GM Science Review: First Report

Comments to the GM Science Review Panel from the Institute of Biology on behalf of the Biosciences Federation

October 2003

Introduction

1. The Institute of Biology (IOB) is a founder member of the Biosciences Federation (BSF), which was established in 2002 to create a single authority within the life sciences that decision-makers can consult for opinion and information concerning the formulation of public policy. The BSF now represents 26 societies with a cumulative membership of 60,000 bioscientists (see www.bsf.ac.uk).

   The IOB is an independent and charitable body charged by Royal Charter to further the study and application of the UK's biology and allied biosciences. The IOB has a number of Affiliated Societies and individual members with a specialised interest in the area of this consultation and is, therefore, ideally placed to respond on behalf of the Biosciences Federation.

Summary of statement

2. This statement's principal points include:
   i. A debate on GM crops that attempts to be scientifically based is welcomed. Science is able to help establish an objective picture of the potential risks and benefits of GM crops, but whether they are accepted (and the commercial potential realised) is beyond the scope of science (paragraph 3).
   ii. There is continuing concern over the way in which the public discussion and scientific analysis of GM technology has been conducted by the Government (paragraph 4).
   iii. The GM Science Review's First Report is welcomed as a critical document that attempts to provide a balanced review of the evidence on the concerns surrounding GM technology. However, the debate would be better informed if a scientific review of the potential benefits of GM technology were also included in the report (paragraph 5i).
   iv. We endorse the view that we should proceed with caution. Regulation and management structures should be handled carefully and thoroughly, but should still reflect a willingness to 'proceed'. We would also emphasise the need for this process to embrace the principle of remediation (paragraph 5ii, 5iii).
   v. Evaluation of environmental impacts should recognise that biogeographical differences may occur (paragraph 5iv).
   vi. There are many unknowns. It is vital that research on the potentially invasive effects of GM plants and other issues that may arise as GM technology develops is supported with sufficient funding and resources (paragraph 5v, 5vii).
   vii. Changes in agricultural practice have resulted in a decline in farmland biodiversity over the last few decades and the contribution of all novel crops and techniques to reversing this trend should be rigorously evaluated (paragraph 5vi).
   viii. The BSF and the IOB and its Affiliated Societies have submitted several advisory documents to government and other bodies. These are still relevant and are reproduced in Appendix 1 of this response (paragraph 6).

General

3. The aim of the GM Science Review is stated as '*to air the scientific issues and for a panel…to summarise the current state of scientific knowledge, identifying the consensus, what the uncertainties are, how these might be reduced, and where there are gaps in knowledge, so as to inform both Government and the public.*' A debate on GM crops that attempts to be scientifically based is welcomed. Science can provide information for the debate up to a certain point, but economic, social and political factors also come into play. Science is able to help establish an objective picture of the potential risks and benefits of GM crops, and the safety of GM foods, but whether the risks are accepted (and the commercial potential realised) is dependent on forces outside the scope of science. For example, insurance companies may initially offer high premiums or refuse to insure farmers who use GM crops, which would prohibit their use.

4. There is continuing concern over the way the public discussion and scientific analysis of GM technology has been conducted by the Government. For example, the report of the GM Science Review was not available to act as a foundation for the public debate 'GM Nation?' because they were conducted in parallel. Dialogue between the Government and the public would have been enhanced by clear communication of the scientific issues. In addition, consulting on separation distances for GM crops after the trials have begun and then dropping the consultation altogether does not help to give the impression that the scientific analysis is open and informed (see the document referred to in 6ii).

Comments on the First Report of GM Science Review

5. The First Report[a] of the GM Science Review panel, published in July 2003, considers the potential use of GM crops in the UK following an extensive review of the literature. Comments on this report are detailed below.

    i. The report is welcomed as a critical document that attempts to provide a balanced review of the evidence on the popular concerns and questions surrounding GM crops and food. Many of the issues raised are not specific to GM, and this is acknowledged to a certain extent in the executive summary. However, discussion surrounding GM technology is, in essence, a risk-benefit analysis and the debate would be better informed if a scientific review of the potential benefits of GM technology (including an analysis of *who* will benefit) were also included in the report.

    ii. We agree that there is doubt surrounding the consequences of using GM technology in agriculture and the view that we should proceed with caution is endorsed. Regulation and management structures should be handled carefully and thoroughly, but should also still reflect a willingness to proceed.

    iii. We agree with the recommendation that regulatory processes must consider each GM crop as an individual case, but would emphasise the need for this process to embrace the principle of remediation (see the document referred to in 6i).

[a] GM Science Review Panel. *First Report. An open review of the science relevant to GM crops and food based on the interests and concerns of the public.* July 2003. Available at: http://www.gmsciencedebate.org.uk/default.htm

iv. We agree that environmental impacts should be evaluated on a country-by-country basis and recognise that biogeographical differences may occur. Large, isolated farms in the USA and Canada are very different to the small-scale farms embedded in the countryside that are characteristic of the UK and rest of Europe.

v. The impact of GM plants and other novel crops is not fully understood and the report states that more knowledge is needed in this area. It is important, however, to ascertain exactly how much knowledge and research would be enough: the report highlights widespread disagreement on how much data is needed to demonstrate that GM crops are environmentally sustainable in the long-term. We support the view that large-scale studies are required in order to go some way towards determining the impacts of GM crops on wildlife, non-target organisms, soil and below-ground processes. A nationally co-ordinated, properly designed and adequately funded monitoring scheme is required to detect future changes in biodiversity, with design and funding considered prior to commercialisation. Such a scheme would, in fact, be desirable independent of the introduction of GM technology (see 5vi). Considering the importance of this and related research, we have serious concerns about the year-on-year cuts in the research budget at the Department for the Environment, Food and Rural Affairs.

vi. It is important to note that changes in agricultural practice have resulted in a decline in farmland biodiversity over the last few decades.[b] The effects of all novel crops and techniques, including GM technology, on biodiversity should be rigorously evaluated in terms of their contribution to reversing this trend.

vii. New issues will arise as GM technology develops, for example, GM crops for medicines and renewable resources for industry, and our knowledge of new technologies must keep pace. Research in this area must be supported with sufficient funding and resources, and should take place in an environment free of fear and intimidation.

