

## **Ionizing Radiation**

and the dose is small

The effects of irradiation on living systems may be studied by looking for effects on the living cells, for changes in the biochemical reactions, for evidence of production of disease, or for changes in the life or normal growth patterns (Fig 44-4) Interpretation of such findings is not simple Extensive research in this field is continually being carried out in many laboratories

The human body is composed largely of water and of other materials containing hydrogen, carbon, oxygen, nitrogen, and smaller amounts of other elements In human tissue, these elements are present in the proportion of about one nitrogen atom to twenty oxygen, to five carbon, and to forty-five hydrogen atoms It is therefore important to study the effects of radiation on water and on materials of a composition which resemble human tissue

Irradiation of water produces large numbers of free electrons which have been ejected from the parent atoms, leaving positive ions In this process of ionization, there is dissociation of the water molecule and the release of oxidizing agents In the human body, there may be changes of structure of organic molecules and changes in the biochemical processes Some of these same changes may be occurring independently of the radiation, so the mechanisms are complex and are being studied intensively

### **Types of injuries**

The accumulation of knowledge of the effects of radiation on man was begun in 1895 when Roentgen discovered the X ray Radiation from uranium was discovered by Becquerel in 1896 Alpha, beta, and gamma rays were identified shortly thereafter, and the neutron was discovered in 1930 Injurious effects were experienced by these early workers in nuclear science As radiation was applied to man for healing purposes, effects such as skin redness, dermatitis, and skin cancer were noted, as were loss of hair and eye inflammation It was found that the incidence of cancer and of certain blood diseases was higher among radiologists than would be expected for a chance distribution in the population studied

The pool of health experience data was obtained from (a) early radiation workers,

(b) medical personnel who routinely administered radiation for diagnostic and therapeutic purposes, (c) patients who were treated with radiation, and finally, (d) a group of workers who painted dials with luminous paints containing radium It became apparent that exposure to ionizing radiation was associated with a higher-than-normal incidence of certain diseases, such as skin, lung, and other cancers, of bone damage, and of cataracts It appeared also that there was some evidence of life shortening

### **Relating dosage to damage**

Extensive work was done in an attempt to relate the dose received to the damage A great deal of laboratory work was also carried out with various biological systems (both plants and animals) in order to learn more about the conditions of irradiation, the effects produced, and the relative effectiveness of the kinds and energies of radiation

From all these studies came the bases for determining "maximum permissible levels" of exposure, which were statements of the doses that could be taken with little chance of later development of adverse effects

Maximum permissible levels of external and internal radiation have been published (See "References"—US Department of Commerce, Bureau of Standards *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure*, Handbook 69, and *Permissible Dose from External Sources of Ionizing Radiation*, Handbook 59)

In previous years, the basic guides for permissible external exposure have come from the National Committee on Radiation Protection (NCRP), which has worked closely with the International Commission on Radiological Protection (ICRP) The NCRP guides were first published in *NBS Technical News Bulletin 41* in February 1957, a revised statement appeared in 1958

More recently, the Federal Radiation Council has recommended "radiation protection guide" values for external radiation and "radioactivity concentration guides" for radioactive materials found in the air and water (See Federal Radiation Council, Washington, DC *Federal Register*, "Radiation Protection Guidance for Federal