be clever and imaginative problem solvers. There is a clear economic incentive in offering the local engineer a real partnership in the technical effort, over and above the personal satisfaction and personal values which accrue" (p. 343).

But, as Gaden also writes, "Perhaps the greatest difficulty will be psychological, not technical." As long as the meaning of science is not understood, and human attitudes and activities are governed by irrational beliefs, little advance can be expected. And this is why I consider the inclusion of papers such as those by Eban, Birkeland, Myrdal, Foster, Mrak, and Mudd as perhaps the most valuable part of the book. They present a clear and compelling picture of the nature and significance of science, which I should like to illustrate by quoting at some length from the masterly article "Science and politics" (pp. 28 to 37) by Abba Eban, then Deputy Prime Minister of Israel.

"A society in which scientific truth is held in respect must be, or must ultimately become, a free society. Scientific empiricism cannot be reconciled with social dogmatism. On the one hand, scientific enquiry needs more and more help from governments. On the other hand, there is danger in the situation in which a growing proportion of research is officially directed, especially if it is directed for military ends.

"Statesmen must somehow be inhibited in their tendency to demand what are called 'practical results' from scientific research. When governments support scientific research in the hope of receiving economic or military results, they are doing the right thing for the wrong reasons. Science should be fostered primarily for its humanizing influence, for its emphasis on reason and order and truth, for its caution in relation to unproved assumptions, for its experimental audacity, and for its respect towards the mystery of nature. . . .

"But the investment in science must be initially disinterested. Creativity cannot be commanded by governmental order any more than a government can, by the allocation of huge funds, decree that Hamlet or the Book of Job shall be written on its soil.

"As the scientific community within each state and across the world grows more numerous and more influential, the insistence on conditions for free uninhibited thought will grow stronger, and the allurements of authoritarian government will decrease. This, I think, is the ultimate social and political effect of a diffusion of scientific knowledge. The evidence of history is strong, that those societies are most creative and progressive which safeguard the expression of new ideas. Skepticism and dissent, which are the essence of science, are also the heart of political freedom. . . .

"Therefore, an understanding of scientific method and of scientific history is an indispensable part of any liberal education. This involves new thinking on traditional concepts of educational method and curriculum. Access to the world of scientific ideas is no longer the prerogative or the burden of a specialized elite, it is for the great mass of people. It is the first condition of creative citizenship, of economic productivity, of political consciousness, of technical capacity, and of social understanding. . . . Even for elected politicians, a discreet measure of literacy is no longer regarded as an insuperable handicap. And literacy today includes an affirmative understanding of scientific ideas and their social effects. These ideas can no longer be excluded from the humanistic curriculum. . . .

"In many respects, all nations are similar. But it is that diversity, in which each nation finds something specific and distinctive in itself, which may constitute its main contribution to the universal treasurehouse of culture. The need, however, is strong and urgent to reconcile cultural diversity with a broad, universal solidarity. And it is here that I must conclude with a politician's ultimate tribute to the scientist: You have achieved what is remote from us, the basis of a universal community of thought and action, respecting national differences, but also transcending them. The easy flow of discourse, the conceptual affinity, the unspoken sense of fraternity, which pervade the scientific world, may perhaps be the heralds of our highest ambition, to establish a family of nations, bound together in a covenant of freedom and peace" (pp. 34 to 37).

Along with Stuart Mudd's comment that "the necessities of mankind, in this age of nuclear warfare and of explosive population growth, have outgrown our ancient loyalties. The dangers, the maladjustments, the solutions sought relate to mankind, not only to this or that segment of mankind. The unit of survival has truly become the human species" (p. 471); these ideas might profitably be pondered by those who are responsible for making policy decisions which, alas, are all too often based on considerations that show an unfortunate lack of understanding of the scientific enterprise.

Experimental Flame Research

Flame Structure. R. M. Fristrom and A. A. Westenberg. McGraw-Hill, New York, 1965. xiv + 424 pp. Illus. $17.50.

The authors, who are on the staff of the Johns Hopkins Applied Physics Laboratory, have been in the forefront of experimental flame research for more than a decade. This book is a scholarly and well-organized summation of their own techniques and results, already more or less familiar to their co-workers in the field through their many publications and lectures, integrated with closely related work by others, and made intelligible to nonspecialists by the provision of background material.

In its chosen primary area of coverage, the microstructure of stabilized, laminar, premixed, hydrocarbon-oxygen flames, this is easily the most comprehensive treatment available. The minutely detailed descriptions of experimental techniques and methods of data analysis, the many carefully prepared figures and tables, and the compilation of some 500 references to the literature deserve favorable mention.

However, it is necessary to add a warning for the benefit of those readers who seek detailed coverage of flame structure other than coverage of one-dimensional, laminar, premixed, gaseous flames. Detonations, turbulent flames, cellular flames, cool flames, dust flames, droplet flames, soot-forming flames, metal flames, solid propellant flames, diffusion flames, monopropellant liquid-strand flames, and the like are either superficially mentioned or completely ignored. The authors clearly prefer, in their choice of experimental work and in their writing, to exhaustively treat a single important phenomenon rather than to become involved with every type of flame which may occur in practical situations. Their success in clarifying understanding of fundamental processes in the premixed laminar flame is impressively presented in their book, and it serves as an example of what can be done, an example that may stimulate others concerned with these alternate types of flames.

