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The Works of Sir John Leslie (1766-1832).

Professor of Mathematics, Edinburgh, 1805-1819.
Professor of Natural Philosophy, 1819-1832.

By E. M. HORSBURGH.

The Edinburgh Mathematical Society, at the opening of the session on 4th November, 1932, paid tribute to the fame of Professor Sir John Leslie by a Centenary celebration. An account of this will be found in the *Edinburgh University Journal* for the current year. In view of the recent amazing advances in Science, both pure and applied, it is of interest to observe where mathematics and physics stood at the beginning of this brief interval of exactly one century.

Leslie was a self-taught mathematician and physicist, diverted into the straight path of mathematics at the mature age of eleven or twelve by a gift of mathematical books from the minister of Largo. As a professor, he was considered by his colleagues to know the whole field of mathematics and physics of his day. His life time marks the dawn of Britain's great period of prosperity, in which her engineering, commerce, industry and science raised her to a lofty position. It is of interest to know what was being taught and accomplished in mathematics and natural philosophy at this time. Accordingly it has been thought that readers of the *E.M.S. Notes* might like a few comments on some of his greatest works.

Leslie was a man of strong individuality, with some charming inconsistencies, and many delightful prejudices. People had not then achieved the dead level of mass production in character, appearance and goods. In Leslie's mind we observe a strife between the contrasting outlooks of the pure scientist and of the engineer. The former was his ideal, the latter was congenital. When he entered the University as Professor he at once remodelled the teaching, first in Mathematics, and then in Natural Philosophy. In both of these huge subjects he endeavoured to write a complete set of text books for the student. He was a most voluminous writer, but only a few of his most important publications can be touched on, and these only in the shortest manner. His prefaces are of great interest to those who seek to study the man. His style is somewhat ponderous, but it is vivid, and one seems to see and hear the speaker.

In mathematics he was an ardent geometer. We look on the reform of Euclidean geometry as modern, but even in 1805 Leslie was a keen reformer. Judging by remarks embalmed in the margins of his text books, like Pope's grubs in amber, the mathematical students must have got a nasty jar when Leslie wielded his new broom among the time-honoured propositions of Euclid. Though so devoted an admirer of the ancient Greeks, his constructive bent makes his geometry practical. His University course, as displayed in his University text books, by neglecting, or subordinating computation, algebra, co-ordinate geometry, differential and integral calculus, is enough to startle a mathematician. But his setting out of the Euclidean herbaceous border will be viewed with interest by the teacher, who may find incidentally many valuable rooted cuttings, suitable for transporting to the forcing frame of the examination paper. In trigonometry he works by proportion, as was then the universal habit, and so is without that wealth of trigonometrical identities now such a familiar feature of text books. He has a great enthusiasm for geometrical analysis, but this is not analytical (co-ordinate) geometry. He even expresses a distinct dislike to that fundamental subject. This is another of his prejudices. He admires its power but mislikes it for apparently subordinating the logic. His geometrical analysis is well worthy of study. Such was the subject matter of Vol. I. of his mathematical course. It went through four editions and was translated into French and German, a high honour at that time.

The second volume consists of three treatises, *Geometrical Analysis*, *Geometry of Lines of the Second Order*, and *Geometry of the Higher Curves*. The first treatise is a continuation of a corresponding section in Vol. I. He explains analysis as the procedure by which a proposition is traced up to a known operation, or an admitted principle. This is a sort of inverted form of solution.

The reverse of this constitutes synthesis, the method usually employed for explaining the elements of science. Thus analysis presents the method of invention, while synthesis directs the course of instruction. In this order the propositions are expounded.

The second treatise, *Lines of the Second Order*, is in two parts. The first portion deals with the more simple properties of conics, while the higher part treats chiefly of the construction of conics to satisfy all sorts of conditions.

In his *Geometry of Higher Curves* he has collected into one text "all the remarkable curves above lines of the second order," which had been till then scattered through the pages of continental writers in "volumes difficult of access." We may suspect that he clad them in geometrical robes, so as to follow the British fashions at the time. He remarks quaintly: "The superior elegance and perspicuity with which the geometrical process unfolds the properties of these higher curves, may show that the fluxionary calculus should be more sparingly employed, if not reserved for the solution of problems of a more arduous nature." After that it comes quite as a shock to meet mere differential equations masquerading in such elegant geometrical company, but these are seen to be rank outsiders, members of the *nouveaux riches*. Perhaps, however, it may be permitted at the present day to regret that the minister of Largo had not included a book or two of analysis in his original gift.

His collection of higher curves is closely followed in modern works. The volume ends with a section on spirals, one of his many interests.

