Citizen Science and Microbiology: Good Germs, Bad Germs

Have you ever wondered about the bacteria that live on your chopping boards? How about those in your sink, or the murky depths of the plughole? And if so, were you thinking only about pathogenic 'germs', or also about the wider microbial communities that might persist in your homes? And how does such thinking sit with contemporary understandings of 'good bacteria', and the popular discourse that we might be 'too clean' for our own good? Taking advantage of recent developments in DNA sequencing, a citizen science project called *Good Germs Bad Germs* is exploring the ambiguously understood microbial ecologies found in peoples' kitchens. Working with a small community of public participants, the project is concerned with the questions people ask about bacteria in their homes, and what happens when they work with scientists to find out the answers.

In recent years, scientists from many disciplines have begun working more closely with the public when conducting research. These 'citizen science' projects have multiple benefits, including their ability to collate vast datasets and to enthuse the public about the conduct of science. For some practitioners, involving the public in the conduct of scientific research is also an ethical imperative. But 'citizen science' is something of a catch-all term. It is used to describe a range of experimental practices that may differ significantly in the forms and depth of public engagement they permit[i].

The riverine metaphors of 'upstream' and 'downstream' are often used to distinguish these different types of citizen science[ii]. Downstream citizen science aims to educate and enthuse the general public about scientific inquiry whilst also collecting big datasets, and it does this through asking people to collect data according to pre-set protocols. Common examples of downstream engagement include wildlife surveys, like the RSPB's Big Garden Birdwatch. By contrast, upstream citizen science aims to involve publics in shaping the goals, directions, and practices of scientific research. It is labelled 'upstream' because the public are involved at an earlier stage in the process. Rather than being educated by scientists (acting as the gatekeepers to knowledge), publics work with scientists to decide what questions to ask and how to ask them[iii]. While downstream citizen science is increasingly prevalent, especially given the communicative possibilities in a networked age, upstream citizen science remains somewhat rare in comparison.

The *Good Germs Bad Germs* project is attempting to facilitate 'upstream' citizen science in the field of microbial ecology. It was inspired by recent 'downstream' citizen science experiments that have investigated bacterial communities living in the built environment[iv]. Led by a cast of high profile microbiologists including Rob Knight, Rob Dunn, Jack Gilbert, Holly Ganz and Jonathan Eisen (amongst others), such work has been enabled by the revolution in DNA sequencing that has made identifying the manifold bacteria in an environmental sample increasingly affordable[v]. Those projects and others like them invited people to swab inside their houses (their kitchens, toilets, beds, clothes, phones and even their pets), their workplaces, and on transport vehicles[vi]. They then utilised DNA

sequencing (especially 16S rRNA sequencing) to identify the types of bacteria present in each site. These various experiments have produced important and robust scientific findings, and using public participants as 'data collectors' has enabled cost-effective science whilst simultaneously educating and enthusing people. But they remain resolutely 'downstream'.

The *Good Germs Bad Germs* project takes citizen microbiology further upstream by asking the participants not simply to swab pre-defined sites, but to help design the experiments as well. The project group consists of the inhabitants of 14 households (all located within walking distance of a community centre in Oxford) working alongside a small team of social and natural scientists. It began by repeating an existing 'downstream' citizen science experiment, in which each household was asked to swab five common areas in their kitchens – a microbial 'kitchen safari'. The aim for the first experiment was to introduce the participants to the technology, so that they might then shape the future experiments themselves. They were also given a sixth swab to sample somewhere they thought might be interesting, in a prelude of things to come. The swabs were processed using 16SrRNA sequencing, and the bacterial communities present in each site were characterized. The results were presented and discussed at a group meeting in the community centre, and the group then decided what they would like to explore in the next experiment.

There have been five rounds of these microbial experiments so far. In addition to their initial 'kitchen safari', the households have chosen to explore the bacterial communities on chopping boards, the effects of different cleaning products on microbial communities, and the changing microbial ecologies in fridges. In each round of experiments, the participant group has taken more ownership of the experimental design, with the academic team shifting into a consulting role about what might or might not work given the vagaries of the microbiological technologies being used. In the most recent round, this devolution of experimental choice and design has proceeded the furthest, with each household selecting their own inquiry – from tracing the microbial signatures of their pets, to the micro-ecological changes in kitchens concurrent with the introduction of Christmas trees.

Given the small sample sizes in these various 'experiments', especially the recent round, the aim is not to produce particularly robust scientific findings. Rather, the aim is to use upstream citizen science as a policy-relevant tool to investigate peoples' understandings, practices and concerns. As a result, the crucial site in this work is not the kitchen or even the lab, but the group meeting where results are discussed and new experiments shaped. Through allowing participants to choose what to investigate, and through in-depth discussion of the findings (and their limitations), the project can identify putative public concerns that would remain obscure in traditional 'downstream' citizen science models. The project is thus using upstream citizen science not simply to 'educate people', or even to 'educate scientists about people', but to provide important insights into peoples' hygiene practices and understandings in a world characterized by both 'good' and 'bad' microbes. After all, the public policy message has, for generations, been to vilify all germs; but increasingly, such messages are becoming less tenable[vii].

[i] Irwin, A. 1995 *Citizen Science: A Study of People, Expertise and Sustainable Development*, Routledge, London

[ii] Wilsdon, J. and Willis, R. 2004. *See-through science: why public engagement needs to move upstream*. London: DEMOS.

[iii] Whatmore, S. 2009. Mapping knowledge controversies: science, democracy and the redistribution of expertise. *Progress in Human Geography*, 33, 587-598.

[iv] Cavalier, D., and Kennedy, E**.** (eds) 2016. *The Rightful Place of Science: Citizen Science.* ASU. Arizona.

[v] For example: Flores, G. *et al.* 2013. Diversity, distribution and sources of bacteria in residential kitchens, *Environmental microbiology* 15(2), 588–596 Lax, Simon, *et al.* Forensic analysis of the microbiome of phones and shoes. *Microbiome* 3.1 (2015): 21.

[vi] Konya, T.; Scott, J.A. 2014. Recent Advances in the Microbiology of the Built Environment, *Curr Sustainable Renewable Energy Rep*, 1:35-42

[vii] Bloomfield, S.F. 2016 In future we are going to have to view our microbial world very differently. *Perspectives in Public Health*. 136:4, 183-185