Biotechnology education in Europe

Vivian Moses

Date received (in revised form): 20th January, 2003

Professor V. Moses
holds two visiting professorships (at King's and University Colleges, both in London) and was coordinator of an EU programme to look at biotechnology education in the member states, Switzerland and the USA, and Director of The Centre for Genetic Anthropology at UCL. He is also Chairman of the CropGen panel, an information service that makes the case for crop biotechnology to the public.

Keywords: *biotechnology, education, European Union, Framework 5, public understanding, Switzerland, USA*

Abstract

This study was not intended as a catalogue, but as a comparative overview of the range of opportunities for education in biotechnology open to citizens in the various member states of the EU – opportunities organised by governments and their agencies, by educational establishments, by a wide variety of organisations and institutions variously interested in informing/influencing public attitudes and, of course, by the media in its many forms. Switzerland was included because of its experience of a referendum on genetics and biotechnology as well as the USA, where it all started. A number of suggestions are made for improving public understanding of biotechnology and for establishing a code of best practice taking into account the cultural differences between countries. Perhaps the most important is that biotechnology education is a long-term issue requiring a long-term view; it should not be constrained by short-term funding.

INTRODUCTION

It was not until the first transgenic agricultural products began to reach the retail marketplace in the 1990s that the general public came face-to-face with biotechnology and had to make decisions about their personal involvement. Many people were poorly equipped to do so. Their scientific base was weak and, before long, a number of pressure groups began to campaign against the use of the new products. The bulk of the public became confused by the conflicting statements for and against, the more so as a number of food and other health scares had recently gained great prominence. Faced with conflicting claims for the new products, especially those involving food for which there was no perceived urgency and anyway there were plenty of other options, the safest course seemed to be to maintain a healthy distance.

While often well aware of the economic importance of the new developments, governments, scientific establishments, industry and consumer groups recognised the need for the public to be helped to make informed decisions for themselves. A multiplicity of initiatives resulted at all levels, including the European Commission; with varying degrees of enthusiasm and urgency, different countries and different groups within them began public educational activities of many diverse sorts with the intention of bringing understanding where confusion had reigned.

In 2002, an EU-sponsored study undertook an overview of those responses in the countries of the European Union together with Switzerland and the USA: in Switzerland because it is the only country in which biotechnology has been put to a popular vote while the USA is where modern biotechnology started and is the nation whose population has been most exposed at the retail level. And an overview is what it was, not a catalogue: that would have been an overwhelming task, to become outdated the moment it were completed. The participants are listed in Table 1.

BACKGROUND

Biotechnology is set to make a progressively significant impact on the economies of nations rich and poor, and on the lives of their citizens. Many developments will be regarded as ongoing industrial progress of no great concern to

Professor V. Moses
Department of Life Sciences,
King's College,
Franklin-Wilkins Building,
150 Stamford Street,
London SE1 9NN, UK

Tel: +44 (0) 20 8451 0784
Fax: +44 (0) 20 7848 4500
E-mail: V.Moses@qmul.ac.uk

Table 1: Participants in the study

Austria	Otto Doblhoff-Dier, University of Agriculture, Vienna
Belgium	Rene Custers and Ann Van Gysel, Flanders Interuniversity Institute for Biotechnology, Zwijnaarde
Denmark	Dorte Hammelev, EIBE, Roskilde University
Finland	Susanne Somersalo, Licentia Oy, Helsinki
France	Gerardo Bautista, Contemporary Publishing International, Paris
Germany	Susanne Benner, Max-Planck-Institute for Plant Breeding Research, Köln
Greece	George Sakellaris, Institute of Biological Research and Biotechnology, National Hellenic Research Foundation, Athens
Ireland	Rhona Dempsey, National University of Ireland, Dublin
Italy	Stefania Uccelli and Leonardo Santi, Istituto Nazionale per la ricerca sul cancro, Centro di Biotecnologie Avanzate, Genova
Luxembourg	John Watson, European School, Luxembourg
Netherlands	Patricia Osseweijer, Delft University of Technology, Delft
Portugal	Alexandra Quintanilha and João Howell Pato, Instituto de Biologia Molecular e Celular, Porto
Spain	Louis Lemkow and Joanna Cáceres, Universitat Autonoma de Barcelona, Bellaterra (Cerdanyola del Vallès)
Sweden	Lynn Åkesson and Susanne Lundin, Lund University
Switzerland	Richard Braun, BIOLINK, Bern and Petra Frey, Institute for Plant Sciences, Zürich
UK	Brendan Curran, Queen Mary and Westfield College, London
USA	Peggy Lemaux, University of California, Berkeley, CA
Coordinator	Vivian Moses, King's College, London