Further information

6. The BSF and the IOB and its Affiliated Societies have submitted several advisory documents to government and other bodies since the debate began several years ago. In the absence of new data, these responses are still relevant, and the following documents are reproduced in Appendix 1 of this response (and can also be found on www.iob.org):

   i. **The Use of Genetically Modified Crops in Developing Countries.** Comments from the Biosciences Federation on the Nuffield Council on Bioethics discussion paper. August 2003 (see page 5)

   ii. **Review of Separation Distances for GM Crops**. A response to MAFF [now Defra] from the Institute of Biology. July 2000 (see page 8)

   iii. **Genetically Modified Organisms and the Environment**. A response to the consultation from the Environmental Audit Committee of the House of Commons from the Institute of Biology. April 1999 (see page 14)

[b] Chamberlain DE, Fuller RJ, Bunce RGH, Duckworth JC & Shrubb M. Changes in the abundance of farmland birds in relation to the timing of agricultural intensification in England and Wales. *J Applied Ecology* 2000: **37**; 771–778. Krebs JR, Wilson JD, Bradbury RB & Siriwardena GM. The second Silent Spring? *Nature* 1999: **400**; 611–612.

iv. **Genetically Modified Crops: The Social and Ethical Issues**. A response to the Nuffield Council on Bioethics Consultation from the Institute of Biology, the Association of Applied Biology, the British Crop Protection Council, the British Ecological Society, the British Electrophoresis Society, the British Grassland Society, and the Institute of Horticulture. August 1998 (see page 16)

Openness

7. The BSF is pleased for this response to be publicly available and will be shortly placing a version on www.bsf.ac.uk (the IOB will also be placing it on www.iob.org). Should the GM Science Review have any queries regarding this response then they should in the first instance address them to Catherine Joynson, Science Policy Advisor, Institute of Biology, 20 Queensberry Place, London, SW7 2DZ [email: c.joynson@iob.org].

Appendix

Comments from the Biosciences Federation on the Nuffield Council on Bioethics discussion paper 'The use of genetically modified crops in developing countries'

August 2003

Introduction

1. The Biosciences Federation (BSF) was founded in December 2002 in order to create a single authority within the life sciences that decision-makers can consult for opinion and information to assist the formulation of public policy. It brings together the strengths of the Institute of Biology and societies that were formerly members of the UK Life Sciences Committee. Those societies that have already joined the Biosciences Federation (see www.bsf.ac.uk) represent some 60,000 members and cover the whole spectrum from physiology and neuroscience, biochemistry and microbiology to ecology, so it is ideally placed to respond to the above discussion paper.

Summary of response

2. This response's principal points include:
    i. The BSF generally agrees with the conclusions of the Nuffield discussion paper (paragraph 3).
    ii. The paper should, however, recognise the limits of the science and focus on practical mechanisms that can help us to 'proceed with care' (paragraphs 4–6).
    iii. The paper should include discussion on mechanisms of remediation (paragraph 7).
    iv. Where the water balance is fragile, GM crops should be assessed for water requirements prior to use (paragraph 8).

Comments on the discussion paper

(References in square brackets relate to paragraphs in the Nuffield discussion paper)

The BSF generally agrees with the conclusions of the discussion paper

3. The BSF generally welcomes the recent discussion paper[c] by the Nuffield Council on Bioethics – a follow-up to its 1999 report.[d] The BSF agrees with the suggestion that GM technology may help to increase agricultural production in developing countries and address the ever-worsening problem of mass under-nourishment. However, the BSF also accepts the paper's view that corporate control, lack of directed research, political unrest, local traditions and conflicting regulations at local, national and international levels may be barriers to exploiting any benefits of this technology.

[c] Nuffield Council for Bioethics. *Discussion Paper: The use of genetically modified crops in developing countries.* June 2003. Available at: http://www.nuffieldbioethics.org/publications/pp_0000000017.asp

[d] Nuffield Council for Bioethics. *Genetically modified crops: ethical and social issues*. May 1999. Available at: http://www.nuffieldbioethics.org/publications/pp_0000000009.asp

The paper would do better to focus on how to approach the application and development of GM technology using sound ethical principles, rather than concentrating on the uncertainties of science

4. The BSF feels that the report puts more into discrediting the concerns of the anti-GM lobby over scientific uncertainty than it does into dealing with practical issues. This approach does little to foster the development of the technology, either here, or in the developing world. A reasoned view is that there are potential benefits from the introduction of GM, and possible risks, and the first has to be balanced against the second.

5. By dwelling on the uncertainty debate [*sensu* 37-47], the report is dragged into the mire of shaky logic and contradiction. For example, the paper argues for a less conservative interpretation of the precautionary principle [119] suggesting that the technology can be controlled by regulation. It then argues that current European regulations are likely to frustrate the adoption of GM crops in the developing world [172,177] implying, perhaps, that the regulations should not be too strict. In addition, while it upbraids the argument that invoking 'natural world order' is a reason for not using GM, it assumes that the 'natural world order' [43] (including the legislative process) can cope with GM releases [47]. Given the current state of our knowledge, neither position is tenable in science. The report should say so and focus on how to approach the application and development of GM technology [section 5,6] using sound ethical principles.

6. It should be remembered that there can be no certainty about the long-term safety or benefits of genetically modified crops, because the issues are complex and the facts few. While recent reports from the Royal Society[e] and the Government[f] conclude that the consumption of currently available GM crops poses no significant risk to human health, they do indicate that future initiatives will need to be assessed on a case-by-case basis [*sensu* 116]. Opinion on the environmental impact of genetic modification is even less certain. This uncertainty suggests that an 'evidence-based rational assessment' [3] might find it unethical to invoke science to justify any position on the subject, except perhaps one of caution. A report purporting to represent bioethics should be open and straightforward about this uncertainty and simply set out the ground rules on how we might proceed 'with care' [119] in order to maximise benefits and contain and remedy problems.

Discussing mechanisms of remediation would lead to a more balanced report

7. While the paper reviews bio-safety issues [130–160] relating to risk management, risk assessment and traceability, any mechanism that claims to 'proceed with care' [119] should include the principle of remediation, i.e. financial provision for correcting mistakes. This approach is central to European environmental management regulations, and very much part of the common and contract law tradition of paying for what has been damaged, for example, the ironstone fund.[g] How mistakes are traced, and whether EU regulations will be able to exert control over mistakes that have originated outside the EU are issues that should be discussed. Dealing with this matter in the report will improve its comprehensiveness.

[e] Royal Society. *Genetically modified plants for food use and human health—an update.* February 2002. Available at: http://www.royalsoc.ac.uk/policy/

[f] GM Science Review Panel. *GM Science Review, First Report.* July 2003. Available at: http://www.gmsciencedebate.org.uk.

[g] Mineral Workings Act 1951.

Where the water balance is fragile, GM crops should be assessed for water requirements prior to use

8. The BSF accepts that using GM technology to breed crops with resistance to moisture-stress may help to use land and water more productively and conservatively [28, 33]. Where yields are improved by GM technology, however, there may be an increase in water demand with implications for local water sources such as groundwater and streams. Therefore, in areas where the water balance is fragile, GM crops modified for one purpose (e.g. higher net yield) should also be assessed for water requirements prior to use. GM technology can increase water use efficiency, however, which may compensate for any need for more water.

Openness

9. The Biosciences Federation is pleased for this response to be publicly available and will be shortly placing a version on www.bsf.ac.uk. Should the Nuffield Council on Bioethics have any queries regarding this response then they should in the first instance address them to Catherine Joynson, Science Policy Advisor, Institute of Biology, 20 Queensberry Place, London, SW7 2DZ [email: c.joynson@iob.org].

