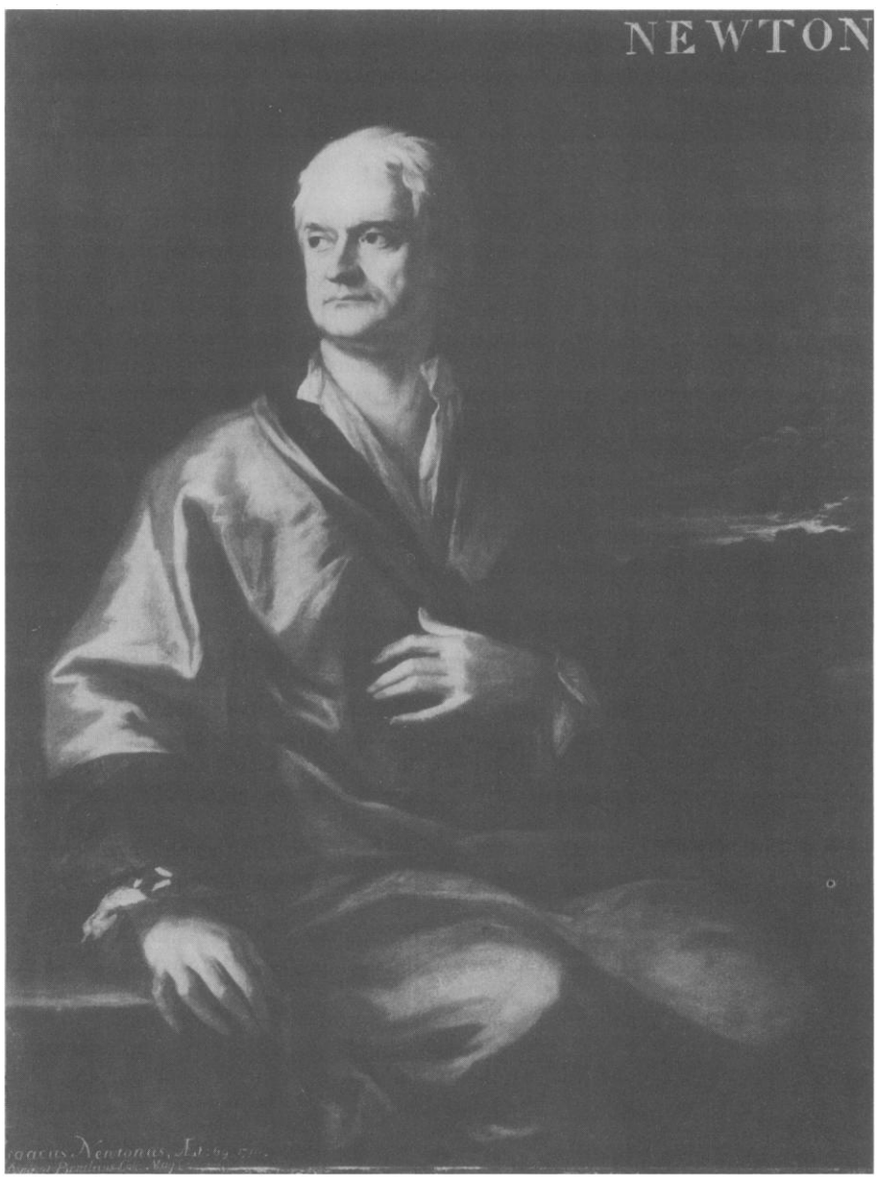
Isaac Newton

Never at Rest. A Biography of Isaac Newton. RICHARD S. WESTFALL. Cambridge University Press, New York, 1981. xviii, 908 pp., illus. $49.50.

You may ask why we are being subjected to a 900-page biography of the most renowned figure in the annals of science. There have after all already been major studies of Newton by over a dozen authors since David Brewster's pioneering *Memoirs* in 1855, and beginning in the 1950's a virtual avalanche of popular works, symposium proceedings, learned articles, and publications of documents that is enough to frighten away all but the most courageous of specialists. Why yet another entry for library catalogues, and at that a long, expensive, and laborious work that requires considerable energy to absorb?

Because this is the first detailed biography of Newton written by a professional historian of science who, over the years, has mastered the prodigious literature, weighed it judiciously, and still manages to reveal new insights by delving into the mass of Newton's unpublished writings. Westfall has produced a work of major significance, likely to stand as the classic treatment of Newton for decades to come. It is at once an imposing synthesis based on recent research, particularly the work of Herivel, Whiteside, and the editors of Newton's correspondence; an independent assessment of the eccentric personality that shaped the unfolding of his ideas to the world; and a treasure trove of new views that future writers will want to explore, and no doubt dispute. Clearly the concentrated and persistent efforts of a distinguished scholar, the financial support provided by the National Science Foundation, the National Endowment for the Humanities, and various private foundations, and the industry of Newton scholars everywhere have paid off handsomely.

