along with the practices resulting from such belief. He sees superstitions as growing out of the human need to understand and predict events. Many superstitions, though lacking empirical validation, have embodied some logical elements and have offered comfort and reassurance in troubled times. Because of the many inexplicable phenomena connected with reproduction and childbirth, an especially large number of superstitions have grown up around this subject. In *The Midwife and the Witch,* a fascinating record of a variety of such superstitions and practices, Forbes has provided a few glimpses into the medical practices, social life, and intellectual traditions of the times—primarily the period from the late Middle Ages to the 17th century.

The book is composed of ten more or less independent chapters, dealing with such topics as sex reversal (specifically in fowl), sexual anomalies in animals (such as the freemartin), fertility and pregnancy tests, sex prediction, and the variety of good-luck charms employed during childbirth. The last three chapters are specifically concerned with the midwife—her social status, her role as medical and spiritual guide, her alleged relations with the powers of evil, and the attempts made by both church and state in the later 16th and early 17th centuries to raise the standards of her profession.

The book is elaborately researched and contains a vast collection of information about many curious beliefs. The variety of means employed to predict the sex of an unborn child provides a particularly good example of the detail which the author brings to this study. We learn that observation of the urine of a pregnant woman was frequently used in Renaissance Europe as a means of sex prediction. One test involved allowing a vial of urine from a pregnant woman to stand overnight; if the liquid became cloudy at the bottom of the vial the child would be male; if the liquid became cloudy in the middle region of the vial the child would be female. If no turbidity was visible it was certain that the woman was not pregnant at all. Another urological test involved the effect of the urine on germination of seeds. It was widely believed in the 15th and 16th centuries that seeds watered with urine from a pregnant woman would germinate faster than those watered with urine from a nonpregnant woman. Furthermore, germination was supposed to offer a reliable prediction of the child's sex. Barley and wheat seeds were sown at the same time in a small plot of earth, and watered with urine from a pregnant woman. If the wheat sprouted first, the child would be a boy, but if the barley sprouted first, the child would be a girl. In recounting these and other curious beliefs, Forbes shows how many paths man has followed to satisfy his impatience over events of the future.

To the historian of medicine the insights which the chapters on the midwife, in particular, give into many aspects of medical practice in 16th- and 17th-century Europe are interesting and valuable. The appalling state of the knowledge possessed by most midwives, the lack of any standards for entrance into the profession, and the often dangerous combination of rule-of-thumb practices and magical procedures involved in actual childbirth indicate how little was known among most people about reproductive phenomena. A particularly interesting aspect is the story of attempts of both church and state to upgrade the midwife profession by licensing procedures. The author points out that most such attempts were aimed principally at insuring that the midwife had a good character (that is, was not in league with the Devil) rather than at insuring that she possessed a thorough knowledge of her profession. Nowhere did the boundary between sound medical practice and superstition become more indistinct than in connection with reproduction and childbirth during this period of western history.

Particularly useful to scholars is the extensive bibliography of over 900 items which Forbes has included. Many secondary items provide valuable hints for further and more specific research on a variety of topics raised in the present study. Inclusion of many quotations from primary sources is also a help to scholars, while providing an intriguing authenticity for the author's account.

Many of the chapters in the book are modified versions of articles previously published in various scholarly journals, and as a result the book as a whole lacks unity. Chapter 2, a detailed discussion of the etymology of "heifer," "freemartin," and "ridgeling," does not add anything important to our understanding of past beliefs about sexual anomalies. A difficulty that stems partly from the lack of unity is that the author has not drawn many conclusions from his work. Even within the individual chapters, there is little attempt to analyze the common sources of certain beliefs, the philosophical and religious assumptions underlying a particular set of superstitions, or the relations between views of the supernatural in general and important social or intellectual trends of the times. It may be that such analyses are at this point impossible because of an insufficiency of such specific studies as those Forbes has presented, but one might wish that Forbes himself had kept these larger aims in view.

Despite these disappointments, however, the book is a valuable and extremely interesting supplement to studies (such as F. J. Cole's *Early Theories of Sexual Generation*, Oxford University Press, 1930) on early ideas about the biology of reproduction.

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A System of the World

Celestial Mechanics. Vols. 1–4. PIERRE SIMON DE LAPLACE. Translated, with a commentary, from the French edition by NATHANIEL BOWDITCH. Reprint of 1829–39 edition. Chelsea, New York, 1966. 3940 pp., illus. $79.50.