Review of Separation Distances for GM Crops

A response to the MAFF consultation

July 200

1. The Institute of Biology is the independent and charitable body charged by Royal Charter to further UK biological interests. The Institute's 16,000 individual members and 76 specialist Affiliated Societies span the spectrum of bioscience from molecular to ecological concerns. It is ideally placed to respond to a wide range of consultations. The Institute is pleased to respond to the Ministry of Agriculture Fisheries and Food (MAFF) on the above issue.

Summary of response

2. This response's principal points include:
   a. The Institute's membership contains both environmental biologists (concerned with ecological and conservation issues) as well as agricultural biologists (concerned with food supply and farming issues). As an independent and charitable Institute, it is well placed to produce a balanced response.
   b. While part of this consultation relates to biology, as much relates to intangibles such as 'the [acceptable] level of varietal purity', 'farmer concern' and 'farmer notification procedures'. These issues are political and societal.
   c. Doubling the distance does not result in halving the risk of contamination, indeed the low risk at the distances discussed is barely changed.
   d. It is impossible to achieve zero risk. Even organically grown crops are not 100% free from contamination at a biochemical or toxicological level nor is there complete (100%) genetic homogeneity of organically grown crop cultivars.
   e. The seed industry has already developed protocols for preserving the genetic purity of cultivars. These protocols work to arbitrarily defined levels of purity: the protocols are born of practical pragmatism.
   f. *If* there is currently such farmer and public concern over the question of 'crop purity', that stringent protection measures are politically deemed necessary, *then* one option would be to employ the guidelines for 'Basic Seed' just for the short-term, during the GM (Genetic Modification) safety research phase.
   g. The distances for 'basic seed' are greater than for certified seed so that following monitoring and research, once safety has been demonstrated, more appropriate levels with shorter distances should be employed. The proposed SCIMAC annual reviews are therefore most welcome. MAFF might make its own appraisals.
   h. There is concern over the short timescale allowed respondents to this consultation. and we do urge that this is taken into account when interpreting the responses and forming an overall balanced set of conclusions. Our concern is based on the Cabinet Office guidelines for written consultations. Short timescales do not increase a perception of openness, engender public confidence, nor facilitate the provision of best scientific advice to underpin policy.

General points

Representing both environmental and agricultural biological interests, the IoB can provide a balanced response.

3. Separation distances for GM crops are an issue that is publicly sensitive. Because the Institute's membership contains both environmental biologists (concerned with ecological and conservation issues) as well as agricultural biologists (concerned with food supply and farming issues), the independent and charitable Institute of Biology has access to the necessary range of expertise to provide a balanced response.

Part of this consultation relates to non-biological dimensions

4. While part of this consultation relates to biology, as much of it relates to intangibles such as 'the level of [acceptable] varietal purity', 'farmer concern' and 'farmer notification procedures'. These issues are political and societal, though science may illuminate the debate. As such this response is submitted with the concerns in mind that some members of the public have for GM technology. However, it is hoped that ultimately the case for properly managed GM technology will enable the public to recognise the benefits it offers.

Crop separation distances are just one factor determining gene flow.

5. Varietal purity is an issue of public and political acceptability. So far the GM debate has been driven largely by commercial interests on one hand, and the belief-systems of (an undefined) part of the public on the other. There cannot be any one UK distance for any anemophilous (wind pollinated) crop species given the number of variables present. Similar arguments apply to entomophilous (insect pollinated) plants. Such variables include: regional climatic differences, topography, the acreage of crops planted, farm management practices, etc. Indeed local variation in these is not considered in the current guideline distances. The distance between crops is therefore just one factor determining (potential) gene flow.

The SCIMAC figures do confer some protection of varietal purity. However doubling the distance will hardly affect risk.

6. The SCIMAC (Supply Chain Initiative on Modified Agricultural Crops) figures do confer a measure of protection of varietal purity. The question is whether this degree of safety is publicly and politically acceptable? However, given that these figures are based on the longstanding experience of conventional (non-GM) seed production, there is a logic to them. Furthermore, increasing these distances will not proportionally increase safety. For example, doubling the distance does not result in halving the risk of contamination. Indeed the low risk at the distances discussed is barely changed.

It is impossible to achieve zero risk.

7. It is impossible to achieve zero risk, and it should be noted that even organically grown crops are not 100% free from contamination in terms of biochemical micro-organisms (including mycotoxins), nor is there complete (100%) genetic homogeneity of organically grown crop cultivars. Consequently, given the existing procedures for approving novel foods, it is difficult to see what additional risks GM crop contamination poses humans above those already posed by conventional food crops. Indeed, that there have been no mass human toxicity events with GM crops to date is exactly as expected given existing controls and protocols.

Despite the existing level of safety, employing the precautionary principle would provide further assurance while research provides clarification.

8. Despite the evidence for safety, it is understandable that some of the public may have doubts until research can further assure protection. This Institute, together with a number of its Affiliated Societies, with either agricultural and/or environmental expertise, has already suggested the use of the precautionary principle as the way forward and to engender evidence-based confidence in the technology's application (Institute of Biology *et al*, 1998). The move towards gradual unrestricted outdoor release should only take place once previous (more restricted) trials have proven satisfactory.

The current separation guidelines are pragmatic, but does MAFF consider them satisfactory?

9. Given MAFF's concern over the recent incident – involving seed accidentally containing a small proportion of GM seed – is sufficiently great as to prompt this review of the separation of GM crops from non-GM crops, it is presumably concerned as to whether or not the minimum separation distances are great enough? The current SCIMAC (Supply Chain Initiative on Modified Agricultural Crops) Guidelines are provided by industry and – being based on Certified Seed Distances used for conventional crops to maintain purity – are a pragmatic way forward. The question MAFF needs to answer is whether these are satisfactory or not?

If *there is socio-political concern over crop purity* then *separation based on Basic Seed criteria would provide added protection*

10. *If* there is currently such farmer and public concern over the question of 'crop purity' that further protection measures are deemed necessary, *then* one option would be to employ the more stringent of the commercial protocols proven over the years with conventional crops. This is in line with the precautionary principle and need only be in place while research ascertains gene flow and other GM safety matters with greater precision (to public and political satisfaction). As MAFF points out "current standards are based on existing knowledge and the longstanding experience in the production of Certified Seed". More stringent standards (with regard to crop separation only) are used for Basic Seed. Being the seed that generates Certified Seed, Basic Seed standards are higher and the resulting crop purity is greater. Basing the separation distances on the requirements for Basic Seed should also provide some additional assurance with regard to the possible contamination of hybrid rape. Conventional hybrid rape contains a high proportion of sterile males, so leaving it open to external pollination. With regard to beet, though it is biennial, producing flowering heads in the second year, there is the question of rogue bolters during the first year. SCIMAC guidelines call for farmers to remove flowering heads. Here MAFF needs to assess the level of public trust that flower head removal will *always* happen, though it should be noted the part of the plant used for food is not a product of pollination. Again increasing the distance to that for Basic Seed would provide added safety and reassurance while research continues into gene flow and GM safety issues.

