Framing the Gene

A science communication study of how newspapers frame different meanings of the gene concept, with applications for science education

PhD Thesis

Rebecca Bruu Carver

Department of Behavioural Sciences in Medicine

Faculty of Medicine

University of Oslo

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Main supervisor: Jarle Breivik, Faculty of Medicine
Second supervisor: Ragnar Waldahl, Faculty of Humanities

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To my knowledge, this is the first PhD in science communication in Norway. This PhD has therefore been a most exciting, yet challenging, experience for me. I have had to pave a way through unchartered territory, convince people that science communication is worth studying, and build up a network from scratch. I would not have been able to do this alone. The most influential person in this journey has been my main supervisor, Jarle Breivik, Associate Professor at the Department of Behavioural Sciences in Medicine (Faculty of Medicine). I know it has not always been easy, but your enthusiasm for science communication has been a key driving force throughout this project. Thanks also to my second supervisor, Ragnar Waldahl, Professor at the Department for Media and Communication (Faculty of Humanities), for always being positive and for introducing me to the fascinating world of media framing.

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Yours faithfully,

Rebecca Bruu Carver

Oslo, Norway, 20th September 2012

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I. **Carver, R.,** Waldahl, R. and Breivik, J. (2008) Frame that gene: A tool for analysing and classifying the communication of genetics to the public. *EMBO reports* 9(10): 943-947.

II. **Carver, R. B**., Rødland, E. A. and Breivik, J. (2012) Quantitative frame analysis of how the gene concept is presented in tabloid and elite newspapers. Accepted for publication in *Science Communication.*

III. **Carver, R. B.,** Wiese, E. F. and Breivik, J. (2012) Frame analysis in genetics class: A model for teaching media literacy in science education. Submitted to *International Journal of Science Education Part B: Communication and Public Engagement*

1. Introduction

1.1 Background

This is a thesis about *media framing*, on how the media can portray a scientific concept—like the gene—in many different ways. This is important because the media can affect how people come to understand science. I became interested in how the media communicate science whilst doing my Master's degree in science communication at Imperial College London. During a work placement as a journalist for a broadsheet newspaper in London, I was repeatedly surprised by how much the editor changed the title and opening sentences of nearly every piece I wrote (without consulting me), to such an extent that the meaning of the story sometimes changed. It occurred to me there and then that the way information is presented can no doubt have an impact on how a story is read and understood by the audience, and that there are many different ways to tell the same story. This is essentially what framing is about, which is the central concept in this thesis.

Another important concept in this thesis is the *gene*. Besides my initial training as a natural scientist, I became particularly interested in genes and genetics whilst working in a mobile DNA exhibition for children some years later, based in Oslo Norway. The exhibition, called 'SciLab', consisted of a 40-foot container that encased an interactive DNA lab equipped with modern technology for simulating DNA analysis. We gave children a 'mystery DNA sample' from an organism on earth, and it was their challenge to analyse the genes to find out what it was. They seemed to enjoy this activity and they asked many weird and wonderful questions about genes and DNA. Their parents seemed equally enthralled. It occurred to me that genes and DNA are concepts that fascinate people of all ages, because genes say something about who we are, and are fundamental to life and evolution.

This project sprung out of numerous discussions with Associate Professor Jarle Breivik, who was manager of SciLab at the time, and has expertise in cancer genetics as well as a passion for science communication. We began discussing the difficulty of defining what genes are and how to communicate this to the children. We also wondered what sort of understanding the public has about genes, and how the mass media might be influencing their understanding. Our discussions lead us to the major problem at hand:

> Understanding what genes are is important in many aspects of life, from taking part in political debates on scientific matters, to helping individuals make personal choices about genetically modified foods, personalized medicines, genetic testing or gene therapy. We know that the mass media play an important role in shaping and reflecting public perceptions of science. We also know that the media communicate science by organizing concepts and stories into meaningful *frames.* But we do not know what "gene frames" are currently present in the international media, or how these may be affecting public perceptions. The major aim of this thesis is therefore to investigate the different ways the gene concept is framed in the media. Further, in relation to increasing demands for a scientifically literate public, another major question arises: Can increased awareness of such frames help people become more critical readers of gene-related information in the news?

To help us plan the project we took contact with Professor Ragnar Waldahl from the Department of Media and Communication at the Faculty of Humanities, University of Oslo, who became my second supervisor. Ragnar has expertise in media and communication research and introduced me to the concept of framing. He was familiar with framing in the context of political campaigning and the influence of the media on voting decisions. His suggestion for applying framing to the study of genes in the media happened at a time when framing studies were becoming popular within the academic field of science communication. It was therefore decided that framing would be a useful and timely approach to studying how genes are communicated in the media.

The thesis consists of three separate yet related studies: The first study was designed in close collaboration with Ragnar Waldahl. We wanted to find out exactly what *gene frames*—what different representations of the gene concept—were present in the current media. We conducted a qualitative frame analysis of Norwegian and British newspapers and discovered five different gene frames.

In the second study, we investigated the distribution of these five frames in a larger international newspaper sample to see if there were any differences in how tabloid and elite newspapers frame the gene concept. The second study was largely quantitative and we sought statistical help from biostatistician Einar Andreas Rødland from the Department of Informatics at the Center of Cancer Biomedicine, University of Oslo.

The third study is a little different, because it presents a practical application of the results of the first two studies. We wanted to see if an awareness of the five gene frames would help school science students become more critical readers of media texts, which in turn could enhance their knowledge about genes. We therefore designed a short teaching program involving media framing activities. This last study was designed at a time when media literacy was becoming a key goal in science education, and is therefore a particularly timely study. Whilst planning this study, we sought expertise from the science education community at the Norwegian Centre for Science Education, and in particular, Professor Doris Jorde. We later established a close collaboration with Eline Wiese from the Department of Behavioural Sciences in Medicine at the Faculty of Medicine, University of Oslo. Eline Wiese has expertise in science pedagogy and helped us with the third study.

The overall summary of my thesis (sections 1 to 9, before the papers) is structured in such a way that it follows the general outline of a scientific paper. However, Paper I establishes the main framework for Paper II and Paper III, so readers would be advised to turn to the results of Paper I before reading the methods for paper II etc. In the introduction, I have chosen to begin by introducing the field of science communication, in order to show the wider context of this thesis. Next, I describe the concept of media framing, and then the gene. By presenting the major concepts in this order I hope to show the reader how I “see” the concepts in relation to each other: science communication is the overarching field that the thesis falls into, and media framing of the gene is a part of this.

1.2 Introducing Science Communication

1.2.1 Political context

This project was initiated when the Norwegian Education Minister at the time (Øystein Djupedal) had just delivered a strategic governmental report on the importance of science in society. The main impetus for the report was a general concern that there was not enough recruitment of young students into science and technology careers. The report was called "A Joint Promotion of Mathematics, Science and Technology (MST): Strategy 2006-2009" and it suggested that one of the key goals of the coming years would be to *improve science communication* to the public (The Norwegian Ministry of Education and Research, 2006). Science communication is defined as the use of appropriate skills, media, activities, and dialogue to produce awareness, enjoyment, interest, opinions and/or understanding of science for members of the public who are non-expert in a particular field (Burns, O'Connor, & Stocklmayer, 2003).

Similarly, in 2000 the UK government issued an influential report—the "House of Lords Select Committee on Science and Technology Third Report: Science and Society"—also calling for initiatives to improve the communication of science to the public. The government issued the report in response to concerns that public confidence in science had plummeted following a number of complex scientific issues with misguided media coverage, including genetically modified crops and the BSE fiasco. The report highlighted that: "The culture of United Kingdom science needs a sea-change, in favour of open and positive communication with the media. This will require training and resources..." (Select Committee on Science and Technology, 2000, paragraph 7.46). An important recommendation was to encourage more training for scientists in science communication: "Research Councils and universities should strongly encourage communication training for scientists and, in particular, training in dealing with the media" (Select Committee on Science and Technology, 2000, paragraph 3.22).

In America, there has been a particular focus on public (or civic) *scientific literacy*, broadly defined as the understanding of basic scientific concepts, scientific processes and applications of science in society (Miller, 1998). Already in the 1950s, the American Association for the Advancement of Science (AAAS) called attention to the importance of public understanding of science for human progress. The U.S. federal government responded by authorizing several billion dollars to improve science education in public schools (Gregory & Miller, 1998). The U.S. has therefore focussed predominantly on promoting scientific literacy in *schools* (not predominantly via media, as in the U.K.). In 1986, the National Science Education Standards for the first time stated that "scientific literacy requires the ability to critique the quality of evidence or validity of conclusions about science in various media, including newspapers, magazines, television, and the Internet" (Krajcik & Sutherland, 2010).

The main arguments for encouraging science communication and for promoting scientific literacy generally fall into five types of arguments cited in the literature (Durant, Evans, & Thomas, 1989; Gregory & Miller, 1998; Millar, 2002; Miller, 1998; Miller, 2004; Royal Society, 1985; Stocklmayer & Bryant, 2011; Thomas & Durant, 1987). These are:

1. The democratic argument

Many political decisions involve science, and these can only be genuinely democratic if they are subject to an informed public debate. In modern society, decisions have to be made about energy and climate policy, genetic engineering, embryo research, the disposal of toxic substances, and so on. Informed citizens can exert their influence through voting and lobbying. However, it is potentially problematic if people vote either for or against a scientific development based on misconceptions. For example, surveys show that almost 50% of people think nuclear power stations cause acid rain (which they do not), 45% do not know whether ordinary tomatoes contain genes (they do), and over 50% believe antibiotics kill viruses as well as bacteria (which they do not) (Durant et al., 1989; Miller, 2004). It is therefore important to have a scientifically literate public.

2. The economic argument

According to the economic argument, an educated public can help speed technological development and contribute to national prosperity. Scientific and technical achievement is generally a sign of a nation's international standing. For example, scientific developments such as lasers and transistors have revolutionized modern technology (Gregory & Miller, 1998). A steady supply of highly trained scientific and technical workers is therefore necessary for any country wishing to compete internationally.

3. The utility argument

Scientific knowledge may be practically useful for people living in scientifically and technologically advanced societies. People need to make personal decisions about diet, health, safety, and so on. For example, an individual facing a personal decision on gene therapy would need some understanding of DNA and the mechanisms of gene expression, in order to understand why gene therapy may or may not work (Miller, 2004). The public are also potential consumers of numerous scientific and technological products; they need to be scientifically aware in order to make informed decisions about what to buy (Millar, 2002). For example, in order to avoid misconceptions, fear or disappointment, the public would need to understand what it means to be "predisposed" for a disease before ordering a genetic test on the Internet. Promoting health literacy in the public is therefore important.

4. The social argument

The social argument suggests that it is a moral duty of scientists to inform the public about what they do, because researchers use public tax money to fund their research (Royal Society, 1985). Greater public awareness of current research and the importance it may have for society can lead to increased public appreciation and support for science (although in some cases more knowledge in a particular topic can lead to heightened concern). According to the social argument, it is important to maintain a close relationship between science and society, in order to avoid alienating people who feel they cannot keep up with the latest developments in science. Whilst informed scepticism is important, people who feel entirely shut off from current discussions about science may be more inclined to form radical "anti-science" groups that seriously threaten the integrity of modern thought (Gregory & Miller, 1998).

