

we may hope to gain about the behaviour of nuclear spins in solids and their interaction with their environment.

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BIOLOGICAL HAZARDS OF NUCLEAR AND OTHER RADIATIONS

By Dr. C. AUERBACH

THE dangers of ionizing radiation to human health have long been recognized by a small circle of experts. The early radiologists had to pay a tragic toll of death and disease for their ignorance of the cellular damage caused by radiation, and geneticists, foremost among them Muller, have for many years warned against the much less obvious, but in no way less real, danger to future generations. Only during the past year or two has a wide public become disturbed about the biological effects of ionizing radiation because of their connexion with nuclear fission. Fantastic over- and under-estimates of these effects have appeared in the popular press and have been used as ammunition in the war of opinions between those who oppose and those who support the continuation of atom and hydrogen bomb tests. The more sober and cautious statements of the biologists themselves tend to be regarded with suspicion as being biased by political convictions. It is therefore greatly to be welcomed that authoritative digests of scientific experience and opinion have been prepared and published independently in Great Britain and the United States*. The British report has been commissioned by the Government, the American one by the National Academy of Sciences. Both have been prepared by leading authorities in physics, medicine, genetics and allied fields, the British one by a committee appointed by the Medical Research Council, the American one by six separate committees dealing with the impact of radiation on genetics, pathology, meteorology, oceanography and fisheries, agriculture and food supplies, disposal and dispersal of radioactive wastes. The American report thus covers a very wide field, including such questions as the possible influence of atomic bomb tests on the weather or the use of isotopes in agricultural and oceanographic research, while the British report, after an introductory chapter on the nature of radiation and its action on living cells, is concerned only with the proved or possible effects on the individual, his immediate progeny, and future human populations.

* Medical Research Council. The Hazards to Man of Nuclear and Applied Radiations. (Cmd. 9780.) Pp. vii+128. (London: H.M. Stationery Office, 1956.) 6s. 6d. net.

National Academy of Sciences—National Research Council. The Biological Effects of Atomic Radiation: a Report to the Public from a Study by the National Academy of Sciences. Pp. ii+40. The Biological Effects of Atomic Radiation: Summary Reports from a Study by the National Academy of Sciences. Pp. xiv+108. (Washington, D.C.: National Academy of Sciences—National Research Council, 1956.).

Although only the British report indicates in its title that nuclear fission is not the sole source of ionizing radiation, it is clear from both reports that the present dangers arise much more from excessive use of X-rays than from bomb fall-out or from atomic energy establishments. Thus, ironically, the public anxiety about nuclear weapons has resulted in reports which emphasize long-neglected dangers in medical practices. In Britain, X-ray diagnosis, mainly of hip, lumbar spine, lower abdomen and pelvis, adds at least 22 per cent and possibly much more to the average amount of natural radiation (3 r.) which the gonads receive during the genetically important period from conception to thirty years. In the United States, X-rays are estimated to add 3r. to a background radiation of 4.3r. Even allowing for the facts that this figure includes therapeutic as well as diagnostic X-rays and may represent a maximum compared with the British minimum, this amazingly high contribution of X-rays to the gonad dose of the average American reflects the excessive use of X-rays in that country. Both reports agree in considering the present level of ionizing radiation due to nuclear fission as negligibly small, and in estimating that this level would rise to about 1 per cent of the normal background radiation, if nuclear weapon testing should continue at the present rate. The formidable technical problems which even in the near future will be posed by the accumulation of radioactive waste are brought home by the forecast that in 1965 nuclear reactors in the United States will be producing somewhat more than 10 kgm. of fission products per day.

The hazards to the exposed individual himself are negligibly small when accidents or nuclear warfare are excluded. A shortened expectation of life through accumulated low doses of radiation, which is mentioned in the British report only as a hitherto unproved possibility, is suggested by American data on the comparative life-spans of radiologists and other physicians. Repeated exposure to doses which are individually harmless may increase the incidence of leukaemia, as shown by a follow-up of British patients who had received prolonged X-ray treatment for ankylosing spondylitis. The British report recommends, therefore, that no individual should receive more than 200 r. of total body radiation, spread over tens of years, and that the maximum weekly exposure, averaged over any period of thirteen consecutive

weeks, should not exceed 0.3 r. Among fission products likely to be ingested only strontium-90, which is retained in the bone, may constitute a danger, but its present level is negligibly low.

