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Science Studies in a Liberal Arts Curriculum

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From the perspective of a British undergraduate student and many academics, this chapter may seem an anomaly. The idea of studying subjects related to science in an institution closely affiliated with a Faculty of Arts, and even the meaning of a 'liberal arts' education itself, may provoke blank stares or evoke mistrust. The word 'Studies' in the title may also suggest unappealing connotations of a cobbled-together, post-1960s palette of subjects designed to appeal to a fickle audience unable or unwilling to engage deeply enough with a discipline to make it their own. While subjects such as Environmental Studies and Science Studies appeared in the 1970s partly as a reaction to student criticisms of the irrelevance of traditional disciplines, these subjects can play a crucial role in the undergraduate curriculum of a flexible institution. And such subjects represent not merely a *reaction*, but also a positive action to create productive new academic perspectives. Rex Taylor and the University of Glasgow committees that sketched the original curriculum for Crichton, aware of these possibilities, based three of the initial five lectureships on Scottish, Environmental and Science Studies.[1] Subsequent appointments, notably in Media Studies, Health and Social Studies and Creative and Cultural Studies, have reinforced this curricular approach.[2] As a result, the Crichton campus of the University of Glasgow became a test-bed that has nurtured a highly fertile jostling of academics, courses and perspectives to yield a unique product.

Before highlighting the potential of carefully crafted interdisciplinary studies of science, though, it is important to point out that their study at an institution such as the Crichton Campus has strong historical precedents, and is anything but an anomaly. The *artes liberales*, taught in academic institutions of the Middle Ages, incorporated all scholastic knowledge that would be of benefit to a free man in his pursuit of further knowledge. When the University of Glasgow was founded in 1451, the *artes liberales* combined training in philosophy and theology to prepare the student for studying science in the broadest sense of the word. The medieval curriculum identified seven such arts, divisible into two groups. The first group comprised the sciences of logic, language and oratory in the form of dialectic, grammar and rhetoric, and was known as language studies, or the *artes sermocinales*. It was deemed to be an elementary three-fold study, or *trivium*. The

second group, known as the *quadrivium*, encompassed arithmetic, geometry, astronomy and music.[3] These disciplines, related to mathematics and the physical world, were deemed to be of intermediate difficulty. Together, the seven disciplines provided the background for the study of the natural world itself, a subject area that today would be distinguished as science proper. The inter-relatedness of these subjects continued into the modern period, and the appearance of explicit university departments of 'natural philosophy', or 'science' was a phenomenon of the late nineteenth century (indeed, the word 'scientist' was coined only in 1833 by William Whewell in England). During the same half-century, from the 1830s to the 1880s, the subject of sociology was created as a prospective statistical science, and scholarly study of the history and philosophy of science got well underway.

In this way the differentiation of academic disciplines evolved alongside the study of their principles and evolution. In the Victorian context, the history and philosophy of science came to represent and to document the progress of western thought and, along with it, what was then seen as the natural superiority of western society. Only from the mid-twentieth century, though, was the history of science taught as an academic specialism in more than a handful of universities. Only then did professional societies for the history and philosophy of science gain many members. Academic departments teaching these subjects became more frequent during the 1950s and 1960s, but found various disciplinary homes. Some were associated with departments of history or philosophy in Faculties of Arts or Humanities; others were affiliated with Faculties of Science. Departments of science and engineering became more self-reflexive during the 1960s and provided a sprinkling of courses for would-be scientists and engineers about the histories of their subjects, or concerning their professional role in wider society.

