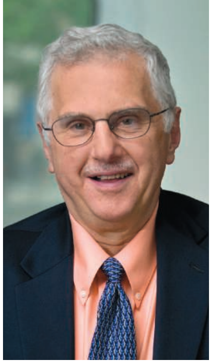

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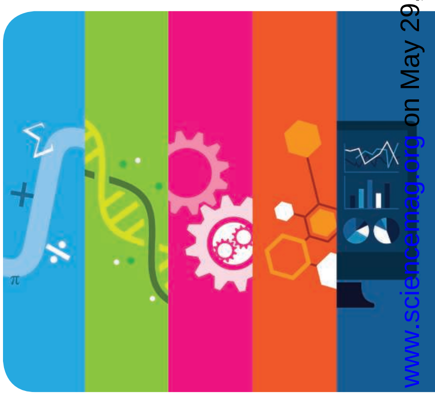
Creativity at the Interface

THE BIOCHEMISTRY THAT MAKES LIFE POSSIBLE IS BASED ON A COMPLEX NETWORK OF MANY thousands of interactions between molecules, and it presents an enormous challenge to the scientists trying to understand it. This special issue of *Science*, with its focus on computational biology, demonstrates how mathematics and computer science are being successfully harnessed to tease apart this complexity (see p. 171). But we are only at the very beginning of the process, and it is certain that reaching a true understanding of cells and organisms will require many more contributions from mathematicians, computer scientists, engineers, physicists, and chemists to complement the efforts of biologists. For this reason, graduate schools have become increasingly enthusiastic about recruiting outstanding students with strong backgrounds in these fields to address challenging problems in the biological and biomedical sciences. This is an important trend, except that too often faculty mistakenly assume that learning biology is easy, leaving these very talented young people nearly on their own to acquire the biological wisdom that they will need to explore the many mysteries in living systems. In fact, it is not at all easy to acquire the type of deep understanding of biology that is required to make wise decisions about what is, and what is not, an important problem to investigate; and a successful career in research will require much more than just a union of different expertise and tools.



Doing good science is a highly creative endeavor, much like producing a piece of art. Like an artist confronting a blank canvas, any scientist exploring biological systems is faced with an enormous number of choices. The first choice concerns exactly what problem to investigate with the tools that are available. To make this critical decision wisely, one needs to appreciate how solving any particular problem relates to clarifying other poorly understood aspects of a cell or organism, because the research problems of greatest interest will aim to fill these important gaps. Should those who mentor young scientists place more emphasis on preparing them to make such judgments? More specifically, what type of graduate courses could most efficiently address this need?

The next critical step is to design a promising strategy for attacking the chosen problem. Creativity is essential if one is to make a unique contribution, and a broad knowledge of what has previously been accomplished is key. As the French mathematician Henri Poincaré wrote more than a century ago: "To create consists precisely in not making useless combinations and in making those which are useful and which are only a small minority. Invention is discernment, choice . . . Among chosen combinations the most fertile will often be those formed of elements drawn from domains which are far apart. . . . The true work of the inventor consists in choosing among these combinations so as to eliminate the useless ones . . ." *

In biology as in other fields, the vast majority of possible investigations that could in principle be carried out are uninteresting, involving what Poincaré might have called "useless combinations of prior knowledge," and should be avoided. But how to choose? Should mentors spend more time helping students and postdoctoral fellows think broadly about research strategies, with the aim of preparing them to address the most important problems, whose solutions could fill critical gaps in our knowledge? Courses that explicitly analyze the decisions that outstanding scientists have made, emphasizing some paths not taken, could be productive here.

In biology, scientists are producing an enormous amount of data, but many creative new approaches will be needed to convert the data into the deep understandings of biological mechanisms needed for breakthroughs that benefit humanity. How to best train the next generation to meet this challenge is a fascinating question to contemplate, as we work to improve the effectiveness of the scientific enterprise and expand its role in the world.

– Bruce Alberts

10.1126/science.1223013

*H. Poincaré, *Mathematical Creation*, in J. R Newman, *The World of Mathematics*, vol. 4 (Dover Publications, Mineola, NY, 2004) (www.ias.ac.in/resonance/Feb2000/pdf/Feb2000Reflections.pdf).

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