review carefully this literature, one would have to weigh all of the conflicting reports on this subject. It is not clear what if anything of significance is there, apart from the obvious effects of excessive heating.

Carpenter, in the final chapter, concludes "it is too early to accurately evaluate the public health significance of electromagnetic fields on human health." In what sense is it too early? This is hardly virgin scientific territory. One digest lists 15,500 scientific and engineering papers published since 1972 related to biological effects, mechanisms of interaction, and clinical applications of electric and magnetic fields (Information Ventures, 1994). Nearly 100 epidemiology studies, and since 1990 more than a dozen long-term animal studies, have appeared, related to the question of electromagnetic fields and cancer. It is not too early to sift through the scientific evidence, and to weigh carefully the evidence for hazards, paying close attention to the validity and relevance of individual studies. A dozen or more consensus groups have done this, of course, finding consistently that the evidence for a real hazard from weak electromagnetic fields is weak and unconvincing. A British committee chaired by the eminent epidemiologist Sir Richard Doll, for example, found "no firm evidence" of a link between exposure to electromagnetic fields and cancer (National Radiological Protection Board, 1992). It is not too early to compare the risks, if any exist, with other risks we all face in daily life, or to place the issue in the context of other public health problems in our society.

But in a sense Carpenter is right. New issues are emerging, faster than older issues can be resolved. In the 1960s and 70s, a hot topic was the possible health effects of low-level microwave energy. (Remember the flap over the microwave-irradiation of the U.S. Embassy in Moscow?) Concerns about possible health risks of strong 60 Hz *electric* fields figured prominently in a lawsuit in the 1970s against a proposed high voltage power line in New York; its settlement funded the New York Power Lines Project that was supposed to address the health concerns once and for all. More recently (in part because of an epidemiology study funded by the Power Lines Project), public attention has shifted to possible health effects of the weak *magnetic* fields from neighborhood distribution lines. Other recent issues include speculated hazards from cellular telephones, police radar units, and video display terminals. The latest concern (from abstracts of two forthcoming scientific papers being circulated on the Internet) is a possible link between having an "electrical" occupation and Alzheimer's disease. Despite decades of research, public controversy, and litigation (Foster, 1993), few if any measurable health benefits have resulted from these controversies. If there is a problem, how can we identify it most efficiently? If science cannot identify a problem clearly or show that none exists, how can we develop the collective wisdom to live with the uncertainty?

REFERENCES

Adair, R. K. 1991. Constraints on biological effects of weak extremely-low-frequency electromagnetic fields. *Phys. Rev. A.* 43:1039–1048.

Carstensen, E. L. 1987. Biological Effects of Transmission Line Fields. Elsevier, New York.

Foster, K. R., and W. F. Pickard. 1987. Microwaves: the risks of risk research. *Nature.* 330:531–532.

Foster, K. R. 1992. Health effects of low-level electromagnetic fields: phantom or not-so-phantom risk? *Health Phys.* 62:429–436.

Foster, K. R., D. Bernstein, and P. W. Huber. 1993. Phantom Risk: Scientific Inference and the Law. MIT Press, Cambridge, MA.

Information Ventures, Inc. 1994. EMF Database (CD-ROM). Information Ventures, Inc., Philadelphia, PA.

Liburdy, R. P., D. J. de Manincor, M. S. Roos, and K. M. Brennan. 1992. Permeability of the blood-brain barrier of the rat is not significantly altered by NMR exposure. *Ann. N. Y. Acad. Sci.* 649:345–349.

National Radiological Protection Board. 1992. Electromagnetic fields and the risk of cancer. National Radiological Protection Board: Chilton, Didcot, Oxon, UK.

Prato, F. S., R. H. Frappier, J. M. Wills, and R. R. Shivers. 1992. Blood-brain barrier permeability in rats is not altered by exposure to magnetic resonance imaging at 1.5 tesla. Proc. First World Congress for Electricity and Magnetism in Biology and Medicine, 14–19 June, Lake Buena Vista, FL. p. 73.

Salford, L. G., A. Brun, K. Sturesson, J. L. Eberhardt, and B. R. Persson. 1994. Permeability of the blood-brain barrier induced by 915 MHz electromagnetic radiation, continuous-wave and modulated at 8, 16, 50, and 200 Hz. *Microsc. Res. Tech.* 27:535–542.

Shivers, R. R., M. Kavaliers, G. C. Teskey, F. S. Prato, and R. M. Pelletier. 1987. Magnetic resonance imaging temporarily alters blood-brain barrier permeability in the rat. *Neurosci. Lett.* 76:25–31.

