Public perceptions of Industrial Biotechnology

A report prepared for the Department for Business Enterprise and Regulatory Reform (BERR) and Sciencewise

February 2009

Overview

About this research

Between October and November 2008, Opinion Leader conducted research to explore public perceptions of Industrial Biotechnology[1] (IB). The research was qualitative and exploratory in nature, and sought to understand what 'excites' and 'worries' people about this emergent technology in a variety of its applications. As one part of this it explored perceptions of genetic modification (GM) – both in terms of genetically modified crops used as feedstocks and genetically modified organisms (GMOs) used in IB processes. Findings from the research will contribute to the Industrial Biotechnology Industrial Growth Team (IB-IGT) report containing a series of recommendations and an action plan for the sector to 2020 expected in Spring 2009.

Main findings

It is well documented that the public find science and technology confusing. A report on Public Attitudes to Science prepared for Research Councils UK and the Department for Innovation, Universities and Skills[2] has shown that over half of the population believe that 'science and technology is too specialised to understand'. Our research also demonstrates that there is little thought about the processes behind the products in people's everyday lives and very little awareness of biotechnology. For most, the science behind biotechnology is a complete unknown and for this reason can appear intimidating, in some cases even sinister.

Drivers of public perceptions

- Public perceptions of IB are informed by a variety of attitudinal and contextual factors. These primarily include: concern about the economic climate, concern about climate change, levels of understanding (and misinformation) about science and technology; and levels of trust in Government and in industry.
- Those taking part in this research often struggled to focus on IB per se. Its use in a variety of contexts raised a wide variety of questions, not least of which was about 'our way of life' generally. Participants' first and preferred response to the challenges we face was to re-evaluate modern life, before embarking on anything new. For example refining existing processes to make them more efficient. However, there was also some resistance to new ways of doing things, seen to often present new issues, illustrating a contradiction in public reaction to new developments.

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[1] Europabio define industrial biotechnology as the application of biotechnology for the processing and production of enzymes, chemicals, materials and bioenergy. .Biotechnology is a broad term, referring to the modifying of biological organisms to improve their industrial usefulness http://www.europabio.org/Industrial_biotech/index.htm

[2] Public Attitudes to Science 2008: A Guide. Report prepared for Research Councils UK and the Department for Innovation, Universities and Skills by People Science and Policy Ltd/TNS March 2008

- The economic downturn has given rise to an appetite for technologies that are efficient, produce less waste and that can even use waste to produce something useful, such as fuel. However, at the same time, people are concerned about cost and seek reassurances that the use of IB will not mean higher prices for the consumer.
- Compounding this uncertainty and 'fear of the unknown', is a pervading mistrust of government and industry who are not felt to be working in the public interest. 'Profit' or anything associated with industry are viewed with great suspicion and there is little faith that the Government will effectively resource the control and monitor industry.
- While suspicious of 'Government', people are supportive of 'the national interest'. People are particularly protective of the UK's position in relation to global economies and interests; keen that we get our 'fair share' by gaining economically from developing IB whilst not making disproportionate efforts (to other countries) in areas such as reducing carbon emissions.

In order to fully comprehend all of these wide and often interlinking issues, the main desire is to see the bigger picture at all points, to make comparisons and acknowledge alternatives in order to place every issue within its context.

What worries the public about IB?

- Those taking part had a number of issues and concerns with IB, both in the overall sense and with regards to specific examples of it (such as bioplastics and biorefineries).
- However, following dialogue with a range of scientists, many of these issues were addressed and no longer presented significant concerns.
- The main concern running through deliberations on the different aspects and applications of IB was the use of GM in any application. This was also the 'scientific story' most on their radar after exposure in the press in recent years. As many understood more about the science of GM their concerns where more specifically focussed on genetic modification of crops as used in feedstocks, rather than GMOs being used in IB processes.
- Of key concern was the natural/unnatural dichotomy which many taking part struggled to reconcile. For some, the issue was one of principle; is GM right? But for others of greater concern was how GM crops and GMOs can be contained and, if it was not, what the implications are for people, the environment and ecosystems.
- There are questions surrounding just how 'green' IB really is. Participants in the research sought to understand the balance and scale of its impact not just on climate change but also on the physical environment and ecosystems.
- Perhaps unsurprisingly, people were concerned to know how the growth of this new technology and economy might impact on their lives. There was concern and confusion about cost, with many misunderstanding the role the consumer would play in driving demand and prices. Some also questioned the relative quality of IB products against products made via conventional processes.

- Further concerns emerged around how the development of IB would actually be achieved on a realistic and workable scale both in the UK and globally; with many anticipating that the challenge in converting to a bio-economy would be significant, requiring global and political co-operation.

What excites people?

- There was limited awareness about the availability of fossil fuels. Once informed about known fossil fuel reserves, many of those taking part expressed high levels of concern about both the availability of and reliance on these reserves for fuel and other products. Given this, there was a desire to seek alternatives to fossil fuels and to find these alternatives quickly.
- IB is perceived as potentially offering "hope" to some of the key challenges the world faces, provided the implications are properly managed and IB is adopted on a larger scale.
- There is a great deal of enthusiasm for the idea of Britain as leaders in new science and technology fields which appeals to people's sense of national pride.
- Related to this is an interest in what IB developments in the UK might mean for regional labour markets and 'British' jobs.
- Processes which are efficient, produce little or no waste and use sustainable or renewable feedstocks are very much welcomed. This is particularly powerful in the context of an economic downturn and climate change, which together, have led some to question 'our way of life' (the amount we consume, waste etc)
- There was particular excitement around medical advancements which could bring many benefits 'for the greater good' as well as potentially impacting on people's everyday lives and needs.

Lessons for communications and policy

Overall

- First of all, there are issues around the term itself, with connotations of things very removed from people's everyday lives – industry, science and technology – making people 'switch off' before even knowing what IB is.
- Furthermore, IB is a broad area covering many different applications, making it difficult to grasp. The link between the different elements of IB is not intuitive to the lay public and is often not helpful, causing confusion about where and how they overlap. For example, GM is a feature in some but not all IB applications.
- A lack of understanding about market forces, global economics and the public's role as consumers leads to confusion about IB's role and impact in their lives. Specifically, the drive to make a profit was seen to be irreconcilable with an environmental agenda.
- There is a desire for a solution to the challenges of climate change and depletion of fossil fuels that would present no issues and give no rise to concern; people are less keen for 'difficult' or complicated solutions. There is a tendency in the first instance to reject IB on the basis that it presents issues and implications which need consideration and regulation. People are more able to

make an informed choice if they are in possession of the full arguments and can see why decisions are necessarily difficult.

- Initial reactions to some aspects of IB are very negative, and people are not ready to trust new developments easily. The exception to this was medical applications as the personal benefits were more immediately obvious. In general, it takes a long time to challenge popular perceptions and it is only after substantial time with scientists that public opinion can change.

Key barriers

- The main barrier to public acceptance of IB is fear of the unknown, based on a limited knowledge of science in general and a fundamental lack of understanding of IB specifically.
- This vacuum of information is currently being filled with stories about the more controversial developments, namely GM and biofuels, thus creating immediate emotive associations which will need to be overcome.
- There are some very complicated messages to communicate around IB in order to gain public understanding and potentially acceptance.
- Furthermore, there are elements of IB that the public find worrying, even with greater understanding. Namely GM crops, cost, quality and land use in developing countries.
- Negative messages in the public domain about these issues could have a dramatic impact on public acceptance. People are keen to hear what green groups, such as Greenpeace and Friends of the Earth, think about these emergent technologies. Indeed, the views of these organisations, and others independent of government and industry, such as think tanks, are largely perceived as credible sources. An opposing view from these organisations is likely to be given weight by the public.

Key opportunities

- Despite low awareness levels, the public have the potential to become enthused about scientific developments.
- The overriding need is for a greater level of factual information; to dispel myths and to address misinformation.
- Factual information is compelling and can change views. Some areas of information about IB in particular have a considerable impact. These are:
  - Knowing the 'generational' story of IB: getting over the reticence about 'new' developments by demonstrating that it is not something new but is part of an evolution
  - Understanding the science behind IB processes: overcoming the fear of 'scary science' and in particular dispelling myths about GMOs
  - Knowledge of the alternatives; to put the concerns and benefits in context
  - Information about regulation: who, why and to what degree are different aspects of IB regulated? Giving the impression of an excess of regulation, to the extent where IB is so restricted it can barely happen in the UK, gives a signal that IB really is something to worry about. This was particularly in evidence, for example, in relation to information about the

restriction of GM crops in Europe. It begs the immediate question, if it wasn't so bad, why have they banned it? An apparent lack of or inconsistent regulation on a specific application prompts concerns about safety.

- Delivery of this information is crucial, with the equal potential to motivate or alienate. In order for this to be successfully received as 'factual' and understandable, delivery must be carefully considered and measured in terms of:
  - Relating IB to ordinary life: gaining buy-in and understanding via tangible examples, rather than alienating by talking about abstract scientific concepts
  - Providing the right amount and weight of information: achieving a style that presents nothing that is too overwhelming but equally not too nominal or condescending
- The source of the information is also important; using scientists, academics or 'expert' views help to demonstrate that information is balanced and informed. This may also help to tackle the wider image of scientists operating 'alone' and not communicating with the public. Equally, getting the help of non-governmental organisations (NGOs) would greatly aid communication of the issues.

1. Introduction

1.1 Background

In August 2008 BERR, in partnership with DIUS' Sciencewise Programme, commissioned a project to explore public perceptions of Industrial Biotechnology (IB) to contribute to the thinking of the Industrial Biotechnology Innovation and Growth Team (IB-IGT). The IB-IGT, which is facilitated by BERR's Bio-science and Chemicals Unit, aims to help address one of the major challenges facing today's society - limited resources of raw materials and energy. Furthermore, global warming is driving a move to a low carbon knowledge-based bio-economy and all the major facets of UK society and economic activity including the manufacturing industry are being challenged to demonstrate their sustainability.

Industrial Biotechnology is seen as a potential answer to these challenges. The European Union (EU) is leading a drive for transition to the bio-based economy in member states. The vision is that by 2025 increased use of IB will drive down reliance on fossil fuels for energy production and chemical and material production e.g. plastics, and will improve the efficiency and environmental sustainability of products produced by EU industries. This shift to a bio-based economy will also ensure that European industries are innovative and remain competitive in what is expected to be an increasingly challenging and technologically advanced marketplace.

The IB-IGT exists to facilitate the creation of a strategic view collectively from the chemical and bioscience industries on what the innovation and growth challenges are for their future competitiveness. It will identify the facilitators and barriers that will help or hinder the development of the full range of technologies and mechanisms required to capitalise on the opportunities IB presents. In spring 2009 the IB-IGT will produce a comprehensive report containing a series of recommendations and an action plan for the sector to 2021.

