Nanotechnology: Views of the General Public

Quantitative and qualitative research carried out as part of the Nanotechnology study

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Prepared for:

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1 Introduction

This report presents the findings of the research undertaken by BMRB Social Research on behalf of the Royal Society and the Royal Academy of Engineering's Nanotechnology Working Group. This research comprised two elements: a qualitative strand, consisting of two evening workshops, and a quantitative strand, for which questions were placed on BMRB's face-to-face omnibus survey from 8th to 14th January 2004.

The quantitative research aimed to assess awareness about nanotechnology, and also whether nanotechnology would have a positive or negative effect on quality of life. The qualitative workshops aimed to examine public awareness of and attitudes towards nanotechnology, and to examine views on its likely environmental, health and safety, social and ethical implications. They also aimed to identify areas for concern and any questions the public had about nanotechnology. Finally, the workshops aimed to discuss the regulation of nanotechnology.

1.1 Structure of the report

The report begins by covering the background to the research. The qualitative sample and rationale behind it are discussed. The qualitative and quantitative methodology used to conduct the research is then given, including the format of the qualitative workshops and their use of experts.

Respondents' knowledge of and attitudes towards other new technologies are then examined, providing an attitudinal backdrop against which to view the later chapters discussing nanotechnology in particular. The positive and negative aspects of new technologies are discussed, as is the process by which respondents form conclusions about whether a new technology is "good" or "bad".

The report then turns to respondents' knowledge about nanotechnology and the sources of their awareness. Their reactions to nanotechnology, both in terms of the concept and on being given further information, are then discussed. Their thoughts on possible ethical, financial, social and political, environmental and health and safety implications are considered, and the issues of reliability, control and regulation are also presented.

Hardening attitudes, and the attitudes of those adopting a "wait and see" opinion about nanotechnology are then discussed.

2 Summary

There was limited awareness about nanotechnology seen in the qualitative workshops, and also in the quantitative research, in which 29% of respondents said they were aware of the term. Awareness was higher among men (40%) than women (19%), and was slightly lower for older respondents, falling from around a third for those aged under 55, to a fifth (20%) of those aged 65 or over. There was also a clear pattern by social grade, with awareness peaking at 42% for ABs and falling to 16% of DEs.

The majority (68%) of those who were able to give a definition of the word felt that it would improve life in the future, compared to only 4% who thought it would make things worse. Supporting the findings of the qualitative research, which showed that respondents' decisions about whether a technology is "good" or "bad" depends on what it is used for, 13% said that whether nanotechnology would make things better or worse depended on how it was used, despite the fact that this was not presented as an option on the questionnaire.

The more in-depth exploration of respondents' views that was possible in the qualitative workshops revealed that, although there were major concerns about nanotechnology, as with any new technology, the mood was not one of unrelieved negativity. Indeed, there was much that respondents thought was positive, or potentially so. However, it was felt that nanotechnology was very much an untried technology, and as such its potential benefits and drawbacks would only become clear over time.

2.1 Key concerns and reassurances required

Respondents were concerned about many aspects of nanotechnology, including:

- Its financial implications: whether there would be an adequate return on any investment made by the UK; also whether the UK could afford *not* to invest; and who might make such an investment, and with what sort of hoped-for return;

- Its impact on society: employment; social freedom and control; the position of the Third World in relation to industrialised nations; and the possibility of corporations gaining influence;

- Whether or not nanotechnology, and devices using it, would work, particularly for applications used within the human body;

- The long-term and side-effects of nanotechnology: whether enough was being done to establish what these were, and whether or not lessons had been learned from the past (e.g. from nuclear technology); and

- Whether nanotechnology could be controlled: whether this could be done internationally as well as nationally; whether the public would be involved and whether they would be capable of making a contribution; also, whether the public's contribution to the debate would be listened to

It was felt that reassurances on the above were necessary, although the balance of respondents' concerns obviously varied from individual to individual.

2.2 Key positives

There was also much that respondents were positive towards. The key areas in which it was felt that nanotechnology had a potential contribution to make, or which interested respondents, included the following:

- The exciting nature of nanotechnology: the sense that it was untried and, as such, had untapped potential, and an unknown number of ways in which humankind and individuals could benefit;

- The possible applications of nanotechnology: respondents were particularly positive towards medical and, to a lesser extent, cosmetic applications;

- The possible creation of new materials, potentially being more useful and creating less waste;

- A sense that nanotechnology was a natural technological progression and that, in the future, arguments against nanotechnology developments will appear to be ridiculous; and

- A hope that nanotechnology would improve quality of life, both through the creation of new products and new medical treatments

3 Background to research and sample

In June 2003 the Royal Society and the Royal Academy of Engineering were commissioned by the UK Government to carry out a joint independent study of likely developments in nanotechnology and to examine whether nanotechnology raises, or is likely to raise, new health and safety, environmental, social or ethical issues which are not covered by current regulation.

The study as a whole aims to:

- Define what is meant by nanoscience and nanotechnology;
- Summarise the current state of scientific knowledge on nanotechnology;
- Identify the specific applications of the new technologies, in particular where nanotechnology is already in use;
- Carry out a forward look to see how the technology might be used in future, where possible estimating the likely time scales in which the most far-reaching applications of the technology might become reality;
- Identify what environmental, health and safety, ethical or societal implications or uncertainties may arise from the use of the technology, both current and future; and
- Identify areas where regulation needs to be considered.

To do this, various groups of stakeholders are being consulted, including:

- Academia;
- Scientists and engineers;
- Civil society groups;
- Policy-makers;
- Industry;
- Special interest groups; and
- The general public

BMRB Social was commissioned to carry out research with a sample of the general public as part of this study. This research was both quantitative and qualitative in nature, and had two strands. The first was a survey with a representative sample of 1005 adults aged 15 or over in Great Britain. This was designed to give a measure of awareness of nanotechnology among members of the general public and whether they thought it would have a positive or negative effect on quality of life. The second strand consisted of two in-depth workshops with members of the public, which aimed to explore their ideas about and attitudes towards nanotechnology, and to identify and discuss areas for concern and questions they had. They also aimed to discuss the issue of the control and regulation of nanotechnology. It was not the remit of the workshops to explore public behaviours associated with nanotechnology and its applications – as these would be largely hypothetical at present – although the present attitudinal research will provide a context for any future work which may do so.

3.1 The qualitative sample

Two workshops were held: one with respondents fitting an ABC1 socio-demographic profile (professionals) in London; and one with respondents fitting a C2DE profile (those working in skilled or unskilled manual jobs, or dependent on state benefits) in Birmingham. Respondents were aged from 18 upwards and the genders were mixed. Those working with science or technology in a professional capacity were excluded from the sample, with the only exception being those using computers. Those using computers could not be involved with them in a design and developmental sense.

	Total	**Socio-economic grade**		**Age**		**Ethnicity**		**Gender**	
London	23	A	4	18-34	10	White	16	Male	12
		B	12	35-54	6	Afro-Caribbean	7	Female	11
		C1	7	55+	7				
Birmingham	27	C2	14	18-34	9	White	19	Male	15
		D	10	35-54	9	Asian	8	Female	12
		E	3	55+	9				

3.1.1 Rationale for the qualitative sample

3.1.1.1 Divisions used

The sample was designed to take account of five variables:

- Location;
- Socio-demographic grade;
- Age;
- Ethnicity; and
- Gender

It was felt to be important to cover all these areas for two reasons: firstly, to provide a more accurate reflection of society (obviously important in any study purporting to represent the views of the "general public"); and secondly, to allow for any differences to be examined, although the extent to which this is possible in a small-scale study is limited. The reasons for choosing specifically these variables were based on previous experience of conducting qualitative research with the general public, and are set out below.

3.1.1.1.1 Location

Qualitative research is often carried out in more than one location in order to take account of any prevailing differences between different geographical areas. The specific locations used can vary (for example, in some studies it might be advisable to contrast urban with rural areas, or different countries). For a study involving just two workshops, where no other specific factors are indicated, it is more usual to contrast London with a provincial city, typically Manchester, Leeds or Birmingham.

3.1.1.1.2 Socio-demographic grade

It is also well known that socio-demographic grade is linked to the nature of participation in discussion groups. Professionals not only tend to be more articulate but also more dominant in a group situation, which is one reason why some separation is often attempted when qualitative research into academically "difficult" or complex topics is conducted. This allows potential issues around respondents dominating the discussion, or deferring to others who appear to be better-informed (whether or not this is in fact the case) to be minimised, and makes for the preservation of a more balanced group dynamic. A list of the occupations represented in each workshop is given in Appendix 7.3.

3.1.1.1.3 Ethnicity

It was felt to be important to include the views of ethnic groups in the study, in order to present a more accurate picture of British society and to take into account any prevailing cultural issues. It is often the case that, unless specific quotas are set for the inclusion of ethnic minorities, the resulting groups will be composed mainly of white people. It was therefore decided that quotas would be put in place to ensure that the views of ethnic minority people were reflected in the study. It was decided that, to avoid "tokenism" and the implicit assumption that all ethnic minorities are the same, to concentrate on one ethnic minority group in each area: Afro-Caribbean in London and Asian in Birmingham. While clearly not a comprehensive coverage of ethnic minorities, it was felt that the size of the study made this the best way of examining any potential cultural differences.

3.1.1.1.4 Age and gender

Age and gender are standard demographics used in social research and quotas are usually set to ensure that the findings of the research are not biased towards a younger or older age group, or towards either gender.

3.1.1.2 Setting out the sample

The decision to set out the sample as above was based on a number of factors. Taking into account the variables above (location, socio-demographic grade, age, gender and ethnicity), location was an obvious variable according to which the sample needed to be split.

It was known that the sessions would consist of three breakout groups as well as plenary sessions, so the decision was taken further to split the sample along demographic lines, in order to take account of any differences. Of the remaining four variables (socio-demographic grade, age, gender and ethnicity), it was felt that socio-demographic grade and age were the natural ways in which the sample should be split.

The reasons for this were threefold. Firstly, the nature of the research, being concerned with science and technology, suggested that that age and socio-demographic grade might affect respondents' views. Secondly, keeping respondents broadly consistent in terms of age and social background enables discussion groups to bond more quickly, thus facilitating discussion. Lastly, where the research does not specifically concern gender or ethnicity, it is standard practice for groups to be mixed in these terms.

The issue of dividing respondents for the breakout groups had also to be considered, and carried out in a way that would not cause offence. It was felt that carrying out the ABC1 group in London and the C2DE group in Birmingham would make the socio-economic division less visible. It was also thought that, of age, gender and ethnicity, age was both the

most useful (in terms of having a potential effect on responses) way to divide respondents, and the way least likely to cause offence on separation.

London groups were split in the way described above; however, the Birmingham sample was divided into two instead of three owing to staff sickness[1].

