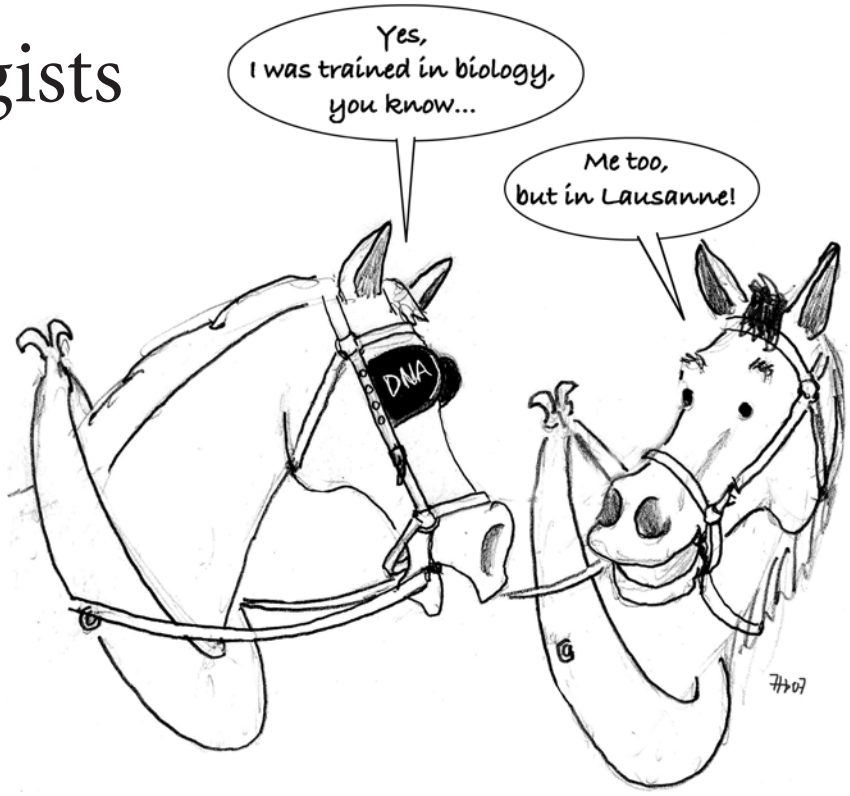
EMBO *reports*

viewpoint

Citizen biologists

The Lausanne experience

Jacques Dubochet



Sex is an important concept for students of the biological sciences. At the University of Lausanne in Switzerland, sex is even more important because several of the professors are reputed specialists in the field (Bernasconi *et al*, 2006). Therefore, as at any university with a biology department, biology students learn everything we know about the evolution of sex, its importance and effects. However, for students of the social sciences, sex has a very different meaning, particularly when focusing on gender studies. This is even more true for some of their professors, several of whom take the view that biological sex is of little importance; that only gender—what society makes out of sex—matters.

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During their second year of the biology curriculum, and as part of the University of Lausanne's Biology and Society course, biology students have to analyse and discuss a topic with relevance to society. On occasion, one group had the task of understanding the views of social science students undertaking gender studies. To this end, they held intensive discussions with their peers, attended courses relating to gender studies and finally reported to the rest of the class with two conclusions. The first was that the discussions had been extremely difficult and any exchange of views was virtually impossible—the students in gender studies held vastly different opinions and theories about sex than did the biologists. The second was that only two years before, the biology students had no problem discussing and exchanging their points of view with these former high-school friends. Two years at the university had succeeded in putting them—perhaps forever—in separate and impregnable compartments. What a strange university.

This anecdote is worrying, but hardly surprising. The responsibility for this poor state of affairs falls on many shoulders because it involves communication—or lack thereof. For the specific case of the biologists—the one that is of interest to us—we can identify at least one reason: our students enter an ivory tower of science from which they look down at society without engaging the real world.