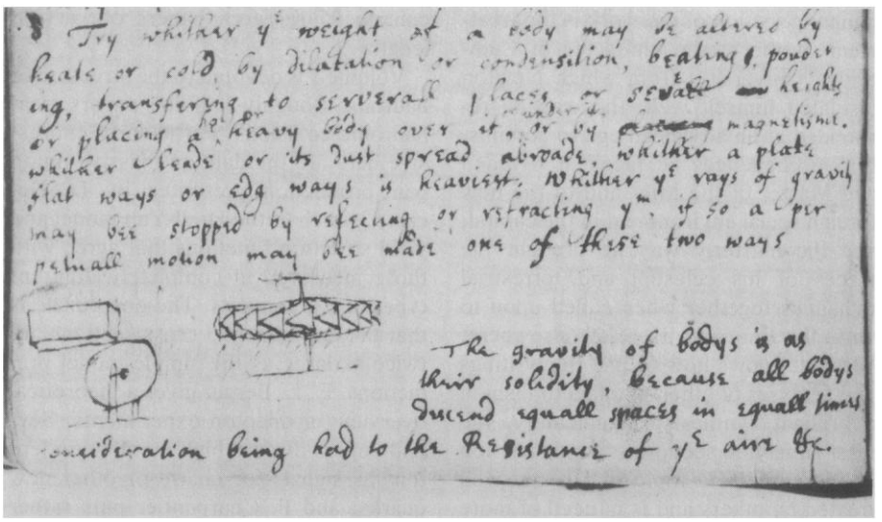


Newton at 67. Portrait by Sir James Thornhill, 1710. [From *Never at Rest*; courtesy of the Master and Fellows of Trinity College, Cambridge]

In Westfall's account, Newton's central contributions still stand firmly on a tripod composed of mathematics, mechanics, and optics, subjects that preoccupied him over the whole of his career. But it should no longer be possible after this monograph to conceive of his original concepts as emerging full-blown from that miraculous year of 1665–66, when the Cambridge student established general rules for solving the quadrature problem, formulated laws of mechanics that accounted for circular motion, and discovered the chromatic nature of white light. Westfall convincingly shows that these brilliant accomplishments—spaced out over three calendar years—were only the beginning of Newton's creative work. They amounted to more than momentary glimpses or protracted insights into the future, but far less than the new theories on which his revolutionary reputation would eventually rest. Westfall tells us that "in 1666, by dint of keeping subjects constantly before him, he saw the first dawnings open slowly. Years of thinking on them continuously had yet to pass before he gazed on a full and clear light."

Unlike psychologist-biographers who sense they have a grasp on what motivates originality, Westfall sidesteps an explanation of creative genius. He explores in depth Newton's familial background, his social milieu as a youth, his independent personality, his fascination with mechanical devices, and the nature of the academic environment at Trinity College; he knows from various frag-

ments what works Newton read and makes intelligent guesses about the order in which he puzzled over them; he marshals all the evidence available on the surrounding physical circumstances and the sequence in which these brilliant ideas came. But in the end Westfall recognizes that Newton was sui generis and that nothing more convincing than his "genius" can account for this remarkable creativity. In the preface, Westfall even confesses that he feels too ordinary a mortal to take a true measure of Isaac Newton. There may be something self-serving in this display of modesty, and I found it slightly out of place. But Westfall is essentially correct in observing that superior intellect is not something historians can completely decode; the most they can do is to set down the story in as intelligible a form as documentation allows. That Westfall does with great skill and detail.



Newton's sketches of perpetual-motion machines powered by the flux of the gravitational stream. [From *Never at Rest*; courtesy of the Syndics of Cambridge University Library]

No biographer has revealed more about his subject's family and educational background. Contrary to what another recent biographer of Newton, Frank Manuel, would have us believe, there is no direct evidence that Isaac harbored a deep hatred of and had a fixation on the mother who abandoned him for a 63-year-old second husband when he was a mere infant. Westfall suggests that on his infrequent trips away from the university the young Newton went to look after his widowed mother and their holdings. More important, he profited from support that originated in his stepfather's family wealth and more likely chose to apply to Trinity because of his uncle. We also learn of the probable influence at critical points in his Cambridge career of one Humphrey Babington, brother of his landlady at Grantham. Thus in a number of small ways, particularly when Sir Isaac of London lent money to relatives of his stepfather, one derives a picture of a man willing to face his responsibility to kin, even if they turned out to be a nuisance. Newton does not emerge as a man obsessed with the trauma of his youth but more like a tolerable relative who did not turn his back on local acquaintance at Woolsthorpe or Grantham.

