The Public Understanding of Biotechnology in the Media

A report for the National Advisory Council on Innovation and the National Biotechnology Advisory Committee

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Executive Summary

Biotechnology has the potential to contribute towards addressing several national priorities, including aspects of health, food security, and environmental sustainability. It is thus important for public agencies to have a clear understanding of factors that advance or impede the development of biotechnology in South Africa. One of the key arenas in which these factors are found is within the public sphere - within which the media is a key player. This study therefore seeks to determine how biotechnology is understood by members of the media, and whether this understanding is advancing or impeding the development of biotechnology in South Africa. As such, this report focuses on three key research questions. Firstly, it seeks to understand how the media represent biotechnology and related issues, and what factors currently shape these representations, both positively and negatively. Secondly, it asks what the key areas of concern are in respect of entry into, and support of, the South African biotechnology sector. Finally, it seeks recommendations regarding policy objectives and recommendations for enhancing the media's role in advancing biotechnology in South Africa.

Thus, firstly, a literature review was conducted in order to define the conceptual and theoretical space in which to situate these questions. The first part of this review focussed on the broader issue of how the public engage with science and scientific institutions. Approaches to this question have evolved over recent decades, moving from an emphasis on scientific literacy, to an emphasis on attitudes towards science, and finally to the Science in Society model, which views the engagement as a social construct within the public sphere. The latter model was chosen as the broader conceptual framework for the study.

The second part of the literature review focussed on previous studies seeking to understand and measure media representations of biotechnology. This identified a core literature that used a methodology based on media analysis and the contextualisation of media analysis findings within the 'public sphere' heuristic. This methodology was applied to the current study.

The first empirical component of the study was a media analysis, which drew on the online archives of print and online news publications to identify articles related to biotechnology. These articles were coded according to variables reflecting frames, themes, tone and actors. Analysis of this database provided quantitative answers to questions about how biotechnology is represented in the media. The process of sample selection revealed that biotechnology is generally under-reported in the South Africa print media, but substantial in the online media. The two thematic loci were focused on genetically modified plants and animals for human consumption, and on health applications of biotechnology, including stem cell research.

Overall, articles had a greater focus on the benefits of biotechnology than the risks. Reporting of controversies tended to be unbalanced, as 66% of relevant articles reported only risks or only benefits, rather than both. This also had a clear thematic association, as these unbalanced representations viewed health applications favourably and GMO plants unfavourably.

The second empirical component consisted of interviews with science journalists and academics. Key findings included:

- Biotechnology is generally under-reported in the South African media, and is moreover episodic in nature.
- GMO and health applications of biotechnology are the main focus areas in the media
- Both journalists and the public are polarized with respect to biotechnology-related controversies.
- Journalists need to contend with large firms seeking to influence media representations.
- The relationship between journalists and scientists is characterized by tension and mutual suspicion, in which journalists perceive scientists to be inaccessible and scientists perceive journalists to be unreliable in reporting on their research results.
- Government performs poorly with respect to providing access to information about biotechnology activity in public institutions.

The conclusion highlights the key issues arising from the empirical components of the study, and introduces recommendations for further research, as well as recommendations for policy objectives and interventions.

Recommendations for further research include:

1. A larger scale and scope for the empirical components of the study, which would render a more representative sample, allow for a longitudinal study, and include radio and television in the analysis.

2. A widening of the research question to include an analysis of demographic data, which would make it possible to develop a model of received messages among the South African population.

3. Expanding the interview sample to include firms, NGOs and government actors.

Policy objectives and recommendations include:

1. Expand the scale of biotechnology reporting in the media, and expand access to this reporting to a greater proportion of South Africans. Public media channels such as the SABC could create a science desk or specialised programming related to biotechnology. In particular, radio has the potential to reach large proportions of the population, especially in rural areas, that are beyond the reach of print and online media.

2. Foster objective, balanced, and scientifically accurate reporting. Make better use of the existing press ombudsman, for example providing support to NGOs or SMMEs seeking to use the ombudsman to correct unbalanced reporting. Also, NBAC could hire a professional media company to put forward balanced messages about biotechnology.

3. Foster a closer and more productive relationship between journalists and scientists. Government could create an engagement platform for scientists and the media, for example where journalists could be trained to have a better understanding of science. In this context a useful organisation to engage with would be the South African Science Journalists

Association (SASJA). This could take several forms, including: workshops drawing together scientists and the media in order to improve their relationships and close the communication gap; journalists could be invited to spend time in scientific laboratories to gain a more tacit understanding of science; journalists, government officials, students and learners could be sent to SciFest in order to gain knowledge about biotechnology.

4. Enhance the public sector's willingness and ability to provide access to public information. A specialised directive for the communication offices of the relevant departments (Department of Science and Technology, Department of Trade and Industry, Department of Higher Education) could aim at improving their performance in communicating with the media. This would relate specifically to responding to queries and cultivating an ethic that public information belongs to the public and should therefore be freely disseminated.
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1. Introduction

Biotechnology has the potential to contribute towards addressing several national priorities, including aspects of health, food security, and environmental sustainability. It is thus important for public agencies to have a clear understanding of factors that advance or impede the development of biotechnology in South Africa. One of the key arenas in which these factors are found is within the public sphere - within which the media is a key player. The media play a key role in promoting public awareness of biotechnology, which in turn is an important driver in terms of advancing biotechnology in South Africa. A high level of public awareness, coupled with access to fair, objective, and scientifically accurate reporting and information, is more likely to lead learners and students into biotechnology career pathways, more likely to stimulate entrepreneurial activity, and more likely to lead to fair and positive outcomes where there are controversies.

This study therefore seeks to determine how biotechnology is understood by members of the media, and whether this understanding is advancing or impeding the development of biotechnology in South Africa. These objectives imply three key research questions:

1. How do the media represent biotechnology and related issues, and what factors currently shape these representations, both positively and negatively?
2. What are the key areas of concern in respect of entry into, and support of, the South African biotechnology sector?
3. What recommendations can be made regarding the motivation and objectives for public dialogue in the media in respect of knowledge gaps and misunderstandings, as well as new innovative processes and methods of information dissemination, within the constraints of the cost and context of implementation?

Section 2 of this report presents a literature review that defines the conceptual and theoretical framework of the study, including reviews of the public's relationship with science and previous research into biotechnology in the media. Section 3 presents the methodology derived from these reviews. Section 4 presents an analysis of South Africa media outputs related to biotechnology. Section 5 presents the findings of interviews with science journalists and academics. Section 6 highlights the key findings and conclusions. Section 7 identifies recommendations for further research. Section 8 concludes with policy objectives and recommendations.

2. Conceptual and theoretical framework

Conceptual, theoretical and methodological frameworks are required for answering the three main research questions. The broad theoretical framework within which to situate these questions is found in the literature related to the public engagement with science. This literature addresses questions such as: what kind of relationships should exist between the public and scientific institutions, what role should the public play in the policy-making process, what kinds of knowledge and attitudes are relevant to these relationships and processes, and how should we measure them?

A more focused theoretical framework is found in the substantial literature on aspects of biotechnology in the media. There are two key components of this literature. Firstly, there is a body of research related to measuring and analyzing public knowledge of and attitudes

towards biotechnology, in which the media is one of the independent variables that affect knowledge and attitudes. Secondly, another body of research seeks to understand how the media (re)presents biotechnology, including a) efforts to provide a theoretical framework within which to situate media representations, b) empirical research that searches for and codes biotechnology-related media outputs, and c) analysis of empirical research in the context of policy-making and other research agendas.

The methodology employed for this study has been substantially influenced by previous investigations that have had similar aims and objectives. These investigations employed a media analysis methodology, including a set of taxonomies and variables developed over a number of years and through several major research projects, which can be considered global best practice in this area of research.

The methodology for the other source of primary data for the project, interviews with key informants, was directly informed by the research questions, and also by the need for these interviews to contextualize the media analysis findings.

Section 2.1 of this paper explores the literature relating to the 'public's engagement with science'. Section 2.2 explores the literature related to biotechnology in the media. Appendices present the research tools developed for fieldwork interviews and the media analysis.

2.1. The Public's Relationship with Science

The assessment of the understanding and engagement between science and the public has been located in different theoretical paradigms: scientific literacy, public understanding of science, and science and society. These paradigms have evolved from one which saw the public as 'deficient' in science to ones which emphasise the participation of the public in science. A substantial body of research is related to this broad theoretical movement. Overviews can be found in Bauer, Allum and Miller (2007), Gregory and Lock (2008), Miller (2004) and Ziman (1991). Several conceptual approaches to understanding the public's understanding of scientific issues are reviewed in Felt and Fochler (2008), and Laugksch (2000). Some approaches are based on an experiential approach, such as Stockmayer and Gilbert (2002) or the deficit model (Allum and Sturgis, 2008). Related debates include those over scientific citizenship (Elam and Bertilsson, 2002), the role of participation (Durant, 1999), and cultural aspects (Razza, Singh, and Dutt, 2002). These debates inform different approaches to research methodology, for example as outlined by Bauer, Petkova and Boyadjieva (2000). Understanding public scientific literacy requires a specialised set of tools (Miller, 1998).

In South Africa there have been several studies undertaken by Pouris (1991, 1993, 2001, 2006). A key source of knowledge about biotechnology and public attitudes in South Africa is a previous report prepared for NACI on the impact of the South African public's perceptions and knowledge of biotechnology on the biotechnology industry (NACI, 2009).

The earliest paradigm through which to view the relationship between science and the public emerged in the 1950s, when the Cold War and the space race heightened international scientific rivalry (Miller, 2004). The American government identified a need to facilitate the

relationship between the public and science. John Miller, a Fellow of the American Association for the Advancement of Science, proposed the concept of *Scientific Literacy* and developed an instrument to measure this literacy (Bauer et al., 2007).