5. The cultural argument

According to the influential 'Bodmer Report' published by the Royal Society in the UK, "without some understanding of science, an individual is cut off from much of the richness of contemporary human thought" (Royal Society, 1985, p. 10). Following this argument, science is the greatest cultural achievement of modern society and people should therefore know something about it. Furthermore, according to Richard Dawkins, Professor emeritus of Public Understanding of Science, young people should be encouraged to appreciate the beauty of nature and learn to love science for its own sake[1]. We should consider science as a part of our

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[1] Dawkins said this verbally in a public lecture I attended in Oslo.

cultural heritage, just as we do music, history, art or literature. General public understanding of science would serve as an intellectual stimulus to the whole of society.

1.2.2 Studying and researching science communication

In response to the government policy imperatives, around fifteen to twenty years ago academic institutions around the world began to set up full degree programmes in science communication at Bachelor and Master level (Mulder, Longnecker, & Davis, 2008). Most of the courses are currently in the UK, US, Italy, Spain, the Netherlands, Canada, New Zealand and Australia, but are gradually expanding to China, India, South Africa and Latin America.[2] Most of the students on these programmes are previous scientists who go on to become media and communication professionals. A core element of their training is learning how to explain scientific issues to non-scientists.

The establishment of academic programmes spurred international research in the field of science communication, which has rapidly grown during the past two decades. Science communication research at the PhD level and beyond is growing. Dedicated journals such as *Science Communication* and *Public Understanding of Science* have facilitated the growth and sharing of such research. Science communication research draws on four main disciplines: science, social studies of science, media studies and education studies (Mulder et al., 2008). Individually, each of the four disciplines has a much longer history, but when combined they form a relatively new interdisciplinary field. This thesis lies mostly within media studies and education studies, which I describe in more detail below:

1. Science

Knowledge of the natural sciences, life sciences, mathematics or engineering is a prerequisite for science communication researchers, including knowledge about scientific content as well as the process of scientific discovery. Most researchers in science communication therefore already have a scientific background or degree, and draw on this knowledge in the subsequent three areas of research.

2. Social studies of science

Social studies of science (SSS) or "science and technology studies" (STS) have roots in sociology, policy studies, philosophy and ethics. Sociologists of science examine the practices

[2] Whilst Norway seems to be moving in the right direction, it still has to establish more permanent science communication courses at university institutions.

of science and scientists, based on the assumption that social processes influence the formation of all knowledge (Gregory & Miller, 1998). For example, Collins and Pinch (1993) investigated the intricate ways in which scientific controversies are resolved and how new theories are validated, and found that in practice these were a lot messier than the clean-cut methods and logical processes of science that are usually portrayed to the public. Such knowledge, if communicated, can help the public gain a deeper insight into the time-consuming process of scientific discovery.

3. Media studies

The majority of science communication research has focussed on the media's presentation of scientific information (Mulder et al., 2008). There are several reasons for why studying science in the media is particularly widespread, and important:

Firstly, the mass media are the public's primary source of scientific information after formal education (Bauer, 2005; Condit, 1999b; Conrad, 2001; Eyck & Williment, 2003; Falk, Storksdieck, & Dierking, 2007; Holliman, 2004; Nelkin, 1995; Nelkin & Lindee, 1995; Nisker & Daar, 2006; Petersen, 2001; Wellington & Osborne, 2001).

Secondly, the mass media have the possibility of shaping public perceptions and opinions about science. They do this by organizing and presenting information in such ways that it conveys particular meanings for their audiences. Audiences actively use this information to construct meaning and make sense of the world: The mass media can therefore influence public understanding of science (Gamson & Modigliani, 1989; Priest, 2006).

Thirdly, the mass media also reflect public perceptions and opinions, simply by being a part of our culture. Journalists share the same language, thoughts, beliefs and attitudes as the public. They attempt to write what they think the public wants to hear (McQuail, 2005). Media content can therefore be an important indicator of what the public think about science (Gamson & Modigliani, 1989).

Over the past five years, there has been increasing interest in the role of *media framing* in science communication, as scientists and other science communicators have come to realize the important impact framing can have on how the public understand and participate in scientific debates (Bubela et al., 2009; Condit, 2007; Nisbet & Mooney, 2007; Nisbet & Scheufele, 2009; Reis, 2008). Framing research, which shall be discussed in detail in section 1.3, investigates *how* issues are presented in the media through the use of various communication devices. The same scientific issue may be framed in different ways, and each frame conveys a different perspective for the audience.

4. Education studies

A major focus in current science education research is how to equip students with the ability to critically read mass media reports about science (Deboer, 2000; Jarman & McClune, 2007; Jarman, McClune, Pyle, & Braband, 2011; McClune & Jarman, 2010; Millar & Osborne, 1998). This is because, for the majority of students, informal learning sources—such as the mass media—are believed to be more important than formal education for *lifelong* learning in science (Falk et al., 2007; Jarman et al., 2011; Rennie & Stocklmayer, 2003; Rundgren, Rundgren, Tseng, Lin, & Chang, 2010; Wellington & Osborne, 2001). Furthermore, since the focus of modern science education is now not only on developing knowledge of scientific content and processes, but also on preparing students for future life (Falk et al., 2007; Jarman et al., 2011; Rennie, 2011), understanding science in the media is therefore becoming increasingly important.

Exploring the link between media and education studies

Figure 1 displays the two main sources of scientific information for the public. It shows that both the media and formal science education act as gateways between the scientific community and the general public (Wellington, 1994).

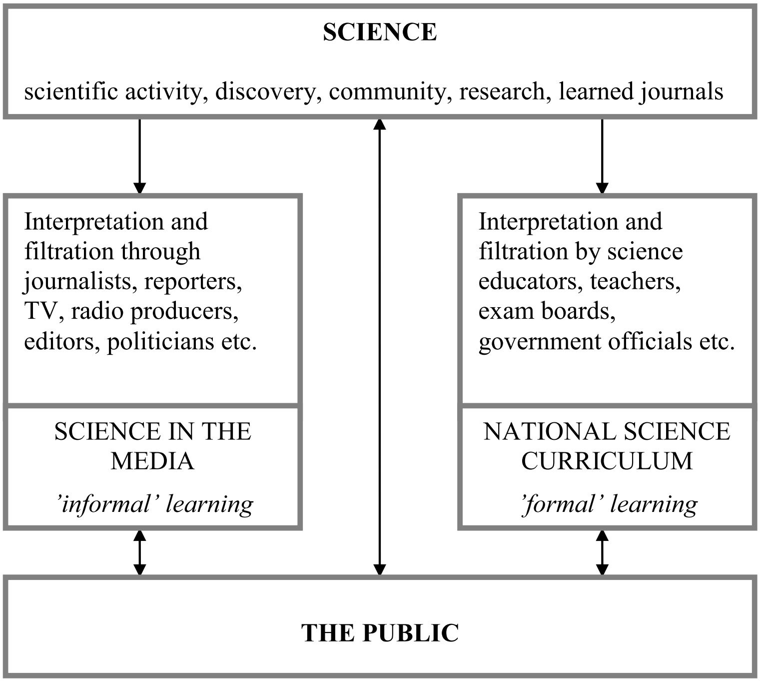

Figure 1. Both informal and formal learning are important for public understanding of science. Adapted from Wellington (1994), p. 288.

Recognizing the importance of the media for life-long learning in science, science curriculum developers around the world are now beginning to implement *media literacy* or "media awareness" as a formal curriculum goal in science (McClune & Jarman, 2010). Media literacy involves "the ability to engage critically with science in the news" (Jarman & McClune, 2007).[3] Exactly what this entails differs slightly between countries. For example, in the United States, The National Research Council has recently proposed that K-12 science students should be able to:

- read media reports of science or technology in a critical manner so as to identify their strengths and weaknesses (National Research Council, 2011, chapter 3, p. 18).

Previously, the National Science Education Standards specified that students should:

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[3] The ability to engage critically with science in the media ('media literacy') is one *of many* components of scientific literacy; scientific literacy is a very complex concept, which is beyond the scope of this thesis to discuss in detail.

- be able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions (National Research Council, 1996, p. 22).

In the UK, the English National Science Curriculum expects students at Key Stage 3 (ages 11-14) to:

- gain an appreciation of how science is represented and sometimes misrepresented in the media (Qualifications and Curriculum Authority, 2007, p. 212).

And in Northern Ireland, the 2007 Key Stage 3 Science Curriculum expects students to:

- become aware that there is usually more than one way to view an issue (Council for Curriculum Examinations and Assessment, 2007, p. 8).

In Norway, the new (2006) National Curriculum in biology states that students should:

- discover new knowledge in biology from different sources and to evaluate information and claims in the media on an academic basis (Grønlien, Ryvarden, & Tandberg, 2008, p. 379).

Despite the growing emphasis on media literacy in science education, there is very little research or guidance available on how to teach and learn about science news in the classroom (Jarman et al., 2011; Stocklmayer & Gilbert, 2011). Previous research shows that whilst science teachers commonly use newspaper stories to highlight the relevance of particular topics, they lack the tools or skills to teach the students how to critically analyse these reports (Jarman & McClune, 2002; Kachan, Guilbert, & Bisanz, 2006). Studies also show that university science students perform poorly when asked to interpret the quality of everyday media reports of science (Korpan, Bisanz, Bisanz, & Henderson, 1997; Norris, Phillips, & Korpan, 2003; Pettersen, 2005; Pettersen, 2007), and even the top achieving science students find this task difficult (Norris & Phillips, 2003). There is therefore a clear need for new teaching activities and programs that can equip students with the necessary tools for critical analysis of science in the media (McClune & Jarman, 2010). A new journal was recently established— *International Journal of Science Education, Part B: Communication and Public Engagement*— to encourage research in this area, as well as to forge links between science education and science communication research more generally (Ogawa, 2011; Stocklmayer & Gilbert, 2011).

To mention one of very few studies already published in this area, McClune and Jarman (2010) systematically interviewed twenty-six experts within science communication, journalism, media education and science education about the skills required for critical reading of science-based news reports. They drew up a long list of key elements of knowledge, skills and attitude, including the following suggestions that students should:

- be aware that journalists work with an audience in mind
- recognise that text can be interpreted in different ways
- understand that news is a construction
- recognise the characteristics of newspaper articles (e.g. provocative headlines) and be aware of the impact these can have on the reader
- compare what they read to their existing science knowledge

As shall become clearer in the next section of this thesis, the above elements relate directly to the concept of framing, since framing is also about the construction of reality. By analyzing the framing of a news story, we expect that students may acquire key skills of media literacy.

In broad terms, this thesis therefore addresses two important and timely areas of research within science communication. These are:

- **the media's framing of scientific knowledge (genes)**
- **incorporating 'media literacy' into science education**

1.3 Media Framing

1.3.1 What is media framing?

The concept of framing generally refers to how aspects of reality are organized and made sense of, and has roots in many disciplines spanning from sociology (Goffman, 1974), economics (Kahneman & Tversky, 1979), psychology (Tversky & Kahneman, 1981), politics (Gitlin, 1980), cognitive linguistics (Lakoff, 2004) and media & communication (Entman, 1993; Gamson & Modigliani, 1989; Kitzinger, 2007). This thesis is concerned with framing in the context of media and communication, and is particularly attentive to the growing emphasis on the importance of framing in science communication (Bubela et al., 2009; Condit, 2007; Nisbet & Mooney, 2007; Nisbet & Scheufele, 2009; Reis, 2008). In a recent article entitled *"What's next for science communication?"* Nisbet and Scheufele (2009, p. 1770) wrote:

> At a theoretical and descriptive level, framing research offers a rich explanation for how various actors in society define science-related issues in politically strategic ways, how journalists from various beats selectively cover these issues, and how diverse publics differentially perceive, understand, and participate in these debates.

