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PROPOSED BIOLOGICAL EXPERIMENTS
1951 FIELD TESTS OF
ATOMIC WEAPONS
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BY

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The central radiobiological problem answerable only by actual bomb tests is whether or not the various kinds of biological effects can be accounted for from a knowledge of the amounts and kinds of radiations and their distribution in space and time. This presupposes rather complete information about the fluxes of neutrons and gamma rays at various points and the energy distribution of these radiations. Adequate information of this nature does not now exist, hence any program of biological investigation must be in close parallelism with the necessary instrumentation program of the physicists to determine the above fluxes at points where biological exposure is carried out.

Tests which have been tried and found to be not amenable to quantitative analysis or which are difficult to carry out in a satisfactory manner under field conditions will be omitted from this discussion. Only tests which cannot be duplicated under laboratory conditions and which show promise of positive useful results will be discussed in this paper. As to the details of biological exposure, these should be carried out with a few different species of test organisms whose reactions to the component radiations is now well understood. These organisms are few in number at this time and will be hereafter referred to as "calibrated" test species. Further, adequate facilities and skilled personnel will be an absolute necessity in the immediate vicinity of the test area. It goes without saying that unless the liaison between instrument test sections and biologists is nearly perfect the tests will have little biological significance. As will be pointed out later, certain of the biological work proposed will provide check points on the physical measurements to be done by the physicists.

From data collected under such conditions, one might hope to determine whether the ion saturation effects resultant from the heavy ionization at

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detonation produce damage unexpected from laboratory information. It should be here pointed out that many of the biological effects reported or observed upon organisms at Hiroshima, Nagasaki, and Bikini far exceeded those which would be expected on the basis of data available from instrumentation at Trinity and Bikini, as extrapolated and interpreted to areas in the actual bombed cities. Whether this represents a decreased instrument sensitivity or response due to ion saturation conditions, markedly increased biological response to the same phenomenon, other operative mechanisms, or a combination of any or all of the above responses is at present an unanswered question. There is considerable need for further laboratory work on fast exposures. Data from more closely controlled biological and physical tests appear imperative to answer this problem. Proper correlation and comparison of these testing methods might give mutually supporting data.

Well "calibrated" test organisms at present appear to be mice, corn, Drosophila, and Tradescantia. If a second mammalian species appeared mandatory considerable "calibration" work would have to be done regardless of the choice of mammal to be used. The choice would probably be between rats, hamsters, or guinea pigs. It is not believed that sufficient data exists upon the response to radiation to consider other organisms well "calibrated." Acceptance of this view rules out dogs, cats, goats, sheep, and swine as test organisms. Due to the confusion concerning specific tissue or organ system quantitative response in mammals, the best criteria for observation of these mammals would appear to be acute lethality, longevity as reflected in the mean life span of survivors of acute lethal effects, and possibly genetic studies of these survivors.

Mammalian experiments visualized then consist of exposure of reasonably large but not unwieldy groups of mice (and perhaps one other mammal to be selected as above indicated) in immediate proximity to physical measure-

ment sites. Some of these animals would be shielded from various component radiations, and all would be afforded blast protection. Immediately after detonation, these animals would be picked up and returned to the base animal laboratory for study. Study would merely consist of frequent observation to determine the time of death in acute lethal effects, with the possible preservation of the carcasses for future histologic study in the United States. Surviving animals would be shipped to a laboratory in the United States at a later date for longevity study.

If it were decided to study mammalian genetic effects, it might be necessary to expose a few more animals, females of the species, provided it appeared mandatory to breed exposed females. This would be to avoid complicating longevity studies on surviving females through the superimposition of obstetrical and post-partum fatalities on the data. There appears, on the other hand, no good reason why the surviving males could not be used for breeding and longevity studies. At any rate, Doctors Donald R. Charles (Rochester University) and W. Russell (Oak Ridge National Laboratory) should be consulted prior to making a final decision as to the value of a genetic study on survivors. If studied, the mammals should be bred as soon after exposure as possible to determine the percentage and types of mutations, and then bred later to determine recovery, if any, with subsequent maturation of germ cells.