In the past, the metaphor of the tower was relevant when the time between scientific discovery and practical application was long, and wealthy scientists pursued their personal research interests at a whim. It was a time when the right to 'freedom of research' was considered to be as important as the right to freedom of religion or freedom of speech. Remarkably, constitutional texts—such as Article 20 of the new Swiss Constitution—preserve the original sense of this concept, "The freedom of scientific research and teaching is guaranteed" (Swiss Confederation, 1999).

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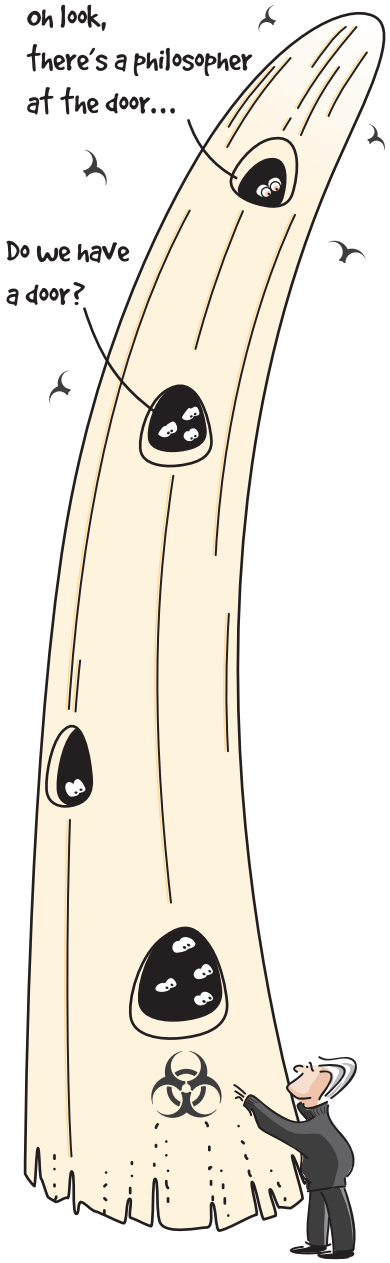
But the world in which scientific research takes place has changed profoundly since the Second World War, if not earlier. It is no longer possible to view science as an enterprise that is somehow disconnected from society, and our day-to-day working practices attest to this. Good laboratory practice is now codified in strongly formulated regulations, we are not allowed to present our results according to our inclinations, and the notebook has become a legally binding document. Furthermore, research is no longer funded by wealthy private patrons, but is paid for in the majority by public money and

companies. The bottom line is that modern research must have some form of support or acceptance from the public at large. Without public support, it is difficult to pursue unpopular research topics or methods; for example, it is now difficult to do research on genetically modified plants in many European countries, or on stem cells in the USA. The same might become true for nanotechnology. The ivory tower is gone and all scientists—biologists, in particular—have a responsibility to society.

In what way must researchers be responsible? Twenty-four centuries ago, Hippocrates of Cos (*circa* 460–370 BC) called on physicians to act in the best interests of the patient—a commandment that has been the guiding principle of the medical profession to the present day, albeit with changes over time to the interpretation of 'best interests' and 'patient' (Beecher, 1966; Beauchamp & Childress, 1994). Now, the legal framework that defines medical responsibility is well developed and no practicing medical doctor can ignore or avoid it. As such, any respectable medical school prepares its students to comply with these ethical and legal obligations.

For biologists, it is more difficult to develop general ethical principles because they have no overarching duty to guide their efforts; they do not have patients whose best interests they must serve. Scientists might develop drugs or therapies and products that have an impact on human health or the environment but, in most cases, they only have an indirect responsibility for the application of their research; hence, their responsibilities are not well defined. For example, we have seen that it is possible to recreate the influenza virus that caused the pandemic in the winter of 1918/19—one of the most dangerous pathogens humanity has ever encountered (Tumpey *et al*, 2005). Whether it was ethical to recreate this virus as a purely scientific endeavour is a matter of debate, but it would be naive and dishonest not to consider the fact that, in the wrong hands, such a virus could be a weapon—scientists cannot evade ethical questions under the false premise that they are only responsible for doing the research. More such situations will inevitably arise as biology increasingly understands and masters the functions of the body, its genes and the mind.