Statistical Thermodynamics of Chemists and Biochemists by Arieh Ben-Naim

Plenum Press, New York, 1992. 697 pages. $85.00

Reviewed by B. K. Lee, National Institutes of Health

This is the latest in a series of monographs by the author on the statistical thermodynamics of systems of biological interest. The other books include Water and Aqueous Solutions (1974), Hydrophobic Interactions (1980), and Solvation Thermodynamics (1987). The new book appears to contain much of the material in these earlier monographs.

The book consists of eight chapters. The first three give the general theory and many of the concepts that are used in the later part of the book. The basic relations of statistical thermodynamics are summarized in the rather short first chapter. The concept of the "frozen equilibrium" is introduced early and is used extensively throughout the entire book. The remainder of the general theory part is devoted to the various cases of ligand binding to a (large) substrate, including the allosteric effect. The presentation tends to be pedagogical, but it is clear, imaginative, interesting, and thorough.

Chapter 4 is a delightful presentation of the one-dimensional system, which can be tackled by means of a special technique. The idealized system of helix-coil transition is treated this way.

The next two chapters deal with the general theory of liquids and solutions. These are uniquely Ben-Naim in style and cover much of the same material as in his earlier book, "Water and Aqueous Solutions." There is a heavy emphasis on the mixture model, the Kirkwood-Buff theory, and the various ideal behaviors of the solutions. The sections on solvation thermodynamics and preferential solvation are lucid and authoritative. However, one cannot fail to notice some conspicuous absences. Only a short section is devoted to the perturbation theory of liquids, whereas the modern integral equation theory is hardly mentioned at all. A section is included on the theory of electrolyte solutions. However, there is neither a discussion on the stability or pH titration behavior of macromolecules in the salt solution nor of the computer-based numerical solution techniques for such a system. There is also no discussion on the solvation of polymer molecules more flexible than butane. It would have been nice if a discussion were included on the solvation effect of the Flory's polymer model. In fact, a general statistical mechanics textbook for the biochemists might be expected to include a description of the polymer statistics, which is also missing in this volume.

The last two chapters deal specifically with water and aqueous solutions. The solvation effect is considered for a number of specific cases, including ligand binding, allosteric effect, helix-coil transition, protein-protein interaction, and the stability of proteins and micelles. Actual experimental data are prominently used here. The experimental data are given without references to their source. Also, unlike in earlier chapters of the book wherein the exposition has been careful and rigorous, drastic assumptions are now made without sufficient care. For example, it is suggested on page 600 that the cavity part of the protein-protein association be estimated simply as $P\Delta V$. However, the cavity part is the main bulk of the hydrophobic effect, which certainly is much more than $P\Delta V$. The more conventional approach is to assume that the cavity part is proportional to the surface area, or perhaps to the excluded volume. By not mentioning the area proportionality approximation, the author ignores a huge amount of literature on the topic without discussion. (In the case of the volume proportionality, the form of the energy is the same as $P\Delta V$, but the coefficient will be much larger than the ambient pressure.)

In the Preface, the author states that the book was written for those who are not "specialists in statistical thermodynamics." However, the level of sophistication is such that an average non-specialist will find the book difficult. There is another potential problem for such a reader. For example, in estimating the penalty for desolvating a hydrogen bondable group, it is assumed that the conditional solvation Gibbs energy of the four "arms" of a water molecule is independent of each other. The mathematical procedure used to justify this assumption is clearly and beautifully presented in Appendix B. However, while following this procedure, one finds that two crucial assumptions are made: (a) that the hydrogen bond energy, ϵ_{HB}, is the same regardless of the bonding state of the water molecule (non-polarizable water model) and (b) that there is no interaction between the molecules bonded to one water molecule. Because these two assumptions make each bond independent, a biochemist does not need a formal mathematical justification to know that the solvation free energy of the four "arms" will be independent in this case. What interests a biochemist is not the mathematical exercise of the proof, but the validity of the above two assumptions. However, the book does not give any justification at all for assumption (a) and only a poor one for assumption (b). The impression is that the author is interested more in the procedure of statistical mechanics than in the relevant biochemical issue itself. This is apparently a deliberate feature of the book. The author states in the Preface that "the style of the book is didactic, emphasizing the mothods rather than elaborating on specific examples." This bent may be fine for a book for the specialists in statistical mechanics, but will be annoying to average biochemists.

The book is an excellent source of equations and of the techniques of statistical mechanics. It is therefore a useful reference book. However, it is written in a serial fashion in that the later chapters are difficult to read without the knowledge of the earlier chapters. This feature, and the didactic style, make the book feel more like a textbook than a reference book. It is probably suitable as a textbook for a graduate course in statistical thermodynamics for biochemists, provided that the numerical results given are properly de-emphasized.