The IB-IGT identified that public opinion could be a key barrier to the adoption of some aspects of this technology as IB is both a relatively unknown technology and is connected with the wider debate around GM. The IB-IGT believes that in order for it to effectively influence government policy and develop meaningful communication strategies, it is key to have an evidence base, which includes an understanding and appreciation of the public's perspective of IB and its potential uses.

1.2 About this research

BERR commissioned Opinion Leader to carry out a public dialogue exercise to establish public views, aspirations and concerns regarding the use and potential development of IB. The results of this dialogue

are being considered alongside the views of other stakeholders and will help to inform recommendations made by the IB-IGT on future industrial biotechnology policy.

The research was not intended to deliver a verdict, or examine whether participants were 'for' or 'against' IB. Rather, it aimed to address a broad spectrum of questions, with the overarching aims being:

- To enable the IB-IGT to make better informed decisions on policy for the uptake of IB by the chemicals and chemicals-using sectors that take account of public views,
- To identify the key issues of importance for consumers to help with potential future communications exercises and public dialogues.

Questions the research aimed to answer included:

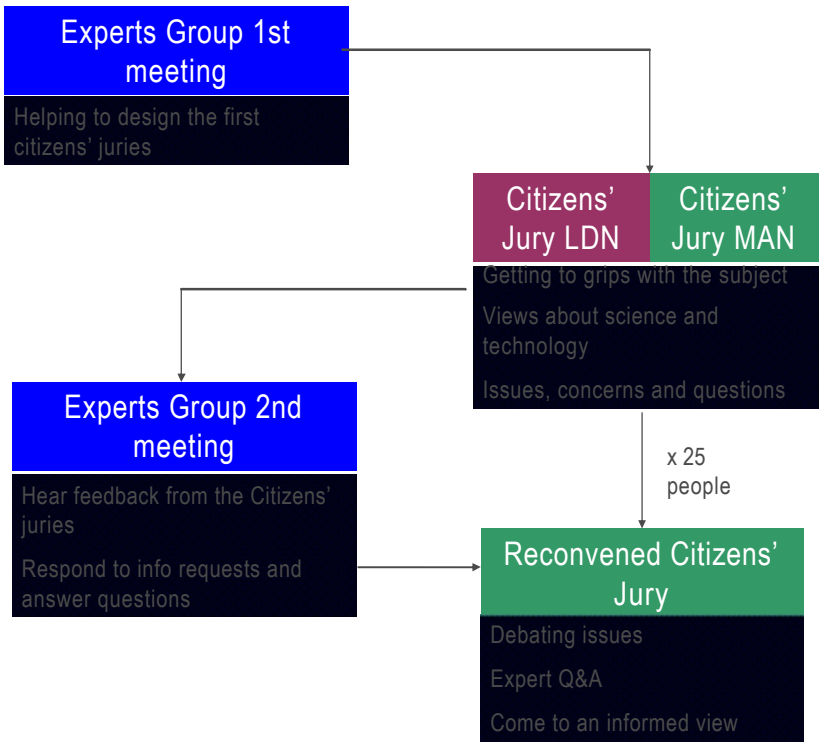
- How is IB perceived by the public? – is there any understanding of how IB (including using Genetically Modified Organisms (GMOs)) is used to the benefit of consumers and the environment and what are the concerns?
- What are people's opinions of renewable chemicals and the use of crops for chemicals as opposed to their use for bio-fuel, bio-energy and food?
- Public issues in relation to IB – what are the perceived risks, opportunities and concerns both about where IB may be applied and under what frameworks / conditions?
- Is there such a thing as a green consumer for 'biochemicals' and would consumers pay a price premium for this technology?

1.3 Approach

The research was qualitative in nature, using a Citizens' Jury approach. This Jury was convened in two stages, to consider and deliberate the subject of IB. A Citizen's Jury approach involves intensive discussions over a number of days using deliberative methods to stimulate in depth discussions. Essentially this means providing participants with the time and information to empower deliberation and informed debate.

The purpose of this Jury was to explore and identify the perceived concerns and areas of interest that arose amongst this group, as an indication of perceptions in the wider public. Given the complex nature of the subject and the need for a balanced approach, the Jury was supported by a Project Advisory Group (PAG), made up of stakeholders. Both met in two stages (see figure 1 below) enabling a dialogue between the two groups.

Figure 1: The structure of the research



The Project Advisory Group (PAG)

The Project Advisory Group (PAG) was intended to include key stakeholders in the industrial biotechnology field (including scientists, policy makers, industry and NGOs) and to achieve a balance of different perspectives. The group's main purpose was to contribute to the development of materials for the public and to respond to questions raised after the first Citizens' Jury. They played a key role in informing the deliberative discussions by inputting information sources and helping to develop accurate materials, suggesting speakers, and ensuring the public were exposed to a variety of view points on IB and its use.

A range of stakeholders from across different organisations were invited to take part to try and ensure a range of perspectives were represented. The reasons that stakeholders gave for not attending were various, but were mainly because of time commitments or because they felt they did not having a sufficiently developed view at this stage on Industrial Biotechnology. Key materials were made available for comment to all invitees. The table below is a record of invites and attendance.

Category	INVITED	ATTENDING PAG 1	ATTENDING PAG 2
BERR	Sue Armfield Richard Daniels Chris Barrell	Sue Armfield Richard Daniels Chris Barrell	Sue Armfield Richard Daniels
Sciencewise (on	Sarah Young Pippa Hyam	Sarah Young Pippa Hyam	Pippa Hyam

behalf of DIUS)			
IB-IGT Working Group members	Humber Chemical Focus Boots Akzo Nobel (formerly ICI) Unilever Warwick University Janet Bainbridge	Hilary Allan (Akzo Nobel) Guy Barker (Warwick University) Bob Crawford (Unilever)	Janet Bainbridge (IB-IGT)
Other Government bodies	BBSRC		Monica Winstanley (BBSRC)
NGO	Chemicals Watch Genewatch National Consumer Council Friends of the Earth Greenpeace Which?	Rob Reid (Which?)	Mamta Patel (Chemical Watch) Rob Reid (Which?)

1st PAG

The aim of the first PAG meeting was to enable members of the PAG to understand the context and planned process of this research and the proposed role of the group and their role within it. It also enabled members of the PAG to contribute to the development of draft materials being used in the first Citizens' Jury, and particularly to help ensure they were accurate, balanced and fit for purpose.

2nd PAG

The second PAG meeting was held after the first stage of Citizens' Jury. The Group heard findings from the first Citizens' meeting, and in particular the questions they raised. The Group then discussed how best to respond to the questions and information needs of the Citizens' Jury, by suggesting Panel speakers who could act as 'witnesses' at the Jury's second meeting.

The Citizens' Jury

The Citizens' Jury took place in two stages, as outlined in Figure 1. The process involved a mix of different activities including presentations, panel discussions, discussion groups and individual exercises to ensure that everyone could contribute to the process. Some of the discussion groups were led by the participants themselves, while others were facilitated by the Opinion Leader team. All discussions were recorded and note takers were also present creating a record of discussions and questions. Sufficient time was allowed for discussion and reflection in order to make sure that the information was fully digested. This was especially important given the complexity of the issues at hand. A copy of both agendas can be seen in Appendix 1.

Stage one

Stage one took place in two locations, London and Manchester, during early November 2008 and lasted a day and a half. It was designed to be exploratory and give participants the chance to own the process:

- To bring participants up to the same basic level of knowledge about biotechnology and;
- To allow them to set the structure for the second stage of the process, with identification of key question areas for further deliberation and required perspectives.

A broad outline of Stage one was as follows:

Day 1: Getting to know each other, introduction to the topic, purpose and process, brief discussion about science and technology in general

Day 2: Initial neutral briefing on IB[3], with specific applications, initial briefing on the context of this discussion, introduction to some of the differing opinions around IB

Stage two

At Stage two half of the London participants and half of Manchester's participants were then reconvened for a two day event in London in the interests of maintaining an appropriate size of Jury. At stage two a panel of "witnesses" were convened for participants to question to enable them to attain a deeper understanding of the issues. Building on the first stage of the Jury and the second PAG meeting, three particular case studies were identified by the PAG to act as vehicles for the Jury's discussions on IB; these were bio plastics and polymers, speciality chemicals and bio refineries. A number of witnesses were identified across industry, government and the third sector and invited to provide information and answer questions according to their expertise and points of view. Participants were then given the opportunity to questions these witnesses directly. The witnesses were selected from recommendations by the PAG to enable the key areas of interest identified by the Citizens' Jury in the first stage to be explored. They were recruited from industry, academia, and charities to allow a balance of perspectives and range of expertise. At the end of each case study session participants went into facilitated discussion groups to respond to the information they had just heard and reflect on how it made them feel about IB overall. At the end of the final day participants were invited to pull together their thoughts on IB and to present back to the stakeholders in the process, namely representatives from BERR, Sciencewise and the IB-IGT.

An overview of the two-day process at Stage two was as follows:

Day 1: Recap on Stage one, introduction to the broad spectrum of IB, presentations and Q&A on bioplastics and discussion groups

Day 2: Presentations and Q&A on Speciality Chemicals and Bio-refineries with presentations, discussion groups, and Q&A with a final discussion group and citizens' presentation to the IB-IGT summing up their perceptions.

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[3] This briefing was provided by a science communicator – Susan Aldridge in London, and Sabine Flitsch in Manchester

The list of witnesses who took part over the two day period in Stage 2, within the three case study areas were as follows:

Context / background

- Paul Goddard, CIO, CoEBio3
- Sue Armfield, BERR
- Andrew Perrins, DECC

Bioplastics and polymers

- Dr. Ray Elliott, Senior Project Lead Analytical Science and Karen Holt, Senior Regulatory Manager for Biotechnology, Syngenta
- Tom Oliver, CPRE
- Paul Davidson, WRAP
- Garry Staunton, Technology Director, The Carbon Trust
- Jack Stilgoe, DEMOS

Speciality chemicals

- Surinder Chahal, CRODA
- Bob Holt, Pharma Intermediates
- Dr Edward Marshall, Imperial College, London
- Julie Mc Donald, Chemistry Innovation Knowledge Transfer Network

Bio-refineries

- Richard Stark, Head of Commercial Development, British Sugar
- Graham Rice, INEOS Bio
- Adrian Higson, National Non-Food Crop Centre
- John Sime, Bioscience for Business KTN
- Richard Whitlock, Frontier Agriculture Ltd
- Mark Harvey, Department of Sociology, University of Essex

Sampling and recruitment

Participants were selected broadly to reflect the composition of the wider general public. They were selected to represent a range of viewpoints in terms of:

- Gender
- Age
- Ethnicity
- Socio-economic group and/or education
- Work status (including those in full time work)

Participants were not informed of the exact nature of the topic in advance, although they were told that it would be discussing new scientific developments. This was to avoid introducing any bias in terms of attitudes to biotechnology. Similarly, participants were screened to make sure they were not working in the scientific field, in order to ensure that the Jury started from a similar place in terms of prior knowledge. The fact that participants are selected to represent the general public inevitably means that education levels and interest in current affairs will vary between participants.

