view; but I would make just two comments upon it. First, under experimental conditions we can observe the genesis of any particular action, and so avoid those false inferences to which observation of the action by itself might naturally lead. Secondly, under experimental conditions we can

compare the behaviour of normal animals with that of spinal or decerebrate preparations, and thus test such mistaken assumptions as that mind is required in order that an animal should respond differently to different stimuli, or be modified by its environment.

Sir John Leslie, 1766-1832

By Prof. D. F. FRASER-HARRIS

THE centenary occurs on November 3 of the death of Sir John Leslie, mathematician and physicist. Leslie was a native of the small town of Largo in Fife, where his father, a most intelligent man who had come from the neighbourhood of St. Andrews, was a cabinet-maker. Leslie's mother's name was Carstairs. When only thirteen years old, John was sent to the University of St. Andrews to study for the ministry of the Church of Scotland, but after six sessions there and one or two years at Edinburgh until 1787, he gave up the idea of the Church and devoted himself to the study of his favourite mathematics. His paper on "The Resolution of Indeterminate Problems" had the honour of being admitted to the *Transactions of the Royal Society of Edinburgh* when its author was as yet in his twenty-second year.

In 1793 appeared Leslie's translation of Buffon's "Natural History of Birds" in nine volumes which he had made for John Murray.

Unsuccessful as a candidate for a chair first at the University of St. Andrews and then at the University of Glasgow, Leslie retired to Largo, where he carried out these experiments which, when published in 1804 as "An Experimental Enquiry into the Nature and Properties of Heat", made his name famous throughout the world of science. In this now classical research, he employed his famous cube to study the relative absorptive and reflecting powers of a large number of materials. The 'differential thermometer' which he had devised some years earlier was now found exceedingly useful. This instrument has been described by an enthusiastic admirer as "one of the most beautiful and delicate that inductive genius ever devised as a help to experimental enquiry". The essay of 1804 won for Leslie the recognition of the Royal Society, the Rumford Medal of which was awarded him in 1805.

In the same year, Leslie was a candidate for the chair of mathematics in the University of Edinburgh, vacant through the translation of Playfair to that of natural philosophy. Leslie, whose testimonials included one from Sir Joseph Banks, was vastly better qualified in science than his only opponent, a minister of Edinburgh; but the clergy, professing to see in his essay 'an infidel note' because he had quoted approvingly some remark of Hume on cause and effect, opposed in the most vehement manner his election to the chair. All intellectual Scotland was in a state of ferment; the case was argued for two days before a court consisting of 180 members and by a majority of

only 12 at midnight on the second day was Leslie acquitted of heresy (May 1805).

In 1809 Leslie published his "Elements of Geometry" which saw four editions. In the following year he succeeded in freezing water by artificial evaporation. A quantity of water was placed alongside some sulphuric acid in the receiver of an air-pump from which the air was rapidly removed. This diminution of pressure caused a vigorous evaporation from the water, the vapour being taken up by the acid as fast as it was produced. Leslie's evident joy at seeing the crystals of ice forming in the water has been testified to by an eye-witness. Leslie is therefore the 'father' of refrigerators and all manner of appliances for producing low temperatures. Most of the pieces of apparatus used in these researches were made by Leslie's own hands, and are now carefully preserved in the University of Edinburgh.

In spite of having made these fundamental discoveries in the science of heat, Leslie believed to the last in the objective existence of cold, and, in expressed opposition to Wells, held that dew was the result of "cold pulsations from the azure sky".

In 1819, on the death of Playfair, Leslie was elected to the more congenial chair of natural philosophy.

Clerk Maxwell has told us that Leslie was the first to give the correct explanation of the rise of liquid in a narrow tube by capillary attraction.

Leslie, who had travelled widely and read as widely, was in 1820 elected a *correspondant* of the Paris Academy of Sciences. He was the author of a large number of essays on mathematical and physical subjects, one of the most valuable of which was his "History of Mathematical and Physical Science during the Eighteenth Century" in the seventh edition of the "Encyclopædia Britannica".

Probably Leslie's most celebrated student was Thomas Carlyle, whose ticket, duly signed for the class of mathematics, may still be seen in the Carlyle House, Cheyne Row. Leslie had a high opinion of Carlyle's mathematical powers, and he helped him to his first appointment (1814) as teacher of mathematics in Annan Academy.