Electorates and public 'debates'

the layman but other areas are likely to be of enormous interest. In particular, the sheer pace of progress in genetics will inevitably continue to disconcert, puzzle and perhaps frighten the non-specialist, especially if he or she has a poor understanding of the underlying science. It will be even more essential in the future than at present for an informed citizen to know about biotechnology and understand something of its scientific basis. Nevertheless, it is clear that many members of the general public are well aware of their limited appreciation of some new technologies as the 2001 Eurobarometer illustrated only too graphically (Table 2)

Table 2: Eurobarometer on Biotechnology: 'Do you feel adequately informed about biotechnology?'

Country	Tend to agree (%)	Tend to disagree (%)	No answer (%)
Austria	19.2	69.8	11.0
Belgium	9.2	83.3	7.5
Denmark	14.8	81.3	3.9
Finland	7.8	88.4	3.8
France	8.9	87.6	3.5
Germany	11.7	79.2	9.1
Greece	9.4	87.1	3.6
Ireland	7.9	82.5	9.6
Italy	11.5	71.8	16.7
Luxembourg	13.8	80.5	5.8
Netherlands	20.1	71.7	8.2
Portugal	8.3	78.7	13.0
Spain	6.2	85.2	8.7
Sweden	2.8	95.5	1.7
Switzerland	17.4	74.8	7.7
UK	12.2	81.4	6.4
USA	No data		

Sources: Eurobarometer[1], Scholderer[2]

It is generally agreed that modern democracies depend upon informed electorates. The problem of disseminating information exists at two levels: addressing the adult electors of today and ensuring that the voters of tomorrow have a good grasp of important issues through the normal processes of educating children and young people.

Electorates have often shown themselves to be remarkably perceptive when presented with political choices, but the complexity of contemporary technologies, together with the scientific, engineering and societal problems they bring with them, are all too frequently poorly appreciated. Public 'debates' on biotechnology (if that is what they were), particularly discussions on transgenic plants and foodstuffs and on embryo research, have taken place in most member states over the past decade. Conducted largely in the press, and on radio and television, those controversies have usually taken the form of news items, interviews with experts and interested parties, or editorial opinion.

Some newspapers and magazines print letters from their readers and there is audience participation in a number of broadcast programmes. The current genetically modified (GM) crops debate in the UK promises to be more comprehensive and thorough.

New technologies often have a rough ride

The levels of discussion often show all too clearly that many journalists and broadcasters, as well as their readers, viewers and listeners, have a poor idea both of the underlying science and of the technology of biotechnology which, for many, is synonymous with genetic manipulation. Biotechnological items are frequently presented in a form that precludes balanced discussion, particularly when the people involved have a limited understanding of the facts and issues. 'Balance' often takes the form simply of a statement of opposing views, with no real engagement. The public becomes bemused by poorly understood terminology, cajoled by promises, and worried by risks and threats which, as individuals, they feel unable to evaluate. Yet people are not sure on whom they can rely: every spokesman for every viewpoint speaks with conviction and determination. No source is really trusted: some authors who write science books and articles intended for the general reader appear not always to have a good grasp of the scientific realities of their subject matter.[3]

Do organically-grown tomatoes contain genes?

Until about 150 years ago, before electricity became commonplace, most people had a fair idea of the technologies among which they lived. Even steam engines were relatively easy to understand, although clockwork might have been more difficult. However, with the advent of electrical devices, technology became more complex and often threatening; electric equipment is concealed and in many cases there is little if anything to see. Some people feel that modern genetics, at the very centre of life, is the latest in a long line of malign developments which include nuclear energy, novel weaponry and a host of others. Von Wartburg and Liew[4] have noted that 'the introduction of a new technology marks a turning point for society. . . . Among other consequences, (it) leads to a redistribution of resources . . . new skills and knowledge become more in demand, old skills and knowledge become obsolete. . .'. It is not surprising that novelty, biotechnology included, is often misunderstood, misinterpreted and resisted.