The impact of biological research on society and the public's interest in what scientists are doing with their money have become apparent during the past decades. In many cases, research has wide public support; biological research is the basis for new medicines and therapies against both infectious and chronic diseases, and biological knowledge is the raw material of the pharmaceutical and growing biotechnology industries that create jobs and tax incomes. However, research using controversial methodologies or into controversial subjects has increasingly become the subject of heated public debates whenever it has an impact on widely held moral beliefs, human health or the environment. The ongoing discussions and attempts to legislate various areas of research—such as work on genetically modified crops, the use of human embryonic stem cells, the use of animal testing, so-called dual-use research that could be exploited for nefarious purposes—attest to the interest and concern of politicians and the public. Of course, debates about the trustworthiness of scientists and their moral standards are not helped by highly publicized cases of scientific misconduct or fraud.

The result is that biological research and biologists themselves have come under increasing public scrutiny, both for the topics they research and the methods they use. To prevent the weaponizing of dangerous biological research, for example, various commentators have proposed a code of ethics or something similar to the Hippocratic Oath for biologists (Revill & Dando, 2006; van Aken, 2006). Similarly, cases of misconduct have led to ever-stricter regulations of laboratory practice (Kreutzberg, 2004). The message is clear: biologists have not only a responsibility to society for the moral conduct of their research, but also an ethical obligation to consider the uses it might be put to in the future. The ivory tower of isolated research and refused culpability cannot stand any longer.

But should these responsibilities be taught at a university during the course of a biology degree programme? Many lecturers will reject such an idea on the grounds that a good biologist is someone with a broad biological knowledge and solid experimental training; the rest is politics to be dealt with by someone else. For many students, the answer is even more pragmatic: they simply do not have time to add an extra burden to their course schedule. Moreover, the few courageous ones who do broaden their view and take courses in other disciplines are often regarded as 'interesting' at best or 'uncommitted' at worst.

The faculty of biology and medicine at the University of Lausanne decided to change this attitude. For the entire duration of their degree, biology students at Lausanne must take part in the Biology and Society programme. The workload is not heavy—on average one hour per week—but the programme is compulsory and accompanies the students

Table 1 | General organization of the Biology and Society programme

Degree level	Course type	Course subject-matter	Aim
Bachelor: 1st year (2008)	Compulsory course and optional seminars (group work)	History and epistemology of the life sciences	Basic knowledge for understanding biology in the broader framework of historical development and its social implications
Bachelor: 2nd year	Course and compulsory group work	Introduction to biological ethics	Case studies by groups of students
Bachelor: 3rd year	Course and compulsory reading	Social sciences for biologists	Understanding that social science studies are relevant, useful and important
Master/PhD: 1st and 2nd year (still in development)	Courses and optional individual or group projects	Case studies in biomedical ethics; project in the public understanding of science etc.	Specialized courses; group or individual projects; preparation for a career in interdisciplinary fields

throughout their studies. From its initiation in 1999—which was actually requested and supported by students—the Biology and Society programme has developed over the years and has now nearly reached completion (Table 1; Dubochet, 2003).

Designing a programme to teach biology students how to be responsible scientists starts with two fundamental questions: what to teach, and how to teach it? The answers are far from easy. For example, how is a student's progress in the programme to be assessed? Can the system of multiple-choice examinations be adapted to Biology and Society questions? The dilemma a student faces with a question such as "Stem cell research: good/bad? (underline the right answer)" suggests that other ways must be explored. In addition, how should the course be taught? Are *ex cathedrâ* lessons, in which the professor presents well-structured information, more effective than problem-based learning? But, of course, the most important question is what to teach; what does a biologist need to learn to become a good citizen?