From the 1970s, an even wider variety of academics began to scrutinise the meanings and purposes of the scientific enterprise for the first time since the Scientific Revolution of the seventeenth century. Some were historians, charting the rapid rise of a scientific outlook in intellectual thought; others were philosophers seeking reliable methods for the acquisition of new knowledge about the natural world, continuing a study that had begun centuries earlier; but others were economists, political philosophers and policy analysts, attempting to understand the potent role of science in twentieth century wealth-creation and national supremacy, or sociologists concerned with the social impact of science and technology, and even with how society comes to produce, trust and employ scientific

knowledge; yet others were literary scholars intrigued by the scientific currents threaded through modern literature and permeating visual media. This proliferation of disciplinary perspectives led to the coalescence of clusters of approaches in academic institutions that stressed various flavours. Today, influenced by their differing institutional contexts and academic profiles, these perspectives may underscore any combination of historical, philosophical, sociological, economic and literary explorations of science and technology, ranging from their content and methods to their influences and effects. Too wide-ranging to be classed a 'discipline', these science studies nevertheless unite scholarly attention on what has grown to become one of the most powerful components of modern society.

For students expecting a discipline-based undergraduate education, studying such aspects of science in a liberal arts environment can be both uncommon and liberating. Most universities offering post-graduate degrees (like the University of Glasgow) are firmly segregated into disciplinary ghettos (indeed, the training for one of us (Johnston) took place in a Physics Department for the first two degrees, and a Department of Philosophy for the third; for the other of us (Harvey), Geography departments provided the academic background). For academics working in disciplinary environments, it can be both intellectually intimidating and physically awkward to reach colleagues in another department. On the other hand, smaller institutions, such as American liberal arts colleges, often do not offer post-graduate education and so may not accord the same importance to academic research as do their larger counterparts. The Crichton Campus, however, has the advantages of both these environments. As a part of the University of Glasgow, it benefits from the intellectual ferment of post-graduate students and scholarly research; its academics, members of a British university encouraged (indeed, compelled) by the periodic Research Assessment Exercise (RAE), seek to publish thoughtful and original research for international audiences; and as a numerically small but scenically breathtaking site, the Crichton Campus brings together some one-and-a-half dozen academics (the size of a typical university department) from a variety of disciplinary and career backgrounds. This mixing both necessitates and encourages the interdisciplinarity that is at the heart of the undergraduate curriculum and some of the academic research at the campus, notably in the field of Science Studies.

As discussed by other contributors to this book, the Crichton curriculum is intentionally interdisciplinary, drawing closely on the nineteenth-century Scottish model successfully exported to America.[4] This generalist approach, emphasising broad philosophical

principles, informs the courses and their inter-relationships. An excellent example of this approach is the mixed curriculum developed to combine Environmental Studies and Science Studies, probably the first such curriculum in the UK and equally uncommon in the USA.[5]

Most components of Environmental Studies, forming one of the five degree designations offered, are taught largely from a scientific perspective, reflecting the academic background of the teaching staff. Alongside such courses, the subject of science studies is introduced as a core first-year course and via optional second and third year courses, dissertations and projects. The analytical themes for the Science Studies courses are history of science and technology, philosophy of science (principally epistemology, ontology and moral philosophy) and the sociology of science and scientific knowledge (including the study of interest groups and culturally-influenced beliefs).

Our teaching argues that an understanding of the inter-related technical, social and philosophical aspects of environmental research provides a strongly positive approach to engaging real-world problems, by promoting an understanding of multiple viewpoints in the technical and cultural issues at the centre of modern scientific debate. This contextual interdisciplinarity[6] challenges both lecturer and student to look beyond the unproblematic establishment of environmental scientific facts to the creation of an environmental science discourse.

As we noted above, Environmental Studies and Science Studies in both the UK and North America began to coalesce as interdisciplinary academic subjects during the late 1960s and 1970s. In both countries some of the obvious triggers for interest in historical and social studies of modern science and technology was the questioning of environmental consequences of technological growth, the rise in pollution and the apparent abuse of 'the commons'.[7] Widely publicised cases such as the Torry Canyon disaster in 1967[8] and questions of nuclear reactor siting through the 1970s began to engage the public directly in questions of policy-making and the evaluation of scientific facts. Students, too, increasingly demanded that academic curricula reflect and relate to their social environments.[9] Thus Science Studies and Environmental Studies addressed some common themes from their very beginnings as academic subjects.

