

Introduction

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BIOLOGICAL organisms, including man, that are successful must continually adjust to their ever changing environment. Many of these adjustments are made unconsciously by man. Others are made only by conscious effort after the change in the environment is recognized and comprehended. The latter changes must be detected directly by the sensory receptors, or else some consequence of the change must occur very quickly in order to allow adjustment before permanent damage occurs.

Ionizing radiations cannot be detected by the nervous system: they cause no pain, and man does not react immediately to them. Also, most of their effects are delayed, or their expression is delayed. Therefore, these radiations are an especially insidious kind of change in the environment, for permanent effects may be brought about before knowledge of the need for adjustment exists. The problem is especially serious at low levels of irradiation, for effects may be delayed for tens of years, as exemplified by the watch dial painters.

This symposium was designed to examine the known facts concerning the biological effects of low levels of long-continued irradiation, how the several changes are brought about, what general problems present themselves, what responses arise as a consequence of them.

Although public discussion of these matters is recent, scientific inquiry into the effects is not. For instance, the Argonne National Laboratory, supported by the United States Atomic Energy Com-

mission, has been active in the biological problems of low-level radiation since the beginning of the atomic era in 1943. The early formal work on the effects of internally deposited radioelements in mammals was carried on at the University of California at Berkeley, the University of Rochester, and at the Metallurgical Laboratory of the University of Chicago, the immediate predecessor of the Argonne National Laboratory. Speaking for the history of my own laboratory, I note that the measurement of the toxicity of plutonium and of numerous fission products was begun over thirteen years ago. The first truly chronic observations of the toxicity of strontium-90 became available just recently, eleven years after the injection of three dogs by Brues and his associates with the first material available.

Interest in the effects of low-level, long-continued irradiation from external sources has had a longer history, from the beginning of the research supported by the Manhattan District. Sacher, Hagen, and others at Argonne, Boche and others at Rochester, Zirkle and Raper at Oak Ridge, among others, began studies before 1943 from which a substantial part of our knowledge of the tolerance of man to radiation comes. These programs continue, consisting of methodical large-scale studies of the difficult problem of the measurement of effects of small amounts of radiation on living organisms. Speaking again for Argonne, 35% of the funds for biomedical research are used directly for studies that deal with the tolerance of mammals to radioelements and external radiations; the other 65% supports basic research in the radiation problem.

That the genetic effects of radiation have been under intensive investigation for many years is so well known as hardly to need comment. Since Muller and Stadler first studied the relation between radiation and inherited effects twenty-five years ago, genetics and cytology have been two biological disciplines in which ionizing and low-energy radiations have been used constantly as tools.

Building up a large store of knowledge useful in evaluating the

toxicity of these agents, today's large-scale programs directed toward these unsolved problems are outgrowths of pre-atomic research—begun long before the first reactor was built. But while the interests of scientists have been longer than many might suspect, our history is short when measured against the time that will be required for satisfactory understanding of the problems. Our knowledge in many important areas is insufficient, or exists not at all.

So far as the scientific facts to be presented here are concerned, I believe these summaries have to be accepted as interim assessments of knowledge—for the final answers will be available only after much more work, and, because of the nature of the problems, after the passage of many years.