conglomerate by thrust faulting on Sugar Loaf Mountain, southeast of Center Haverhill. About two miles south of Pike, the Blackberry schist was studied. Here many small zigzag folds were noted. Eastward, on the higher hills, the southward extension of the Northey Hill thrust fault was observed. Later, a section through the Blackberry formation, the Pike Volcanics and the Albee formations was seen. The Mascoma igneous dome was viewed at the end of the trip.

The general plan followed by Dr. Billings and his co-workers illustrated the stratigraphic sequence in proper order; showed conclusively the collected evidence of lithological change in any formation due to progressively increasing metamorphism from northwest to southeast; showed fossiliferous horizons which aided in dating the formations; and, finally, the sequences, structures, contact effects and intrusives of the various magma series. All the attending geologists agreed that the trips were exceptionally well organized, well prepared and most instructive.

At the general business meeting of the association on Friday evening, 118 people, representing 24 colleges, were in attendance. Dr. Lloyd W. Fisher, of Bates College, was selected as secretary-treasurer to succeed the late Dr. Edward H. Perkins. The College of the City of New York will be host at the annual field meeting in 1937.

LLOYD W. FISHER,
Secretary, New England Field Geologists' Association

SCIENTIFIC BOOKS

AN INVITATION TO MATHEMATICS

An Invitation to Mathematics. By ARNOLD DRESDEN. xiii + 453 pages. 1936. Henry Holt and Company. $2.80.

WHILE this book serves as basis for a course in first-year college mathematics, it departs strikingly in form and content from the traditional text-books familiar to all who have been exposed to required freshman work in this field. The author aims to present to his readers some broad vistas of mathematical development, expecting of course more than passive and cursory attention but demanding very little in technique. The reader may hope to find not only much of the charm and symmetry of mathematics but as well a lively appreciation of the fundamental significance for modern life of the expanding achievements of mathematical science. The treatment follows neither a rigid pedagogical, logical nor historical form but draws together in a moving net of conversation, suggestion, warning and proof many topics often isolated, some of which are seldom accessible to the college undergraduate. In addition to material in analytic geometry and in the calculus one finds much time devoted to number theory, non-Euclidean geometry, postulational systems, projective geometry, geometry of the triangle, differential geometry, etc., including even the four-color problem, Fermat's unproved theorem and the syllogism. In a work of this kind the choice of interesting problems within the technical scope of the reader presents a challenge met with singular success. The book is the outcome of several years of classroom experiment by a scholarly, reflective and sympathetic teacher. The chapter and section headings appear in picturesque allegorical phrasing, almost equally adapted, one might imagine, to describing "The Wonders of Geology," "The Rise of the Italian Renaissance" or "The Romance of Cleopatra." The "Contents" is thus useless for purposes of reference, but the remarkable collection of indices at the back sets a standard to appease prosaic-minded critics.

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British Association Mathematical Tables. Vol. V. Factor Table. By J. PETERS, A. LODGE and E. J. TERNOUTH, E. GIFFORD. xv + 291 pp. London, 1935. 20s.

THOSE who have to do with the peculiarities and mysteries of whole numbers, whether they be amateur or only professional number theorists, will be interested in this unique factor table. The particular usefulness of this table is not due to its extent—tables covering up to 100 times as much territory may be had—but rather to its completeness. Larger tables usually omit those numbers which are multiples of 2, 3, 5 or even 7 and give only the smallest prime factor of each number in the table. The present table gives for each number up to 100,000 its complete decomposition into primes, thus giving at a glance information which, if the larger type table were used, might require three or four divisions, consulting the table each time at a different page. Another feature of the table is the manner in which primes are represented. While larger tables merely leave a blank entry to indicate a prime, in the present table the primes are printed in bold face so that the reader is assured of having entered the table correctly. Of course these advantages are not gained without a sacrifice of space. Most pages cover only 350 numbers, as compared with 21,000 in Lehmer's table. No attempt is made to crowd the page with figures.

From the introduction it is evident that the table is

one of the most accurate ever published. Three copies of the table were prepared by different authors by quite different methods and these copies were collated six times. The table has also been read against nine other tables, and lists of errors in these latter are given in the introduction, together with a bibliography of 15 factor tables beyond 100,000.

It need hardly be said that for problems necessitating the rapid and frequent examination of five figure numbers this table will prove immensely practical. The need for such a table was first pointed out by Cayley more than sixty years ago. It is interesting to note from the introduction that a well-known New England manufacturing firm has published eight editions of a similar table to 10,200 for use in gear design.