Increasing separation might increase research costs, but this represents a fraction of the R&D budget MAFF has been asked to restore by Parliamentary Select Committee and academia

11. The distances for 'Basic Seed' are greater than for Certified Seed and so, if used, will reduce the number of sites available for research, as well as marginally increase research costs. The Institute of Biology and a number of its Affiliated Societies (Institute of Biology *et al*, 1999) have already expressed their concerns over the one and a half decade decline in Government Departmental R&D budgets; a concern recently shared by the House of Commons Select Committee for Science & Technology (2000). Indeed MAFF's R&D budget has been one of those most severely cut despite increasing concerns. The extra costs from increasing the separation distances discussed above would represent a fraction of the decline in MAFF's R&D budget and so could easily be affordable should the decision be made to restore its research funding to its mid-1980s real-term level.

If research confirms safety, so shorter distances should be employed. The annual review of distances is welcomed.

12. Following monitoring and research, if safety has been demonstrated more appropriate levels, with shorter distances, can and should be employed. The proposed SCIMAC annual reviews on behalf of industry are therefore most welcome and MAFF should be encouraged to make its own appraisals.

If distance is increased and research fails to find gene flow of concern, then the onus must be on those who do not believe in this aspect of GM safety to prove their case.

13. Meanwhile, if the crop separation distances are increased and research fails to find any gene flow that would threaten the non-GM status of neighbouring crops, then the onus must be on those who do not believe in this safety aspect to GM technology to prove their case.

Specific consultation questions (in bold)

A What, if any, amendments do you think are necessary to the separation distances set out in the SCIMAC guideline? Indicate why you think the changes are needed and bear in mind that the larger the separation distances, the more onerous the safeguards would be for GM and non-GM producers

If *there is sufficient concern* then *separation might be based on Basic Seed distances.*

14. *If* there is sufficient concern, as suggested there might by this consultation, *then* it would be prudent to base the separation distances on those used for Basic Seed as opposed to Certified Seed at present. The reasoning is given in the preceding paragraphs, but we suggest that any increase in distance need only be employed while research into gene flow and related GM safety matters is undertaken. If, as it currently appears, research shows the non-GM status of neighbouring conventional crops is not threatened then distances should be decreased appropriately. Hence, regular reviews of separation distances in the light of research are welcome.

B Given the link between separation distances and crop purity, what thresholds for GM content in non-GM crops can realistically be aimed for?

0.5% and 1% threshold levels are in most instances likely to be realistic. 0% is not.

15. 0.5% and 1% threshold levels are in most instances likely to be realistic. Lower levels can be detected but the point comes where the nature of the genetic modification determines the level of detection possible. A 0% threshold level can never be achieved, no matter the ability to detect the presence of genetic modification, as this would require 100% sampling.

C What procedures are needed for farmers growing GM crops to notify their neighbours and others about their intention?

The Institute has no view.

16. The Institute of Biology has no view on this.

D Other suggestions for the practical safeguards on the growing of GM crops

Temporal separation should be noted. Apiary practice needs examination.

17. Due regard to the separation of crops in time as well as spatial distances is required. Volunteers from self-sown seeds can subsequently rise. Secondly, an examination of apiary practice and movement is required in case advice for the bee-keeping community is needed.

Openness and transparency

The short time scale allowed this consultation does mean less time for considered thought.

18. The short time scale allowed respondents for this consultation is of concern, particularly given the importance and sensitivity of the subject. The time scale was half that recommended by the Cabinet Office guidelines *How To Conduct Written Consultation Exercises* (1998). There is a concern as to whether respondents will have had sufficient time to give full thought to the issues/implications and, as importantly, to have consulted sufficiently widely. While we do understand the need for a rapid decision, we do urge that this reduction in time scale is taken into consideration when interpreting the responses.

The Institute is pleased for MAFF to reproduce this evidence

19. In line with Government policy on openness the Institute is pleased for MAFF to reproduce this evidence as it sees fit, and in turn the Institute of Biology will shortly be making this publicly available on *www.iob.org* The Institute requests MAFF permission to reprint its consultation document alongside this response. Should MAFF have further queries relating to this response then in the first instance it should contact: Jonathan Cowie, Institute of Biology, 20-22 Queensberry Place, London, SW7 2DZ.

References

Cabinet Office (1998) *How to Conduct Written Consultation Exercises: An Introduction for Central Government*. EX30 1988-9. Stationery Office: London and Norwich.

Institute of Biology, Association of Applied Biologists, British Crop Protection Council, British Ecological Society, British Electrophoresis Society, British Grassland Society and the Institute of Horticulture (1998) *Genetically Modified Crops: The Social and Ethical Issues (A response to the Nuffield Council on Bioethics Consultation).* Institute of Biology: London.

Institute of Biology, Association of Applied Biologists, Association of Clinical Cytogeneticists, Association of Clinical Microbiologists, British Association for Cancer Research, British Association for Lung Research, British Association for Psychopharmacology, British Association for Tissue Banking, British Ecological Society, British Electrophoresis Society, British Grassland Society, British Phycological Society, British Society for Animal Science, British Society for Immunology, Freshwater Biological Association, Institute of Horticulture, Institute of Trichologists, Marine Biological Association, Nutrition Society, Scottish Association for Marine Science, and the Society for the Study of Fertility (1999) *Government's Expenditure on Research and Development: Forward Look* 1999 *– A consultation response to the House of Commons Select Committee for Science & Technology*. Institute of Biology: London.

House of Commons Select Committee on Science and Technology (2000) *Government Expenditure on Research and Development: The Forward Look*. Stationery Office: London and Norwich.

Genetically Modified Organisms and the Environment

A response to the consultation from the Environmental Audit Committee of the House of Commons

April 1999

1. The Institute of Biology is the independent body charged by Royal Charter to represent UK biologists and biology. It is pleased to be able to respond to the above consultation but regrets that, due to the time limitation, it has not been able to provide additional detail.

[The consultation's questions are in bold]

Is there a need to develop a strategy for assessing and managing the environmental implications of the release of GMOs?

2. Recent developments and interpretation of the existing assessment mechanisms suggest that it would be prudent to strategically review the existing arrangements.

Should this strategy include the formal assessment of the environmental benefits of GMOs along with their risks?

3. It should. Each release of a different type of modified organism has its specific risks and benefits.

If so, does the Government have adequate mechanisms for developing such a strategy in terms of:

a) the co-ordination of existing policy and regulation?

4. The core components are in place but an interdepartmental consultation would facilitate co-ordination.

b) oversight of, and influence over, the direction of the development of GMOs?

5. While much is being done by the Research Councils and the UK Science Base, equally much GMO development is being undertaken independently in the Private Sector and overseas. The UK Government therefore has limits to its influence on the development of GMOs.

c) the assessment of direct and indirect risks, including the cumulative impact of GMO releases over time?

