science or mathematics approximates that of the master's degree level, and who have, through writing or other means, been of substantial help to their fellow-teachers. Such teachers are good "professionals" and merit higher prestige than is accorded to teachers generally. We propose to honor them with citations as Distinguished Service Teachers. Since these citations are intended not only to reward excellence but also to call public attention to the importance of good teaching, the citations will be awarded in the teachers' own schools.

If financial backing can be secured, even more might be done. For example, the teachers selected for citation might be given monetary awards; or the expenses might be underwritten for each year's group to attend the annual meeting of the AAAS.

The scope of these plans is flexible. The number selected each year should be small enough to make the citation a real honor, yet large enough to make the motivation and prestige values as widely effective as possible. Perhaps 100 Distinguished Service Teachers a year would be a good starting level.

Intelligently administered, rank and honors are not only an award to those who receive them but an inspiration to those who aspire to them. For many individuals, and particularly those who are sincerely attracted by the opportunity to guide the intellectual development of young people, the respect accorded the teacher may provide the best measure of the value that society places on teaching.

Consultants to Teachers

The plans described here are designed to retain experienced science teachers in the classroom and to increase the number of young people who prepare to teach science. Even if these goals are achieved, the greatly increased high-school enrollment of the next few years will in all probability necessitate the use of many science teachers with less than adequate preparation. It is proposed, therefore, to undertake a pilot study of a method for "upgrading" the work of relatively inexperienced and inadequately prepared teachers.

The plan provides for the employment in each of several geographic regions of two competent science or mathematics teaching counselors—expert consultants —who will tutor, assist, and serve as a source of information and help to the less-experienced and less-competent science teachers of the region. These consultant teachers would have no administrative supervision over their colleagues and would be employed only in regions in which supervisory help in science and mathematics is not already available within the school system.

If one such consultant were made available to each group of 20 to 25 teachers, the increase in staff would amount to only 4 or 5 percent. The number of teachers will increase anyway; perhaps this type of increase would be more effective than others. It seems worth while to test the hypothesis that the total effectiveness of instruction will be greater with such consultants than if the same individuals simply taught classes all day.

If this hypothesis is borne out, it is hoped that the demonstration will encourage school systems, state departments of education, and colleges and universities to assume permanent responsibility for providing continuing consultant services in science and mathematics to nearby high-school teachers of those subjects.

Role of the AAAS

It should be obvious that the AAAS can work more effectively on some of the foregoing proposals than it can on others. On the one hand, the AAAS has strategic opportunity to work toward the assumption on the part of scientists of greater responsibility for the training of science teachers. On the other hand, there is nothing unique that the AAAS can do on the problem of raising teachers' salaries.

There are so many facets to the problem of bringing about a sizable increase in the supply of well-prepared high-school teachers of science and mathematics, and of improving high-school teaching in these fields, that the AAAS cannot hope to achieve any large measure of success without the concurrent efforts of many other groups and organizations. Although it will supplement and sometimes cooperate with other programs looking toward the same ends, the AAAS will concentrate its major effort on the projects that it is particularly well qualified to carry out by virtue of its broad representation of scientists and science teachers in all the sciences at all levels.

