced by R. G. Macfarlane, an objective is to make a comparative examination and by this means to reveal areas of research which might produce further understanding of evolutionary pathways of stasis, and of hemostasis in man. It is evident that, as the species examined become more closely related to man, the sum of experimental detail rapidly increases.

The view of the situation in the human, accepted by the Oxford group, is summarized under the title "Human blood coagulation and the haemostatic mechanism" by R. Biggs. For those who may welcome a reminder as to the general phenomena of stasis and coagulation, before involvement with detail, the "General summary and conclusions" provided by C. M. Hawkey might be examined next. The remaining chapters deal with mechanisms of stasis in species representing essentially all of the phyla, and with particular aspects of mammalian systems. Hemostatic mechanisms in invertebrates are dealt with by A. E. Needham, hemolymph coagulation in arthropods by C. Grégoire, the functional physiology of blood platelets by G. V. R. Born, the bound carbohydrates in platelets, plasma, and vascular endothelium by E. P. Adams, A. T. Nurden, and J. E. French, aggregation and nucleotide concentration of platelets in different species by D. C. B. Mills, hemostasis in the hamster by A. G. Sanders, blood coagulation in nonhuman vertebrates by R. K. Archer, fibrinolysis in animals by C. M. Hawkey, clotting defects due to "abnormal" clotting factors by K. W. E. Denson, selectional trends in the structure of fibrinogen by B. Blomback, comparative aspects of the subunit structure of fibrinogen by T. Cartwright, and the clottable protein of *Limulus polyphemus* blood cells by N. O. Solum.

DAVID F. WAUGH
Department of Biology, Massachusetts Institute of Technology, Cambridge

Thermodynamics

Entropy for Biologists. An Introduction to Thermodynamics. HAROLD J. MOROWITZ. Academic Press, New York, 1970. xvi, 196 pp., illus. $6.95.

The jacket of this little book depicts for us a cool, green glade among tall trees through which the sunlight gently filters, an inviting spot covered with ferns, moss, and lichen. The message seems to be clear, and in case anyone remains in doubt the author makes it even clearer in his introduction to the first chapter, when he points out that "biological energetics and energetic ecology have become major focal points in the life sciences." Unfortunately, this is as far as it goes—neither biological energetics nor energetic ecology receives further attention, unless it be a passing reference, until the very last chapter, which discusses briefly the information content of living systems. Any reader who starts off, as I did, in expectation of finding an analysis of specific biological or ecological problems in thermodynamic terms is doomed to disappointment. In fact, the book is precisely what its subtitle says it is. As such it is distinguished from most other introductory texts chiefly by its use of elementary information theory whenever possible.

The author states that he has written an introduction for people in the life sciences who wish to master the concepts of what he calls thermal physics "without being forced to a degree and rate of symbol manipulation foreign to their patterns of thought." I am afraid that this is a vain hope—the degree and rate of symbol manipulation are pretty high by the standards of most of the biologists I know who might be expected to profit from this account. Perhaps there are some for whom it will serve as the "what's it all about" book the author claims it is, particularly among undergraduate students. But I, for one, closed the covers with the impression that Morowitz has fallen with a resounding bump between two stools.

The need for a text of this kind can hardly be questioned. For example, the claim that thermodynamics is not relevant to biology (believe it or not) has recently been advanced in certain quarters with such vehemence that the innocent biologist may be forgiven if he begins to be convinced. In these quarters, it seems, the god of kinetics reigns supreme. From quite a different quarter the unsuspecting biologist is assailed by claims that classical thermodynamics, although relevant, contains serious flaws; and he is modestly offered a flawless version with which to replace it. Little wonder if he turns back to his microscope muttering "a plague o' both your houses." This book does make a serious attempt to provide him with a basis for critical assessment of such ideas, whether crackpot or otherwise.

The development follows fairly conventional lines except that, as mentioned above, a good deal of emphasis is placed on the relationship between entropy and information. The most successful chapter in many ways is the one dealing with probability and information, which gives an excellent thumbnail sketch of information theory. In a later chapter information is related to both entropy and energy, thus enabling Maxwell's demon to be exorcized with considerable dispatch. In between, a heroic effort is made to acquaint the reader with the essentials of statistical mechanics and statistical thermodynamics in 30 pages. I fear, however, that those who do not have a taste for mathematical argument will rather quickly fall by the wayside, while those who do will find the lack of rigor frustrating. The title of the book being what it is, I was somewhat startled to find nonequilibrium thermodynamics dismissed early on as "a field of study which is in its infancy and about which very little is known." So much for the Onsagerists, as Truesdell (who would surely applaud this remark) calls them. Messrs. Prigogine, de Groot, Mazur, Katchalsky, and Curran, take note!

Despite a sprinkling of minor errors, which can evidently never be completely eliminated and may have something to do with the subject of the book, the presentation is well done and attractive. (Some misquoted equation numbers have the appearance of leftovers from an earlier version of the manuscript.) The chapters are uniformly short, since the medicine obviously has to be administered in small doses, and each one finishes with a few representative problems (no answers given). The author has a regrettable tendency to write the first law as

$$dU = dQ - PdV + \sum_i \mu_i dn_i + \text{additional work terms},$$

a nice pitfall for the unwary student. The reader should be forewarned that this equation is meaningful only for closed systems, and reversible ones at that.