KENNETH D. KEELE, *Leonardo da Vinci's 'Elements of the science of Man'*, New York and London, Academic Press, 1983, 4to, pp. xiii, 385, illus., $90.00.

It is at first sight imaginative but also in a sense perverse that a journal concerned with the history of medicine should have invited a historian of art to review this major new book on Leonardo da Vinci's anatomical and physiological researches. Perverse, since it runs the risk of perpetuating the misconception that Leonardo was foremost an artist. He was, it is true, *first* an artist, for he was trained as a painter and draughtsman (and perhaps as a sculptor too) in the cultural ferment of early Renaissance Florence. But the most fertile and productive explorations of Leonardo's maturity were in the field of "science", in the broadest possible sense of the word. Painting was for Leonardo just one branch of *scientia,* and drawing was for the most part merely a tool for the clearer illustration and exposition of the fruits of his profound and extensive scientific thoughts and investigations.

In this respect, the value of his training as a draughtsman in Verrocchio's Florentine workshop during the 1460s is inestimable to us, as it was to him. Without the innumerable brief, but vigorously illuminating sketches and diagrams which pepper his notebooks on the "science of man", many of his ideas and experiments would be less directly intelligible to the twentieth-century mind. Fundamental discoveries which condition our scientific thought about the elemental facts of the physical world post-date Leonardo's view of physics, which was based still on symbolic, even mystical medieval beliefs about the nature of the physical world. Today's scientist is thus orientated very differently towards the subjects that Leonardo tackled.

It is crucial to Leonardo da Vinci's intentions that those who read Kenneth Keele's synthesis of his investigation of the "Mechanics of Man" should realize that his illustrations are intended in no sense as creative works of art. They are rather the most direct and informative illustrative diagrams which at that time a scientist (anatomist, physiologist, philosopher of science as Leonardo was) could possibly have provided for his text. Dr Keele makes this clear at once in his introduction, writing that "[Leonardo] designed [his anatomical drawings] to reveal the mechanism of 'Man the Machine' ". Likewise, Keele has designed his discussion to reveal Leonardo the student of "Man the Machine" through a systematic analysis of many aspects of Leonardo's scientific studies. So broad is the context and range of Leonardo's contributions in this field, as equally is Kenneth Keele's contribution to Leonardo studies, that full evaluation is beyond the individual competence of either the historian of art or the historian of science. Like Leonardo, Keele includes numerous diagrammatic sketches in order to throw further light on the reconstructed treatise 'on the elements of mechanics' which Leonardo himself later integrated with "his investigations on the movements of man and animals as well as his [finished] anatomical drawings". Keele's monumental work is self-effacingly described as "an outline of the results of such studies", in which the author has confined his efforts "to clarifying the principles underlying Leonardo's researches in each major field". Throughout the book, Keele shows his profound and sensitive understanding of Leonardo's thoughts and mind, the product of many years of devotion to the thorough study of the vast mass of writings and drawings which survive to testify to the depth and complexity of Leonardo's researches.

The text opens with an instructive scientific biography of Leonardo da Vinci, which sets out chronologically the development of his enquiry into the Mechanics of Man in relation to historical information on his career. It is at once clear that Keele wishes to share with the reader his perception of "Leonardo emerging from the artist-engineer through the phase of art and invention into the creative scientific artist of maturity so characteristically embodied in his science of man". Detailed discussions of the wide-ranging facets of Leonardo's investigations are each pursued in a separate chapter: on the eye ("the Gateway to Science"); on the senses, which are separately considered by Leonardo with extraordinarily perceptive anatomical study though often misunderstanding the physiology involved; on the anatomy of mechanisms and movements; on the nervous, respiratory, digestive, urinary, and reproductive systems; and, as a culmination, on the heart, "the most powerful muscle". Each chapter is arranged more or less chronologically, often opening with quotations from early, relatively uninformed and naïve notes and diagrams that set the base level from which Leonardo's understanding of

each problem developed, for, as Keele says, "the movement of Leonardo's mind through his life constituted a continuum".

Before embarking on his analysis of Leonardo's perception and understanding of the anatomy and physiology of these aspects of Man and Machine, however, Keele considers the general principles of Leonardo's physics in a succinct discussion of his theories of the four elements and the four powers. "It is not easy to put ourselves into Leonardo's world", he writes, because the preconceptions with which Leonardo was brought up are very different from those accepted in post-Newtonian physics. In a remarkable extended analogy, Leonardo himself showed that he followed the medieval summation of classical, principally Aristotelian, and later thought in identifying the microcosm of Man with the macrocosm of Earth. Both the macrocosm and the microcosm are composed of the four elements, earth, water, air, and fire; and in parallel, the elements of earth and man are controlled by the four Powers of Nature, movement, weight, force, and percussion. Leonardo explained all the forms and forces of Man the microcosm as best he could in terms of these two simple and coherent quartets, and it is fundamentally important both to Leonardo and to Keele that the reader should comprehend this basis of Leonardo's physics and understanding of the physical world.

In his Epilogue, Keele ties together the many threads he has pursued through this volume, which, although large, is nonetheless of necessity only an abbreviated account of Leonardo's entire scientific output. "To do Leonardo's work justice," Keele writes, "every chapter should be expanded into a book." It is an immense enterprise to produce a synopsis of such clarity and depth from so huge a corpus of surviving notes and sketches. Dr Keele has here made an important contribution not only to the history of medicine but also to the history of art, for he illustrates many little-known sketches alongside celebrated Leonardo drawings, and offers insights into the nature of Leonardo's mind and thought which the student of his paintings and drawings will do well to take in. For, in Leonardo's view, painting "explains the causes of Nature's manifestations as compelled by her laws": without the brilliance of draughtmanship which Leonardo displayed in all the drawings reproduced in this book he could not have started to discuss constructively most of the manifold problems in the science of Nature and Man that he investigated, because the language of science at his time was woefully inadequate to the task. Perhaps, then, the art historian has after all a useful part to play in disucssion of this book, for in Leonardo da Vinci's work more profoundly than in that of any other great thinker art and science mix and fuse in coherent complementarity.

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F. W. J. McCOSH, *Boussingault. Chemist and agriculturist,* Dordrecht, D. Reidel, 1984, 8vo, pp. xv, 280, illus., £35.50.

Jean Baptiste Boussingault (1802–87) is generally remembered for three things: as the friend and collaborator of J.B.A. Dumas (though, in fact, the *Essai de statique chimique des êtres organisés,* 1841, was written entirely by Dumas); as a scientific agriculturist whose work brought him into conflict with Liebig, both over the significance of nitrogen in crop rotation and the origin of fat in herbivores; and as the chemist who attended the 1860 Karlsruhe conference on atomic weights where he put into practice his aphorism that "it is not chemistry that grows old but chemists!" by urging that none of the congress's resolutions should be binding upon individual chemists.

However, in this affectionately-written, well-documented, critical biography, Boussingault and his family stand symbolically for France's slow industrial revolution in "a union of steel manufacture, civil engineering, chemistry and agriculture". The son of a shopkeeper, Boussingault was one of Humboldt's many protégés. Like his patron, he trained as a mining engineer before spending ten exciting years in South America (1822–32) in the mining academy at Bogotá in newly liberated Colombia. His experiences there added considerably to the observations of Humboldt and Bonpland and sustained Boussingault in publications into