Recruitment took place using a network of independent recruiters, who followed a screening questionnaire and sample quotas in order to achieve a good mix of participants. The profile of the Jury at each stage can be seen in Figure 2. Participants were paid an incentive of £250 each at the end of the final Jury (£85 at the end of the first stage) to thank them for their time and to cover any incidental expenses.

Figure 2: Demographic breakdown of Citizens Jury

	Stage one, London	Stage one, Manchester	Stage two, London and Manchester
Age			
18-24	2	3	3
25-29	2	2	2
30-44	7	7	6
45-59	9	6	7
60-64	3	3	5
65+	1	3	1
Gender			
Male	11	12	12
Female	13	12	12
SEG			
AB	5	5	7
C1	7	9	9
C2	6	6	6
D	1	2	0
E	5	2	2
Ethnicity			
White British	21	20	20
BME	3	4	4
TOTAL	24	24	24

Evaluation

The project was evaluated by an independent freelance evaluator. The report of the evaluation will be published separately[4].

[4] The report of the evaluation will be available through Sciencewise in Spring 2009.

2. Prologue to findings

This report presents analysis from both stages of the Citizens' Juries; from Stage one in London and Manchester and from the Stage two event in London.

The following considerations should be taken into account when reading this report:

- The findings address perceptions of Industrial Biotechnology (IB), as defined by the scope of the IB-IGT, but are based on reactions elicited specifically via the case studies and presentations used during the deliberative process. The case studies presented to participants are included in Appendix 2:
  - Biofuels
  - Bioplastics
  - Speciality chemicals
  - Biorefineries
- The report is thematic; looking at the main areas of concern and interest that emerge about IB overall and how these views develop. However, participants struggled to see IB as a specific technological development without placing it in a wider and more general context. Concerns were often expressed in response to specific applications. For this reason we consider reactions to these applications as separate case studies in Appendix 4.
- For a more detailed chronology of the deliberative process readers should refer to the methodology at the beginning of the report in 'The Approach'. Detailed agendas are also included in the appendix. Reports of the Project Advisory Group meetings are available from Sciencewise.
- Although designed to be indicative of the perceptions of the wider public, this report is qualitative in nature, based on the views of a small sample of participants.
- The findings of this report will naturally reflect the specific context at time of research and headlines within the media for example around the economic downturn as well as environmental headlines. These are referenced in 'The Context'.
- We include quotations throughout the report to illustrate participant views. However it should be noted that these are not based on transcripts, which would not have been practical in the Jury environment, so citations should not be taken as verbatim notes. Citations are labelled according to the meeting that they occurred within:
  - Stage one, London
  - Stage one, Manchester
  - Stage two

The chapters making up the main body of this report are as follows:

- The context
- What worries people about IB
- What interests people about IB
- Lessons for communications and policy

3. The context

3.1 Introduction

Like any research project, this piece of work took place in a context. Context can have a significant bearing on research findings so it is important for this to be considered up front. This chapter sets out the context which surrounds and influences public perceptions of IB.

An overriding challenge of the research was in getting participants to focus on IB in particular. From the experience of this project, it seems clear that the public acceptability of the various IB applications is very much determined by other outside factors. The recurrent and thematic factors throughout the research, and which featured in almost all discussions, were:

- Economic climate
- Level of concern about climate change
- Attitudes to 'our way of life'
- Attitudes to science and technology generally
- Trust in Government
- Trust in business/ industry

These contextual factors at times stimulated a more positive response to IB generally and its specific applications. For instance, views expressed on bio-plastics were very much driven by an overriding concern for 'our way of life' which related to concerns about consumptions levels, waste and the perceived impact this has had on both the economy and the environment. Equally, there was potential for negativity towards IB stemming from other contextual factors, such as traditional attitudes to government and industry. Furthermore the issue of biofuels and land use had been in the press at the time of the research, a factor which may have impacted on opinions, at least initially. Overall, these factors were not identified or considered in isolation but constituted the 'bigger picture' in which developments in IB take place.

3.2 The economic climate

Perhaps unsurprisingly, cost is of paramount importance for those taking part, as it is in many areas of research. This relates to any perceived financial impact that might be felt by the consumer (via increased prices of products) and to the citizen (in terms of raised taxes to pay for wider changes for example). However, given the economic climate, cost was an even more prevailing area of interest for this piece of research, reflecting public awareness about the rising cost of living and the state of the economy. It is important to note that the economic climate in which this research took place had several specific impacts on public attitudes with both positive and negative potential in relation to IB.

Given the popular sentiment that current economic difficulties are the result of inherent weaknesses in the financial system, there is a strong appetite for new initiatives. This is a unique situation in that rather than reverting to a 'safe option' during a period of crisis, there could be a reverse effect; embracing new and innovative alternatives. This understanding of the need for change underpinned much of the public's opinion throughout this engagement.

Furthermore, as concern for the economy is felt at a local and individual level, there is perhaps a greater level of enthusiasm for anything which might stimulate growth in local labour markets and mitigate against an expected rise in unemployment. Equally however, this economic volatility means cost is a strong - if not the strongest - factor in the public's decision making process. The way in which a new undertaking translates into the economy may also more naturally supersede most other considerations. For example, the environmental effects of any initiative such as its carbon footprint, and sustainability or its impact on the developing world, may become less important to the consumer.

3.3 Levels of concern over climate change

In contrast to the low level of knowledge about science in general, awareness of environmental issues was relatively high.

> "We can go on holidays far away, but we'll be paying for that in terms of pollution"
>
> Stage one, Manchester

However, whilst there are indications of concern over climate change[5], the majority of the public do not view themselves as responsible for taking personal action to mitigate it.[6] There is currently a difference between what people say about climate change, and what they feel motivated to do. Evidence of increased public action on waste reduction in particular[7] suggests that there are some exceptions to this however.

The manner in which climate change is discussed is likely to impact on public attitudes to IB. From the experience of this research, the public respond well to messages around efficiency. For example 'stopping' and 'combating' wasteful behaviour, in an effort to curb climate change. As such, participants

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[5] In a major 2007 report by Ipsos Mori entitled Tipping Point or Turning Point – social marketing and climate change 88% believed, irrespective of cause, that the climate was changing, 46% believe human activity is the main cause in climate change and almost half, 44%, are very concerned about climate change

[6] Tipping Point or Turning Point – social marketing and climate change, Ipsos Mori, 2007 - The public perceive themselves as individuals and local communities as only minor actors – only 4% believe they have a large influence to combat climate change while 33% believe they have none. Largely the British public look to both government and business for action on climate change

[7] A recently published report from the Environment Agency shows that almost a quarter less waste was sent to landfill in 2007 compared to 2001. See 'Waste Information 2007' at www.environment-agency.gov.uk

were keen to consider anything which might produce less waste or carbon, and, which might actually use existing waste to produce energy.

Whilst there might be enthusiasm for new, more efficient technologies, this enthusiasm is not unreserved. The very idea of 'technology' is bound up with industry which, in itself, gives rise to scepticism about the motivations of 'big business'. For example, there is doubt cast over any business which purports to be developing 'green' solutions. Many perceived business to be part of the problem, rather than part of the solution.

> "We wondered how we had done so much with science and technology, but had done so much damage to the environment"
>
> Stage one, Manchester

3.4 Attitudes to 'our way of life'

The twin challenges presented by the economic situation and climate change led some participants to raise questions about 'our way of life' generally. Excess or waste were viewed with distaste. Environmental and economic developments have fuelled a significant demand for material efficiency. This emphasis on efficiency – financially, materially, socially – extends from local to international level. Throughout this research, participants raised concern that the western 'way of life' may be negatively affecting both the people and the environment of the rest of the world.

> "Obviously the public buy them [cheap clothes] and they are very popular, but I don't think that it is very fair how they are treated in their own countries, I mean they get paid a pittance"
>
> Stage one, Manchester

> "It worries me when it [exotic food] has come all the way around the world…it's miles before it gets to you, that worries me"
>
> Stage one, Manchester

3.5 Attitudes to science and technology generally

It is well documented that public knowledge of science and technology is low. A report on Public Attitudes to Science prepared for Research Councils UK and the Department for Innovation,

Universities and Skills[8] recorded that 56% of respondents surveyed believed that 'science and technology is too specialised for most people to understand it'[9]. The sentiment is echoed in this research with almost all participants giving themselves a low rating of their confidence with science and technology. At the beginning of the first stage of this process, 42% of participants judged they knew very little about science and technology, with a further 37% who 'did not know much'. (Charts are included in Appendix 5).

What awareness there was about science and technology appears to come from the media, for example, stories about recent developments and debates in science and technology. In some cases this can provoke interest in science and technology, in others, suspicion and distrust. Those taking part in this research commented that these stories gave mixed messages regarding science and technology. The Large Hadron Collider at CERN for example, which was being launched at the time of the research, was subject to very polarising media representation.[10] In this context it is likely that the portrayal of IB will be subject to similar treatment.

Beyond reactions to specialist media stories, science and technology both have a tendency to be initially viewed in abstract terms.

> "[Science is] mastering your environment"
>
> Stage one, London

> "[Science is] people's desire to push boundaries to new levels"
>
> Stage one, Manchester

Without direction, most people are unable to see how science and technology relate to everyday life. Evidence suggests that the majority of the public are only likely to pursue further information about scientific developments if they have a personal interest in them.[11]

During stage one of the deliberative process, concerns expressed about IB were actually a product of a wider fear of science and technological developments in general. People were worried about the capacity for science to take things "too far". There was a strong sense that many current technologies were not helping people to live more fulfilling lives. It was felt that current technology leads to greater

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[8] Public Attitudes to Science 2008: A Guide. Report prepared for Research Councils UK and the Department for Innovation, Universities and Skills by People Science and Policy Ltd/TNS March 2008

[9] Ibid.

[10] Landmark experiment to unlock secrets of Big Bang could cause end of the world, say scientists in court bid to halt it – Daily Mail 1/09/08

Scientists switch on 'secrets of the universe' machine – Daily Mail 11/09/08

[11] Public Attitudes to Science 2008: A Guide. Report prepared for Research Councils UK and the Department for Innovation, Universities and Skills by People Science and Policy Ltd/TNS March 2008

alienation and a more fractured society and could have detrimental impacts upon both health and social skills for example. In this context there is a tendency to defer to 'the good old days' as preferable.