The problems of understanding new technologies are not new. In a 1996 EU survey[5,6] (and others[7–9] are broadly in agreement), some 30 per cent of respondents took the view that, while GM tomatoes 'contained genes', organically grown ones did not. Genetic uncertainty is not confined to plants and foods: in that same EU survey, 50 per cent of those questioned either did not think that more than half the human genes are identical to those of chimpanzees, or did not know (Durant *et al.*,[6] Appendix 2, Table 2i). Widespread public unfamiliarity with novel technology has been with us for a long time: parallel cases have been reported from much earlier periods, for example during the introduction of the electric telegraph in the middle of the nineteenth century.[10]

Landes[11] has commented that

> the ultimate advantage and beneficence of scientific knowledge and technological capability is today under sharp attack, even in the Academy. The reasons for this reaction, often couched in preference for *feeling* over *knowing*, range from disappointment at Paradise Unfound to resentment by laymen of unknowable knowledge.

It is exactly to circumvent this problem of 'unknowable knowledge' that education in modern technology is so critical – and nowhere more so than in biotechnology.

One of the objectives of this project was to consider best practice guidelines for the education of the public with respect to biotechnology. In this context, how people in different countries

perceive situations and react to information will be important. Wursten[12] has emphasised the deeply rooted cultural values that vary between populations and countries, resulting in significant diversity in the ways in which people organise their society, choose roles for their government and decide how institutions should function. Such contrasts, which include educational practices as well as public attitudes to education and various forms of information, are often gravely underestimated. The consequence is that organisations, including universities and other education establishments, often think that approaches successfully applied in one culture will naturally lead to the same success in others. But this is by no means always the case – proper allowance must be made for divergence of attitudes, values and perceptions.

What the study was about

SCOPE OF THE INQUIRY

In all the participating countries, the following were surveyed:

Do people really wish to know? Can they be bothered to find out?

- government at all levels – national, regional and local;
- formal education – curricula and other activities in schools and universities;
- scientific societies, national academies, etc. – information for the public;
- industry, trade associations, retailers – information for the public;
- consumer associations and public advice bureaux;
- environmental and other special interest groups – statements and information for public consumption;
- political parties – relevant policies when enunciated;
- financial sector – information for investors;
- newspapers and magazines;
- radio and television;
- bookshops and libraries – material for the general reader, especially in the local language;
- museums and exhibitions.

In each case we asked for details of activities, the intended recipients, how activities were promoted, the extent of variation within the sector and, where possible, what the public responses had been. Methods involved extensive interviews with those directly involved, scrutiny of published material and some views of third parties.

A WISH TO KNOW

Although biotechnology is a more prominent public issue in some countries than in others, there was everywhere considerable popular interest in learning more about it, again expressed more cogently in some places than in others. Even when people had heard of it as an activity and recognised its possible importance, there was almost invariably a wish to learn more.

There were widespread general comments about the difficulties of understanding the subject, especially with respect to its underlying science. Indeed, in discussions with many members of the public it soon becomes clear that although they are familiar with some of the words ('gene', for example) and have a limited idea of what they mean, their understanding is often too simplistic to sense their implications, either positive or negative. Thus, people may know enough to acquire a rather vague sense of beneficial advances in knowledge and technology – or a fear of what they might mean – but are unable to work out for themselves why these should be the case and so may become unduly influenced by strong advocates of particular viewpoints. Difficulties are not confined to science: they extend to the economic implications

and social consequences of biotechnology in practice. There is often a failure to realise that biotechnology is primarily a commercial activity and that, in our societies, commerce is almost always undertaken for profit by private sector. Thus, confusion arises between *science* perceived as an intellectual activity undertaken for cultural reasons rather than for any commercial gain, and *biotechnology* which is directed to the production of goods and services for sale in the marketplace.