6. Government funded work in this area has only recently begun. While some GMOs (particularly those with no relative wild species within the UK) pose little risk, potential ecological risks may be associated with others. It may take a few years before we can begin to ascertain which of the higher risk of modified organisms may be released with safety and which classes pose higher risks, for which further research will be required before their low-risk release can be assured.

d) the contribution that GMOs might make to more sustainable agriculture?

7. The scope of the full benefits of this technology has yet to be practically appreciated. In theory there is still considerable benefit to be achieved.

What mechanisms exist, or are needed, for incorporating public values and concerns regarding the environmental implications of GMOs, alongside the results of scientific assessment, within the decision-making process?

8. This is not a biological question. Nonetheless we consider it preferable that policy mechanisms should be publicly transparent so as to assure public confidence.

What is feasible and desirable in terms of preserving consumer choice by segregation and labelling – particularly the issue of the 'labelling for process' to provide for consumer influence over the use of GMOs and their environmental implications?

9. While there is great public desire for there to be clear labelling as to the presence or not of GM material in the individual consumer's food chain this cannot always be guaranteed.

   a) because the genetic modification may not be expressed in the final product (eg: oil from soya) hence may not be detectable

   b) because the expression of the genetic modification may be within naturally occurring limits and therefore may not be detectable

   c) because the modified organism might have been used earlier in the food chain (for example non-modified cattle being fed modified grain) and hence may not be detectable.

10. If labelling were to become mandatory it may be advisable to have more than one class of label to take into account such limitations. The consumer could then decide on the risk.

11. It is not clear how environmental concerns could be incorporated into anticipated labelling legislation.

Genetically Modified Crops: The Social and Ethical Issues

A response to the Nuffield Council on Bioethics Consultation from the Institute of Biology, the Association of Applied Biology, the British Crop Protection Council, the British Ecological Society, the British Electrophoresis Society, the British Grassland Society, and the Institute of Horticulture

August 1998

1. The Institute of Biology, as the independent charitable body charged by Royal Charter to represent UK biologists and biology, is pleased to respond together with its following specialist Affiliated Societies: **the Association of Applied Biology, the British Crop Protection Council, the British Ecological Society,[‡] the British Electrophoresis Society, the British Grassland Society and the Institute of Horticulture.** The Institute of Biology with its 16,500 members and 75 Affiliated Societies is well placed to consider life science consultations. In this instance, in addition to the aforementioned specialist societies, representatives from a number of the other Affiliates have provided comment on an informal (unattributable) basis.

Summary

2. This response does not represent official policy. It has been compiled to inform discussion and debate. Principally we note and consider:
   - i. that Genetically Modified (GM) crops can greatly contribute to human well-being
   - ii. that there are human health, environmental safety and propriety concerns
   - iii. that, with the proper regulatory regimen enforced, benefits are likely to greatly outstrip concerns so that ethically there should be effort to realise benefits
   - iv. that there should be complete transparency as to the presence of GM foods in the human food chain
   - v. that it is not unethical to favour some crop genes *per se* compared to others but there are, for some, ethical concerns as to the size of the species gap across which genes are transferred
   - vi. continued GM research is required to maximise benefit and minimise risk.

Status of this response

Is that of an informed discussion document rather than an affirmed policy statement

3. We recognise that: *a*) ethical criteria are derived culturally and not empirically; *b*) consequently ethical criteria are apt to change with time and circumstance; and *c*) controversial issues themselves engender a spectrum of views, even within a comparatively informed and homogeneous sub-section of the population such as the UK life science community. Nonetheless, despite the amorphous nature of many GMO ethical issues, the existence of controversy raising many social questions makes it important that the biological community (independent of the bio-industries, pressure groups, and Government) makes a contribution, albeit short of a formal policy statement. This response should therefore be seen as an informed contribution to current discussion.

[‡] In addition to contributing to this common discussion perspective, the British Ecological Society is pleased to make a number of additional points independently in its own response to the Nuffield Council.

Consideration of 'ethics'

We consider the human well-being, and the integrity of the natural environment ethical dimensions, not religion

4. This response's consideration of the term 'ethics' is in the main (but not exclusively) made with regard to safety -- human well-being and the integrity of the natural environment -- and propriety matters. We note that human well-being is also related to environmental integrity *via* the now commonly accepted definition of environmental sustainability -- that of the ability of the environment and its resources to sustain subsequent generations. However, unlike the dictionary definition of 'ethics', we make no reference to any religious dimension.

General points

GM Crops can greatly contribute to human well-being (which it would be unethical to ignore), and while there are risks we are confident that these can be minimised

5. We are certain that the potential for Genetically Modified (GM) Crops to contribute to the World's food supply is considerable; indeed, such contributions are already being added. While much of the current food shortages are due to distribution and other social phenomena, it has become recognised that the global population will face (given current circumstances and existing trends (see Annex 1)) food shortages arising out of demographics (principally a nine to eleven billion population in the mid-21st century, a few decades away).[1,2,3] Consequently, in terms of human well-being, it would be *unethical* not to explore the possibility of realising such contributions. However, it is equally realised that there is the potential for Genetically Modified Crops to undermine human well-being both ecologically (through gene transference to other species and subsequent ecological degradation) and biomedically (principally toxicologically and through immunoreaction). Nonetheless, we are confident that it is possible to reduce risks considerably to a point where there is probably less environmental risk than already exists associated with a number of current human activities (including certain agricultural practices). We consider that the current ethical debate (of which the Nuffield Council's current consultation is a part) is integral to the overall process by which GMO crop risks are lowered and their benefits maximised.

There have been no GMO disasters to date

6. While not a cause for complacency (especially considering the embryonic nature of GM science), it is encouraging that there have been no GMO disasters to date. Given this, together with the potential for GM crops to greatly contribute to human food supply, it underlines the ethical dimension of actively exploring this potential contribution to alleviate (future) hunger; especially since food shortages are anticipated in the next century. If there had been GMO disasters then this ethical argument would be, at least partially, undermined.

Specific points
[(Qn.) *Questions in bold italics relate to those posed by the Nuffield Council*]

Q1. ***Do GM crops and food pose ethical questions about what is acceptable with regard to the manipulation of nature? If so what are the key ethical questions from your perspective?***

Yes, but opinion is divided as to the nature and extent of these ethical questions

7. From a biological perspective there are two broad categories of ethical issues (see paragraph 4 above). First safety. In terms of risk there are health and safety concerns associated with the use of GMOs and there are also environmental

concerns. Both these have clear links to human well-being. Secondly, there are propriety concerns. These too are related to human well-being (albeit primarily through the economic and indirectly through the ecological, system). The question here is who owns, and hence has a right to the profits arising from, GMOs and/or their modified genes? There are, as yet, unresolved tensions here and opinion is divided. On the one hand, companies developing GMOs need to have their research costs recouped. On the other less-developed nations, whose species' genes may be used, require value to be realised on their native genetic biodiversity if the said biodiversity is to be conserved for the global good even if the cost has to be met globally rather than locally.