> "There is not so much community spirit and things like that"
>
> Stage one, London

> "People want the ploughman, it's natural and organic"
>
> Stage two

The role of science and technology in every day life is, for the most part, not fully understood or appreciated by the public. Significantly, as evidenced by this research process, attitudes towards science and technology are largely based on lack of understanding in the absence of any factual information, rather than any inherent antipathy towards scientific and technological developments per se, including biotechnology and the use of GM. It would seem that confusion and misunderstanding of science and technology naturally lead to suspicion and mistrust rather than support or enthusiasm. The experience of this research has shown that, as others have found[12], when the public are engaged with science and technology, there is great potential to excite and stimulate interest.

3.6 Trust in Government

A strong distrust in the efficacy and intentions of Government was apparent throughout this research. Cynicism about Government was not uniquely related to engagement with IB, but is a phenomenon wider than the barriers of this research project. Distrust appears as the default position of the public, and one resorted to in many cases out of habit rather than in relation to specific experience. Distrust is most evident when referring to 'the Government' as a whole, and is considerably reduced when 'Government' is deconstructed into departments, ministers etc. With regard to the Government's efficacy as an overseer of IB, there is a delicate balance in public attitudes between perceptions of the Government as overbearing or as inactive. There is a strong desire and expectation for transparency of information on the Government's role and performance in relation to IB.

3.7 Trust in business / industry

There is also suspicion of the private sector. The perception is that industry is as a purely profit driven sector, willing to circumvent regulations and responsibility in the pursuit of its own gains. The pursuit of profit - whilst essential for any business - mars the public's perception of the private sector. Throughout this process an attitude persisted that if a venture was profitable, this most often denotes shortcuts in

[12] Public Attitudes to Science 2008: A Guide. Report prepared for Research Councils UK and the Department for Innovation, Universities and Skills by People Science and Policy Ltd/TNS March 2008

other areas, such as safety or environmental policy. That business might be profitable and socially responsible is an understanding that takes longer for the public to accept.

> "They're not doing it for people, they're doing it for profit. You'll never hear the whole truth because it's profit based"
>
> Stage two

Undoubtedly, these low levels of confidence are affected by the current economic climate and general disillusionment with business and the private sector. In addition, as with Government, the public become less suspicious when 'industry' is deconstructed into different sectors and pursuits; pharmaceuticals, agriculture, energy and so on.

3.8 Summary

There is a genuine appetite to consider new developments within the current and future context (as far as this can be known). It is clear that current financial, environmental and social considerations have fostered new priorities in public attitudes. Nonetheless the experience of this research has shown that the public might be resistant to viewing any scientific development or Government action in isolation. There is a demand to understand not just the technology itself but how this will be applied and with what effect, both for the individual and in terms of wider global consequences. People have limited knowledge about science and technology generally and are cynical about Government and industry's influence on it. They therefore have the potential to be both enthusiastic about and suspicious of new scientific developments.

4. What concerns people about Industrial Biotechnology

4.1 Introduction

Public opinion has been identified by the IB-IGT as a potential barrier to the adoption of some aspects of IB. This research has found that public perception does present some challenges which will need to be addressed by communication strategies. The public have a range of concerns about IB, but most of these are based on myth and misinformation, or a knee-jerk reaction to reject the unknown. These concerns diminish or disappear altogether following exposure to information and dialogue with scientists.

This chapter sets out the main reservations the public are likely to have, based on the experience of this research. These fall into the following areas:

- Biotechnological processes and their industrial applications: bacteria and enzymes, GM crops and genetically modified organisms (GMOs)
- The human or consumer impact: cost, quality and land use in developing countries
- The environmental impact: climate change, ecosystems, impacts on the physical landscape, and GM and the natural environment

Cutting across all of these areas were questions around regulation and control. Whether it be with regards to the technology itself, land use or safety, regulation is very much at the forefront of peoples' concerns.

4.2 Biotechnological processes and their industrial applications

Many initial concerns about biotechnological processes were based on their unfamiliarity and fear of the unknown. As a science which people are not familiar with participants perceived this to be a new development and sought reassurances about it. Overall this fear is based not on experience, but stems from a lack of knowledge and general suspicion of industry and scientists working in a business context.

People were worried that as a 'new' science there may as yet be unknown consequences of its use. Participants made reference to one case - the thalidomide controversy in the 1960s - where a scientific development in medicine 'went wrong' with horrendous consequences. Lack of understanding naturally gives rise to suspicion as participants imagined that industry might exploit the public's limited knowledge to do things that would not be acceptable otherwise.

> "We just don't know what's going into the stuff"
> "They probably disguise what's going into the stuff"
>
> Stage two

An overriding concern about the biotechnological process was that the science involved will go "too far" by creating something "unnatural" which could then not be reversed. This concern arose particularly in relation to GM crops, but also in relation to using bacteria (GMOs) to produce enzymes where they would not usually do so. In the initial stages, concern that there may be "no going back" and the question "where do we stop?" arose frequently. There was a sense that scientists themselves might not know what the consequences of this might be before it was too late.

> "We don't know what the long term effects might be"
>
> Stage one, Manchester

> "Where do you draw the line?"
>
> Stage two

Bacteria and enzymes

During the initial stage of the research, participants were given an introduction to biotechnology and how the use of this technology has evolved, from bread making, alcohol and insulin to advanced biofuels. Participants received briefing on bacteria and enzymes, plant breeding and GMOs. Exposure to this information raised a variety of questions around: whether bacteria is safe, how enzymes and bacteria interact and whether enzymes go on doing things once they have performed their intended function (and are there therefore unintended consequences).

Some worries originated from a basic lack of understanding about enzymes and bacteria. People were unaware about the existence of enzymes and bacteria in the human body, for example in the stomach, and were surprised to hear about their role. Participants also did not initially trust the use of bacteria in IB processes, based on the assumption that bacteria were harmful; that they were something that causes illness and food poisoning and that they were difficult to control.

> "Bacteria can eventually mutate and become to resistant to vaccines and things"
>
> Stage one, Manchester

The main initial concern people had about the use of bacteria and enzymes was about changing the nature of the bacteria by making it do something it wouldn't naturally do i.e. create enzymes. In the development of insulin for example, participants were worried about whether the bacteria and the insulin enzyme could really stay separate or if they might become mixed somehow.

> "Could the gene from the bacteria mix with the pig enzyme?"
>
> Stage one, London

Information about enzymes and bacteria during the panel discussions in Stage two, gave rise to further questions about the interaction of enzymes and bacteria. For example, in relation to information about the potential for use of biotechnology in refining crude oil, there were concerns that the oil itself would be unnaturally changed as a result. Although participants could see the benefits of both of these products, they would only be acceptable if they did not create something genetically different or "unnatural" in the process.

> "If you create the ideal bacteria and it makes the crude oil more runny, then you've changed the environment of the crude oil, haven't you?"
>
> Stage two

Equally, people were concerned about what happens to enzymes and the bacteria used to make them at the end of the biotechnological process. They were worried about these being released, due to a fear about their impact on the natural environment. Some wondered whether the bacteria and enzymes could still keep doing unknown and uncontrolled things when they are flushed away.

Specifically, participants were concerned about the long-term health impacts that could arise for example by leaking by-products into the environment. This links to concerns about the spent enzymes and bacteria being "unnatural" and therefore having the potential to interfere with nature and the natural balance. In particular, a connection was made with a perceived increase in allergies and asthma in the general population, making people feel that IB could have similar long-term effects.

> "You can see more people and their health reacting to this interference around you"
>
> Stage two

Participants mistrusted industry's role in maintaining public safety. They questioned how certain industry was that particular by-products were as benign as they maintain when released into nature. They also suggested that industry, and scientists employed by industry, might take decisions that could be dangerous in the interests of profit.

> "If you found that [a dangerous bacteria] could make crude oil really runny, you'd use it wouldn't it? Even if it was unsafe?"
>
> Stage two

> "I still have an issue that this is eventually to make money for business and so it may be exploited and abused"
>
> Stage two

For this reason, participants sought reassurance about regulation to control the release of by-products. It was not sufficient to know just that there was regulation in place to control this, but rather they needed to know for themselves what that regulation was and why it was in place. Many concerns were answered by this information about regulation[13] and the fact that bacteria are killed once used. Participants were also less worried when they learnt that bacteria need certain conditions in order to survive[14].

However, information about the adaptability of bacteria to survive, for example in nuclear-contaminated conditions, caused further confusion. It seemed to suggest that bacteria were in fact almost indestructible. Concerns about spent bacteria escaping into the environment were only alleviated by several pieces of information: that there is strict regulation in place to kill the bacteria; that in any case they are developed to such an extent they could not survive outside of laboratory conditions; and that, although they can adapt, this takes a very long time. Even with this information, it would appear that people remain unclear about enzymes and bacteria and whether they are safe after they have been used in IB processes or could potentially impact on the natural environment.

There were also concerns about the health impacts of direct human consumption of products that have been made using IB processes. People wanted to know whether products containing enzymes were safe and how they were deemed to be safe. For example, based on an awareness of the possible allergic reactions to biological washing powder, some worried about allergic reaction, or the potential for unknown long-term effects, through consumption of other IB products that contained enzymes. They were also unclear about the definition between which products actually contained enzymes and which had been made using enzymes.

> "Has there been an increase in allergies, eczema for example as a result of increased enzymes in products?"
>
> Stage two

> "Why would a product be deemed unsafe? What problems could it cause?"
>
> Stage two

> "Is the enzyme just a catalyst or is it part of the product?"
>
> Stage two

Overall, people were unsure about the role that IB plays in the process of making products that they use in everyday life. Many participants were surprised when they learned the extent to which IB is already prevalent in the production process.

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[13] A presentation by Bob Holt, Pharma Intermediaries

> "Isn't there a loophole that we are already consuming it through the food chain?"
>
> Stage two

Genetic modification (GM) and GMOs

The use of GM in IB was a significant area of concern.

At first, participants were extremely wary of GM of any kind, in terms of products and its use in industrial processes. This was largely driven by media stories around GM food and crops in combination with a lack of understanding of what GM actually is. In particular, participants had picked up stories in the popular media about "monster" products, or so-called 'Frankenfoods'[15]. There was little awareness of the use of GMOs in industrial processes.

Towards the end of Stage two, participants explained how a misunderstanding over what GM actually was had been the source of their fear about its use in IB. After having understood the process behind GM, they could see it as a natural extension of conventional plant breeding techniques that have been employed for many years. Some even became concerned that there was no positive or balancing information in the public domain and criticised the role of the media in this. Participants also felt that GMOs were crucial to IB and that without it IB would not be able to deliver solutions to current and future challenges.

