Studies on damages of biological cells and their constituets caused by heavy ions

A. Matsuyama, F. Yatagai, S. Kitayama, I. Kanako, Y. Hattori, S. Okada*, K. Sakamoto*, Y. Yamawaki*, S. Sawada*, M. Sasaki* and N. Oda* (Institute of Physical and Chemical Research, Wako-shi, Saitama-ken, Japan)

In order to accumulate available informations on high-LET radiobiology and basic data for clinical radiation therapy, investigations at cellular and molecular levels have been conducted using charged particles accelerated in the IPCR cyclotron. The outline of the current status of our research is as follows:

1. LET dependence of radiosensitivities of several bacterial and mammalian cells Bacterial cells(E. coli B/r and B_{s-1}, M. radiodurans and B. subtilis 168 spores) and cultured mammalian cells(Chinese humster V79) were bombarded with charged particles of different LET as well as gamma or X rays.1,2,3)

2. Determination of the efficiency of production of DNA strand breaks in bacterial and cultured mammalian cells The LET dependence of single-strand break formation in E. coli B_{s-1} has been determined. 4) A DNA fiber autoradiography of high-LET radiation induced double strand breaks of DNA and their rejoining in mouse leukemic L5178 cells is now under way.

3. Genetic effects of heavy ions on bacteriophages, bacteria, Streptomyces spores and mammalian cells These biological cells were exposed to genetic-level doses of heavy ions and α-particles and the mutation frequency induced were determined under specified experimental conditions.

4. Effect of high-LET charged particles on template/primer activity of DNA in situ Using the permeable cells of M. radiodurans, their DNA synthetic activity after high-LET bombardment was compared with that after low-LET irradiation.5)

5. Inactivation of ribonuclease A in aqueous solution by cyclotron beams In the framework aming at revealing specific features of the damage on biological substances caused by heavy ions, experiments have been started on the inactivation of bovine pancreatic ribonuclease A(EC 2.7.7.16) by irradiating with cyclotron beams.6)

6. Methodological studies on high-LET irradiation of biological materials Trials to improve the procedures and devices for irradiation of biological materials of different radiosensitivities and the dosimetry have been made. The significant effect of secondary electrons emerged from the air layer just in front of biological samples on inactivation of bacterial cells was evidenced with E. coli K12 rec^- and uvr^- mutants.7) The

physical determinations of the spectrum and angular distribution of secondary electrons are now undertaken.

References

1) F. Yatagai, T. Takahashi and A. Matsuyama, Inactivation of bacterial spores by charged particles, J. Radiat. Res., 15, 90 (1974).

2) Idem, Inactivation of bacterial cells by cyclotron beam, ibid., 16, 99 (1975).

3) Y. Yamawaki, F. Yatagai, I. Kaneko, K. Sakamoto, S. Okada and A. Matsuyama, The effects of cyclotron beams on survival of cultured Chinease humster cell V-79, IPCR Cyclotron Progress Report, 10, 117 (1976).

4) K. Igarashi, F. Yatagai, T. Takahashi and A. Matsuyama, LET dependence of DNA single-strand scission in E. coli Bs-1 by charged particles, J. Radiat. Res., 15, 148 (1974).

5) S. Kitayama, F. Yatagai and A. Matsuyama, Effects of heavy ion on the DNA synthesis in bacterial cells, IPCR Cyclotron Progress Report, 9, 98 (1975).

6) Y. Hattori, F. Yatagai and A. Matsuyama, 20th Annual Meeting of Japan Radiat. Res. Soc., Sendai, Oct. (1977).

7) F. Yatagai and A. Matsuyama, LET-dependent radiosensitivity of Escherichia coli K-12 rec and uvr Mutants, Radiat. Res., 71, 259 (1977).

---

* Affiliation of several authors from:

Y. Yamawaki, S. Okada and K. Sakamoto, The University of Tokyo

S. Sawada, Hiroshima University

M. Sasaki, Tokyo Medical and Dental University

N. Oda, Tokyo Institute of Technology