Recent British experiences make the subjects of Environmental and Science Studies particularly relevant to incoming Crichton students and to the general public. A relatively

compact and densely populated country, Britain has a legacy of human management of the countryside with no remaining wilderness areas. There is a close association between food production, heavy industry (and the resulting pollution) and urban conurbations reflected in a long history of pollution crises and legislation. For most Britons, humankind's effect on the environment is inescapable and obvious.

In recent years, there has been skyrocketing concern in Britain over problems with health, the environment and scientific authority following from a rapid succession of issues and new acronyms. In 1988 salmonella in eggs filled headlines; during 1990 Bovine Spongiform Encephalitis (BSE, or "mad cow disease") was identified, and by 1996 blamed for human deaths; the cloning of Dolly the sheep near Edinburgh in 1997 brought scientific ethics to public attention; the summer of 1999 was dominated by a vociferous public debate and political debacle over the testing and marketing of genetically modified (GM) foods; and from spring 2001 the contentious facts, containment strategies and politicisation of foot and mouth disease (FMD) have filled newspapers. Between these major events, food poisoning, inoculation (the MMR vaccine affair) and radioactive contamination affairs have excited public discussion.

These issues are particularly pertinent to Southwest Scotland and to the Crichton Campus. Dumfries & Galloway is a rural region that combines mixed farming, small towns and stands of forest. The area has the highest rate of farms converting to organic status in Scotland. It boasts internationally important sites including Special Protection Areas and Special Areas of Conservation (both designated under European Community Directives) and Ramsar Sites,[10] designated under the Ramsar International Wetlands Convention. Part of its coastline is being considered as a World Heritage Site. Around 75,000 hectares of land are protected by national legislation.

On the other hand, like many other areas in Britain, there is a nearby nuclear power station,[11] waste incinerators and landfill sites. Its dairy and sheep industries were affected significantly by the radioactive fallout from Chernobyl in 1986. Its coastline has measurable contamination from discharge by the Sellafield Nuclear Fuel Reprocessing Plant, located near the Sellafield nuclear reactor (70 km south of the campus)[12]. Several areas in the region are used as military practice sites where depleted uranium shells have been fired regularly and where low level flying by fighter jets is a commonplace. A chemical plant is located on the outskirts of Dumfries itself, and Gretna (25 km west) was the site of the largest munitions chemicals factory in Britain during the First World War.

Some of these sites have provided placements for third-year students and topics for undergraduate projects.

One of the more recent concerns – and one of immense economic importance to the immediate region – was the foot and mouth disease crisis of 2001. Most of the students studying at Crichton were affected directly or indirectly by the widespread culling, decline of support industries, and restrictions on movement. Field classes, for example, were cancelled; some students were restricted to infected farms; most felt or saw the effects on local employment and tourism. In such a context, science is not abstract academic concern: its claims and effects are challenged daily in the fields, on the streets and in the classrooms.

Thus food production, pollution and livelihoods are inextricably interlinked at the Crichton Campus. The environment, and science's influence on it, are immediate public and personal issues in the minds of our incoming students. Students entering first-year courses have consequently been highly polarised on these issues. Many had convictions without substantive background knowledge; others were bewildered and isolationist. As university lecturers, we are aware that the students entering our campus are concerned about the very public issues of environmental management, ethical policy and scientific reliability. Our challenge was to develop a relevant curriculum, one that could convert this inchoate awareness and concern into solid knowledge and reasoned perspectives. Thus pedagogy was based on a theoretical approach combined responsively with current events.

How far can students acquire a critical understanding of environmental issues beyond the rapidly changing and media-dominated constructions of these activities? Our student body, as a whole, has evinced an unexpectedly strong interest in ethical issues, and has demonstrated a willingness and ability to relate them to historical cases and sociological perspectives. Our general approach, therefore, has been to work with the inbuilt differences of disparate and opinionated groups to construct courses with interwoven threads of environmental and health-related science, ethics, critical thinking and historical and social studies of science.