Entman (1993) referred to framing as "a scattered conceptualization" and saw it necessary to clarify its meaning in order to enhance the theoretical rigour of communication studies. To give a precise definition, it is first necessary to distinguish between the frames we find in media texts with the frames of reference that exist in the mind of the reader (Chong & Druckman, 2007; Entman, 1993; McQuail, 2005; Scheufele, 1999). The first type are often referred to as *content frames* or *media frames*, and are manifested by key words, phrases, metaphors and a variety of other textual devices found in media content. The second type are often referred to as *individual frames* or *audience frames,* which are the "mentally stored clusters of ideas that guide individuals' processing of information" (Entman, 1993, p. 53).

This thesis is primarily concerned with media frames and media framing, for which Entman (1993, p. 52) provides a useful definition:

> Framing essentially involves selection and salience. To frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a

> way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described.

To make something "more salient" means to bring more attention to it. Kitzinger (2007) likens this to taking and editing a photograph: First you select the perspective (widescreen or close-up), you decide what to focus on, what to include and what to leave out. Later, you may edit colours, shading, contrast or other effects to emphasize certain aspects of the image. Similar to how a photographer "frames" a particular view of reality, a journalist frames a particular view on an issue: First they decide what to focus on, who to interview and what questions to ask, what facts to include and what context to put it all in. Then they may colour their writing with catch phrases and metaphors in order to bring attention to certain aspects of the story. The editor may sharpen the focus even more by using a catchy and sensational heading. All these small adjustments invite a particular way of interpreting the story for the reader. The same event or phenomenon may be interpreted and framed in several different ways, as illustrated in Figure 2.

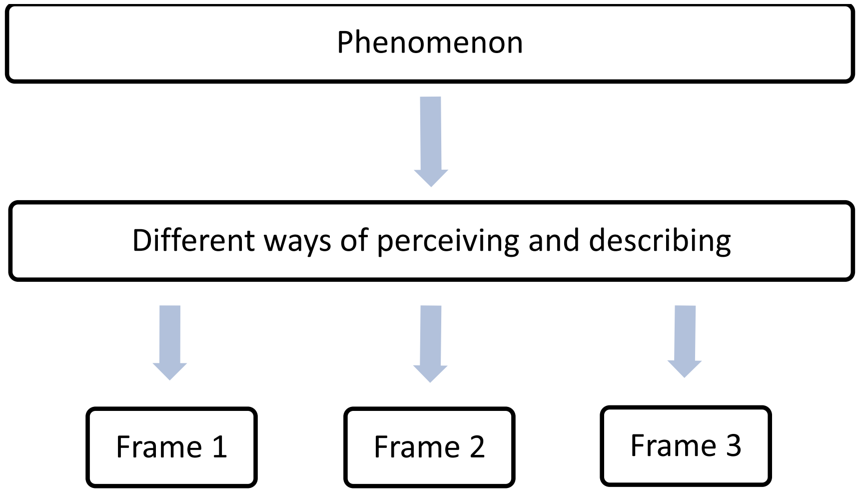

Figure 2. A phenomenon can be perceived and presented through different frames. Adapted from Gericke (2008).

Media frames are manifested through the presence or absence of various text elements—called *framing devices* or features—including certain keywords, stock phrases, stereotyped images, sources of information, and sentences that “provide thematically reinforcing clusters of facts or judgments” (Entman, 1993, p. 52). Other framing devices might include metaphors and historical examples (Gamson & Modigliani, 1989; Kitzinger, 2007). Not all these framing devices have to be present in order to help readers recognize and place an issue within a particular frame (Kitzinger, 2007). As Gamson and Modiglinani (1989, p. 3) pointed out, often the whole frame may be identified simply by “a deft metaphor, catch- phrase, or other symbolic device”.

For example, on the issue of asylum and illegal immigration, Van Gorp (2005) found that Dutch newspapers presented asylum seekers as either victims or intruders: A news story with a “victim” frame would often describe the situation of a single family, presenting them as innocent people in need of help. Evoking emotions of compassion, the journalist would use metaphors such as “they are being hunted”, and convey the idea that returning home would result in death. A story with an “intruder” frame on the other hand would often show a picture of a “batch” or “flood” of individuals, presenting them as criminals actively trying to abuse the system. The journalist would play on stereotypes of xenophobia (distrust of strangers) in an attempt to evoke negative emotions. Each frame therefore presents a very different perspective on the same issue.

Every news article has a frame (Tankard, 2003), and some articles contain several. Most often an article will have a *dominant frame*[4] which has the “highest probability of being noticed, processed, and accepted by the most people” (Entman, 1993, p. 56). This relates to the word *salience* in Entman’s definition above, which literally means “making a piece of information more noticeable, meaningful or memorable to audiences” (Entman, 1993, p. 53). Common sites for the dominant frame include headlines and opening and closing paragraphs (Kitzinger, 2007), but may also be present elsewhere in the text. If other frames are also present in the same article these are often less salient and appear further down. For example, in the media’s framing of genetics and medicine, Petersen (2001, p. 1263) found that, “in discussions where environmental influences are mentioned, references tend to be made only in passing and, in most cases, well into the article or towards the end…”.

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[4] Entman (1993) calls this the “dominant meaning”.

Framing exists everywhere all the time; it is an unavoidable process of communication (Entman, 1993; Kitzinger, 2007; Nisbet & Scheufele, 2009). If we did not frame information, we would be surrounded by a "confusing morass of sensations" (Kitzinger, 2007, p. 137). All people (not just journalists) frame information when they are communicating, and this happens both consciously and subconsciously. Some framing decisions are obvious and conscious, such as when choosing a sensational title such "Born gay", whilst other framing judgements are more subtle and "accidental", e.g. highlighting that a vandal comes from a broken home, that a murderer has schizophrenia, or that a rapist is black. The subtle descriptions may reflect personal prejudices (or frames) of which one may not be fully aware.

When framing is done consciously, authors will often frame information with a particular audience in mind (Nisbet & Scheufele, 2009). Although frames should not be confused with policy positions (Gamson & Modigliani, 1989), the elaboration of certain frames "offers an argumentative advantage in the public debate" (Bauer, Kohring, Allansdottir, & Gutteling, 2001, p. 40). For example, Nisbet and Mooney (2007) have demonstrated that Democrats and Republicans use different frames to argue for or against climate change: Democrats tend to frame global warming as a *Pandora's Box* of catastrophe, using images of hurricane devastation or polar bears on diminishing ice sheets to evoke "alarmist" reactions in the public. Republicans on the other hand tend to emphasize the *scientific uncertainty,* highlighting the economic risk of investing money in green technologies or other prevention efforts. Similarly, the authors suggest that scientists should also learn to actively frame information to make it relevant to different audiences (Nisbet & Mooney, 2007).

Besides political motivation, there may be many other factors affecting one's choice of frame. A journalists' decision on how to frame an issue, for example, may depend on various internal and external factors (Scheufele, 1999): Internal factors include their personal ideology and attitudes; external factors include the political, ideological or journalistic style of the medium they work for (e.g. type of newspaper), the professional norms and journalistic routines of the work place, the social norms and values of the society, or influence from external sources (such as direct pressures from elites or interest groups).

Framing in tabloid versus elite newspapers

Concerning the type of medium (e.g. type of newspaper) and its relation to framing, most studies to date have tended to analyse the presentation of scientific topics in *elite*[5] newspapers only, such as *The New York Times*. There has been very little focus on the framing of science in tabloids. The main reason for choosing elites only is that, compared to tabloid newspapers, the elites are considered more influential in the political arena (Nisbet & Lewenstein, 2002). They are also generally more accessible in libraries and databases, and are therefore easier to research.

Tabloids, however, have much larger audiences, and are therefore also likely to have an important impact on the public's understanding of science (Evans, Krippendorf, Yoon, Posluszny, & Thomas, 1990; Maeseele & Schuurman, 2008). Tabloids and elites also have very different audiences: Tabloid readers have lower levels of education, income and social status that readers of elite newspapers (Chan & Goldthorpe, 2007). Studying elites only may therefore not be representative of a broad public opinion, and there is currently a call for studies that include and compare different types of news outlets (Crawley, 2007; Maeseele & Schuurman, 2008; Priest & Ten Eyck, 2003).

Very few studies have explicitly compared media framing of science in tabloids and elites. Priest (2001) compared the press coverage of human genetics and disease in U.S. tabloid and elite newspapers. She found that the elite newspapers more often used words associated with uncertainty, whereas the popular newspapers more often used words implying certainty (Priest, 2001). This may be related to the different journalistic styles in elite and popular newspapers: Popular press articles are generally more sensationalized and less objective in their reporting style (Entwistle & Hancock-Beaulieu, 1992). Priest's study was based on a limited number of articles, and more studies investigating the framing of science in different types of newspapers are wanting.

1.3.2 Effects of media framing

The possible effects of a frame—what Entman refers to as *framing functions*—are to help the receiver define problems, diagnose causes, make moral judgments and/or suggest solutions to the problem/issue being described (Entman, 1993). Many scholars have argued that the media,

[5] Also called "broadsheet" or "quality" newspapers

by framing issues the way they do, are likely to exert a powerful influence on the audiences' understanding of those issues (Bubela et al., 2009; Entman, 1993; Nisbet & Scheufele, 2009; Petersen, 2001; Priest, 1994). However, it is very difficult to know precisely how frames actually affect audience thinking, and as Entman (1993, p. 53) has pointed out, "the presence of frames in a text, as detected by researchers, does not guarantee their influence in audience thinking". Van Gorp (2005, p. 487) has also noted that "Frames do not represent something that is present in a news text, independently of readers of the texts".

Previous studies on framing effects suggest that the impact of framing will primarily depend on two things: (a) the extent of exposure to specific frames (e.g. how frequent and long-term they are used in the media); and (b) personal background knowledge. People's previous knowledge, experiences and beliefs interact with the frames they encounter in the process of forming meaning (Kitzinger, 2007; Priest, 1994; Waldahl, 2007). There seems to be consensus that the less knowledgeable the receiver is on a particular issue, the stronger the framing effect (Bubela et al., 2009; Chong & Druckman, 2007; Scheufele & Tewksbury, 2007). In such cases, individuals rely more heavily on mental shortcuts, values and emotions provided in the frame, rather than comparing the relative strength of alternative frames (Bubela et al., 2009; Chong & Druckman, 2007).

1.3.3 How to identify media frames

In media and communication research, *frame analysis* is the method of identifying frames in texts. Researchers identify frames by unpicking the process through which a frame is presented (Kitzinger, 2007). Frame analysis may involve qualitative and/or quantitative methods. In principle, there are two different, but related approaches; inductive and deductive.

