battling benighted theological catastrophists whose allegiance to Genesis did not permit an ancient earth. That battle had been won, in part by catastrophists who read the geological record literally and envisioned a long history, infrequently punctuated by major upheavals recorded directly in strata. Lyell's gradualism was an inference based on a (correct) belief in the imperfections of the geological record. It did not arise as a direct and superior observation of strata, and it was as much a product of social preferences for stately change as a conclusion forced by fossils and ancient environments.

Darwin's formulation of natural selection, a transfer of Adam Smith's laissez-faire economics into nature, arose from his immersion in the literature, philosophy, sociology, and economics of the 1830's, not only from a pure vision of finches and tortoises. Yet Stone cannot handle this in his mythology and must paint Darwin's reading of Malthus as a glorious and catalytic accident, rather than as the directed, albeit groping, culmination of an explicit search for an evolutionary mechanism. Stone thereby brushes past the single most important incident in Darwin's intellectual life with a paragraph or two. What else can one say about disembodied serendipity? Pages for subsidiary details, and barely a passage for the greatest event in the history of biology!

Stone also simplifies to the point of misrepresentation the issues swirling about the publication of the *Origin of Species* in 1859. He conflates Darwin's defense of the fact of evolution with his justification for the theory of natural selection as its mechanism—a distinction Darwin always drew with great care because he realized both the weaknesses of his theory and the incontrovertibility of evolution as a fact. (He wrote, for example, in the *Descent of Man*: "I had two distinct objects in view; firstly to show that species had not been separately created, and secondly, that natural selection has been the chief agent of change.") Since Stone equates natural selection with evolution and depicts all opposition to evolution as lingering Bibliolatry, he cannot properly describe the legitimate scientific arguments that swirled about the concept of natural selection, even within Darwin's own circle. He ascribes Hooker and Lyell's reticence to religion (not entirely incorrectly, of course) and bypasses their cogent doubts (in the absence of an adequate theory of heredity) about the creativity of natural selection. (Lyell wrote in his journal that he could equate natural selection with just two members of the "Hindoo triad"—with Siva the destroyer and Vishnu the preserver, but not with Brahma the creator.) Stone doesn't recognize Huxley's opposition at all, though Huxley was a saltationist who objected strongly to Darwin's conflation of natural selection with gradualism. (Stone reproduces Huxley's famous comment only partially: "As for your doctrine, I am prepared to go to the stake for it." Huxley actually wrote, in a letter to Darwin containing his first comments on the *Origin*: "I am prepared to go to the stake, if requisite, in support of chapter 9, and most parts of chapters 10, 11, 12." For the rest, Huxley gives his criticism: "You have loaded yourself with an unnecessary difficulty in adopting *Natura non facit saltum* [nature does not make leaps] so unreservedly.")

Science is the most dialectical of human endeavors. Embedded in culture, it possesses unparalleled power to alter the very systems that nurture it. Stone catches this ambivalence when Lyell urges a reluctant Darwin to admit his error and acknowledge Agassiz's glacial theory for the origin of some Scottish topography. Darwin, pained but acknowledging the inevitable, is saved from further remonstration by a summons to tea. He remarks: "That's an area where people can make no mistakes. High tea. With thin sandwiches of tomato, watercress and cucumber, hot scones buttered inside and served with strawberry jam."

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Hales's Activities

Stephen Hales. Scientist and Philanthropist. D. G. C. ALLAN and R. E. SCHOFIELD. Scolar Press, London, 1980 (U.S. distributor, Biblio Distribution Centre, Totowa, N.J.). xii, 220 pp. $50.

Stephen Hales (1677-1761) was probably the most important English scientist of the 18th century. In two major works entitled *Vegetable Staticks* and *Haemastaticks*, published in 1727 and 1733 respectively, he made a number of significant contributions to plant and animal physiology, and also, through his study of the production or absorption of "air" in chemical reactions, to chemistry. The importance of his work was widely recognized in his own day, and in addition to being a fellow of the Royal Society of London he was in 1753 accorded the distinction of being elected one of the eight *associés étrangers* permitted under the statutes of the Royal Academy of Sciences in Paris.

The titles of Hales's books reflect the distinctive approach he adopted in his scientific investigations. This so-called "statical way of inquiry" focused on the fluids flowing in plants and animals and led Hales to make quantitative measurements of such "mechanical" factors as volume, pressure, and rate of flow. His measurements on plants led him to deny the then commonly held opinion that sap circulated through plants in a manner analogous to the circulation of blood in animals. He observed the variation in sap pressure during the day and noted that the pressure increased when his plants were exposed to the sun. Eventually Hales reached a full understanding of the role of "perspiration" in causing the sap to rise, and in a brilliant series of experiments he successfully determined the rate of loss of water through the leaves of a large sunflower. He also realized that transpiration alone could not account for the remarkable rise of sap in his vines during the "bleeding season," and this led him to the discovery of root pressure as an important additional factor in the process.

Hales acquired considerable notoriety for his experiments on living animals, experiments that seemed entirely out of keeping both with his position as "perpetual curate" in the quiet Thames-side village of Teddington and with his own innocent and simple character. In the best known of these experiments he measured the blood pressure in a live mare directly by tapping one of the animal's femoral arteries and observing how high the blood would rise in an attached vertical tube. In another experiment he made a wax cast of the left ventricle of an animal in order to determine the internal volume of the chamber and thus (after multiplying by the pulse rate) the cardiac output. He also made an extensive study of the flow of blood through the capillaries, eventually concluding that its force was far too small to account for muscular action in the way some physiologists had supposed.

