lum hospital, for within this seemingly alien institution lay the origins of many of the relationships, attitudes, and organizational patterns that characterize our modern facilities. Before the Civil War, hospitals were few in number and concentrated in the major cities of the East Coast. As charity institutions providing care for the indigent or the homeless, they often addressed issues that were only tangentially related to health and illness. The hospital was an institution that served the "worthy" poor or those who became dependent upon the larger community for a variety of reasons, including indigence, old age, abandonment, and unemployment. Illness was necessary for admission, but it was not sufficient. Generally organized by elite lay persons, hospitals were "shaped as much by dependence and traditional notions of class, deference, and social responsibility as they were by the categories and capacities of medicine" (p. 71). The institution was class-bound; the relationships between medical personnel, administrators, trustees, workers, and patients formed around the hierarchical and paternalist mores of antebellum American society.

Every aspect of the antebellum hospital reflected class relationships. Trustees who saw themselves as guardians of the community controlled the hospitals tightly and showed younger house staff little more respect than they might any other hired hands. Doctors who sought closely guarded hospital privileges often saw the institution as a training ground and a stepping-stone toward a profitable private practice. Nurses, often drawn from the patient population or from lower-class groups, found their aspirations circumscribed by the ideology that associated nursing with femininity and service. Indigent patients were treated with a combination of condescension, contempt, and concern by trustees, physicians, or others who visited them at home before admission to evaluate their medical condition and moral environment.

Rosenberg's critical point is that the hospital was a reflection of the society that created it. Its medical care, nursing, administration, and even architecture reflected the moral underpinnings of the larger community. For example, in his chapter "Ventilation, contagion, and germs" Rosenberg presents a finely textured and penetrating analysis of the social origins of modern antiseptic and aseptic techniques. Unlike more traditional accounts that emphasize the role of science in these innovations, Rosenberg's shows that their origins lay in the moral codes of the community. In his discussion of the introduction of statistical thinking and hygiene in the mid-19th-century institution, he points out that even Florence Nightingale, often credited with introducing order and hygiene, worked from a basically social understanding of the relationship of morality, cleanliness, and disease: "Her ideas of pathology and therapeutics were rooted in a more fundamental vision of society, a way of organizing and controlling the world that transcended the specifically medical form in which that vision was projected" (p. 129). The views of Nightingale and the hospital reformers in the United States who adopted many of her ideas "didactically underlined the connection between behavior, environment, and health—and thus constituted a systematic program for hospital reform" (p. 130).

The Civil War, with its vast expansion of the hospital experience to patients from a wide variety of social classes, proved central in reshaping American attitudes; the introduction of the germ theory reshaped medical thinking; the development of a paying-patient financial base redirected trustee and administrative interests. By the early 1920s, the fundamental relationships between trustees, physicians, medical schools, nurses, workers, and patients that characterize present-day hospitals had largely been established and the basic medical orientation of the institution had been worked out. The hospital was on the way to altering an earlier social mission that required it to look outward to the larger community. It increasingly turned inward, seeking its legitimation from its own medical and in-patient concerns. Rosenberg sees the tangential role that the hospital out-patient and social service departments play today as stemming from this movement away from more traditional social functions. By the early 20th century, the paternalist awareness of the patient and his or her place in the larger community became a peripheral motivation at best. "Outpatient and dispensary care (like social service) were never to escape the stigma of poverty medicine; never a part of the economic structure of medical practice and generally occupying an area of minor technical interest, they remained a marginal concern" (p. 335). Social service, once the bedrock upon which the institution was founded, became "a mere glance outward of little significance in comparison to the compulsion exerted by the forces that shaped the hospital in its inward vision" (p. 335).

Rosenberg's book is a powerful and elegant discussion of the origins of modern hospital practice. He finds meaning in hospital annual reports, newspapers, trustee minute books, diaries, medical and administration journals, and doctors' daybooks that might easily be missed by a less skilled historian. He sees the hospital as a microcosm of the changing beliefs, values, and ideals of American society and through the hospital provides us with a clearer picture of our own attitudes toward medicine, poverty, and dependence.

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Gravity: Foundational Questions

Quantum Concepts in Space and Time. R. PENROSE and C. J. ISHAM, Eds. Clarendon (Oxford University Press), New York, 1986. x, 358 pp., illus. \$80. Oxford Science Publications. Based on a conference, Oxford, U.K., March 1984.