> "What has made me more comfortable about [GM] is the realisation that this is not necessarily that different from what was going on before. It is more of an acceleration of what has happened"
>
> Stage two

Once the process of GM was more fully understood, the main concern about its use in IB was situations where the public or the environment might come in direct contact with products that were genetically modified, for example feedstocks or cosmetics. There was much less concern about using a product that had involved using GMOs to make it than there was about GM crops. In the case of feedstocks for biofuels concerns focussed on cross-contamination within the natural environment (addressed in 4.4 'Impact on the environment'). In the case of speciality chemicals, people were initially unsure about using products on themselves that were genetically modified, for fear of unknown consequences on their health. This remained an issue in the case of using GM in developing feedstocks. When it became clear that the use of GMOs to make products did not involve asking people to come into direct contact

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[14] A presentation by Paul Goddard, Centre of Excellence in Biocatalysis, Biotransformation and Biocatalytic Manufacture (CoEBio3)

[15] "Alert over the march of the 'grey goo' in nanotechnology Frankenfoods", Daily Mail, 02 January 2008 http://www.dailymail.co.uk/sciencetech/article-505561/Alert-march-grey-goo-nanotechnology-Frankenfoods.html

with anything 'GM', but that it was just a small part of a technological process, there were far less concerns about its usage. There was a large difference for most people between GM crops or GM food and GMOs used as part of a process in the laboratory.

> "I feel that there is a difference between GM as crops for food on the table and the other GM being used for enzymes and other products being used for pharmaceuticals"
>
> Stage two

Crucially, the laboratory environment was perceived to one in which GM could be contained and controlled, preventing any change to the wider environment or adverse impact on humans. The laboratory was considered to be a safer, more contained environment when compared to the application of IB in an external environment (outdoors).

> "In the lab it is controlled and reversible, whereas in nature you don't have that"
>
> Stage two

For a minority of those taking part, GM was a moral issue, quite regardless of whether it was 'safe' or not. Whilst many were familiar with the arguments around "playing God" however, for most the principle of changing genes was neither a moral issue nor an enduring concern; it was the potential and unknown effects of it that was key.

4.3 The human / consumer impact

Perhaps unsurprisingly, the impact that IB might have on consumers and the general public was a significant area of concern. This was in response to arguments that were considered in both Stage one and Stage two around possible human impacts both in the UK and in developing countries.

Cost

Cost was a major concern for participants in a variety of ways. The key questions surrounding cost were:

- How much would products made using IB processes cost?
- Would there be hidden costs in the conversion to an IB economy?
- If there were cost savings, would industry 'pass them on' to the consumer?

Many concerns about cost highlighted a lack of understanding about the role of the consumer and the economics of supply and demand, that is, how consumer demand can influence both what is available and how much it costs.

The main concern surrounding cost was that IB products would cost more or that expensive processes would cause other products' prices to increase. The assumption that IB products would cost more was based partly on associations that people made with organic or ethical products costing more. Most viewed these sorts of price differentials with suspicion. People felt that this would just be another way of making more money:

> "It would be so easy to say 'It's green – pay more'"
>
> Stage two

Some said that they would pay more for an IB product if they knew that it was sustainable and had 'green benefits' for their own and for their children's future. However, for the majority it was felt that, especially in such an economic climate, these sorts of choices would simply not be realistic:

> "When you have got rising unemployment, and people living on benefits of £60 a week then every penny counts"
>
> Stage two

Participants also worried about any costs associated with adapting their current products to be able to use IB products. For example, needing to convert their cars to take biofuels or to buy new cars that can run on biofuels. These were seen to be potential hidden costs of IB that could impact on them in the future.

Concern was also expressed that, if in the future more efficient biotechnology processes brought cost savings to industry, that these would not be 'passed on' to the consumer. This is indicative of a confusion about the role that they as consumers would play, in terms of increased demand leading to economies of scale in production and therefore lower costs. They deferred instead to industry and government, questioning 'why isn't industry making this happen?' This desire was in marked contrast with fears expressed at other times that industry/Government would dictate change, and thus prevent consumer choice.

> "What cost savings would appear if GM was more widely applied? How could [your company] apply cost savings - would it be passed onto the consumer?"
>
> Stage two

There was also confusion about the knock-on effect that consumer demand could have further on down the supply chain. It was quite an insight for participants, for example, that the chemicals industry might be subject to both consumer demand or the lack thereof for particular products i.e. that even if the chemical industry had the potential to develop chemicals more efficiently using IB processes, users of these chemicals further down the supply chain would not use them in their products if there was a perception that consumers would not buy the end products because they were created using IB

processes. Participants had assumed that the relationship between consumer and industry worked in reverse, with industry simply taking the decision to use IB and consumers powerless to influence this decision. They assumed at a certain point, IB products would begin appearing in shops and that they would either be labelled (in which case they as consumers could make a choice about whether to buy them) or worse would not be labelled (thus forcing the consumer into unknown consumption of IB products). Participants did not understand that if public perception was seen to be a major barrier to IB-derived products, manufacturers would not use IB-derived chemicals and the products would be unlikely to appear on their shelves. This concept provoked further contradictory reactions. Many did not altogether welcome the perceived personal responsibility imposed by consumer choice, imagining rather that industry would 'set' the prices and initiate change. There was a sense that, whilst Government / industry should not stand in the way of consumer choice, when this choice is difficult they would rather someone else make the decision for them.

> "Can't we put the responsibility off of the consumer onto the producers?"
>
> Stage two

Functionality and quality

As well as wanting to know if products made using IB processes would cost more, there was a concern about whether they would function as well as oil-based products and if they would be the same quality.

Concern emerged that IB may produce sub-quality products, for example cars on bioethanol would not run as well. Participants were not willing to sacrifice quality. Most wanted any replacements to be at least as good as what is currently available.

> "Does biofuel have similar performance to ordinary fuels in your car?"
>
> Stage two

Participants also wondered how IB products would be integrated into current systems. For example, some wondered whether biofuels could be used in an ordinary car. Participants were concerned to hear that, whilst bioplastic bags are biodegradable, they are not recyclable[16]. There was distinct concern over the problems that bioplastic bags could present to the recycling process. Participants also questioned how they would know which bags were made of bioplastic in order to make decisions on recycling. Some suggestions were made about colour-coding bags for this purpose. The switch to IB seemed to present many issues which, if ineffectively addressed, could have large impacts on the consumer.

Reflecting the desire for less waste and an appetite to change 'our way of life' (see Chapter 3 'The context'), participants were keen to know whether bioplastics would be as durable as plastics made

[16] In a presentation by WRAP

from oil. It was felt that things should be built to last and reused and that, on balance, this would be preferable to making something in a sustainable way but then throwing it away. In bioplastics for example, the fact that they could biodegrade was felt to be less important than whether it could be used over and over again. Once people understood the idea of carbon lifecycles they were able to understand more clearly the role of IB products in the environment. Questions were raised about durability and that, if bioplastic bags are not such good quality, we will have to make more of them which will in turn be worse for the environment.

> "Are bioplastics all as durable as the normal plastics?"
>
> Stage two

Land use and impact on developing countries

Concerns also arose specifically about the displacement of agricultural land by the feedstocks needed to produce first generation biofuels. This was seen to have the potential to impact negatively on human populations in developing countries by taking over land that would have otherwise been used to produce food.

In the first stage of the research, participants were presented with background information about some of the global challenges that we are facing including climate change, oil reserves, growing populations and pressures on food supply. They then reflected on some of the potential arguments for and against both first and advanced biofuels, in this context. People raised particular concerns about the pressures on land use across the world and on food shortages in developing countries and the impact increased first generation and advanced biofuel production might have on this situation. It was felt to be clearly unacceptable if there was any chance that increasing the use of land for making biofuels might lead to greater food shortages. For many this gave rise to unease and raised questions about exactly what the impact of increasing feedstock cultivation for biofuels would be and these concerns continued into the second stage.

> "Are people in the Third World going to suffer?"
> "There is not enough land to produce biofuels and bioplastics, the world is straining to make enough food now"
> "It's just being done on price, the rich people will pay more for their fuel than the poor can pay for their food"
>
> Stage two

4.4 Impact on the environment

Concern over the effects of IB on the environment ranged from local impacts (participants own communities) to the national and international (rain forests). What participants term 'environmental

impacts' encapsulates concerns about not only climate change, biodiversity and rainforests but cross-contamination of genetically modified crops and the impact of large oil refineries on the appearance of the physical landscape.

Climate change

In relation to climate change and sustainability, the public want to know whether, overall, IB has less impact on CO_2 levels than traditional industrial processes. Perhaps as an indication of a 'green fatigue', definite suspicions were in evidence surrounding the potential environmental benefits of IB.

> "I think that CO_2 is a bit of a red herring, because the carbon has got to go somewhere"
>
> Stage one, Manchester

Whilst participants did ultimately see the sustainability of IB as a benefit, they were suspicious of green messages about IB. For participants environmental statements about IB's benefits in terms of being renewable and biodegradable sounded opportunistic. At the extreme, arguments raised in panel sessions about the environmental benefits of IB were declared by some to be a form of "moral blackmail" or coercion.

Familiar with the concept of a 'carbon footprint', participants quickly became eager for a direct comparison of biofuels and bioplastics, for example, with traditional fuels and plastics. Participants were less familiar with the concept of a carbon lifecycle. When the Carbon Trust presented at Stage two, this raised questions about what really is green if everything produces carbon. People then recognised that whether something is 'green' or not depends on how much carbon a process expends and that you have to look at the 'carbon footprint' of a product from the start of its development through to its final usage and disposal. Overall considerations of how 'green' IB is raised more questions than it answered and remained an open issue.

Impact on ecosystems

Concerns were raised about the dramatic impact the increased development of IB could have on fragile environments in developing countries. Similarly to concerns about the human impacts, this concern focussed on the need for feedstocks. Participants were worried that if countries think there are economic benefits to growing feedstocks which are not subject to environmental controls, this would lead to deforestation and subsequent impacts on global biodiversity and CO_2 levels. Participants with existing knowledge on the subject of bio-fuels were very aware of the potential problems surrounding bio-fuels and the potential for further deforestation to allow bio-fuel feedstock cultivation.

> "Could they still be stripping down rainforests and other precious lands, where are they going to find the land, if it [bio-fuels industry] grows that big?"

Stage two

"You are destroying the world's lungs"

Stage two

Impact on physical environment

Others were more concerned about impacts closer to home, in relation to the impact of biorefineries on the appearance of the physical landscape. During the panel session on biorefineries it became apparent to participants that, for bio-fuels to be produced on a sufficient scale to be profitable, there would be a need for large biorefineries to be built. For many this raised immediate concerns about ruining the countryside, whether they came from a rural or urban background. It was less about living near a biorefinery and more about the physical appearance of the countryside.

