Fear of Physics: A Guide for the Perplexed

Lawrence M. Krauss
Basic Books, New York, 1993. 206 pp. $20.00 hc
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This is one of those books about how a physicist (or, to be specific, a *theoretical* physicist) thinks, and it may well be the best of its genre. It opens with the well-known joke about the theorist, hired by dairy farmers as a consultant, who opens his presentation to his clients with: "Assume the cow is a sphere." Lawrence M. Krauss then goes on to demonstrate just how much one can say about a cow without assigning it any more structure than that phrase implies.

Each of the book's six chapters is defined by a theme rather than a subject, and under each theme a wide range of topics is addressed. The first chapter, for example, is entitled "Looking Where the Light Is," and as one might guess from the bovine opening gambit, it concerns the insights that can come from ignoring all the messy details that Nature presents to devil us.

Chapter 3 is entitled "Creative Plagiarism," a reference to the surprising ability of good scientific ideas to prove useful in a variety of seemingly unrelated contexts. The chapter starts with Galileo's work on falling bodies and ends with the Higgs mechanism, having passed in sequence through atomic structure, Hawking radiation, Kepler's laws, Newton's law of gravity, dark matter, electromagnetic unification, relativity, the uncertainty relations, Feynman's path integral formalism, quantum electrodynamics and superconductivity—all in 56 compact pages and without any abrupt discontinuities in the narrative. This is undeniably a dazzling exhibition of intellectual prestidigitation, but it is likely to leave in the dust any reader not already familiar with most of the topics.

The book's tone is stridently upbeat and appealing, so an intelligent lay reader who is willing to "damn the torpedoes" and plow through could come away much richer. Krauss makes you *want* to understand what a virtual particle is, even if he leaves you with the feeling that you don't *quite* get it.

In the area of history, Krauss is better than most physicists. (It sometimes bothers me that authors who would die of embarrassment at a wrong equation cheerfully propagate historical gaffes.) For example, in the fifth chapter, "The Search for Symmetry," Emmy Noether and her famous theorem relating conservation laws to symmetry principles finally get their due. But while the book deals lucidly with ordinary space–time symmetries, a lay reader is likely to end up unconvinced that gauge symmetry is a symmetry at all.

In the final chapter, "It Ain't Over Till It's Over," Krauss displays a commendable skepticism toward what purport to be so-called "theories of everything." Whether or not such a theory exists in principle, in actually confronting the phenomena it would seek to encompass we will always be forced to fall back on *effective* theories, those appropriate to a particular scale. In making this point Krauss is close to the viewpoints of biologist Stephen Jay Gould and fellow physicist Philip Anderson.

Perhaps the most suitable audience for this book would be undergraduate physics majors trudging wearily through the traditional introductory course. It could whet their appetites for the fun that is to come and might show them how the seemingly outdated topics they are currently studying can still be relevant to what's happening in physics today.

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Spin Glasses and Biology

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There is no claim in *Spin Glasses and Biology* that spin glasses—alloys of manganese or iron in copper, silver or gold—exist in biology. Rather, the book is based on the hope that specific systems in biology are sufficiently analogous to spin glasses that the concepts developed in the study of spin-glass behavior will be useful in understanding these biological systems. The systems range, as the book's seven essays do, from evolution and genetics to protein dynamics and neural networks.

Such reasoning by analogy has not been the most productive approach in physics. The fact that an atom is like a miniature solar system is not the most interesting thing about it. The idea that space acts like an elastic medium did not turn out to be very productive either. So why should the method be resurrected now in the application of the concept of a spin glass to biology? Evidently because a number of physicists have become fascinated by the possibilities. The notions that spin glasses seem to offer to biological applications are, as listed in Daniel Stein's preface, "frustration, quenched disorder, replicas, ultrametricity, metastability, irreversibility and maybe robust criticality, among others."

The introduction by Philip Anderson refers to the dream of Lars Onsager and others that genuine statistical mechanics of nonequilibrium systems would eventually arise and point to a general concept of life and the way it arose. According to Anderson, neither dissipative structures nor deterministic chaos can characterize the "steady complexification of the space of living things." Life requires some organizing principle, for which the solution-tree concepts developed for spin glasses may provide an ideal theoretical framework.

The style of the book is uneven. The smooth pedagogy of Peter Wolynes ("Spin-Glass Ideas and the Protein-Folding Problems") and the abstract scholarship of Stuart Kauffman ("The Origins of Order: Self-Organization and Selection in Evolution") contrast with the in-your-face assertiveness of the interesting article by Robert Austin and Christine Chen ("The Spin-Glass Analogy in Protein Dynamics"). The book is well edited, although there is no index, and some typos are in evidence.

One of the recurring themes of the book is that of evolution as a walk on a rugged landscape; the sharp peaks are local fitness optima. Because deleterious mutations are removed by interactions of the phenotype with the environment, the walk will be uphill and will soon be halted—the mutant form stabilized—at a local optimum. This theme is developed for the evolution of species and punctuated equilibria by Gérard Weisbuch, for self-organization in prebiological systems by Daniel Rokhsar and for the maturation of the immune response by Alan Perelson and Catherine Macken. The model of neural networks presented by Hanoch Gutfreund and Gérard Toulouse is a highly formalized discussion of such network functions as learning, categorization and generalization.

The strength of the book lies in its lofty perspective, in which phenomena not usually thought of as related are seen as details on a vast canvas. Its weakness is the development of highly restrictive, even unrealistic, models upon which complex formalisms are built without, frequently,