pirical criteria, he complains, and this clashes with historical evidence. Accordingly, Laudan constructs a remedy from historical examples that involves nothing less than the redefinition of scientific rationality and progress. For Laudan, "the rationality and progressiveness of a [scientific] theory are most closely linked . . . with its *problem solving effectiveness*" (page 5)—a seemingly innocuous assertion that actually vindicates countless heresies because, unlike others, Laudan distinguishes problem-solving from fact-explaining.

The innovative key to his unorthodoxy is the notion of conceptual problems, or non-empirical difficulties, that confront scientific theories. These may range from logical inconsistencies within a theory to tensions between the theory and the "well-founded" aspects of one's world view. Laudan's genius lies in his realization that inclusion of these matters in one's model goes far toward explaining historical episodes that empirically-based philosophies consider anomalous. Moreover, Laudan shrewdly observes that scientists pass judgment not on the problem-solving effectiveness of individual theories, but on *research traditions*—that is, on sets of "ontological and methodological 'do's and 'don'ts' " (page 80) around which theories are clustered. And through the mechanism of conceptual problems, variations of extrascientific beliefs *can* and *have* produced *variable* grounds for assessing such research traditions. In short, Laudan's model espouses not the elimination of rationality but its "evolving character" (page 170).

Surprisingly, after this reshuffling, science still looks like a noble—and progressive—enterprise, not a doomed, Quixotic search for "Truth" ridiculed by relativists. Far from a garden-variety positivist, however, Laudan sees science not as a pilgrimage to absolute Truth but as an evolutionary procession in which ground is given in one place and gained in another. Progress occurs through movement to more fertile real estate. One faults such a suggestive schema with difficulty.

But Laudan abuses his own creation in part 2, where he considers the "application" of the model in related fields. Having undermined traditional notions of rationality, Laudan feels obliged in this section to defend scientific progress against what he believes are its bitterest detractors—sociologists of knowledge. He endorses strongly the "arationality assumption," which posits that scientific behavior admits of a sociological explanation only in those cases in which grounds for a "rational" choice are absent. (An Edinburgh sociologist of knowledge, S. Barry Barnes, decimates this assumption in his well-known book, *Scientific Knowledge and Sociological Theory* (1974); one can understand a philosopher's ignorance of this sociological work.) But to be "rational" in Laudan's plan, one must pick that research tradition which maximizes problem-solving effectiveness. And how does one assess effectiveness of this sort? Is solution of ten "trivial" problems better than solution of five "important" ones? "*In principle*," says Laudan, "we can determine whether our theories now solve *more important* problems than they [once] did . . ." (page 127, italics added). "*If* we *could* show . . . that . . . one [research] tradition has been a more progressive problem solver than its competitors, then we would have legitimate, rational grounds for preferring it" (page 192, italics added). Unfortunately, what works in principle is often tricky in practice; how one *weights* problems is *always* a critical determinant of problem-solving effectiveness—even when a "rational" choice is made. And as Laudan himself admits, problem weighting is a phenomenon which, more than most, "seems intuitively to be subject to . . . social influences" (page 222). In short, the ever-present external culture *can* influence science, even when it *is* rational.

The glory of Laudan's system is that it *preserves* scientific rationality and progress in the presence of social influence. We can admit extrascientific influences without lapsing into complete relativism. It is a shame that Laudan himself misses this. Nonetheless, his eminently readable—if execrably proofread—essay is a must for both observers and practitioners of science.

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Liquids and Solutions: Structure and Dynamics

P. Kruus
582 pp. Marcel Dekker, New York, 1977. $45.00

The chemistry and physics of the liquid state is a vital and active field. In the last fifteen years, new developments in experimental and theoretical methods have resulted in a dramatically improved understanding of the properties of dense fluids and have led to a vast extension in the information obtainable from experimental probes. In *Liquids and Solutions: Structure and Dynamics*, Peeter Kruus presents an introduction to the chemistry and physics of liquids, suitable for senior undergraduates or entering graduate students, which emphasizes the experimental aspects of the field. Kruus, an associate professor of chemistry at Carleton University in Ottawa, has worked for some years in the application of ultrasonic absorption methods to liquids and solutions.

