however. This fascinating subject is given short shrift. There is no mention of the revolutionary discovery of Emerson that two different light reactions cooperate in photosynthesis, the result of his experiments with *Chlorella* and *Porphyridium*. The studies of extranuclear inheritance in the algae *Chlamydomonas* and *Acetabularia* by Sager, Granick, and Gibor do not appear, nor do the experiments of Joyce Lewin on silicon metabolism in diatoms or any of the work on energy transfer in photosynthesis or on phototaxis (Haupt, Halldal). It is of course necessary to be selective in covering such a huge subject. Those interested primarily in the classical treatment of taxonomy and ecology of the larger freshwater algae will be satisfied with Prescott's choice.

BEATRICE M. SWEENEY
Department of Biological Sciences, University of California, Santa Barbara

Creative Engineering

Education for Innovation. Based on a conference, Woods Hole, Mass. DANIEL V. DE SIMONE, Ed. Pergamon, New York, 1968. x + 182 pp. $6.

Engineering education, to judge by its practice of continual self-assessment, is evidently among the most introspective of professions. Whereas engineering itself was originally an art, its educators have noted in turn the lack of sufficient mathematics, humanities, and science in the undergraduate curriculum, and have moved concertedly to fill the gaps. Matters have now come full circle, and the current trend is toward strengthening the art—without, however, losing what has been gained in the other three educational stems. The book under review is noteworthy evidence of this trend.

In the summer of 1965 the National Academy of Engineering, the National Science Foundation, and the Department of Commerce sponsored at Cape Cod a conference on creative engineering education among an invited group of 86 educators, executives, inventors, innovators, and entrepreneurs. Eight of the participants spoke individually on various aspects of the subject, and then the entire group broke up into five panels for the workshop type of discussion. The editor of the book, director of the Office of Invention and Innovation in the National Bureau of Standards, finally assembled the taped proceedings, eliminated inessential repetition, and correlated the papers and discussions from the floor as sequent chapters of the book.

Because most of the talks were extemporaneous, their edited versions still have an attractive and informal spontaneity. By the same token, they vary considerably in depth and in the degree of innovation they themselves manifest. All, however, adhere closely to the schedule formulated by the editor in his introduction:

> In sum, we shall concentrate on six principal themes or propositions: (1) Inventors and innovators are the vital elements of technological change, which is the business of creative engineering; (2) the art of creative engineering has been orphaned in the engineering schools; (3) the creative requisites of invention and innovation can be encouraged and an understanding of these processes can be taught; (4) research on the processes of technological change, including a synthesis of existing knowledge, is needed and should be undertaken on a comprehensive multi-disciplinary basis; (5) improving the climate for creative engineering education requires positive inducements to faculty and students; and (6) greater cooperation among the universities, industry, foundations, professional groups and government is essential to the development and support of creative engineering education.

The very effective opening chapter, "Creative engineering and the needs of society," is by J. Herbert Hollomon, then assistant secretary of a federal department and now a university president; he pleads therein for a broadening of engineering to include problems of civilization—whether social, political, or economic—not normally considered technological but requiring much the same approach for their solution. C. Stark Draper, in "Education for creativity," draws upon his long experience with the development of guidance systems to emphasize the necessity of identifying and cultivating the limited number of potential creators as they reach college age. Under "Engineering and the many cultures," a professor of law, John C. Stedman, delineates the obstacles to creativity and shows that cross-disciplinary activities are required to strengthen the creative effort.

"Factors influencing creativity" are seen by Calvin W. Taylor, a professor of psychology, to be negative more often than not: authoritarian teaching, desire for conformity, ridicule by one's peers, pedagogical emphasis on knowledge rather than thought. William Bollay, an aeronautics professor, points to Zwicky's "morphological approach," the case method, project laboratories, systems studies, and design theses as significant "new directions in engineering education." "The process of invention" is depicted graphically by a highly successful inventor, Jacob Rabinow, in one of the most enjoyable chapters of the book. Richard S. Morse, corporation executive, illuminates in "Innovation and entrepreneurship" the important role played by the generation of new enterprises. And "Trade-offs and constraints," by Robert C. Dean, Jr., a professor of engineering, discusses the implementation of six experimental workshops in creativity conducted across the country under the auspices of the Commission on Engineering Education and the National Science Foundation in the summer of 1965.

The first of the six panel discussions is summarized by B. Richard Teare, Jr., formerly an engineering dean, under the title "Educational objectives in the preparation of engineers"; except for lack of originality, little fault can be found with the conclusions. Robert B. Banks, with the Ford Foundation in Mexico, reviews the findings of the same panel on "The motivation and development of faculty": in essence, the need for greater recognition of, and reward for, creative engineering education. The panel on "Strategies and teaching methods," as reported by Ray E. Bolz and Dean, enumerates and discusses a dozen or more new ways and means for nurturing creativity now in use at leading colleges in the country. In the firm belief that creativity can be taught, Rabinow's panel makes a number of salient recommendations for "educating prospective inventors" in high school and college, and Morse's panel does much the same for "preparing innovators and entrepreneurs." Finally, under the heading "Improving the environment for creativity," Taylor's panel report not only rises above the usual limitations of group effort but prompts a lively closing discussion that is by no means devoid of novelty.

An appendix listing the participants and their connections reads like a Who's Who in Engineering Education and Related Fields. Such apparent catholicity makes it the more puzzling to note that the list includes essentially none of those primarily responsible for the recent (1968) "Final Report of the Goals Committee" of the American Society for Engineering Education!

HUNTER ROUSE
College of Engineering, University of Iowa, Iowa City