With his would-be peers at Cambridge and London, on the other hand, Newton was hardly ever friendly. He treasured solitude, resented conventional social contact, and could not tolerate contradiction and criticism because he was impertinently sure of his prowess. Westfall recounts in stunning detail the well-known stories of Newton's protracted conflicts with Hooke, Flamsteed, and Leibniz and reminds us repeatedly how easily he could fly into a rage when his ego was pricked. None of us would be likely to enjoy dealing with him as a colleague. He was haughty and often unnecessarily rude and seldom displayed any charity toward those engaged in similar pursuits, except when he needed them as patrons or could expect to dominate their careers and command loyalty by recommending them. For all this negative characterization, it must be admitted that Newton was usually right in his substantive judgments, that his critics did in fact frequently misapprehend his work, and that they were often as vain, stubborn, and provocative as he was.

Moreover, his career ultimately depended upon colleagues. Newton's genius might never have been known had his fellow natural philosophers not pestered him and galvanized him into action. He never sought fame by conventional means, though he surely craved it. His relationship with the London scientific community was fitful and fiery until he settled there. But he waited until Hooke died before lording over the profession and taking over the presidency of the Royal Society, where he ruled autocratically starting in 1703. Prior to this, everyone had to tease out his creation: Henry Oldenburg, secretary of the Royal Society, cajoled him to send in his color theory; the mathematical entrepreneur John Collins spread his calculus theorems; Edmond Halley pried the *Principia* out of his cabinet; the physicist Roger Cotes pushed him into major revisions in the second edition; and Abraham De Moivre and Samuel Clarke spurred him on with emendations of his *Opticks*. All of them immediately recognized his superior abilities and sought to have his brilliance shared with other virtuosi. But, unlike most of his admirers, Newton resisted the contemporary trend to make science a communal and cooperative enterprise. Fortunately he was prevailed upon to give his work to the public and forced to turn his genial discoveries into coherent papers and rationally argued treatises.

There were two areas of passionate concern that Newton never fully revealed to the world, alchemy and theology. In recent years scholars have been prone to make extravagant claims concerning these activities of our genius. Westfall clearly does not share Newton's conclusions on either subject, but he is professional enough to discuss them with sympathy and assigns them a serious place in Newton's view of the world. Both served to feed Newton's need for a metaphysics in the analysis of his natural philosophy and played a central role in his blending of the mechanical philosophy with the concept of force and activity that seemed to pervade the universe. He sought to divine these forces through a study of arcane texts, religious and alchemical, and used his own money and superior abilities as an experimenter to wrest additional secrets from nature in his rooms at Trinity. Specialists will undoubtedly differ with Westfall's interpretation, but his presentation appears plausible and judicious to me, though not beyond debate. My major concern is however with the small effort he expends to assess Newton's views in the light of the knowledge of his day. Westfall has a better appreciation of and interest in Newton's more conventional and proven achievements in mathematics, optics, and mechanics than in these secretive activities.

For me the most impressive and illu-

minating section of the work is the treatment of the sterile character of Cambridge University, from which Newton insulated himself well; the way he responded at an advanced age to administrative challenges he faced as Warden and Master of the Mint and to the new foreign social environment in the capital; and the masterly way he brought the pieces of his celestial and terrestrial dynamics together when called upon to write the *Principia*. Here, as elsewhere, Westfall knows how to use the writings and analyses of other scholars to fashion a brilliant synthesis. Significantly, the least satisfying section is the discussion of the *Opticks*, a topic that is not well treated by others and is in need of more study. I was left puzzled by the way Newton was able to juxtapose his color theory with several periodic optical phenomena discussed on the basis of his excellent observations. That is just one of many subjects that have not been exhausted. But Westfall will surely have brought its discussion to a new and higher plane with this magnificent biography.

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Particle Physics

Proceedings of the Fifteenth Rencontre de Moriond. Les Arcs-Sovoie, France, March 1980. J. TRAN THANH VAN, Ed. Editions Frontières, Dreux, France, 1980. In two volumes. Vol. 1, Elementary Constituents and Hadronic Structure. 706 pp., illus. $65. Vol. 2, Electroweak Interactions and Unified Theories. 606 pp., illus. $65.