Inductive frame analysis

Inductive frame analysis is used to systematically categorize data in order to define frames and establish framing schemes. A framing scheme (sometimes also called a framing *typology*) is a list of all the relevant frames with corresponding depictions of their meaning (more detailed schemes might also list key words, phrases and metaphors etc. associated with each frame).The challenge is to identify and describe previously unrecognized patterns in communication. This is often performed qualitatively through manual categorization of data and is fairly labour-intensive, although some computer-assisted programs can also help identify frames by the key words that are associated with them. There are four main ways of analysing frames inductively:

- The *hermeneutic* approach: These studies provide a descriptive account of media texts, linking frames up with broader cultural elements (Matthes & Kohring, 2008). For example, Coleman and Dysart (2005) examined the media's framing of the Kennewick man and used a "liberal examination of framing" that addressed issue selection, the use of particular sources, language and metaphors, and central themes. They examined news coverage using a "close reading" of news articles, "noting particular frames that emerged…" (Coleman & Dysart, 2005, p. 13). Whilst such studies can offer detailed descriptions of frames, it is often difficult to tell how the frames were extracted from the material.

- The *linguistic* approach: Frames are identified through linguistic elements such as syntax, script, theme and rhetoric, and are recorded in a data matrix (Matthes & Kohring, 2008). For example, Pan and Kosicki (1993) examined how the media frame public policy issues and constructed a complex data matrix with all the linguistic elements for each article. This approach is therefore highly systematic, but also very labour-intensive, and therefore not suitable for larger text samples.

- The *manual* approach: Frames are first generated by reviewing the previous literature and/or qualitatively analyzing a variety of texts on the designated topic. A set of "working frames" or "hypothetical frames" are then used to code subsequent material, and are refined if necessary during the coding process. For example, Tankard (2003) used this approach to analyse the media's framing of abortion and first came up with a list of six working frames. Coders then used these to analyse a sample of articles from newspapers and magazines dealing with abortion, and found that some of the frames either did not exist, or had to be re-categorized, resulting in a final list of just two main frames. An advantage of this method is that it attempts to be systematic and takes into account previous studies. Another virtue of the manual approach is that it directs attention to the latent content, which can reveal deeper or hidden meanings (McQuail, 2005). The validity and reliability of the approach however strongly depends upon how well the researchers define the criteria for identifying frames (Matthes & Kohring, 2008).

- The *computer-assisted* approach: This is based on the assumption that frames are manifested by the use of specific words (Entman, 1993), and uses cluster algorithms to identify words that tend to occur together in texts. For example, Crawley (2007) used a computer program (WordStat 4.0) to identify the frequency of key words associated with agricultural biotechnology. She then used factor analysis to see how the most important key words grouped together to form clusters, or frames. Other variations of this method include hierarchical cluster analysis (Matthes & Kohring, 2008) or semantic network analysis combined with cluster analysis (Murphy & Maynard, 2000). In general, computer-assisted approaches are highly quantitative, and an obvious advantage is the objectivity in frame extraction and the large amount of data that can be analysed (Matthes & Kohring, 2008). However, a major disadvantage is that computer programs cannot detect the latent meaning or context in which words occur (the same word may carry very different meaning in different contexts). Another disadvantage is that techniques involving cluster analysis often assign texts to one frame only, and do not consider cases where there may be several frames present in a text.

There is no doubt some overlap across all approaches and most studies contain elements of more than one. For instance, almost any framing study uses linguistic devices such as key words to identify frames to some extent, although they do not scrutinize them in such detail as the linguistic approach would (Matthes and Kohring 2008).

Deductive frame analysis

Deductive frame analysis applies a previously established framing scheme to identify and quantify the presence of predefined frames in a dataset. This typically involves quantitative analyses to find out the prevalence of various frames in a sample. An inductive frame analysis may thus form the methodological basis for subsequent deductive analyses. There are two main approaches for deductive frame analyses described in the literature:

- A frame is considered a holistic variable that is identified by its *latent* meaning. Latent meaning refers to what is “hidden” beneath the obvious surface elements of a text (Lombard, Snyder-Duch, & Bracken, 2002). This contrasts to *manifest* meaning, which is revealed more obviously by information “on the surface”. Researchers use previously established framing schemes as guides for identifying frames. The meaning of a frame is indicated by the presence or absence of key words, phrases, depictions or metaphors. For example, Nisbet and Lewenstein (2002) used an already-established framing scheme for identifying biotechnology frames, taking into account the latent meaning of each frame.

- A frame is considered a sum of various parts; a list of questions is drawn up about various aspects of the frame (e.g. type of topic mentioned), to which coders have to answer “yes” or “no”. Their answers are used to code the presence of a particular frame. For instance, Semetko and Valkenburg (2000) analysed the presence of five politics frames in Dutch newspapers by developing a series of 20 questions to which the coder had to answer yes (1) or no (0). They considered answers to at least three questions for measuring the existence of a particular frame. Alternatively, answers to questions may be graded in a Likert scale, as suggested by Beyer (2010). Using a Likert scale necessitates that the frames encompass elements that are clearly either present or absent (e.g., specific topics or use of specific sources), and tends to be most suited to identifying *generic* frames, as shall be described in the next section.

1.3.4 Examples of media frames

Frames may be categorized into three main types: generic frames, issue specific frames, and scientific concept frames.

Generic frames

Most framing research to date has been oriented towards describing and identifying *generic* science news frames in the elite newspapers (Van Gorp, 2005). A generic frame involves an overarching perspective that may be applicable to a variety of different topics. As a key example, Gamson and Modigliani (1989) developed a framing scheme from a qualitative analysis of how nuclear energy was discussed in television news coverage, newsmagazine accounts, editorial cartoons, and opinion columns in the US. They developed a list of seven frames, including the *progress* frame (generally positive), which emphasizes the benefits of technological development and economic growth, and the *public accountability* frame (generally negative), which criticizes the nuclear industry for being more interested in its own economic interests, rather than the public’s interests.

Gamson and Modigliani's frames have later been adapted for analyses of the media's framing of other science topics, including biotechnology (Bauer et al., 2001; Nisbet & Lewenstein, 2002) and genetics (Ten Eyck & Williment, 2003). Nisbet and Lewenstein (2002) for example, adapted Gamson and Modigliani's original scheme in their analysis of press coverage of biotechnology. Nisbet and Lewenstein's (2002) list of biotechnology frames are applicable to the majority of science policy debates, and have been used to describe different political views on evolution, climate change, plant biotechnology and nanotechnology (Nisbet & Mooney, 2007; Nisbet & Scheufele, 2009).

Issue specific frames

Science topics can also carry frames that are specific to that particular topic only, which relate more to their scientific meanings than the political views. Such frames are often referred to as *issue specific* frames and have been found for topics such as nanotechnology (Anderson, Allan, Petersen, & Wilkinson, 2005; Stephens, 2005), mental illness (Paterson, 2007) or genetically modified crops (Cook, Robbins, & Pieri, 2006).

Scientific concept frames

Although more rare, a framing scheme may even focus on the meaning of a single scientific concept. For example, in the embryonic stem cell research debate, the embryo is the key concept for both opponents and supporters; what differs in their arguments is how they frame it. Williams, Kitzinger and Henderson (2003) tracked the words, images and metaphors used to describe the embryo in the U.K. media reporting of stem cell research, and identified two main frames: Supporters of embryonic stem cell research framed the embryo as invaluable material for developing therapies. They focused on the embryo's scientific importance, using scientific words such as 'blastocyst' and metaphors such as 'florescent frogspawn' in order to dehumanize it. The supporters also often showed microscope images of a tiny cell cluster to signify how non-human it is. The opponents on the other hand framed the embryo as a precious human life. They would avoid using scientific words or showing its small size. Instead, they would often show a picture of a foetus a few months old (with toes and fingers), and they would describe it as a 'very young human being'. This is potentially misleading, since it is only the pre-14 day embryo which is actually used in stem cell research.

Kitzinger (2007) has produced a framing table that clearly shows the two different frames and their various framing devices in the stem cell debate (summarized in Table 1). I found this table very helpful for visualizing the concept of framing, and therefore include it here as an example of how to present a framing scheme.

Table 1: Framing the Embryo – an example of a framing scheme

Framing devices	**Pro-embryonic stem cell research:** **Embryo = invaluable material for developing therapies**	**Anti-embryonic stem cell research:** **Embryo = a precious human life**
Metaphors which 'humanize' or 'dehumanize'	'florescent frogspawn'	'very young human being'
References to size	'microscopic' or 'smaller than this full-stop.'	not mentioned, or only to emphasize vulnerability, e.g. 'tiny, vulnerable being'
Images	Photographs of pre-14 day embryo	None, or show a foetus several months old
Language about cells	'blastocyst'	'human' embryo
Use of the word 'potential'	Potential of the research to lead to medical advance	Potential of embryo to become a human being
Origins of embry	'left over' or 'surplus' (from fertility treatment)	'deliberately created to be destroyed' (by cloning techniques)

Note. Source: Kitzinger (2007, p. 144-155)

1.4 Communicating Genetics

1.4.1 Genes in science

The concept of the *gene* was coined in 1909 by Danish botanist Wilhelm Johannsen to represent a discrete unit of heredity (Johannsen, 1909; Roll-Hansen, 1989). The name derives from the Greek *genesis* (birth) or *genos* (origin), and was originally considered an abstract entity that determined particular characteristics of an organism (Gerstein et al., 2007).The concept emerged from a synthesis of Gregor Mendel's work on inheritance patterns in pea plants, and Charles Darwin's theory of descent with modification. In the decades that followed, the gene became a central concept in biology but its meaning constantly changed in the face of new genetic discoveries.

During much of the first half of the last century, scientists regarded genes as concrete physical entities linked to particular traits. In 1953, James Watson and Francis Crick's discovery of the chemical structure of DNA revolutionized molecular biology and lead to the beginnings of "The Central Dogma". This explained the mechanism by which genetic information was copied and transferred from DNA to protein, paving the way for several advances in genetic technology. Arguably, the most influential genetic achievement of the last century was The Human Genome Project, launched in 1990. By 2001, it had produced a draft sequence of the 24 human chromosomes and the positions of all known genes.

One of the main aims of the Human Genome Project was to gain a better understanding of the genes involved in human traits and diseases (Baltimore, 2001). It was thought that the human genome would be like an "instruction book for human biology", which could, for example, allow for the development of designer drugs that targeted specific molecular pathways involved in disease (Collins & McKusick, 2001). However, the hunt for so-called "disease genes" proved difficult, because scientists discovered that what a gene is, and what it does, depends very much on the cellular environment, on interactions with other genomic elements, gene products and other factors present in the cell (Stotz, Bostanci, & Griffiths, 2006).

Many diseases are not caused by a single gene mutation, they arise from a complex interplay between environmental factors and multiple gene variants (Balmain, Gray, & Ponder, 2003). Even the most apparently clear cases of so-called "single gene diseases" —

such as sickle cell, cystic fibroses, or Huntington's chorea—vary enormously with regard to severity, range of symptoms, or time of appearance (Condit, Parrott, & O'Grady, 2000). The thalassaemia blood disorders for example, show considerable variation in sufferers exposed to different climates (Weatherall, 2000). It is therefore impossible to predict with certainty the clinical course of any disease, even if we know the exact genetic makeup of an individual (Dougherty, 2009). Most scientists talking about disease risk therefore prefer to use the term "susceptibility genes" to indicate that genes merely increase the probability or risk of developing a disorder (Hall, Morley, & Lucke, 2004).

Through the course of the last century we have therefore learned that the functions and nature of genes are vastly more complex, and more confusing, than what was originally thought (Keller, 2000). In an article in *Nature* entitled *"What is a gene?"* Pearson (2006, p. 399) concluded that: "the more expert scientists become in molecular genetics, the less easy it is to be sure about what, if anything, a gene actually is." The gene still is, however, a DNA sequence that codes for a protein. This is still the working definition for many scientists, but those at the forefront of genomics, including *epigenetics*, regard it as seemingly old-fashioned (Pearson, 2006).

