art, music or the drama, neither of these speakers would have professed, facetiously or otherwise, want of knowledge of the functions of the institution they honored by their presence, or of the meaning of subjects surveyeed by it. Mr. Justice Darling, for example, said he had heard of the Royal Society as he had heard of the equator, and had been told that the society "concerned itself with medicine and biology, and particularly natural knowledge and natural philosophy, but the moment the knowledge became unnatural—and so far as he could see most of it was—then the society had nothing more to do with it." Of course, the society was founded for the promotion of *natural* knowledge by inquiry as against *supernatural* by revelation or authority. Mr. Justice Darling should understand the distinction, for he referred to Francis Bacon several times in the course of his remarks, though always incorrectly, as "Lord" Bacon. As Sir Charles Sherrington, who presided, said, "The field of truth which the society explores is in the realm of natural knowledge, and the manner of the exploration of this field is in research." Sir Ernest Rutherford was right when, in responding to the toast of "The Medallists," he referred to the spirit of adventure possessed by every scientific pioneer. In no other department of intellectual activity is this spirit more manifest, and in none are such fertile provinces being opened. To us it seems strange, therefore, that so little is commonly understood of the origin and purpose of such a body as the Royal Society, now in its two hundred and sixtieth year, or of the achievements of modern science represented by it.—*Nature.*

SCIENTIFIC BOOKS

United States Life Tables 1890, 1901, 1910, and 1901-1910. Explanatory Text, Mathematical Theory, Computations, Graphs, and Original Statistics. Also Tables of United States Life Annuities, Life Tables of Foreign Countries, Mortality Tables of Insurance Companies. Prepared by JAMES W. GLOVER. Bureau of the Census 1921, pp. 1-496. 4to.

Since their appearance some years ago Glover's earlier United States Life Tables have been a standard reference work on mortality in this country. With characteristic thoroughness, the author has extended and improved his earlier work, and has produced what may well be regarded as, at the moment at least, *the* standard actuarial reference work. For it can be said that in this present volume so much of actuarial science as concerns itself with the construction of mortality tables is covered with meticulous attention to detail. Nothing is left to the imagination of the reader and little to his intelligence. Every point in regard to the construction and the interpretation of life tables which could possiby arise to puzzle a voyager into these placid, because carefully "smoothed" seas, is explained thoroughly, comprehensively, and completely, with copious illustrations domestic and foreign in origin.

This is as it should be. Life tables have had the quite undeserved reputation of being mysterious documents, capable of being understood only by the highest order of intellects. As a matter of fact they are, of course, nothing of the sort, but only a quite obvious and simple set of derivative functions from age specific death rates. Such an exposition of actuarial arts and science as Glover gives in this volume will most effectually remove from the mind of the careful reader any lurking notion that there is an element of the occult or transcendental in life tables, and will impress him with the simple virtues of these documents. He must, however, be a careful, by which is meant painstaking, reader, because no light or fantastic touches will cheer his way through the solid, substantial mass of lucent but lucubratory details.

To turn to technical matters, it may be said that in the construction of the United States tables (based upon Registration Area data variously subdivided demographically for three different periods) Glover has followed the most highly approved, orthodox actuarial methods. The q_x values were smoothed between ages 5 and 85 by osculatory interpolation using fifth differences. The first 5 years of life were dealt with by a special method based upon German official procedure, and this section was welded

to the main portion by fourth difference interpolation formulas. The upper tail end of the curve was graduated by Wittstein's formula and welded to the main portion by the application of Spencer's 21-term formula. Glover felt it important to alter the raw figures as little as possible and apologizes in various places for little roughnesses in the tables, especially around junction or welding points.

Much might be said about the orthodox actuarial philosophy regarding the smoothing or graduation of raw data. The present reviewer finds himself in disagreement with some of it, looking at the whole matter from the broad standpoint of scientific methodology. But this is clearly not the place to enter upon a discussion of this mathematically recondite and emotionally delicate subject. Suffice it to say that the reviewer is acquainted with no more honest, through, and skillful application of the standard actuarial methods than that of Glover in the construction of these tables.

Altogether this is a substantial and notable contribution to American vital statistics. We may well be proud of it. It stands at least on a level with the very best that any country, not excepting the Registrar-General's Office of England and Wales, under Farr and Ogle and Stevenson, has produced in the same line. Every health officer and vital statistician should have a copy of it on his desk. Two features of the book are especially noteworthy. The first is that the best recent life tables for Australia, Denmark, England, France, Germany, Holland, India, Italy, Japan, Norway, Sweden, and Switzerland are given in full for comparative purposes. The second is that there are given, for the United States, tables of life annuities, premiums and commutations. This last is an interesting departure for an official government publication. Hitherto in litigation involving questions of life expectancy in the settlement of estates, etc., the courts have had to depend for their actuarial basis in the main upon the material of insurance companies. Now official tables based upon the experience of the original registration states in 1910 may be used, and all elements of uncertainty as to bias will be removed. Furthermore, by the use of the premium tables one can make intelligent examination of the alluring proposals made to him for the purchase of insurance, whether by theoretically grasping commercial institutions or by theoretically eleemosynary foundations.

Finally, it may be pointed out that this volume makes a first rate text-book for the systematic study of the basic elements of actuarial science. The reviewer is using it in this way at the present time, in a course in life table construction, with great satisfaction. It may be purchased from the Superintendent of Documents at a cost of $1.25 per copy, cloth bound, a price which is only a small fraction of what any commercial publisher would have to charge for a book so expensive to manufacture.

RAYMOND PEARL

SPECIAL ARTICLES

X-RAY CRYSTALLOMETRY: X-RAY WAVE LENGTHS, SPACE-LATTICE DIMENSIONS AND ATOMIC MASSES

THE fundamental equation in X-ray spectrometry and crystallometry is

$$\lambda = 2d \sin \theta$$

wherein d is the perpendicular distance between adjacent planes in the crystal which reflect in the first order at a glancing angle of incidence θ, X-rays of wave-length λ. Since only θ in this equation is capable of direct measurement the absolute magnitudes of λ and d can only be determined if some other relation between them can be found, or if either can be determined independently.

The method first used was to obtain a value of d from the density of the crystal, the number of molecules in its unit of structure, and the mass of a single molecule. The first of the last-named quantities can be measured directly, the second is an integer the choice of which can be guided with sufficient accuracy from the X-ray data, and values for the third have been obtained by a variety of methods, perhaps best by the determination of electrochemical equivalents and electronic charge. No other relation between λ and d than that given above is at present known to exist, *i. e.*, no other quantity than θ is known to depend upon these two variables only, so that the first suggested method of