Miller proposed a type of scientific literacy benchmark, by which a scientifically literate person should be able to understand basic scientific facts, understand the methods that scientists use in experimental design, positively appreciate the outcomes of scientific research, and reject superstitious beliefs (Miller, 1998, 2004; Laugksch, 2000). The Scientific Literacy model contends that the public does not know enough about science to participate fully in science policy issues, and intends to measure this deficit so that policy measures to mitigate it can be put in place. Thus the focus of this model is on knowledge about science, rather than on attitudes towards science or the social context of attitudes towards science.

Miller argued that a lack of understanding of the scientific project results in the public being hostile towards the science and technology community and suspicious of their innovations. Such negative attitudes can cause public outcries and thus hamper scientific and technological progress (Allum et al., 2008, Pouris, 2001) and prevent the public from reaping the attendant benefits (Miller, 1998). The Scientific Literacy model thus calls upon the science community to educate the public about science (Bauer et al, 2007; Burns et al., 2003), as increased scientific literacy will lead to more positive attitudes towards science, resulting in increased public support (Laugksch, 2000). In addition the public will be better equipped to take advantage of S&T innovations that will enhance their quality of life (Durant, 1999). To this end Scientific Literacy measures sought to provide governments with a base-line of literacy from which to formulate policies to increase public scientific literacy.

According to this view, the focus of research questions about science and the media should be on the extent to which scientific knowledge is imparted through the media. However, this approach would fail to capture information about attitudes towards science or the social context which informs these attitudes, and would therefore have limited utility. This problem was one of several criticisms of the Scientific Literacy model that emerged in the 1970's. The scientific literacy model assumed a causal link between the acquisition of scientific knowledge and a positive attitude towards science. However, theorists questioned this assumption, since variables such as cultural, social and political contexts were overlooked (Raza et al., 2002), and because no provision was made for the acquisition of knowledge leading to a negative attitude towards science (Bauer et al, 2007). Also, the model did not attempt to understand scientific knowledge or attitudes within their social context. For example, the model proposed that identical questionnaires be completed by all demographics, and held that superstitious and religious beliefs indicated scientific illiteracy (Raza et al., 2002).

In the 1970's, enquiries into the relationship between science and the public shifted to a focus on attitudes, rather than scientific literacy. The term "Public Understanding of Science" (PUS) grew out of this new focus (Gregory and Lock, 2008). A report entitled "Public Understanding of Science" was published by the Royal Society in England to raise concerns about the political vulnerability of the scientific community due to waning levels of public support for S&T (Miller, 2004; Ziman, 1991). This model was predicated upon the assumption that increased scientific knowledge among the public would result in more positive attitudes towards science (Allum et al, 2008; Bauer et al., 2000). Thus more effective

communication of science and technology issues, with a focus on shaping pubic attitudes, rather than only public scientific literacy, should result in positive attitudes and increased interest (Gregory & Lock, 2008; Bauer et al, 2007). The Eurobarometer and US National Science Foundation surveys began to use normative measures based on the PUS model. These surveys sought to measure both scientific literacy and attitudes toward science (Bauer et al. 2000).

However, the assumption of a causal relationship between scientific literacy and the creation of positive attitudes towards science continued to be questioned. Allum et al. (2008) conducted a meta-analysis of 193 PUS studies conducted from 1989 to 2004. The study found that there was a weak positive correlation between scientific literacy and attitudes, but this was not sufficient to indicate a causal relationship.

The relationship between general attitudes to science and attitudes to specific scientific issues is also not a simple one. Allum et al (2008) found that there was a strong relationship between general attitudes towards science and attitudes towards the controversy over genetically modified foods; however, this relationship was weak when it came to the issue of nanotechnology. Unpacking the determinants of such a divergence requires an analysis that seeks to examine attitudes towards science as social constructs, which is not possible under the limitations of the PUS model.

During the mid 1990's the Science in Society paradigm emerged out of these criticisms. This model held that the relationship between science and the public is not based only on literacy or attitudes, but also on the public's social, cultural and political environments (Bauer et al., 2007). It therefore argued for the significance of understanding bi-directional aspects of the relationship between science and the public.

For example, concerning the question of trust between the public and the scientific establishment, Bauer et al (2007) argue that misconceptions within the scientific community about the public's low levels of scientific understanding influence science and technology policy, which in turn can further exclude the public from engaging in the policy process. Thus, rather than focusing only on the 'deficit' in public knowledge or attitudes, the Science in Society model also examines options for institutional change which will see a greater involvement of the public in the policy formulation process. This could be facilitated by mediators - people or institutions tasked with mediating between the public, the scientific community, industry and policy makers – for example pressure groups, non-governmental organisations, science communicators and politicians. Mediators could also be tasked with communicating science information to the public. This would be part of the broader imperative implied by the Science in Society model – that science communicators (such as journalists, public information officers, or museums) are vital in the process of the science community and the public working together with the aim of building both scientific knowledge and positive attitudes towards science (Burns et al., 2003).

The Science in Society model is thus particularly suitable for efforts to understand issues of scientific attitudes as represented by the media. The model supports a bi-directional analysis, in which public attitudes influence the performance of science, and the scientific establishment (including government officers) in turn influences public attitudes. Within this context, the representation of science and technology in the media is a key factor. These

representations play a significant part in determining public attitudes, and also play a role in facilitating public dialogue over scientific issues, and thus in facilitating communication between the public and science.

The Science in Society model was therefore adopted as the most suitable conceptual framework for this study. The research question and questionnaire design take into account questions of scientific information and attitudes towards science. They also include questions of mediation between science and the public, with a focus on the role of the media. Media outputs will be analysed with a view to understanding how these could impact on public opinion. This will make it possible to integrate these research findings with any further research on surveys into public attitudes that provides data regarding the formation of these attitudes within a social context and in response to media messages – in other words, this study provides an understanding of one half of a bi-directional relationship, and opens up a door to engaging with the other half. Thus, although outside the scope of this research project, a complementary set of research questions would concern the other side of the bi-directional relationship between the media and the public. While the media analysis presented here will answer some questions about the composition and dynamics of media representations of biotechnology in South Africa, further research would be required to understand what impact these representations have on the public's knowledge and attitudes. This would require surveys of the public that include questions about scientific literacy in the area of biotechnology, attitudes towards aspects of biotechnology, exposure to biotechnology in the media, and the impacts of this exposure on both knowledge and attitudes.

2.2. Biotechnology in the media

The origins of biotechnology, in its broadest sense, go back to the development of selective breeding in agriculture. However, the contemporary definition of biotechnology is restricted to applications of technologies related to manipulating DNA (Bauer, 2005). Thus, modern biotechnology is commonly seen to have originated in 1973, when the first patent on recombinant DNA techniques opened up prospects of designing organisms and reaping economic benefits from them. These issues did not make a large impact on public discourse for some time (Cantley, 1995; Torgerson et al, 2002). The global controversy surrounding biotechnology received great impetus following the production of genetically modified soya in 1996, and the birth of Dolly, the cloned sheep, in 1997. The world media played a key part in influencing public debates about genetic modification and cloning (see Lassen et al, 2002). For example, the prospect of genetically modified crops prompted debates about food safety, genetic integrity, labeling policies, and traceability of food. Dolly the sheep prompted debates about the ethics of human cloning for reproductive or therapeutic purposes.

The applications of biotechnology are numerous, and many of these applications have generated controversies of their own. These include: in vitro fertilization, stem cell research, biological weapons, gene therapy, genetically engineered vaccines and other pharmaceuticals, genetically modified plants and animals, and even human cloning (Nisbet & Lewenstein, 2002). Most of these technologies have experienced associated controversy and media coverage.

In the context of the 'Science in Society' perspective on the relationship between science and the public, technology must be regarded as an outcome of and input to social processes (Bauer et al, 2007; Bauer, 2005). A core literature on the role of the media in the public sphere of biotechnology has been developed using such a framework, in which biotechnology is considered a 'social movement'. Martin Bauer of the London School of Economics is a central figure in this literature, which ascribes several key characteristics to biotechnology as a social phenomenon. Firstly, biotechnology projects need to mobilize support, whether from firms, governments, academics, or the good will of the public. Secondly, imagined future scenarios and reasoned arguments more or less determine this support in society. Thirdly, the technology movement is not homogenous and may have internally conflicting goals. Fourthly, the actors of this movement encounter a public sphere where they are (re)presented in a manner that informs attitudes and public perceptions of the technology. Finally, a technology movement is not a unified movement, but rather consists of integrated competition among actors, for example over public good will or regulatory arrangements (Bauer & Gaskell, 1999; Bauer, 2002).

These characteristics inform the core heuristic that shapes many studies of biotechnology in the media, one that is centred around the idea of the public sphere, as expressed for example by Habermas (1989). This heuristic was developed by Bauer in his 2002 paper, 'Arenas, platforms, and the biotechnology movement', and was applied in a large research project to measure media representations of biotechnology in Europe (Bauer, 2005).

