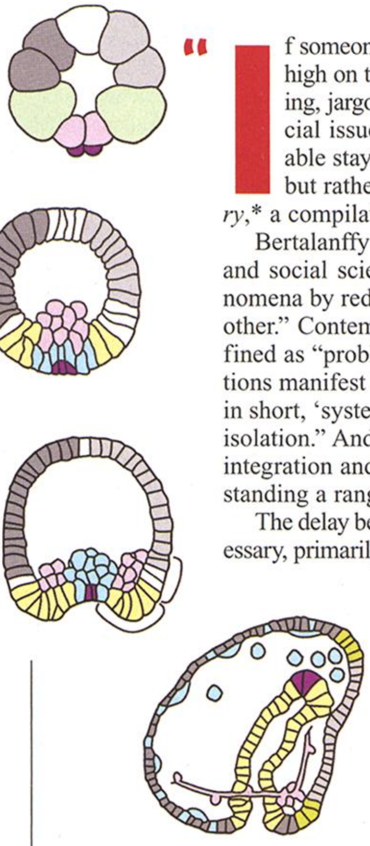
Whole-istic Biology



PAGE 1669

"If someone were to analyze current notions and fashionable catchwords, he would find 'systems' high on the list. The concept has pervaded all fields of science and penetrated into popular thinking, jargon, and mass media." In keeping with this fashion, *Science* presents this week a special issue with emphasis on systems biology. And we note that this is a trend with remarkable staying power, for the words quoted above were written not for today's issue of *Science*, but rather in Ludwig von Bertalanffy's 1967 introduction to his book, *General System Theory*,* a compilation of his writings, some of which date back to 1940!

Bertalanffy applied general systems theory not only to biology, but to psychology, economics, and social science as well. In his view, old-fashioned science "tried to explain observable phenomena by reducing them to an interplay of elementary units investigatable independently of each other." Contemporary science, on the other hand, recognized the importance of "wholeness," defined as "problems of organization, phenomena not resolvable into local events, dynamic interactions manifest in the difference of behavior of parts when isolated or in higher configuration, etc.; in short, 'systems' of various orders not understandable by investigation of their respective parts in isolation." And this remains an effective definition of systems biology as practiced today with the integration and application of mathematics, engineering, physics, and computer science to understanding a range of complex biological regulatory systems.

The delay between the early pronouncement of the theory and the work presently assembled was necessary, primarily to accumulate sufficient descriptions of the parts to enable a reasonable reassembly of the whole. Kitano's Review (p. 1662) provides an overview of the systems biology field and identifies areas where attempts to derive systems-level understanding are still thwarted by the absence of required extensive and precise information.

Csete and Doyle (p. 1664) bring an engineer's perspective to their Review on biological complexity. Biologists can learn much from a discipline whose practitioners design control systems (such as that of the modern passenger jet) that generate, every minute, a volume of information similar to that in the entire human genome. They provide insights into system design from a more manageable set of parts: the modular plastic pieces that make up the "Legome." In a Review of modeling the function of cardiac cells and the heart, Noble (p. 1678) reminds us that we are just beginning to write the "user's guide" that must accompany the huge "parts catalog" emerging from efforts in genomics and proteomics. Davidson *et al.* (p. 1669) demonstrate that a genomic regulatory network can explain the early development of the sea urchin embryo. These regulatory circuits prescribe the ordered expression of genes that determine the fates of developing cells and move those cells together down a one-way path to yield a functional organism. Bertalanffy would be satisfied, as he notes in his book that this remarkable inexorable development of the sea urchin embryo, even from a fertilized egg that is divided or fused, was the very observation that "led the German biologist Driesch to embrace vitalism, i.e., the doctrine that vital phenomena are inexplicable in terms of natural science." Bertalanffy thought differently and argued that in a system open to its environment, the initial conditions do not determine the final steady state, and thus "the supposed violation of physical laws" proposed by Driesch "disappears."

Also, at *Science*'s Signal Transduction Knowledge Environment (STKE), Lok describes design similarities between electronic circuits and cellular signaling networks. The robustness of cell system behavior, such as the immune response, can also be understood through mathematical models, as described by Chakraborty. –LISA CHONG AND L. BRYAN RAY

*Ludwig von Bertalanffy, *General System Theory, Foundations, Development, Applications* (George Braziller, New York, 1969).

CONTENTS

REVIEWS

See also content in Science's STKE (stke.sciencemag.org; see p. 1595).

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