3.1.2 Incentives

Respondents were given an incentive of £50 for attending the three-hour workshop. Incentives are used as standard in conducting qualitative research as, unlike in quantitative research, focus groups and workshops often take place at some distance from the respondent's homes. Incentivising respondents therefore makes it more likely that they will attend, thus cutting down on the need to reschedule groups. This was felt to be a particular issue considering the timing of the workshops, which both took place in December.

Not incentivising respondents also makes it more likely that those who attend will be those with an agenda of their own, or with a special interest. This can make it difficult to collect unbiased information. A further reason for using incentives is to aid inclusion by helping to overcome any financial difficulties associated with participation – for example, paying for a babysitter for those with children, or transport for those with mobility problems.

3.2 The quantitative sample

The face-to-face omnibus survey on which the questions were placed uses a random location sampling technique. This is a single-stage sample design, taking as its universe all Enumeration Districts (EDs) in Great Britain. Interviewers are provided with street lists with specific addresses so that the choice of location is not within their control. Within each sampling point, quota controls are set in terms of gender, age and working status - characteristics which are known to have a bearing on individuals' probabilities of being at home and so available for interview.

[1] The research team were still able to take account of any differences in terms of age in the Birmingham workshop, and the reported findings take account of such differences, but the Birmingham quotes do not have an age band reported for this reason.

3.3 Research methodology

3.3.1 Qualitative

3.3.1.1 Format of workshops

The workshops were three hours long and comprised both plenary sessions, where the whole group came together for discussion, and breakout groups, where respondents were divided into smaller units (three groups in London and two in Birmingham). These sessions served different purposes. Whole-group discussion allowed the concept of nanotechnology to be introduced and respondents to discuss their initial reactions. They also allowed respondents to share and discuss the topics covered in the breakout groups. The smaller breakout groups allowed more in-depth exploration of the themes and issues arising than would have been possible in the whole-group setting, and also allowed all participants to be involved.

The programme of breakout groups and plenary sessions, along with the topics covered at each stage, can be seen in the timetable below.

10mins	Introduction, welcome	Give background about project, give aims and agenda, explain what will be required of respondents
20mins	First breakout group	Respondents' views about new technology. Introduction of the concept of nanotechnology without giving information. Respondents' initial reactions, if any.
30mins	Plenary session	Scientist presents basic information about nanotechnology and the possible range of its applications to the whole group. Opportunity for respondents to ask questions.
10mins	Tea break	
60mins	Second breakout group	Group discusses the acceptability of nanotechnology. Five scenarios in which nanotechnology might be used are provided and initial reactions to each examined. Scientist rotates between the groups at set times and for set periods in order to answer questions.

40mins	Second plenary session	Respondents feed back what the groups have learned and discussed on a group-by-group basis for 10-15 minutes. For remainder of sessions, whole group discusses what they have learned while scientist remains available to answer questions raised during the course of the discussion.

3.3.1.2 Use of experts

All sessions were moderated by a professional researcher from BMRB Social Research. However, because of the nature of the research and the likelihood that respondents would have questions that the research team were not able to answer, it was decided to use scientists from the Nanotechnology Working Group as "expert witnesses".

Having a scientist at the workshops to give an expert viewpoint was useful in a number of ways. Firstly, it allowed respondents to feel that their questions were being taken seriously and thus encouraged them to participate further in the discussion. Secondly, it allowed the research team to concentrate on moderating the group discussions instead of setting up a dynamic where the researcher was viewed as the "expert". Thirdly, this dynamic might have led the research to founder, as there would inevitably have been many instances where the research team were unable to answer a scientific or technical query. The scientists' involvement therefore allowed respondents' responses to be based as much on fact, as opposed to speculation, as possible.

3.3.1.2.1 Involvement of the scientists

Scientists' tasks were:

- To deliver a basic explanation of the concept of nanotechnology to the whole group during the first plenary session;

- To draft stimulus materials including scenarios explaining some of the uses of nanotechnology before the workshops took place;

- To be on hand while respondents discussed the scientists' pre-prepared scenarios in order to answer questions during the second breakout groups; and

- To be on hand during the closing session to answer questions that respondents might have.

3.3.2 Quantitative

Questions were placed on BMRB's face-to-face omnibus survey from 8-14th January 2004. The questions were asked of a representative sample of 1005 adults aged 15 or over in Great Britain. All interviews were conducted in-home.

The questions were designed to gain a measure of the self-reported level of awareness of nanotechnology, and for those who self-reported that they were aware of it, to find out what they believed nanotechnology to be, and whether (broadly) they thought it would be a positive or negative development. The questions asked are given in Appendix 7.4.

4 Knowledge about and attitudes towards new technologies

This chapter provides a summary of respondents' knowledge about new technologies and their attitudes towards them, and attempts to unpack the factors that have influenced the forming of these attitudes. It brings out the differences between the ways in which respondents view consumer and non-consumer technologies. It then turns to consider positive and negative elements about new technologies: what triggers respondents to form positive or negative opinions and how they reach a conclusion about whether a technology is "good" or "bad". Finally, it examines the sources of information respondents have about new technology. This chapter forms an important explanation of the context to respondents' views about nanotechnology, as nanotechnology is another "new" technology.

4.1 Awareness of new technologies

4.1.1 Consumer technologies

When asked what recent technological developments they were aware of, respondents gave an enormous variety of answers, including:

- Communications: the development of the Internet and its becoming widespread in the home and workplace; the development and increasing sophistication of mobile phones; satellite and cable TV; and digital radio and TV;
- Digital cameras;
- DVDs;
- Minidisc;
- Performance fabrics;
- Developments in computer technology leading PCs to become smaller and more sophisticated;
- Watches;
- Carbon fibre tripods for use in photography;
- Switch cards;
- PlayStations; and

- MP3 technology and iPods

Respondents' initial responses when thinking about technology centred largely on its consumer applications. They did not spontaneously associate the word "technology" with other applications, and tended to have to be prompted to think about these with a phrase such as "scientific developments". Indeed, there were respondents who specifically said that they drew a clear mental distinction between the two descriptions.

"I'd define that as more scientific developments than technology."

(Male, 35-54, ABC1, London)

4.1.2 Non-consumer technologies

Not all applications respondents perceived as being "technology" were consumer products, however. They were also aware of applications such as:

- The new "tilting" trains;
- Oyster cards (London)
- Laser-based measuring tools;
- GPS technology;
- MRI scanning;
- Armaments; and
- Technology that can "smell" plastics.

When respondents considered "technology" also to include the area of "scientific developments", the range of applications they named widened to include those in the medical and forensic fields, which could not be bought. These were often those that had received extensive media coverage, such as:

- Genetics: cloning (animal and human); GM products; the human genome project; the development and improvement of forensic DNA testing
- Transplants: organ donation from animals; face transplants;
- IVF and embryo selection; and
- Stem cell therapy.

There was no spontaneous mention of nanotechnology, either when respondents were discussing "technology" or "scientific developments".

4.1.3 Pace of technological change

The pace of technological change was felt to be accelerating. Respondents could feel isolated and left behind by this, particularly amongst the older age groups. This sense of isolation was exemplified in various ways from their own lives, including:

- Feeling unable to get to grips with a new technology (e.g. computers) completely;
- Being used to an out-of-date version of a commonly-used product and feeling unable to use later versions (e.g. Microsoft Windows);
- Feeling bewildered by the number of different products and types of products on the market and feeling increasingly unable to keep up with them;
- Feeling that it was difficult as a consumer to keep up with the latest technologies (e.g. replacing an entire vinyl record collection with CDs); and
- Making the decision to buy a new consumer product, e.g. a digital camera, but then not being able to use it.

"Everything seems to gallop… I mean you've got records, then you've got CDs, and you've got videos and everything has just come on top of each other. I've got that many different things in here that it's unreal."

(Female, C2DE, Birmingham)

"I think the principle is devastatingly exciting, absolutely wonderful, brimming with possibilities, I just wish they'd slow up and teach us first… Let us know how to operate the damned videos before we can go to the next stage."

(Male, 35-54, ABC1, London)

"We're so inundated with so much new technology, it's impossible to keep up with all of it."

(Male, 18-34, ABC1, London)

"The one guideline is that it's going to be superseded in the next six months, I mean I replaced almost all my vinyl onto CD, and then some bastard started talking about mini CDs, I just went through the roof and thought, 'I've just been ripped off'."

(Male, 35-54, London)

"I feel like there's a yawning gulf between me and understanding... I have a digital camera that I bought in October two-and-a-bit years ago, I can't even bring myself to open the instructions, it's probably obsolete by now."

(Female, 55+, ABC1, London)

It could be felt that the fast pace of technological change meant that society became more "throwaway" and ready to abandon things that were still useful, just because they were out of date or because a better item was available.

"Whatever they make today is out of date by tomorrow, so that's why we are a society that just becomes disposable, because we advance tomorrow's technology, and we make a better item."

(Male, C2DE, Birmingham)

Respondents could also feel isolated from the world of science as a whole, and not just from its consumer applications. There was a feeling that scientific knowledge has advanced so much that it is now impossible for scientists fully to understand each other's work. It was thought that, if scientists could not share their work among themselves, it would be too complicated to share with a lay audience. This created a feeling that scientists were an elite body, and some respondents felt this made them less accountable.

"There was a point where technology could be explained to the proletariat, they would understand; even a car technology you can understand, but the technology now has moved on. You have to be so specialised."

(Male, 55+, ABC1, London)

4.2 Positive and negative aspects to new technologies

Respondents were generally positive towards most of the new technologies they named, with GM foods, embryo gender selection and human cloning being exceptions. Conversely, even those technologies that they felt positive towards were often thought to have a negative side. Overall, there was the view that nearly all technologies have both points in their favour and points against them. The balance of these was therefore crucial in determining whether respondents felt positively or negatively towards the technology as a whole.

"I think you have positive and negative aspects about anything that has an element of technology."

(Female, 18-34, ABC1, London)

4.2.1 How respondents form positive and negative opinions about new technologies

Respondents appeared to form an overall opinion about how they felt about a new technology by assessing its likely positive and negative impacts. However, the most important factor among these was whether or not it was likely to have a positive impact on their own lives. Generally, most other factors would be subordinate to this in importance to respondents so, for example, it was perfectly possible for respondents to acknowledge that a technology had many negative aspects, but still to use it.

4.2.1.1 Negative impacts

Respondents weighed up the pros and cons of a new technology by assessing its negative impacts against its positive impacts. Negative impacts respondents said they considered included the effects of a new technology:

- On their sense of morality;
- On the environment;
- On children;
- On the family, and society as a whole;
- On developing nations;
- On health

4.2.1.1.1 Sense of morality

The impact of a new technology on respondents' sense of morality was an important negative factor influencing their opinions. Respondents referred to a technology as not being "natural", which meant in this context something more than "that which does not occur in nature". It was particularly likely to refer to something that subverted respondents' ethical beliefs or notions of good taste. This was often also described as "not being right".

