could have been used to make reference to the approximation methods of Rashevsky and others, which have been used extensively. Also discussed in this chapter is the model system of Turing, in which diffusion, coupled with chemical reactions, leads to inhomogeneities of concentration which are stable. These inhomogeneities could be the basis for the development of patterns in morphogenesis. The arguments for this example are necessarily qualitative, but the graphical presentation makes the process understandable.

Although there are additions and changes that could have substantially facilitated the reading and understanding of some of the topics discussed, many biologists with diverse interests could profit from reading this book, becoming acquainted with unfamiliar areas of mathematics or gaining insight into the ways in which mathematical ideas can prove to be useful aids in understanding biological processes.

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Organization

The Art of Organic Forms. PHILIP C. RITTERBUSH. Smithsonian Institution Press, Washington, D.C., 1968 (distributed by Random House, New York). x + 152 pp., illus. $10.

Most scientists have esthetic reactions to their subject matter. On a plane of deep abstraction, a theoretical physicist may see beauty in a mathematical relationship. More objectively, to a mammalogist the teeth of beasts are beautiful, and a pathologist may apply that adjective to a suppurating abscess. An artist, professionally esthetic, is not likely to appreciate those examples, but there is a wide range of forms—a diatom, an orchid, an impala—appealing in an esthetic way equally to scientist and to artist. One might add a snowflake and a bird's song as further examples, but it is noteworthy that most of the examples that rise to mind are organic and are visual.

That community of reactions among scientists and artists does not in itself constitute a functional connection between science and art. Some connection may be claimed in terms of search for truth along different paths, but the two concepts of truth involved are so equivocal that little concrete sense emerges. It is more significant that the sciences and the arts have in common a search for organization and relationships that in scientific terms are rationally meaningful and in esthetic terms are emotionally satisfying. That, too, may be especially evident in the organic and the visual.

It is that sort of connection that is traced historically by Ritterbush in a broad sweep from the botanist Nehemiah Grew, born 1628, to the painter Michael Clark, born 1946. The thesis is that organic forms, that is, the forms of living things, are in fact organized to unique degrees and in unique ways, that this kind of organization often has been taken as an exemplar by artists, and that artistic or esthetic perception conversely sometimes has been a guide for scientific comprehension of organisms. This history is a fascinating one, and it is here well and succinctly told—the text in the volume totals only about 75 pages.

It is emphasized that reference is not to the literal copying or illustration of organic forms on the part of artists. "Rather than imitate the external forms of nature, which [Kandinsky] compared to trying to recreate the sound of the chicken farm in music, the aim of art should be to represent the innermost quality of nature, its atmosphere." And indeed the 24 reproductions of paintings in this volume are almost completely nonrepresentational. Those that do most nearly resemble actual organic forms, for example Kawashima's "New Symbolism," are not the most esthetic, and they suggest parody more than organic creativity. Others, for example "Geography of Phantasy" by Tobey, have no evident relationship to the concept of organic form, or indeed of organization. Nevertheless, the collection as a whole does illustrate artistic concepts that do embody organic analogies without homologies. However, some of the works given special emphasis in the text, for example those of Ernst Kupferman, are not illustrated.

The other side of the thesis is the influence of esthetics on science. It is demonstrated that such an influence exists, but the impression left is that when esthetic considerations became really dominant over scientific enquiry the result was, at best, a blind alley. Goethe's idealistic morphology, treated at length in introducing this side of the matter, is a good example of the flat failure of the primarily artistic approach to scientific problems. Unfortunately Ritterbush's devotion to the idea of fruitful reciprocity of science and art has led him to some extremes that are false or inane. It simply is not true that "the progress of biology beyond the cell theory has consisted in large measure of demonstrating the existence of significant symmetry properties in the organisms themselves (or in forms abstracted to represent them)." It is absurd to impute connection between Harrison's invention of tissue culture and an observer's expectation that figures painted by Kandinsky will similarly flow or extend.

This book was prepared with reference to an exhibit of paintings, also entitled "The Art of Organic Forms," and a catalogue of the exhibit is included. The exhibit has been dispersed, and many of the paintings are now neither visible to the public nor here illustrated.

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Biophysics of Ecology

Energy Flow in Biology. Biological Organization as a Problem in Thermal Physics. HAROLD J. MOROWITZ. Academic Press, New York, 1968. xii + 179 pp., illus. $9.50.

This book is a biophysicist's view of the complex levels of organization of biology, ecology, and the biosphere. It is an effort to resolve the deep contradiction felt by many physicists in the biological tendency toward order in systems whose molecular components have tendencies toward disorder. The book starts with two chapters on physical theorems concerning the behavior of energized populations of molecules, including aspects of steady-state thermodynamics, and a chapter that recapitulates biology into 13 generalizations as seen from the molecular stance. Chapters 4 and 5 are lucid statements of the thermochemistry of protoplasm, including calculations of the entropy contents of formation that will allow more biologists to change their calorimetry data on heats of reaction to potential energies instead of incorrectly using one to approximate the other. Included is the quantitative