Figure 1: Heuristic for understanding the public sphere

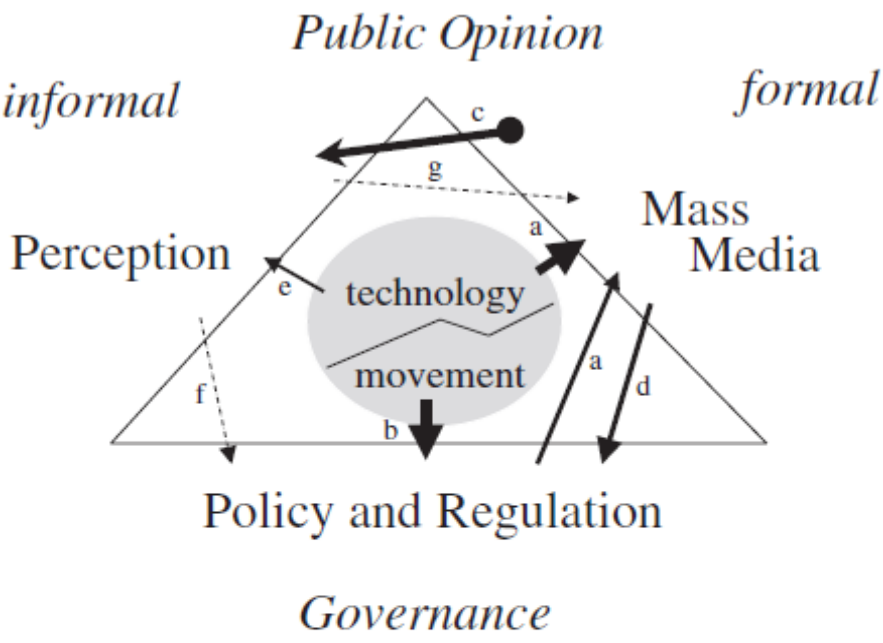

Figure 1: Triangular Model of the Public Sphere of Science and Technology
NOTE: The triangular model of the public sphere of science and technology shows its four main constituencies. The technology movement is at the center, surrounded by the three arenas of the public sphere: regulation and policy making, mass media coverage, and public conversations and perceptions. The triangular model integrates various nonoverlapping distinctions: governance versus public opinion; within public opinion, that between informal and formal public opinion; and the conflicting formations within the biotechnology movements. The arrows suggest principal directions of influence and the hypothetical strength of influences that are subject to empirical testing. The following seven relations can be identified: (a) public relations; (b) lobbying; (c) media effects on public perceptions; (d) media effects on policy making; (e) public lecturing and education; (f) relatively direct contacts with the public, for example, public discussions, consensus conferences, and so on; and (g) feedback effects from audience to mass media production.

Source: Bauer (2002, p150)

The circle at the centre represents biotechnology as a social movement, a network of actors that are more or less for or against aspects of biotechnology. This network is constrained (in the sense of both enabled and resisted by) the structures and processes occurring in the public sphere, including the regulatory framework, mass mediation through the formal media, and the informal conversations of the public. In this context the 'public sphere' is conceived as "a communication system where interested actors mobilize attention in public arenas" (Bauer, 2005, p8), including arenas of policy-making, mass media, and the perceptions and conversations of the public. Representations of biotechnology can be understood within this framework to form bi-directional causal relationships with public opinion and the policy environment.

The relationships between policy making, the media and public opinion are thus complex. On one hand, many actors, for example in politics and business, refer to the media as an index of public opinion – i.e. it is partially a reflection of public opinion. On the other hand, the media circulate messages widely and thus inform public opinion too. It is also important to recognise that powerful actors have an influence over controlling and framing news,

including representations of biotechnology. These include actors from governments, firms, lobby groups, non-profit interest groups or pressure groups, scientists, and the press itself. These actors compete to frame biotechnology-related issues in their own interests (Krimsky, 1991). The contribution of these actors and relationships to the trajectory of biotechnology is a key empirical question (for example in Bauer, 1991, 1995).

In a broader sense, there have been many studies illustrating the utility of analyzing media outputs as sources of technology-related information for the public, for example Wade and Schramm (1969), Robinson (1972), Griffin (1990), Mazur (1981), Coleman (1993) and Dunwoody & Peters (1992). There have also been several empirical investigations focused on biotechnology in the media. Early studies were qualitative in nature and focused on risks and potential threats to public health (Goodell, 1980, 1986). An early quantitative study was undertaken by Pfund and Hofstadter in the mid-seventies (Pfund and Hofstadter, 1981)). Both of these studies found that coverage of biotechnology was dependent on the input of scientists that were willing to engage with the media, and that scientists who were proponents of biotechnology were dominant over those that were critical of it.

Gaskell et all (1999) studied coverage by the *Washington Post* through the 1980s and 1990s. It was found that coverage in the 1980s was framed by discourses of progress and economic prospects, with dominant themes of basic research, industry development, and health applications. The years 1991 to 1996 saw increased attention to the attendant risks. Other examples include studies by Beall and Hayes (1996), Priest and Talbert (1994) and Marks et al (2000).

More recent empirical research includes Nisbet and Lewenstein's (2002) paper analyzing coverage of biotechnology in the elite press in the USA, as well as Bauer (2005) and Bonfadelli's (2005) analyses of biotechnology in the European media, using the same data-set from 12 European countries.

One important contextual difference between the current project and these examples is that South Africa is a highly unequal developing economy. This has theoretical and methodological implications. The 'knowledge gap hypothesis' holds that: "As the infusion of mass media information into a social system increases, segments of the population with higher socio-economic status tend to acquire this information at a faster rate than the lower status segments, so that the gap in knowledge between these segments tends to increase rather than decrease" (Tichernor et al, 1970, p159-160). This hypothesis is supported by empirical studies, which have reported correlations between education and social status with knowledge about science and technology (Bonfadelli, 2005).

However, the hypothesis does not hold in a consistent way; for example some panel studies have shown the gap to become narrower over time. Such inconsistencies have stimulated theoretical refinements to the hypothesis, as in Bonfadelli (1994), Gaziano & Gaziano (1996), Viswanath & Finnegan (1996), and Kwak (1999), most of which include additional variables that moderate the emergence of education-based knowledge gaps, with a focus on motivational factors rather than cognitive factors (Viswanath et al, 1993). Evidence suggests that knowledge gaps tend to be greater in more pluralistic social settings, but decrease in more homogenous societies (Tichenor, Donohue, & Olien, 1980). Micro-level factors include both message- and audience-related factors. Message related factors include the

knowledge topic, the knowledge type, information channels, and the duration and intensity of media publicity over time (see Grabe, 2000; Price & Zaller, 1993; Graber, 2001; McLeod & Perse, 1994; and Viswanath et al, 2000). The message-related factors are salient to this study's scope, and are included where possible as variables in both the media analysis and key informant interview methodologies.

Audience-related factors include: topic-specific interest and motivation to actively seek related information; communication skills related to the effective interpretation and use of media information; prior knowledge and underlying cognitive frames; access to a wide variety of information sources; a tendency to use information-rich media; and relevant social contacts and networks. Audience-related factors largely fall outside the scope of this project, but would be relevant to further research into public attitudes towards biotechnology and how these are informed by the media.

The knowledge gap hypothesis and related evidence questions the normative assumption that mass media in democratic societies always has a positive effect in informing the public; in other words, that an increase in available information will lead to a better informed, and equally informed, public (Bonfadelli, 2005). This is particularly relevant to the South African context, where the world's highest levels of economic inequality are coupled with a national agenda of inclusive growth and development. An understanding of the demographics of media messages, and the efficacy with which demographic segments can convert media messages into useful knowledge, is particularly important. Government would be failing in its agenda of inclusiveness if it facilitated improved media representations of biotechnology that only benefited already privileged sectors of society. Research into the social impact of media messages falls outside the scope of this project, but would form part of an important avenue of related further research. Such a survey of public attitudes towards biotechnology would include questions about the nature of received media messages, educational factors, and motivational factors. These variables would all be useful in constructing an analysis that could describe the impact of biotechnology in the media and test for occurrences of knowledge gaps.

3. Methodology

The methodology for this study is comprised of two main instruments: key informant interviews, and media analysis. The departure point for the informant interviews was the set of three research objectives, informed by the Science in Society model of social context and the variables highlighted as critical by the literature on biotechnology in the media. Thus interview questions sought to understand how biotechnology is represented in the media and what factors influence these representations. Interview questions also asked respondents where the obstacles are to the entry into and support of the South African biotechnology sector, whether for firms, financial capital, human capital, scientists, or journalists. Finally, interviews sought recommendations regarding the purpose and aims of public dialogue regarding biotechnology in respect of both challenges (such as knowledge gaps and misunderstandings) and opportunities (such innovations and new methods of information dissemination). The interview questionnaire is provided in Appendix A.

Informants were chosen from a range of stakeholders, including science journalists, science editors, academics, and non-profit organisations active in the media, using a purposive methodology and the snowball technique.

The second research instrument is a media analysis tool. The methodological departure point for this analysis was the international best practice methodologies employed by Nisbet & Lewenstein (2002), Bauer (2005) and Bonfadelli (2005). These leading studies on media representations of biotechnology are illustrative, within the constraints of the knowledge gap hypothesis and other contextual differences between South Africa and the developed countries in which the relevant surveys took place.

Nisbet and Lewenstein (2002) followed a structured methodology analyzing biotechnology-related coverage in the *New York Times* and *Newsweek* (both American elite press and opinion leaders) between 1970 and 1999. The key variables in this analysis were visible impacts on these messages by various social and political actors, the tone of the coverage, the main issues or themes covered, and the main 'frames' featured in the coverage. These findings were compared to key political and economic events in a search for correlations.

Nisbet and Lewenstein's choice to focus on opinion leading newspapers is based on a commonly held principle in media analysis, that: "stories tend to spread vertically within the news hierarchy, with editors at regional news outlets often deferring to elite newspapers and newswires to set the national news agenda" (Lewenstein, 2002, p371). This principle was applied to the methodology of the current study, which included searches of the archives of South African opinion leaders. However, given the concerns about social inequality in South African and the consequent concerns about knowledge gaps, in the South African context it was necessary to include searches from the popular press in order to gain an understanding of media channels that reach a broader public.