Examples of technologies that respondents did not feel were "right" included GM crops, which aroused spontaneous mistrust. This was because the possibility of, for example, introducing animal DNA into a plant crop, felt wrong to respondents as it was a process that could not occur in nature.

"One of the classic examples is GM food, we all understand that for centuries people have been developing, basic grass has created grain, even by cross-fertilisation, we all understand the genetic side of it. When we

get slightly worried is when they start putting animal proteins into it, because we know that somehow intrinsically that ain't right."

(Male, 55+, ABC1, London)

Other technologies that were felt to be "not right" included, in particular, those involving interference with the natural reproductive process – e.g. cloning and embryo gender selection. These were often referred to as "playing God".

"I'm for a lot of them, (new technologies) *but I've got a lot of reservations about answers in the medical field in particular, in relation to cloning and stuff like that. Messing about with nature, reproduction, playing God."*

(Male, C2DE, Birmingham)

"It doesn't sit well with me. I believe in sort of the natural force of nature to be honest."

(Male, C2DE, Birmingham).

"Playing God" was a phrase that was used in a negative sense, and one which respondents spontaneously reached for to disparage certain technological developments. However, they often found it to be difficult to be more specific about their use of the phrase. For example, they acknowledged that IVF could be described as "playing God" in the sense that it allowed humankind to "create" life, but did not use the phrase to describe this technology as, for example, they could to describe embryo gender selection. This was because IVF was felt to be an essentially beneficial technology in allowing childless couples to have children, whereas embryo gender selection was seen to subvert nature by allowing an imbalance between the genders to be created.

Despite respondents' use of the phrase "playing God", it was also felt that there were certain circumstances where technologies that were felt to do so could have beneficial outcomes. For example, it was acknowledged that embryo gender selection could allow parents to avoid passing on hereditary diseases. It was also recognised that popular ideas about what was "playing God" could change over time. For example, IVF and organ donation, which are generally accepted now, have caused controversy in the past. Crucially, it was felt that, should such a technology, however "unnatural" be beneficial to themselves or their families, respondents would have no hesitation in using it.

"Ten years ago people said that (IVF) was wrong, you're playing God and you shouldn't be doing that, now we take it totally for granted and we think it's marvellous."

(Female, 35-54, ABC1, London)

"Obviously for the family of the person ill, you are going to go for it."

(Female, C2DE, Birmingham)

4.2.1.1.2 Environment

Respondents said they assessed the impact of new technologies against their impact on the environment – for example, whether it created waste, pollution or other problems for future generations, or was wasteful of natural resources. However, their attitudes in this area in particular were not always consonant with their behaviour (see Section 4.2.1.3.1)

4.2.1.1.3 Children

Technologies' potential negative impacts on children were also considered. It was felt to be adults' duty to limit children's access to technologies that might do them harm, whether directly or indirectly, or that might allow them to store up problems for the future. An example of this type of technology was the Internet. This was thought to put children at risk from paedophiles and pornography, as well as potentially having an effect on their articulacy by discouraging verbal communication, and encouraging lack of exercise, obesity, and the health problems associated with these in later life. Section 4.2.1.3.1 describes the extent to which these feelings actually influenced respondents' behaviour.

"Nobody seems to go out and play any more, do they? They are all stuck up in their rooms and you never see them."

(Female, C2DE, Birmingham)

"We've seen the dangers of what can be picked up with computers such as the pornography or whatever, and indeed on a physical level, we still don't know what effect it's having on a child to sit in front of a computer for so long."

(Female, 55+, ABC1, London)

4.2.1.1.4 The family and society as a whole

Potential impacts on society and social interaction, and in particular the family unit, were also considered. It was said that anything encouraging the breakdown of social networks, or having a negative impact on the way people interact with each other, encouraged respondents to feel negatively towards it. Another negative effect was thought to be the uses that rogue elements in society could make of a technology to further their own ends (e.g. terrorists and paedophiles making use of the Internet).

A technology's effects on the family unit were considered, and respondents were similarly less likely to feel positively towards something which made members of a family less likely to talk to each other. Examples of this included the Internet, PC games and PlayStations, which provided family members with an alternative to interacting with each other.

"It's descending with the PlayStations and things, there's no more family dinners left. We don't sit at the table and have Sunday dinners any more."

(Female, C2DE, Birmingham)

4.2.1.1.5 Developing nations

Technologies which had a negative effect on developing nations were also viewed more negatively. This could involve developing countries' economic exploitation, for example by using cheap labour to build appliances, or by large corporations creating patents and developing a stranglehold on the market. Examples of negative effects on developing countries could also be environmental, for example through pollution or the exploitation of their natural resources.

"When you know you're using … part of the world's suffering when you're using it, there's been some kind of exploitation somewhere to do that, then it doesn't sit very comfortably."

(Male, 18-34, ABC1, London)

4.2.1.1.6 On health

Respondents also assessed the impact of a technology on health. A technology could have either a direct negative impact on health or an indirect impact, for example through discouraging exercise.

4.2.1.2 Positive impacts

The potential and actual negative impacts of new technologies were weighed up against their positive impacts. The process by which this was done will be examined in more detail in Section 4.2.1.3. Positive impacts respondents said they considered included their effect:

- On humankind; and
- On their personal quality of life

4.2.1.2.1 Humankind

The potential positive impacts of a new technology on humankind in general were considered. An example of this might be new medical treatments, which respondents might feel were beneficial to other people even if they had never needed to use them themselves.

4.2.1.2.2 Personal quality of life

Personal quality of life was by far the most important positive or negative impact considered by respondents. Even where a technology had a substantial number of negative points against it, it was judged more favourably if it had a positive impact on their own quality of life. A positive impact on their own quality of life could be made in various ways. Examples given included:

- The development of new medical treatments;
- New developments that made their lives easier (e.g. microwave ovens, the Internet);
- Developments that allowed them to save time; and
- Developments that brought down the price of new technology

4.2.1.3 Finding the balance

It appeared that respondents undertook a mental "weighing-up" process, during which the potential positive and negative effects of a new technology were assessed and evaluated in relation to each other. Respondents spoke of a "trade off" or "offsetting" process by which the two were compared. This was apparent when they spoke about the comparative worth of new technologies.

"I think financial gain and commercial gain which is the argument for GM foods, against environmental damage, I think it's a tricky line to run with… you offset the environment against commercial gain."

(Male, 18-34, ABC1, London)

It was surprising, however, to note that in many cases respondents used new technologies and appreciated the positive effects they could have on their lives while appreciating that that their negative impacts could be substantial.

"I have a mobile phone but they can interfere with the brain's own wavelengths… it's good to have a phone if you're in a situation where you need to use one in an emergency, but at the same time the problem is at what cost?"

(Female, 35-54, ABC1, London)

It was concluded that no technology was necessarily entirely good or bad in itself, but only in the applications to which it was put. Respondents also stressed that almost any technology was open to abuse.

"Basically, it's down to exactly what they are going to do with it."

(Female, C2DE, Birmingham)

4.2.1.3.1 Conflicting attitudes

As mentioned above, people were capable of holding attitudes towards new technologies that were not consonant with their actions[2].

These dissonant attitudes were especially apparent when the subject under discussion was a consumable application of technology. Weighing up the pros and cons of consumable technologies tended to take place to some extent, but this process was in the end subordinated by the effect on respondents' own quality of life. Examples of this in practice included:

- Being aware that their clothes were probably made by children in sweatshops (economic exploitation of the Third World) but still continued to buy them
- Knowing that the Internet can encourage rogue elements in society (e.g. paedophiles, terrorists), that it can have a negative effect on family life and social interaction and can, potentially, indirectly affect children's health (obesity, lack of exercise). However, also finding it to be a useful tool or have a positive effect on their personal quality of life, so using it
- Knowing that air travel damages the environment through pollution and involves the consumption of large amounts of natural resources, but not wishing to cut down on the frequency of foreign travel

"At the end of the day people aren't willing to make that sacrifice … once they get back to their real life, that's difficult to give up things they've been used to."

(Female, 18-34, ABC1, London)

[2] This gap between attitudes and actions is recognised in social psychology and is termed cognitive dissonance: a state of mind experienced when it is noticed that various attitudes held are inconsistent with actual behaviour (Festinger, 1957)

"Technology is a wonderful thing, I like my microwave, I like my fridge, I like my computer, I like driving in the car, at the end of the day there's a kind of a trade off there of which I don't actually feel comfortable with."

(Male, 18-34, ABC1, London)

4.2.1.3.2 Non-consumable technologies

The weighing-up process for non-consumable technologies, by contrast, was less pragmatic and more spontaneous. Respondents were more likely to make ethical judgements about, and hence to be critical of, non-consumer technologies. This could lead them to make a spontaneous negative judgement about a technology (e.g. embryo gender selection) that could later be revised (e.g. when asked to consider its applications in preventing hereditary disease).

"At the moment we are divided between ethics when it comes to the human body. But when it comes to, like DVD players, mobile phones, we do not look at the ethics of it."

(Male, C2DE, Birmingham)

Often the potential possibilities of non-consumer technologies were more feared, perhaps because of a sense that non-consumable technologies are more open to abuse, or because something about them aroused suspicion, mistrust, or a feeling that something was "not right".

"Improving quality of life by replacing videos with DVDs, I mean it's like keeping up with the Joneses, you are always replacing things to improve and things like that. That's O.K. But when they are cloning children, there don't seem to be that many boundaries."

(Female, C2DE, Birmingham)

Again, the weighing-up process respondents undertook for non-consumable technologies was generally subordinate to self-interest. They acknowledged that they would use even a technology that they found distasteful if necessary – for example, to save their own life or that of a member of their family[3].

The evaluative process for non-consumable technologies tended to be undertaken through a process where respondents imagined the different scenarios in which it could be used,

[3] They also, however, recognised that this was not always the case. In this context the example of Jehovah's Witnesses was cited as an example where religious views over-rode self interest in relation to non-acceptance of blood transfusions.

some of which they were negative towards and some of which they were positive towards. So, for example, a technology such as GM foods that they were generally negative towards could be understood to have positive applications such as enabling higher-yield crops to feed the Third World. Conversely, a technology they were generally positive towards, such as IVF, could be understood to have applications they would be negative towards, such as enabling elderly women to have children.