Biological Effect of Atomic Bomb Gamma Radiation

Eugene P. Cronkite, Victor P. Bond, W. H. Chapman, R. H. Lee

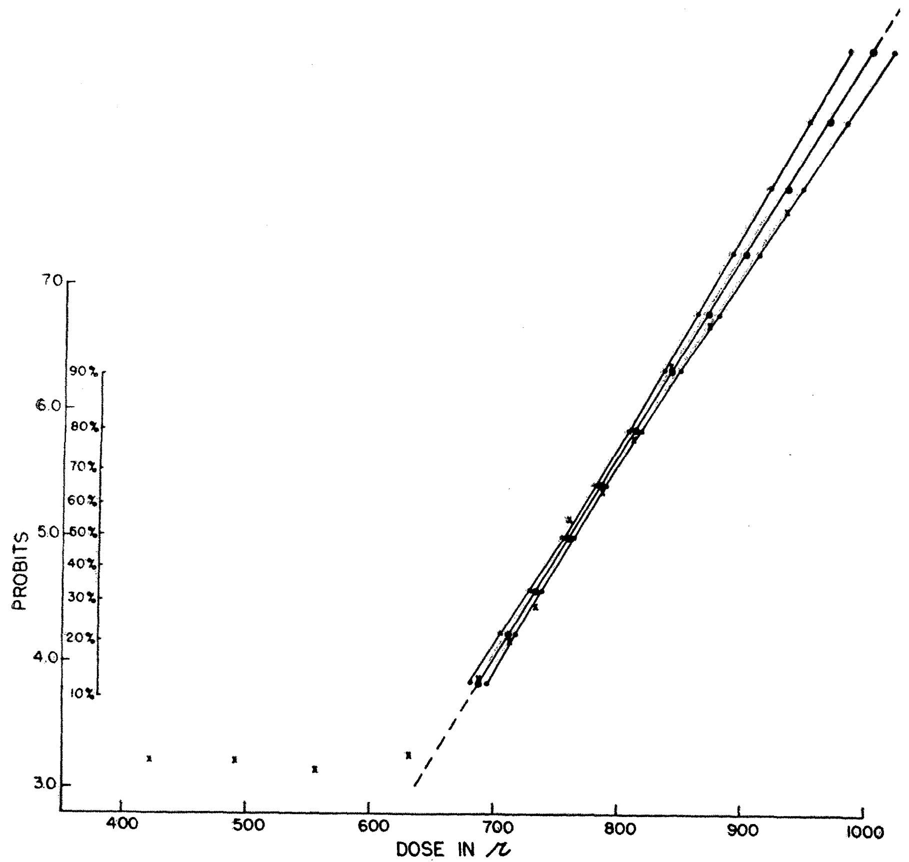
The gamma radiation from the atomic bomb has been appropriately divided into the prompt gamma radiation associated with the fission process and the delayed gamma radiation. The delayed gamma radiation has been subdivided into the initial gamma radiation that extends through the first minute after detonation and the gamma radiation that is associated with contamination by fission products. With the air-burst, the latter is unimportant. The prompt gamma rays are of relatively little importance, because they are filtered out by the materials surrounding the bomb (*1*).

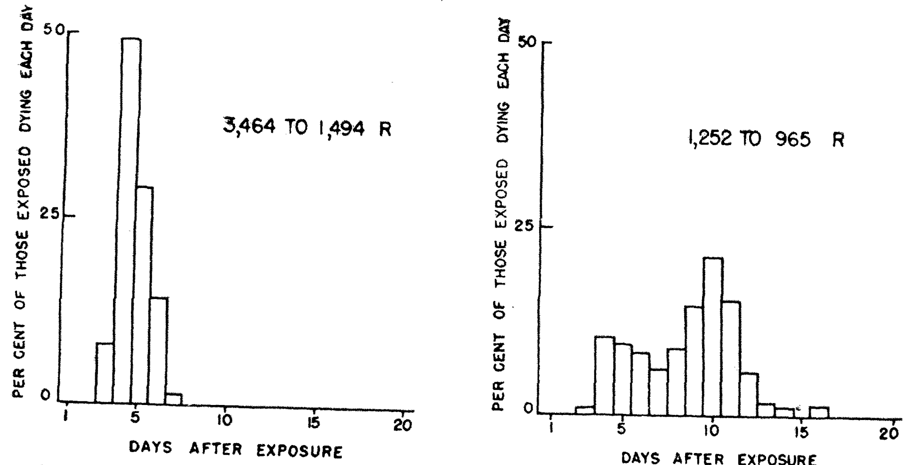
The high dose rate and the reported high effective energy of the initial gamma radiation had led to speculation about the relative biological effect (RBE) of this nuclear radiation as compared with the usual laboratory x-rays and gamma rays. Estimates of the relative biological effect by various competent individuals varied considerably, and a value of 1.0 was considered unlikely. The relative effect and species differences in effect of radiations on mortality was studied extensively by Boche and Bishop (*2*).

