

## Harmonization of Radiation for Human Life - Summary Report of Radiation Hormesis Research -

Sadao Hattori  
Senior Advisor  
Central Research Institute of Electric Power Industry

### Radiation hormesis

In a review article entitled "Physiological Benefits from Low Levels of Ionizing Radiation," published in Health Physics in December of 1982, Professor T.D. Luckey, of the University of Missouri, asserted the "radiation hormesis" with 200 references.

CRIEPI organized a Hormesis Research Steering Committee composed of leading specialists in the field concerned, and began research in cooperation with a number of universities, as well as the National Cancer Research Institute, and the National Institute of Radiological Science.

We carried out experimental activities on the effects of low-dose radiation on mammals. After years of research activities, we are recognizing Luckey's claim. Some surveys including Sakamoto's success of low dose application on cancer therapy and animal experiments have brought us exciting information on the health effects of low-dose radiation.

The interesting results we obtained can be categorized in five groups.

1. Enhancement of immune systems such as lymphocytes and suppression of cancer and so forth.
2. Radio-adaptive response relating to the activation of DNA repair and apoptosis.
3. Rejuvenation of cells such as increase of SOD and cell membrane permeability.
4. Radiation effect on neuro-transmitting system through increase of key enzymes, and hormones.
5. Other beneficial effects, including the therapy of adult-disease such as diabetes and hypertension.

Formation of great numbers of ions, free electrons, and free radicals by ionizing radiation enhances and creates many comprehensive bio-chemical reactions, followed by significant biological responses.

Living materials exist on the homeostatic potentiality which directs all of our physical activities to obtain the survival keeping healthy condition against all kinds of degradation occurring by the environment. This is adaptive response itself.

### Scientific thresholds

Robley Evans showed a clear threshold in past days on radium induced bone cancer. Don Luckey asserted a threshold naming ZEP through animal data survey. Myron Pollycove and Ludwig Feinendegen presented a comprehensive insight on the damage control system of DNA like as prevention, repair, and removal. K. Sakamoto, S. Kondo, and O. Yamamoto have strong confidence on threshold assertion.

### Future

The recent progress of analytical technique on the observation of DNA structural responses greatly contributes the unbelievable success of our research on the adaptive response of low level radiation.

Certain optimum dose rates for various bio-positive effects shall be found in future through really comprehensive animal tests in all kinds of responses categorized above for actual application of low level radiation to obtain healthful condition of human being. Not only dose rate optimization but also various combination with other factors such as food and circumstantial temperature shall be the most economical research subject to obtain, really increased quality of lives of human being in next century.

### Acknowledgment

We appreciate the sincere advice and direction for research activities given by Dr.T.D.Luckey, Dr.S.Kondo, Dr.T.Sugawara, Dr.K.Sakamoto, Dr.T.Yamada, and Dr.H.Tanooka.

### References

- (1) ICLB (1992). Proceedings of the International Conference on Low-Dose Irradiation and Biological Defense Mechanisms, Kyoto, Japan, 12-16 July, 1992 (T. Sugahara, L.A. Sagan, and T. Aoyama, eds.). Elsevier Science Publishers B.V, Amsterdam.
- (2) IKUSHIMA T. (1989). "Radio-adaptive: Characterization of cytogenetic repair induced by low-level ionizing radiation in cultured Chinese hamster cells." *Mutat. Res.* 227:241-246.
- (3) ISHII K., MUTO N., and YAMAMOTO I. (1990). "Augmentation in mitogen-induced proliferation of rat splenocytes by low-dose whole-body x-irradiation." *Nippon Acta Radiologica* 50:1262-1267. [In