4.2.1.3.3 Weighing up the pros and cons: conclusions

- Respondents weighed up the positive and negative aspects of new technologies, but were ultimately largely ruled by self-interest
- Non-consumable technologies tended to be judged more spontaneously than consumable technologies, especially those which were felt to "play God"
- All technologies were felt to have both positive and negative aspects, and the potential for abuse: it is the purpose for which they are used that determines whether respondents felt positively or negatively towards them
- Mental and moral lines and boundaries proved to some extent to be impermanent, and could vary from individual to individual, case to case and over time
- A new technology was ultimately more likely to be judged positively if respondents could see a direct benefit to themselves

4.3 Information about new technologies

Information about new technologies was gleaned from a variety of sources, for example:

- Newspapers (articles, editorials);
- Word of mouth (someone talking about a new technology, seeing a piece of hardware at someone's house);
- Manufacturers' information (advertising);
- TV (news, documentaries); and
- The Internet (websites, search engines)

"Yes, people talk to each other and say, 'I've got a new microwave and this is called such and such, it's really good.' 'Is it good?', 'Oh yes, I've had it for about six months now and no problems.' That's sort of word of mouth."

(Female, C2DE, Birmingham)

It was felt that there was a great deal of information about new technology around, which led to a sense of "information overload". Respondents not only felt that there was too much information, but were not sure how to navigate their way around it or how much of it they could believe. This was due to a number of factors, including:

- Conflicting reports of research carried out into the same subject, and not being sure which to believe;
- Selective reporting of certain elements of research in the media, not giving the whole picture in order to make a better story;
- Different editorial stances in different newspapers leading to different slants being put on the same topic; and
- Manufacturers deliberately using technical language to confuse consumers and make their products look more impressive: "blinding with science"

"It depends who is giving the information because if you get certain newspapers… I know it sounds Big Brother, we've got to go back to who's the owner of the paper."

(Male, 35-54, ABC1, London)

"The biggest mistake I've made in the past is getting this information from the media… it is so vast, if you read all of the broadsheets and tabloids throughout the weekend, you're going to get so many different views on it and unfortunately what you need to do is go out and find out for yourself, and do that research."

(Male, 18-34, ABC1, London)

"I think we're getting too much information about technology and it's done on purpose because it makes it sound more impressive. Look at hair advertising – they start with all the ologies, suddenly it becomes scientific."

(Male, 35-54, ABC1, London)

Respondents could therefore hold the attitude that there was an "information overload" in conjunction with a feeling of not having sufficient specific or reliable information about technology or scientific development.

5 Awareness of and knowledge about nanotechnology

The extent of respondents' knowledge about nanotechnology was investigated during both the qualitative and the quantitative research. Before the scientists gave respondents basic information about nanotechnology during the qualitative workshops, they were asked whether they had heard the word and how much they knew about it.

5.1 Awareness of nanotechnology

5.1.1 Quantitative

As shown in Table 1, the omnibus survey results showed that three in ten respondents said they had heard of nanotechnology (29%). Awareness was higher among men (40%) than women (19%). Awareness was slightly lower for older respondents, falling from around a third for those aged under 55, to a fifth (20%) of those aged 65 or over. There was also a clear pattern by social grade, with awareness peaking at 42% for ABs and falling to 16% of DEs. Any differences by region can be explained by differences in social grade profiles between the regions. Small base sizes make comparisons by ethnicity difficult, but there was no clear difference between white and non-white respondents.

Table 1 - Awareness of nanotechnology (all respondents)

	Unweighted base		Heard of nanotechnology	Able to give some definition (whether accurate or not)
All	1005	%	29	19
Gender				
Male	431	%	40	30
Female	574	%	19	10
Age				
15-24	130	%	35	17
25-34	183	%	30	20
35-44	210	%	33	24
45-54	152	%	32	26
55-64	130	%	26	19
65+	200	%	20	11
Social grade				
AB	181	%	42	30
C1	278	%	32	21
C2	196	%	25	16
DE	350	%	16	9

5.1.2 Qualitative

Some awareness of nanotechnology was observed in both workshops, although awareness was limited. This bears out the quantitative findings, which showed that 29% of respondents overall were aware of the term. Again bearing out the quantitative results, which showed that men were nearly twice as likely to be aware of the term as were women, awareness was particularly low amongst female respondents. Awareness of nanotechnology did not seem to differ according to ethnicity, although it appeared to be a little higher in the ABC1 than in the C2DE group. However, the nature of qualitative research means that it is not possible to make numerical judgements, and the above results are given only as an indication.

5.2 Extent of knowledge about nanotechnology

Perhaps unsurprisingly, given the extent of awareness of nanotechnology as a term, knowledge about nanotechnology also proved low. This was true even for those who had heard of the word. Although respondents obviously varied, some difficulty in defining the term was generally observed.

5.2.1 Quantitative

When asked what they thought nanotechnology was in the omnibus survey, a third said they did not know – often saying that they had "just heard of it", but didn't know what it was. This reduces the proportion who had heard of nanotechnology, and were able to give some definition (however accurate) to one in five (19%). This accentuates the difference by gender – women were more likely than men to say they did not know what nanotechnology was meaning that, in total, 30% of men and only 10% of women had some idea of what nanotechnology might be.

The youngest and oldest respondents were most likely to say they did not know what nanotechnology was. This means that those aged 35-54 were most likely to be able to give some definition of nanotechnology (around a quarter).

Table 2 - Understanding of nanotechnology (all respondents/all heard of nanotechnology)

	All	All heard of nanotechnology
Unweighted base	1005	262
	%	%
Don't know (inc. "not heard of it" for all respondents)	81	34
Micro/small technology/science	5	18
Miniaturisation/making things small or tiny	4	13
Any mention of computing/internet	2	8
Putting small things into the body/blood, implanting	2	6
Miniature/small robots/droids	2	6
To do with atoms and molecules	1	5
Microchips/small microchips	1	4
Making things faster	1	4
Very small measurement/dimensions/nanometres	1	3
Mentions of being medical	1	2
Any mention of electronics/circuits	1	3
Mentions of repair and regeneration	*	1
Science fiction/futuristic	*	1
To do with mobile phones/3rd generation phones	*	*
Other	*	1
COMBINED CODES:		
MAKING THINGS SMALL/SMALL SCALE TECHNOLOGY	14	46
DEFINITION BASED ON PARTICULAR APPLICATIONS	9	30

As shown in Table 2 above, the most common definitions of nanotechnology centred on miniaturisation, or technology on a very small scale. In total 46% of those who had heard of nanotechnology gave an answer in this vein (14% of all respondents). Another frequent approach to defining nanotechnology relied on a particular application such as computing, electronics, or medicine. This type of answer was given by 30% of those who had heard of nanotechnology (9% of all respondents). Table 2 above shows more detail of the particular responses given.

Despite publicity during fieldwork on cancer scares for those working with nanotechnology, this did not appear to have any impact on responses given to this question in the omnibus survey. Respondents in the qualitative workshops, however, did make some mention of stories that had appeared in the media (see Section 5.2.2).

5.2.2 Qualitative

As might be expected in the light of the quantitative findings, those in the workshops who had heard of the term nanotechnology generally knew very little about it and found it difficult to define. One respondent was aware of the length scale used in nanotechnology, and there were others who knew a little about it, such as the fact that it involved "miniaturisation".

"It's technology at the nano, 10 to the minus 9 range, it's machines you can drive, you can find them on the width of a hair, it's technology at that absolutely microscopic level."

(Male, 55+, ABC1, London)

Others proved to have confused it with other words containing "nano".

"The way I've seen it, it's like a toy … kind of like a digital toy where you maybe feed it, look after it like a child… a Nanobaby."

(Female, 18-34, ABC1, London)

There were also those, as in the quantitative research, who had "just heard of it" but could not offer any further information. Some could not describe exactly what nanotechnology was, but were aware of some of its applications, including:

- Tiny machines;
- Cosmetics;
- Performance fabrics;
- Medical applications – e.g. surgery, the brain, eye surgery, pacemakers, microscopic laser beams; and
- Possible uses in space

"I saw a couple of month back that Birmingham University had pioneered a micro-robot and they aim to be able to work in these things in which they can create hearts to help people with heart problems, and where you won't have to have a big pacemaker, you'll have a micro-robot which will keep the circulation running."

(Male, C2DE, Birmingham)

"Do they use it in surgery, do they use it in the human body perhaps, on the anatomy, microsurgery, keyhole?"

(Male, 55+, ABC1, London)

These responses cover a similar range to the results shown in the quantitative findings. Additionally, a sense of wonderment, even disbelief, was referred to by some of the respondents.

"Unbelievably small, and I believe it runs on water or something."

(Male, C2DE, Birmingham)

"Very tiny, you can't imagine something that small with moving parts in it."

(Male, C2DE, Birmingham)

There were also those in the qualitative workshops who were evidently aware of the controversial nature of the subject and the fact that figures in the public eye have either spoken out against it or expressed trepidation about it. Respondents to the quantitative questionnaire did not mention this controversy. However, this could perhaps be because in addition to asking what they understood by the term, respondents in the workshops were asked whether they had heard anything about it, for example in the media.

"Prince Charles is against it."

(Male, 35-54, ABC1, London)

"A guy called Edward Joy is head of some electronics or one of these very large electronics (companies)… *he is alarmed about it, not just Prince Charles."*

(Male, 55+, ABC1, London)

5.3 Sources of awareness about nanotechnology

Awareness about nanotechnology could come from various sources, which included:

- The media – documentaries, Radio 4, TV and magazines such as New Scientist and National Geographic; and
- The workplace – e.g. at a university which publishes information about a nanotechnology project in its newsletter

6 Reactions to nanotechnology

The quantitative research asked those who were able to give some definition of nanotechnology whether they thought it would make things better, worse, or have no effect in the future.

As described in Section 3.3.1.1, in the qualitative workshops respondents were initially given a basic explanation about nanotechnology as a concept and the possible spectrum of its uses (see Appendix 7.2 for the basic text). This was to establish any reactions respondents had to the concept as opposed to specific applications. They were asked their opinions about the concept before being given further information in the form of scenarios showing various applications to which nanotechnology may be put (see Appendix 7.2). Respondents found it easier to react to these and form opinions, although these opinions were not necessarily based only on the scenarios. The scenarios merely provided respondents with a starting point for their dialogue with the scientist.

It is not possible directly to compare the results for the quantitative and qualitative findings on this topic, for two reasons: firstly, the quantitative question was asked to just those able to give a definition of nanotechnology, whereas the nature of qualitative research allowed the feelings of those who were either not initially aware of the term, or who could not give a definition, also to be explored. Secondly, the qualitative workshops explored how nanotechnology might make things better or worse, rather than whether it would do so. The two different approaches do, however, complement each other by providing both a measure and an explanation of awareness and opinion.

6.1 Quantitative – Effect of nanotechnology in the future

Those who were able to give any definition of nanotechnology (whether accurate or otherwise) were asked whether they thought nanotechnology would make things better, worse or have no effect in the future. As this question was only asked of 172 respondents, it is not possible to look at differences by demographics.