This book is a collection of 27 papers that were presented at the last in a triad of meetings, the previous two having been devoted to quantum gravity. As the editors state in their preface, they did not feel the time was ripe to treat that subject again: "Instead, it seemed more opportune to re-examine certain foundational questions relevant to quantum gravity; in particular we wished to explore the possibility that the rules of quantum theory itself might need to be modified before a successful union with general relativity can be achieved. . . . There was however one overriding and unifying theme: the conceptual problems of quantum physics in relation to space and time." This statement of purpose provides a standpoint from which to judge the success of the endeavor. Does a group of physicists with a strong interest in relativity, the accepted theory of space and time, possess wisdom about the conceptual foundations of quantum mechanics that escapes the rest of the physics community?

In broad terms, relativity is an heir of the Cartesian tradition of regarding physical reality as reducible to matter moving in space and interacting by contact. As years went by, matter was replaced by fields, and space-time itself was turned into a dynamical entity. Still, in general relativity theory matter (or fields) is supposed to respect the underlying space-time structure in a contact manner. It is thus natural that relativists should find especially disconcerting the fact that quantum matter does not play the game strictly according to the rules.

First of all, there is a strange element of nonseparability in the behavior of systems

that interacted in the past but parted company and occupy at the time of measurement causally disconnected regions of space. Quite appropriately, it was Einstein who brought this aspect of quantum mechanics clearly into focus, as epitomized today in the so-called Einstein-Podolsky-Rosen (EPR) paradox. The modern experimental corroboration of quantum mechanics in the EPR context is presented by Aspect and Grangier, and the impact of their experiments on local hidden variables theories is discussed by Shimony. Relativity proper does not seem to play much of a role in these contributions. Wald's paper, however, offers an illuminating parallel between the EPR situation and certain predictions based on a bona fide relativistic quantum field theory: how detectors interact with the vacuum fluctuations of a quantum field in such a way that correlated fluctuations in space-like related regions become real particles, and hence, though no causality violation occurs, two phenomena taking place outside each other's horizon need not be statistically independent. Aharonov's paper reviews two other classes of nonlocal phenomena brought into physics by quantum mechanics: those characteristic of gauge theories with systems confined to field-free but nonsimply connected regions, and those in which locally applied forces produce nonlocal changes in a system described by a nonlocalized state function.

The second troublesome problem for relativists—or at least for those who regard the state function as a description of individual systems—is the reduction of the wave packet. Various proposals about how and when the reduction takes place are given in the book. Pearle presents dynamical stochastic models in which the reduction is brought about by randomly fluctuating elements. Károlyházy, Frenkel, and Lukács maintain that gravity—the cherished object of the general theory of relativity—may provide such an element: a smeared space-time metric as the background on which the states propagate. Similar in spirit though different in the identification of the key element is Penrose's vision of the reduction associated with cosmological evolution: at the Big Bang the universe begins in the state of the lowest entropy, with no gravitational degrees of freedom excited, and increases entropy by gravitationally clumping matter together, ultimately into black holes. Phase-space volume created outside black holes is then somehow associated with the wave-packet reduction. Zeilinger shows how recent experiments limit nonlinear terms that one may want to add to the Schroedinger equation to achieve the reduction, and Shimony gives a pessimistic assessment of such attempts. Whereas the papers mentioned above try to explain how the reduction of the state occurs for macroscopic systems, Leggett looks at diametrically opposed situations in which one may actually observe a superposition of macroscopically different states.

The traditional interpretation of quantum mechanics depends on von Neumann's idealization of an instantaneous measurement. Even in a nonrelativistic theory, it is tricky to interpret what happens if a system is observed continuously. Sudbery gives a carefully reasoned analysis of this frequently encountered state of affairs, and Leggett discusses possible experiments related to the "watched-pot effect," the phenomenon in which continuous observation actually hinders quantum mechanical change of the observed system.

Penrose is not the only one who explores the theme of the Faustian unity of macrocosm with microcosm manifested in the dependence of quantum phenomena on the cosmological scenario. Page summarizes the Hartle-Hawking proposal about the boundary conditions for the "state function of the universe": the path integral yielding the state functional of a three-geometry on a compact spatial hypersurface is to be taken over all compact Euclidean four-geometries whose only boundary is the hypersurface in question. In Hawking's aphorism, "The boundary conditions of the universe are that it has no boundary." Everett's interpretation of quantum mechanics with its cosmological imagery of a branching universe is discussed in several contributions. My favorite is a casuistically elegant proposal by Deutsch detailing how to test the Everett interpretation of quantum mechanics "experimentally": an idea that, in spite of the light tone of delivery, is obviously meant to be (and should be) taken quite seriously.