The author has organized the book into three distinct sections. The first gives an introduction to the basic outlines of liquid-state theory. The emphasis here is largely on concepts useful in the interpretation of experimental results. There are, however, several inexcusable omissions. It seems inconceivable to me, for example, that any coherent presentation of the contemporary view of the liquid state can omit a discussion of the role of repulsive forces in determining the structure of a dense liquid. Yet, the author's only mention of this crucial development is a single sentence in a section on perturbation techniques, without justification or elaboration. In a similar vein, Kruus presents a classical description of critical phenomena (and later quotes some experimental critical exponents) without any indication of the ultimate failure of the classical theory or even a mention of scaling. There are, in addition, a number of serious errors in the material that *is* presented. One obvious example is an incorrect diagrammatic expression of the direct correlation function on page 60. Yet another is figure (3.3), which proports to show radial distribution functions for a hard sphere "liquid" but in fact gives the corresponding functions for a Lennard-Jones fluid.

The heart of *Liquids and Solutions* is really its middle section, a series of nine chapters covering a variety of experimental probes of the liquid state. This section comprises over half of the text and includes discussions of the measurement of thermodynamic and transport properties, spectroscopic methods, dielectric relaxation, ultrasonic absorption and the scattering of neutrons and electromagnetic radiation. Each chapter begins with a presentation of additional theoretical material specific to the technique under discussion, then proceeds to a discussion of experimental procedures and finally concludes with an extensive presentation of experimental results for an admirably diverse collection of systems ranging from liquid argon to solutions of macromolecules. Unfortunately, Kruus's organization of the material occasionally results in a poor integration of experiment with theory and even of one technique with another. A summary section at the end of each chapter would have been useful in helping the reader maintain a broader perspective.

The final section of *Liquids and Solutions* contains a series of brief review chapters on aspects of thermodynamics, statistical mechanics and quantum mechanics that are assumed known in the earlier sections but which include material often omitted in the undergraduate chemistry curriculum. Much of this material will be unfamiliar to a great many students, and it would probably

have been wiser to integrate this material with that in the first section. Indeed, some of the notation employed in earlier sections is only defined in the final chapters.

Because of the conceptual and pedagogical lapses described above, *Liquids and Solutions*, by itself, is probably not an entirely satisfactory introduction to the liquid state. Nevertheless, the author's experimental approach to the field may make the book a useful supplementary text. Donald A. McQuarrie's *Statistical Mechanics* or Friedrick Kohler's *The Liquid State* are suitable alternatives for this audience. For a more sophisticated treatment, the reader is urged to consider *The Theory of Simple Liquids* by Jean-Pierre Hansen and Ian R. McDonald.

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Neurophysics

A. C. Scott
340 pp. Wiley-Interscience, New York, 1977. $24.95

Sir Isaac Newton, in Book 3 of his *Opticks*, proposed some queries, "in order to a farther search to be made by others." The 24th of these asks, "Is not Animal Motion perform'd by the Vibrations of [the ether], excited in the Brain by the power of the Will, and propagated from thence through the Capillamenta of the Nerves into the Muscles, for contracting and dilating them?" Here is an enthusiastic book for physicists who would make such a "farther search." *Neurophysics* is written from a far-reaching perspective, extending from the membrane level to fiber, neuron, nerve net, and even to the human mind itself. The bulk of the book is a review of mathematical models of nerves, closely following Alwyn C. Scott's article of April 1975 in *Reviews of Modern Physics*.

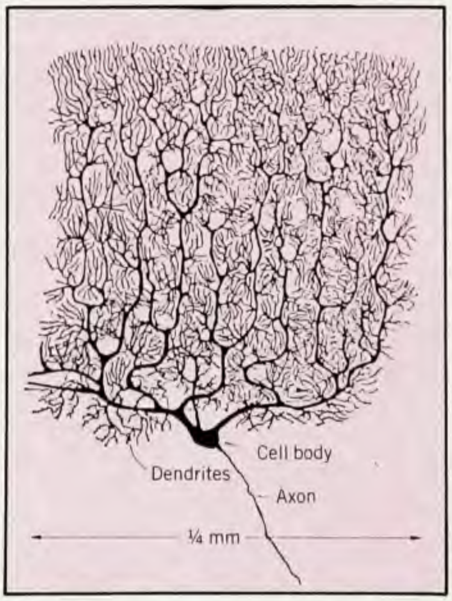
Scott, a professor in the Department of Electrical and Computer Engineering at the University of Wisconsin at Madison and author of *Active and Nonlinear Wave Propagation* (Wiley-Interscience, New York, 1970), writes in the preface that the book evolved from notes for a course attended by students of computer science, mathematics, physiology, physics and zoology, as well as engineering. He feels that it is entirely appropriate that physical scientists play only a minor role in the study of the living brain, but "we still have contributions of value to make."