Table 3 – Effects of nanotechnology in the future (all giving some definition of nanotechnology)

	All
Unweighted base	172
	%
Better	68
Worse	4
Have no effect	4
Depends what it is used for	13
Don't know	11

The majority (two thirds) felt that nanotechnology would make things better in the future, with very few saying it would make things worse. Consistent with the tendency to define nanotechnology by its applications, 13% said it would depend on what it was used for.

6.2 Qualitative

Respondents were asked their reactions to the concept of nanotechnology alone, and then given further information about possible ways in which nanotechnology could be used (see Appendix 7.2). The scenarios were used as a means to help respondents understand more about nanotechnology, rather than as a way of influencing their views.

6.2.1 Reactions to the concept

Scientists were deliberately asked to keep their introductory information as free from detailed information about the applications of nanotechnology as they could, and as far as possible only to refer to applications in terms of mentioning the scope of the technology. This was so that it would be possible to ascertain whether there was anything about the technology in itself, as opposed to its applications, that respondents reacted positively or negatively towards.

Respondents found the initial information about nanotechnology difficult to react to. It was felt that, without concrete examples of the ways in which it could be used, it was difficult to know how they felt about it. There were also those who wanted the scientists to give them a list of positives and negatives in order to make up their mind. Some respondents also, despite the clarity of the scientists' explanations, found the whole concept very confusing and difficult to understand.

"If he told me that, 'okay, scientists have looked at, these are the positive things, if we make a nano and it goes ahead, this is the positive, this is the negative.'"

(Female, 18-34, ABC1, London)

However, despite this confusion, respondents established spontaneous grounds for both suspicion and concern, and also for positive reactions.

6.2.1.1 Negative reactions

Respondents had some spontaneous reactions of suspicion and concern, based on the following grounds, which will be discussed more fully in Section 6.2.2:

- References to "miniaturisation" set off associations with surveillance equipment (although this was not mentioned by the scientists) and led to spontaneous concerns for privacy;

- The phrase "technological development" and a reference to levels of investment abroad made respondents concerned about how much it would cost the UK;

- References to changing materials at the molecular level made respondents wonder whether scientists were trying to manipulate nature and "play God".

There was also a sense that nanotechnology could be abused. In this respect it was not felt to be different from any other technology, but it was thought to represent a widening of scope for those who might wish to abuse existing technologies.

"I'm thinking in my head, 'okay, we're going to create this thing,' something so small, I feel like people's privacy is invaded… because you don't know perhaps when this little thing could be used on you."

(Female, 18-34, ABC1, London)

"Are we trying to control nature, are we trying to manipulate nature… I don't think we should, we don't have the right to play God... I don't know, I can't articulate it, I just think it makes me feel things are getting out of control, there might be a nasty end product."

(Male, 55+, ABC1, London)

6.2.1.2 Positive reactions

There were also respondents who reacted positively to the initial information about nanotechnology. It was felt to be a natural evolution of technology and, in that manner, exciting. It was pointed out that in the sense of being "unnatural", nanotechnology is

fundamentally no different from anything else humankind does to influence its environment.

"Look, from the time the first caveman picked up a bone and slew something or another, then he was interfering with nature, a car which we can more readily understand, that is just a catastrophic impact on nature in every possible way and yet we take that for granted."

(Male, 55+, ABC1, London)

It was also suggested by some of these respondents that the argument over the acceptability or unacceptability of nanotechnology would seem strange to future generations, who would use such technology as a matter of course.

"I just have a gut feeling that if this, if what we're saying now was put in a time capsule and played a hundred years from now, we would look like complete and utter Luddites."

(Male, 55+, ABC1, London)

Some respondents felt that the nanotechnology, because of the smaller length scale which it works on, would enable both consumer and non-consumer goods to be made smaller. It was felt that this would lead to both improvements in performance and usability. A parallel was drawn with the improvement in mobile telephone technology since its inception, with respondents guessing that nanotechnology would be able to make similar improvements.

"Another good use I suppose…'phones and stuff… obviously it used to be a big brick thing, and you can put them in your back pocket, computers, things like that which are pretty good… making a smaller thing, that sort of thing as in size is good."

(Male, 18-34, ABC1, London)

Respondents also reacted positively towards some of the possible uses of nanotechnology that were mentioned. Although these will be discussed further in Section 6.2.2, the mere mention of possible uses in medicine, materials and cosmetics evoked an optimistic response. In particular, respondents were excited about the medical possibilities and immediate questions included what these might be.

6.2.2 Reactions on being given further information

As has been described, respondents found it difficult to react to nanotechnology as a concept without seeing some of the ways in which it could be used. They were therefore shown some possible ways in which it could be used (see Appendix 7.2), and these were used to start a discussion about the technology. As with other new technologies, they

considered the implications nanotechnology might have on several different areas, which can be grouped roughly into the following headings:

- Ethical;
- Financial;
- Social and political;
- Environmental; and
- Health and safety (including reliability)

The issue of possible side effects was also discussed, as was that of control and regulation, although here a certain amount of fatalism was displayed.

6.2.2.1 Ethical implications

A number of concerns were raised about the possible ethical implications of nanotechnology.

Firstly, respondents worried about whether nanotechnology constituted "playing God". As before, this was a spontaneous feeling and respondents were largely unable to explain it (see Section 4.2.1.1). However, although it was accepted both that other technologies "play God" and that they would be willing to use such a technology themselves *in extremis*, there were those who felt that nanotechnology had something that was fundamentally "not right" about it.

In part, this was because of the mention of manipulating matter at the molecular level to form entirely new materials. This led to spontaneous parallels with GM being drawn by some: the analogy was of animal DNA being inserted into plant DNA to create new crops. It was felt that, as GM is different from the normal process of cross-fertilisation of crops, similarly that changing materials at the molecular level was different from any process of manufacturing new materials made possible by more "natural" means. The GM parallel was one which was raised a number of times during the workshops.

Because nanotechnology and GM both involve changes at the most fundamental level to form that which does not occur in nature, both were characterised as *"messing with nature"* in a specific way by *"manipulating the building blocks of nature"*.

"When you actually get into the parts of nature and mess with nature, to the point where we're going into the main fabrics like DNA… That kind of thing. I think a lot of people I felt are having fears like that."

(Male, 18-34, ABC1, London)

"Trying to control nature is … we're trying to go back to the building blocks and try to manipulate the building blocks of nature."

(Male, 55+, ABC1, London)

There were also those who had wider worries about the moral as opposed to the technological capacity of the human race. It was felt that humankind's technological ability advances more quickly than a consensus can be reached on the moral and ethical implications of advances made so far. In this sense, it was felt that nanotechnology extended the lead of the former over the latter.

"The thing that perennially concerns me really is human beings' capability versus their wisdom… humans have these enormous abilities to do things. And I kind of view it like a two-year-old child sitting in front of a plug socket with a screwdriver, in that we can, but should we really?"

(Female, 18-34, ABC1, London)

Some also questioned whether humankind had a genuine need for further technological advances. It was thought by these that science and technology were now looking for outcomes that were impossible, even undesirable. For example, dramatic increases to the human lifespan were thought to come with an accompanying cost to the individual, in terms of quality of life, and to society in terms of the associated economic costs.

"The big ramifications are, how long do we want to live? I have an elderly father and I see his quality of life decreasing, and you wonder what good is it to keep people healthier for longer, to live longer; what is the point? We've reached a plateau now, you don't want to live too long, is there any quality of life… and also how do we treat old people? It's all very well keeping them alive but old people are not well treated in our society."

(Female, 35-54, ABC1, London)

Other respondents felt that science was looking for "answers to the human condition". One respondent gave as an illustration the example of Internet chat rooms, which ostensibly exist to facilitate human interaction but can in practice increase isolation from the physical community in which the individual lives.

"I'm always incredibly wary of technologies that seem not to in any way enhance the quality of actually people's lives, other than compensating for their inherent misery, it's another thing they can buy as a distraction, taking them away from the fact that they're not really very comfortable."

(Female, 18-34, ABC1, London)

"I feel a bit sad about the way the human condition's going in that direction… the dependency on being able to talk and communicate with people all the time, rather than being able to communicate with themselves a bit more."

(Male, 55+, ABC1, London)

6.2.2.2 Financial implications

The figure of US $4billion was mentioned by one of the experts[4] as the US Government's financial commitment to developing nanotechnology. It was felt that this was a great deal of money, and that it would be a particularly large amount for the UK to invest. There were those who wondered how long it would take to see a return on any investment the UK might make, and also those who wanted to know how much the cost to the taxpayer would be.

"Now you came out with a statement that the U.S. is spending about four billion dollars. How much will the U.K. government spend on this sort of research?"

(Male, C2DE, Birmingham)

There were also those, particularly in the C2DE group, who worried about the cost to the individual and whether nanotechnology would only be available to the rich.

Concern was also expressed about the level of investment required was such that only Government and corporations would be able to allocate funds. There were those who speculated that these bodies would only make such a large investment if they could be sure of a return. It was felt that this return might not be one which was necessarily beneficial to society (see Section 6.2.2.3, below). Even universities were not immune to such criticism, with respondents suspecting that they would want to exploit commercially any discoveries they made during the course of their academic researches in the field.

[4] This was mentioned in response to a direct question by a respondent who asked how much the development of the technology was costing.

"Nowadays people are discovering things, universities and now patenting it, instead of putting it into the greater community of science through technical journals and all those things, they're quickly slamming on the patent so they can commercially exploit it."

(Male, 55+, ABC1, London)

However, there were also those who argued strongly for investment. This could be from a financial point of view: it was thought that, if other countries are investing, the UK cannot afford not to do so, and that if it hesitates it risks being "left behind". There were also those who argued for investment from a prestige point of view: that the UK should be investing in science in order to compete academically and intellectually with other countries.

"Other scientists, they win Nobel prizes in physics, chemistry and all that. Are they getting enough support from our Government?"

(Male, C2DE, Birmingham)

6.2.2.3 Social and political implications

The social and political implications of nanotechnology considered covered four areas:

- Employment and industry;
- Social control;
- Developing nations; and
- Increased hold of corporations over society

6.2.2.3.1 Employment and industry

There were those, particularly in Birmingham (where respondents were skilled and semi-skilled manual workers), who were concerned about the possible impact of nanotechnology on industry. It was thought that new materials might make some traditional industries and jobs obsolete. For example, a material made to resemble steel, but lighter, might undermine the steel industry, and self-cleaning glass could affect the livelihoods of window-cleaners. It was also thought that self-repairing materials could impact on the manufacturing industry.

"The British haven't got anything of their own really. Everything is selling out anyway. So steel is the only thing we've got left now, really."

(Male, C2DE, Birmingham)

"It'll put window cleaners out of business."

(Male, C2DE, Birmingham)

However, there were also those who thought that nanotechnology's effect on industry was potentially beneficial. The fact that nanotechnology enables the miniaturisation of devices was thought potentially to enable a saving in terms of materials and energy, which would in turn create savings.