"Refineries are a blot on the landscape – they ruin the aesthetic"

Stage two

GM and the natural environment

The most powerful concern people had about the impact on the environment was the interaction of biotechnology processes, and specifically GM crops, with the natural environment. In fact, at the end of the deliberative journey, it remained the only significant concern about the use of GM in IB processes. For many participants, the risk of GM in an outdoor environment presented too many risks. It was a reoccurring concern that one small change in the natural environment, initiated by genetically modified feedstocks, could have a significant and unpredictable effect. Specific concerns related to disrupting the food chain, for example by making crops resistant to pests, and "cross contamination" leading to mutant crops or even animals.

"How do you know that the product using GM would not contaminate and mix with things in the environment?"

Stage two

In the area of GM feedstocks, participants, during stage two panel sessions, sought the same level of assurance that they were given about the controlled laboratory environment. However, information about strict EU regulations about GM crops only served to confirm participant fears. The persistent concern about IB and the natural environment was that in the context of GM feedstocks, the GM organism would be in the air and in the soil, making it seem much more uncontrolled.

"The only thing that people are worried about [in relation to GM] is that when we grow crops there will cross contamination."

Stage two

4.5 Regulation

The need for regulation and control was a recurrent theme and lack of understanding of it underpinned many of participants' main concerns. Two factors must be taken account in alleviating the public's concerns about regulation and control:

- Suspicion of industry and confusion about economics and market forces
- Suspicion of Government to implement legislation and regulate effectively

Suspicion of industry

A residual suspicion over the role of business in IB, which participants found hard to articulate or qualify, permeated their understanding of industry's role in regulation. There was concern over the degree of perceived autonomy allowed to industry and in some cases participants saw industry as leading the way rather than Government. However, information about regulation alone did not allay participants' concerns over IB. Assurances from industry panel members were easily dismissed and compared to previous, empty assurances in other controversies. Most participants understood industry as having the upper hand in IB, with other players – Government, the public – playing catch up.

> "If it sound too good to be true it probably is"
>
> Stage two

> "Regulation? Sure, but you can't control everyone; business is the main interest and their priority is to make money. They probably side step regulations and go to other countries to do what they want."
>
> Stage two

Suspicion of government

There was also a general concern that Government does not have enough resources to be able to properly monitor developments in IB. Some participants' signalled the need for further central Government co-ordination over the control of IB regulation.

> "I don't trust the Government to put enough money in to regulate it to our satisfaction"
>
> Stage two

However, there were contradictory comments about Government's role in regulation: while under-regulation was initially a major concern, with participants seeking reassurance on almost every aspect

of IB, participants later become concerned about over-regulation. For example, in the case of European regulation blocking plastics not defined as 'bio' being used as biomass in biorefineries[17], opinion changed. There was a concern that regulation might impede progress, particularly within the UK, and mean that IB would develop only in countries which permitted it. The comparison between different regulatory approaches in the US and EU prompted many respondents to express concern that Britain might fall behind.

> "We need strong regulation, I support it but not to the extent that industries are hampered"
>
> Stage two

Regulation of IB is a careful balancing act. Whilst the primary concern was to know that the public are protected, participants were perturbed by evidence of over-regulation. The public essentially want to be able to trust the Government to regulate and police this regulation effectively, at the right level.

4.6 Summary

Many of the main concerns raised about IB by the public echo those of others, particularly environmental groups. This is particularly in relation to increased feedstock cultivation for biofuels and GM. However, some new concerns also emerged.

The public are not concerned about IB as a whole but rather about certain elements of it. The main areas of concern that emerge are in relation to:

- The safety of IB products and processes and how these are controlled
- GM contaminating the natural environment, whether by escaped GM bacteria from laboratories or cross-contamination of GM feedstocks
- Increased cost for the consumer and problems of implementation

[17] A presentation by Ineos

5. What excites people about Industrial Biotechnology

5.1 Introduction

This chapter sets out the aspects of IB that were of most interest to those taking part in the research and that participants were most positive about. It should be noted that this chapter forms a smaller part of the report than the chapter on concerns, not because the public were more negative than positive about IB, but rather because less time was spend discussing these, in order to explore their key concerns in more depth. There was a great deal of interest in biotechnology and its industrial applications. Participants were intrigued by the its potential and ability to bring 'hope' in the light of a number of challenges.

As with concerns, and perhaps more so, people found it easier to see the positives in relation to specific examples of IB, rather than in IB per se. Case study analysis in Appendix 4 documents these specific responses. Some of the emerging themes were cross-cutting and the main areas of interest were:

- Efficient use of resources
- The role it plays in pharmaceuticals
- Potential to reduce dependency on fossil fuels
- Economic benefits

5.2 Efficiency

Given the economic and environmental context, there was a strong appeal in the idea that IB might offer a more sustainable alternative to current industrial processes. To an extent, this was due to the appeal of methods which produce less waste, or which can use waste, and the perceived potential cost savings that this might bring to consumers.

Reduced waste

For many the potential for IB applications to result in less overall waste tapped into their general desire to tackle perceived over-consumption. For participants, IB could do this in a number of ways – via the efficiency of biorefineries, by the conversion of waste into biofuel, by bioplastic's potential to extend the shelf life of food and potential to biodegrade, and through generally making a variety of industries, especially the chemicals sector, more efficient (and therefore produce less CO_2).

Biorefineries overall seemed to offer a more streamlined, efficient industrial process than that of 'traditional' industry. The 'zero-waste' example of British Sugar's bio-refinery in Wissington held particular appeal. By demonstrating efficient use of resources and by-products from the beginning to the end of the process it seemed to offer a 'neat' solution.

> "We were so impressed with the sugar beet factory it's not true"
>
> Stage two

> [On British Sugar]: "You wouldn't think so much stuff would come out of it – I think they're unique in a way"
>
> Stage two

In the example of a company which can turn waste into bioethanol, participants were relieved to find an application that seemed to not only have few controversial considerations, but also seemed to remove some of the worries of modern life. This appealed to their desire for a perfect or easy solution.

Participants welcomed the fact that bioplastics can extend the shelf life of certain food products, thus preventing waste in the supermarket. There was, however, some confusion around the use of biodegradable plastics in some supermarket packaging (the foodstuffs that supermarkets have to spend the most amount of money disposing of). Questions arose about why supermarkets would use bioplastics for some packaging and not others and how they as consumers would know and make informed choices.

Cost benefits

Participants could also identify a personal benefit from greater efficiency. Especially given the economic climate, more efficient processes presented an appealing potential of cost savings for the consumer. Though there was a clear desire amongst many to try to live in a more environmentally friendly manner and engage in activities such as recycling and installing efficient home insulation, the chance to save money proved to be a more motivating benefit of IB.

> "I don't leave my charger in the wall to save cash because if I think about global warming it just depresses me"
>
> Stage one, Manchester

5.3 Medical applications

Participants were extremely positive about IB in pharmaceuticals. Indeed, unlike other applications which came under intense scrutiny and question, participants could only see the positives of IB in medicine. In large part, this is due to a desire to combat illness and extend life and increase quality of life for those who are sick. It would seem that in this area, where there is seen to be no alternative (unlike, for example, bioplastics, where the alternative is perceived to be a change in our way of life), possible drawbacks and implications are given far less weight.

However, in addition to this, the use of IB in the pharmaceuticals sector was imagined to present fewer risks, both to the environment or to people.

Containment

The research and development of medical advancements through IB was understood to take place in a more controlled environment. Participants did not deem there to be as many variables, such as weather, crops, animals involved in the medical process as in others.

> "I'm okay when it's in a controlled environment, in a lab, but not when it's outdoors"
>
> Stage two

End justifies the means

The end result of the IB process in medical advancements justified the means for most participants. On the whole the process itself aroused curiosity and enthusiasm rather than any suspicion or negativity. Whereas other industrial applications such as the use of speciality chemicals in luxury products aroused initial suspicion, often medical applications were deemed not to be 'commercial' and therefore better.

> "I prefer a pharmaceutical / medical end than a commercial one"
>
> Stage two

Participants' curiosity about the application of IB in medicine overrode concerns which arose in response to other applications of IB. For example, the use of bioplastics in the reconstruction of a torn ligament and the benefits of its biodegradability aroused universal enthusiasm amongst participants. This had the added effect of raising enthusiasm levels about IB as a whole.

> "It's really clever technology and it's in its infancy"
>
> Stage two

Furthermore, participants could identify with the benefits that medical applications of IB could bring, for example in producing insulin for diabetics. Medicine was an area where science was felt to bring more benefits than drawbacks.

> "If science hadn't progressed I wouldn't have my thyroxin"
>
> Stage one, London

5.4 Reduced dependency on fossil fuels

The need to find an alternative to oil to help secure the UK's energy supply was a motivating factor in the appeal of IB from the outset.

Participants were shocked to learn about the speed with which oil is predicted to run out and also how reliant the economy and the products we consume are on it. Some discussions focused on the energy-intensive nature of modern life and just how dependent people were upon fossil fuels.

There was also a personal desire for alternatives to oil. Given that energy costs had been steadily rising in the period preceding the research, people's fuel bills highlighted this dependency and thus had made people more aware of energy consumption than they otherwise would have been. IB offered the potential to avoid further increases.

Global and national benefits

Participants were worried about the geo-political implications of fossil fuel dependency and many speculated that problems relating to this could only get worse. They imagined future scenarios as fossil fuels run out in emotive terms and worried about how the UK would secure our supply. In this context, any alternatives, including IB were seen to be increasingly important.

> "As a species we are at a position where we can go one way or another"
>
> Stage one, London

> "[We are] becoming more dependent on natural resources, which people didn't think about 50 years ago but is now becoming quite important"
>
> Stage one, Manchester

> "It's all going to kick off, we'll just start invading countries blatantly to take their oil."
>
> Stage one, Manchester

Participants welcomed biofuels' role as part of "an energy mix", alongside alternative energy solutions such as wind and increased energy efficiency. There were benefits to placing biofuels within 'a bigger energy picture' in terms of making IB appear a more realistically viable aid to energy security. Firstly, it de-stigmatised biofuels by placing them alongside other non-conventional solutions which are being developed to address the energy crisis; solar, wind or nuclear power for example. Secondly it raised further awareness that IB is not panacea to the challenge of fossil fuel dependency and that other measures will need to be taken in addition.

5.5 Economic benefits

The economic benefits that IB could bring were perceived to be national, global and personal. The economic benefits of IB to the UK were of great interest, appealing to a sense of national pride and a desire to restore our position as 'leaders in the field'. However, many felt that this should be a global effort to be truly beneficial. Participants were less sure of the potential for personal cost benefits from the development of IB but would welcome cost savings or increased employment.

