deterministic theory in place of quantum mechanics. Nowadays, however, theorists benefit by good contact with the phenomenology of strong and weak interactions and the field theories are inherently quantum field theories.

Yang points out that geometrization is only a heuristic device for expressing unification. The gauge theories that have already unified electromagnetic and weak interactions and promise to incorporate strong and gravitational interactions are all quantum generalizations of fiber bundles that necessarily incorporate topological complexity. This is the direction in which, while his search for a deterministic theory is being abandoned, Einstein's Riemannian geometry is now being generalized so as to incorporate all interactions.

Bergmann discusses unified field theories under three classifications: those that maintain usual four-dimensional space-time but generalize the Riemannian geometry so as to accommodate a greater variety of physical fields, those that increase the space-time dimensionality, and those that complexify space-time. Penrose twistors and supergravity both fall in the last category. Because spinors appear only in quantum mechanics, supergravity is an inherently quantum field theory.

Gürsey points out that Einstein's failure to unify actually signaled the beginning of a new level of geometrization of contemporary relativistic physics. He is especially good at translating Einstein's program into modern terms. In fact, the papers by Gürsey, Bergmann, and Yang will be invaluable to historians of contemporary physics.

At the intersection of gravitation and quantum theory, J. D. Beckenstein contributes a beautiful exposition of black hole statistical physics. N. Rosen writes on Mach's principle, which was heuristically important to Einstein in his development of general relativity. Because anti-Mach (deSitter) cosmologies are now known in which geometry is fixed by a pure gravitational field without the presence of matter, Mach's principle is now mostly of historical interest. It may be used to select physically admissible solutions of Einstein's field equations. Einstein and Wheeler have, at different times, argued that Mach's principle requires that the universe be closed since only in that case is the solution of the field equations determined only by the matter-energy tensor. It remains to be seen whether our universe is closed and, if so, whether this justifies any interpretation of Mach's principle.

The editor allows his own opinions and contributions to intrude in every section of the book. (Though omitting any details concerning or precise reference to the proceedings of the other half of the Jerusalem symposium, the editor incorporates in the present volume two previously published articles of his own.) This annoying practice detracts from the special and high quality of all the other thoughtful and distinguished contributions to the volume.

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An Irish Scientist

John Tyndall. Essays on a Natural Philosopher. W. H. BROCK, N. D. MCMILLAN, and R. C. MOLLAN, Eds. Royal Dublin Society, Dublin, 1981. xii, 220 pp., illus. IR£10. Royal Dublin Society Historical Studies in Irish Science and Technology, no. 3.

Science in Victorian Britain underwent several conceptual and nonconceptual revolutions. The establishment of the chemical atomic theory, the first and second laws of thermodynamics, the electromagnetic theory of light, and the theory of evolution transformed scientific thought. The pursuit of scientific research, largely avocational early in the century, was a full-fledged profession by century's end. The Irish-born John Tyndall (1820–1893), colleague of and successor to Michael Faraday at the Royal Institution in London, lived through the revolutions and especially influenced the ones involving professionalization.

The present book is a kind of homage to Tyndall organized by groups in Ireland mainly interested in awakening local interest in Tyndall. It is the third in a series published by the Royal Dublin Society to "restore the contributions of Irish scientists and technologists to their proper place in the history of the Country." The organizers feel Tyndall has been ignored in Ireland chiefly because of his opposition to Home Rule and his support for the theory of evolution. To correct the situation, they have assembled 16 essays by different contributors on various aspects of Tyndall's career. The result is uneven. Some essays rest on a strong scholarly base. Some tend toward affectionate antiquarianism. Some are brief dips, too limited to illuminate.

One should begin by reading Joe D. Burchfield's "John Tyndall—a biographical sketch" and Frank M. Turner's "John Tyndall and Victorian scientific naturalism." Burchfield has done considerable research for a major study of Tyndall, and Turner has published widely on matters involving Tyndall directly and indirectly. From these two essays emerges the book's deepest understanding of Tyndall.

Tyndall's support for the professionalization of science followed frustrations in the early part of his own career and involved his ever-present, outspoken concern for fairness, as he saw it. In the early 1840's he argued for better treatment of Irishmen like himself working on the English ordnance survey and lost his job. Like many others, he found it neces-

"Tyndall's Alpine summer home at Alp Lusgen over 2100 m. Note the Weisshorn above the roof. Tyndall had great faith in the efficacy of the lightning conductors attached to the chimney pots." Books, papers, maps, and apparatus belonging to Tyndall remained in the house until 1963, when they were acquired from his heirs by E. J. Wiseman. [From *John Tyndall*; courtesy of E. J. Wiseman]

sary to go to a German university for an education in science. In the early 1850's, even though his scientific research gained him membership in the Royal Society of London, he still could not find a satisfactory scientific position. Though his scientific accomplishments in diamagnetism, radiant heat, and spontaneous generation did not rank with those of Dalton, Faraday, Maxwell, Kelvin, or Darwin, they earned him a large measure of prominence. Coupled with the position he eventually attained at the Royal Institution, this prominence allowed him vociferously and effectively to promote the many aspects of the professionalization of science, to his countrymen's delight and chagrin. He and T. H. Huxley and others led a movement for change. Tyndall, for example, contributed greatly to the spread of scientific knowledge through his popular lectures at the Royal Institution, a lecture tour of America, and his wide-selling books on science. More unsettling to many of his contemporaries was his extension of such activities into a demand for the culture of the scientist to replace that of the clergyman in dominating the national outlook. These matters crystallized in his controversial presidential address in 1874 to the Belfast meeting of the British Association for the Advancement of Science. He was the agnostic scientist arguing that, in fairness, Britain should acknowledge the social and conceptual superiority of science to religion.

The remaining essays discuss specific parts of this overall picture. Of them, I would mention A. J. Meadows's "Tyndall as a physicist" and J. S. Rowlinson's "Tyndall's work on glaciology and geology." Meadows touches on Tyndall's fundamental view of nature as consisting of aether and molecules but in so short an essay cannot give it the full discussion it deserves. Rowlinson explores one of Tyndall's many controversies with other scientists and suggests a common pattern to these disputes of Tyndall's: "Tyndall takes up eagerly some field of research in which there has been already a considerable degree of progress, he adds some new observations or, very often, devises some ingenious experiments, but then claims a greater novelty or distinction for his additions than an impartial observer would allow."

In summary, although this book deserves to achieve the purpose set for it, it is far from being the best that could be written on Tyndall.

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