Environmental Studies at Crichton encourages students' recognition that the physical environment cannot be viewed in isolation because of the impact of human presence on the planet, whilst also stressing that in order to understand the extent of human impact

there must be an understanding of how the environment functions. Whilst drawn from fields of scientific enquiry, the courses always ensure that there is an understanding of wider social, economic, political and philosophical issues. The first introduction that students have to the environment and environmental issues is through a course called 'The Environment and Sustainability' which, while focussing on the technical details of ensuring a sustainable environment (illustrated through issues such as resource/energy use and population), also addresses the social, economic and political issues that are at the centre of much policy making.

This critical approach to knowledge has required a broadening of the teaching of environmental science to incorporate many of the issues tackled in science studies. At the same time, the general themes addressed by the Science Studies courses are illuminated by examples from Environmental Studies. The complementary academic stances of these subjects have been synthesised in a second-year course on environmental ethics co-taught by lecturers from both subjects. Courses on environmental ethics have increasingly been offered at UK universities since the late 1970s, most frequently in departments of philosophy. We have conceived our variant of this course as the symbiosis of two studies. It is not merely a dialogue between two specialisms, but an integrated and complementary approach. It is also designed to appeal to at least two varieties of students: first, those studying for the Environmental Studies degree; and second, those studying for the Humanities degree, with a strong emphasis on philosophy and history of science. Thus we immediately have a richness of perspective offered by those students with a strong interest in the environment, on the one hand, and those students with an interest in moral philosophy and scientific practice, on the other.

The course explores the relationship between value systems, scientific uncertainty and decision-making. The value systems and case studies behind environmental ethics are, of course, unusually wide-ranging. The responses from students have been interesting. One response is muted shock; many are surprised that the course does not necessarily validate their own values. Traditional moral philosophy is anthropocentric: firmly human-centred, based largely on the treatment of one individual by another individual or group. In environmental ethics, however, anthropocentrism is merely one of many systems, ranging from biocentric to ecocentric to Gaian, and with many flavours in between.[13] On the other hand, some of the Environmental Studies students are equally disconcerted to find that their own values are not quite as consistent or defensible as they had thought, or

indeed universally recognised by the class as being morally correct. Animal rights activists, deep ecologists and social ecologists, for example, could have dramatically different responses to some real-world situations that we introduce, such as the acceptability of a waste dump located near their homes. Other fruitful talking points have been whether petrol prices should be raised by the government to discourage the use of cars, even if the local economy would be affected, and whether the various national stances on the reduction of greenhouse gases are defensible in ethical terms.

The essence of Science Studies at Crichton is the exploration of the social and philosophical dimensions of science and technology. This is also a central premise for the Environmental Studies curriculum. The first link between environmental and scientific issues for first year students in the 'core' course 'Issues in Contemporary Society', which as the name suggests, discusses contentious ethics of modern life. During the first two years of the campus, topics included environmental stewardship, the Human Genome Project and agricultural genetic engineering.

Such courses suggest the challenges that we face as educators. One of the most important of these is to teach a wide spectrum of students having a variety of incoming beliefs. Mature students, in particular, often arrive with deeply felt ideas. Some of our students are committed environmentalists. Others arrive as intensely distrustful and dismissive about professional science. Indeed, many begin with a kind of mental paralysis. We can illustrate this by an example. Locally there were plans to construct a landfill site in an area of commercial forest plantation, a development which students commonly identify as being 'wrong' or 'bad' but without necessarily thinking about the overall implication of the alternatives. This is not apathy: it is a commitment to deeply held beliefs, sometimes incomplete, sometimes inconsistent and occasionally intractable.

Our second challenge is to present science studies material – deferred until second year at some institutions, and usually left as course options or electives – to first-year undergraduate students already deeply engaged with amorphous concerns. We feel that the nuanced perspective of science studies is very important for our first year students; unless they can begin to question their own convictions, and the convictions of others, they cannot begin to understand the issues at the centre of current environmental or medical debates. This profound questioning is the central theme of the two core courses mentioned above.