It is by no means always easy to engage members of the public in considerations of complex issues. Most people, who gain much of their knowledge of biotechnology and other scientific matters from the popular media, have no more than a superficial understanding coupled with limited interest. They tend to remember simple if not simplistic phrases and explanations but know little of what they actually mean. Evocative headlines such as 'Frankenstein foods' alert a poorly informed reader about something strange, and perhaps to be avoided, but they may simply not know what the topic is about: the article or broadcast item which follows the headline tends all too frequently to be too shallow and too brief. On the other hand, many people will shy away from a more detailed explanation on the grounds that they are not interested or simply cannot understand.

Whipping up emotional reaction with provocative headlines and statements

This is a major problem and many opinions were offered in explanation. Reading in detail about biotechnology in order to learn enough to make up their own minds on controversial issues does not appeal to most members of the public; they tend to rely on advice from those they regard as 'experts' and in whom, for whatever reason, they have confidence. Those experts, however, have a variety of motivations and agendas of their own – and the public are more or less aware that they do. In some countries, government pronouncements are accepted as being sound advice; in others they are treated with scepticism exactly because they come from government. Industry is clearly suspect as operating in its own commercial interests and even some of the environmental pressure groups, hitherto widely regarded as being honest and dispassionate, are coming to be seen as also having their own agendas which do not necessarily coincide with those of the public at large. Academic and other national bodies may be regarded as sound voices of reason but sometimes they, too, produce confusing messages and lose their credibility. Working scientists are increasingly being seen as responding to funding opportunities so that their own statements have to be judged in that light. And, of course, many researchers are not effective at communicating with the lay public and others do not even try.

Who are the 'experts' on whom the public can rely?

There is a need, in some countries more than others, of respected public bodies and agencies sufficiently prestigious and divorced from the political process that the public can have confidence in the views they express. And if those views are divided, as inevitably they must be, at least the two sides should be expressed cogently and simply enough for the media to be able to report them widely and for readers and listeners to be able to come to an opinion themselves.

ATTITUDES TOWARDS BIOTECHNOLOGY

One aspect of biotechnology education is agreeing just what it might encompass. While recognising that biotechnology applies to traditional activities such as baking, brewing and cheese-making, it is necessary to distinguish between such non-contentious practices and the more recent activities, particularly those making use of genetic manipulation. The phrase 'modern biotechnology' has been proposed (and even used in product labelling) but is in itself not precisely defined. In emotional terms there is also a difference between areas of application. 'Red biotechnology' refers to its medical and healthcare aspects; although there are individuals who have specific concerns about the nature of their medicines, most people accept the advice given by their

medical practitioners and do not question the provenance of drugs and treatments prescribed. Choice is not regarded as much of an issue.

It is very different with food and agriculture, the so-called 'green biotechnology'. Partly because these issues have been much more prominent in public debate and partly because there is indeed personal choice in which foods one eats, there has been a far more vigorous response to the arrival of biotechnology in the food area. Yet even here, people's understanding is limited: there is the classic case of the respondent who ate only organic tomatoes 'because they did not contain genes', the concern that transferring a 'fish gene' to a tomato might somehow confer fishy characteristics on the eater and the failure to appreciate that millennia of classical plant and animal breeding procedures have always had a genetic basis, even though until 150 years ago nothing was known of it. There is a continuum of attitudes even within green biotechnology. While there might be fear of gene profiling in humans, this is acceptable in plant species as a means of improving crops. It is thus important to lay out all the many aspects of the new genetic technology for individuals to consider.

Agricultural biotechnology versus cloning and genetic fingerprinting

Biotechnology is also associated with cloning, an activity of profound concern especially when applied to the human case. Other aspects are only just beginning to impinge on the public consciousness: gene profiling and its implications for disease prediction and the consequences for insurance; genetic fingerprinting and the possible invasion of privacy; and others still to come. Some would therefore argue that it would be helpful for the general public to be able to place 'modern biotechnology' in context in the light of what has gone before. As one of the most significant areas of science to affect public thinking and public action, a defined place for it in the school curricula from the very beginning of tuition (as was indeed found in one or two places) might be one of the best ways of ensuring in the fullness of time a population able to deal with these problems with more confidence than they have at present.

FORMAL EDUCATION

Teaching biotechnology in schools

All of this must be set against the general educational level in science and technology offered to children and students through the schools and universities. It is clear that in the past few decades school curricula generally have included more science and technology but it is very patchy between and even within countries; science education goes up and down, while some individual sciences give way over time to others according to perceived national needs. In particular, the way biology is taught is influenced by the interests and education of individual teachers: the younger ones, who have may have received more molecular biology in their own training, are by and large more likely than some of their older colleagues to emphasise biotechnology where appropriate in their own teaching.

