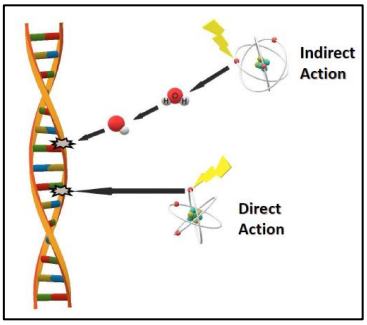
Report of HIMAC experiments

(A03-1) "Multidisciplinary Analysis of the Effect of Low Fluence Particle Radiation on Animals and Biological Adaptations"
Research Group Leader: Mitsuru Nenoi
Visit duration: 27th of May to 5th of July, 2018

Dylan Buglewicz[1], Akira Fujimori[2], Takamitsu Kato[1]
[1]invited researchers from Colorado State University, U.S.A, [2]NIRS/QST

Over the last month here at NIRS we have conducted experiments utilizing the carbon ion beam (June 20) as well as the iron ion beam (June 13). Our experiments have investigated the radiosensitizing effects of the transition metals copper or cobalt on purified double stranded DNA (dsDNA) and purified single stranded DNA (ssDNA) as well as on cell survival using the Chinese hamster ovary (CHO) cell line. Furthermore, we have investigated how these effects may vary when irradiated via carbon ion or the iron ion beams under consistent initial dosages.

The premise behind these experiments comes from how ionizing radiation can induce DNA damage, as it can work directly or indirectly. Direct action, in which ionizing radiation is believed to be most responsible action for inducing dsDNA breaks, this involves ionizing secondary electrons being produced by the incident radiation that then cleaves the chemical bonds. Indirect action involves the incident radiation produces free radicals, hydroxyl radicals, via ionization of the surrounding water molecules that results in DNA damage. However, these hydroxyl radical formations are not only unique to radiation, the hydroxyl attack from the radiolysis of water is identical to that of spontaneously occurring biological events.



We thus postulated that incorporation of a transition metal would increase this indirect action of the high LET carbon ion beam, therefore enhancing the beams ability to induce DNA damage. The addition of a transition metal, such as copper or cobalt, would do so via the Fenton reaction. The Fenton reaction involves the oxidation of the transition metal to create a hydroxyl radical and a hydroxide ion, thus increasing the concentration of the hydroxyl radical formation within the cell.

We have also investigated how the biological lethal dose distribution may vary when irradiated with the monoenergetic or spread out Bragg peak (SOBP) carbon ion beam in a variation to the commonly used clonogenic cell survival assay technique we have developed that has allowed us to incorporate the entirety of the carbon ion beams length in a single system to evaluate how the survival fractions change at different depths in our cell culture flasks. This technique will help determine the lethal dose range in which the monoenergetic and SOBP carbon ion beam can induce cell death at increasing initial dosages. Moreover, this technique will allow us to investigate how far past the Bragg peak the effects of the carbon ion nuclear fragmentation tail is capable of inducing cell death.