Our third challenge as educators is to articulate the scientific and moral objectivity behind our teaching. It is important to emphasise that we are neither 'environmentalists', 'pro-science' nor 'anti-science'. We stress in our lectures that we aim to teach, not preach.[14] This is something that many first year students find either surprising, disappointing or deeply suspicious! It is important to be scrupulous in providing a balanced perspective that respects different stances while stressing the importance – and sometimes the ultimate limitations – of scientific knowledge. This should not be interpreted as merely being politically correct. We are not concerned with giving 'equal time' to opposing groups. We do not try explicitly to balance the statements of Friends of the Earth with those of local chemical firms, or Darwinists with 'Scientific Creationists', or western medical practitioners with aromatherapists (although such examples are indeed discussed in some course seminars). We do, however, explore the reasoning and values underpinning different stances. This is combined with instilling skills in critical thinking – attempting to evaluate the plausibility of factual claims and the coherency of arguments. The students develop such analytical skills through web-based study units and tutorial exercises.

Thus Science Studies courses can be used to inform, teach or propagandise. We use the word "informing" to mean providing facts. But facts – such as those concerning the complex natural environment – can often be contentious or difficult to discern. For this reason, we believe that a typical strategy of first year science or earth science courses does not work here. We cannot merely supply technical details, from 'basic' to 'advanced', and expect our students to gain any deep understanding of the environment as a whole. While we provide the students with technical, often science-based information, we also supply them with the tools to critically assess some aspects of this information. As to teaching, we take it to mean a more wide-ranging activity than merely providing uncontentious nuggets of information. As one student said, he felt that our approach was one of sharing knowledge rather than us imparting facts, and so facilitated student led learning. And as to propagandising, this can all too easily be incorporated into environmental discourse.

Environmental Studies seems to us to be a subject prone either to being trivialised or overtly politicised for a number of reasons. Today, to be environmentally conscious or pro-active is something to which most citizens and, indeed, lecturers claim to subscribe.

Isn't everyone for a 'clean environment', whatever that means? Even inanimate objects – everything from cans of underarm deodorant to hamburger boxes – are designed to be environmentally friendly. Companies, governments, and social groups voice the same message. But the notion of environmental responsibility is now so dilute and ubiquitous that it has ceased to have much intellectual value, and yet it is a concept that has become politicised. Defending waste incinerators, in some contexts, can be as unpopular as defending eugenics. Environmental issues are at the heart of major governmental policy decisions, certainly in Britain. In this context of necessary but sometimes unpopular policy-making, it is all too easy to produce the very opposite of what we, as educators, want. For example, at the end of 2000, Britain was hit by a series of major floods resulting from prolonged periods of rain. These floods were placed firmly at the door of global warming by the Government and environmentalists alike. A few months earlier, equal levels of public criticism were levelled at the price of petrol, an expensive product in Britain owing partly to an 'environment' tax designed to restrain the excessive consumption of petrol and to pay for the research and development of alternative energy sources. In both cases an atmosphere was created that avoided or submerged informed public, and even academic, debate, a position contrary to the ethos of both Science Studies and Environmental Studies.

Both the trivialisation and the politicisation of environmental studies are a danger to its academic expression. Indeed, the issue of bias has been a factor in questioning the academic robustness of environmental studies and science studies have been hotly debated in recent years.[15] This is another reason that we are not interested in being identified as 'environmentalists', 'pro-science' or 'anti-science'. Our courses strive to be analytically neutral, scientifically aware and socially perceptive.

Let us refer back to our challenges outlined above: to teach a wide spectrum of students holding a variety of incoming beliefs; to present the material to students enabling them to confront the sometime conflicting issues at the centre of current environmental or medical debates; to articulate the scientific and moral positions behind our teaching. Our approach to engaging with these challenges has been two-fold: first, to devise an appropriate curriculum and, second, to utilise appropriate teaching methods.