Epigenetics is a fairly recent domain of research, which investigates heritable changes in gene expression that are not coded in the DNA sequence itself (Egger, Liang, Aparicio, & Jones, 2004). Genes are not active all the time, but are expressed ("switched on") by various biochemical cues within the cell. Some of these cues may be the result of environmental influences that happened early in childhood, or even in previous generations. For example, studies in mice have shown that mothers who are more caring and nurturing can affect the chemistry of DNA in their infants, by suppressing their stress receptor genes. These genes remain suppressed throughout the infants' life, allowing them to cope better under stressful situations as adults (Bird, 2007). Scientists working in epigenetics have thus acquired a new "postgenomic" understanding of genes as entities constituted during genome expression (Stotz et al., 2006).

Scientists working in other areas of biology also currently have different ideas about genes. For example, evolutionary biologists see genes as units of natural selection. They unite Darwinian theory based on natural selection with the new knowledge in genetics to explain the gene's role in evolution and disease development. The "evolutionary gene concept" was brought to public attention by Richards Dawkins in the 1976 best seller *The Selfish Gene*.

Dawkins introduced the term “the selfish gene” as a metaphor for a gene’s self-replicating properties—the inherent ability of DNA molecules to promote synthesis of their own template. Dawkins defined a gene as: “any portion of chromosomal material that potentially lasts for enough generations to serve as a unit of natural selection” (Dawkins, 2006, p. 28). In evolutionary biology there is now also a focus on the conservation of various repetitive elements related to gene regulation, and a new sub-field called evolutionary genomics is currently developing (Li, Gu, Wang, & Nekrutenko, 2001).

Developmental biologists, on the other hand, see genes as the coded information manifested in an organism’s evolved life cycle. Bioinformaticians see genes as landmark DNA sequences with clear start and stop positions within genetic-sequence databases (Pearson, 2006). Does it matter that there are different working definitions of a gene in different sub-fields of biology? Do scientists working in different sub-fields find it difficult to understand each other when they talk about genes, and could this hinder collaboration? Also, will scientists working with overly simplistic definitions of a gene discard important results that do not fit (Pearson, 2006)?

To sum up this section, it is clear that the classical view of a gene as a unit of hereditary information aligned along a chromosome, each coding for one protein, has changed dramatically in the face of the molecular biotechnology revolution (Gerstein et al., 2007). The gene can be defined in many different ways, and the scientific community still cannot agree on a single unified definition. This can have important implications for public communication of new genetics. What part of this complex picture does the education system and the media convey?

1.4.2 Genes in education

Due to the growing importance and relevance of genetics in our everyday lives (genomic medicine, genetic testing, genetically modified foods etc.), science educators consider an understanding of the gene concept a crucial aspect of scientific literacy (Duncan & Reiser, 2007; National Research Council, 1996). The gene concept therefore lies at the heart of the upper secondary school curriculum in biology. For example, in the Norwegian curriculum for upper secondary biology, genes occur in numerous topics spanning from proteins and the chemistry of cells, to the inheritance of diseases and traits, reproduction, evolution and the latest developments in biotechnology (Grønlien et al., 2008).

The gene is, however, a particularly challenging concept for both teachers and students to make sense of (Duncan, Rogat, & Yarden, 2009; Knippels, Waarlo, & Boersma, 2005). One of the major difficulties is being able to understand how genes bring about effects across multiple organizational levels; from the cell to the tissue, organ and whole organism (Duncan & Reiser, 2007). In particular, students find it difficult to understand the mechanism of gene expression (Lewis & Kattmann, 2004; Venville & Treagust, 1998). Whilst the scientific community has long acknowledged that genes are expressed in response to the action of other genes and to particular environmental stimuli (Condit, 2007), high school students are seldom taught how environmental factors can influence the development of characteristics (Forissier & Clement, 2003). Schools are still teaching the model of classical genetics, similar to the scientific view of the first half of the twentieth century (Gericke & Hagberg, 2007). The content and framing of high school textbooks are also reinforcing simplistic and deterministic views found in the older scientific models (Gericke & Hagberg, 2010).

Studies of school students' understanding of genes generally find that students view genes as particles that determine characteristics, often linking single genes directly to complex traits (Dougherty, 2009; Duncan et al., 2009; Duncan & Reiser, 2007; Gericke & Hagberg, 2007; Gericke & Hagberg, 2010; Lewis & Kattmann, 2004; Venville & Treagust, 1998). Duncan and Reiser (2007) for instance, asked tenth grade students to write down what they think genes are and what they do in the body, and received statements such as "genes control/determine our traits" and "genes decide who we are and what we look like". This supports previous work by Venville and Treagust (1998), who asked tenth grade students to write down what they knew about the terms gene, chromosome and DNA after a ten-week genetics course. Most of the students wrote statements such as "genes control characteristics" , "genes are located on chromosomes/DNA" and "chromosomes/DNA/genes are found in cells".

Some science educators now worry that school science is lagging behind current science to such an extent that this will make it difficult for students to comprehend modern developments in genetics (Dougherty, 2009; Gericke, 2008; Verhoeff, Boerwinkel, & Waarlo, 2009). Duncan and Reiser (2007) for example argue that there is still too much focus in the curriculum on the Central Dogma, but not enough beyond that. Dougherty (2009) argues that there is too much focus on Mendelian inheritance, which makes it difficult for students to understand that most human traits are the product of genes interacting with an environment. There is a general consensus that the biology curriculum should shift from focussing on single gene disorders to multifactorial and polygenic disorders, in order to teach students about the complexities of genetic causation (Dougherty, 2009; Lewis & Kattmann, 2004; van der Zande, Waarlo, Brekelmans, Akkerman, & Vermunt, 2011; Verhoeff et al., 2009; Verhoeff, Waarlo, & Boersma, 2008).

To sum up this section, it is apparent that the current scientific understanding of genes is very different and more complex than what secondary school curricula currently portray. Students predominantly hold classic molecular/deterministic understandings of genes, and there is a need for teaching more about the bigger picture of genetic causation. Condit (2007, p. 817) has concluded that:

> Although medical genetics is rapidly outgrowing the 'one gene, one disease' model, journalists and lay individuals are still rehearsing their high school biology lectures, which taught eye colour, for example, as a single-gene model of the causation of human characteristics.

1.4.3 Genes in the media

The public rely on media reports for the latest information in genetics. The public want to know things like "Which medical treatment is best for my genetic makeup?" and "What sort of traits can I screen my unborn baby for?" Genetic research has thus been widely covered by the press in the last three decades. There have been numerous studies analyzing mass media reporting of genetics in general (Conrad, 1999; Petersen, 2002; Ten Eyck & Williment, 2003) and genetics-related issues, including biotechnology (Bauer et al., 2001; Gaskell et al., 2001; Nisbet & Lewenstein, 2002; Priest, 1994) and biomedicine (Petersen, 2001). These studies generally suggest that the media have focussed on the positive effects of new genetic discoveries, particularly relating to human health and disease, although there has been some concern about genetically modified foods, particularly in the UK press (Anderson, 2002).

Fewer studies have specifically examined the media's representation of the gene concept. Nelkin and Lindee (1995 and 2004) reviewed a wide variety of American "popular culture" in the 1990s and found that the gene has become a powerful cultural symbol and that there is an overall tendency in society to regard the gene as a mystical entity that determines our lives. They termed this view "genetic essentialism" (Nelkin & Lindee, 2004, p.2):

> The images and narratives of the gene in popular culture reflect and convey a message we will call genetic essentialism. Genetic essentialism reduces the self to a molecular

> entity, equating human beings, in all their social, historical, and moral complexity, with their genes.

Their view of genetic essentialism is interesting because it links genes to biological traits such as cancer and obesity, but it also links genes to traits that are more dependent on culture than biology, such as clothes style and political orientation (Nelkin and Lindee, 2004, p. 2):

> In supermarket tabloids and soap operas, in television sitcoms and talk shows, in women's magazines and parenting advice books, genes appear to explain obesity, criminality, shyness, directional ability, intelligence, political leanings, and even preferred styles of dressing. There are selfish genes, pleasure-seeking genes, violence genes, celebrity genes, gay genes, couch-potato genes, depression genes, genes for genius, genes for saving, and even genes for sinning.

Conrad (2001) examined the news coverage of genetics and mental illness in U.S. newspapers and magazines between 1987 and 1994. He found that the reports were predominantly characterized by three elements: They assumed that a gene for the disorder exists, it will be found, and the outcome will be good. As a parallel to Nelkin and Lindee's concept of "genetic essentialism", he introduced the term "genetic optimism" to describe this dominating news frame, although this frame focuses entirely on biological traits. The frame has an overall positive tone because it gives hope that by knowing which genes are "responsible", scientists will be able to develop treatments for mental disorders based on accurate genetic diagnoses. In addition, the articles with this frame welcome genetic explanations for mental disorders, because they remove the "environmental" blame from families and sufferers.

The studies by Nelkin and Lindee (1995) and by Conrad (2001) both implement *genetic determinism* as a key element in the media's coverage of genetics. Genetic determinism is a perspective that "identifies genes as the sole relevant causal feature of an individual's characteristics and life courses" (Condit et al., 2000, p. 558). It may be exemplified by statements such as "Scientists have found the gene for alcoholism" and "Your genes are making you fat". Many scholars have criticized the media for being deterministic, because deterministic messages convey overly simplistic representations of genetic causation that may mislead the public (Conrad & Markens, 2001; Hubbard & Wald, 1993; Mountcastle-Shah et al., 2003; Nelkin & Lindee, 1995; Nelkin, 1994; Parrott et al., 2004; Petersen, 2001). For example, Hubbard and Wald (1993) criticized genetic determinism and the "new fixation on genes" in the media because it may potentially mislead the public's understanding of health and medicine (1993, p. 6):

> The myth of the all-powerful gene is based on flawed science that discounts the environmental context in which we and our genes exist. It has many dangers as it can lead to genetic discrimination and hazardous medical manipulations.

In contrast to the general claims of determinism in the media however, Condit, Ofulue and Sheedy (1998) and Condit (1999b) have found a more nuanced picture of genetic causality. Condit et al. (1998) performed a content analysis of the degree and type of genetic determinism in major American "public newspapers" and magazines from four different periods from 1919 to 1995. To measure the degree of determinism they categorized each article as either 1) attributing human outcomes to the gene only; 2) attributing outcomes to the gene and to other factors, or 3) explicitly opposing genetic influence. They found that for all time periods the majority of articles fell into the second category, attributing influence to both genes and environment. They also found that the number of articles with purely deterministic contents (category 1) had decreased in the most recent time period.

To sum up this section, it is clear that the gene is a pervasive concept in the media. The majority of studies claim that the media portray genes in a highly deterministic manner, although there are some exceptions that render the overall picture somewhat unclear.

Audience perceptions

In parallel to the media studies above, some studies have also investigated how the public perceive media messages about genetics. Critics have worried that mass media coverage of genetics also encourages views of genetic determinism in the public (Hubbard & Wald, 1993; Nelkin & Lindee, 1995; Nelkin & Lindee, 2004). They worry that this will make people overestimate the importance of genes in their lives, which can for example make them less willing to alter important lifestyle factors to help prevent common diseases such as heart disease (Parrott et al., 2004).

