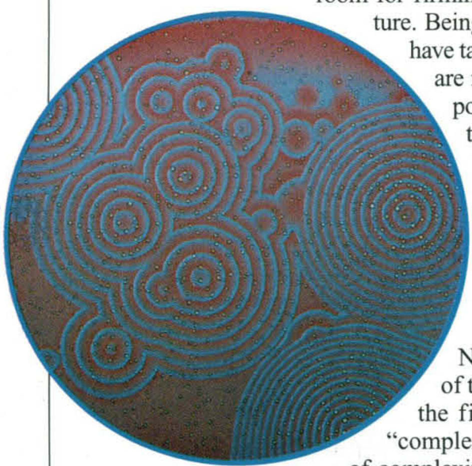
Beyond Reductionism

"All science is either physics or stamp collecting" (attributed to Lord Rutherford). Few, if any, of us subscribe to the view that all real scientific puzzles boil down to a question of physics. Nonetheless, the quotation above focuses in a brave (if extreme) way on a hard, practical issue: how the different fields of science relate to one another. The predominant approach is reductionist: Questions in physical chemistry can be understood in terms of atomic physics, cell biology in terms of how biomolecules work, and organisms in terms of how their component cell systems interact. We have the best of reasons for taking this reductionist approach—it works. It has been the key to gaining useful information since the dawn of Western science and is deeply embedded in our culture as scientists and beyond.

But shortfalls in reductionism are increasingly apparent. Mostly these arise from information overload. The much-used axiom that scientists "know more and more about less and less" may have an element of truth; at the very least, the specialization of sub-sub-subdisciplines is creating barriers to the flow of information. Another problem is oversimplification. Witness the "gene for" syndrome (as in "gene for intelligence" or "gene for sexual preference"), in which genes that contribute to human traits are instead taken to specify that trait.

So perhaps there is something to be gained from supplementing the predominately reductionist approach with an integrative agenda. This special section on complex systems is an initial scan and is necessarily selective; our decision has been to focus on the practical, to give a sense of how new approaches can help in wrestling with ongoing questions. Thus the contributions come (for the most part) from card-carrying earth scientists, molecular biologists, chemists, and so on, not from the small, elite group of scientists whose ideas provide the theoretical underpinning for much of what is reported here.

The section sidesteps a terminological minefield, in part to leave some room for firming up definitions as the approach continues to mature. Being anxious to move beyond the semantic debate, we have taken a "complex system" to be one whose properties are not fully explained by an understanding of its component parts. To further avoid straitjacketing the contributions, each Viewpoint author was invited to define "complex" as it applied to his or her discipline; the additional brief was to give an account of how this notion of complexity has influenced the field to date, to speculate on how it might prompt future directions, and to discuss how developments in one field might be transplanted to others.



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The Viewpoints are complemented by four News stories that provide case studies of the power of this approach in biology. Ecologists may have been the first life scientists to appreciate that their topic is "complex," and one News story tells how the mathematics of complexity is helping ecologists make sense of the forces that drive large fluctuations in wild populations. Other stories describe efforts to build computer models of smaller scale complex systems—the molecular networks within cells—to identify their emergent properties. And one story tells how the new interest in complexity is driving a disciplinary convergence, bringing biology together with mathematics, engineering, computer science, and, yes, physics.

–RICHARD GALLAGHER AND TIM APPENZELLER

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