The measurement methodology employed by Nisbet and Lewenstein was based on that of a previous EU-funded project to research coverage of biotechnology in the print media across ten EU countries (Durant, Bauer, and Gaskell, 1998). A search for biotechnology terms was conducted on the archives of the *New York Times* and *Newsweek* for the years 1970 to 1999. The retrieved articles were coded according to latent frames, themes, tone (i.e. references to risks and benefits), and references to key actors. This coding scheme was similar to those employed by Bauer (2005) and Bonfadelli (2005).

Frames included references to latent content that provides a discursive framework or set of assumptions that frame the discourse. For example, discourses in favour of or against biotechnology as an engine of economic growth would fall under the discourse frame of 'economic prospect'. The framing typology employed by Nisbet and Lewenstein is commonly used for understanding biotechnology in the media, and was originally developed by Gamson and Modigliani (1989), refined by Durant, Bauer and Gaskell (1998) and also used by Bauer (2005), amongst others. Key framing discourses were identified as 'progress', 'economic prospect', 'ethical', 'Pandora's box', 'runaway', 'nature/nurture', 'public accountability', and 'globalization'. Coders of media outputs chose one dominant frame per article.

Themes for each article included references to a particular type of biotechnology, or a particular attendant social, political or economic theme. Each article was coded with up to three key themes. Another latent measure is of the tone of an article. The three variables measuring this capture whether an article mentions the risks of biotechnology, whether it mentions the benefits, and whether it reports on a biotechnology-related controversy. The final set of codes was for the measurement of key actors in each article. These may come from industry, government, education, science, or non-government spheres. Coders could make reference to up to two of the main actors mentioned in an article.

This methodology allowed Nisbet and Lewenstein to construct a profile of media coverage of biotechnology and to track changes in all of these variables over time. This allowed them to correlate these findings with major political, economic, social and scientific events in order to construct a narrative of the relationship of actors in these domains with media representations.

Bauer (2005) used a similar methodology, which overlapped substantially with that of Bonfadelli (2005), and used the same data-set. Bauer also chose to focus on the opinion leading press, for similar reasons. This study measured the media outputs of one or two opinion-leading publications in each of the twelve countries covered by the study, and analyzed the biotechnology coverage of these publications through the coding of key variables and a comparative cross-country analysis. The definition of an 'opinion leader' is contested, but is clearly critical to this endeavour being methodologically sound. The definition employed by Bauer is that an opinion-leading publication is read by other journalists, and is perceived as an apex publication by both government and business. For example, the official British 'newspaper of record' of the British Library was *The Times* until 1987, after which it became *The Independent*. Using similar criteria, in Germany opinion leaders were *Der Spiegel* and *FAZ*, and in France, *Le Monde*.

Bauer used a key-word search of the online archives of these newspapers to collect the relevant media resources, using searches for the terms biotechnology, genetic engineering, DNA, genes, cloning, genetics, genome, and stem cell. He constructed an index of intensity based on an annual count of all references to these search terms in a single newspaper. This provided a measure of 'public salience', or levels of public interest and attention, of biotechnology and related search terms. Previous studies had used similar methods, adjusted to suit different contexts and objectives (Bauer, 1998; Bauer and Howard, 2004). Because of the large multi-country scale, this rendered a total of more 20,000 articles recorded in a coding database. This coding frame used 43 variables, including: size, format, position within the newspaper issue, authors, themes, actors, geographical location of biotechnology events, controversy, risk and benefit arguments, overall framing, and evaluation of biotechnology.

Media analysis, using these best practice methodologies, is thus helpful in addressing the debate regarding media representations of biotechnology. This methodology therefore guided the media analysis of South African media outputs. The details of the variables selected for the coding of South African media outputs related to biotechnology are listed in Appendix B.

The sample selection for this study, like the cases mentioned above, searched the online archives of print newspapers, but expended the search to include the online archives of online media sites. An opinion leading newspaper was included, selected on the same basis as Bauer (2005) and Bonfadelli (2005). In addition, other news sources were selected that speak to different demographics and purposes, with a mixture of regional publications and popular publications.

4. Media analysis

Media analysis helps to answer questions of how the media represent biotechnology and related issues. It can also provide useful empirical data that are relevant to the broader questions regarding the motivation and objectives for public policy and public dialogue in the media that are raised in the key informant interviews. Thus, the current media analysis aims to answer questions such as:

- What themes related to biotechnology are the most prevalent in the media?
- Are these aspects reported on positively or negatively?
- Is reporting balanced (between reporting risks and benefits) or unbalanced?
- Who are the main actors referred to in media representations of biotechnology?
- Are there differences in the representation of biotechnology between publications?
- Are there any relationships between variables such as theme, tone, actor, and publication?

The first step in the media analysis methodology (outlined in section 3) was to identify suitable publications for analysis. The literature suggests that sample publications should be opinion leaders, since these messages in turn "spread vertically through the news hierarchy" (Lewenstein, 2002, p371). However, in the South African case it was decided to expand the sample to include a regional press and an online news site in order to gain some understanding of these media for exploratory purposes.

The selected opinion-leading newspaper was the Mail & Guardian. This newspaper has consistently achieved recognition for its journalism. While this sample was mostly of the print edition of the paper, it also included three articles that existed only on its online division, the M&G Online. This division was established in 1994, and was the first online news publication in Africa. M&G Online makes available articles from the print version on the Mail & Guardian, and also has a number of additional features, including special sites for 'thought leader' blogs, sports, technology, entertainment, and education. The online search found three online 'thought leader' blogs which featured biotechnology in the M&G online archive. The Mail & Guardian is owned by Newtrust Company Botswana Limited, with a minority share held by the London-based Guardian Newspapers.

The first popular regional press that was selected was the City Press, a Gauteng-based newspaper owned by Media24, which in turn is majority owned by Naspers, the South-African based media multinational. However, a search of the City Press online archives found no articles under any of the relevant search terms. This search therefore served to illustrate that regional newspapers may have practically no coverage of biotechnology and related issues – a concerning finding in relation to any policy agenda that aims towards increased awareness and encouraging public debate.

The second popular regional press that was selected was the Sowetan, a publication of the Avusa group, which also includes major print publications such as the Sunday Times, The Times, Business Day, The Herald, The Mercury, and many others. The Sowetan is also a Gauteng-based regional newspaper. Here a full search of all the relevant terms yielded only four articles. This very small presence has similar implications to the City Press result for policy seeking to spread awareness and debate.

Finally, an online news site was chosen to illustrate the coverage of biotechnology in the online media. IOL is South Africa's second largest online news site (after News24). IOL is the flagship site of Independent Newspapers, the largest newspaper group in South Africa, which publishes 14 daily and weekly newspapers and 13 free delivery weekly community newspapers.

The search method was similar for each of these publications. The online archives of the respective publications were searched, covering the entire period of availability for each publication. The exception in this regard was the search for IOL, which only covered 2009 and 2010. The following search terms were used: biotechnology, biotech, clone, cloning, genetic engineer, gene manipulation, gene technology, gene therapy, re-combinant DNA, bio-fuel, GMO, genetically modified organism, and stem cell. The results of these searches were included in the sample. The exception to this procedure was the search of the IOL site. In this case, the results of the search were so numerous (running into the hundreds or even thousands if one includes the business news site) that all results could not be included in the database. Thus results were restricted to the search terms "biotechnology" and "biotech" and only for the years 2009 and 2010. Despite these restrictions, the sample from IOL.com is larger than the other two samples. Amongst other things, this illustrates the power of online media to provide public access to a wide range of news articles and information about biotechnology.

Table 1: Sample profile

Publication	**Type**	**Search Status**	**Time period***	**Number of articles**
Sowetan	Print media, regional	Complete	2008-2010	4
City Press	Print media, regional	Complete	n/a	0
Mail & Guardian	Print media, opinion leader	Complete	2005-2010	13
Mail & Guardian Thought Leader	Online media, opinion leader	Complete	2007-2008	3
IOL	Online media, national leader	Only searched for 'biotechnology' and 'biotech'	2009-2010	30

**time period reflects the date range of articles rendered by the search process. The exception is the IOL search, which yielded a far larger sample and was therefore restricted to articles from 2009-2010, and to only two search terms*

Each article was printed, read, and coded according to the set of variables defined in the methodological framework and listed in Appendix B. These included variables related to

frame, tone, themes, and featured actors. The process of coding media is time-consuming, and acted as a constraint on the size of the sample. Since this particular media analysis is only one component of a small (one month) study, there was only sufficient time available to collect an indicative sample, rather than a representative one. With greater resources, further searches could be conducted for other publications, in more depth, and could even be extended to media channels such as radio, television, cinema. Further background research into the composition of the South African media and the publics for these media would make it possible to more directly relate the media analysis to the South African public that receives these messages. For example, by identifying the demographics of various media channels, one could construct a profile of the different sets of messages received by different demographic sectors in South Africa. Such a line of research would require substantially more resources, but would have more far-reaching policy applications. Also, a larger sample will allow for a longitudinal study that examines changes in the key variables over time, something which would also have valuable policy applications.

However, within the resource limitations of the current study, the data are useful: the sample represents the entire set of biotechnology-related articles from the archives of the regional print publication, the opinion leading print publication, and the opinion leading online publication (M&G Online). Only the IOL site had too large a search result to fully include all relevant articles. The sample therefore does tell us something concrete about these specific publications.

Once all the articles were coded and the results recorded in a database, analyses of these findings could begin. Analysis provides and entry into the subject of media representations of biotechnology in South Africa, and the key informant interviews provide more depth.

4.1. Findings

Summary profiles of the distribution of these variables in the sample are illustrated in tables 2 to 5 below. Note that the variable for 'frame' only coded one term per article. Therefore the summary results for this variable will total 100%. However, up to three themes and two actors could be coded for each article, so the summary results for these variables will total more than 100%. Moreover, this raises the analytical task of identifying relationships between themes and actors that are not made evident in the summary data.