To explore the extent to which the public interpret messages about genetics in a deterministic fashion, Condit (1999a) performed a reception study in the U.S. that investigated 137 college students' interpretation of highly deterministic news items. She found that 28% of the respondents offered explicitly deterministic interpretations, whereas 42% were explicitly non-deterministic. The non-deterministic interpretations generally viewed genes as *probabilistic* causes rather than absolute, recognising that genes play only a partial role in generating physical traits and behaviours. Some of the respondents also mentioned other factors that might play a role (e.g. education, lifestyle, access to health care). Condit concluded that the public generally interpret media messages non-deterministically, and that their interpretations of genetics therefore showed more variety than the critics had suggested.

Bates (2005) found similar results: He conducted a large focus group study investigating how the public use the mass media to express their understandings about genetics. He found that whilst participants drew on specific media accounts of genetics, including films and popular fiction, they processed these messages complexly. The participants integrated what they read with prior media messages to create new ideas. Prior discussions with family and friends also influenced their ideas. He concluded that the public do not seem to have clear-cut deterministic views, but each person forms their own unique mix of ideas.

Several focus group studies have investigated public perceptions of the role of genes in disease (Bates, Templeton, Achter, Harris, & Condit, 2003; Parrott et al., 2004; Parrott, Silk, & Condit, 2003). The studies generally find that the majority of people believe genes play a partial (not absolute) role in disease, but extremely few people have an understanding of how genes interact with other factors. Opinion polls in the U.S. show that between a quarter and a third of respondents endorse genetic determinism, whilst the "non-deterministic" respondents tend to shift their attention over to behavioural explanations—as if the environment was an additional, yet separate factor (Condit, 2007). These studies therefore suggest that the public need a better understanding of the *interaction* between genes, personal behaviours and environment.

To sum up this section, we can assume that analyzing the media can give an important *indication* as to what the public are thinking about genes. We cannot assume a direct linear relationship between media and public discourse, because the public are influenced by many factors and construct their own meanings in complex ways. Research has shown that the public's understanding of genes is not as deterministic as previous media critics have feared. This could also indicate that there is in fact a variety of representations of genes in the media, not just deterministic ones.

Proposed gene frames

In a commentary in *Nature Reviews Genetics,* Condit (2007) drew attention to the importance of framing in the reporting of genetics. For the first time she mentioned the word framing, and proposed several *gene frames*:

- The *genes win!* frame, which portrays the idea that genes trump environments (similar to determinism).
- The *gene-environment interaction* frame, which presents genetic causation as a process involving multiple genes within the context of an environment.
- The *gene versus environment* frame, which focuses on the conflict between genetic and environmental explanations (opposing genetic influence).

These proposed gene frames are similar to the categories used in her previous work (Condit, 1999b; Condit et al., 1998). The difference is that the above frames refer to the *meaning* conveyed in a story, whereas the categories used in the previous studies simply referred to the presence or absence of certain statements. For example, in Condit's 1998 study, an article would fall into the category "genes+environment" simply if the article mentioned "genes" and "environment" somewhere in the article (not necessarily together). In contrast, the *gene-interaction* frame explicitly conveys the idea that genes and environmental factors interact, and articles containing this frame therefore have the possibility of conveying a more interesting and complicated picture of the different interacting variables.

Condit (2007) emphasized the importance for geneticists to be aware of these different frames, in order to provide effective balance or correction when communicating with journalists. In particular, she argued that: "awareness of a reporters' tendency to collapse the *gene-environment* frame back into the *genes win!* frame can help one to generate a clear, consistent counter to this outdated story" (Condit, 2007, p. 817). However, in order to increase awareness of these gene frames, there is a need for more research to clarify exactly which gene frames are present in the media today. To my knowledge, no study has explicitly analysed the media's framing of the gene concept.

1.5 Gaps in knowledge

The literature reviewed in this introduction indicates that:

- Previous studies of the representation of genes in the media have focussed on the American press. We do not know how genes are portrayed in the European press.
- The majority of studies claim that the media portray genes in a highly deterministic manner, although some studies claim the picture is more nuanced. There is a need for clarification.
- Framing is a powerful tool for categorizing media discourse, but whilst several “gene frames” have been proposed, no framing study has investigated the presence or extent of these proposed frames in the mass media today.
- No framing study has explicitly compared how different types of newspapers, such as tabloids and elites, currently frame the gene. This is important to address because different newspapers have different audiences: If different types of newspapers frame genes differently, this could have important consequences for public understanding of science.
- Both the public and school students need a better understanding of the *interaction* between genes and environmental factors in the development of traits and diseases.
- The new curriculum goals within science education expect students to be able to engage critically with science in the media (to become “media literate”), but teachers do not know how to address this. The use of newspapers in the classroom is casual and sporadic, and students are generally uncritical of media reports. There is therefore a clear need for new teaching activities and programs that can equip students with the necessary tools for critical analysis of science in the media.
- No study has specifically explored how an awareness of media framing can be used as a means of enhancing media literacy in the science classroom, and/or for improving students understanding of the gene concept.

2. Study aims

The overall aim of this thesis is to explore how newspapers frame understandings of the gene concept, and how an awareness of this process can help students engage more critically with science in the media and thereby widen their scientific knowledge.

To address the specific gaps in knowledge, the thesis aims to:

1. Identify and describe the gene frames present in the European press media (Paper I)

   We specifically ask:

   - Which gene frames are currently present in Norwegian and British national newspapers?

2. Compare how tabloid and elite newspapers frame the gene concept (Paper II).

   To address this aim, we specifically ask:

   - Do tabloid newspapers (with readers of low socioeconomic status) use different gene frames than elite newspapers (with readers of high socioeconomic status)?

3. Design and evaluate a teaching program that uses frame analysis of media texts in the teaching of genetics (Paper III).

   To address this aim, we specifically ask:

   - Are upper secondary school students able to grasp the concept of media framing and recognize the five different gene frames in media reports?

   - Does an awareness of media framing improve students' understanding of the gene concept?

3. Methods

3.1 Overview

3.1.1 Frame analysis

For many years it was popular in media studies to analyse bias or objectivity, simply coding material into dichotomous categories such as "pro or con", "favourable or unfavourable", or "negative or positive" towards a certain issue, and then making assumptions based on these (Entman, 1993; Tankard, 2003). These traditional *content analyses* would treat all negative or positive terms or utterances as equally influential, thus ignoring the salience of different text elements and how these combine to influence audience thinking (Entman, 1993). According to Entman (1993, p. 57), "Unguided by a framing paradigm, content analysis may often yield data that misrepresent the media messages that most audience members are actually picking up".

Frame analysis, on the other hand, is attentive to the salience of various elements embedded in a text, so that it is possible to pick out the dominant meaning as well as the more subtle ones. It therefore has the potential of getting beneath the surface of news coverage, exposing any "hidden" meanings, and often comprises many different categories in a coding scheme (Tankard, 2003). Further, it adds a new dimension to studying bias because even the same position or slant on an issue can have different frames (Gamson & Modigliani, 1989). For example, in debates over the use of preimplantation genetic diagnosis (a method used to test the genes of a fertilized embryo), those against its use can argue with either of two frames; a *scientific rationalism* frame emphasizes how choosing perfect embryos may affect evolution , whilst a *human rights* frame that says it is unethical since embryos cannot make conscious decisions (Murphy, 2008). Analysis of framing is therefore considered a much more sophisticated approach to the old objectivity and bias paradigm (Tankard, 2003).

An alternative method we might have used is *discourse analysis*, which is about studying and analyzing the use of language (Hodges, Kuper, & Reeves, 2008). In fact, some researchers simply consider frame analysis a "subframe of discourse analysis" (Paterson, 2007). At closer examination however, all variants of discourse analysis (critical, formal linguistic, and empirical discourse analysis) generally attempt to understand meaning at a "meta" level, rather than at the level of actual semantic meaning (Hodges et al., 2008).

Critical discourse analysis for example, which is a commonly used approach, is particularly concerned with how discourses relate to systems of power in society. Discourse analysis is therefore an excellent approach for studying large complex phenomena, but may overlook the subtleties of meaning related to a single scientific concept like the gene.

Inductive frame analysis may seem similar to *grounded theory* in that it involves the gradual identification of themes/issues though constant comparison of data: In grounded theory research, issues of interest are noted in the data, and then compared with other examples for similarities and differences in a continuous process of modification (Lingard, Albert, & Levinson, 2008). However, researchers using grounded theory avoid conducting a literature review and usually approach the data without any assumptions to be tested: Analysis is an *iterative* process, which begins as soon as the first bit of data is collected, and each stage of the analysis guides the next type and amount of data to be collected (Corbin & Strauss, 1990). In framing research on the other hand, using a set of "working frames" drawn from a preliminary analysis, or from the literature, is often very important. Hertog and McLeod (2003, p. 151) have stressed that "To develop the field, frames identified in prior work should always be included and tested in subsequent research".

3.1.2 Comparing qualitative and quantitative approaches

Qualitative research involves the systematic collection, organisation and interpretation of textual material and the exploration of meaning (Malterud, 2001). One of the merits of using a qualitative approach in an inductive frame analysis is that it allows the researcher to discover new insights during the coding process, and adjust categories if necessary (Hertog & McLeod, 2003). However, the very point that qualitative analysis allows for some flexibility and maturation of interpretation renders it a somewhat subjective process. Every individual carries with them a store of personal knowledge, experiences and attitudes that may influence their interpretation of a text. This means that different researchers may interpret the same text differently.

Differences in interpretation do not necessarily result in a failure of reliability, but can actually contribute to an increased understanding of complex phenomena (Malterud, 2001). Multiple researchers may strengthen the design of a study, particularly in cases where two different researchers code parts of the same material and are able to supplement and moderate one another during the coding process. Due to the complexity and richness of this process however, many qualitative framing studies do not explicitly state how the analysis was performed, and often simply say something like, "After several rounds of close reading and moderation, the categories emerged". This is not sufficient to explain how and why patterns emerge, nor to evaluate the quality of the work (Malterud, 2001). In the proceeding sections, I therefore attempt to describe our procedure as detailed as possible.

Quantitative approaches on the other hand, tend to be more reliable (reproducible) because they are often based on a predetermined list of categories. Quantitative frame analyses tend to match media content to already-established frame categories and then map the frequency of occurrence of these categories. A quantitative approach is therefore generally more applicable to deductive frame analysis, although quantitative computer-assisted approaches are becoming popular for inductive analyses (as was outlined in section 1.3.3). These can analyse large amounts of data, and can identify frames by counting the number of times certain framing devices (e.g. key words) appear. However, as already mentioned in section 1.3.3, often one or two key words or metaphors may be powerful enough to set the frame for a whole article. Simply analysing the frequency of certain words may therefore not be a reliable indicator of frames.

Computer-assisted analyses are also poorly suited to determine what is *not* there (Hertog & McLeod, 2003). As Entman (1993) has pointed out, frames manifest themselves by the presence *or absence* of key words, phrases etc., and sometimes it is just as powerful to avoid mentioning something. For example, talking only about genes and not mentioning anything about the importance of lifestyle factors in an article about obesity could reinforce a deterministic frame. A computer-assisted method would miss such hidden features. It would also miss the context in which words appear. Kitzinger (2007) has for example shown that the meaning of specific words vary depending on the context in which they are placed. In the stem cell research debate, both proponents and opponents use the word "potential", but in very different contexts: The proponents emphasize the potential *of the research* that can lead to medical advance, whereas the opponents emphasize the potential *of the embryo* to become a human being (see Table 1 Section 1.3.4).