Field determination of the gamma-ray relative biological effect, using mortality in mice as the criterion, was undertaken by the Naval Medical Research Institute, Bethesda, Md., and the Naval Radiological Defense Laboratory, San Francisco, Calif.; extensive control studies of x-ray mortality on mice were conducted, both in the United States and at the Pacific Proving Ground (*3*).

The control studies consisted of exposing first-generation hybrid LAf_1 mice to laboratory sources of x-rays of several energies and with different conditions of scatter. Approximately 10,000 mice were exposed in various control studies (*4*).

Commander Cronkite, Lieutenant Chapman, and Commander Lee were stationed at the Naval Medical Research Institute, Bethesda, Md. Lieutenant Bond was at the U.S. Naval Radiological Defense Laboratory, San Francisco, Calif. Dr. Bond and Dr. Cronkite are now at Brookhaven National Laboratory, Upton, L.I., N.Y.





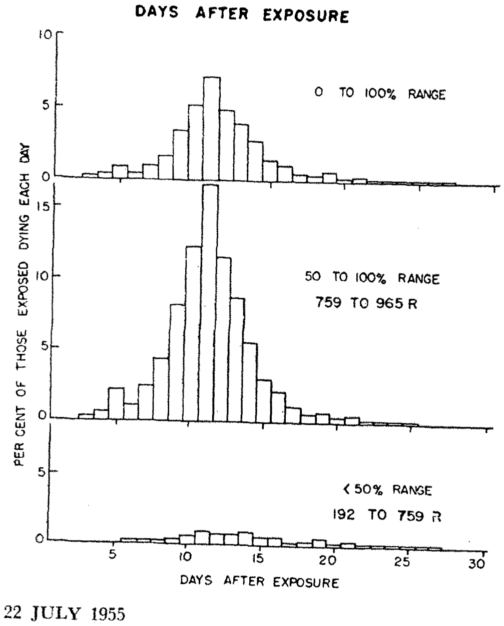


Fig. 1 (top). Probit regression line of mortality as a function of arithmetic dose: *x* observed mortality; • regression line with 95-percent fiducial limits. Note low constant mortality below 650 r. Fig. 2 (center). Pattern of deaths in the supralethal range. Above 1500 r unimodal; below 1500 r bimodal. Fig. 3 (bottom). Pattern of deaths within the lethal range. Above 50-percent mortality, a trend toward bimodality is seen. Below 50-percent mortality, bimodality is absent and pattern tends to be rectilinear.

A total of 4720 mice were selected and randomized for exposure to the gamma-ray spectrum from a nuclear detonation. Detailed selection and randomization with respect to sex, age, and weight were carried out in order to insure data of maximum statistical significance. Multiple estimates of dose were obtained with physical and biological dosimeters placed at the same location as the mice—for example, *Tradescantia,* film packs, and additional mice for splenic and thymic weight changes.

The mice were exposed in cylindrical aluminum containers designed to protect the animals from blast, thermal radiation, and radioactive dust. A total of 28 stations were disposed on both sides of the estimated LD_{50} distance. At these distances the initial gamma radiation from the device has attained equilibrium conditions with the atmosphere.

In Fig. 1 the probit regression line of mortality as a function of roentgens in air, as determined by the Sievert ionization chambers, is given. The estimated LD_{50} was 759 r. The best fit for this regression line was obtained with arithmetic dose rather than log dose (*4*). The excellence of the fit for linear regression above 10-percent mortality is seen. From 190 r, the lowest dose to which animals were exposed in the field, to approximately 620 r, there was a constant mortality of about 3 percent. That this mortality was caused by irradiation is supported strongly by the fact that there was no mortality for the observation period in 640 control mice that were submitted to the same environment. The absolute lethal dose is in the vicinity of 950 r.