Exposure of selected corn seed should be undertaken as a biological test since this is ideal material for work under difficult conditions. Details in this matter should be worked out with Doctors L. F. Randolph (Cornell University), E. G. Anderson (California Institute of Technology), and L. J. Stadler (University of Missouri). There is considerable data available from the corn exposures at Bikini. One of the items of interest is a high proportion of chlorotic sectored plants grown from Bikini exposed seed. This lack of chlorophyl condition cannot be reproduced in the same pro-

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portions with X-rays. Pre-test data should be obtained as to whether or not such effects can be secured with neutrons alone or with mixed radiations. This data could be obtained from cyclotron or shielded and unshielded pile experiments.

Drosophila should be exposed and genetic effects studied. These studies should be done almost immediately after exposure. Sufficient data appears to be known to enable the calculation of the fluxes of neutrons and gamma rays from a study of the dominant lethals and the recessive lethals induced in exposed Drosophila sperm. Because of the differences in relative efficiency of neutrons and gamma rays for the production of these two effects (3 to 1 for dominant lethals and 1 to about 0.7 for recessive lethals) it should be possible to find the proportion of fast neutrons to gamma rays at the point of exposure. This data alone would be of value to the physicist as a check against his measurements by instruments. Genetic studies with Drosophila should start within a few hours after exposure. In this case, the following individuals should be consulted to map out a detailed program. They are: Doctors H. J. Muller (Indiana University), Curt Stern (Berkely), and W.P. Spencer (Wooster College, Ohio).

Tradescantia would appear to offer information of considerable interest if the plants can be obtained in flower at the time of the tests, since it has been extensively studied with regard to effects of X-rays, gamma rays, and fast neutrons of different energies by Doctors Karl Sax (Harvard), Norman Giles (Oak Ridge National Laboratory), and D. G. Catcheside (Cambridge University, England) and his co-workers. Some of these individuals should be consulted regarding feasibility.

For the moment, further tests do not appear practical. It is well to emphasize, however, that this paper represents preliminary thinking on this matter. Much alteration and rearrangement of planning must take place prior

to the testing. Many persons will present other plans or fragments of plans, some of which will have merit. For example, it may be that serious consideration should be given to the use of selected micro-organisms, because of the ease with which statistically significant data can be obtained. In view of the high resistance of most micro-organisms to ionizing radiations as compared to that of higher forms, their usefulness would probably be limited to areas close to the hypocenter. It would appear that blast and heat damage might make this impractical. It is well to caution, however, that many plans will be proposed which may well be of greater financial and spatial magnitude than this, but these should be examined with extreme caution. A small, coordinated series of tests, run upon a sufficient number of test objects to be statistically significant yet not unwieldy, will be a much more workable arrangement with more gratifying and justifying results. Testing with large animals which are not well "calibrated" and cannot be easily shielded from blast or radiation, testing certain physiological, psychological, or cytological responses which are not yet quantitatively established with exactness, or other procedures of greater magnitude but based upon less well understood reactions would be a waste of time, money, effort, and space.

A consideration of the facilities envisioned as necessary for a program such as above proposed seems apropos at this point. As far as the corn problem is concerned, this requires only the procurement of sufficient corn seed prior to embarkation for the testing site, the packaging thereof, exposure, and collection for return to participating institutions. As far as the Drosophila, Tradescantia, and mammalian studies are concerned, a little more elaborate organization and facilities must be available. To get well stabilized test animals and flies, they should be acclimated in the test climate well in advance of the tests. After the test, they should

be retained and studied, at least initially, in the same area. This will necessitate a combined laboratory building and animal house at a shore based installation in the test area. Such a facility could be established in one large Quonset hut or T-63 Building and would provide working space for the entire biological project described above. It might be necessary to air condition the building for the test organisms. This should involve a considerable amount of pre- and post-test work in the test area by individuals concerned with the various experiments. The number of mammals contemplated per test is around one thousand and not over two thousand. Mice don't take up much room or require tremendous quantities of food, so the logistic problem does not appear great.

In any event, preparation for any proposed tests should begin with an early adoption of a plan of experiments to be done, with the immediate initiation of work to secure presently unknown data, and to provide adequate facilities and personnel to vigorously execute the adopted plan of action. Personnel delegated to biological testing duties must be on a full time basis and have no additional functions to perform, such as radiological safety monitoring. It is estimated that the complete program outlined in this paper could be executed by no more than twenty biologists, and probably less, in the test area.