

Student (and staff) research in Environmental Biochemistry

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Background and rationale

Starting from a belief that academic staff have two main responsibilities – to develop their subject and to develop their students' potential – this approach to encouraging student engagement with biochemistry was developed via research into environmental problems. Almost regardless of the degree programme on which students were enrolled, they had an interest in the degradation of the environment, particularly when the degradation could be seen to be linked to human activities. Students were also keen to be taught by staff engaged in research.

The focus of this work was a Level 2 module in Environmental and Ecological Biochemistry, designed as an optional module for students who were primarily interested in whole organism/ecosystem biology, rather than molecular/cellular biology and who were enrolled on degree courses in marine biology, environmental biology, plant sciences, or ecology. The intention was to give students an understanding of the molecular and cellular processes and responses involved in the interaction of organisms with their environment and with environmental change – either natural or anthropogenic.

In addition to the module lectures, there was a research-based practical component. Topics arising from lectures (e.g. coral bleaching; environmental impact of pharmaceuticals) were introduced in workshops and groups of students were asked to carry out a web and literature-based search to try to answer questions introduced in the lectures and at the start of the workshops. Students were given a limited choice of topics to work on, all of which were capable of being further investigated in the laboratory with available equipment and within funding limits.

The workshops gave a different style of introduction to the practical work than students usually had. Doing the work in small groups enabled students to divide up the work and then try to put a coherent story together for the feedback session and having a choice of projects enabled students to focus more on individual interests.

The module aimed to encourage initial guided research into areas of potential interest, giving students a feel for what it might be like doing an Honours project on topics

of interest. The module topics allowed staff research interests to be introduced and practical work developed techniques essential for students in final (Honours) year research projects.

How to do it

The topics for the workshops and practical work followed on almost automatically from the lecture topics. With no textbook on environmental biochemistry, in a sense there was less of a constraint on what 'needed to be done'. A couple of example topics illustrate the approach well.

Most students have heard of coral bleaching and are interested in the causes and consequences. Although corals are not available readily in the UK, coralline algae are found around most of the UK coastline. Coralline algae form an important constituent part of the carbonate framework of coral reefs but little work has been carried out to investigate their responses under conditions that lead to coral bleaching. Setting up seawater tanks under a range of differing environmental conditions is easy (a range of different temperatures from 15 – 35°C is very easy to set up) and the responses of coralline algae can be followed simply by extracting and quantifying their primary (chlorophylls) and accessory (phycobilins and carotenoids) photosynthetic pigments. It is also easy to extract and assay enzymes involved in antioxidant defences.

Coral bleaching is a hot topic at the moment. However, there is so much going on in the environment that there is no shortage of topics. For example, few students are aware of the environmental impact of pharmaceuticals. The introduction of the non-steroidal anti-inflammatory drug (NSAID) Diclofenac (Voltarol) in northern India/Pakistan as a veterinary treatment for lame animals provides a particularly devastating example. When treated animals die, vultures scavenge them. The latter convert the drug to a very reactive quinone-imine that damages kidney and liver proteins leading to death. Over 95% of the vulture populations of northern India/Pakistan have been wiped out since the use of diclofenac was introduced in the early 1990's. Although vultures cannot be used as experimental animals, the common blue mussel, *Mytilus edulis* can readily metabolise

drugs. Paracetamol can be converted to a reactive quinone-imine that is hepato-toxic and is a suitable and inexpensive NSAID for the investigation of the environmental impact of such compounds on non-target organisms (e.g. mussels). Soluble paracetamol tablets dissolved in seawater are readily administered to tanks of mussels. The mussels excrete a pink product and the amount of product excreted is dose-related. The soluble paracetamol contain saccharine and sorbitol as well as the active ingredient. By administering pure paracetamol, the pink excretion product can be shown to be derived from the NSAID, not the other components. The excretion product is easily extracted from seawater and can be identified provisionally by thin layer chromatography against standard compounds. The enzymes detoxifying paracetamol are found in the digestive gland of the mussel. These glands are easily removed and the enzymes extracted and quantified showing the induction of detoxification enzymes following exposure to drugs.

Neither of these examples requires exotic materials or expensive equipment and consumable costs are low. Students showing further interest can be encouraged to undertake Honours year research projects on related topics.

Advice on using this approach

The choice of topics is critical. There must be adequate information available on the web or in the university library to enable students to carry out effective searches, although the lack of formal comprehensive textbooks should not be a problem. This may exclude many interesting topics because of a lack of current, relevant, freely available information. Too many references not in the library or available on-line only by paying are a recipe for frustration rather than engagement, and must be avoided. Each of the lecture topics included some starting references from which students could chase up other material.

Where lab-based work is going to follow the initial workshop, it is essential suitable organisms are readily available and equipment and consumable costs are containable.

Troubleshooting

One of the main problems arises from some students' concerns over the relevance of any molecular/cellular biology to whole organism/ecosystem biology. A choice of topics showing the environmental impact of chemicals and the changes in biodiversity that can arise from even subtle chemical/physical environmental changes can help

to overcome student resistance.

Another major problem is even more fundamental. It is the 'chemo-phobia' displayed by some students – often the result of poor experiences of chemistry at school and a lack of well-designed practical work at university.

The best solution here is to start with confidence-building early in first year with practicals that work, are seen to be relevant to students' interests, and are supervised by demonstrators who have been involved in the development of practicals. There are fewer more confidence-destroying experiences than being 'helped' by demonstrators who don't understand what is going on.

Any extraction procedures or assays should be accompanied by detailed, plain English descriptions from which students can complete procedures step by step, and can keep should they need to utilise it in the future.

Does it work?

This approach works well. It builds on staff research interests and allows students to carry out hands-on practical work after doing relevant web and literature searching and, ideally, working out methodology for extractions/assays etc. Probably the best evidence of effectiveness is the number of publications in peer-reviewed journals with students as co-authors. Although there is no formal textbook for the module, that does not seem to be a major problem for students. Initially the thought of pulling together material from several texts, research papers or from the Internet might seem daunting to some students but most seem to settle into the necessary ways of working quite quickly. Some students, however, do find the lack of a textbook a continuing problem and they need a bit of extra support – often provided by other students.

For Holly Latham (1st author) the Level 2 project led to an Honours project which was published in the journal *Bioscience Horizons* (Latham, 2008)

Feedback from students has been excellent (average overall satisfaction score from end-of-module questionnaires was 4.3/5 (86%) over 12 years).

Further developments

With the graduation of Holly Latham and the retirement of Les Jervis, the module on which this case study is based has now passed to other staff so no further development will take place by the authors.

Reference

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Further information

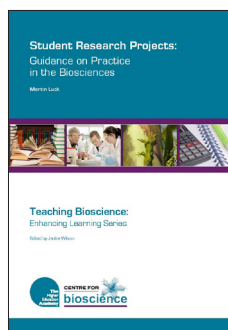
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Accompanying materials



This case study accompanies the Teaching Bioscience: Enhancing Learning guide entitled *Student Research Projects: Guidance on Practice in the Biosciences*, written by Martin Luck and published by the Centre for Bioscience. The associated website (www.bioscience.heacademy.ac.uk/resources/TeachingGuides/) contains a downloadable version of this case study

The lecture/workshop topics/PowerPoint presentations from the module are available from Les Jervis on request.

Case Study published October 2008



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