Our experiences in integrating these two studies indicate that this can be a fertile approach that links contemporary debates to deep understandings of the natural world and society. We argue that this approach, and the teaching methods utilised, are effective means of engaging and teaching our students, and are particularly relevant in the modern British context. Interestingly, we have found that students taking the Environmental Ethics course are drawn from all degree designations, with as many from the Health & Social Studies and Humanities designations as from Environmental Studies.

Another of the degree designations is Health and Social Studies which, like Environmental Studies, raises questions about knowledge itself (medical rather than environmental): how it is acquired, validated and used. In the undergraduate curriculum, the social and intellectual sources of trust in 'facts' are examined, and related to aspects such as media representations, statistical validity and methodologies.

Supporting these applied subjects is a strong and explicit thread of Science Studies in the general curriculum. Our curriculum is perhaps unique in Britain in that first-year Science Studies have been mandatory for all students studying within the five degree designations comprising the Liberal Arts degree. We see this as an acknowledgement of the importance of science and its pervasive effects on daily life. The aim is to teach students that, while rational methods of creating knowledge are the best that we have, these methods have inbuilt limitations and intimate links with culture and society, and are solidly embedded within a system of values and ethics. This emphasis, reflected in Science Studies, Environmental Studies and Health and Social Studies, is illustrated by one of four 'core courses' (or mandatory subjects) taken by all students entitled 'Science: History & Culture'. This is a course about rational knowledge: its evolution over time, its strengths and its weaknesses. The course traces the historical trajectory that has produced our modern reliance on technocentric solutions, and relates intellectual ideas to cultural beliefs. And the content is enriched by multiple perspectives: over the past six years, its seminars have been led, at times, by a physicist (Prof. Rex Whitehead), an anthropologist (Dr John Harries), a philosopher (Dr Stuart Hanscomb), a teacher of literature (Gillian Robertson) and a historian (Johnston). Another course taken by nearly all Environmental and Health and Social Studies students in their third year of study is 'Current Issues in Science, Technology and Medicine', which traces the historical evolution of philosophy of science, but in an unusual format. By exploring cases of scientific and medical controversy, the course illustrates the evolving philosophies of knowledge from the first

formal theory of positivism in the 1830s to the most recent sociological theories ardently debated in the so-called 'science wars' of the 1990s and still controversial today. Crichton's interdisciplinary environment routinely produces unexpected cross-fertilisation. 'Technology in Society', a second-level course on the history of technology, has highlighted the surprising congruence between the research of Crichton archaeologist Helen Loney and the twentieth century historical studies of Johnston. Crichton research seminars have revealed similarities between the health policy research of Sandy Whitelaw and the sociology of quite separate aspects of modern science. And 'Imagined Futures', another third year course developed by Luc Racault and Johnston on the 'history of the future', has made full use of academics at the Crichton including Mark Ward (on Nazi ideology), Ralph Jessop (on literary utopias), Ben Franks (on the Situationists of the 1960s) and Rex Taylor himself (on Marxism). With guest speakers such as Scottish science fiction writer Ken MacLeod, the course weaves together literary, philosophical, political and scientific themes of prediction.

The courses and research that we have discussed are complementary and interdependent; bringing together disciplines with distinct analytical viewpoints and theoretical stances and relating them to the real world. This approach has engaged students from their first semester, and has, to date, produced increasingly analytical and articulate proponents for a variety of philosophical positions with respect to the environment and health. Our conclusion is that our courses provide an effective mixture. Based on the combination of critical thinking and a nuanced appreciation of scientific evidence and historical case studies, they explore the wide range of differing, but self-consistent, moral perspectives.

