Ion-beam-applied Biological Researches at JAERI-Takasaki : A Heavy Ion Microbeam as a Tool for Radiation Biology

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At the Takasaki Ion accelerators for Advanced Radiation Application (TIARA) of JAERI-Takasaki, the innovative R&D is carried out laying emphasis on the effect of ion beams to organisms and on the effective utilization of positron emitters as a probe, in order to solve the problems related to conservation of circumstances and insurance of foods, and the promotion of new industries based on advanced techniques is also aimed.

We are investigating the radiation response of mammalian cultured cells, the nematode Caenorhabditis elegans, and the silkworm, Bombyx mori, using heavy ion microbeam. And the research of plant mutagenesis by means of ion beams and mutant analysis for producing new gene resources are ongoing. The goals are to elucidate the nature of ion-beam induced mutations,

to produce valuable novel mutants in terms of plant breeding, and to elucidate basic functions of plants by using ion-beam induced mutants. We are also developing new applications of radioisotopes for biological and medical sciences by making use of ion-beam technologies, such as the positron-emitting tracer imaging system (PETIS), to understand the plant functions through visualization of the transportation and accumulation of substances such as nutrients in living plants.

One of the most prominent techniques we have developed is a heavy-ion microbeam, as a tool for microsurgery to analyze their normal function of various cell parts, and as a radiobiological tool to elucidate cellular radiation responses in ways that cannot be achieved using conventional broad-field exposures. We have established a single cell irradiation system, which allows selected cells to be individually hit with defined number of heavy charged particles, using a collimated heavy-ion microbeam apparatus at the TIARA in JAERI-Takasaki. Using this system, separately inoculated Chinese hamster ovary cells, confluent normal human fibroblasts, and single plant cells (tobacco protoplasts) have been irradiated. These are the first studies in which single-cell/single-particle hit effects have been investigated using a high-LET heavy ion microbeam. Furthermore, both insparsely inoculated CHO-K1 cells and in confluent human fibroblasts, we have observed ionizing radiation-induced bystander effects, where irradiated cells emit signals resulting in damage to nearby unirradiated bystander cells. KRIA