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From: Joseph G. Hamilton

PLANS FOR FUTURE BIOLOGICAL RESEARCH

The following report attempts to point out the type of research effort in the biological sciences that should be pursued in the next two to five years. The material covered will be restricted primarily to the so-called "Tracer" Research which may be defined as the use of radioactive elements to study the absorption, distribution, and elimination of elements and compounds that either are components of life processes or have toxicological interest. The section under Health by Doctor Robert S. Stone will cover the biological effects of radiation, the mechanisms by which penetrating radiations produce their action, and related problems.

Future effort in the field of tracer research may be conveniently divided into two categories. First, studies which bear directly upon the present and future development of nuclear physics. Second, the type of research effort which has been made possible by placing enormous quantities of radioactive materials at the disposal of investigation in the fields of medicine, pharmacology, physiology, biochemistry, the agricultural sciences, and related fields for tracer research.

The first type of research should have as its primary aim the evaluation of the hazards arising from the operation of nucleonic devices and the handling the many dangerous substances that are now available in such large quantitities. In addition, the security of the nation requires that we be familiar with the problems to be presented should these radioactive materials be released on a large scale by either an accidental atomic explosion, the burning of a pile, or attack against us by a foreign power. The second phase of future biological research effort is extremely broad in scope and space does not permit a discussion of its implications in this report. However, it should be kept in mind that this general type of investigative effort will advance with great rapidity as soon as an adequate supply of radioactive materials can be made available to responsible groups both in universities and commercial organizations. It does seem highly appropriate that steps should be taken to give careful consideration to this problem.

One of the most important health hazards that has arisen from the DSM Projects is the element Plutonium. Sufficient evidence is now at hand to establish that the entry of amounts of the order of 1 microgram into the body may be expected to be attended with most disastrous results. Unfortunately, Plutonium is eliminated from the body at a negligible rate and presents the same ominous character of delayed action, coming many years after exposure, as is only too well known in the case of Radium. While a great deal of valuable

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PROVENANCE

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BOX:	2
FOLDER:	PLUTONIUM INJECTIONS - GENERAL INFORMATION

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information concerning the metabolism of Plutonium has already been established, there is much remaining to be done. One of the most important phases of future tracer studies is the development of a therapeutic procedure to either remove this substance, once it has become fixed in the body or to translocate it from the region about the bone marrow, where it is almost exclusively deposited, to less radio-sensitive regions in the body. It is inevitable that cases of Plutonium poisoning will arise and means must be taken to successfully combat such situations. The development of the therapeutic procedure against Plutonium poisoning can only be done by the various tracer techniques. Continuation of the types of tracer work with Plutonium already in progress should be continued with animals and more extensive studies conducted, whenever possible, with human subjects. It is to be hoped that the heavy isotope program now being conducted by Seaborg and others, will uncover an isotope of Plutonium with a relatively short half-life so that normal human subjects may be employed to further elucidate the unusual metabolic properties of this element. The future, and probable widespread use of Plutonium in enriched piles and its possible purification from Pu^{240} by electro-magnetic and other possible methods, point to the ever present possibility of accidental plutonium poisoning. A more minor, but still significant problem, that needs further investigation, is the behavior of Plutonium in soils and its metabolism in plants.

A fairly general but cursory survey of the metabolism of the more abundant long-lived Fission Products in animals has already been made. Unfortunately, the majority of these radioactive elements are also accumulated in the skeleton which thus imparts to them a very significant health hazard. The preliminary investigations now completed should be supplanted by further and more detailed tracer studies with particular reference to their metabolic properties in man. The development of the therapeutic methods for the treatment of individuals poisoned by long-lived Fission Products should be thoroughly explored. Procedures of this character, successful in the treatment of Plutonium poisoning, quite likely would be of limited value in the treatment of cases of Fission Product poisoning due to the differences of chemical properties of these substances. The group of Fission Products not studied to date and which include those radio-elements of either relatively short half-lives or low abundance should be thoroughly investigated. The study of the deposition and retention of Fission Products in soils and their metabolism in plants have been thus far only very briefly touched. Considerable attention to this general problem is most certainly warranted, in view of the very real possibility of the accidental release of large quantities of Fission Product activity. Already, it has been shown that most of the long-lived Fission Products are very firmly held by the soil and can be assimilated by plants. However, the information now at hand is extremely qualitative in character and much yet remains to be done. Another phase of this problem is the search for practical methods to remove these substances from soils, building materials, etcetera, once they have been contaminated with long-lived Fission Products.