There is also some dichotomy between science teachers, who treat biotechnology in the context of the biological sciences, and those with different backgrounds who might include some elements of bioethics or business and economic considerations in other courses. Science teachers are often not comfortable teaching ethics and economics while teachers in the social subjects are likely to have a limited understanding of the natural sciences. In the complex modern world, in which compartmentalised subject-by-subject learning is no longer adequate (if, indeed, it ever was), biotechnology might act as a catalyst for a more integrated approach.

In the universities, biotechnology is taught mostly as a formal subject within a science environment. There is usually reference made to commercial, legal and ethical implications but in most cases instruction is by practising scientists who are more comfortable when dealing with genetics, biochemistry, microbiology and the rest rather than with patent law,

bioethics or venture capitalism and the operation of the market.

PUBLIC SOURCES OF INFORMATION

Informing the public about biotechnology

Government – national, regional or local – is a major source of information in many countries, probably more obviously in those already or likely to become major producers of biotechnological products. Explanatory booklets are published, some lavishly produced and running to many pages – too many, alas, for most members of the public. Others, via their individual ministries and departments, offer web sites both as general introductions and explanations as well as repositories for relevant official and other information. All of these are particularly useful for interested people, including teachers who are always avid for up-to-date material to supplement their school textbooks. But governments generate so much information that, unless a particular item is given publicity through the popular media, most people will be unaware of it. And even when something does become a news item, it is likely to make no more than a transitory impression on most people unless it is truly spectacular such as the announcement of Dolly the sheep.

Rather than the large 'set piece' science article or broadcast with biotechnological content, a more effective means of communication might be through frequent short items, introduced into rolling news broadcasts or presented as short paragraphs in newspapers and magazines. Each one will make but a slight impression, but if people were to hear and read such items day in and day out, they would before long recognise references to topics they have heard before and gradually build up their own personal pictures of how science is developing and affecting the society in which they live. They would gain the confidence to make up their own minds about issues, be less susceptible to scare stories and empty promises, and be able to relate advances in science and technology to the needs and opportunities they see around them.

Perceived importance of biotechnology by members of the public

The place of science in people's thoughts differs greatly depending on their personal histories and cultural traditions. Citizens in countries long since industrialised and at the forefront of technical advance will probably be more conscious of science and technology in their economies and hence in their own lives, particularly if they themselves are employed in technology-based parts of the economy. In less industrialised, more agricultural countries and regions, there may be less awareness.

It is important also to recognise that not everybody is fixated on biotechnology as a major public issue. Many have never heard of it; even for those who have, it is but one of very many matters which may or may not be of interest, may or may not excite their imagination and often seem remote from their own lives, except perhaps in some special sense. When their medical advisers recommend a new drug, there may be some explanation that it has been designed or produced in a new 'biotechnological' way but few people question medical advice. In some places the issue of transgenic crops and foods is more likely to have been brought to public attention. In the present period of intense debate, information and opinion will come from many sources. It is nevertheless worth remembering that when these foods were first introduced into one or two countries in the mid-1990s, consumers were very satisfactorily informed about them by leaflets in their supermarkets and explanatory articles in consumer magazines; the right balance between complexity and simplicity was readily achieved because consumers had confidence in the sources of information and were not being forced to take sides in a debate.

We have noted the wide variety of information sources, particularly with respect to agricultural biotechnology in which very many interest groups put forward their points of view. The sheer

Ideas for the promotion and understanding of biotechnology

variety and the passion with which many of these advocates on both sides advance their ideas probably only increases the difficulty for the man-in-the-street to understand what is going on and come to his own conclusions. That there is public interest is well illustrated by attendance at museums, exhibitions and displays. Even though these have their own limitations, they are clearly popular. The problem is that the public goes to museums and exhibitions largely as a recreational activity and there is a limit both to how much information is willingly absorbed during a family outing on a Saturday afternoon and how best to display such material in an often crowded museum where it is difficult even to read the captions and see the exhibits properly.

THE FUTURE

What does the future hold?