In 1832, on the recommendation of Brougham, Leslie was created a knight of the Guelphic Order by King William IV in the illustrious company of William Herschel, Charles Bell and David Brewster.

As a bachelor of frugal habits, Sir John had an income much in excess of his needs so that he was enabled to purchase the estate of Coates near

Largo, to which he used to retire in the long vacation.

In person Sir John Leslie was of short stature and very corpulent, with protruding upper teeth, of florid complexion and rather deaf. In spite of these defects, it was a weakness of his in middle life to imagine himself both young and handsome. In keeping with this purely personal opinion, he dyed his hair. Unfriendly observers have related that, as his knowledge of chemistry was not so intimate as that of physics, the colour turned out to be purple. Sir John at times could deal with a

very substantial meal, for it is recorded that in some sort of dietetic contest, he ate two pounds of almonds and raisins at the close of dinner. Another of Sir John's failings was distrust of the medical profession, so that he succumbed to the results of a neglected chill brought on by a severe wetting and complicated by erysipelas on November 3, 1832.

A caricature of Leslie is to be found in the well-known "Kay's Portraits"; and a copy of the bust by S. Joseph has been placed in the National Portrait Gallery at Edinburgh.

Statistical Methods in Industry

THE conception of the ordinary business man, whether in England or the United States, of the function of statistics in industry is generally a vague one. To many the word means no more than lists of figures open to various interpretations, while few have realised that the essential element lies not in the figures but in the science of their analysis. Marketing, costing, advertising, adjusting output to anticipate fluctuations in prices and demand, and recently studies in industrial psychology, have become recognised fields for the statistician. But the link between the methods of statistical analysis and the problems of the engineer, that is to say, of the man who is concerned with the efficiency of methods of production and the quality of the thing produced, has up to the present been very little realised.

Yet when dealing with mass-production industry, the scientific method of investigation is essentially the statistical method. For whether the manufacturer is concerned with the diameter of a shaft, the strength of cotton thread or the resistance of electrical equipment, he cannot succeed in producing exactly the same article again and again; and any attempt to analyse this variation in order to locate and if possible remove some of its causes, must be based on statistical technique.

Dr. W. A. Shewhart, of the Bell Telephone Laboratories, who visited London in May to give three lectures at University College on the "Rôle of Statistical Theory in Industrial Standardization", is chairman of a committee on the development of statistical applications in engineering and manufacturing, sponsored jointly by the American Society of Mechanical Engineers and the American Society for Testing Materials. He has been largely responsible for the development of this work in the United States, and his presence in England provided just the opportunity that was needed to bring together men in different fields who had begun to realise the importance of this work in England. An immediate development resulted when the British Standards Institution called to a round table conference representatives from several engineering groups, societies and research institutes. At this meeting a small committee was

appointed under the chairmanship of Mr. B. H. Wilsdon, of the Department of Scientific and Industrial Research, Building Research Station, to investigate the whole problem from the point of view of standardisation and specification. This Committee is preparing a report which will include a pamphlet intended to serve as an introduction to the subject for manufacturers and others faced with these problems. Similar action, it is understood, has been taken in Germany by the Deutscher Normenausschuss.

It is true, of course, that for a number of years individual firms have here and there made use of statistical theory in laying out efficient research programmes to improve the quality of production, or to establish sampling plans to reduce the cost of inspection; but there has been little contact between those interested on these lines. The practical worker has not fully realised the potentiality of the statistical tool, nor has he had any opportunity of discovering how similar problems have been dealt with in the research institutes or factories of other firms in the same field or in other industries. At the same time, the mathematical statistician has not understood the lines along which theory could be developed most helpfully.

Recently in Great Britain Dr. Egon S. Pearson, of the Department of Applied Statistics at University College, London, has taken a leading part in an attempt to bring together those different interests. Dr. Pearson has not only made important contributions to the theory involved in this new field of practical statistics, but also has had the advantage of making a close study of its application to large-scale American engineering problems; while at the York Meeting of the British Association he contributed a paper on statistical methods in the quality-control of output, which attracted a considerable amount of attention.

The Biometric Laboratory at University College, with its position in London and its long tradition as a workshop of statistical tools, would appear to be admirably placed as a centre for the development of education and research in this particular field.