In comparing this book with other recent combustion treatises, I found that the treatment overlaps to some extent that of C. P. Fenimore's *Chemistry in Premixed Flames* (Macmillan, 1964) but contains a far more comprehensive account of experimental techniques. Fenimore discusses a greater variety of chemical processes, however (soot formation, nitric oxide decomposition, and halogen effects, for example). Neither book explores the theory of flame structure in depth. The recently published volume, *Combustion Theory*, by F. A. Williams (Addison-Wesley, 1965) covers entirely different ground; for example, its eight-page author index fails to list either Fristrom or Fenimore (Westenberg is briefly mentioned). Students who wish to acquire an overview of current combustion research should certainly look at *Combustion Theory* as well as *Flame Structure*.

Flame Structure is remarkably free from errors, as far as I noted. On page 139, Fristrom's "frustrum" is really a frustum, and (p. 30) the H_2-F_2 flame is actually much hotter than the authors are willing to concede.

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Biological Energy Transformations

Bioenergetics: The Molecular Basis of Biological Energy Transformations. Albert L. Lehninger. Benjamin, New York, 1965. xvi + 258 pp. Illus. Paper, $2.95; cloth, $6.

This book presents in a clear and easily readable form the transformations and use of energy in biological systems. It is very welcome because it is good to be reminded that the flux of energy through a living system is essentially what makes the system alive, and that an understanding of energy feed-in into biosynthetic processes was the necessary premise, for example, for today's dramatic comprehension of the biochemistry of information transfer.

It is agreeable that, in a text geared to students largely in biology and medicine, thermodynamic formalism is kept at a minimum and its meaning is explained in a commonsense manner rather than in abstraction. In this commonsense environment, one is all the more surprised to find the old complaint that the terms "energy-rich" or "high-energy" bonds are misnomers, repeating the, by now, rather stale reference to a usage in a different context of the term "bond energy" as the energy liberated in the formation of a bond (for pertinent discussion, compare W. P. Jencks, in *Survey of Progress in Chemistry*, vol. 1, p. 249). Nonetheless, the book is filled with squiggles (~); the urgent need for this symbol standing for energy-rich bonds has, indeed, made some sections of metabolic literature almost a kind of "squiggology." If one does not like high-energy or energy-rich bonds, one might well speak instead of "high group potential," a useful and more flexible term that is not introduced here.

The main strength of the book is quite naturally the discussion of biological energy transformations, this being the author's field of greatest experience. The outline of biosynthetic mechanisms, in some ways, does not come off as well. For example, a synthesis of sucrose from glucose 1-phosphate and fructose is mentioned as being exergonic; in fact, it is an endergonic reaction, and the biosynthetic path for sucrose is, rather, through uridine diphosphoglucose (UDGP) + fructose, which is exergonic [L. F. Leloir, in *Proc. Plenary Sessions*, 6th Intern. Congr. Biochem. **33**, 15 (1964)]. Subsequently, UDPG is presented in the synthesis of glucosidic bonds in glycogen, and the rather large "waste" of energy in this synthesis is emphasized. Elsewhere in the book, however, there may be a little too much fascination and marveling about the perfection of biomechanisms at a time when, in some fields, we are discovering that manmade devices are frequently superior.

One would have liked to see a few more references to pertinent literature. Although the author included a partial quotation of the famous introduction by Lewis and Randall to their *Thermodynamics* (McGraw-Hill, 1923), the name of G. N. Lewis does not appear in these pages. This is particularly deplorable to those who consider Lewis a pioneer in the application of thermodynamics to biochemical problems, and who grew up using, as he proposed, the ΔF rather than the ΔG for change in free energy. The use in this book of ΔG, in view of the almost exclusive use of ΔF in biological literature, should at least have been introduced as an alternative to ΔF rather than without further explanation.

Finally a word on the reference to negative entropy as a measure of information. Here I should like to quote from MacKay (in *Man and His Future*, p. 154): "One could say that whereas physics looks for explanations in terms of the *dependence of force upon force*, the science of communication constructs its "causal chains" out of the *dependence of form upon form*, . . . regardless of where the necessary energy came from." I think that, at the moment, there is a great deal of loose talk which glosses over this fundamental difference.

My minor reservations are not meant to detract from the great usefulness of this book as an introduction to biological energy transformations. The large number of well-designed illustrations will be quite helpful to the newcomer's understanding of essential features, on which the book rightly concentrates.

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Cytogenetics

Human Chromosome Methodology. Jorge J. Yunis, Ed. Academic Press, New York, 1965. xiv + 258 pp. Illus. $8.50.

A new era in cytogenetics was instituted in 1956 when Tjio and Levan published the report that human cells contain 46 chromosomes. Since that time events have moved with almost explosive rapidity, and the large accumulation of literature describes results of great importance to both fundamental biology and medicine. The coincident rise in interest in the practical aspects of this phase of genetics has resulted in the publication of a large number of monographs and reviews on the subject.

This book, however, does in part fill a need unmet by most other re-