Despite the apparent differences between qualitative and quantitative approaches, Malterud (2001) has argued that they should not be seen as incompatible, but rather as complementary. A number of studies use combinations of both, because they are good for different purposes (McQuail, 2005). For instance, the majority of computer-assisted frame analyses actually involve an element of human interpretation or organization of material at some stage—such as making sense of the final word clusters, or deciding which key words to include or exclude in a data matrix or algorithm.

3.2 Paper I

In Paper I, we used an inductive approach to identify and define the gene frames present in a selection of major Norwegian and British national newspapers. We base our method on the manual approach described in section 1.3.3 because the differences in meaning of the gene may be subtle and may also be dependent on the context in which the gene is mentioned (e.g. molecular biology, evolution, disease etc.). Our approach aims to strike an appropriate balance between the broadness of the hermeneutic approach and the specificity of the linguistic approach.

3.2.1 The preliminary frames

As a starting point for our frame analysis, we retrieved a set of preliminary or "hypothetical frames" from the literature, including previous media studies and scientific discourse. From previous media studies, these included:

- *Deterministic:* Assumes the gene is a definite cause for a particular trait, usually a disease or disorder (Nelkin and Lindee 1995).
- *Symbolic:* Detaches the gene from its biological form & function; used as a symbol for something non-biological. E.g "Saab with USA genes*"* (included in Nelkin and Lindee's category "genetic essentialism").
- *Gene-environment interaction*: Presents genetic causation as a process involving multiple genes within the context of an environment (Condit 2007).
- *Gene versus environment* frame: Focuses on the conflict between genetic and environmental explanations (opposing genetic influence) (Condit 2007).

From the scientific literature (textbooks and scientific articles about genetics) we retrieved the following:

- *Materialistic:* regards the gene as a distinct molecular entity (from the classic textbook definition).

- *Evolutionary:* treats the gene as a more dynamic and abstract entity (e.g. Dawkins' selfish gene and Darwinian selection).

I also conducted a small pilot study where I tested various combinations of the word "gene" in the main Norwegian newspaper database (Atekst), in order to find the most suitable search command for retrieving gene-related articles. I then retrieved a sample of 25 Norwegian news articles and performed a small frame analysis. I attempted to identify the hypothetical gene frames in order to become more familiar with the various framing devices that helped define each of them. I could identify all of the six hypothetical frames more or less, although some of the frame categories seemed to overlap or include more than one perspective, so I knew that further adjustment would be required in the main analysis. This was not mentioned in Paper I due to space limitation.

3.2.2 Material

We chose to analyse newspapers, rather than other types of media such as TV, Internet or Radio, because newspapers are a superior source of in-depth information for the public (Jarman & McClune, 2007). They also provide one of the most efficient ways to study a mass medium (Crawley, 2007): Compared to broadcast news, newspaper material is more easily archived and accessible via electronic databases, and is therefore easier to explore systematically. Although Internet material is becoming increasingly important as a source of information for the public, its text continually changes and its archived material is more incomplete than printed newspapers (Crawley, 2007).

We chose *national* newspapers, rather than regional, local or niche newspapers, because national newspapers address a broader audience and are therefore likely to be most representative of the type of information about genes the majority of people receive (Evans et al., 1990). Further, since previous media studies about genes and genetics have been limited to the U.S., we chose newspapers from Norway and the U.K in order to gain insight into the European context. Due to the qualitative nature of the study, which involved in-depth analysis of textual meaning (frames), it was also important to choose newspapers from countries that matched our language capabilities. We limited our scope to a recent time-period (2003-2006) in order to capture the contemporary context at the time of this study.

As mentioned in section 1.3.1, studying one type of newspaper only—such as elites—may not be representative of the newspaper landscape as a whole, since tabloids, "mid-market"[6] and elite newspapers have very different journalistic styles (Entwistle & Hancock-Beaulieu, 1992; McQuail, 2005) and also cater for very different audiences (Chan & Goldthorpe, 2007). In order to capture a range of stories about genes that are as representative as possible of the general media discourse, we chose to include an equal number of articles from a major tabloid, mid-market and an elite newspaper from each country. We chose *The Sun, The Daily Mail* and *The Guardian* from the U.K., and *VG, Dagbladet* and *Aftenposten* from Norway.

To retrieve gene-related articles we searched for ("gene" OR "genes") in the electronic database Factiva for the English articles, and ("gen" OR "gener") in the Atekst database for Norwegian articles in the period 01.01.2003 – 31.12.2006. We included all types of articles in the search (news briefs, news articles, commentaries, editorials, and feature articles). Each resulting list of articles was sorted by date (oldest first), and 50 articles were selected at regular intervals starting with the first. For instance, if the list consisted of 500 articles I would select every 10^{th}. Each article was reviewed to ensure that it mentioned the actual (biological) gene concept. In articles that used the word "gene" only as a name (e.g. Gene Hackman), the next article in the list was selected instead.

3.2.3 Procedure

1. Each article was analysed for the presence of gene frames: I recorded key words, phrases, descriptions and metaphors relating to the gene in an SPSS database. These framing devices and the meanings they conveyed were compared with the hypothetical frames. I attempted to assign each article to a tentative frame category (e.g. "deterministic" or "evolutionary"). In cases where there were framing devices that matched several frames, I noted which of these was most dominant, followed by which was secondary or tertiary in prominence. Articles that contained similar frames with similar framing devices provided confirmation of the frame category. Articles that contained new depictions or perspectives of the gene that did not seem to fit any preconceived category were assigned to new tentative categories.

[6] "Mid-market" or "mid-brow" newspapers tend to lie somewhere in-between tabloids and elites in terms of journalistic style and seriousness.

2. To clarify the frame categories, I developed a preliminary codebook that described the meaning of each frame category and the various framing devices associated with each one. This was continuously developed during the coding process.

3. Moderating process: During the first part of the coding process a second coder (my main supervisor) coded 25 of the same articles I had coded. We compared and discussed our interpretations, and where there were discrepancies, we suggested new ways of refining the frame categories.

4. I analysed each article several times and regularly discussed my interpretations with the second coder. Articles were continuously compared with one another to see how their framing features matched or differed. Category boundaries were refined and new frames emerged as more material was analysed, some of which were classified into sub-frames. Every time we made a category adjustment, I recoded all previously analysed articles. See Figure 3 and the following section on the evolution of the five frames for a detailed description of this process.

3.2.4 Evolution of the five gene frames

The frame analysis consisted of four main stages of category refinement, summarized in Figure 3 and explained below. We choose names for each frame that we thought reflected the main connotations associated with that frame. For example, the materialistic frame denotes the physical "realness" of DNA and genes as material that can be identified, isolated, moved and manipulated. Some of these names were however modified during the frame analysis as the meaning of each frame category became clearer.

Stage 1: We started with the six hypothetical frames derived from the literature, and described in section 3.2.1.

Stage 2:

- It soon became clear that the original "gene + environment" frame encompassed two related ideas: The idea that genes are predisposing factors for traits, and an extension of this—that genes are expressed in response to environmental cues. These two ideas convey different levels of insight into genetic causation. Articles that portrayed genes as predisposing factors indicated that there might be other causal factors involved, but did not mention what they may be, whilst other articles explicitly mentioned environmental factors that might affect the expression of genes. We therefore decided to reclassify the articles with the former idea as “relativistic” because these articles focussed on the gene as a relative risk factor in the development of traits and diseases, whilst the articles with the latter idea were reclassified into a separate sub-frame called “interactive”, because these conveyed more insight into gene-environment interaction.

Stage 3:

- We came across some “anti-deterministic” articles that criticized genetic determinism, but also conveyed insight into the complex nature of genetic causation. These were therefore included in the “interactive” frame.

- Articles with the “gene versus environment” frame treated genetic and environmental factors as separate entities. Since such an “either or” perspective underscores determinism, we decided that such articles should be classified as a sub-frame of determinism. In addition, because the majority of these articles mentioned genes in debates over whether a condition was cause by genes *or* environment, we called this sub-frame “nature-nurture”.

- It became clear that the “symbolic” articles used the gene in two different ways: Some articles used the gene as a *metaphor* for describing resemblance between non-biological items, e.g., “The new Mazda has some Ford genes”. We reclassified these into a sub-frame of the symbolic frame called “metaphoric”. The other type of symbolic articles tended to use the gene as a figure of speech to emphasize a viewpoint, e.g., excusing yourself for buying too many new clothes by saying “I have inherited a shopping gene from my mom”. We reclassified these latter articles into a new sub-frame called “rhetorical”.

- A small subset of articles mentioned the gene in the context of evolution, but in a much larger evolutionary timeframe, for example in articles about human evolution. We categorized these as a new sub-frame of the evolutionary frame, called “historical”. We simultaneously reclassified the original “evolutionary” frame as a sub-frame called "unit of selection". It still portrayed the gene in a classic Darwinian perspective, as well as including the more radical ideas of Richard Dawkins.

Stage 4:

- The "interactive" sub-frame from stage 2, which had originated from the hypothetical "gene + environment" frame, now seemed to resemble the "unit of selection" sub-frame more than it did the "relativistic" sub-frame. The "unit of selection" sub-frame was concerned with the selection of genes in response to external environmental influences, and the "interactive" sub-frame was (similarly) concerned with the expression genes in response to environmental stimuli, albeit in a more immediate context (e.g. genes' response to toxins in a cell). The "relativistic" sub-frame however did not address the environmental component in any way. We therefore moved the "interactive" sub-frame from the relativistic to the evolutionary frame. It was now regarded as a sub-frame of the evolutionary frame, together with the historical and unit of selection sub-frames. The previous relativistic sub-frame became its own frame.