"Well, it's got to be good for industry, hasn't it? They can make smaller machines to do the same job as some massive machines do. It's not as if you are going to use so much energy up, there's going to be a saving there."

(Male, C2DE, Birmingham)

6.2.2.3.2 Social control

There were those who worried that the development of nanotechnology was being undertaken in order that Government might gain social control. They were suspicious that the level of financial investment required was such that only governments and corporations could afford to make it – and that, if they made it, they would hope for some return (see also Section 6.2.2.2). In the case of Government, the hoped-for return was deemed to be increased control over society.

Respondents also worried about the potential to have 'chips' implanted in the arm, for example to monitor health. Although they could see the potential benefits they also felt that this could be misused, for example to enable people to be tracked and monitored. There were also those who thought that this potentially extended the ID card debate. A particular fear was that people could be implanted with such a chip without their knowing, due to the probable size of such implants. There were even those who thought that Government might be enabled to scan their thoughts.

As mentioned before, one of the respondents' first reactions on hearing of the length scale on which devices using nanotechnology are built was a spontaneous concern for privacy. This was thought to be particularly important if nanotechnology enabled surveillance equipment to be made that was invisible to the naked eye.

6.2.2.3.3 Developing nations

The impact of nanotechnology on developing nations was also considered. It was felt that, if the industrialised world had access to nanotechnology and the Third World did not, the already large gap between the two would increase. Respondents also feared that the Third

World would therefore not be able to benefit from any of the potential benefits of nanotechnology.

It was also feared that the Third World would be economically exploited and that if corporations were to invest in nanotechnology they would want a return. One of the scenarios felt to be most likely was that large corporations would put patents on, for example, drugs. Again, parallels were drawn with the behaviour of large corporations over GM in the Third World: GM crops were felt to have been marketed as a way to feed people more cheaply, but to have in fact been too expensive for Third World farmers to buy.

"People in different parts of the world (already) *do produce the same drugs, off the shelf drugs, that big companies do at far less cost. And the reason they can't do it is because they get sued. And the big drug companies, they're the only ones who can afford this nanotechnology and they're the only ones who can fund it at the moment, so they're not going to go away at all, they're going to get bigger and more powerful."*

(Male, 35-54, ABC1, London)

6.2.2.3.4 Increased hold of corporations over society

As with Government, it was felt that corporations would only make the financial commitment needed to develop nanotechnology in the hope of some return. It was argued that this could involve exploitation of consumers in both the industrialised and developing worlds, for example, by the creation of patents, thus artificially inflating prices (see Section 6.2.2.2, above). This could mean that consumers might not benefit from some of the potential impacts of nanotechnology, such as decreased consumption of raw materials and energy driving down prices.

There were also those who were concerned that corporations might benefit from information made available as a result of the use of nanotechnology. For example, if a monitoring device was used to maintain a person's health, a life insurance firm might demand to see the results of this before granting life insurance.

"I think it's very scary because I think it fundamentally comes down to economics, who are the people who are going to access this? It would be probably major corporations who dictate how we're going to live our lives, they could say, 'you are not getting any health insurance.'"

(Male, 35-54, ABC1, London)

6.2.2.4 Environmental implications

The environmental impacts of nanotechnology were also considered. Possible ways in which it was thought nanotechnology might affect the environment included the potential

issues around disposability of materials created through nanotechnology. Respondents wondered whether they would be biodegradable or, like plastics, create environmental hazards. There were also those who thought that nanotechnology might encourage society to become more "throwaway" by promoting the purchase of new products.

"I'd have one thing (that would concern me) *and that would be disposal…i.e. can they be disposed of in an environmentally friendly way?"*

(Male, C2DE, Birmingham)

Nanotechnology could potentially be beneficial to the environment if it could, through miniaturisation or improved performance, enable fewer raw materials or natural resources to be used.

6.2.2.5 Health and safety implications and reliability

Respondents were very positive towards the possibilities of nanotechnology in the medical field, particularly in terms of earlier diagnosis and treatments. However, they also had concerns about the long-term, potential side effects of nanotechnology, and about its reliability.

6.2.2.5.1 Diagnosis and treatments

Even respondents who were worried about nanotechnology conceded that it might have worthwhile applications in the medical field, and this was generally agreed to be potentially one of the most important uses of nanotechnology.

Respondents were very positive towards the idea of improved diagnostics allowing disease to be identified at an earlier stage. The idea of easier monitoring of chronic conditions, such as diabetes, kidney disease and high blood pressure, was also thought to have many positive possibilities. It was stressed that such information should remain private, however, and not be shared with organisations such as insurance companies or employers.

"It must be quite, touch wood, good for the cancer bit... It must be exciting now for people who have got it or in years to come think that could cure it, this small thing. Could you put it into healthy people? Could you use this in healthy people to pick up something that might occur?"

(Male, C2DE, Birmingham)

"It would depend who had access to the information; that would be the main thing. You could have employers taking the fittest, keeping them on and getting rid of those not so fit. If access was given to employers it could be open to (abuse)."

(Male, C2DE, Birmingham)

The potential for improved delivery of treatments to treat disease more effectively also gained a favourable response. Respondents were particularly positive towards the notion of improved cancer treatments. The potential for miniaturisation of hardware was also thought to have positive possibilities in the medical field, for example by allowing devices such as dialysis machines and pacemakers to be made smaller, allowing patients to be treated at home instead of having to spend time in hospital. It was also hoped that treatments using nanotechnology might allow patients to be spared the necessity of undergoing an operation.

"Miniaturisation for heart pacemakers… that will be good because people won't have to go every two or three years to replace the batteries or something like that."

(Male, C2DE, Birmingham)

"If they could make a medication up which would mean you could take a tablet and have your eyesight restored or improved without need of an operation, that's surely got to be a good thing. I knew a fellow, 90 years old. They wouldn't give him an operation because they said he was too old to put under anaesthetic. Yet if they could give him a medication like this which would help him with his eyesight, that's got to be good, isn't it."

(Male, C2DE, Birmingham)

However, there were also concerns expressed about the development of new treatments versus the importance of investing money in the prevention and the development of cures. These respondents felt that it might be more important to either stop diseases from manifesting themselves in the first place, or to cure them completely once they had, rather than treating the condition (a distinction was made between the two).

"It's all very well creating some nanotechnology-based drug or whatever it is that cuts away tumours et cetera, it's not curing cancer, what it's doing is cutting away the cancerous growth but it's not curing cancer. Do you think that this sort of development in technology is going to take away resource from actually curing these things, rather than treating them?"

(Male, 35-54, ABC1, London)

6.2.2.5.2 Long-term and side effects

Nanotechnology is still at too early a stage of development to be able to be certain of its long-term and side effects. It was felt that nanotechnology might have certain side-effects that have not yet been considered, such as potential allergies for users of cosmetics and sunscreens. There were those who urged clinical trials for all products containing nanotechnology.

"You could be allergic to it, certain types of titanium. I'm allergic to some kinds of soaps. You wouldn't think soaps, do you know what I mean?"

(Female, C2DE, Birmingham)

"So when we come back in 20 years' time and all this nanotechnology's been used, 'ah, actually it's killing you.'"

(Male, 35-54, ABC1, London)

"When there have been years of study to have that shown to me, then I'll think about using the stuff."

(Female, 35-54, ABC1, London)

Long-term effects were a particular concern. Respondents felt that, even were they to be assured that nanotechnology was perfectly safe, they would have trouble believing it. Parallels were drawn with the development of nuclear technology and plastics, which, it was felt, had both been hailed as "the future" in their time, but had proved to have serious long-term effects on individuals and the environment.

"Plastics. 30 years ago, 40 years ago, we were told that plastics was the answer to everything, and we're still trying to bury it in the ground and destroy the planet."

(Male, 35-54, ABC1, London)

"We don't understand it, we don't really know because it's a new technology, we don't know what it's going to do, we don't know how long it will last, we don't know how to get rid of it, we don't know what the health effects of it are. It's the same with the nuclear power industry, people forged ahead with something that they didn't really understand, they didn't trial it for 50 years and now kids in Sellafield are making poos that are classified as toxic waste."

(Female, 18-34, ABC1, London)

The above issues were of especial concern because respondents were aware that nanotechnology is already in products that are on sale. For some, this was felt to be unacceptable. However, there were also those who admitted that they would probably buy

the products anyway, particularly if they offered a unique selling point (such as a face cream that offered the total eradication of wrinkles) or were manufactured by a brand name they trusted. Respondents indicated that they would try such products themselves before using them on their children.

"A bad reaction to it or something… I would put the cream on myself and test it before the children."

(Female, C2DE, Birmingham)

6.2.2.5.3 Reliability

In addition to the potential health and safety implications of nanotechnology, there were also those whose worries were centred on the practical questions of whether nanotechnology would work and whether it would work in the way it was intended to.

Respondents acknowledged the room for human error in anything man-made, and therefore questioned whether appliances using nanotechnology would be an exception. They wondered what would happen if such appliances failed to work, or did something they were not supposed to do. This was a particular issue when discussing devices for use inside the human body, such as diagnostic pills and machines to repair damaged tissue. Respondents wondered what would happen if, for example, a machine intended to kill cancerous cells began to attack healthy tissue instead. Applications that remained on the surface of the body, such as sunscreens, were not felt to carry the same level of risk, although respondents still expressed concern about them.

"If you are relying on a mechanism to work... we always do fear with technology, I mean I've seen it in the workplace when the computers go down, there's this great fear, we can't get this information that we put in, we can't get it back. But there is the benefit then that when it does work, things are faster, things are better."

(Male, C2DE, Birmingham)

"If it destroys the good cells in your body it's creating more problems than it's fixing."

(Female, C2DE, Birmingham)

6.2.3 Control and regulation

Respondents were unsure as to the extent to which control and regulation would be possible in practice, although they were strongly in favour that the attempt should be made. As described above (see Section 6.2.1.1), it was felt that there would be those who would attempt to abuse almost any technology, and that nanotechnology would be no different.

Parallels were drawn with nuclear technology. Respondents suggested various bodies as potential regulators, but were divided on the extent to which the public should be involved.

6.2.3.1 The nuclear industry

It was argued that a technology might be possible to regulate nationally but impossible to enforce internationally, and again the analogy to nuclear technology was made. Nuclear technology was considered to be particularly pertinent when discussing this issue, as it was said that although attempts are made to regulate its development and use internationally, these can only be possible to a limited extent. It was feared that the same would be true of nanotechnology. Respondents also feared that the consequences of rogue nations or terrorist groups gaining access to nanotechnology might be similar to, or worse than, those resulting from their acquisition of nuclear weapons.

"As long as there are restrictions and controls it seems to be a very good idea."

