PhD Project Advertisement

Project title: Nanoplastics in the food chain: from food, to cells, to function
Project No: FBS2023-44-Parker-sr

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Project description:

Globally, plastic production has doubled in the past 20 years to more than 460 million tonnes. With only ~9% of plastic waste officially recycled, the remainder is either incinerated (19%) or buried in landfill (50%), leaving ~22% being illegally disposed of in unregulated terrestrial burial sites, or aquatic environments. Once in the environment, these plastics fragment into micro-plastics (MPs, <5mm) and nano-plastics (NPs, <1000nm). There is compelling evidence from our oceans, seas, and rivers that these microscopic fragments of plastic waste accumulate in several species, some of which have been found to cause disruption to hormonal systems, and even to changes in behaviour. In addition, plastics enter the food chain including, potentially, humans. On dry land, there is evidence that NPs can also be taken up by plant roots, and therefore again, potentially enter the human food chain. What is not clear, presently, is the extent to which these NPs may be up-taken via transport from food, the distribution across the body system and organs, and the effects this may have on our health.

Of particular concern is the impact NPs may have on the nervous system, and model organisms can help address this knowledge gap. For example, in aquatic organisms NPs, once ingested, are absorbed through all parts of the digestive tract (mouth, oesophagus, stomach, intestines), causing severe problems with the microbiome and metabolic disorders. In addition, NPs can affect neuronal transmission, having a profound effects on muscle tissue, neuronal development and behaviour. As NPs are retained in the body, there is potential for life-long accumulation and increased toxicity across the life-span. This has potentially significant implications for lifelong health and healthy ageing in a range of species, including potentially humans, especially in poorer countries where the levels of plastics pollution are extremely high.

Objectives and hypotheses of the project

During this project the goal will be to examine the movement of NPs from the environment into animals, and the impact this has on the whole animal system. You will do this in the widely used model organism, the zebrafish. The project has three specific aims:

1) To examine translocation of NPs between food and the whole animal system.
2) To evaluate the modulatory effects of NPs on neuronal and non-neuronal cells in the central nervous system (CNS) at environmentally relevant levels.
3) To establish the effects of long-term dietary exposure to NPs on neurotoxicity, behaviour, and cognition.

Towards these aims, the project has two independent, interrelated Work Packages (WPs) which will be carried out at both the University of Surrey (where you will spend the bulk of your time) and the University of Reading (where you will spend some of Year 2):

WP1 (Surrey) will test the hypothesis that NPs enter the food chain via third-party consumption. Through experiments in an established model organism, the zebrafish, we will evaluate NPs concentrations in the blood, organs, peripheral tissues and CNS of zebrafish exposed to low doses of nano-plastics in their food using radiolabelled (14C) NPs following the co-investigator's established method. We will use zebrafish because of the availability of transparent animals (transgenic casper line) for in vivo tracking of radio-labelled in organs and in the CNS (eg with transgenic zebrafish that

express GFP under the her4.1 promoter, which specifically marks glial cells, or zebrafish that express GFP under the elavl promoter, which marks neuronal cells). Second, we will examine the effects of chronic exposure to NPs on behaviour and cognition using established protocols from the Parker lab at Surrey.

WP2 (Reading). We will test the hypothesis that NPs specifically induce a neurotoxic effect on glial cells in vitro. We will test the effects of NPs on the electrical properties of both neuronal and glia cells. We can examine Ca2+ dynamics in glial and/or electrophysiology. In addition, we will example neurophysiological read outs in neurones to determine effects on synaptic function.

Training opportunities:

This interdisciplinary project will equip the student with a broad range of skills that will place them in a very strong position as a bioscientist for the future. The skills developed across the three supervisors' labs will allow the student to move in several different directions after the project. As well as learning specific skills in analytical chemistry, pharmacology, molecular biology, behavioural biology and informatics, the skills will include in vivo, in vitro, and in silico approaches. They will be trained in all the skills required for a career as an academic scientist (writing up work for publication, preparing and delivering presentations, writing funding applications). They will acquire a critical knowledge of animal welfare and animal experimentation (including personal licence training from the Home Office) and will have their training strongly nested in the principles of the 3Rs of in vivo research. This will include using the PREPARE (Norecopa) and ARRIVE (NC3Rs) guidelines. In addition, they will be trained in the principles of Open Science, including pre-registration of studies, and sharing of all data.