The third volume was to contain (i) Descriptive Geometry ; (ii) Theory of Solids (including Perspective); (iii) Projection of the Sphere ; (iv) Spherical Trigonometry. This work was not published, though the subject matter may have been taught. Though Leslie did not write on the various branches of mathematical analysis he must have introduced such subjects to his classes.

Later in life he recast the elements of Vol. I into "*Rudiments of Geometry*," which he intended to act as a course of what is now called Practical Mathematics.

His *Philosophy of Arithmetic* obtained high praise when it appeared. It is a mine of curious information, He traces the rise of numbers and their symbolic representation from primitive savages to cultured times. He unearths unheard of users of the different scales of notation, and deals with arithmetical operations in the various scales. Hence follow the abacus with its uses, the digital arithmetic of the middle ages, and Napier's "Bones." Thus it contains portions of the information collected with trouble from other sources in the *Napier Tercentenary Handbook* of 1914. Leslie gives an extended multiplication table, and displays another prejudice, a partiality for the table of quarter squares. But after 1820 he turns from the mathematical side, and devotes himself to "a work of greater urgency," *The Elements of Natural Philosophy*. Leslie was considered by his colleagues to be familiar with the whole field of pure science of his time. Hence his University course in Natural Philosophy is of interest still, though its limitations sound odd to us now. We recognise that it forms a perfect foundation for modern text-books, even though Properties of Matter masquerade as Somatology, Dynamics as Phoronomics, Light as Photonomics, and Heat as Pyronomics. Electricity and Magnetism then discussed respectively the "phaenomena" of the rubbing of amber, and of the loadstone. How different now!

But in 1933 it is almost startling to find that Leslie argued from observations with his photometer that bodies are, or matter is, so diffuse that the ultimate particles "may bear no sensible proportion" to the space which they occupy.

When he comes to Mechanics, his pure scientific soul is revolted that the inspiring subject of Dynamics should ever thus "descend to improve the vulgar arts." Yet the engineer in Leslie comes out, even though he be unconscious of it. More than one third of his *Pure Natural Philosophy Course* is occupied by this low and vulgar subject. Even in hydrostatics he soon leaves the narrow way of pure physics to wallow in the mire of stowage of cargo, metacentres and their uses, water flow, and its application to water supply and such like vulgarities. His text-books suggest a position like that held by "T and T′" in the nineties. He was the first to give a true explanation of capillarity.

Leslie first achieved fame by his researches in Heat, and this remained his favourite subject to the end. Since the days of Gilbert of Colchester, *circiter* 1570, it had been taught that heat was a form of matter, but an imponderable. Great attempts were made about 1800 by Rumford, Leslie, and Davy, independently to clear up the mystery of its nature. They all decided that it had *some* dynamic equivalent, but this was not obtained till 1843, long after Leslie's death. Apparently he thought of heat and cold as fluids, like the recent idea of positive and negative electric fluids, and held that matter had a capacity for heat. The crucial point about 1800 was to explain heat produced by friction. This was a perplexing subject and led to a vast amount of experimenting. Was this after all a generation of matter? Had an impossibility become true?

Leslie's experimental work dealt chiefly with the laws of radiant heat, of which he says "no part of physical science appeared so dark and neglected." Great progress could be made, and was made, in the subject of Heat, even though the investigator was ignorant of its ultimate nature. In his views of the propagation of heat between insulated bodies he considers it as communicated through the medium of the intervening air, but his use of the word elsewhere suggests strongly that he means ether. Among the various subjects of this book he discusses the theory of his photometer, and of atmospheric heat. In the next volume he purposes to discourse on Frictional Heat, the Sun as source of Heat, Climate, Humidity, Hygrometry, and hopes "to prepare a solid foundation for erecting a system of meteorology." His death occurred before this volume was completed. His pamphlet on *Heat and Moisture* (1813) is a supplement to his earlier work on heat. It is of strongly meteorological tendencies, and gives a description of certain instruments, chiefly meteorological, invented by him. These were (1) his famous differential thermometer, with a modification thereof, the pyroscope; (2) his photometer, a species of black bulb differential thermometer; (3) hygrometer (wet and dry bulb); (4) hygroscope; (5) atmometer, an instrument for measuring the rate of evaporation. These instruments, together with his writings on the subject, show that he had fulfilled his hope in meteorology. If one name must be chosen as the founder of this science, it would seem to be that of Leslie.

From his work on the emissivity of surfaces, and the artificial production of cold, we may also claim him as a pioneer in that vast branch of modern engineering, mechanical refrigeration.

Out of the wide field of his activities there has only been space to touch upon these few subjects. Leslie was a quaint and original man, as well as a famous one, of whom our University may be proud. His writings appeal to us still, as they mark so important a stage in the history of science.