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In Lausanne, we already had a programme that helped to answer these questions. The Interfaculty Seminar in Biomedical Ethics was initiated by Jacques Diezi nearly 20 years ago and brings together teachers and students from theology, law, medicine and biology. Its focus is problem-based using real-world examples, and the four participating faculties select several case studies on the basis of two main criteria. First, the case must deal with a real problem that was recently encountered by the university or was connected to the university—usually the person who was directly involved in the case helps with the preparation. Second, the case must focus on a crucial aspect of biomedical ethics—this year it is 'business and money'.

Six students from three faculties form a group—always two from law and two from theology paired with two from medicine or two from biology. The group then chooses one of the proposed case studies and prepares it for presentation as part of the course. While doing so, they can rely on the expert who knows the case first-hand and on the members of the teaching committee. The group is given the largest possible autonomy to develop its analysis and draw conclusions. However, it is emphasized that the approach should be interdisciplinary and not transdisciplinary; in other words, each group member should develop a global view rather than simply juxtapose the others' views. The presentation, which lasts for approximately two hours, takes place in the presence of the students and teachers of the course, as well as other interested people, including those from outside the university. After a short presentation by the specialist, the students have about one hour in which to present their analysis and conclusions with ample time for discussion afterwards during which efforts are made to avoid monopolization by professors.

For the students, the preparation of a case generally requires considerable time and effort. They must all become familiar with the way their own speciality relates to the case, as well as understanding the approach of their colleagues from other disciplines. The main effort is devoted to synthesizing a coherent presentation that covers all aspects of the case from many disciplinary directions. They generally succeed in the task and, although they like to emphasize the differences in their approaches or conclusions, very few groups fail to reach a common consensus. Many years of experience in the Interfaculty Seminar have convinced me that people almost always reach a consensus when they are working together on a practical ethical question, even when they come from very different starting positions.

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In most cases, the presentations are thoughtful, and convey to the audience a depth of knowledge and understanding that is generally more exhaustive than that of most professionals in the contributing field. An amazing illustration was offered many years ago in a session about informed consent. During the initial presentation, the expert explained the document he used to record the informed consent from every patient participating in his experiments. At the bottom of the form was only his signature—none from the patient. The students dealt with the case tactfully and in detail. They actively contributed to making sure that such an error is very unlikely to happen again in Lausanne.

A recurrent question among the course organizers concerns the extent of knowledge required to think usefully about bioethical issues; in other words, what is the minimum 'ethical viaticum' that a biology student will need for their professional career? In fact, even this minimum background is frequently lacking among students and more experienced scientists.

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An example of the widespread lack of ethical background knowledge and training occurred two years ago during an intense public debate about a new animal house for the University of Lausanne. The plan for the house was challenged by a call for a referendum and a request from a sufficient number of citizens that the matter be decided by popular vote. Of course the theme was good material for the Introduction to Biological Ethics course for students in their second year and an online discussion forum was installed. Soon the discussion took an unexpected turn. Some commentators pointed out that animals are not always ideal models for human physiology; experimenting with humans would be more realistic. In particular, they said, there are certainly prisoners who would agree to serve only part of their sentence and in return volunteer as patients in experiments. So, along with the animal house, why not build some cells for humans? Things got out of hand and two weeks away from the referendum vote we thought that some external malevolent agitators were at work. We closed the forum, removed it from the web and had a serious discussion with the students. It emerged that those who had expressed these ideas were among our best students and only had the best of intentions. They had simply not considered the implications of their proposals and were frighteningly ignorant of the terrible lessons of the past when it comes to human experimentation.

Indeed, the Interdisciplinary Seminar has deliberately kept the teaching of basic knowledge to a bare minimum. The first session of the course is the only *ex cathedrâ* lecture to provide students with some 'tools for ethics'. This toolbox contains a little philosophy, in order to clarify that what is in nature must not to be mixed up with what ought to be; a brief overview of the history of science; general remarks that describe how the basic rules of scientific ethics took shape in the face of cruel realities; and an introduction to some present-day legislation.