Returning to the claims that began the chapter, the suite of science studies courses illustrates how interdisciplinary subjects at the Crichton Campus provide both a liberating ability for students to pursue ideas beyond traditional academic boundaries, and also how such interconnectedness enriches a cohesive and flexible undergraduate curriculum. The unusual conditions at the Crichton have helped achieve these pedagogical aims. Rex Taylor's Crichton Campus brought together people, environment, facilities and – most importantly – the freedom to explore new approaches.

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Notes

[1] The first five lecturers were Mhairi Harvey (Environmental Studies), Sean Johnston (Science Studies), Valentina Bold (Scottish Studies), Ralph Jessop (Philosophy and Literature) and Jane Cavani (Modern Languages).

[2] Stephen Harper (Media Studies), Carol Hill (Health and Social Studies) and Tom Pow (Creative and Cultural Studies) were joined by lecturers, Faculty Assistants and University Teachers providing Crichton-developed courses in subjects ranging from archaeology to history to creative writing. For a full list, see Appendices 2 and 3.

[3] Elements of the *trivium* and *quadrivium* in modern form are evident in the core courses implemented at Crichton: 'Text and Communication' focuses on aspects of language, text and presentation; 'Argumentation-Rhetoric-Theory' deals with oratory and logic; 'Issues in Contemporary Society' concentrates on ethics and argument; and 'Science: History and Culture' explores aspects of astronomy, mathematics and reasoning.

[4] Davie, George Elder, *The Democratic Intellect: Scotland and Her Universities in the Nineteenth Century* (Edinburgh: Edinburgh University Press, 1961).

[5] A portion of this text was presented at the *Taking Nature Seriously* conference, University of Oregon, Eugene, Oregon, in February 2001, and later revised for publication in *Discourse: Learning and Teaching in Philosophical and Religious Studies* 1 (2002): 130-140. The Eugene campus had recently introduced a combined Environmental Studies/Science Studies option in their Environmental Studies degree, apparently the only such linkage in the United States.

[6] Boden, Margaret, 'What is interdisciplinarity?', in Cunningham, Rachael (ed.), *Interdisciplinarity and the Organisation of Knowledge in Europe* (Office for Official Publications of the European Communities: Belgium, 1999), pp. 13-23. Boden defines contexual interdisciplinarity as being "concerned with the social relevance, public acceptance and ethical justification of scientific research"

[7] Hardin, Garrett, 'The tragedy of the commons', *Science*, 162, 1968, 1243–1248.

[8] The Torry Canyon spilled 119,000 tonnes of crude oil, polluting miles of the French and British coasts.

[9] Soule, M. E and Press, D., 'What is environmental studies?', *Bioscience* 48, 1998, 397-405.

[10] Ramsar sites, named after the Convention on Wetlands signed in Ramsar, Iran, in 1971, are often designated for their importance to wildfowl habitats.

[11] The second oldest power reactor in Britain, Chapelcross, is 22 km west of the campus and employs some of our students and members of their families. While currently in the process of decommissioning, the site will continue to be a repository for radioactive material and closing-down operations for decades to come, and is not planned to revert to a greenfield site until the 22nd century.

[12] Harvey, M. M. and Allan, R. L., 'The Solway Firth Saltmarshes', *Scottish Geographical Magazine* 114, 1998, 42-45.

[13] As taught in some Philosophy departments, Environmental Ethics focuses on issues of animal rights. We prefer to extend the discussions of moral questions to plants, microbes, and atmospheric chemistry.

[14] Indeed, one student exercise in the original 'Issues in Contemporary Society' course was to vote on whether the lectures have been pro- or anti-genetic engineering, an

exercise that opens the door to the debate on the objectivity of scientific investigation and reporting. The approach contrasts with recent programmes in Britain under the rubric 'Public Understanding of Science', which sometimes tend to promote the unalloyed benefits of science from the perspective of practising scientists.

[15] See, for example, Soule and Press, 1998 *inter alia.*; Maniates, Michael, 'Environmental Studies: The Sky is Not Falling', *Bioscience* 50, 2000, 509-517, and Ross, Andrew (ed.), *Science Wars* (Duke Press: London, 1998).