(Male, C2DE, Birmingham)

"They said the same thing when they created atomic energy, and when scientists created that atomic energy, that was all well and good… in the beginning it was all, 'but this is wonderful, this is science, this is advancement', but now we've got into a stage where we have countries that we're frightened of getting hold of nuclear weapons."

(Male, 18-34, ABC1, London)

6.2.3.2 Bodies suggested as possible regulators

Respondents were, however, keen that attempts should be made at regulation. Various bodies were suggested as possible regulators of nanotechnology. These included:

- The Government;
- GPs;
- Through the courts, including the Court of Human Rights;
- An independent body; and
- A collection of stakeholders (e.g. representatives from science and academia, religion, members of the public, ethicists, and Government)

The issue of whether it would be possible to trust whoever was assigned the task of regulation was raised, with respondents wanting to know "who would guard the guardians".

"I suppose a body of people taken from all different aspects that we've mentioned so that there are checks on (everything). The feeling came across that we didn't really trust everyone a hundred per cent. We felt the best way for it to be monitored is to have somebody in place and they've all got to be answerable to each other and that's the only way."

(Male, C2DE, Birmingham)

"The thing is with control and I agree, some person is going to have to decide what the controls are, what the boundaries are to the users of that thing. Who do you trust to control it? Do we trust anyone?"

(Female, 18-34, ABC1, London)

6.2.3.3 Public involvement

There were those respondents who thought it was vital for the public to be involved in any future regulation. However, the willingness or ability of the general public to participate in such a way was questioned, especially by the ABC1 group of respondents, although the C2DE group believed public participation would be possible. There were also those who had a fatalist approach and thought that contributions from the public would make no difference to the debate in any case.

It was argued that Government and scientists did not have the right to make decisions about nanotechnology on behalf of the public without consulting them first. This issue, however, was not thought to be limited to nanotechnology. It was felt that a "democratic deficit" also exists in other areas of policy-making. The issue of public participation was therefore felt to be a much wider one.

"Not just simply applied to issues like science, but all issues that actually the general public should be heard… and we're not on all kinds of issues… the public has not been heard over tuition fees at universities, these things have not been properly debated and then suddenly they're thrown at you and you're told, 'this is the only way to go', and I think this is what gets people very, very upset."

(Male, 55+, ABC1, London)

There was also some feeling, among the ABC1 group in particular, that the general public would neither be interested in, nor equipped to, participate in such a debate. It was said that most people did not have the articulacy or knowledge to form an argument against an issue such as nanotechnology. In part, this was felt to be because the general public assumes that scientists are always right, or that they are always working towards benign ends.

"The bulk of the population don't have the vocabulary or the knowledge to form an argument against it… I think a lot of people think scientists are like policeman, they still have this thing that they're right, it's kind of an authority."

(Male, 55+, ABC1, London)

6.2.3.3.1 Fatalism

Respondents also expressed a lack of confidence that the public voice would be listened to even if it did enter the debate. A parallel was drawn with the war in Iraq[5]. Respondents pointed out that this went ahead despite massive public opposition. Should the public express dissension over nanotechnology, it was felt likely that their opinion would be similarly ignored.

"The Iraqi war is a prime example, you can have the biggest demonstrations ever, masses of people saying 'we fundamentally totally disagree with it', and it still goes ahead anyway. Where I'm coming from now is I don't care, God knows what is happening, there are human cloning projects going on all over the world

without us really knowing, it doesn't make any difference because we don't have any choice any more."

(Female, 18-34, ABC1, London)

This led to a certain degree of fatalism. There were respondents who, while having opinions about nanotechnology and expressing them in the workshops, also said that their having an opinion was not worthwhile, because nanotechnology would be introduced whatever they, or others like them, said.

6.2.4 Hardening attitudes

A certain degree of hardening of respondents' attitudes was observed during the workshops. There were those who had a negative or positive opinion about nanotechnology at the beginning of the evening, or who had formed such an opinion at an early stage in the discussion, and who either did not change it, or moved towards a more extreme position during the evening. However, there were also those who saw both potential good and bad in nanotechnology, and those who adopted a "wait and see" approach. This hardening of attitudes is not unique to nanotechnology, and can be seen in other types of research where respondents are asked to articulate their opinions for and against a topic.

[5] The research was undertaken against the backdrop of continued debate about whether the war against Iraq was justifiable.

6.3 "Wait and see"

There were both respondents who started the workshops with hostile feelings towards nanotechnology, and those who began in a positive frame of mind. Similarly, there were those who knew nothing, but formed initial positive or negative reactions, which grew more confirmed as the workshop progressed. However, there were also those who adopted a "wait and see" approach to nanotechnology. These respondents pointed out that the technology is in its infancy and, as yet, relatively untried. They felt that its effects, for bad or good, would only become clear over time.

Those adopting this attitude, however, still exhibited divided reactions. There were both those who:

- Found the possible implications of nanotechnology a cause for concern; and
- Those who were philosophical about the future development of nanotechnology

Those who found the possible implications of nanotechnology a cause for concern, while acknowledging its possible future benefits, also thought that the technology was proceeding without enough knowledge about long-term and side effects. It was felt that, as with nuclear technology, these could be greater than currently imagined. These respondents wanted the development of nanotechnology to be halted until more was known, and it was a particular concern to these people that nanotechnology was already used in the manufacture of products currently on sale. Although it was acknowledged that the discussion might seem over-cautious in the future, it was felt that this did not warrant risks being taken in the present day.

Those who were more philosophical about the possible implications focused more on whether or not nanotechnology would work, rather than whether or not it would prove to be dangerous. These respondents were not as vocal about nanotechnology's long-term implications, whether because of a feeling that they would not be listened to in any case, or because they were unconcerned.

7 Appendices

7.1 Topic guide used in workshops

45101666

October 2003

Nanotechnology
Public Attitudes
Topic Guide – Final
Workshops – 3 hours

Aims:

- **To explore public attitudes towards new technologies and nanotechnology in particular**
- **To examine the factors driving the acceptability or otherwise of new technologies and nanotechnology in particular, and what triggers the public to respond positively or negatively towards them**

1. INTRODUCTION AND WELCOME (10mins)

- Welcome and thanks for attending
- Research conducted on behalf of the Royal Society into new technology and public attitudes towards it **(Don't mention nanotechnology until the breakout groups)**
- Don't worry – we are not expecting them to be experts and have specifically selected them not to be
- About BMRB
- Aims for the day
  - Find out about their attitudes towards new technologies and what makes them acceptable or unacceptable
  - Will be having both sessions where the whole group is together and smaller sessions in order to discuss the issues
  - Sessions will be led by one of following people (introduce moderators)
  - Scientist will be on hand to provide expert guidance (introduce scientist)
    - Especially since some of what we discuss will be new to everyone
  - Briefly outline agenda
    - Remind them to make notes of anywhere where they want to know more/need to ask further questions

2. FIRST BREAKOUT GROUP (20mins)

- Introduce self
- Confidentiality
- Introductions from group – name, job, where live, children
- Tape-recording – will produce a report at the end but will not identify individuals
- This is an opportunity to pool information we have and to identify what uncertain about – they are all starting from the same point of knowing very little
- Remember, the focus is not on what they know or how much they can learn, it is on their opinions and how they change
    - If they hear a piece of information or something that changes their opinion, whether positively or negatively, indicate and the moderator will make a note of it

- What new scientific developments or technologies can they name in the past 5 years
- What did they think about them
    - Were they positive or negative towards them
    - Any they were particularly positive towards
    - Any they were particularly negative towards
- What do they think makes a new technology a good thing or a bad thing
    - How do they judge this (good or bad thing)
        - Is it more to do with information or gut reaction

- Do they perceive a need for information about new technologies, or are they happy not knowing anything
    - Where do they currently get information from
    - Is it something they actively seek out or are they happy to take it as it comes
        - Would they know where to go to get information if they needed more
        - Thinking about their habits and daily lives would this be something they would be likely to do

- Have they heard of nanotechnology (the word)
- Have they seen anything about it in the media
- Is anybody able to put into words what they understand by the concept

3. FIRST PLENARY SESSION (30 mins)

- Andrew Thomas: Welcome back
- Hand over to scientist (1 minute)
- Scientist gives prepared explanation of nanotechnology (4-5 minutes)
- Group has opportunity to ask questions while scientist answers them and AT moderates (20 minutes)
- Send groups off for second breakout session
    - Explain that they will now talk about their reactions and be shown some more scenarios in which nanotechnology might be used
    - Scientist will be rotating between the groups one at a time so that they can ask questions

4. SECOND BREAKOUT GROUP (60 mins)

- Explain that the scientist will be coming to talk to the group in
    - 15 minutes
    - 25 minutes
    - 40 minutes
- What were respondents' instant reactions to the scientist's talk on nanotechnology
    - Give reactions in one or two words
        - Note these down to use in plenary session
    - Instant reactions
        - What was the trigger that made them think that way
            - What did it immediately make them think of
            - What do they associate it with
                - Why do they do this
                - What is it about it that makes them think this way
                - What sorts of things in everyday life does it make them think of
    - What were their positive reactions (note down)
    - What were their negative reactions (note down)
- Show respondents the application scenarios
    - What are their initial reactions

- **Scientist comes into first group**
- Talk through each scenario with the group
    - What do they think the benefits of this application would be
        - Note benefits down on a flip chart
    - What do they think the drawbacks of this application would be
        - Note drawbacks down on a flip chart

- **Scientist comes into second group**
- How does this <u>type</u> of technology make them feel (i.e. not just the scenarios but the underlying science; fact that we are now able to do these things)
    -
    - What feelings or emotions does it inspire
    - What kinds of questions does it raise in their minds
        - Note these down to ask the scientist about
    - What kinds of concerns does it raise
    - What kinds of hopes does it raise
    - How acceptable is it
        - What things make it acceptable or unacceptable

- **Scientist comes into third group**
- Looking at all the scenarios, what words would they use to describe their reactions
    - Note them down to use in next plenary session
- Do they have concerns
- Do they see benefits
- Do they still have questions
    - Note all above down

- Do they have any concerns about ethical issues in light of the scenarios discussed, or anything else that has been raised in the discussion so far
    - What are these
    - What specifically makes them worried (what "rings alarm bells")

- What do they think about regulation
    - Do they have any concerns about it
    - Do they trust that nanotechnology will be regulated
    - Who do they think will regulate it
        - Would this be different from who they would like to regulate it
    - Do they have any concerns about what might happen if it were unregulated
    - Do they have any concerns about it "falling into the wrong hands"
    - How far do they believe regulation will be possible

- Would they feel that they needed further information about nanotechnology in order to form an opinion, or not really
    - Would they know where to get it
    - Taking into account their lifestyles, would they be likely to seek it out
- Are there any factors in their background that they feel predispose them towards reacting in a certain way (e.g. religion, presence of children, education)
- Explain that all groups will feed back in the plenary session – what would they like to report
    - Initial reactions to concept
    - Reactions to scenarios
        - Questions about scenarios
    - Benefits and concerns
    - Differences in reactions before and after speaking to the scientist
    - Further questions
- Choose a spokesperson