The publication of the present table was made possible by a bequest of Lieutenant-Colonel Allan J. C. Cunningham, a veteran table maker and author of more than forty major tables in the theory of numbers, to the British Association for the Advancement of Science, whose committee for the calculation of mathematical tables is responsible for the preparation of the table.

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SPECIAL ARTICLES

INACTIVATION OF TOBACCO-MOSAIC VIRUS BY X-RAYS[1]

RECENT experiments of the writers have shown that tobacco-mosaic virus is inactivated by exposure to x-rays from a copper target having a characteristic K radiation of 1.537 Å. The virus used in the experiments was extracted from diseased *Nicotiana tabacum* L. var. Turkish plants. It was adjusted to about pH 7 by addition of approximately 3 grams of $Na_2HPO_4 \cdot 12H_2O$ per 100 cubic centimeters, filtered through a layer of celite (Hyflo Standard-cel), and then through a Berkefeld "N" filter candle. The solution thus obtained was placed in small Syracuse watch glasses and allowed to dry for 18 or more hours. It was exposed to x-rays at a distance of 5.0 centimeters from the copper target. After exposure the virus was taken up in a solution composed of a mixture of 0.1 molar K_2HPO_4 and 0.1 molar KH_2PO_4 at pH 7. Quantitative measurements were made by counting the numbers of necrotic lesions produced in *Phaseolus vulgaris* L. leaves inoculated with the virus samples tested. The data show that the survival ratios for virus exposed to x-rays follow a simple exponential curve with a slope of $e^{-0.079t}$, where t is equal to the time of exposure in minutes. The curve, plotted on semi-logarithmic paper, is shown in Fig. 1. The type of curve obtained suggests that the absorption of a single unit of energy in a virus particle is sufficient to cause inactivation of the particle.

The same type of curve is applicable to the killing of many living things by x-rays. The survival ratios for bacteria, *B. coli, B. aertrycke* and *Staphylococcus aureus,* exposed to x-rays follow this type of curve.[2]

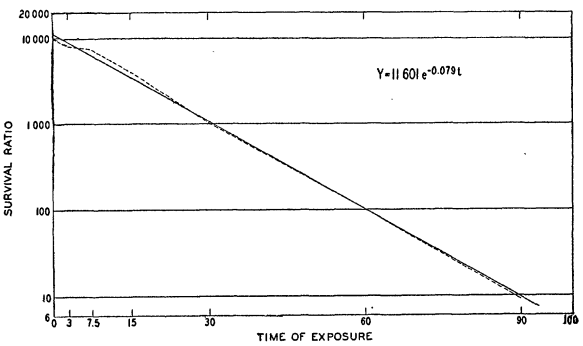

FIG. 1. Survival curve of tobacco-mosaic virus exposed to x-rays from copper. The time of exposure is shown in minutes. The dash line presents the averages of six experiments. The total lesion counts for these data were 127,264.

Drosophila melanogaster sperm are killed in a like manner.[3] Results obtained with *Drosophila* sperm are of particular interest because of their analytical possibilities. Irradiation of *Drosophila* sperm by x-rays of wave-lengths from 2.29 Å to 0.7 Å, or less, results in death of the sperm, the production of lethal rearrangements in the chromatin (either within the gene or the linin thread) and gene mutations. Each of these characteristic effects of radiant energy may be expressed by exponential curves. The best evidence available indicates that the gene is a single unit capable of reproducing itself some time during the cell cycle. Absorption of energy within this unit may cause alterations leading to one or more of the effects mentioned above.

The virus of tobacco mosaic is composed of particles the size of which is estimated to be of the same order as that of genes. Tobacco-mosaic virus also resembles

[1] The writers are pleased to acknowledge their indebtedness to Dr. R. W. G. Wyckoff for the use of his x-ray equipment.

[2] R. W. G. Wyckoff, *Jour. Exp. Med.,* 52: 435, 1930; *ibid.,* 52: 769, 1930; *Jour. Gen. Phys.,* 15: 351, 1932; R. W. G. Wyckoff and T. M. Rivers, *Jour. Exp. Med.,* 51: 921, 1930.

[3] John W. Gowen and E. H. Gay, *Genetics,* 18: 1, 1933; for a general survey and literature on biological effects of radiant energy, see "Biological Effects of Radiation," edited by B. M. Duggar, McGraw-Hill Book Company, 1936.