The close of the 18th century in astronomy is nowhere more completely epitomized than in the great Treatise on Celestial Mechanics of Pierre Simon de Laplace, which appeared in five enormous volumes between 1799 and 1825. As a synthesis of astronomical thought since the 17th century it embraces the achievements of the major mathematical astronomers of the continent who built so well upon the firm accomplishment of Isaac Newton: d'Alembert, Clairaut, Euler, Lagrange, and others. Laplace joined his skills and discoveries to them all in the creation of a scientific masterpiece, but it was above all from Lagrange that he received the most. On certain special problems, such as those dealing with secular inequalities, the two were almost constantly in touch; between 1773

and 1784, for example, each took from and fed upon the other in a remarkable series of intellectual rebounds that produced some of the most important general results in all of gravitational astronomy. Viewed from a historical distance, the *Celestial Mechanics* is clearly a response to the basic question generated by Newton's enunciation of the law of universal gravitation. Given the position and the movements of the members of the solar system at any set time, is it possible thereafter to deduce mathematically from the gravitation which mutually binds them their positions and motions at any other time? Of course such deductions would have to agree with actual observations. The resounding affirmative which Laplace's formulation gave, 100 years, almost to the moment, after the question was first posed as the essential, implicit query of the *Principia* taken as a whole is not only a measure of Laplace's own grasp of theoretical mechanics and his powers of mathematical analysis, but a final vindication (if such there need be) of the incredible richness of Isaac Newton's insight into the fundamental problems of matter and motion.

By setting the Newtonian problem in its most general form—a concern for the attraction between elements of mass, with the forces exerted between whole bodies considered as the sum of these forces properly adjusted for the larger shapes or conglomerates involved—Laplace derived a system of the world as close to fulfilling the mechanistic ideal of the scientific revolution of the 17th century as any which have ever been produced. The ten books (85 chapters) of the translated work move from a statement of the general law of equilibrium and motion (founded, of course, on the law of universal gravitation) through problems of the movement of and about centers of gravity, the figures of the heavenly bodies, and the theory of planetary motion as well as of satellites, especially the difficult problem of the moon, to a theory of comets, the oscillation of the sea and atmosphere, and almost in passing to comments on the stability of the solar system and the role of theory in science. If the great clock metaphor for the running of the universe thus found substance in Laplace, it was not without the casual dismissal of little irregularities. Discrepancies between observation and theory were there, but their incremental character, attributable to correctable errors of observation or calculation, did not ripple the calm scientific world of post-Laplacian mechanics. Laplace's own words, perhaps, spoke for them all:

> It is chiefly in the application of *analysis* to the system of the world, that we perceive the power of this wonderful instrument; without which, it would have been impossible to have discovered a mechanism which is so complicated in its effects, while it is so simple in its cause. The mathematician now includes in his formulas, the whole of the planetary system, and its successive variations; he looks back, in imagination, to the several states, which the system has passed through, in the most remote ages; and foretells what time will hereafter make known to observers [vol. 3, p. xiii].

About 20 years after the publication of the fourth volume, Laplace added a fifth. Actually this last volume, which appeared in parts (books XI and XII in 1823, XIII, XIV, and XV in 1824, and XVI in 1825), completed a program announced at the beginning of the treatise—to comment historically upon those whose labors had contributed to the content of the *Celestial Mechanics*. But having continued his research over the long years of its publication, Laplace took advantage of the occasion to add to the last volume a considerable amount of material that had either appeared elsewhere (in the *Mémoires de l'Institut de France* or the *Connaissance des Temps*, for example) or simply reflected his reexamination of certain problems. Thus the original French edition contains not only a historical *aperçu* but a return voyage. A Celestial Mechanics Revisited thus gives us a rare historical opportunity to notice what a great scientist chooses to add to an earlier masterpiece. Unfortunately, this is not made available to us in the present reprint, though it would have been simple enough to add the last volume either in the original language or in modern translation.

Nathaniel Bowditch, whose *New American Practical Navigator* in editions without end continues to be a useful text down to our own day, made the translation of the first four volumes between 1814 and 1817; but the late appearance of the fifth volume, other obligations, and finally death, prevented him from undertaking the final one, though there are extant notes for the task. The whole enterprise was obviously a labor of love, for this translation is much more than a linear shift from one language to another. It is armed with intelligent, clarifying commentary that brings light to dark passages and elucidates those intuitive transitions of the mathematician so frequently obscured by a dismissing reference to the obvious. In Laplace this nonrevealing process was nearly always announced by the phrase "Thus it plainly appears." The praise for Bowditch's achievement came from extraordinarily high places: Babbage, Bessel, but best of all, perhaps, was Legendre's comment:

> Your work is not merely a translation with a commentary; I regard it as a new edition, augmented and improved, and such a one as might have come from the hands of the author himself, if he had consulted his true interest, that is, if he had been solicitously studious of being clear.

There is much about Bowditch himself in a "Memoir of the translator" (including the interesting observation that he is supposed to have translated all or a part of Newton's *Principia*) that was part of volume 4 of the original edition. In transferring this biographical sketch in the present edition to volume 1, the publishers have neglected to indicate that it was written by his son, Nathaniel Ingersoll Bowditch. Worse yet, the last volume having appeared in 1839 and the first in 1829, some readers of the reprint (in spite of the publisher's inadequate warning) may worry about a posthumous biography preceding the decease of the subject.

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Huxley's Classic of Explanation

On a Piece of Chalk. THOMAS HENRY HUXLEY. With an introduction and notes by LOREN EISELEY and illustrations by Rudolph Freund. Scribner's, New York, 1967. 90 pp. $4.95.

During the 1868 meeting of the British Association for the Advancement of Science in Norwich, Thomas Henry Huxley delivered a lecture for the workingmen of the city. Building the lecture around a piece of chalk, he described