National benefits

The main desire was that the UK gain economically from IB. However, how this should happen was less straightforward. Participants were defensive of the UK's role in several ways:

- Firstly it was felt that the UK should 'take the initiative', by becoming a pioneer in the applications of Industrial Biotechnology, and that we should not fall behind due to overregulation
- Secondly that, having secured the initiative with developing IB, we should prevent any loss of intellectual property to other countries or loss of any investment.
- Lastly it was felt that we should not do more than our 'fair share' by investing in IB while others continue using fossil fuels

Many saw the domestic development of emerging biotechnologies as a means by which Britain could ascend in world status. This is partly based on a romantic attachment to Britain's traditional and declining industries, such as steel works and coal mining. Participants spoke about Britain's prominence in the Industrial Revolution and the possibility of the UK repeating this achievement by harnessing the potential of IB.

> "Wouldn't it be great if we could be world leaders?"
>
> Stage two

> "The Industrial Revolution started here – let's do it again"
>
> Stage two

Participants were very interested to know about the predicted scale of IB and queried how much investment – agricultural, financial, time – would be needed to yield a return. Contradicting concerns that IB would go 'too far' in terms of safety, many wanted reassurance that it could 'go far enough', and would not be hampered by regulation. Particularly around the area of energy, participants queried how soon IB would become a viable alternative energy source and how much investment would be needed in the process.

Participants were concerned to keep the benefits within the UK economy. It was felt that there was a risk in investing in research and development and, at the same time, in industry being limited by

regulation (such as that which relates to GM). They imagined scientists being trained up to work in IB and then going to work abroad where there was a stronger IB sector.

The desire to support Britain's economy was combined with a rejection of Britain doing more than its share, compared to other countries, in terms of its efforts to reduce CO_2 and tackle climate change[18]. The point that Britain is attempting to reduce its greenhouse gas emissions whilst developing nations, particularly China, were industrialising and increasing their emission levels was made several times.

> "All these countries like China, the USA and India not signing up to the Kyoto treaty, it doesn't seem like we can do anything"
>
> Stage one, Manchester

The conclusion of all of this was that the UK should maximise economic rewards where possible, but that in the longer term and larger scale, IB needs a global effort The desire was for the UK to reap the benefits of new IB technology where it is a win-win (both economically and in terms of reducing the impact of climate change). Beyond these immediate gains, it was felt that there should not be any increased national expenditure in the UK without simultaneous global responsibility.

Global economic benefits

Prompted by panel presentations on the progress made in biorefining and the switch to a biofuels-based economy in countries like Brazil, some were excited about the advantages that IB could bring for the global economy and a re-balance of wealth. Many were intrigued by the developments in countries such as Brazil and India and in many cases these developments were seen as an impetus for the UK to act and ensure they were not left behind.

> Question: "How do bio-refineries compare in different global regions?
> Panel: "Brazil is the only country that has put itself on the track to sustainable non-petrol dependent economic growth"
>
> Question: "What about countries that don't have the natural ingredients that others do?"
> Panel: "There's no local solution to this, you have to think globally"

Personal economic benefits

Though participants were primarily engaged with the potential benefits of IB for Britain's economy, they were keen to know more about the potential benefits for the consumer. From the consumer perspective, the most fundamental benefit would be a fall in the price of consumer goods. However, many remained

[18] It should be noted that many participants expressed this view in spite of information given from the IPCC on Britain's per capita contribution to CO2 emissions.

unsure about how and if this would happen. Questions were raised around whether IB products really would be cheaper. Some did recognise that there may be some personal benefits in terms of increased employment from the new industries and in the construction required in setting them up. However, for the majority, it was difficult to imagine just how this would happen without more understanding of the scale of IB in the future.

5.6 Summary

Once the initial barriers of lack of knowledge were overcome, the 'newness' of IB prompted interest. Having been introduced to many of the applications, the overall feeling amongst the group was one of excitement about the possibilities for the future that IB could offer and how the many different applications might allow for a fundamental re-organisation of the way industry operates. There was an appeal, for example, in the global and national benefits of a strengthened position for the UK, greater efficiency and less waste, alleviating a growing sense of ill-ease at 'our way of life'.

Unsurprisingly, overall, participants were most interested in elements of IB that addressed their own concerns and might impact on their own lives, such as medical applications. Direct personal benefits were not always entirely clear to participants, especially in terms of exact cost-savings or personal efficiencies. However, they will undoubtedly be an area of significant public interest.

6. Lessons for communications and policy

6.1 Introduction

Public perceptions change considerably as a result of increased overall understanding and in reaction to some points of specific information. The barriers to IB are considerable but not unassailable, as the deliberative process showed.[19]

This chapter explores the reasons for any change in opinion with a view to informing how best the IB-IGT can overcome any barriers in public perceptions and maximise opportunities:

- Overall lessons
- Key barriers
- Key opportunities
  - Content
  - Delivery
  - Source

6.2 Overall lessons

There are some specific elements of IB that are likely to present barriers to understanding, and therefore to acceptance. However, there are also some opportunities. This section sets out the overall lessons for communications and policy which are cross-cutting:

- The language of IB is unfamiliar and off-putting
- People struggle to see IB as a whole
- Economic misunderstanding confuses the role IB could play
- Public perceptions do not change easily

The language of IB is unfamiliar and off-putting

The language of IB is both unfamiliar and inaccessible to the public. It also has certain negative connotations based on association. These had a number of effects, according to this research.

Given that the term 'Industrial Biotechnology' links biology, technology and industry, any confusion that the public has over one of these elements is increased when they are linked into one term. Such a complex term alienates people and distances IB from everyday life. It also reinforces the perception that IB is not something that impacts normal people and gives the impression that it is the sole concern of scientists in laboratories.

[19] Please see Appendix 4 for a record of changing opinions.

The term 'Industrial Biotechnology' also has some negative connotations. Distrust of industry and fear of science mean that the term industrial biotechnology evokes negative images and creates the sense of something sinister. The language of 'mutation' and 'GM' is also emotive and therefore not conducive to having a reasoned debate on the subject. In order to overcome these effects, those taking part in this research suggested renaming IB.

> "If I said to a friend, 'Industrial Biotechnology'- they'd think that I was talking about chemical warfare"
>
> Stage two

> "Maybe you should rebrand yourselves – change the name – green chemists for example, industrial sounds sinister."
>
> Stage two

The public struggle to see IB as a whole

Biotechnology has various industrial applications and each of these have very different associated issues. Looking across the examples of IB given in the research, participants struggled to see what they had in common and struggled to see IB as a whole.

One consequence of such a broad range of applications under one term was that participants often felt overwhelmed and confused, largely because the issues that came up in debate were so wide ranging. This could have a wider detrimental effect in confirming the public's sense that science is confusing. [20]

Another consequence of such a broad area is that any debate concerning one industrial application of biotechnology can easily become confused with issues relating to a different application or even beyond the scope of IB. Because GM is used in several different IB applications it led participants initially to confuse issues they had about GM from one application to the other. For example, the fear of GM crops creating 'wild' gene pools was related by participants to the use of GMOs in the manufacturing of chemicals. It also led to comparisons outside the scope of the particular aspect of IB being discussed. For example, references were made to issues about eating GM foods when discussing the development of feedstocks for biofuels.

However, this inability to see IB as a whole also means that any negative public reactions do not mean that they public are rejecting IB overall. In fact by breaking IB down it is clear that it is not IB in itself that

[20] 56% of respondents surveyed believed that 'Science and technology is too specialised for most people to understand it' - Public Attitudes to Science 2008: A Guide. Report prepared for Research Councils UK and the Department for Innovation, Universities and Skills by People Science and Policy Ltd/TNS March 2008

is problematic but some of its constituent parts. The public prefer to respond to applications on their own merits rather than appraising IB as a whole. For example, biorefineries are much less contentious than bioplastics. Whilst using feedstocks for bio-fuels might be contentious in terms of land use, use of waste biomass is not, nor is the use of algae for making biofuels.

Economic misunderstanding confuses the role IB could play

A misunderstanding of market forces and supply and demand can lead to confused notions of the role that IB could play within an economy. This has a number of effects.

Firstly it makes it difficult for people to see how IB would become part of everyday life. Participants were unaware of the implications of their actions as consumers and that an increased supply of IB products would only happen if there was a demand for it. Many assumed for example that products made using IB would just arrive in supermarkets or in the petrol pumps.

This in turn can engender a passive and reactive view to the growth of IB. Participants questioned why industry and Government were not 'making IB happen'. This is indicative not only of a degree of suspicion about Government's competence but also an unrealistic impression of the power and reach that Government has. It can also lead to a view of IB as an industry that could either be harnessed and owned by the UK, or that could somehow be lost and escape to benefit other countries' economies.

As a further result of this confusion, the personal or direct benefits to the public can seem unclear. Participants at times struggled to see how IB would benefit them, either through tax revenue, job creation or eventual cost savings.

Public perceptions do not change easily

It takes a long time to challenge popular perceptions and it is only after substantial time with scientists that public opinion about IB can change. People are not ready to trust new developments easily, based on a number of contextual factors.

Suspicion of Government, industry and science makes the public less likely to trust any new development. There is also a distinct sense of safety in the old ways of doing things, of known consequences and less complicated potential issues. Given the economic and environmental climate, there is a desire for a solution to the challenges of climate change and depletion of fossil fuels that would present no issues and give no rise to concern.

> "[in relation to biofuels] It's kind of scary when you think that this is a solution and it comes back with all these problems"
>
> Stage one, Manchester

People are less keen for 'difficult' or complicated solutions. Therefore, there may be a tendency in the first instance to reject IB on the basis that it presents issues and implications which need consideration and regulation.

6.3 Key barriers

There are some fundamental and not inconsiderable barriers to public acceptance of IB. Some of these are overcome by greater understanding. Others remain even after consideration and deliberation. This chapter sets out the following key barriers:

- Fear of the unknown
- The complexity of the subject
- Polarising information in the public domain
- Issues of concern
- Trust of independent sources

Fear of the unknown

The main barrier to public acceptance of IB is fear of the unknown. IB is viewed as a new scientific development and therefore raises immediate fears and suspicions. This is based on limited knowledge of science in general and a fundamental lack of understanding of IB specifically.

Without knowledge of the science behind IB processes and products, IB can seem very intimidating. People are particularly concerned about the long-term consequences of such a new technology. Given that IB is so unfamiliar and complex, people require a lot of information to facilitate understanding and therefore reassurance about these processes.

The complexity of the subject

Potentially there are some very complicated messages to communicate around IB in order to gain public understanding and acceptance.