A qualitative comparison of the bomb data with that using x-radiation at a potential of 250 kvp showed no differences with respect to signs of illness, mean survival time, or pattern of survival time. The pattern of daily deaths as a function of time after exposure varied with the dose. In Fig. 2 the supralethal pattern is shown. Above 1250 r, the distribution of deaths is clearly unimodal, with deaths occurring between the third and seventh days. Between 950 and 1250 r, the distribution of deaths is clearly bimodal, with peaks occurring on the fourth and tenth days after exposure. In Fig. 3 the pattern of deaths within the lethal zone is given. The first peak of deaths is small and occurs only in the 50- to 100-percent-lethal range. Below the LD_{50} no distinct peak was obtained. Figure 4 is a tridimensional graph of the daily deaths as a function of dose and of time after exposure.

The first peak of deaths has been well correlated with irreversible gastrointestinal injury; and the second peak, with the sequellae of pancytopenia (anemia, infection, and hemorrhage) (*5*).

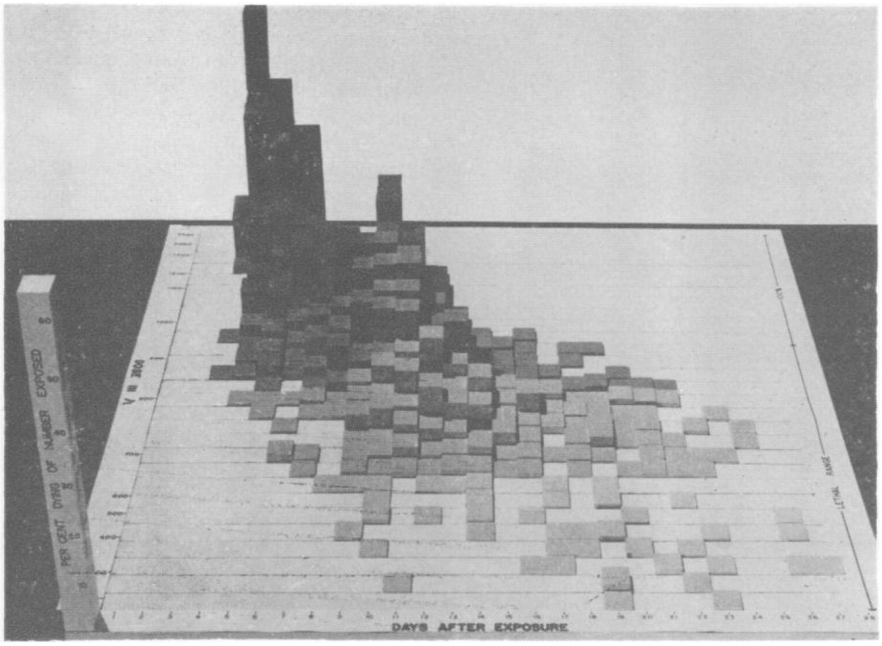


Fig. 4. Tridimensional graph of daily deaths as a function of dose and of time after exposure.

To determine quantitatively the relative biological effect of any toxic agent, it is essential to determine that the biological and physical factors are identical in every respect, except the factors in question—in this case, the dose rate and the energy. The dose-rate problem was approached experimentally in the laboratory, and no significant difference between 15 and 2500 r/min could be ascertained. The latter dose rate is an approximation of the mean dose rate delivered by the bomb within the lethal range.

Two remaining problems were (i) selection of control data that were biologically comparable to the bomb data and (ii) selection of physical measurements for both the bomb and the control data that best indicated the energy absorbed by the mice. To select control data that were biologically comparable, it was necessary to consider the properties of the statistical methods used for anaylsis. The relative biological effect was based on the comparison of linear regression lines determined by probit analysis. The equation for the linear regression line is $y = a + bx$, where y is the percentage of mortality expressed as probits, and x is the arithmetic dose. When the best linear regression is obtained with arithmetic dose (instead of log dose) the method of comparison is as follows.