For a calculation of the genetically permissible dose, as distinguished from that which is harmless to the individual, new considerations become relevant. Not only is the genetical material by far the most radiosensitive part of the organism; the linear increase of mutation-rate with dose and the absence of a lower threshold make the exposure of many individuals to very small doses genetically as dangerous as that of a few individuals to large ones. There is, in fact, no innocuous dose from the genetical point of view, and the permissible dose-level has to be reached by a compromise between the immediate benefits of ionizing radiation and the damage to future generations. We still lack the data for an even moderately accurate quantitative estimate of the genetical effects of a given dose on human genes. Calculations use extrapolations from experiments on lower animals and include premises on which geneticists differ among themselves.

It is therefore encouraging to find a considerable measure of agreement between the conclusions of the British and American geneticists. Both estimate that the doubling dose, that is, the dose which would double the mutation-rate, lies most probably within the range from 30 r. to 80 r. In the final result, this dose would double the incidence of genetically caused defects; but for recessives this may take a very great number of generations. American geneticists estimate that the effect on the first generation of doubling the gonad dose would consist in an additional 200,000 cases of genetically caused tangible disabilities among 100 million births. In Great Britain, 200 more cases each of manic depressive insanity and schizophrenia and 1,500 of severe mental deficiency would be expected among the first generation of 20 million births. For hereditary traits which show continuous variation about the normal, an increased mutation-rate results in increased proportions of the extreme variants on either side of the mean; but if the trait has already been subjected to much selection towards one extreme, as is likely for human intelligence, it is mainly the minus variants which will be increased in number. The maximum dose which the British report considers tolerable from a genetical point of view is 50 r. to the gonads in excess of the natural radiation up to the age of thirty, and this should be received by not more than 1/50 of the total population. The American report recommends that

records of the accumulated life-time exposure to radiation should be kept for every individual, that the average exposure of the population's reproductive cells to radiation above the natural background should be limited to 10 r from conception to age thirty, and that individual persons should not receive a total accumulated gonad dose of more than 50 r. up to age thirty, and not more than 50 r. additional up to age forty.

In the manner of presentation the two documents differ fundamentally. The American report clearly aims at being intelligible to the general public. Full reports with technical details are being prepared and will be published at a later date. Although the various sections differ in the amount of technicalities they contain, they all state unambiguously the relevant facts, conclusions and recommendations. In particular the section on genetics is a model of popular exposition of a difficult and debatable problem. Where differences of opinion between scientists exist, these are stated; but instead of confusing the general reader with controversies, stress is laid on the points of agreement. To make quite sure that the main facts and conclusions reach the widest possible public, these are once more summarized in a brief "Report to the Public". The British report is written in a spirit of scientific humility and caution which may well leave the general reader with a feeling that it would be best not to bother much about a subject on which so little is known. There is nothing in the British report corresponding to the categorical American statements: "Any radiation is genetically undesirable", or "From the genetic point of view, they [the radiations] are all bad". Yet it is likely that the authors of the British report would agree with these statements. For the scientist, especially the geneticist, the report is highly interesting, just because it deals in great detail—partly in the form of thirteen appendices—with the data, calculations and considerations on which the final conclusions are based. The intelligent and educated general reader who is willing to spend time and effort on understanding the report will no doubt learn very much from it; but it is to be feared that he will be in a minority, and that the general public, including our legislators, will prefer to get its information second-hand from newspaper digests which, based on a document of this nature, can scarcely fail to be one-sided or otherwise misleading, especially as the report gives little guidance for such a purpose. It seems highly desirable that a digest for the public be prepared as soon as possible by the authors of the report.

NEWS and VIEWS

Royal Botanic Gardens, Kew:

Sir Edward Salisbury, C.B.E., F.R.S.

SIR EDWARD SALISBURY, who has been director of the Royal Botanic Gardens, Kew, since 1943, is resigning from that post, having reached the age of seventy. To botanists, both in Britain and throughout the world, Sir Edward is well known, not only for his outstanding botanical work (especially on plant form, reproduction and ecology) but also for his splendid books, which include those for the specialist, those for the student and those for the

layman. Through these books, Sir Edward has exerted a profound influence on the advancement of botany. For many years he has worked also for the advancement of science in general (but especially the biological sciences) through various societies of which he has been president or vice-president or secretary. For example, he was honorary secretary of the British Ecological Society during 1917-32 and its president in 1928. He has been president also of several other scientific societies.

Sir Edward Salisbury has been one of the pillars of the Royal Society for many years. During 1945-55