Human health and safety concerns are primarily immunological and toxicological

8. The health and safety issues are largely immunological and toxicological in nature. Immunological because individuals sensitive to a protein eating a crop not normally associated with the said protein but modified to manufacture it, would have an adverse immunological reaction. Peanut protein is the oft quoted example.

Bridging evolution-determined genetic gaps

9. Environmental integrity concerns will result if GMOs bridge evolution-determined genetic gaps. These have the potential for disrupting complex long-established, evolution and ethnobiologically-determined interactions (for example, local land-management systems). It is not known how well ecosystems are buffered against the effects of gap-bridging phenomena, so the risks associated with GMOs are difficult to assess. Indeed, given the complexity of ecological processes, the GMO-mediated bridges may well be chaotic and so for all practical purposes (given that it is unlikely that all attractors will be properly identified) will be unpredictable. Given that this is an unknown, we can come to no firm conclusions regarding risks at this stage.

Genetic manipulation of crops per se *is no more or less ethical than breeding*

10. Aside from the safety and economic issues discussed above, it should be noted that genetic manipulation of crops *per se* is no more or less ethical than conventional breeding programmes. At the heart of genetically modifying organisms is the concept of manipulating genes. Notwithstanding the result (whether or not it bridges genetic gaps, or its ecological and economic consequences), the idea of favouring some genes at the possible expense of others is no more or less ethical than a programme of breeding: for that is exactly what breeding programmes do. If one were to argue that the manipulation of genes by itself was unethical then the domestication of dogs from wolves, or high-yield wheat strains from wild-type grasses, *etc*., would be equally unethical. This would ethically undermine the applied biological foundations on which our global society depends, and on which humanity has relied for thousands of years.

There are non-science based, public concerns relating to ethics of the degree of genetic manipulation (as opposed to manipulation itself)

11. We note here that genetic gap-bridging manipulation does have a non-biological and non-safety ethical concern for some of the public. *i.e.* there are, we believe, common public concerns not so much with the genetic manipulation itself (even if that is how the concern is erroneously expressed) but the 'degree' of manipulation. Transferring genes from animals to plants is viewed by some as less ethical than, say, transferring genes between plant species. The closer related the species between which genes are transferred, the closer GM techniques come to those of 'normal' (non-GM) breeding, and the less ethically controversial they become. Where an individual (or society collectively) draws the line between what is ethical

and what is not, is made on a variety of criteria that are in the main unrelated to science. Furthermore, the decision arrived at is variable, both between individuals and collectively with time. There is no single 'right' answer. This does not make such line-drawing any more or less valid on a social basis, but it is not an exercise scientists can undertake on behalf of society (other than for themselves as individual members of the public in their own right). However, what the scientific community can do is to inform society of the scientific dimensions. Equipped with current scientific knowledge, individuals and society can make their decisions on an informed basis including (importantly) that of current scientific uncertainties.

Q2. ***What are the principles by which we should control the development and application of GM crops? Do present regulatory systems reflect these principles.***

European development controls are largely based on the precautionary principle and are theoretically satisfactory, controls on applications have theoretical flaws only (these have not yet been manifested to our knowledge)

12. Given the above (paragraphs 7-11) the question that arises is whether our current practice of manipulating genes in the laboratory does undermine the safety derived from existing genetic gaps, and whether 'present regulatory systems' adequately control biomedical risk when GM crops are consumed? Taking as read that all human activity has risk associated with it and that we live with risk all the time,[4] do the present regulatory systems 'safely'[*] control *a)* the development, and *b)* the application of GM crops *via* well-regulated testing, licensing, and approval protocols? Here the present UK and EU 'development' controls, which are largely founded on the precautionary principle, are in theory pragmatically sound. Indeed, to date as we understand that there have been some 10,000 trials of GM plants (some 2,300 in OECD nations) with no GM-related ecological impact of consequence, it is therefore difficult to ascertain grounds for meaningful concern. However, this history is short and GM releases few compared with the number to be expected should the technology become widely used. Nonetheless, with regards to the 'application' of GM crops (*i.e.* their consumption), current UK and EU controls do not fully employ the precautionary principle in that not all GMO containing foods have to be labelled. It is possible to envisage some (as-yet-undeveloped) GM crop causing illness for susceptible individuals when consumed despite current EU controls. This is a theoretical flaw and not one that has yet caused harm. Any such harm would not be in the food industry's medium-term interest and may not be deliberate. [Interestingly, there are signs in the UK of increased voluntary labelling beyond that required by EU regulations. In May 1998, the Consumer Association[5] welcomed major UK supermarket chains labelling all GM foods including those where (due to mixing with non-GM stock early in the processing and supply chain) there was doubt as to the presence of GM material or not (see paragraph 13) -- for instance, soya.]

An example of a theoretical risk despite current EU controls

13. For illustrative purposes we present a purely theoretical example of harm that could arise despite current controls. A small proportion of the population is allergic to a particular peanut protein and so cannot eat peanuts without having a severe allergic reaction (which in some cases, if untreated, can be life-threatening). These people know who they are. They avoid peanuts and, as far as possible, avoid foods that may contain peanuts. On a pragmatic day-to-day basis they know that they are at

[*] Here we consider 'safely' as control ensuring that there is no significant risk of 'significant' harm? 'Significant' we consider as the degree of likely potential to permanently affect the genetic make up of wild species on a regional basis beyond that due to existing (non-GM) agricultural practices, or to cause biomedical illness beyond that due to existing (non-GM) food consumption.

risk, and while it may be that they accidentally eat a (normal) dish containing the protein, for them to ingest the protein unknowingly means that it is in all likelihood a trace ingredient and the reaction would be probably (though not necessarily always) noticed in time for medication to be taken. However, if a crop was genetically modified to express this gene then the 'loopholes' in current EU legislation mean that the foodstuff sold need not be labelled, hence consumers at risk not alerted. The loopholes in question exist in the EU Novel Foods Regulation (of May, 1997). The regulation recognises that in some instances it i not possible to segregate (hence label)some GM and non-GM foods. Here the oft quoted example is imported US soya, where GM and non-GM soya is mixed so early in the refining-*cum*-distribution chain that it is not possible to distinguish between the two at the point of entry to the EU (let alone at the point of sale to the consumer). However, importantly such types of risk are known to the European food industry and it is most unlikely that they would knowingly expose their consumers to such a risk, as it would not be in their interest. (See also paragraph 12.)

We support current EU proposals for all *GM (and GM/non-GM mix) foods to have distinct labelling*

14. Current EU proposals are for *all* GM foods to have distinctive labelling even if there is uncertainty, and that this is based on the precautionary principle. We are most supportive of this proposal which is championed by the Consumers' Association. This support is not borne out of any meaningful biological risk (as in the main we believe that the current GM regulations together with current EU practice provide ample consumer safety). It is due to the need to reduce possible public fears through ensuring that there is transparency and consumer choice. We are firmly of the view that the consumer must be fully informed as to what it is s/he is buying. Ensuring that there is public confidence in the food supply system is vital. (It is relevant to note that food scares (as exemplified by the BSE crisis) can result in food wastage which is unethical in a world with hunger.)