Our investigations have shown that biotechnology is generally recognised as an important factor in modern life and efforts are made in both the public and private sectors to ensure the public at least has access to explanation and understanding. Many good ideas and initiatives have come to light, some on a large scale funded by governments, industry or other major organisations, others run on a shoe-string by interested individuals (often schoolteachers). There is undoubtedly enthusiasm but nothing can be achieved without resources, which may be difficult to come by and offered only for short-term initiatives. The problem is then how to continue after the start-up phase.

SUGGESTIONS FOR PROMOTING BIOTECHNOLOGY UNDERSTANDING

The study concluded with a number of recommendations.

Research publicity

Scientific research institutions should aim to spend 5 per cent of their budgets on public communication, setting forth clearly for public information what they are doing and how society does or might benefit.

Communications training for scientists

University scientists and other research scientists need to be rewarded for communicating with the public, for instance by being given brownie points towards a promotion; they need to form networks with journalists, editors and policy makers. They also need training for communication with the public and with the media and should develop alliances with groups that are perceived to be credible: patient groups, environmental non-governmental organisations (NGOs), etc.

Public relations expertise

Those involved in biotechnology publicity should work together with professional communications specialists. Presenting potentially technical material to a lay audience requires skill and experience, something already available to the communications industry. Responding to breaking news clearly, rapidly and simply is a skill for which few scientists have been trained or seem to show natural aptitude; most need help.

Science fairs and open days

There have been many successful events under the heading of 'Science Fair', 'Open Day', 'Science Week', 'Day of Genetic Research', 'Meet the Scientist', etc. On these occasions, the public are invited to the research laboratories of universities and industries or scientists set up exhibitions in the streets, in shopping centres, on fairgrounds and other places where people normally gather. Of course, only a small number of people can be reached at any one event. However, if repeated on a regular basis, for instance every year, or done by multiple institutions, the visibility is obviously increased. In addition, when done well, the events will attract media attention; in particular they are likely to be reported as a news item on national or at least on

local television. These encounters and their reporting have promoted transparency, helped build trust and have contributed to the public dialogue.

More ideas for the promotion and understanding of biotechnology

Mobile and virtual laboratories

Mobile hands-on biotechnology laboratories have been successfully touring around Germany and Switzerland for several years. In general, these laboratories are assembled on a van chassis, with each offering 12–15 working places. They are staffed by scientists who run half-day or full-day hands-on courses which include such experiments as DNA isolation, electrophoretic separation of nucleic acids or polymerase chain reaction (PCR). Courses are for students or science teachers, and can take place at schools or at science fairs. Other versions of proactive scientific outreach in biotechnology takes place in most countries.

Adult education

Evening courses on biotechnology addressed to adult audiences could be provided by universities and others; the University of the Third Age might be encouraged in this direction. The contents should be directed to people with no scientific background, and include economic relevance, impacts on the existing industrial and farming practices, potential benefits, possible risks, labelling, patents, ethical, moral concerns and so on.

Consensus conferences

Lay panels (also called *consensus conferences*), debating groups, public fora, etc., have shown themselves to be an effective way of entering into dialogue with the general public. The timing of the panels is crucial: the best results were obtained when the subject matter was of political moment, particularly if it were on the current parliamentary agenda. These panels are costly and take many months to prepare. They do not, in general, provide political solutions but they do show clearly public opinion on matters of current concern. When arranging consensus conferences on science-related issues, the public should be included and journalists invited to cover the event.

Information for journalists

One route to pro-activity with the media is via the AlphaGalileo web site[13] which helps to communicate the achievements and relevance of European science, engineering and technology to non-specialist audiences via the mass media. There are several listservers in the USA used by the press to find experts in particular fields. Services such as ProfNET ask people to lend their names to lists of individuals who make themselves available to answer questions from the press. Those taking on this responsibility must realise the time constraints under which most press reporters work. Many US universities provide training for university personnel in interacting effectively with the press. Professional organisations to which scientists belong, as well as universities, have contact persons for the press who are responsible for identifying individuals within their organisation who can answer questions from journalists and others.

