[O32] Linking Research and Teaching in Microbiology

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Introduction

My research focuses on the interactions occurring between microorganisms and inert surfaces, specifically: oral microbiology, especially denture hygiene; food hygiene, and the characterisation of hygienic food contact surfaces; and the production, characterisation and evaluation of surfaces that may have antimicrobial properties. The topics translate well into activities for undergraduate teaching, being current, applied, and interdisciplinary. In fact, since the majority of the planet's microorganisms exist attached on surfaces (Donlan, 2002), often forming the community structures called 'biofilms', the research provides useful illustrations of the fundamental mode of existence of microorganisms. This article describes some examples of research-led teaching in these topics (Healey, 2005), and also satisfies 'the expectation that teaching is informed by research activity' (HEFCE, 2009).

Fig 1: Biofilms and deterioration

Lectures

Although course and module curricula outline learning outcomes, there is ample opportunity to utilise home-grown findings in lectures, tutorials and laboratory classes. For example, lectures on oral microbiology (year 2, microbiology module) provide a useful illustration of the normal microbial flora of humans, and allow plenty of images and data from our research, as well as confidence in the currency of the supporting literature. Our work on bad breath, probiotics, yeast infections, toothbrush contamination and so on captures the imagination quite well too!

Biodeterioration of cultural heritage provides a novel and fascinating aspect of applied microbiology. By focusing on the range of substrata available (cave paintings, frescoes, buildings, textiles etc), the nature of the interactions occurring between microorganisms and art can be explored and developed. I have previously described a lecture that elaborates on the diverse links microbiology with art (Verran, 2008), delivered as part of the first year microbiology module. The lecture develops into more creative links, and extends into sci-art collaborations. The associated assignment provides a real active learning opportunity (http://resources.glos.ac.uk/ceal/resources/casestudiesactivelearning/undergraduate/casestudy10.cfm): students are asked to work on a 'product' linking microbiology and art. These loose requirements allow freedom of imagination, and the opportunity to utilise other expertise and interests. In effect, many skills associated with 'research' are employed. This is now the sixth

iteration of the project, and the creativity of the students continues to impress. Final year projects allow some opportunity for further exploration of the students' own ideas.

Fig 2. Amy O'Toole photographed 'Biofilms around Manchester' for her first year assignment, and explored the nature of the biofilms for her final year project.

Tutorials

Although the biofilm mode of growth is fundamental to microbial existence, the topic tends to receive scant attention in text books, with the odd paragraph at the end of various sections. So, students need to use the scientific literature (fairly selectively due to the considerable amount of information available), and the internet, which itself provides a useful opportunity for critical evaluation of information. Thus, in a tutorial, final year students (medical microbiology module) are asked three questions: what is a biofilm? What particular features make biofilms important in medicine? What is the range of biofilm-associated infections? By pooling their findings, key words and over-arching concepts can be identified, and the importance of the scientific literature in research on recent topics is emphasised. In addition, the students are referred to a new hypertextbook on biofilms (www.erc.montana.edu/biofilmbook/), and are invited to contribute to the evaluation of this evolving document.

Laboratory classes

Although it is not difficult to conceive open-ended, exploratory lab classes based on research, time and cost constraints pose challenges. The development of the activity in itself is time consuming, and a successful activity ought to be disseminated. The American Society for Microbiology (www.asm.org) publishes peer-reviewed curriculum resources that include 'Exploring oral biofilms and the contamination of toothbrushes', and 'Chairside diagnosis for plaque-associated oral infections' from my laboratory.

A different lab class that evolved indirectly from my research is a study on the contamination of mobile phones. Students monitor the contamination of their phones, compare the bacteria isolated with those on their skin, and consider the potential impact of such cross-contamination in the hospital setting. The activity demands a critical evaluation of the limitations of the laboratory class, perusal of the (thin) literature on phone contamination in particular, and inanimate objects in general, and suggestions for future work that would extend and explore observations in more detail. Masters projects, some work comparing different decontamination methods, and new collaborations and publications (Brady *et al*, 2009) were additional benefits.