Although the Interdisciplinary Seminar in biomedical ethics has been favourably received, its limitations are evident. The seminar is optional and only about 10% of the students take the opportunity. Furthermore, students can only elect to take the course during their third year or later, which is too late to take advantage of the open minds of freshmen students. Finally, the restricted number of hours limited to one semester means that it cannot go much beyond an introduction. However, it turns out that the course, despite its limitations, has provided one huge advantage: it prepared the way for the biology faculty to set up the more extensive Biology and Society programme.

The Biology and Society programme starts in the first year with a course on the history and epistemology of life sciences. Its primary goal is to keep the students' minds open while they are intensively trained in their new speciality. The course shows how the vitalist and spiritualist 'natural biology' became 'natural science' through increasing confidence in the power of observation, and how it developed into present-day biology through the coherent framework of Darwinism and molecular biology. It also explains how the scientific method developed in the seventeenth century makes it possible for scientists to appropriate the work of others, and how this still applies today in daily laboratory work and the basic rules of publication.

The second year is an introduction to biological ethics and the relationship between science and society. It is based on the idea that these topics are best understood by thinking and debating, rather than by direct learning. As in the Interdisciplinary Seminar, the groups of students mostly analyse real case studies that cover all aspects of a biologist's research. Some examples are authorship in collaborative work, gender bias, scientific misconduct, industrial funding, endangered species, drug testing, biosafety and the protection of genetic or mental privacy. The course also trains students to work in groups and to present their deliberations. In fact, the mentors attribute as much importance to the way the group works together and the quality of the presentation as they do to the content of the report.

The third year is the most challenging. As illustrated previously, there is a considerable gap between biology students—or any natural sciences students—and students of the social sciences or humanities. The Biology and Society programme was set up to encourage mutual understanding; thus, during the third-year course, a professor in social sciences has *carte blanche* to explain to biology students why social sciences and humanities are interesting, important and relevant. Reciprocally, a biologist explains to social science and humanities students the merits of biology. It is apparent that the biology professor has a gratifying task—topics such as the evolutionary roots of human altruism or the possible origin of beauty appeal to psychology or art students. The task of the social scientist is more difficult and remains a challenge for the years to come.

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The second part of the programme takes place during the Master and PhD-level studies. It is optional and flexible, and aims to encourage personal initiatives based around three main concepts: ethics, communication and interdisciplinarity. Credits are obtained through two complementary activities. The first is further participation in courses on topics like those mentioned above, but at a more advanced level and enriched with the expertise of other faculties such as history, philosophy, law, economics and linguistics. The second is a project by an individual or a group of students. Students can participate or initiate interdisciplinary events such as a colloquium, a web-forum or a round table discussion. They can also join some of the ongoing projects organized by the Interface sciences–société (http://www.unil.ch/interface) on the public understanding of science, technology and risk assessment.

Whether biologists from Lausanne are good biologists might be inferred from the good reputation the university has gained over the years and from the satisfaction of employers with its graduates. But finding out if Lausanne-trained biologists are also better citizens will remain a matter of debate. There are, however, two achievements of the Biology and Society programme that are self-evident but worth mentioning. One is the fact that a high proportion of the professors and researchers in the biology department have been directly associated with the Biology and Society programme, either as course teachers or as mentors. In doing so, they have become familiar with the programme and, in most cases, have become sympathetic to it. The time when its usefulness was a matter of debate among members of the faculty is definitively over.

The other is related to the geography of Lausanne's campus. To the east are social sciences and humanities; to the west are the natural sciences and polytechnics. In the middle runs a small river, the Sorge, which in terms of interdisciplinarity and cultural exchange might seem more like the Grand Canyon. This was not always the case; the great natural philosophers of the Baroque and the Enlightenment were, as the name implies, both natural scientists and philosophers.

Given the public's increasing interest in and scrutiny of the life sciences, it is important that natural scientists engage in debates with their colleagues from the social sciences and humanities about the implications and social impact of their work. The Biology and Society programme has to cross the Sorge to contribute to mutual understanding and, in doing so, will bring east and west, science and the humanities, closer together in a common humanistic culture.

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