A th rough survey of the metabolism of Radium, Actinium, Thorium, Protoactinium, Uranium, Neptunium, Element 96 and Element 98 should be made. Two purposes will be served by this effort. First, Protoactinium 233, Uranium 233, Neptunium, 237, and Element 98 ^{241} are formed in large amounts in chain-reacting piles, and Thorium 234(UX_1) and Uranium 234 are encountered in certain phases of the different methods for the Uranium 235 separation processes. Particular attention should be given to the metabolic characteristics of Uranium since the half-life of Uranium 233 and Uranium 234, the latter being encountered in Uranium 235 separation processes, are within an order of magnitude of the half-life of Plutonium. A corollary to future

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Uranium tracer studies is of course the search for methods for removal of this element once it is deposited in the body. Second, a correlation between the chemical and metabolic properties of this series of heavy elements will lead to a better understanding of the mechanisms which are responsible for the unique and ominous predilection of Plutonium for the skeleton.

Another phase of tracer investigation which deserves some attention, is the study of the metabolism of the long-lived induced radioactivities from stable elements exposed to intense neutron fields. Such materials include Carbon 14 which is produced by the interaction of neutrons on both Nitrogen and Carbon. This general problem will appear whenever materials are employed in the presence of intense neutron irradiation that can give rise to induced radioactive elements with appreciable half-lives.

Radioactive tracer techniques should also be employed for studying the behavior in the body of the materials used in the nucleonic program which possess chemical toxicity. Space limits a discussion of all the elements in this category which may be encountered but of immediate interest are Uranium, Beryllium, and Flourine.

There are military considerations which can be significantly aided by the results of properly planned tracer research. The distribution of Fission Products and the production of induced radioactivities by an atomic explosion, as well as the possible military application of radioactive warfare with either the long-lived Fission Products or induced radioactivities, such as radio-Tantalum, may deserve evaluation in the future. A great deal of the information already acquired by tracer techniques and the future effort outlined in this report, is directly applicable to answering some of these problems should they arise. However, there are special questions which concern the military applications of atomic warfare which cannot be answered without additional effort. These include characteristics of radioactive materials left after an atomic explosion, the dispersion by the blast, the possible methods by which active materials might be employed as weapons, and the various counter measures.

APPENDIX I - PERSONNEL REQUIREMENTS

The tracer work within the nucleonics program has been done primarily at the Universities of California, Chicago, and Rochester and at the Clinton Laboratories, in Oak Ridge, Tennessee. However, I feel that the scope of effort is such that the opportunity to attack the many problems described in this report should be extended to other research groups. The direction of this type of work should be in the hands of men who have had a sufficiently broad background in the biological sciences, radio-chemistry, and nuclear physics to enable them to adequately grasp the character of the type of effort that is laid before them. Moreover, investigators in this field of tracer research should work in close collaboration with the chemists, and physicists in the field of nucleonics and at such locations where active nuclear research is being carried out. Under these conditions, the biologists would become familiar with the new problems brought to light by the continuing developments made by their colleagues in chemistry and nuclear physics, and at the same time, receive invaluable aid in their own problems of instrumentation, chemical isolation, et cetera..

The estimate of the number of research workers needed to carry on the

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tracer program, described in this report, is difficult to make. In the first place, the factor of time is a most important one. Secondly, the degree of thoroughness with which each problem is to be investigated is also a problem; and thirdly, the degree of success that is to be achieved will alter any predictions made at the present time. These variables are more difficult to estimate in the biological sciences than in either chemistry or physics. However, if one assumes that all of the work in the foregoing report should be completed in approximately five years, the following very rough estimate can be given.

There should be a minimum of at least six men, well trained in the biological sciences, who have had ten years research experience, of which three years have been devoted to problems that have required the use of radioactive tracers. Three of these men should have had medical training, and more than a superficial acquaintance with radio-chemistry and nuclear physics is essential for all six. Men of this group should assume the responsibility of the direction of the general problems described in the report. They should have to assist them fifteen to twenty well trained younger men with graduate degrees in physiology, biochemistry, and the allied biological sciences. An equal number of men who have had college training in biological fields would be needed and at the same time they would receive training in this particular field. An appropriate number of technicians, laboratory assistants, etcetera, would be required; probably a total of forty full time people in this category would be quite adequate. Space does not permit a discussion of how the various phases of this tracer program should be divided among different research groups and institutions. However, careful consideration should be given to facilities such as piles, cyclotrons, etcetera, and the presence of active research programs in radio-chemistry and nuclear physics within the same institution.

APPENDIX II RELATIVE URGENCY OF THE DIFFERENT PHASES OF THE TRACER PROGRAM

At present, the most urgent phase of the entire program is to develop an effective therapeutic procedure for Plutonium poisoning and to extend our knowledge of the behavior of this substance in the body by more complete tracer studies. Metabolic studies with Uranium and the search for therapeutic measures to combat the possible poisoning with Uranium 233 and Uranium 234, is, in my opinion, of immediately succeeding importance. The search for methods to combat Fission Products poisoning, is likewise a problem that deserves high priority in this program. The other problems which include metabolism of the other heavy elements, the less important members of the Fission Products group, and the soil and plant studies which, while significant in their importance, are not as urgent as the subjects listed above.

An appraisal of the priority to be assigned to the phases of tracer research which will be of significance to the development of military applications of atomic warfare, can better be made by those more familiar with future policies in this problem.

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