Frame

The 'frame' of the selected articles can be seen as a meta-theme, an indication of latent content or the discourse framework that characterizes the article. The frame is normatively neutral, for example a frame of 'ethics' may be constructed to hold arguments either for or against biotechnology, or both. The framing typology drawn from the methodological framework is illustrated below. This typology is adapted from Durant, Bauer, and Gaskell (1998) and originally was developed in part by Gamson and Modigliani (1989):

Progress: celebration of new development, breakthrough; direction of history; conflict between progressive/conservative-reactionary

Economic prospect: economic potential; prospects for investment and profits; R&D arguments

Ethical: call for ethical principles; thresholds; boundaries; distinctions between acceptable/unacceptable risks in discussions on known risks; dilemmas. Professional ethics.

Pandora's box: call for restraint in the face of the unknown risk; the opening of flood gates warning; unknown risks as anticipated threats; catastrophe warning

Runaway: fatalism after the innovation; having adopted the new technology/products, a price may well have to be paid in the future; no control any more after the event

Nature/nurture: environmental versus genetic determination; inheritance issues

Public accountability: call for public control, participation, public involvement; regulatory mechanisms; private versus public interests

Globalization: call for global perspective; national competitiveness within a global economy; opposite: splendid isolation

Table 2 illustrates the profile of the framing of the sample articles. The most common frame, accounting for the majority of articles, was 'progress'. This in most instances referred to medical or scientific progress. Of the 28 articles with a 'progress' frame, two had themes of animal cloning, three had themes of GMO plants, and the remainder had health-related themes.

Table 2: Frames

	% of articles
Progress	56
Ethical	24
Economic prospect	12
Public accountability	8

Articles under the frame of 'ethical' accounted for 24% of the sample. The most common themes under this discursive framework were related to GMO plants and related food risk, which occurred in 6 of the 12 articles. Of the remaining articles, four had medical themes, one was concerned about the genetic modification of domestic animals, and one was about frontier DNA research.

Articles with the frame of 'economic prospect' were largely about GMO plants (4), and the remainder about biofuels (1) and pharmaceutical (1) applications. Finally, articles under the frame of public accountability were about GMO plants and related food risk (3) and stem cell research (1). Discursive frames were unevenly represented among the publications. For example, the Mail & Guardian had a higher proportion of articles in an ethical frame (7 of 16, or 44%) than the average (24%).

Themes

Table 3: Themes

	% of articles
GMO plants	36
Food risk	24

Ethical issues	20
Stem cells	20
Diagnosis/predictive medicine	14
gene therapy	14
pharma/vaccines	14
Genetic sequencing	12
Environmental risk	10
Animal cloning	8
Legal regulations	8
Economic prospect	6
Biofuels	2
DNA research	2
Health	2
HIV	2
In vitro fertilization/reproduction	2
Microorganisisms	2
Religion	2

Overall, the two broad thematic areas are 1) GMO plants (and animals) and the related food and environmental risks, and 2) health applications of DNA research, including stem cell research. These sets of themes account for almost the entire sample, highlighting two clear loci of media representations of biotechnology: health-related themes accounted for 58% of the sample, and themes related to the genetic modification of plants and animals for human consumption accounted for 48%. Both of these themes are in turn linked to the theme of ethical issues.

The most common single theme in the sample was that of GMO plants, which occurred in 36% of the sample. Strongly related to this was the theme of food risk, which occurred in 24% of the articles. The link between these two themes is clear, with 11 of the 18 articles (61%) about GMO plants also having a theme of food risk. The remaining article with a food risk theme was related to animal breeding/cloning for human consumption.

Ethical issues occurred in 10 articles (20% of the sample), and this theme was related to stem cell research (4 articles), GMO plants and food risk (2), gene therapy (2), animal breeding, in-vitro fertilization, and general DNA research (1 each). Thus the ethical debates centre on the use of biotechnology in stem cell research and other health applications, and in the genetic modification of plants and animals for human consumption.

Taken together, health-related themes are the most common, and include stem cell research, diagnosis and predictive medicine, gene therapy, pharmaceuticals and vaccines, genetic sequencing, general health, HIV, and in vitro fertilization. Overall 29 articles or 58% of the sample featured health-related themes.

Tone

A profile of the reporting of risks and benefits associated with biotechnology is presented in table 4. Biotechnology appears to be a field that is generally reported in the context of its risks and/or benefits – only 4% of the articles did not report on risks or benefits. For the remainder, the reporting of benefits outweighed reporting of risks (78% of articles versus 42%), indicating a generally positive attitude towards biotechnology.

Table 4: Tone

Summary of sample (n=50)	
Reported no risk, benefit, or controversy	0%
Reported risk	42%
Reported benefit	78%
Reported controversy	54%
Profile of sample (n=50)	
Reported neither risks nor benefits	4%
Reported risks only	18%
Reported benefits only	54%
Reported risks and benefits	24%
Profile of sample reporting controversy (n=27)	
Reported controversy, but no risk or benefit	0%
Reported controversy and risk only	33%
Reported controversy and benefit only	22%
Reported controversy, risk and benefit	44%

'Sensationalism' is a normative notion, and thus not amenable to objective measurement excercises such as a media analysis. However, measures of tone can be used as proxy measures of sensationalism or unbalanced reporting in the media. For example, articles that report on only risks or only benefits are likely to be examples of unbalanced reporting. Here the data clearly show that such reporting is predominant: 18% of articles reported only on risks, and 54% only on benefits; thus 72% of articles present only risks or only benefits.

More pertinently, one can focus on articles that report on a controversy related to biotechnology (n=27). In these cases, balanced reported would require a mention of both risks and benefits, or neither. Once again, the majority of articles in this group do not represent both sides: only 44% mention both risks and benefits, leaving 66% that report in an unbalanced manner on biotechnology controversies.

This begs the question: which controversies are reported on in a balanced way, and which are reported on in an unbalanced way? This can be answered by calculating the number of articles with themes that fall into the following categories: 1) reporting on controversy and risks only and 2) reporting on controversy and benefits only. This can be contrasted to articles with themes where there is 3) reporting on controversy with risks and benefits. The findings according to these categories are presented below in Table 6:

Table 5: Profile of tone by theme in set of articles reporting controversy (n=27)

Benefits only	N=6	**Risks only**	N=9	**Risks and benefits**	n=12

Stem cells	5
Ethical issues	2
Diagnosis/predictive medicine	1
Economic prospect	1
GMO plants	1

Food risk	8
GMO plants	8
Environmental risk	3
Ethical issues	3
Legal regulations	3
Animal breeding/cloning	1
Religion	1

GMO plants	5
Ethical issues	4
Food risk	4
Stem cells	3
Economic prospect	2
Environmental risk	2
Gene therapy	2
Biofuels	1
DNA research	1
In vitro fertilization	1
Legal regulations	1
Microorganisisms	1

Table 6 reveals differences in representations of controversial themes. Twelve of the 27 articles reporting controversies reported both risks and benefits of biotechnology. Nine articles reported only the risks, and are thus examples of unbalanced reporting. This set of articles is dominated by articles related to GMO plants and related food risk (8 of the 9 articles). The remaining article has a theme of animal cloning for human consumption, which is cognate. The other themes occurring in this set are secondary or tertiary themes related to GMO plants and animals, such as environmental risk, legal regulations, or religion. Thus, unbalanced reporting that reports only the risks related to biotechnology controversies largely takes place in the terrain of biotechnology applications in plants and animals for human consumption. By contrast, unbalanced reported of controversies that reported only benefits but not risks tended to be about stem cell research (5 of the 6 articles). In relation to the other variables, this finding highlights a key distinction in the representation of the two main sets of themes present in representations of biotechnology in the sample: unbalanced reporting of controversies tends to view stem cell research favourably and GMOs unfavourably.

Actors

Table 5 illustrates the distribution of actors in the sample. The most common actors mentioned are biotechnology producers (i.e. firms) and university scientists, each of which feature in 40% of the sample. Other significant actors are institute scientists (18%), government (16%) and agricultural NGOs (14%). Grouping actors into higher-level groups reveals four key sets of actors: scientists, including both university and institute scientists, are represented in 52% of articles, producers are represented in 40%, NGO's, including agricultural, environmental, and bioethics NGOs, are represented in 20%, and government in 16%.

Table 6: Actors

	% of articles
Producer	40
University scientist	40
Institute scientist	18
Government	16
Agricultural NGO	14

Environmental NGO	8
Religious	6
Bioethics NGO	2
Doctor	2
Farmer	2
Public	2
Regulators	2
Scientists (group)	52
NGOs (group)	20

Publications

Summary profiles of key variables across the three publications making up the sample are presented below (Table 7). The data are all presented as percentages of the articles from that publication, with the exception of certain data related to tone. This allows for easier comparison of the proportions of each variable present in each publication. However, the small size of the sample from the Sowetan limits the utility of the data for this particular publication.

Table 7: Summary by publication, %

Frames	M&G N=16	IOL n=30	Sowetan n=4	Total n=50
Progress	50	60	50	56
Ethical	44	17	0	24
Economic prospect	0	25	50	12
Public accountability	6	19	0	8
Themes				
Health related themes	50	57	75	58
GMO related themes	50	40	75	48
Tone				
Reported risk	50	40	25	42
Reported benefits	50	83	100	78
Reported controversy	63	53	25	54
Reported controversy & risk only*	60	10	0	22
Reported controversy & benefits only*	20	13	0	33
Reported controversy with risk & benefit*	20	56	100	44
% unbalanced reporting of controversy*	80	44	100	55
Actors				
Scientists	43	57	50	52
Producers	43	43	0	40
NGOs	25	20	25	20
Government	13	20	0	16

** as % of articles reporting controversy*

In terms of frames, it is of interest that the M&G has a substantially higher proportion of ethical frames to its articles (44% versus the 17% of IOL). IOL in turn features higher proportions of frames of economic prospect and public accountability.