Student profile:

This project would suit a candidate with a biological or chemical sciences background, with a keen interest in applying experimental science to real-world scenarios. Strong interest in promoting and improving sustainability. Ability to drive would be an advantage to facilitate moving between institutions.

Stipend (Salary):

FoodBioSystems DTP students receive an annual tax free stipend (salary) that is paid in instalments throughout the year. For 2022/23 this will be £17,668 and this will increase slightly each year at rate set by UKRI.

Equality Diversity and Inclusion:

The FoodBioSystems DTP is committed to equality, diversity and inclusion (EDI), to building a doctoral researcher(DR) and staff body that reflects the diversity of society, and to encourage applications from under-represented and disadvantaged groups. Our actions to promote diversity and inclusion are detailed on the FoodBioSystems DTP website.

In accordance with UKRI guidelines, our studentships are offered on a part time basis in addition to full time registration. The minimum registration is 50% FT and the studentship end date will be extended to reflect the part-time registration.

References:

[1] OECD. Available from https://www.oecd.org/environment/plastic-pollution-is-growing-relentlessly-as-waste-management-and-recycling-fall-short.htm

[2] Amereh, F., Babaei, M., Eslami, A., Fazelipour, S., & Rafiee, M. (2020). The emerging risk of exposure to nano (micro) plastics on endocrine disturbance and reproductive toxicity: From a hypothetical scenario to a global public health challenge. Environmental Pollution, 261, 114158.

[3] Sana, S. S., Dogiparthi, L. K., Gangadhar, L., Chakravorty, A., & Abhishek, N. (2020). Effects of microplastics and nanoplastics on marine environment and human health. Environmental Science and Pollution Research, 27(36), 44743-44756.

[4] G. Fackelmann, S. Sommer (2019). Microplastics and the gut microbiome: how chronically exposed species may suffer from gut dysbiosis Mar. Pollut. Bull., 143, 193-203

[5] Yang, H., Xiong, H., Mi, K., Xue, W., Wei, W., & Zhang, Y. (2020). Toxicity comparison of nano-sized and micron-sized microplastics to Goldfish Carassius auratus Larvae. Journal of hazardous materials, 388, 122058.

[6] MacLeod, M., Arp, H. P. H., Tekman, M. B., & Jahnke, A. (2021). The global threat from plastic pollution. Science, 373(6550), 61-65.

[7] Al-Sid-Cheikh, M.; Rowland, S. J.; Stevenson, K.; Rouleau, C.; Henry, T. B.; Thompson, R. C. Uptake, Whole-Body Distribution, and Depuration of Nanoplastics by the Scallop Pecten Maximus at Environmentally Realistic Concentrations. Environ. Sci. Technol. 2018, 52 (24), 14480–14486. https://doi.org/10.1021/acs.est.8b05266.

[8] Al-Sid-Cheikh, M.; Rowland, S. J.; Kaegi, R.; Henry, T. B.; Cormier, M.-A.; Thompson, R. . C. C. Synthesis of 14C-Labelled Polystyrene Nanoplastics for Environmental Studies. Commun. Mater. 2020, 1 (1), 97. https://doi.org/10.1038/s43246-020-00097-9.

[9] Cleal, M., Fontana, B. D., Ranson, D. C., McBride, S. D., Swinny, J. D., Redhead, E. S., & Parker, M. O. (2021). The Free-movement pattern Y-maze: A cross-species measure of working memory and executive function. Behavior research methods, 53(2), 536-557.

For up to date information on funding eligibility, studentship rates and part time registration, please visit the FoodBioSystems website.