If paired experiments are performed in which the apparent doses differ by a constant factor because of relative effect such that x is modified by c and all other factors are constant, then the equations are connected in the following manner:

$$y = a + bx = a + b\ (cx)$$

showing that the intercept a is characteristic of the drug or radiation employed, while the slope bc contains the relative effect factor. The determination of the relative biological effect demands then that the intercept a of the experimental and control regression lines be not significantly different. Calculation of the relative biological effect therefore becomes the direct ratio of the slopes or the inverse ratios of the LD_{50}'s.

Data existed where the intercept a for the bomb and x-ray control data were essentially the same, but the determination of the proper numerical values to be used for the respective LD_{50}'s remained.

From the work of Ellinger (*6*) and from the extensive control data, it was apparent that scattered x-rays, as well as the primary beam, were important with respect to the mortality of mice. From the control data, it appeared that scatter was not completely additive. The greater the degree of scatter, the lower the LD_{50}'s, suggesting that scatter was more effective than the primary beam. However, in the absence of a precise method to determine the relative effect of the scatter, scatter was merely added to the air dose in obtaining the proper or the best value of the LD_{50}.

When considering the scatter of the primary beam, and the study in which the intercept a was most comparable to the intercept a for the bomb data, a value of 650 r for the control x-ray LD_{50} was obtained.

From the physical measurements of radiation that were made in and outside the exposure apparatus, and from direct measurement and calculations of the influence of the exposure apparatus on the air dose, it was determined that the best approximation of the LD_{50} for the bomb radiation was 680 r; thus giving

$$\text{RBE} = \frac{(\text{LD}_{50})\text{x-ray}}{(\text{LD}_{50})\text{bomb}} = \frac{650}{680} = 0.96$$

If one compares all the sets of data neglecting the intercepts, the widest range in the relative biological effect is 0.9 to 1.1. One can therefore conclude that the relative biological effect (using mouse mortality as an end-point) of the initial radiation from a nuclear device is essentially unity. For animals of increasing size, depth dose considerations may alter the apparent relative biological effect.

It should be noted that the relative biological effect obtained in these studies was higher than the values reported for high-energy gamma radiation under conditions of exposure in the laboratory (*4, 7*). The present conditions of exposure differed from those in the laboratory in that, at the distances from the bomb used, the gamma-ray beam was in equilibrium and a sizable component was present with energy less than 200 kev (*8*). Hence, even though the source energy was high, the energy of photons of the degraded beam delivering a large part of the dose to the animals was comparable to that obtained with x-rays at a potential of 250 kvp. Thus, a relative biological effect of approximately 1 would not be unexpected under the circumstances.

References and Notes

1. Details of the energy and dose rate of the atomic bomb gamma radiation can be found in the handbook on atomic weapons published by the Government Printing Office, 1951. The established terminology is somewhat confusing. What is called initial radiation is in reality the mixed gamma from early fission products and neutron reactions with the atmosphere and components of the device.
2. R. D. Boche and F. W. Bishop, in *Biological Effects of External Radiation*, H. A. Blair, Ed. (McGraw-Hill, New York, 1954), Chap. 1.
3. This work was performed at the U.S. Atomic Energy Pacific Proving Ground in 1951; publication was delayed owing to delay in official clearance.
4. A best fit with arithmetic, rather than log, dose for mouse x-ray mortality has been reported on by Cornfield in data obtained in control studies for this fieldwork. The full statistical analysis of data is contained in E. P. Cronkite *et al.*, "Relative biological effectiveness of atomic bomb gamma radiation," NM 006-012.04.86 Naval Medical Research Institute, Bethesda, Md., in preparation.
5. V. P. Bond, M. Silverman, E. P. Cronkite, *Radiation Research* 1, 389 (1954).
6. F. Ellinger, *Radiology* **44**, 125 (1945).
7. J. T. Brennan *et al.*, *Nucleonics* 12, 31, 48 (1954).
8. L. D. Gates, Jr., and C. Eisenhauer, "Special distribution of gamma rays propagated in air," *Tech. Anal. Rept.* AFSWP No. 502A, January 1954.