The proportion of themes was remarkably consistent across the publications, with an approximately even split in all cases between GMO-related themes and health-related themes. This again underscores that these are the two key areas of biotechnology reporting.

The Mail and Guardian had a higher proportion of articles reporting a controversy compared to the other publications. However, these articles were also more likely to represent these controversies in an unbalanced way. This is an unexpected finding for an opinion-leading publication, which in principle should be characterized by balanced reporting. IOL was more positive about biotechnology, with 83% of articles reporting on its benefits, and only 40% on its risks.

References to actors were relatively similar across the publications, with scientists and firms featuring prominently, followed by NGOs and government.

4.2. Media analysis summary

The process of sample selection was informative, as it provided an indication of the availability of biotechnology-related messages in the media. The fact that a search of the City Press archive rendered no articles at all, and that the search of the Sowetan archives rendered only four, indicates that these popular regional presses provide only very limited or no articles about biotechnology. The Mail & Guardian rendered thirteen articles. However, the real bulk of information about biotechnology is available online, with hundreds or thousands of articles available on IOL. This suggests that the richest source of news articles about biotechnology is the online media rather than the print media. Any strategy developed to better manage the public's engagement with biotechnology in the media would need to take this into account; at the same time, such a strategy would also have to take into account that a large proportion of the South African public does not have access to the online media.

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The most common frame for representations of biotechnology was that of 'progress', which in most cases referred to medical or scientific progress. The 'ethical' frame accounted for about a quarter (24%) of the sample, followed by the less common frames of 'economic prospect' and 'public accountability'.

The two thematic loci in the sample were 1) genetically modified plants and animals for human consumption and 2) health applications of biotechnology, including stem cell research. These accounted for 48% and 58% of the sample respectively. Both of these groups were related to the theme of ethics. Moreover, there was a clear link between the theme of GMO plants and that of food risk.

Articles had a greater focus on the benefits of biotechnology (78%) than the risks (42%). Reporting tended to be unbalanced, as 72% of the sample reported on only risks or only benefits, rather than both. A better measure of balanced reporting, focusing on articles addressing a controversy, also revealed a predominance of unbalanced reporting: 66% of articles reporting on a controversy reported only risks or only benefits, rather than both.

This also had a clear thematic association, as these unbalanced representations viewed stem cell research favourably and GMO plants unfavourably.

The key sets of actors referred to in the sample were scientists (52%), producers/firms (40%), NGOs (20%) and government (16%).

There were some differences with regards to these variables across publications. The Mail & Guardian had a higher proportion of ethical frames than the other publications, although it also had a higher proportion of unbalanced reporting of controversies (contrary to expectations from an opinion-leading publication). However, other variables showed a remarkable consistency across publications. All publications had a relatively even split between GMO-related articles and health-related articles, and all featured a similar mixture of scientist, firm, NGO and government actors.

5. Key informant interviews

The sample for the interviews was chosen by a purposive snowball methodology. Starting with a science journalist, recommendations and contact details were obtained from all participants, as well as from the project steering committee. A total of eleven interviews were conducted. The findings for four of these have not been used[1]. Thus the final sample consists of the findings from seven interviews. Participants included:

- one technology editor from an online news publication
- two freelance science journalists
- one science journalist for a regional print publication
- one freelance journalist and science fiction author
- one academic from the media departments of a university
- one university scientist from a department of microbiology

Given the resource and time constraints of the project, the sample was focused on journalists and academics. However, further research in this area would benefit from greater resources directed at providing a larger and more diverse sample. The inclusion of firms, NGOs, government agencies, and participants from other media channels such as television and radio would enrich the empirical basis of the research.

All participants were administered the questionnaire provided in Appendix A. However, not all of the questions were relevant to all of the participants, for example academics could not report on the biotechnology reporting trends of their publication. In other cases participants did not have access to the required information. Within these constraints, the structured interview schedule was answered by all participants and digitally recorded. These digital records were later analysed and the answers and key discussion points extracted. These findings were in turn entered into a matrix that would allow for easy summary, comparison, and analysis. This analysis is presented below. The focus is on presenting relevant comments in a qualitative and thematic fashion.

[1] Four of the interviews were completed under provisional approval of the HSRC's Research Ethics Committee, but before the granting of final approval. Although final approval was subsequently granted, the committee requested that the project abstain from using the findings of these interviews.

5.1. Findings

What are the key issues reported in biotechnology coverage in the South African media?

Responses to this question were generally in line with the findings of the media analysis. Three participants identified GMO and health applications as the two main focus areas in the media; two participants identified only GMO as a key issue. However, it was reported that articles with a GMO focus are more likely to have a local subject matter, while articles covering stem cell research (the most common representation of health applications) often originate from foreign line feeds and have foreign subject matter.

Three participants noted that biotechnology is under-reported in the popular South African media, and that no biotechnology topics regularly have a high media profile, especially compared to reporting on politics, economics, arts and sport. However some specialist publications, such as Farmers Weekly, which have a direct interest in biotechnology related issues, do have more extensive coverage of biotechnologies that direct affect their readership.

Other points arising from this question were related to the manner of reporting. Two participants (the online news editor and an academic) noted that there are two general approaches to the reporting of biotechnology issues. One approach focuses on the science of biotechnology. The other adopts a moralizing point of view that focuses on the ethical implications of the science, rather than the science itself. This approach is often made from a reactionary and/or religious point of view.

A point raised by four participants was that coverage of biotechnology in the South African media is episodic and often related to specific events, such as scientific breakthroughs or current controversies.

What is the ethical tone of these messages?

There is contestation over the ethical implications of biotechnology, particularly around GMOs, with voices on both sides of the debate. The debate is polarised with little middle ground.

Related to this is the role of unbalanced reporting in framing the ethical tone of biotechnology coverage. Journalists are not always sufficiently educated, and thus often report in a sensationalist manner without fully understanding their subject matter. This problem can be mitigated through a focus on reporting that uses only scientifically valid evidence, rather than non-scientific evidence and opinions.

The editor of the online news site noted that normative reactions from readers can be gauged by examining online postings commenting on articles. Here it was reported that comments about biotechnology articles are polarized between two points of view. Firstly, there is the strict moralizing view – "how dare scientists engage in this kind of research?" This viewpoint perceives biotechnology to be unethical and "playing god". Comments with this view don't speak to the science in question, but focus on the ethical implications of the science. A second point of view focuses on the science in question, and these comments

generally put forward the belief that it is the acceptable role of science to ask questions and push boundaries. There is little or no middle ground between these two positions – indicating that debates about biotechnology are polarised in society as well as in the media. However, this polarisation is rarely if ever about the validity of the science itself - the polarisation is about ethical implications only.

What are the main sources of information used to construct representations of biotechnology in the media?

The different participants gave markedly different answers to this question, reflecting their different roles and contexts, although their responses on the whole reflected the findings of the media analysis, with a focus on scientists, firms, NGOs, and government actors.

The online media editor was constantly approached by firms with new products seeking to advance their marketing agenda. He noted that it therefore falls upon journalists and editors to distinguish between genuinely revolutionary products and gimmicks or marketing hype, in order to provide the public with information of value. However, this is not consistently achieved, particularly by junior journalists.

The same participant reported that his personal strategy for reporting on biotechnology (and journalism in general) was to aim for neutrality. For example, when writing a recent article about GMOs, his practice was to invite a range of stakeholders, including scientists, anti-GMO NGOs, and Monsanto, to comment. The article thus represented the responses of these stakeholders. More generally, he aims to "go to the best minds as far as possible" for sources, for example scientists at UCT and the CSIR. He believes the role of the journalist is to take the enormous knowledge of scientists and "compact it into 300 words or less". This is sometimes difficult, but is important in terms of user (i.e. reader) accessibility.

Interestingly, in an attempt to write a piece on GM potato farming in South Africa, the editor was unable to gain access to any farmers to comment; after great effort he confirmed an interview with one farmer, but the farmer cancelled at the last minute without explanation. All the farmers he spoke to were not comfortable commenting directly, and referred the participant to AgriSA. This seemed suspicious: if farmers had nothing to hide, why would they not comment on the matter?

For the science journalist from the regional print publication, the main source of information is academic institutions, for example the CSIR and university scientists. She steers away from firms and marketing messages. She also uses 'PubNet' - a large global database of science-based peer-reviewed articles, including biotechnology articles and evaluations of biotechnology products - to verify or refute the claims of biotechnology (and other) firms. It was also noted that English language newspapers often have multinational ownership and affiliations, and therefore receive news line feeds from abroad – for example the Independent Newspapers group. However, the Afrikaans press must rely on Reuters or foreign correspondents, and thus have less access to international news stories.

One freelance science journalist relies on court documentation and attendance of court cases, scientific journals, and in-house journals of science organisations. In seeking these sources she utilises a purposive methodology to follow leads. The other freelance science journalist picks up information and story leads from abroad rather than from South Africa,

following international news feeds. She also attempts to elicit information from local universities and organisations like TIA, but finds that they "are not releasing enough information to keep local journalists going". She reports that there are some PR officers in universities that keep journalists informed, but not to a sufficient extent.

Academics commenting on the sources of information used by journalists could only speak in general terms, not having had first-hand experience. The media department academic reported that journalists rely on information from lobby groups, scientists, government (in terms of policy), and people affected in some way, for example farmers. The scientist reported that journalists rely too much on un-refereed sources from the internet, which reduces the quality of their reporting.

What are the demographic targets of these sets of messages?

This question was poorly answered, as few respondents had access to quantitative data describing their readership.