Neurophysics begins with physical principles—Maxwell's equations—and in the first chapter gives a sophisticated derivation of the nonlinear diffusion equation. The material in this chapter traces its historical origins to Lord Kelvin's cable equations.

The emphasis on mathematical analysis as opposed to biological observations tends to make the book difficult to follow. For example, in chapter 3, "The Active Nerve Membrane," which begins on page 28, the reader only learns of such important experimental facts as the resting potential on page 41 and the ion-concentration ratios on page 42 (the absolute concentrations of sodium and potassium inside and outside the membrane are not given at all). It appears to me that readers not familiar with the subject would do well first to study Alan Hodgkin's readable little volume, *The Conduction of the Nervous Impulse* (Thomas, Springfield, Ill., 1964).

The book introduces the Nernst–Planck equation (although only for sodium ions) implicitly, in terms of the chemical potential. The analysis that follows deals with steady-state sodium currents, although only transient sodium currents are observed in squid axon (potassium ions carry steady curents); perhaps the motivation for this approach should be stated explicitly. On page 36 the constant-field approximation is mistakenly equated with electroneutrality; these are distinct simplifying replacements for Gauss's law and (when used in conjunction with the Nernst–Planck equation) yield different solutions. This material should be supplemented by Tobias Schwartz's review in *Biophysics and Physiology of Excitable Membranes*, edited by William J. Adelman Jr (Van Nostrand Reinhold, 1971).

The usual voltage-dependent conductance is defined and, after presenting a set of voltage-clamp data, Scott proceeds to the Hodgkin–Huxley phenomenological expressions. Despite Scott's remark about "an inevitable (and regrettable) tendency to consider [these equations] as 'graven on a stone tablet,' " the dependence on these, and more generally on voltage-dependent membrane conductances, remains heavy in the book.



A Purkinje cell of the human cerebellum, about $\frac{1}{4}$ mm across, drawn by Ramon y Cajal. A single nerve cell may communicate with 80 000 other neurons. Reproduced from *Neurophysics*, by A. Scott, reviewed here.

The next chapter begins stimulatingly with mention of the Kolmogoroff–Petrovsky–Piscounoff equation, which despite its origin in genetic diffusion has the form of the nonlinear diffusion equation derived for membranes, with the current density taken as a given function of membrane voltage. This equation was shown to evolve from a steplike initial condition to a solitary wave with constant speed, quite analogous to excitation of a nerve impulse. Scott points out that the equation, $P = uE$, which relates the power P and energy density E to the propagation velocity u, applies as well to the conduction process as to the burning of incense or a candle. He then analyzes the Hodgkin–Huxley equations, in which the constant-velocity propagation condition is assumed rather than derived. He deals with computational difficulties, propagation of the leading edge of the action potential and two simplifications: the FitzHugh–Nagumo equation and the Markin–Chizmadzhev model. There is also material on the myelinated axon, fibers with changing diameter and the decremental conduction of narcotized fibers, the latter leading to an interesting variational approach by the author. The book describes an electronic nerve analog: the neuristor, a superconductive niobium device.

Scott discusses the important questions of stability of solutions and the threshold of excitation, as well as interactions within a single neuron, the dendritic tree of which may accept as many as 80 000 inputs from neighboring nerve cells. After briefly discussing the transmission of information from one nerve to another at synapses, Scott proceeds to the branching of dendrites and axons, which in a drastic simplification may be treated by a Boolean algebra. The assumptions of an all-or-none process, latent addition at synapses and time delays produce the McCulloch–Pitts neuron, which makes a suitable element for neural nets. These nets have become embodied in machines, both conceptual and actual, known as "Perceptrons."

The last chapter deals with the human mind, a subject that appears to be far too broad to be discussed in a meaningful way on the basis of the earlier topics. It asks, and answers in the negative, whether mental characteristics might emerge from the nets of model neurons discussed. The conclusion, bolstered by trendy and mystical quotations, casts doubt on the viability of the scientific enterprise in the area of the mind. Scott makes it clear that he disagrees with B. F. Skinner's view