Over the past five years experimental evidence has steadily mounted in support of what are now the standard descriptions of three fundamental forces in nature: the strong, short-range interactions between hadrons (for example, protons and neutrons); the weak, short-range interactions common to hadrons and leptons (for example, electrons); and the familiar long-range electromagnetic interactions between charged particles. The implications of these three theories are often best tested in very high energy collisions. One of the numerous conferences at which new results are reported is the Rencontre de Moriond, held in the French Alps each March for two weeks. The papers presented at these meetings are less formal than those published in the research journals but not as pedagogical as the lectures at summer schools. The two volumes of 1980 proceedings contain 95 research papers of varying lengths.

Volume 1 is devoted to the structure of hadrons. Roughly half the papers treat hadronic collisions. Particularly impressive here are the data on massive muon pair production presented by D. Decamp, which fit the Drell-Yan model and yield structure functions that agree with those measured in completely different types of experiments. The one puzzle is that the experimental cross sections are twice as large as the simple model predictions. E. L. Berger gives a theoretical overview of dilepton experiments. Several papers discuss high momentum leptons as signals for charm or other new quarks, and P. Charpentier puts rather strong limits on the production of B mesons from trimuon and like-sign dimuon events. There is a rather standard assortment of papers on hadronically induced jets and on photoproduction.

New data are presented on deep inelastic muon scattering by J.-M. Thenard, K. Rith, Y. Sacquin, and R. Johnson and on deep inelastic neutrino scattering by D. Schlatter and P. Fritze. At momentum transfers as large as 200 GeV^2 the scaling violations at large x are as expected but are slightly ambiguous at small x. Unfortunately, the data presented are preliminary.

A. Petersen, D. Schmidt, G. Mikenberg, and H. B. Newman, each representing one of the four major groups at PETRA, display very beautiful results on hadronic jets produced in e^+e^- collisions. Each of the four reports is quite thorough and presents solid evidence for the existence of three-jet events at energies of 30 GeV (center of mass). The significance of these events and theoretical expectations for the future are thoroughly discussed in a 40-page report by S. Wolfram.

Volume 2 deals with the electroweak interactions and unified theories. B. Gittelman, P. Skubic, and S. Herb from CESR as well as J. K. Bienlein and K. R. Schubert from DORIS report on the first measurements of the $b\bar{b}$ bound state system. The masses and leptonic widths of three very narrow states and one broad one are measured and agree with theoretical models as described by A. Martin. M. Oreglia, D. Aschman, and G. J. Feldman from SPEAR each present very precise results on radiative transitions between states of the lighter mass $c\bar{c}$ system. They see evidence for only one pseudoscalar state that does not decay into two photons and are able to measure the angular momentum of the χ states from the angular distribution of the photons associated with their production and decay. R. Marshall, W. Bartel, H. Spitzer, F. Vannucci, and D. H. Saxon from PETRA each report on the search up to 35 GeV for $t\bar{t}$ states, heavy leptons, weak electromagnetic interference, and free quarks. From 2-GeV measurements at Orsay, A. Cordier presents evidence for the ϕ' resonance partner of the ρ'. In a section on muon and neutrino physics there are several papers on beam dump experiments and dimuon events and a nice review by M. Strovink of multilepton production. J. Trischuk presents the results of several emulsion experiments that measure charmed meson lifetimes.

The small collection of theoretical papers on grand unification provides a useful review. K. Kang introduces the SU(5) model and then follow two papers of more than 40 pages each—a lucid and practical discussion by D. V. Nanopoulos of the SU(5), SO(10), and E_6 grand unified models and a pedagogical gem by K. D. Lane and M. E. Peskin on dynamical symmetry breaking.

These volumes are not intended to provide an overview of the field. They are extremely topical and in many instances the reports may already be superseded by journal articles.

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Developmental Biology

The Development of the Vertebrate Limb. An Approach through Experiment, Genetics, and Evolution. J. R. HINCHLIFFE and D. R. JOHNSON. Clarendon (Oxford University Press), New York, 1980. xvi, 268 pp., illus., + plates. $59.

This excellent book is the first to attempt a comprehensive review of vertebrate limb development. It draws together information and ideas from the fields of evolutionary biology, genetics, and experimental embryology. In many ways the book is inconclusive, and it raises as many questions as it answers. But it is just this kind of bold statement that will contribute to the process of getting some of the loose ends tied up.

The book has a pleasing symmetry in that it both begins and ends with evolutionary considerations. In between are chapters on adaptation and diversity, embryology, regeneration, and pattern formation. Throughout the book the authors attempt to discuss as many different vertebrates as possible, although the experimental sections concentrate on the chick wing. This is not a criticism of the