Though regulatory systems reflect principle, lack of adherence needs to be monitored and penalties given

15. While the EU regulatory systems do reflect the precautionary principle and so far the growing of GM crops has not resulted in any ecological disaster, any system's merits are only valid if the system is adhered to. It is with regret that we note that in April (1998) some companies breached the terms of their consent to release, resulting in the Advisory Committee on Releases to the Environment (ACRE) deeming it necessary to 'name and shame' companies. If we consider it important that we do not turn our back on the opportunities GM crops can bring, it is equally important that the public has confidence in GM crops and research and that good companies are not penalised because of a few incidents resulting in poor PR. While we regret that 'naming and shaming' had to take place, we recognise the need for ACRE's action. The regulatory systems must be transparent and be seen to work through effective penalties.

Imports currently can circumvent the regulations which themselves provide no guarantees

16. There is currently a lacuna in regard to tracking GM *versus* non-GM agricultural products traded on the World market (*cf*. paragraph 12, soya). Furthermore, GM-plants may be imported accidentally. For instance, GM-tomato seeds may be imported in the guts of air travellers. They will survive passage through a human and may subsequently germinate. It is therefore difficult to conceive of regulations, no matter how tight, providing complete guarantees of eliminating unknown GM imports.

There is an urgent need for a holistic strategy to combat the growth in antibiotic, insecticide, fungicide and herbicide resistance

17. Antibiotic, insecticide, fungicide and herbicide resistance are increasing problems. For instance, whereas in 1950 there were less than 20 species of arthropod (mainly insects) resistant to one or more chemical pesticide, by the late 1980s this number had increased by over 21 fold to over 420. Over the same time, the number of resistant strains of plant pathogen had increased from under 10 to over 50, and weeds from none to about 50.[2] The use of 'resistance' genes in GMOs is therefore of legitimate concern. The Institute of Biology has in the past called for there to be a holistic strategy to address the question of resistance in its various forms across both the agricultural and biomedical sectors.[6] (These different forms of resistance have at their base a similar Darwinian mechanism.) This concern has recently been noted by the House of Lords[7] despite their original consultation document stipulating that, since the Nuffield Council would be undertaking this consultation on GM crops, their Lordships' enquiry would have a narrower focus.

Q3. ***Is there an ethical obligation to ensure that non-GM foods continue to be available and distinguishable from GM foods?***

Depending on the modifications, not necessarily. But overall on humanistic ethical grounds, there must be choice and labelling.

18. From a purely biological perspective it all depends on how the GM-foods were modified. Biomedically, if the foods were modified to express proteins likely to cause allergies then safety would be compromised and choice would need to be retained. Similarly, if the modification enabled crops to be sprayed with herbicides, then environmental integrity might be compromised, so again choice arguably should be available for the concerned consumer. On the other hand, if crops were modified so as to survive on marginal land, or were enhanced nutritionally without human risk, then there would be little 'biological' reason to object to a lack of choice. Similarly, if the modification enabled their to be out-of-season crops, it might not be practically possible to provide a non-modified option. Nonetheless, we are in favour of consumer choice being retained where possible on humanistic ethical grounds. Clear GM labelling should be mandatory. [However, we note that less developed nations may not be able to afford the luxury of choice and that this raises social (non-biological) ethical questions.]

Q4. ***How can consumer choice be adequately protected****?*

Through regulation as required

19. The consumer may be adequately protected through periodic review and the introduction of regulation as required. (Though, to be consistent, one can equally argue that the choice should also be preserved in favour of consumer access to GM-crops should GM-techniques lead to a lowering of price, or confer other consumer benefits such as out-of-season crops.)

Q 5. ***How should we handle uncertainty that exists in making predictions about the long-term environmental impact of [GM] crops?***

Despite uncertainty, GM risks need to be accepted and GM research continued. Avoiding risk through turning our back on the potential benefits to be realised from GM technology will lead to other (non-GM) environmental impacts

20. Uncertainty is by its very nature unquantifiable, yet it is possible to ascertain the need to take risks by looking at the certainties. Given that we are confident that

the human population will nearly double by the mid-21st century,[3] it is extremely probable (*i.e.* almost certain) that agricultural systems will be stretched to the point of being incapable of meeting demands in the same way as demands are met today. Furthermore, we consider that this situation is likely to be exacerbated due to land-use competition for biofuels. It is therefore imperative that we look for new ways of improving production (over all output) and productivity (efficiency *per* unit area). It is therefore important that we continue to research into GM crops and explore the ecological risks rather than do nothing. Even though doing nothing will incur no GM-ecological risk, it will incur the considerable environmental impact costs associated with hunger.

There are a number of potential ecological impacts to consider

21. The ecological impacts that may arise through bridging genetic gaps (see paragraph 9) principally include those arising through the possible hybridization with wild relatives of the GM crop. These can impact in a number of ways:
    - by the creation of 'super weeds', which can be further complicated through 'stacking' whereby a wild strain receives more than one transgenic gene from more than one GM-crop strain growing nearby
    - by genetic erosion (particularly vulnerable are high genetic biodiversity regions (where many strains of the same species may co-exist))
    - through 'genetic pollution' of the natural gene pool.

Use of the precautionary principle combined with incremental release

22. We consider the preferred way to handle GM-ecological uncertainty is to adopt the precautionary principle engaging in indoor-laboratory trials first, and going through a number of trials, gradually moving toward unrestricted outdoor release only once the previous (more restricted and confined) trials have proven satisfactory.

Continued GM research is *actively reducing risk (example given)*

23. While engaging in research and developing GM crops does have associated, but uncertain risks, researchers are actively seeking ways of reducing this risk. This route is not fruitless. One recent (1998) development[8] is that of inserting the modified gene into chloroplast and not the nuclear DNA. As pollen DNA only comes from the nucleus (pollen does not contain chloroplasts), it is possible to remove the risk of pollen transmitting GM-material. Maternal transmission of GM material would be more restricted (far more particles of pollen are produced compared to seeds, and pollen is also far more mobile).

Use of terminator technology (2nd example) but this has other (non-ecological) ethical drawbacks

24. Risk can also be reduced through the use of 'terminator technology': genes that are expressed in embryos at a very late stage in development allowing crops to develop normally, but killing them at maturation so effectively making the harvested seed sterile. This modification helps ensure that there *should be* no offspring crops (in fact, though the risk is reduced, it is not eliminated). However, there are other (non-ecological) ethical difficulties with this. Such genetic manipulation effectively puts the company owning the GM crop in a very powerful position. This could potentially stifle competition and operate against the common good interests of crop producers and consumers.

Through independent (publicly funded) research -- UK SET funding must be restored

25. While all research is welcome, special regard should be given to independent (hence publicly funded) research, as this should be seen to be independent from commercial and political pressures. This is just one reason that it is important that real-term UK Science SET funding is restored.

Q. 6. Do people wish to be more involved in decision-making about the application of the technology? If so how can this be achieved?

