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levels of total beta emitters. Such differences in the radioisotopic composition of different species of organisms were ascribed to ecological and physiological factors. P^{32} and Zn^{65} were the most highly concentrated isotopes in all organisms. The patterns of geographical distribution of radioactive contaminants in aquatic organisms of the Columbia River also varied among species of organisms. These differences were attributed mainly to ecological factors and biological habits. P^{32}, Zn^{65}, and Cr^{51} were common in organisms collected at the mouth of the river which is 580 kilometers from the outfalls of the Hanford reactors.

56. *The Effect of Nutritional Factors on the Survival of Irradiated Bacteria.* S. DAVYDOFF and G. DUCATEZ,* Commissariat à l'Energie Atomique (France), Service d'Hygiène Atomique et de Radiopathologie.

Studies of Stapleton, Sbarra, and Hollaender gave evidence that the postirradiation nutritional conditions influence the survival of *Eschericha coli* strain B/r. We did not find similar results with γ-irradiated *Serratia indica*, which we had used in previous experiments. We measured survival by counting the microorganisms which were able to develop colonies after plating on nutrient agar. In the work described here we study by means of another technique the survival of irradiated bacteria on various media. We compare the lag phase of growth curves in liquid media of γ-irradiated *Serratia indica* and controls, both on complete medium (beef-extract nutrient broth) and synthetic minimal medium. The results are similar to those obtained in our first experiments, that is, survival of *Serratia indica* after γ-irradiation does not seem to be affected by nutritional factors under our experimental conditions.

57. *Dose-Rate Effects in Bacteria.* D. L. DEWEY and J. W. BOAG,* British Empire Cancer Campaign Research Unit in Radiobiology, Mount Vernon Hospital, Northwood, Middlesex, England.

Ionizing radiation in sufficient doses will remove dissolved molecular oxygen from an aqueous system containing organic substances by various radiochemical processes. The sensitivity of most biological systems is dependent on the oxygen concentration at the time of irradiation. If a sealed system containing oxygen and biological material (in this case, bacteria), is given a relatively large dose, then the first part of the dose will be given in the presence of oxygen and the remainder in the absence of oxygen. Thus, the over-all biological damage should lie between the aerobic and anaerobic sensitivities. If very high dose rates are given to a continually oxygenated system, then oxygen will be removed from the "active sites" more rapidly than it can be replaced by diffusion. Thus, with increasing dose rates the radiosensitivity would be expected to approach the anaerobic level. For an experiment of this kind with bacteria one requires to give a dose of a few kilorads within a few microseconds. This paper describes an experiment in which the electron beam from a 1.5 Mev linear accelerator was used to irradiate a double cell, one half containing bacteria maintained aerobically, the other half bacteria maintained anaerobically. At the window of the accelerator the electron current in the pulse reaches ½ amp and the pulse duration is 2 microseconds.

58. *Detection of Plutonium Contamination in Humans by the Autoradiographic Method.* N. L. DOCKUM, A. C. CASE, G. VOGT and E. J. COLEMAN, Biology Operation, Hanford Laboratories, General Electric Company, Richland, Washington.

Plutonium is a toxic substance that may be a hazard in industry. Following entry into the human body and absorption by tissues, plutonium is eliminated with difficulty. The International Commission on Radiological Protection recommends that the total-body limit that should not be exceeded by personnel responsible for handling this toxic substance be 0.04 μc. The autoradiographic technique, using 5-μ paraffin sections in contact with 5-μ NTA emulsion for 10 hours and similar sections of sputum for 3 days, was found to be more sensitive for detecting contamination with plutonium than tests with a scintillation counter. Both human and pig

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skin were tested. The autoradiograms showed characteristic alpha tracks in the emulsion at sites of plutonium deposition following its uptake either in solution or in particulate form. Chemical analysis of the human tissue sections revealed a total quantity of 0.024 μc of plutonium on the fingernail, 0.0046 μc in the skin puncture specimen, and 2.2×10^{-6} μc in the 24-hour sputum sample. Autoradiography is recommended as a routine procedure to supplement information gained from chemical analysis and counting procedures in human plutonium contamination incidents.

59. *Chemical Structure and Protection Against Ionizing Radiation.* DAVID G. DOHERTY and RAYMOND SHAPIRA, Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

An extensive series of compounds structurally related to *S*,2-aminoethylisothiuronium bromide hydrobromide (AET) and its homolog *S*,3-aminopropylisothiuronium bromide hydrobromide (APT) have been synthesized and examined for protective activity in 101 × C_3H mice given a single whole body lethal dose (900 r) of X-radiation according to our sequential test technique. All of the compounds intratransguanylated in a manner similar to AET and APT [Doherty, Shapira, and Burnett, *J. Am. Chem. Soc.* **79**, 5667 (1957); Khym, Shapira, and Doherty, *ibid.* **79**, 5663 (1957)] to yield the corresponding mercaptoalkylguanidines although the rate was dependent on the nature and position of substitution. Wide variations in toxicity and protective activity were found, and two broad types of activity emerged. The first type is that of the parent compounds AET and APT where the radiation $LD_{50/30}$ is related to the compound dose up to a maximum dose of 1500 r. In the second type, protective activity can be observed at very low compound dose levels, but the maximum $LD_{50/30}$ is only 1100 r even though the amount of compound required for 1100 r is increased eightfold. In this class a pair of optical isomers, D and L-*S*,2-aminobutylisothiuronium bromide hydrobromide, have been found where one form is three times as effective as the other. An obvious explanation for such behavior is selective binding on sensitive biological sites. Tissue distribution as well as inter- and intracellular binding studies with isotopically labeled compounds have shown this to be the case. The chemical structure of all these compounds, as well as *in vitro* chemical evidence, is in accord with the premise that they can function by neutralizing the free radicals formed by ionizing radiation. Since the isotopic evidence indicates that they are selectively distributed within the animal, they apparently function as protective agents because they are radical traps in the right place at the right time.

60. *Radiation Sensitivity of Specific Groups in Solid Polyethylene.* MALCOLM DOLE and T. F. WILLIAMS,* Northwestern University, Evanston, Illinois.

The clean infrared spectrum, the simplicity of its structure, and the possibility of incorporating into it radiation-sensitive groups make polyethylene a model substance for radiation studies. On irradiation of polyethylene samples containing vinyl or vinylidene unsaturation, these groups disappear with yields higher than the totality of all other effects involving structural changes in the methylene chain, such as cross-linking, ring-linking, and growth of vinylene unsaturation. Up to concentrations of 0.1 molar the *G* value for vinyl decay is first order with respect to concentration, $G = kc$, until over half the groups have been removed. Above the melting point there is no deviation from the first-order law. Vinylene growth is accurately represented by a function involving zero-order formation and subsequent first-order elimination. Vinylene groups when randomly incorporated into the crystalline regions seem to have a protective action toward vinyl groups, but in the liquid or amorphous phase the action appears competitive. The independence of the hydrogen yield on the concentration of reactive groups indicates that these groups are not scavengers for hydrogen atoms. There is no dose rate dependence. Quantitative calculations indicate that the vinyl groups are activated by excita-

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