Media centres

Media centres, such as the one established at the Royal Institution in London, provide a science access point for journalists and others where information about science is readily available and through which introductions can rapidly be made with expert scientific opinion for journalists dealing with science stories. One of the objectives will be to attempt to anticipate important scientific and technological events so that such a centre is prepared for responding without delay to journalists' queries and need for background information.

Usable science information for press and broadcasting journalists is especially important for small language countries such as Finland, Greece and Portugal. Because there is not much translated literature in their languages, broadcasting

and the press are the main channels for informing the public; alerting journalists to new activities and findings is thus of primary importance. It would be extremely helpful if the EU were to earmark funding for such activity.

Still further ideas

Scientific games and toys as communication vehicles

Scientists might collaborate with commercial companies to create products for entertainment: suggestions include science-based computer games, cookery books (perhaps involving biotechnological products), movies, documentaries, theatre and toys. The products must be professionally designed and marketed by experts in the appropriate business and not be regarded simply as teaching aids or associated with formal education.

Universum

In Austria, a co-production between broadcasting and publishing has produced a successful magazine which develops science topics from the television programmes and gives them wider publicity via the printed text.

Specialist public library facilities

The main public library in Genoa has one computer dedicated to biotechnology. The opening screen lists links to important biotechnology sites both in Italian and in English. It would be extremely valuable if such facilities were widely provided not, of course, solely for biotechnology but for a variety of important public issues. The opening screen would then offer a choice of topic, which would lead to the links page. Siting such access computers in public and school libraries, and similar central access points, would be of immediate value in facilitating public access to a range of views on such topics.

Frequency of news items

A major problem with the public dissemination of scientific and technological information is that many people react simply by turning their attention elsewhere because such they feel that such matters are of no interest to them. Part of their difficulty lies in unfamiliarity with the subject matter, coupled with insufficient concern to pursue the topic further. However, if very short scientific items were regularly presented within other contexts, readers, listeners or viewers would inadvertently acquire a sense of familiarity and some would begin to take a conscious interest.

Biotechnology information agencies

As a contribution to the agricultural biotechnology/GM crops debate, CropGen was set up in the UK as an industry-funded but otherwise quite independent organisation with the mission of making the case for crop biotechnology. In Switzerland the GENSUISSE foundation and the INTERNUTRITIO agency have similar functions in communicating on biotechnology in the medical and the agricultural fields, respectively. A similar function is played by VIB in Belgium, which has among its objectives well-considered and objective communication.

Effective distribution of biotechnology information

The effective marketing and distribution of educational information are of critical importance. Reports from every country show a large and increasing number of organisations, governmental bodies and university departments addressing themselves to their members or the general public through bulletins, books, reports, periodicals as well as by public gatherings and laboratory visits. At the same time, most people declare they feel insufficiently or inadequately informed as the Eurobarometer findings show (see Table 1). This paradox comes partly from the scant attention these actors pay to distribution and marketing aspects when conceiving a given scientific publication or public event. No matter how good an idea

might be, if it is not adequately marketed and distributed, it will have a negligible impact because few people will know about it and fewer still will have access.

Cooperative extension

Specified universities in the USA have Cooperative Extension programmes, functioning through a continuum of individuals from faculty located on campus to university personnel stationed all over the state. Their role is to facilitate communication between consumers and university researchers. Because county-based personnel have close ties with the local communities, this situation provides excellent opportunities for education and outreach.

Information for professionals

Organisations linking professionals in a given discipline often provide educational opportunities for their members. In the biotechnology context, these groups include dieticians, public health officers, lawyers, teachers, farmers and doctors. Providing targeted educational programmes for them leverages the efforts of educators since group members pass on such information to their clients.

Biotechnology is also for developing countries

It is important to stress in communications for the public that biotechnology is not just for the rich countries but has enormous real and potential value for the Third World, both in health and agriculture. Material can be obtained from publications produced by prestigious organisations such as the OECD, UN Development Programme and others.

A CODE OF BEST PRACTICE?

The participants in the project recognised, of course, the critical important of both government and the media in helping the general public to understand and deal with the realities and issues of biotechnology. We could do no more than assume that government at all levels is well aware of these matters as many of them have made very clear by their publications and other activities. It is, alas, also clear that government decision makers may have limited scientific understanding and experience; this does, of course, extend to the whole of science and science-based activity and is not restricted to biotechnology. Governments should be encouraged to include more people with scientific experience at the highest political levels, the better to reach the most appropriate conclusions on the increasing number of science-based questions of public concerns.