Hales's scientific influence was most strongly felt, however, in chemistry. Prior to his work it was generally agreed that air did not participate in chemical reactions but merely acted as a solvent and carrier for various "steams" and other, grosser active reagents. In a long chapter in *Vegetable Staticks*, Hales presented many experimental proofs that air could be "fixed" in some processes and regain its elasticity in others—that is, that it could enter into chemical combinations in the same way as other matter. Hales himself never envisaged that there might be more than one "air" involved, and hence in his experiments he was content merely to measure the volume of air absorbed or released, without testing for differences in chemical behavior; indeed, had he noticed any such differences he would have attributed them not to real differences between the "airs" involved but to different impurities floating in a single undifferentiated elastic medium. Even so, his work had a profound influence on the succeeding generation of chemists. It led directly to a more detailed study of the chemistry of gases and thence to the crucial advances in chemical understanding that we normally associate with the name of Lavoisier.

In his own day, Hales was at least as well known for his philanthropic endeavors as for his science. He was an influential opponent of the notorious gin trade and played a significant part in having it brought under legislative control. He was an active member of the Society for Promoting Christian Knowledge and one of the trustees of the charitable trust that established the colony of Georgia in North America as a refuge for England's poor. He also sought to apply his scientific knowledge to alleviate suffering. He devised an effective ventilator for ships and an improved method for distilling seawater. In addition, his chemical investigations led him to a long but ultimately unsuccessful search for a satisfactory solvent for those painful sources of human affliction, kidney and bladder stones. Late in life, he played a leading role in the establishment of an important new London institution, the Society for the Encouragement of Arts, Manufactures and Commerce.

These various facets of Hales's career are described in detail in this new biography, in which Schofield provides the chapters on Hales's science and its influence and his inventions and Allan those of a more orthodox biographical kind. In addition to its 140 pages of text, the book includes a full calendar of Hales's correspondence and writings and a complete bibliography of his published works. It is the more welcome because the only other book-length biography, by A. E. Clark-Kennedy, though reprinted some years ago, is still not widely accessible. Furthermore, Schofield in particular has profited from the progress that has been made since Clark-Kennedy's day in our understanding of the way science evolved during the 18th century. His closing chapter on Hales's scientific reputation and influence is the most important in the book and represents a substantial advance on Clark-Kennedy's work. Disappointingly, however, even here the book develops few new or more general perspectives on Hales's work or career, apart from something of an attempt by Schofield to fit Hales into the general mechanism-versus-materialism classificatory scheme for 18th-century British science that he has proposed elsewhere.

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Solid State Physics

The Lattice Dynamics and Statics of Alkali Halide Crystals. JOHN R. HARDY and ARNOLD M. KARO. Plenum, New York, 1979. x, 314 pp., illus. $32.50.

In 1959 John Hardy wrote the first paper on the "deformation-dipole" model at approximately the same time that William Cochran published his investigation of phonons in a crystal (germanium) using the "shell" model of Dick and Overhauser (1958). The models are similar, since both consider the effect of displacement-induced dipolar forces resulting from the deformation of the electronic charge density in a lattice wave. This was the most important step in bringing the theory of lattice dynamics into quantitative contact with experimental data, in particular with neutron inelastic scattering results obtained by Brockhouse and other groups after 1958. In the subsequent two decades there was a fruitful period during which the essential features of lattice forces and related properties in many crystals were clarified. An important part of this clarification may be attributed to the use of what are nowadays called "dipolar models."

In the present book Hardy and Karo offer a comprehensive study of the static and dynamic properties of alkali halides. Discussion of the deformation-dipole model may be regarded as the "hard core" of the book, although many other features are discussed. After an introduction and a review of dipolar models, there is a detailed and useful presentation of dipolar coupling coefficients, Debye-Waller factors, and specific-heat data. After that, the experimental phonon dispersion curves of alkali halides are compared, in detail, with the rigid-ion model, the polarization model, and two versions of the deformation-dipole model. The treatment up to this point contains many impressive examples of agreement between experimental data and the deformation-dipole model, and the presentation of different deformation-dipole models is often very detailed. On the other hand, other interesting and successful approaches are not treated.

The last third of the book contains an interpretation of two-phonon infrared and Raman spectra of alkali halides as well as a short account of impurity dynamics and statics in alkali halides. Many useful references to the relevant literature and to the explicit use of dipolar models in actual calculations are given. The comparison of the models with experimental data and the consideration of the results of other groups are less satisfactory. There is no discussion of the microscopic theory or of models that try to establish explicit connections between the electronic band structure and properties of phonons. The authors state that both of these topics are beyond the scope of the book.

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Achievements in Astronomy

Oort and the Universe. A Sketch of Oort's Research and Person. Liber Amicorum Presented to Jan Hendrik Oort on the Occasion of His 80th Birthday, 28 April 1980. HUGO VAN WOERDEN, WILLEM N. BROUW, and HENK C. VAN DE HULST, Eds. Reidel, Boston, 1980 (distributor, Kluwer Boston, Hingham, Mass.). viii, 210 pp., illus. Cloth, $29; paper, $12.95.

Jan Hendrik Oort is, by common consent, the most influential astronomer of the present century. Born on 28 April 1900, Oort has made sustained and fundamental contributions to astronomy for some 60 years, and his major accomplishments during the past six decades are landmarks in the continuing development of astronomy. They include his discovery of galactic rotation in 1927, followed by his discussion of the galactic dynamics in the vicinity of the sun, his determination of the force field perpendicular to the galactic plane in 1932, his role in van de Hulst's prediction of the 21-centimeter line of hydrogen, his discussions relating to the formation and growth of interstellar grains during World War II, his first delineation of the spiral arms in the Milky Way system