# Understanding Microbial Communities; Function, Structure and Dynamics

4-month scientific programme at the Isaac Newton Institute

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Microbes – single-celled, microscopic living organisms - make up most of the biomass on earth and are found in all types of habitats, including soils, oceans and surfaces, and insides higher organisms such as plants and humans. Almost never are such habitats occupied by a single microbial species, but rather by many species that co-exist as a *microbial community*. Recent technological developments in DNA sequencing allow us to characterise the species composition of communities from a variety of environmental and medically-relevant habitats. However, there is an enormous gap between current empirical knowledge of microbial community composition and experimental and theoretical understanding of their function, structure, and dynamics. Key unresolved questions are:

- Do microbial communities achieve a higher-level function?
- How is this function stabilised?
- What drives evolutionary and ecological processes of community function?
- What determines the level of complexity in microbial communities?
- Could simpler and minimal communities for a given function be developed and stably maintained?

It is not possible to answer these questions using empirical data on microbial community composition alone. Data on functional traits within communities and their temporal and spatial distribution are also needed, and a theoretical foundation, involving mathematic, for evaluating biological data and testing hypotheses must be developed

This programme was focused on the development of mathematical approaches to microbial community research and was timely because data on microbial communities had been accumulating for about a decade and the field had started to attract attention from both experimentalists and theoreticians. Moreover, funding bodies, as well as industry had started to recognise the important role of microbial communities in the understanding of biology, with important biotechnology and medical applications.

The programme began with a keyote leacture *On the (un)reasonable (in)effectiveness of mathematics in biology* by Stanislas Leibler (Rockafellar Universiyty) who was the Rothschild Distinguished Visiting Fellow on the programme. Over the following four months over 150 scientists, with a diverse range of backgrounds in mathematics, physics, microbiology, ecology, economics, and computer science, participated. To nurture cross-fertilisation among this community and to encompass such a wide range of backgrounds there were many weekly informal seminars, three short workshops, a PhD school and an industry-academia day.

A key scientific outcome was the establishment of networks among scientist with common interests from disparate research areas and an enthusiasm for collaboration that was reflected in the development of a co-authored *opinion paper* to help shape the future of the subject. This paper has been submitted as an invited review article to *The ICME Journal Multidiscilinary Journal of Microbial Ecology* with about 50 co-authors. In addition to this very tangible scientific evidence of community building, the programme emphasized the need to move from empirical studies of microbial communities to their dynamical and functional analysis.

The programme succeeded in bringing together the majority of scientists currently working on microbial communities and in consequence the programme may be seen as a landmark in the development and expansion of the field of microbial ecology, with particular emphasis on microbial communities research.

To encourage a healthy influx of young scientists into the study of microbial communities, several early career scientists and doctoral students were invited to the programme and lectures from leading scientists were specifically designed to help them become engaged in the field. Several students and early career scientists spend extended time at the Institute, developing their own ideas and establishing research areas that should help launch their careers.

Among the respondents to the post-programme questionnaire, 90% rated the programme as above 80% excellent. Specific comments highlighted the success of the event, particularly in terms of networking and connecting empirical and theoretical scientists. A majority said that they had become aware of new research questions and contacts as a result of participation in this programme.

The importance of microbial communities for health, industry and the natural environment cannot be overstated. This potential was explored with an “Open Business Event” during which industrialists, academics and regulators came together to evaluate the industrial and medical potential of the emerging field of microbial communities research. The impact of the programme was reflected in the subsequent BBSRC announcement of a focus area within their current strategic funding plan with the same title as the program; *“Understanding Microbial Communities”.*