Probably some do. The OST's instigation of a bioscience public debate is particularly welcome

26. Opinion varies. Some probably do. Including lay members on safety boards is one way. The current OST proposal for a public consultation on developments in the biosciences is welcome.

Q. 7. *What benefits do you think that this technology might have in developing countries? Under what conditions could these benefits be realised?*

Benefits could be potentially very considerable

27. We are confident that the potential benefits to developing countries could be considerable and possibly on the order of the first green revolution (which capitalised on the use of artificial fertilisers combined with the introduction of selected crop cultivars). Benefits from GM crops could include:
    - reducing pressure on land due to agriculture becoming more concentrated so freeing land for non-agricultural use, or reducing the pressure to encroach on non-agricultural land
    - reducing the need for agrochemicals
    - manipulating crops so that they are better suited for their end-use.
    - developing drought and salt-resistant crops
    - improving crops' nutritional values
    - developing pathogen-resistant crops (though this has some risk attached to it)
    - creating less perishable crops.

But companies need to see a return on their GM R&D investment, while farmers in developing countries require financial protection

28. Companies developing GM-crops will naturally want a return on their substantial R&D investment. This might effectively place GM crops out of financial reach of farmers in developing countries unless the receive loans from western institutions, or alternatively make GM crops available through multinationals. Mechanisms need to be devised whereby both farmers in developing countries have their livelihood protected while companies developing GM crops receive a fair return on their up-front R&D investment.

Q. 8. *What are the responsibilities of companies with regard to the development and commercialization of GM crops?*

GM crops should uniquely meet proven socio-economic needs safely.

29. Companies should ensure that GM crop species meet proven socio-economic needs that cannot be met by non-GM agriculture, and that this is done safely *and* with full adherence to international regulation.

In addition to earlier concerns, traditional productive sustainable farming practices may be threatened: a regulatory framework to which GM companies should adhere is required to take into account this bio-social dimension

30. There is a danger that companies will displace traditional productive sustainable farming practices, and this may have a significant ethnobotanical and/or biodiversity cost. It is debatable whether companies should have immediate regard for such considerations, unlike the concerns for environmental and biomedical safety cited above. However, companies must operate within a regulatory framework and have due regard for any regulatory protocols established, and be responsible for adhering to them. Such regulation might have regard to these bio-social dimensions. Adherence, though, will need to be independently monitored. Transparency, to engender public confidence, is required, while companies need 'a level playing field' on which to compete fairly.

Monopolistic and environmentally damaging practices need to be avoided

31. The are concerns that companies might be tempted to market GM crops of little net agricultural benefit and/or GM crop packages (GM unique herbicide-resistant crops sold together with the relevant herbicide). Farmers might become attached to such marketing packages which are, in effect, monopolistic and possibly environmentally damaging depending on the quantity of herbicide required for the crop's management regimen, and the ecotoxicological nature of the herbicide itself. Cause for such concerns would be negated through adherence to sound regulatory protocols.

International funding of a base level scheme may protect developing nations

32. The problem of developing nations not being able to afford satisfactory monitoring of GM protocols needs to be addressed. It may be that a base level scheme (which would not prevent individual countries from having more stringent measures) would need to be established and run on an internationally funded basis.

Q. 9. ***What is the ethical acceptability of patents associated with novel GM crops?***

GM crops may be patented, not individual genes

33. We strongly believe that firms that develop GM-crops have the right to recoup their development costs, and that patents and intellectual property rights are ways that could secure such returns. We are less certain as to the exact detail of how this might be done. We tend towards the view that while modified crops should be patentable individual genes by themselves should not.

There may be possible merit in associating propriety genetic rights with principal natural plant communities

34. While individual genes should not be patentable there is an argument that the inherent value of regional biodiversity is fundamentally genetic. Consequently genes from plants from an identifiable area lend value to the (strain of) local species as a whole. There is therefore a logical argument that propriety genetic rights are associated with a plant community (even if the genes themselves are not patentable by those merely transferring them between species). Such royalties could lend value to the preservation of local biodiversity.

Further information

The Institute and learned societies involved in this response are pleased to have contributed to this Nuffield Council on Bioethics consultation. We look forward to receiving any documentation arising out of this exercise. We are pleased for this response to be publicly available and will be placing it on the Worldwide Web. For further information regarding the Institute's consultations and its Affiliated Learned Societies, individuals may refer to *http://www.iob.org* Learned institutions, governmental bodies and agencies who wish the Institute to engage in consultations should, in the first instance, contact Jonathan Cowie (Science Policy) or Anne Jordan (Education) at the Institute of Biology, 20-22 Queensberry Place, London, SW7 2DZ.

References and Notes

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Annex 1

Indicators of the forthcoming demographic shortfall in future Global food supply

- Globally some 40% of terrestrial primary productivity (the biomass produced through photosynthesis) is affected by systems managed by Man.[†]

- World food grain production has been very broadly stable since the late 1980s (1,600-1,780 million tonnes *p.a.*). Against a backdrop of rising global population this means that since 1984 to 1995 *per capita* production has fallen from 346 kg to ~293 kg.

- World meat production has maintained a steady increase throughout the second half of this century from 44 million tonnes *p.a.* in 1950 to ~192 million tonnes in 1995, such an increase that *per capita* consumption has also grown over the same period from 17.2 kg to 33.4 kg *p.a.*

- though the World fish harvest continues to rise, this is due to the rise in aquaculture (fish farming), the total fish catch from the sea has declined from its peak in 1990.

- the World's carry-over stocks of grain have declined**:** and in 1995, at 296 million tonnes, stocks were at their lowest since the early 1970s. In terms of days of grain, carry-over stock was the lowest level since the mid-1960s. The forecast level for 1996 is to be lower still at around 50 days worth of stock.

- the World grain harvested area has had a slightly declining trend since the late 1970s. Putting this in context with a growing World population then the World grain harvested area *per* person has markedly declined from ~0·225 hectares *per* person in the mid-1950s to under 0·13 hectares *per* person in 1994. Whilst some of this decline is due to set-aside policies, the majority of it is due to a combination of the industrialization of land use (particularly in Pacific rim countries) and desertification. Set-aside land could be brought back into production but, for instance, the total area of corn set aside in the US (1995) is only 2 million hectares (less than 0·4% of the World total grain farmland). [In short, set-aside land provides a negligible cushion.]

Reproduced from: IoB (1996) *Agriculture and biodiversity: A consultation response to the Government Panel on Sustainable Development from the Institute of Biology (with comments from the British Society for Soil Science and Freshwater Biological Association).* Institute of Biology: London. The full text is on **www.iob.org**

[†] This is not to say that 40% of terrestrial primary productivity is managed, directly or indirectly by human kind, but that this productivity takes place *within* systems managed by humankind. In other words, we are not just talking about the food eaten by humans, or even this together with the food produced as animal fodder which is in turn consumed by humankind, but all the biological productivity that exists in farms, parks, moorland, woodland, lakes and boreal forests that are managed by our species to some degree or other.