The media are commercial undertakings with their own imperatives, differing greatly across Europe. Members of the public are usually fascinated by scientific advance and technological novelty when put to them in an attractive and comprehensible manner. The media everywhere must recognise the public importance of and interest in scientific matters and provide for their readers, listeners and viewers accordingly.

Suggestions for a code of best practice

The following suggestions for a code of best practice are directed primarily to the public sector; commercial organisations will make their own decisions based upon their perceived needs. Indeed, many private companies involved with biotechnology already have extensive and high-quality educational material and outreach programmes.

- As an integral part of formal education, the relevant authorities in each country should ensure an adequate level of science-based biotechnology instruction in an ethical, economic and social context.

- Teachers should be encouraged to maintain and update their understanding of biotechnology.

- Educational and research institutions should institute, extend and reinforce

their outreach activities in biotechnology to all sectors of society.

- Reseachers in biotechnological areas should be afforded credit for outreach activities, just as they are for publications; outreach should be regarded as an essential component of career development. As part of their scientific education, research and other scientists need to receive training for communicating with the public, and specifically for working with the media.

- Interdisciplinary activities and approaches should be encouraged in biotechnological applications and implications. Teachers should be specifically assisted to offer lessons relating biotechnology to economics, ethics and social issues.

- Researchers and their institutions, academic as well as industrial, should proactively cultivate a network of contacts: for journalists and others to have access to the relevant scientists, and for scientists to know which journalists to call.

- Scientific academies and associations should be encouraged to address major issues of science and technology in the context of the local culture and in language which the general public can readily understand.

- Professional organisations on whose activities biotechnology impinges should be encouraged to develop educational programmes focused on emerging topics of potential interest to their members.

- Biotechnology education is a long-term issue requiring a long-term view; it should not be constrained by short-term funding.

- The updating and marketing of EU-sponsored educational material needs to be undertaken on an ongoing basis.

Acknowledgments

This study, sponsored by the Commission of the European Union under Framework 5 (contract no. HPRP-1999-00007), was undertaken as a collaboration by the participants shown in Table 1. The full report may be downloaded from URL: http://www.boku.ac.at/iam/ebe/finalreport.htm

References

1. Eurobarometer 52.1 (2000), 'The Europeans and Biotechnology', INRA (Europe) (URL: http://europa.eu.int/comm/research/quality-of-life/eurobarometer.html).
2. Scholderer, J. (2000), 'Kampagnen zur Gentechnik und ihre Wirkung auf Verbraucher', in Schell, T. V. and Seltz, R., 'Inszenierungen zur Gentechnik', Westdeutscher, Wiesbaden , pp. 214–222.
3. Appleyard, B. (1999), 'Brave New Worlds; Staying Human in the Genetic Future', HarperCollins, London.
4. Von Wartburg, W. P. and Liew, J. (1999), 'Gene Technology and Social Acceptance', University Press of America, Latham, MD.
5. European Commission (1997), 'The Europeans and modern biotechnology', Eurobarometer 46.1, DG XII, Brussels, Table 6.
6. Durant, D., Bauer, M. W. and Gaskell, G. (Eds) (1998), 'Biotechnology in the Public Sphere – a European Sourcebook', Science Museum, London, Appendix 2, Table 2b.
7. Hoban, T. J. (1997), 'Consumer acceptance of biotechnology: An international perspective', *Nature Biotechnol.*, Vol. 15, p. 232.
8. Hoban, T. J. (1996), 'Trends in consumer acceptance and awareness of biotechnology', *J. Food Distribution Res.*, Vol. 27, p. 1.
9. Hoban, T. J. (1996), 'How Japanese consumers view biotechnology', *Food Technol.*, July, p. 85.
10. Standage, T. (1998), 'The Victorian Internet', Weidenfeld & Nicolson, London.
11. Landes, D. (1998), 'The Wealth and Poverty of Nations', Little, Brown and Co., London.
12. Wursten, H. (1999), 'Culture and management', presented at the EFB Workshop 'Focus on future issues in biotechnology', Dublin, 1–9 April.
13. URL: www.alphagalileo.org