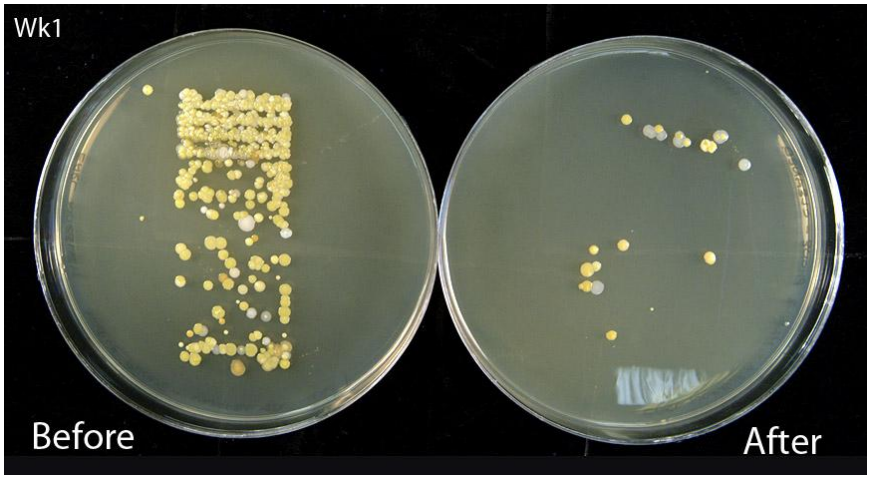

Fig 3: wiping a mobile phone with a moist antimicrobial cloth reduces contamination

Student Project Work
Some students ask for lab/research experience during their summer vacations. Some are funded, others unpaid. These activities also provide potential introduction opportunities for third stream activity. One cannot guarantee the success of a student project, but the external partner can get to know the laboratory and the staff, and opportunities then arise for subsequent links. The students also gain useful employability skills.

Final year student projects provide culmination of the training of individual students as graduate scientists, and can help them decide if they enjoy laboratory research as a potential post-graduate pursuit. Undergraduates become integral members of our research group. We have published findings from several student project topics in peer-reviewed scientific journals, with the students as co-authors. For example we have developed a niche of expertise exploring the potential for cross-contamination in dental technology laboratories, where dentures and other prostheses are fabricated and repaired (Verran *et al*, 2004).

Final Comments
It is clearly our job to 'teach'. Not all of us have the opportunity to be both research-active and teaching-active, but it is a most enjoyable and energising combination, which generates new ideas, research areas and collaborations. The students get an idea of the research that is going on around them, and how it impacts more generally on the study of microbiology. (Hopefully, it also encourages interest in microbiology!) The more open-ended laboratory classes illustrate many aspects of research, particularly critical evaluation of results. For the smaller number of students who are involved in laboratory based research projects, the one-to-one interaction with their supervisor is a new and valuable experience, as is working with others in a research laboratory. Some flavour of research culture is imbibed. During a brief collaboration with colleagues at the Institute of Education I was interviewed about 'being a researcher', with questions having been posed by B.Ed students. The aspect that they found most fascinating was that I actually had friends and colleagues whom I met at conferences, corresponded and collaborated with, and had kept contact with over many years. Their idea of the researcher, not an uncommon perception, was of the lone individual in the laboratory. Clearly this is not the case: teaching enables us to nurture research (and other) skills, show how research informs discipline knowledge, transmit the enthusiasm that makes us researchers in the first place – and demonstrate that we are quite human after all!

Further information
Our activities in research, consultancy, education and communication are summarised on the website www.sci-eng.mmu.ac.uk/intheloop. Case studies, publications, educational resources and public engagement activities are included to emphasise the relevance of our work to the wider world.

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