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Investigating the Long-Term Effects of Chronic Radiation Exposure on Cellular Mechanisms (Ref IAP-17-130)

University of Stirling, Biological and Environmental Sciences
In partnership with Centre for Ecology and Hydrology Lancaster (Contaminants Group)

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Key Words	**Radioactivity, Environmental contamination, Environmental protection, Phagocytosis, reactive oxygen species, Immunity**

Overview

Despite decades of research into radiation effects on wildlife, controversy remains concerning the dose rate at which significant impacts occur for different types of organisms[1]. Recent studies around sites of reactor accidents Chernobyl (1986) and Fukushima (2011) have indicated potential biological effects in the field and which are at odds with our expectations from laboratory studies[2]. Furthermore, in humans exposed to radiation from the Mayak Nuclear Facility, the cellular impact of chronic radiation, as observed in increase somatic mutations, frequency of micronuclei, and nitric oxide and apoptosis in peripheral blood lymphocytes, seems to affect 'radiosensitive humans' but not every individual[3]. Given there is increasing interest in understanding how and why sensitivity to radiation exposure varies between individuals, there is a need to better understand the effects of radiation not only on whole organisms, but also on cellular functions and to link the impact of exposure to a distinct physiological effect.

Within this project we will expose two well characterised model organisms, namely the waxmoth larvae (*Galleria mellonella*) and the freshwater protozoa *Tetrahymena thermophila* to a constant source of radiation, in our radiation facility, which mimics the radiation conditions in contaminated environments. Next we will compare the impact of chronic radiation on these organisms through the study of a range of biochemical and immunological responses, such as gene/protein expression, melanisation, phagocytosis, reactive oxygen species (ROS) production/accumulation, etc.

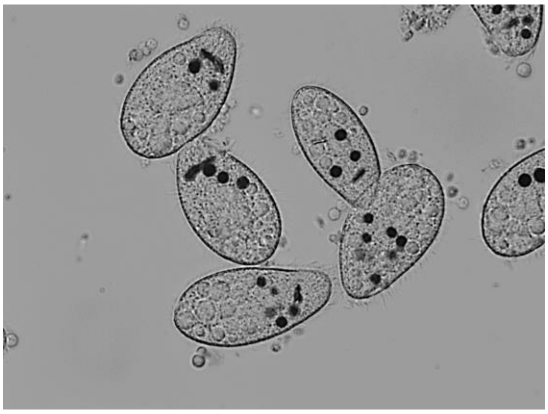

Figure 1: Fresh water protozoa, *Tetrahymena pyriformis*, which had phagocytosed ink (black vesicles)

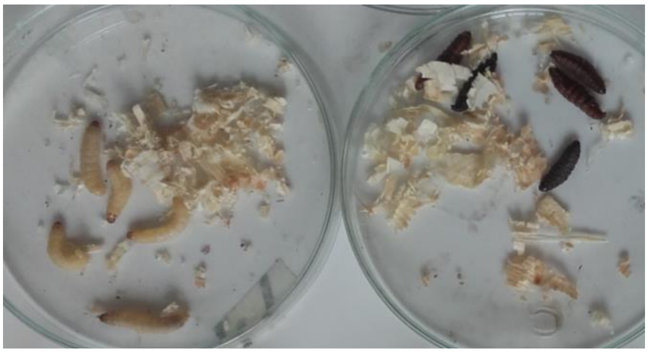

Figure 2: Waxmoth larvae, *Galleria mellonella*, alive (Left) and dead (Right).

Methodology

The project will utilise the specialist experimental facilities at the University of Stirling for radiation exposure experiments. The student will expose the research grade model organisms to a constant, low-dose radiation for fixed periods of time, under optimal light and temperature conditions. Next they will assess the ability of these model organisms to phagocytose or clear bacterial and/or fungal pathogens, as well as its ability to produce/accumulate ROS. This will be assessed by fluorescence microscopy, flow cytometry and plate reader.

Furthermore, regulation of specific genes will be determined – by 1D and 2D protein electrophoresis from proteins extracted from either the hemocytes (*G. mellonella*) or entire cells (*T. thermophila*). Any interesting up- or down- regulated genes will be analysed by mass spectrometry.

Timeline

Year 1: Understanding the invertebrate immune system; conduct a literature review and design an appropriate research strategy work within the radiation facility and experimental setup for the laboratory studies; Culturing and/or maintaining model organisms; familiarisation of experimental (biochemistry/cell biology) protocols

Years 2 and 3: Implement the laboratory programmes by introducing the model organisms to constant low-dose radiation; performing experiments to determine the cellular impact of radiation on these model organisms;

Year 4 (six months only): Thesis finalisation and paper writing (although it is anticipated that these activities will be ongoing throughout the PhD).

Training & Skills

The key analytical techniques required for this study are already established at the University of Stirling and include:

Biochemistry skills – SDS-PAGE, western blotting, mass spectrometry

Cell biology skills – Phagocytosis assays, infection assays, epifluorescence / live-cell microscopy, plate reader

The student will also receive training in experimental design, data analysis, and radiological protection related to the project work.

The student will benefit from wider interaction within the research groups at Stirling and CEH Lancaster. Personal development modules are offered by the Stirling Graduate School and appropriate CEH training courses will be available to the student. Courses we envisage the student attending are: Effective Research, Scientific Writing, Statistics for Environmental Evaluation (and use of R), Presentation Skills, and Radiological Environmental Protection. The student will be expected to present the results of their research annually at the BES student symposium and to attend the annual UK COGER meetings which have an emphasis on encouraging students to present their work. The student will also be expected to present their work at one international conference.

The student will have the opportunity to interact with wider student networks (and training opportunities) though the European Radioecology ALLIANCE. .

References & Further Reading

[1]Beresford, N.A., Copplestone, D. 2011. Effects of Ionizing Radiation on Wildlife: What Knowledge Have We Gained Between the Chernobyl and Fukushima Accidents? Integer. Environ. Assess. Manag., 7, 371–37.

[2]Copplestone, D., Beresford, N.A., Howard, B.J. 2010. EDITORIAL: Protection of the Environment from Ionising Radiation: developing criteria and evaluating approaches for use in regulation. J. Radiol. Prot., 30, 191-194.

[3]Veremeyeva G1, Akushevich I, Pochukhailova T, Blinova E, Varfolomeyeva T, Ploshchanskaya O, Khudyakova O, Vozilova A, Kozionova O, Akleyev A. 2010. Long-term cellular effects in humans chronically exposed to ionizing radiation. Health Phys. 99:337-346.

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