5. SECOND PLENARY SESSION (40 mins)

- Andrew Thomas: Welcome back
    - Explain that respondents are going to feed back some of what they have been discussing
        - Then the whole group will talk about their reactions
    - Scientist will remain on hand in case questions need to be answered
- First group feeds back
- Second group feeds back
- Third group feeds back

- What have respondents learned over the course of the day
- Do they feel their opinion has changed or not really
    - They may not have had an opinion to start with
- Do they feel able to judge whether nanotechnology is acceptable or unacceptable now
    - What have they heard that has made it acceptable/unacceptable
- What piece of information has had the biggest impact on them during the day

- What are their reactions to nanotechnology and its applications

- What do they think the wider implications of nanotechnology would be
- Are there any questions they feel still need to be answered
    - Any gaps they feel they have in their knowledge
- Any concerns they still have

- To sum up: could they describe their attitude towards all they have heard and seen about nanotechnology in one or two words

- **THANKING AND CLOSURE:** Feed back to participants that their views will be considered by the Royal Society working group in its deliberations
    - Will report back to the Government's Office for Science and Technology, which is part of the Department for Trade and Industry
    - They can have a copy of this report should they wish – please leave their names and addresses with BMRB
- We have some booklets available for anyone who would like further information on the subject

7.2 Stimulus materials used in workshops

7.2.1 London, 1st December

7.2.1.1 Initial explanation

Over the past 6000 years mankind has been making more and more complicated structures. Think of the things we use to tell the time. Stonehenge was built, essentially, to tell the time. Over the years time pieces have become smaller and smaller. The pocket watch was an amazing example of miniaturisation for its time.

Other things have also become smaller and smaller. We can see this in everything around us – mobile phones, digital cameras, and personal computers. Nanotechnology is essentially the end of this road of making things smaller because it is dealing, in its extreme form, with the building blocks of nature – the atoms and molecules which make up everything around us. This means that it is not a technology which can only be used in some areas, but one which can be used in many areas – from cars to personal computers, drugs and to make new materials.

Nanotechnology means technology on a very small, or nano, scale. To put the scale in to perspective, consider the head of a pin compared to the length of the British Isles. Imagine being able to position the pin to an accuracy better than the size of the pin head anywhere in the British Isles. Now imagine doing the same thing at the same scale in the distance between your outstretched arms. That is the scale of the nanometer, the length after which nanotechnology is named and the size of those atoms and molecules.

Apart from the obvious advantages of making things smaller and so using less raw materials and being able to make them more complicated, there are some ways in which nanotechnology is unique. Since everything around us is built from atoms and molecules, then any technology that is able to engineer new materials means that it is possible to make materials behave exactly how we want rather than trying to adapt to what nature has provided.

The properties (things materials can do) of everything around us, colour, strength, whether or not a material conducts electricity, are determined on the nanometre length scale. Engineering on this length scale therefore means we have further control of these properties.

7.2.1.2 Scenarios – examples of ways in which it is intended nanotechnology should be used

7.2.1.2.1 Scenario 1:

Health

Nanotechnology will make available tools to use in the home that will allow illness and disease to be detected long before physical symptoms appear. For example, a toothbrush that in addition to cleaning your teeth also measures the level of chemicals in the mouth (in your saliva) and tells you whether you have tooth decay or gum disease.

7.2.1.2.2 Scenario 2:

Information technology

Nanotechnology will ensure that computer chips and computer technology go on shrinking further and further so that, for example, a complete computer could be housed in a matchbox.

7.2.1.2.3 Scenario 3:

New materials

Nanotechnology will allow the design of completely new materials to do new things that are not possible for the natural fibre to do. There are already jeans available with a coating that makes them completely repel water, but the fabric does not feel any different from ordinary jeans. You can also buy tennis racquets made from a nano-scale fibre, similar to the carbon-fibre ones that have been available for some years but specially designed to be both lighter and stronger than it is possible for carbon-fibre racquets to be.

7.2.1.2.4 Scenario 4:

Drugs

Nanotechnology will allow drugs to be targeted accurately to the site where they need to be delivered in the body. For example a current cure for macular degeneration (a form of blindness) is based on this form of technology. The drug only attaches itself to the damaged tissue in the eye and is then released. In the future it may be possible to kill tumours without destroying the surrounding tissue by injecting them with tiny particles coated with gold. When these are heated, the tumour could be destroyed without harming the surrounding flesh.

7.2.1.2.5 Scenario 5:

Sensors

Nanotechnology will allow for sensors to be made very small so that, for example, the temperature in buildings, and whether there are people there can be constantly monitored. An implant could be put into a human to constantly monitor their health and relay it to their data file, stored locally, for example in a credit card format.

7.2.1.2.6 Scenario 6:

Cosmetics

Old-style sunscreens are made from large particles of a chemical called titanium dioxide, which is a neutral material used in paint and for other things. To block sunlight this has to be mixed with chemicals, which are toxic and which are absorbed by the skin to some degree. Newer sunscreens can use much smaller particles of titanium dioxide, which by themselves block the light so extra chemicals don't have to be used. Another way nanotechnology could be used in cosmetics is to deliver chemistry into the skin to smooth wrinkles.

7.2.2 Birmingham, 16th December

7.2.2.1 Initial explanation:

The development of new technology since the beginning of Industrial Revolution two hundred years ago has seen the invention of more and more complicated machines, containing smaller and smaller component parts, which have produced amazing increases in performance: for example, in the field of transport compare the horse-drawn carriage to the latest jumbo jet.

The most recent chapter in this development has been the microelectronics revolution: we can see this in everything around us – from digital televisions to mobile phones, digital cameras, and personal computers. The amazing abilities of these machines have been made possible by miniaturizing the basic mechanical and electronic components down to the micro scale: a micrometre is one thousandth of a millimeter or one millionth of a metre. The next big revolution will be nanotechnology: a nanometer is one billionth of a metre. This will be essentially the end of this road of making things smaller because it is dealing with the basic building blocks of nature – the atoms and molecules which make up everything around us. A nanometer is about the size of five or six molecules of water. This means that it is not a technology which can only be used in some special areas, such as electronics, but it can be used in many areas – from new materials to medicines, from personal computers to paint. Many scientists and engineers are now predicting the beginning of a New Industrial Revolution.

Apart from the obvious advantages of making things smaller - they use less raw material, are more energy efficient, and they can be more complicated and so do more things - there are some ways in which nanotechnology is unique. Any technology that is able to engineer new materials at the atomic scale means will make it possible to make materials behave exactly how we want them to, rather than trying to adapt to what Nature has provided. The properties of everything around us, colour, strength, whether or not a material conducts electricity, are determined at the nano scale. Engineering on this length scale therefore means we have control of these properties. Nanotechnology might also be used to deliver drugs to a specific target – rather than flood the entire body, and by making nano scale detectors it might be possible to detect disease even before symptoms appear.

7.2.2.2 Scenarios – examples of ways in which it is intended nanotechnology should be used

7.2.2.2.1 Scenario 1:

Health

Nanotechnology will make available tools to use in the home that will allow illness and disease to be detected long before physical symptoms appear. For example, a toothbrush that in addition to cleaning your teeth also measures the molecules in your saliva and tells you whether you are going to have tooth decay or gum disease.

7.2.2.2.2 Scenario 2:

Information technology

Nanotechnology will ensure that computer chips and computer technology go on shrinking further and further so that they will become much more powerful.

7.2.2.2.3 Scenario 3:

New materials

Nanotechnology will allow the design and manufacture of completely new materials to do new things that are not possible with natural materials. There are already jeans available with a coating that makes them completely water repellent (and stain resistant), but the fabric does not feel any different from ordinary jeans. You can also buy tennis racquets made from a nano-scale fibre, similar to the carbon-fibre ones that have been available for some years but specially designed to be both lighter and stronger than it is possible for carbon-fibre racquets to be.

7.2.2.2.4 Scenario 4:

Drugs

Nanotechnology will allow drugs to be targeted accurately to the site where they need to be delivered in the body. For example a current cure for macular degeneration (a form of blindness) is based on this form of technology. The drug only attaches itself to the damaged tissue in the eye and is then released. In the future it may be possible to kill cancer tumours by injecting them with tiny particles coated with gold. When these are heated, the tumour could be destroyed without harming the surrounding healthy tissue.

7.2.2.2.5 Scenario 5:

Sensors

Nanotechnology will allow for sensors to be made very small so that, for example, the temperature in buildings, and whether there are people there can be constantly monitored. An implant could be put into a human to constantly monitor their health and relay it to their data file.

7.2.2.2.6 Scenario 6:

Cosmetics and health products

Old-style sunscreens contain large particles of a chemical called titanium dioxide. To block sunlight this has to be mixed with chemicals, which are toxic and which are absorbed by the skin to some degree. Newer sunscreens can use much smaller particles of titanium dioxide, which by themselves block the light so extra chemicals don't have to be used. Another way nanotechnology could be used in cosmetics is to deliver vitamins into the skin to smooth wrinkles.

7.3 List of occupations represented in workshops

7.3.1 ABC1 – London, 1st December

Graphic Designer

Lawyer

Environmental Consultant

Ophthalmic Surgeon

Admin Worker

Planning Statistical Analyst

Trainee Teacher

Student

Director

IT Consultant

Theatre Producer

Customer Services Admin

Freelance Artist

Primary Teacher - Head of Dept.

Film Producer

Architect

Director of Housing Association

Professor of Oriental Studies

Social Worker

Hotel Manager

Manager of Farmers' Market

Interpreter

Teacher of Further Education

7.3.2 C2DE – Birmingham, 16th December

Builder

Assembler

Mechanic

Unemployed (3 respondents)

Sales Assistant (2 respondents)

Engineer (2 respondents)

Machinist

Fast Food Counter Assistant

Tool setter

Driver

Driver

Dinner Lady

Factory Worker (Unskilled) (3 respondents)

Care Assistant

Chef

Mechanic

Bus Driver

Fireman

Alarm Engineer

Painter and Decorator

Postman

7.4 Quantitative questionnaire

Q1. Have you heard of nanotechnology?

- Yes
- No
- Don't know

IF YES AT Q1 ASK Q2

Q2. What do you think nanotechnology is?

- (type in verbatim for coding later)
- Don't know

IF YES AT Q1 AND NOT SAID DON'T KNOW AT Q2

Q3. Do you think nanotechnology will improve our way of life in the next 20 years, it will have no effect, or it will make things worse?

- Improve
- Have no effect
- Make worse
- DO NOT READ OUT – Depends on what it is used for
- Don't know