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.

D. H. LEHMER

LEHIGH UNIVERSITY

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]

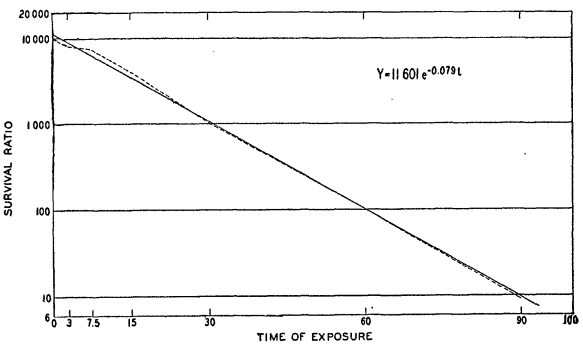

FIG. 1. Survival curve of tobacco-mosaic virus exposed to x-rays from copper. The time of exposure is shown in minutes. The dash line presents the averages of six experiments. The total lesion counts for these data were 127,264.

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.

genes in other respects; both are incapable of reproduction outside of living cells, they produce similar effects, as, for instance, variegation or mottling, in plants, and they are, under natural conditions, capable of mutating to new forms which retain the ability to reproduce themselves. The virus differs from genes in being able to move from cell to cell and in being capable of inoculation into the cells of healthy plants. The fact that tobacco-mosaic virus is inactivated by radiant energy of the x-ray and ultra-violet[4] bands in a manner similar to that of genes suggests an alteration in the virus particles comparable to that which takes place in genes.

JOHN W. GOWEN
W. C. PRICE

THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH, PRINCETON, N. J.

VERTEBRATE REMAINS FROM CENOZOIC ROCKS

VERTEBRATE remains from the sediments filling the Rio Grande Basin of northern and central New Mexico are fairly common, yet they are not so common as to deserve no notice when new bones appear. Moreover, fossils from these sediments always lend assistance in the interpretation of the complicated history of this great trough. Although good exposures of valley fill are plentiful in Socorro County, fossil remains from the fill are very scarce.

In April, 1935, the writer unearthed the complete lower jaw of a four-tusked mastodon from the fill about six and one half miles northeast of Socorro, along the south bluff of Arroyo de la Parida. The material in this exposure is unconsolidated sand and gravel, light in color, poorly sorted and highly cross-bedded. The pebbles are much waterworn and are made up of a wide variety of igneous and metamorphic rocks, with a few fragments of sedimentary rocks. Unquestionably, the material was laid down by a river flowing in the basin near Socorro.

Photographs of the jaw and a plaster cast of the teeth were sent to Dr. C. L. Gazin, of the United States National Museum, for study. Dr. Gazin has kindly reported that the jaw apparently belongs to the genus *Rhynchotherium* and that its age is certainly upper Tertiary, probably upper Pliocene.

In February, 1936, Mr. Martin Dykers, a senior in the New Mexico School of Mines, discovered a horse tooth in the same exposure. The tooth was reported by Dr. Gazin to be a lower left molar and is tentatively referred to the genus *Plesippus*. The age, Dr. Gazin states, is apparently upper Pliocene.

Thus, some of the basin deposits near Socorro, generally referred to the Santa Fe formation, are rather definitely proved to be upper Pliocene in age.

About 14 miles south of the above locality, the writer obtained another small collection of bones from the base of a bed of pumicite. This bed is located about three and one half miles northeast of San Antonio, Socorro County, along the east bluff of the Rio Grande. It is underlain by some thirty feet of light-colored gravel and sand and buff silt, typical of the Santa Fe formation as developed east of the Rio Grande near Socorro.

The bones from the pumicite were kindly determined by Dr. A. Wetmore of the United States National Museum to be parts of the humerus, ulna and radius of the turkey, *Meleagris gallopavo,* not distinguishable from those of the modern turkey. According to Dr. Wetmore, this species of turkey has not been reported anywhere from Pliocene deposits, and from Pleistocene deposits only in Pennsylvania, Tennessee, Arkansas and Florida.

Professor Kirk Bryan, after a recent visit to this exposure, expressed an opinion, based on stratigraphic and structural evidence, that the pumicite might be a part of the upper Pliocene deposits. The fossil evidence, however, favors the Pleistocene for its age, although there is no reason why this species of turkey should not occur in Pliocene deposits. The relation of the pumicite to the underlying and overlying sediments and, consequently, the age of the bones can be determined only after more careful field work in the vicinity. In any event the bones are as old as early Pleistocene and hence are a contribution to the paleontology of the Southwest.

C. E. NEEDHAM

NEW MEXICO SCHOOL OF MINES

CONTAMINATION AND COMPACTION IN CORE SAMPLING

FOR a number of years marine sediments have been sampled by means of coring instruments of various types. The cores obtained have been sectioned; mechanical and chemical analyses have been made; and in some cases, micro-fossil studies have been undertaken. This detailed work has been accomplished with little regard for the contamination of the materials which may have taken place as the core sample was obtained. Also, the vertical extent of the material being dealt with before coring was not considered. Therefore, an investigation of this method of sampling seemed desirable.

An opportunity to carry out such a study was obtained during the summer of 1936 spent at the Woods Hole Oceanographic Institution with the helpful guidance of Mr. H. C. Stetson. The magnitude of the contamination taking place was determined by a num-

[4] W. C. Price and John W. Gowen, in press.