Returning to the question posed at the beginning of this review—What do relativists have to say about the interpretation of quantum mechanics that is missed by other groups of physicists?—I find it rather surprising how little relativity is actually used in these papers. I think it is fair to say that most of the contributors are happy to explore the interpretational difficulties posed by standard *nonrelativistic* quantum mechanics. Relativists know, of course, how to describe the structure of a Newtonian, nonrelativistic space-time in geometric terms; it seems, however, that they feel no urge to use this expertise to elucidate the interpretational problems of nonrelativistic quantum theory. By and large they proceed as everyone else does when writing about this class of topics. Consequently, the "unifying theme" of the organizers does not clearly emerge in the bulk of the proceedings.

What about the conceptual reconciliation of the special theory of relativity with quantum mechanics? The towering historical achievement in this respect is the famous Bohr-Rosenfeld analysis of the measurability of the field strengths of the quantized electromagnetic field. Curiously, none of the contributions explore this particular theme. There are, however, two papers in which special relativity becomes prominent: that of Bialynicki-Birula, which attempts to take into account time-reversal invariance by doing quantum mechanics on two copies of Minkowski space-time that are patched together, and the previously mentioned discussion of correlated quantum fluctuations by Wald.

For a true relativist the touchstone of any interpretation of quantum mechanics should be whether it accommodates in a natural way gravity and the associated structures of a curved space-time manifold. If one discounts the technical papers, only a couple of

Prices of Books

Average per-volume prices of books reviewed in *Science* 1982–1987. Data are for hard-cover books except where books were available only in paperback. For the 37 books reviewed that were issued simultaneously in hard and soft cover, the average difference in price between the two versions was $25.51, or 54% of the hardcover price (range, $10 to $61, or 22% to 72%). The average prices per page for the technical books in the natural sciences for the years covered were 11.1¢, 11.1¢, 12.0¢, 12.7¢, 12.2¢, and 12.5¢. For earlier data from *Science* and other relevant information see *Science* **211**, 933 (1981) and **235**, 95 (1986).

Category	Price (dollars)					
	1982	1983	1984	1985	1986	1987
All books	44.05	41.93	45.38	47.02	47.02	47.37
Technical books in natural sciences	51.70	51.18	55.29	49.66	53.57	59.06

contributions reach this stage. Anandan studies the effects that interacting gravitational and electromagnetic fields treated classically exert on quantum mechanical particle probes. Smolin discusses stochastic quantization on a curved background. On a more fundamental level, Károlyházy *et al.* and Penrose seek to explain the reduction of the wave packet as a gravitational effect, and Page reviews the Hartle-Hawking boundary conditions for the "wave function of the universe." Here we finally encounter some fascinating conjectures about how general relativity and quantum theory may meet in an unexpected manner. These papers bear the seal of relativity as a field. Károlyházy *et al.* and Penrose, however, never quite work their speculations into a coherent theory, and Page, like the sources he reviews, does not come to grips with the subtle problems of the probabilistic interpretation of the "state function of the Universe." One is left with an uncomfortable feeling that the founding fathers of quantum mechanics, by following its unpleasant consequences *bis zum bitteren Ende*, left us, as well as the subject, at an impasse. To get beyond the present stage, one cannot accept any reasoning that is less painstaking, less orderly, and less profound than theirs. Misunderstood and mistrusted, distorted and dismissed, and very probably provisional, the traditional interpretations of quantum mechanics, those of the Copenhagen school and of von Neumann, still stand (unfortunately, I feel) unsurpassed.