For some, there is a fine line between informing and coercing and this is particularly the case when material is difficult to process. Some participants had the tendency to become defensive when confronted with the unfamiliar, and preventing this involves careful attention to tone and content. Given the complex nature of some of the processes in IB, achieving the right tone is not always easy.

Polarising information in the public domain

What people have heard about elements of IB is generally controversial. Media stories about the more controversial developments, namely GM crops and biofuels, have created immediate emotive

associations in the public domain which will need to be overcome. In the case of GM, participants were much more familiar with the counter arguments to this technology than any argument in support of it.

The impact of this polarising information, in combination with the cynicism amongst the public when regarding actions by big companies or the government, presents a distinct barrier for IB.

Issues of concern

There are elements of IB that the public find worrying, even with greater understanding. Not least of these is GM, both in terms of GM crops and GMOs. Participants were particularly concerned about any potential cross-contamination of 'unnatural' organisms with the 'natural' environment. This was primarily in relation to GM crops breeding with natural crops but there were also, to a lesser degree, residual safety concerns about escaping bacteria.

Participants were also concerned about the long-term impact of GM and GMOs on human populations. There were distinct concerns about the large-scale development of feedstock and how this will impact on land use. Information about regulation will likely only appease these issues to a certain degree.

Trust for independent sources

Negative messages in the public domain about these issues could have a dramatic impact on public acceptance. Participants were extremely keen to hear what green groups, such as Greenpeace and Friends of the Earth, think about these emerging technologies. Indeed, the views of these organisations, and others independent of Government and industry, such as think tanks, were largely perceived as credible sources. An oppositional view from these organisations is likely to have weight with the public.

6.4 Key opportunities

Despite low awareness levels and considerable immediate barriers, the public have the potential to become enthused about scientific developments. The overriding need is for a greater level of factual information; to dispel myths and to address misinformation. This section looks at the opportunities around information in terms of:

- Content
- Delivery
- Source

Content

Factual information is compelling and can change views. Some areas of information about IB in particular have a considerable impact:

- Understanding the science behind IB processes
- Knowing the 'generational' story of IB
- Putting IB in its energy context
- Putting IB in its social context
- Information about regulation

Understanding the science behind IB processes

By understanding many of the scientific processes behind IB, many of the barriers of fear and suspicion surrounding IB can be alleviated. Given the general low levels of knowledge of the fundamentals of science, concepts that are critical to understanding IB, such as enzymes, organisms or chemicals are largely misunderstood. This is also the case with GM - both of crops and of organisms used in industrial processes (GMOs). Explaining the fundamental processes and terminology significantly aids understanding and acceptance. To a certain extent, it aids acceptance of the use of GMOs within controlled laboratory environments.

Knowing the 'generational' story of IB

Positioning the developments in IB within a much longer scientific evolution has the potential to help overcome the significant barriers about new developments. It even has the potential to gain buy-in. It does this by increasing understanding and reassuring of IB's place within a longer process of development.

Understanding biotechnology's evolution from basic methods, such as beer distillation, to much more refined uses in industrial applications aids comprehension of IB overall by providing tangible examples that people can relate to. It also grounds IB, making it seem less of an as an abstract innovation.

Understanding the history of biotechnology helps to place IB in context and reassure that this is not a scientific leap. This in turn helps to allay many of the public's concerns that IB may be 'out of control' and offers assurance that reaching this point has been a slow and deliberate process rather than fast or unchecked.

Understanding where IB is now, and where it has come from, also highlights the benefits and potential for IB in the future. Participants could more easily identify the benefits of advanced biofuels, for example, having already understood the issues surrounding 'first generation biofuels' such as land use and insufficient scale. Understanding GM as just part of an evolution to make processes more efficient also had impacts on levels of acceptance. Knowing the various hurdles and milestones involved in the evolution helps to create more of a sense of ownership in making IB a success.

Putting IB in its social, environmental and economic context

Putting IB firmly within its environmental and economic context will directly tap into a desire for changes to 'our way of life' and demonstrates how IB can address these.

By highlighting the social and environmental challenges we are facing, participants could see the societal impetus to develop products that were more efficient and sustainable. By highlighting the economic benefits of IB, participants began to appreciate the wider movement that is underway and the necessity that the UK stay abreast - if not to the forefront - of these developments.

This wider context also helped participants understand the benefits of IB by relating them to environmental and societal issues which they were already familiar with. Issues regarding over-consumption, over-spending and resource exhaustion, for example, were all matters that participants were aware of and which helped to frame IB for participants.

Putting IB within the current energy context

Placing IB within the current energy context has several benefits in aiding public acceptance. Crucially this should take account not only of decreasing known oil reserves but also how IB fits in relation to other renewable energy sources.

Firstly, placing IB within its energy context highlights the need for an alternative to a reliance on fossil fuels and oil based products. Once participants fully understood the current situation, the potential benefit for IB in alleviating this was compelling. Placing IB within the context of other energy sources also makes the role of IB clearer, as one part in a broader solution. This is more appealing than IB as a direct replacement to oil and raises fewer suspicions about overstated benefits. It also helps to manage expectations. Positioning IB alongside more familiar renewable technologies such as solar or wind power also de-stigmatises IB by reminding the public that IB is not the only development responding to a changing global environment.

Information about regulation

Given the large concerns about control of biotechnological processes and impacts, information about regulatory procedures will have a significant impact on public acceptance of IB. This communication should include information on the origin, process and purpose of IB regulation. Regulation was an area of concern which cut across many different IB applications and provoked numerous questions not only about under-regulation but also over–regulation. Those taking part in the research sought reassurance that regulation was set at the right level by Government; it should protect the public and environment from adverse effects whilst also allowing industry the chance to harness the full potential of these carefully controlled applications. For participants there should be co-operation to ensure parity nationally

and internationally. Given this outlook, acceptance of IB is best achieved by demonstrating the full extent of both national and international regulation.

Delivery

Corresponding to the most influential content areas the key delivery factors are:

- Relating IB to ordinary life: gaining buy-in and understanding via tangible examples
- Providing the right amount and weight of information: achieving a style that presents nothing that is too overwhelming but equally not too nominal or condescending

Relating IB to ordinary life

Given the complexity and lack of awareness of IB, making IB more familiar to the public will be important. The unfamiliarity of the subject led participants to view IB as an abstraction, alien to people's lives. Everyday applications and benefits of IB were not immediately evident. Therefore, to facilitate understanding, relating IB to everyday life is crucial. People need to see how IB relates to their lives: the plastic bag in the supermarket; the insulin they use for their diabetes; the shampoo they wash their hair with; the cream they put on their face. This will also aid buy-in by involving the public in IB and removing the sentiment that it is solely the preserve of academics and industry.

Education about IB was seen to be a missed opportunity currently. When discussing communication methods, participants expressed concern that any education scheme would be targeted solely at academics and college graduates and not 'ordinary people'. For many participants, their children were crucial in their own education, imparting knowledge they had learnt at school to their parents.

Providing the right amount and weight of information

An effective communication strategy will need to explain as plainly as possible the science behind these processes in order to engage rather than alienate the public. Given initial low levels of knowledge amongst the public and the complexity of IB, the amount and weight of information imparted is critical.

An excess of information or long scientific explanations, for example, have the potential to disengage the public. Content which is too opaque and appears to be hiding facts, could fuel negativity. Equally, content which is too basic, in information and tone, makes people hostile because they feel 'patronised' or 'manipulated'.

By achieving a balance of information, the public's interest can be stimulated. This should involve building knowledge carefully; securing the basic foundations of understanding first before moving on to more complex or unfamiliar examples. For example, starting with everyday examples – beer, cheese, wine – before introducing exciting but complex examples such as the use of bioplastic ligaments in

medical interventions. There are therefore inherent advantages in unfamiliarity with IB, allowing any communication strategy to use both the everyday and the exceptional as methods to engage the public. Whilst an effective communication strategy should explain the ordinary, it can also capitalise on peoples' innate curiosity in the extraordinary.

Source

The source of any information about IB is important to public perception and acceptance. Using scientists, academics or 'expert' views substantially helps to demonstrate that information is balanced and informed. This may also help to tackle the wider image of scientists operating 'alone' and not communicating with the public.

Participants were continually looking for someone to give them an unbiased, neutral and well-rounded perspective on the issues in question. They wanted to hear from strong proponents in conjunction with strong opponents. In fact, participants assumed that there would be a negative case in every instance. However, participants rapidly realised that, just as witnesses could not provide black or white answers about IB, the opinions of sources were not straightforward either. Scientists or academics that work as industry advisors for example caused particular confusion for participants, seeming to compromise their perceived neutrality.

Looking at the different sources of information provided in the research, factors leading to trust were;

- Negative or balancing viewpoints
- Expert or broad understanding

Negative or 'balancing' viewpoints

Participants actively sought to know as many negatives as possible regarding IB. This was not necessarily out of a desire to reject IB but rather in order to frame the argument. For this reason university-based academics and scientists were most welcomed, as they were understood to be both expert and neutral. This confidence was lessened somewhat when scientists were identified as being connected to industry.

Expert or broad understanding

Scientists carried a certain novelty which participants appreciated, in part due to their perceived impartiality but also due to public regard for their ability to provide facts.

However, without provision of a more lateral approach to IB's issues and benefits, the information often seemed contrived. For this reason, academics that worked with and understood IB within a broader

social, economic and environmental context appealed, particularly for providing the complete picture that participants desired.

6.5 Conclusions

Public perception does not present an unassailable barrier to IB overall.

There are distinct barriers around the terminology of IB, especially given the limited scientific knowledge amongst the general population. The emotive associations of certain elements of IB as depicted in the media also present a barrier which can impact on acceptance of the whole. There are inherent risks in public trust of the views of negative independent sources such as environmental groups and their ability to influence public opinion.

However many of the barriers inherent in IB can be overcome by an increased understanding: about IB processes, about regulation, about the ways that IB fits in public life and how it has evolved. There is an opportunity in galvanising the public appetite for the positive and exciting benefits that science and technology can bring, and in the desire to hear more from scientists on a day-to-day basis.

Crucially, many of the remaining concerns that people have about IB are actually in relation to specific elements; namely large-scale development of feedstocks and genetic modification of these feedstocks. This is because these are seen to be the least controllable elements of IB, with the most significant potential for negative consequences. The public, on greater understanding, perceive a distinct difference between IB uncontrolled in nature and IB 'in the lab' and this difference presents a distinct opportunity.

Only once able to explore and interrogate the harm that the different applications of IB might have on human populations or the environment via factual information can people begin to think about the benefits they could have for peoples lives, to the country and to the world. It is therefore essential to provide the public with the factual information they need to facilitate this understanding.