- Japanese.]
- (4) ISHII K., HOSOI Y., and SAKAMOTO K. (1993). Stimulation of Anti-Tumor Effect by Low-Dose Irradiation-Inhibition of Spontaneous Metastasis. Central Research Institute of Electric Power Industry, Report T92030. [In Japanese.]
  - (5) KONDO S. (1988). "Radiation hormesis." *Radial. Biol. Res. Comm.* 23(4):197-198. [In Japanese.]
  - (6) KONDO S. (1993). Health Effects of Low-Level Radiation. Kiniki University Press, Osaka, Japan and Medical Physics Publishing, Madison, Wisconsin.
  - (7) LIU S.-Z., LI X.Y., XIA EQ., YU H.Y., QI J., WANG FL., and WANG S.K. (1985). "A restudy of immune functions of the inhabitants in a high-background area in Guangdong." *Chin. J. Radiol. Med. Prol.* 5:124-127.
  - (8) LORENZ E. (1954). Biological Effects of External Gamma Radiation, Part I (R.E., Zirkle, ed.), McGraw-Hill, New York, P.24.
  - (9) LUCKEY TD. (1980). Hormesis with Ionizing Radiation. CRC Press. Boca Raton, Florida.
  - (10) LUCKEY TD. (1982). "Physiological benefits from low levels of ionizing radiation." *Health Phys.* 43:771-789.
  - (11) LUCKEY TD. (1991). Radiation Hormesis. CRC Press. Boca Raton, Florida, P.239
  - (12) MIFUNE M., SOBUE T., ARIMOTO H., KOMOTO Y., KONDO S., and TANOOKA H. (1992). "Cancer mortality survey in a spa area (Misasa, Japan) with a high radon background." *Jpn. J. Cancer Res.* 83:1-5.
  - (13) MINE M., NAKAMURA T., MORI H., KONDO H., and OKAJIMA S. (1981). "The current mortality rates of A-bomb survivors in Nagasaki City." *Jpn. J. Publ. Health* 28:337-342.
  - (14) MIYACHI Y., KASAI H., OHYAMA H., and YAMADA T. (1992). "Depression of mouse aggressive behavior by very low-dose x-irradiation and its unusual dose-effect relationship." In: *Low-Dose Irradiation and Biological Defense Mechanisms*, Kyoto, Japan, 12-16 July, 1992 (T. Sugahara, L.A. Sagan, and T. Aoyama, eds.). Elsevier Science Publishers B.Y., Amsterdam. pp.171-174.
  - (15) MORI T., KUMATORI T., HATAKEYAMA S., IRIE H., MORI W., BABA K., MARUYAMA T., UEDA A., and AKITA Y. (1989). "Current status of the Japanese follow-up study of the Thorotrast patients and its relationships to the statistical analysis of the autopsy series." In: *BIR Report 21, Risks from Radium and Thorotrast*. British Institute of Radiology, London. pp.119-124.
  - (16) MORI T (1990). "Japanese Thorotrast study." In: *Current Encyclopedia of Pathology*, Vol.10, Nakayama-shoten, Tokyo, pp.135-184. [In Japanese.]
  - (17) OHNISHI T., MATSUMOTO H., OMATSU T., and NOGAMI M. (1993) "Increase of wpt53 pool size in specific organs of mice by low doses of X rays." *J. Radial. Res.* 34:364.
  - (18) STEWART A.M. (1982). "Delayed effects of A-bomb radiation: A review of recent mortality rates and risk estimates for 5-year survivors." *J. Epidem. Commun. Health* 36:80-86.
  - (19) WATANABE M., SUZUKI M., SUZUKI K., NAKANO K., and WATANABE K. (1992). "Effect of multiple irradiation with low dose of  $\gamma$  rays on morphological transformation and growth ability of human embryo cells *in vitro*." *Int. J. Radial. Biol.* 62(6):711-718.
  - (20) YAMAOKA K., EDAMATSU R., and MORI A. (1991). "Increased SOD activities and decreased lipid peroxide level in rat organs induced by low-dose x-irradiation." *Free Rad. Biol. Med.* 11(3):299-306.
  - (21) YONEZAWA M., TAKEDA A., and MISONOH J. (1990). "Acquired radioresistance after low-dose x-irradiation in mice." *J. Radial. Res.* 31:256-262.
  - (22) YONEZAWA M., MISONOH J., and HOSOKAWA Y. (1993). "Radioresistance acquired after low doses of X rays in mice." In: *Proceedings of the International Symposium on the Biological Effects of Low-Level Exposures of Radiation and Related Agents (ISBELLES '93)*. Changchun, China. pA8.
  - (23) HATTORI S., State of Research and Perspective on Radiation Hormesis in Japan *International Journal of Occupational Medicine and Toxicology*, Vol.3, No.2, 1994.
  - (24) Feinendegen L.E. et al. Radiation Effects Induced by Low Doses in Complex Tissue and Their Relation to Cellular Responses personal communication March, 1996.
  - (25) ISHI K., WATANABE M., Participation of gap junctional cell communication on the adaptive response in human cells induced by low dose of X-rays, *Int. J. Radial. Biol.*, Vol.69, No.3, 291-299, 1996.
  - (26) Billen Daniel, Spontaneous DNA Damage and its Significance for the Negligible Dose "Controversy in Radiation Protection," *Radiation Research* 124, 242-245, 1990.
  - (27) Cohen A.E and Cohen B.L. Tests of the Linearity Assumption in Dose-Response Relationship for Radiation Induced Cancer. *Health Phys.* 38:53, 1980.
  - (28) Calabrese E.J., McCarthy M.E., and Kenyon E. "The Occurrence of Chemically Induced Hormesis," *Health Phys.* 52:531-542 (1987).