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Imaginative Biochemistry

Free Radical. Albert Szent-Gyorgyi and the Battle over Vitamin C. RALPH W. MOSS. Paragon House, New York, 1987. xx, 316 pp. + plates. $22.95

This book is much more than the story of Albert Szent-Györgyi's battle over the discovery and function of vitamin C. It is a biography that covers his personal life, his entire scientific career, and his political beliefs and activities, particularly in Hungary and the United States. Szent-Györgyi was always in search of peace. As Studs Terkel says in his foreword, "Albert Szent-Gyorgyi saw the world, he saw hope. . . . As scientist, poet, and maverick, he always defied the 'institutional truths'." He didn't like to catch small fish, so when he went fishing he used the largest hook he could find. And, as he said, if you want to build a house you have to dig a foundation. He dug deep in science because he wanted to build the skyscraper of modern medicine.

The story of the discovery of vitamin C (formerly ignose, godnose, and hexuronic acid) is covered in detail. The story had its tragic moments, involving a battle of two scientists over priority of discovery. In 1937 Szent-Györgyi received the Nobel Prize for studies on cellular respiration and the isolation of vitamin C. His studies on respiration demonstrate the imagination of this great scientist. He stepped into a bitter argument between two giants of biochemistry, Otto Warburg and Heinrich Wieland. Warburg argued that oxidation was due to the activation of oxygen by his "Atmungsferment" (cytochrome oxidase), while Wieland argued that the activation of the substrate by dehydrogenases was the primary event in oxidation. Through brilliant experiments Szent-Györgyi demonstrated that both were correct. Using minced pigeon breast muscle, he demonstrated that dicarboxylic acids, such as fumaric acid, were an essential coupler between the dehydrogenase and cytochrome oxidase for biological oxidation. Thus, activation of substrate à la Wieland and the activation of oxygen à la Warburg—the so-called Szent-Györgyi cycle—were both essential for biological oxidation. This discovery was later used by Krebs in his brilliant work describing the citric acid (Krebs) cycle.

Szent-Györgyi's later work on muscle biochemistry could also have been the basis for a Nobel Prize. He and his co-workers Ilona Banga and F. Bruno Straub prepared myosin threads on a slide and observed them under the microscope when adenosine triphosphate was added. The threads began to contract and shrink to a third of the original size. Szent-Györgyi described this observation as "perhaps the greatest excitement of my life." Subsequent developments in work on myosin A and B, actin, and ATP interactions are described in some detail in the book. The excitement is best summed up in Szent-Györgyi's own words: "Muscular contraction is one of the most wonderful phenomena of the biological kingdom. That a soft jelly should suddenly become hard, change its shape and lift a thousand times its own weight, and that it should be able to do so several hundred times a second, is little short of miraculous. Undoubtedly, muscle is one of the most remarkable items in nature's curiosity shop." Szent-Györgyi soon decided that muscle behavior could not be described in terms of orthodox chemistry. Rather, the distribution of electrons over the entire molecular structure must be understood if one is to answer the question What is life? Thus his beginnings in the study of quantum biology.

Among the many other aspects of Szent-Györgyi's life covered in the book is his move to the Marine Biological Laboratory at Woods Hole, Massachusetts, which initiated an interesting phase in his career. He bought a wonderful home, Seven Winds, on Penzance Point, where he had regular sessions with visiting scientists. This was where a number of ideas concerning quantum biology were developed. Szent-Györgyi's ideas on the electronic states and protein structure and organization in relation to cancer were discussed extensively at these sessions.

During this period Jane McLaughlin played an important role in Szent-Györgyi's life, as did his cousin Andrew and Andrew's wife, Eva. He needed good people around him to challenge the many "wild" ideas that came along. Michael Kasha recalled his visit: "Life with the Szent-Gyorgyis was colorful and gay. Swimming in the cold ocean, fishing for flounder, daring motor boat rides through narrow channels in the nearby islands, night fishing for a striped bass in the swift tidal currents around the peninsula, volley ball—all these things were part of the informal life of Albert Szent-Gyorgyi. Mornings of intensive science and late afternoons of intensive recreation became the delicious summer diet at Woods Hole."

Many scientists will be interested in reading the details about how "Prof" supported his research, including his interaction with Stephen Rath, and, in particular, the role of Franklin C. Salisbury and his wife, Tamara, in starting the National Foundation for Cancer Research. His interaction with Warren Weaver at the Rockefeller Foundation and with Armour and Company are classic examples of grantmanship, which Moss covers in a wonderful way. Prof could not write a grant. He didn't know how to write down his ideas and what he might anticipate in the way of results. If he could do that, then he didn't think it was worth doing.

Moss has done a remarkable job in capturing the spirit of this "free radical" whose motto was "Long live imagination."

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