The online news publication has a readership of two million unique users per month in South Africa. Thus the publication is aimed at the average consumer, rather than the science community, and thus hard science must be 're-packaged' for this readership. The average age of their users is 40, with more females than males.

The regional print publication has a readership of approximately 300 000 in the Afrikaans language, with a racial profile of approximately 50% white and 50% coloured.

Other participants were not in a position to provide demographic data. However, these two findings illustrate the importance of online media in relation to biotechnology.

How, in reporting on biotechnology, do the media relate to other actors, including universities, government, NGOs, and firms?

Universities

The relationship between journalists and university scientists is characterised by tension and mutual suspicion. Journalists perceive scientists to be inaccessible and not sufficiently cognisant of the importance of engaging with the media, while scientists perceive journalists to be unreliable in terms of accurately reporting on their findings. This is partially a result of fundamentally differing cultures, with academics structured by patient collection of scientific evidence and journalists structured by tight deadlines and immediate results. Scientists fear that their work will be misunderstood or misrepresented by the media – and this is a sound fear often based on previous experience.

The scientist included in the sample reported that she is more open to interaction with journalists than most scientists, but that her relationship with journalists is variable. For example, there is a particular journalist whose calls she won't take because that journalist has previously 'twisted my words'. She reports that most of the time journalists are interested in scientists' work and present a balanced view, but that often sub-editors impose sensationalist headlines that distort the message of the article.

She also reports that it is problematic when journalists don't come back to scientists to check for factual correctness. This has happened to the participant, and is frustrating and strains the relationship. However, this is a rare occurrence and in general her relationship with journalists is positive and she finds their reporting to be balanced and professional.

No formal networks between journalists and biotechnology scientists were mentioned in the course of the interviews. Rather, journalists appear to relate to individual scientists through informal networks built over time through personal relationships.

One problem that a freelance journalist mentioned about universities was that they send out institutional news (e.g. awards won, new staff, etc), but publicly disseminate very little news about research outputs. This creates a distance between universities and journalists and between universities and the public. It is common to pick up information about South African research from international sources before hearing from local sources. Foreign scientists are friendlier to the media than local scientists, and respond to queries far more readily and quickly. Journalists believe that local scientists reportedly view them as 'the enemy'.

Government

As is the case with universities, participants reported that there are no formal relationships between journalists and government, although some journalists have cultivated informal relationships and networks within government.

All the journalist participants reported that government and parastatal agencies, particularly DST, the NRF, and MRC, perform poorly in terms of providing access to information. Calls and emails are not returned.

NGOs

NGOs were not mentioned by any participants as a common source of information about biotechnology. However, they play a role in media representations of biotechnology in that they are perceived as the ethical opposition to firms in the debate surrounding GMOs – for example the opposition between BioWatch, an anti-GMO organisation, and Monsanto, the world's largest GMO producer, which has played out in the media and in the courtroom.

NGOs are perceived by some journalists to be activist groups that speak on behalf of the poor and vulnerable in the face of corporate might, and by others as a 'lunatic fringe' that uses pseudo-science to advance misinformed agendas. One journalist perceived NGOs to have the upper hand over firms in the media debates surrounding GMO, due to their dedicated mission of engaging their opposition through the media, and also due to indifferent or weak responses from firms. Other journalists perceived powerful firms to have the upper hand over under-funded NGOs.

Firms

Firms are perceived to be actively pushing their special interests through engagement with the media. The prime suspect here is Monsanto, the largest multinational in the sector, responsible for producing a large proportion of the world's seed stock, followed by other biotech multinationals such as Syngenta. One participant was particularly cynical of large biotech firms, on the basis that they have a financial interest in pushing their technologies onto an ill-informed and/or resistant public. She finds these firms to be disingenuous in their approach - for example claiming to want to solve world hunger, when really their incentives are financial gain. She finds it ironic that, in her view, poor farmers can't afford expensive GM seeds. Moreover, it is argued that existing dry-land crops such as millet and sorghum should be used rather than GM drought-resistant maize, which only serves the vested interests of large firms. Lobby fronts of these firms strongly influence media representations and policy to achieve their business and financial aims, including 'squashing' research that identifies health risks associated with GMO plants. Government is also unduly influenced by firms – "Often government publications appear to have been written by Monsanto".

From the point of view of the online news editor, the main interaction with firms is when they seek to masquerade a sales pitch as innovation. Thus firms hawk their wares as a way to get publicity that they don't have to pay for. The participant in these cases needs to spend time separating the sales pitch from the content that is valuable to the user (reader).

According to academic participants, big firms do indeed lobby through the media. This provides a further reason why South Africa needs an educated pool of journalists that can separate the sales hype from the relevant information, particularly in the area of GMO foods. Journalists that aren't educated are more easily swayed, will more easily accept marketing pitches, and won't look at relevant issues such as whether small scale farmers can afford seeds. On the other hand, they are also more likely to fall prey to unscientific anti-GMO arguments rather than seeking objective scientific evidence.

One freelance journalist is also an advertorial writer who provides content free of charge to newspapers on behalf of paying clients. She reported that such infiltration means that it is becoming increasingly difficult to tell the difference between an editorial and an advertorial space in the popular media. This can lead to confusion and biased messages.

Recommendations for public policy

When asked whether government policy currently has any role in shaping biotechnology representations in the media, all respondents replied in the negative, with the exception of the university scientist, who noted that the GMO act requires notification in three local newspapers before conducting field trials of GMO plants. However, participants offered several suggestions for how the government could intervene to facilitate improved representations of biotechnology in the media.

All of the interview participants (in the only case of unanimous opinion in this study) held the view that a key public policy intervention should be to improve the performance of government in terms of providing access to information: "If government departments want the best information to be out there, they must share it with the media rather than trying to obfuscate it." All participants complained that government departments do not pick up

phones or answer emails requesting information about public activities in the sphere of biotechnology. Two participants specifically identified middle management (i.e. Director level) within government as being reluctant to share information.

One participant reported that government officials are reticent to speak to journalists as a result of working in silos, which results in a 'control' or 'fiefdom' mentality within these silos that makes officials reluctant to give any information to anyone. There is also a 'why should I' attitude that does not consider government accountable to journalists. Even communication departments within government do not communicate with journalists. One respondent reported that "Government has become absolutely hopeless" with regards to interacting with journalists. According to the interviewees, government needs to see interactions with journalists as opportunities to spread positive messages and information, rather than locking them out.

One policy option for reducing imbalances between these actors, whatever these might be, could be to establish a specialised ombudsman for biotechnology in the media. This possibility was suggested to all interview respondents. However, all respondents reported that this would be unnecessary as there is already an effective media ombudsman in operation, and moreover there is not sufficient media output in the area of biotechnology to keep such an ombudsman busy. Thus alternative policy measures must be explored that would be able to enhance neutrality in biotechnology reporting. Key efforts here should be directed at making better use of the existing ombudsman and increasing media access to neutral actors such as scientists.

Other recommendations included:

- Two participants questioned the efficacy of SAASTA, asking what their outputs and impact have been in relation to their mandate. The recommended a review of SAASTA and its strategies.

- Two participants noted that a positive event with respect to public engagement with biotechnology is the annual SciFest in Grahamstown. This has a powerful effect on visitors, particularly children, in terms of the popularization of science, including biotech. This provides an opportunity – for example sending journalists, government officials, and even students and learners there to gain knowledge about biotechnology.

- Greater transparency about field trials and product labelling would put some public fears about GMOs to rest.

- Government should create an engagement platform for scientists and the media, for example where journalists could be trained to have a better understanding of science. In this context a useful organisation to engage with would be the South African Science Journalists' Association (SASJA).

- One participant asked why the SABC doesn't have a science desk, especially in the context of what DST is saying about the role of biotechnology in the development of the country. Also, radio has the potential to reach large proportions of the

population, especially in rural areas. This could be used to disseminate positive messages about biotechnology to demographics that are usually excluded from biotechnology debates.

- One participant suggested that the National Biotechnology Advisory Committee (NBAC) hire a professional media company to put forward balanced messages about biotechnology, including both 'good news' and 'bad news' stories. It would also be useful to feature first person stories from people directly affected by biotechnology, for example rural subsistence farmers – these are very direct and powerful messages.

- Workshops drawing together scientists and the media in order to improve their relationships for mutual benefit would help to close the communication gap between these two groups.

- Journalists should be invited to spend time in scientific laboratories to get a more tacit feel for science.

6. Conclusion

Public awareness of biotechnology, coupled with access to fair, objective, and scientifically accurate reporting and information, is an important driver in terms of advancing biotechnology in South Africa. The media play a key role in cultivating such a public awareness. It is thus concerning that both the media analysis and the key informant interviews found that biotechnology is generally under-reported in the South African media, and this coverage is moreover episodic, and related to specific controversies or scientific discoveries. Searches of the full online archives of one regional publication found no references to biotechnology at all, while another regional publication featured only four articles over a period of three years. Even the opinion-leading publication featured only 16 articles over a period of six years. On the other hand, a search of the online news site rendered hundreds of articles. Thus, access to media representations of biotechnology is greatest in the online media; at the same time, much of the South African population does not have access to the online media.

This has some policy implications. While South Africans with access to the internet have a wealth of reporting about biotechnology at their disposal, those on the other side of the digital divide do not. This may hamper the cultivation of public awareness of biotechnology, particularly amongst the less privileged. Policies that make information about biotechnology available through media other than the internet would thus have value in terms of fostering such awareness. Since radio and television are primary media for much of the population that do not have access to the internet, these media might be appropriate for such interventions. However, clarity on how these interventions should be constructed should be premised on further research directed at broadening the sample to include radio and television coverage.

Biotechnology in the media is mostly reported within the discursive frame of scientific progress, and to a smaller extent within the frame of ethical enquiry. Within these frames, both the media analysis and the key informant interviews identified two dominant thematic

loci, namely 1) genetically modified plants and animals for human consumption and 2) health applications of biotechnology.

However, these two thematic loci are reported in substantially different ways. The most striking of these differences is with respect to the reporting of controversies, where GMOs tend to be reported on unfavourably (reporting on risks but not benefits), and health applications favourably (reporting on benefits but not risks). Articles about GMO plants and animals had a focus on the related risks to public health and the environment, together with a common concern about the ethics and business practices of the multinational firms that now control a large proportion of the world's supply of agricultural seeds. On the other hand, health applications, mostly related to breakthroughs in stem cell research conducted abroad, were celebrated for their benefits with little focus on the risks.

Interviews shed light on how these media representations are shaped. Journalists and editors were suspicious of the motives of large GMO firms, and tended to view their engagement with the media as self-serving 'infiltration' to further agendas that are often at odds with those of public health or environmental sustainability. Academics, however, viewed the behaviour of these firms more neutrally, perceiving them to be self-serving but also as essential engines of technical progress and resource allocation.

These findings have policy applications. Debates about stem cell research were all related to events taking place in the USA, South Korea, and other locations outside of South Africa, and are thus not key to the local development of biotechnology. On the other hand, debates about GMO plants and animals were often related to events in South Africa, and have direct relevance to domestic priorities. Thus, interventions seeking to mediate controversies should be targeted at debates about GMO applications of biotechnology. For example, efforts to bring scientists and journalists closer together, or efforts to create a space for open dialogue between firms and NGOs, might achieve more through a focus on GMO than on biotechnology in general.

One of the key policy objectives mentioned by most interview respondents was to aim for objective and balanced reporting, rather than 'sensationalism'. This is in line with the third key research question, namely the motivation and objectives for public dialogue. Interview participants highlighted that the question of sensationalism in the media is a normative association not amenable to objective measurement. However, proxy measurements can be used to provide indicators of unbalanced reporting. Viewed as a whole, the media analysis sample revealed a predominance of unbalanced reporting: 66% of articles reporting on a controversy reported only risks or only benefits, rather than both. This is a concerning finding that merits a policy response.

Fair and accurate reporting also requires a level playing field for the various actors influencing the media. The actors recorded in the media analysis were scientists (52%), producers/firms (40%), NGOs (20%) and government (16%). However, interviews highlighted that these actors play very different roles in influencing media messages. Scientists are perceived as being the most neutral and objective actors and sources of information. They are also perceived to be suspicious of journalists and inaccessible. Scientists, on the other hand, fear that inadequately trained journalists will misrepresent their research, or they feel that engagement with the media should not fall within the ambit of

their work. Fostering a closer and more productive relationship between journalists and scientists is thus a key policy objective in terms of enhancing both access to information and neutrality in the reporting of biotechnology.

In terms of the other actors, both the media analysis and interview findings indicate that the key area of contestation is between big firms and NGOs. Interviews suggested that policy in this area should focus on fostering engagement that is based on science rather than rhetoric. Some journalists were suspicious of large firms, and suggested that government policy should rein in the power of firms to 'infiltrate' the media, but were unclear as to how such policy regulations could be designed. Other journalists considered NGOs to be the actors that require restraint, as they often enter debates without sufficient scientific evidence, and are guilty of promoting 'pseudoscience'.

Government actors appeared in a minority of articles in the media analysis. This corresponds to interview findings: all of the interview participants reported that government currently plays no role in the construction of articles about biotechnology in the media. Moreover, all interview participants reported that government is dysfunctional with regards to providing access to information. Thus another key policy objective is to implement measures to enhance the public sector's willingness and ability to provide such information.

7. Recommendations for further research

While the trends identified through the media analysis and interviews are indicative and have utility within the current research project, a larger study would render more useful data. With respect to the media analysis this would entail:

- a larger spread of publications and a greater depth of sampling to allow for a more representative sample
- the inclusion of radio and television media channels in the sample
- a larger sample allowing for longitudinal study of the dynamics of media representations
- a link between media analysis and demographic data in order to develop a model of received messages among the South African population.

With respect to the key informant interviews, this would entail:

- expanding the sample to include firms, NGOs and government actors
- expanding the size of the sample in order to gain greater representivity.

8. Policy recommendations

Key policy objectives and recommendations are summarized in Table 8:

Table 8: Policy objectives and recommendations

Policy objective	Policy recommendation
Expand the scale of biotechnology reporting in the	Public media channels such as the SABC could create a science desk or specialised programming related to

media, and expand access to this reporting to a greater proportion of South Africans.	biotechnology. In particular, radio has the potential to reach large proportions of the population, especially in rural areas, that are beyond the reach of print and online media.
Foster objective, balanced, and scientifically accurate reporting.	Make better use of the existing press ombudsman, for example providing support to NGOs or SMMEs seeking to use the ombudsman to correct unbalanced reporting. NBAC could hire a professional media company to put forward balanced messages about biotechnology.
Foster a closer and more productive relationship between journalists and scientists.	Government could create an engagement platform for scientists and the media, for example where journalists could be trained to have a better understanding of science. In this context a useful organisation to engage with would be the South African Science Journalists Association (SASJA). This could take several forms, including: - Workshops drawing together scientists and the media in order to improve their relationships and close the communication gap - Journalists could be invited to spend time in scientific laboratories to gain a more tacit understanding of science. - Journalists, government officials, students and learners could be sent to SciFest in order to gain knowledge about biotechnology.
Enhance the public sector's willingness and ability to provide access to public information.	A specialised directive for the communication offices of the relevant departments (Department of Science and Technology, Department of Trade and Industry, Department of Higher Education) could aim at improving their performance in communicating with the public. This would relate specifically to responding to queries from the media and cultivating an ethic that public information belongs to the public and should therefore be freely disseminated.

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Appendix A: Fieldwork Interview Instrument

- A profile of the organisation:
  - Name of organisation
  - Media sub-sector(s)
  - Size of firm/organisation
  - Size of their public
  - Demographics of their public: geographical range, age, race, income, gender, etc.

- A profile of the nature of these messages:
  - What is the spread of biotechnologies that are discussed? For example, is the focus on biotechnology in general, genetic engineering, biofuels, pharmaceuticals, and/or health?
  - Are messages in each of these areas normatively positive and/or negative? To what extent, and driven by what determinants?
  - What are the main sources of information related to biotechnology, in relation to the above?
  - What are the demographic targets of each of these sets of messages: age, geographical location, ethnicity, level of education, income, etc?

- What is the (media) organisation's relationship with higher education institutions, government, and other firms?

- What is the role of advertising and marketing in shaping these messages?

- Is there any role of government policy in shaping these messages?

- The dynamics of biotechnology-related messages: Are there significant trends relating to the profile of these messages, the types of media channels used, normative associations, sources of information, relationships with other actors, the role of advertising, etc ?

- Suggestions for how government could support the dissemination of constructive messages about biotechnology.

- Are there any key areas of concern regarding the entry into, and support of, the South African biotechnology sector?

- Do you have any recommendations regarding the motivation and objectives for public dialogue among this sector in respect of: 1) knowledge gaps and misunderstandings, 2) as new innovative processes, and 3) methods of information dissemination. These recommendations need to consider practicalities in terms of both the cost and context of implementation

- Suggestions for informing the media analysis component of the research project

- Suggestions for further reading to inform the project
- Purposive methodology questions identifying further key interview participants
- Any other pertinent issues that may arise

Appendix B: Media analysis variables

Search terms:

Biotechnology, biotech, clone, cloning, genetic engineer, gene manipulation, gene technology, gene therapy, re-combinant DNA, bio-fuel, GMO, genetically modified organism, stem cell

Frame:

A commonly used framing typology for understanding biotechnology in the media, developed by Gamson and Modigliani (1989), refined by Durant, Bauer and Gaskell (1998) and also used by Bauer (2005), amongst others. The 'Frame' variable can be identified as: progress, economic prospect, ethical, pandora's box, runaway, nature/nurture, public accountability, and globalization. Coders chose one frame per article.

Tone:

- Mention risks
- Mention benefits
- Report controversy

Note that mention of risks and mention of benefits could appear in the same article.

Themes:

Each article can address up to three key themes, chosen from:

Applications:

- Human cloning
- Animal breeding/cloning
- GMO plants
- Microorganisms
- GMO release, plant field test
- Gene therapy
- In vitro fertilization/reproduction
- Pharma/vaccines
- DNA research (general)
- Human inheritance
- Gene mapping
- Diagnosis/predictive medicine
- Military, defense
- Genetic sequencing
- Stem cells

Policy, politics, and economics

- Ethical issues
- Legal regulations
- Voluntary regulations
- Economic prospects
- Patenting/property rights
- General biotech policy
- Insurance issues
- Privacy, protection of genetic information
- Labeling
- Eugenics
- Education, genetic literacy

Safety and risks

- General safety and risk
- Environmental risk
- Local community risk
- Laboratory workers
- Food risk
- Biodiversity
- Public reaction
- Public opinion
- Fear

- Other (i.e. there can be other, minor, themes. Continuously update list).

Featured Actors:

Each article can address up to two key actors, chosen from:

None, not applicable

Government affiliated

- National Executive, president
- Environmental protection agencies
- NRF
- Patent office
- Parliament
- Judiciary
- Local government
- Provincial government
- National government
- Independent review panel

- Military
- Police

General
- The public
- The media

Science or medicine
- University scientist
- University
- Research Institute scientist
- Research Institute
- Scientific organization
- Doctor
- Hospital

Industry
- Producer
- Distributor
- Industry scientist
- Farmer

Other interests
- Religious
- Consumer
- Environmental NGO
- Agricultural NGO
- Bioethicist

Other (i.e. there can be other, minor, themes. Continuously update list).