For simplicity, I can summarize the final five frame categories by how they relate (or do not relate) to genetic causation:

Materialistic: gene as a physical entity (no cause)
Deterministic: gene as absolute cause for trait
Relativistic: gene as a partial cause for trait
Evolutionary: gene interacts with environment to induce effects
Symbolic: gene as symbol for cultural resemblance (non-biological)

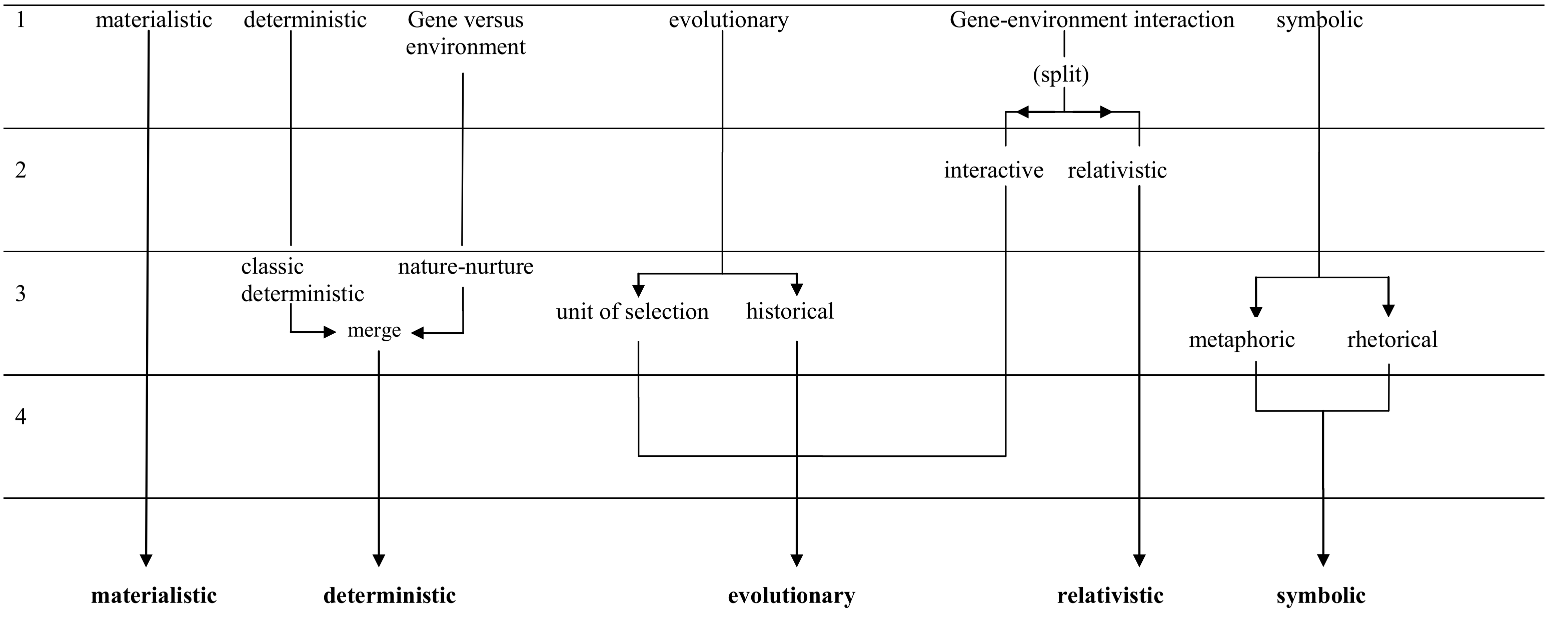

Figure 3. Evolution of the five gene frames

3.3 Paper II

In paper II, we used a deductive approach to identify and map the distribution of the five gene frames in a larger sample of international tabloid and elite newspapers. Our approach is largely quantitative because it aims to investigate the *distribution* of the five frames using the framing scheme developed in the first study. However, it also involves an element of qualitative interpretation in the process of identifying latent meaning.

3.3.1 Material

In order to identify general trends in gene framing between different types of newspapers (tabloids, mid-market, and elites) independent of possible cultural differences, we decided to analyse major national newspapers from four different countries: US and UK newspapers were included to give a broad representation the English context, whereas France and Norway represented different cultural and linguistic traditions within Europe. We also chose newspapers that were among the top ten in readership numbers in each country, excluding niche newspapers, in order to capture a sample that was as representative as possible of the type of information about genes that the majority of people receive.

Characterizing newspapers as either elite, mid-market or tabloid tends to be based on simple hunches or commonly shared knowledge within a particular society, and there are no international criteria for what exactly defines each type. However, previous research has shown that tabloids have readers with lower levels of education, income and occupational status than elites (Chan & Goldthorpe, 2007). We therefore decided to access readership survey data for each of the four countries. The only socioeconomic data that were available for all four countries included information on reader income and education. In line with previous research, which identifies reader education as the more important factor, we chose this as the primary indicator for classifying newspapers (Chan & Goldthorpe, 2007). Based on the newspapers' percentage of readers in the highest education category, we selected one elite, one mid-range and one tabloid newspaper from each country. Please see Appendix 8.1.1 for a detailed description of this selection process.

In what follows, I describe the twelve newspapers chosen for the study. For some of the newspapers, I comment on how the income and/or education of its readers compares with the general population (we include income in subsequent analyses). To make this possible, we had to make the reader income and education categories used in each survey comparable across the four countries. To do this, we calculated a factor that measures the income and education level of each newspaper's readers relative to the rest of the population. First, the categories were arranged in increasing order and described in terms of population percentiles (lowest educated as 0th percentile, highest educated as 100th percentile). For the raw data we used, please see Appendix 8.1.2.[7] We then estimated the change in readership frequency with increasing income or education using log-linear regression: The median percentile per category was used as regressor. If p_i is the percentage of readers and q_i the percentage of the population in category i, we thus used the model $\log(OR_i) \sim Q_i$ where $ORi=[p_i/(1-p_i)]/[q_i/(1-q_i)]$ and the median percentile $Qi=q_1+...+q_{i-1}+q_i/2$, and where category i was given weight q_i to account for its size. The resulting indexes, presented as "income dependency" and "education dependency" in the table in Appendix 8.1.4, represent the ratio of readership at the 100th percentile compared to the 0th percentile as estimated by the gradient of the regression curve. For example, *Le Monde* has an index for reader income of 7.9, which indicates that readers with high income read *Le Monde* roughly eight times as often as low-income readers.

UK newspapers

On an average weekday, 49.4% of the UK population (age 15+) read a daily newspaper (National Readership Survey, 2011). In Britain, it is more common than in other countries to label newspapers as either broadsheet/elite, mid-market or tabloid according to their journalistic respectability. The UK tabloid press has a notorious reputation for sensationalism, and these newspapers are often referred to as "redtop" tabloids. Whilst the newspapers we have selected clearly fall into broadsheet/elite, mid-market and tabloid categories, the UK mid-markets are more like tabloids than broadsheets. We chose the following three newspapers:

The Guardian: A centre-left liberal newspaper for the middle classes. It is one of the UKs most respected newspapers, particularly noted for its science reporting. It has a science editor and numerous science correspondents and, whilst it used to have a well-regarded weekly science supplement ("Life"), it now has a daily news section dedicated to science. It also has a weekly "Technology" supplement. *The Guardian's* dedication to science reflects

[7] The ordering of the UK education categories was not immediately obvious and we had to perform a principle component analysis to form a meaningful ordering of these categories. Please see Appendix 8.1.3 for details.

in its readership, which increases 111-fold from the lowest educated to the highest educated (see Appendix 8.2.4).

The *Daily Mail*: A middle market newspaper with a lower middle class profile and a pro-conservative orientation. It has a particular focus on female readers and publishes a weekly "Femail" supplement about body and beauty, as well as a weekly section on "Good health" featuring new treatments and health-related innovations (Newspaper Marketing Agency, 2011). It has a science editor and numerous health and science reporters. Readership does not depend strongly on education or income, although there is a slight decrease with increasing education.

The Sun: By far the largest newspaper in the UK in terms of circulation. It is most renowned for its sensationalist and opinionated style, sports and celebrities and its Page 3 girl. Whilst it does not have a science column or section, it does have a health editor and the sections "Woman" and "Dear Deidre" often report on health-related topics. It has switched between supporting Labour and Conservatives, and is perhaps best described as populist. Amongst all the newspapers in our study, *The Sun* stands out with an 8-fold decrease in readership from the lowest educated to the highest educated, although readership appears independent of income.

French newspapers

Newspapers have traditionally played an important part of cultural life in France, and the elite newspapers like *Le Monde* and *Le Figaro* have been especially important for defining social classes (Bourdieu, 1984). Though monthly newspaper editions and magazines are now selling more than daily newspapers (Maarek, 2008), 46.3% of the population (aged 15+) still read a daily newspaper (Audipresse, 2010). The distinction between elite, mid-market and tabloid newspapers is less prominent in France, and their tabloids are not as sensational in style as the British. We chose the following three newspapers:

Le Monde: A well respected "paper of record", considered obligatory reading for all of those who want to be kept up to date about politics and culture (Le, 2004). It also features a daily science section "Planète", with a science editor and numerous science journalists. Like *The Guardian,* it holds a centre-left political stance. It has traditionally been associated with the educated upper classes of society (Bourdieu, 1984), which is still strongly reflected in its readership today: Readership increases 250-fold from the lowest educated to the highest educated, making it the newspaper with the highest educated readers in our sample.

Le Figaro: One of the leading European daily newspapers and also an important part of the social and economic life of France (FACTIVA, 2009). It is the second largest national newspaper in France after *Aujourd'hui en France.* Like *Le Monde,* is has been associated with the upper-middle class, but holds a more conservative position. It has three daily sections devoted to economics: "France Politique", "Le Figaro Économie" and "Économie". It also has a daily science section "Sciences Médecine" and, like *Le Monde*, it has a science editor and numerous science correspondents. It also includes a weekly supplement with articles from *New York Times. Le Figaro'*s readership increases 50-fold from the lowest to the highest educated, and 9-fold from lowest to highest income.

Aujourd'hui en France (the national edition of *Le Parisien*): The largest national daily newspaper in France, with a focus on celebrity news and sports (FACTIVA 2009). Whilst it does not have a designated science or health section, it has a few health reporters that cover health-related news (usually appearing as "extra" material under the section "Better living" or "Fact of the day"). Its readership is virtually independent of education (near factor 1), and only increases 2.7-fold from lowest to highest income.

Norwegian newspapers

Norway has only a few newspapers with a national profile, generally based in the capital Oslo, with the three big ones being *VG, Aftenposten* and *Dagbladet*. While we have aimed to select newspapers ranging from elite to tabloid, the difference between these three newspapers is much smaller than in the other countries. Schibsted, a major publishing house in Norway, owns both *Aftenposten* and *VG*. Newspapers hold a strong position in Norway: On an average weekday in 2010, 64% of the population (age 9-79) read a newspaper. This increases to 80% if online newspapers are included, with more than 50% read at least two newspapers per day (Medienorge, 2011). We chose the following three newspapers:

Aftenposten: Traditionally Norway's leading quality newspaper, although it switched to compact (Berliner) format in 2005. It is liberal-conservative, and uses a conservative form of the Norwegian language (Riksmål). It is primarily a subscription newspaper, with less than 10% of its circulation from single-copy sale. In addition to the morning edition, it has an evening edition with a more Oslo-regional profile (published all weekdays) and a weekend magazine (Friday morning supplement). It is notable that none of the selected Norwegian newspapers have designated science and technology sections, although *Aftenposten* has a science page in a weekly supplement called "Amagasinet". There are some science journalists writing for this supplement who occasionally write larger science features. Readership (estimated from morning edition numbers) increased 9.3-fold from the lowest educated to the highest educated, much less than for elite papers from the other countries. It increased 3.8-fold from lowest to highest income.

Dagbladet: Originally affiliated with Norway's social liberal party until it declared itself politically neutral in 1977. True to its history, it remains in the political center today. Although it switched to the compact (tabloid) format in 1983, and has received criticism for being tabloid in form as well, it has maintained a somewhat academic reputation with a particular focus on culture and debate (and is a popular outlet for academics to write commentaries). Its readership however only increases 2.9-fold from the lowest to highest educated, and 3.7-fold from the lowest to highest income, which is only slightly less than *Aftenposten*.

VG (short for *Verdens Gang*): Switched to the compact (tabloid) format in 1963. Members of the Norwegian resistance established the newspaper shortly after World War II, who declared it politically and financially independent. Although still considered a tabloid newspaper in form as well as format, it is widely respected and has won prizes for investigative journalism as well as for photojournalism. The readership drops slightly with increasing education; readership amongst the highest educated is 60% of what it is amongst the lowest educated. However, it increases 1.6-fold from the lowest to the highest income percentile.

American newspapers

The U.S. has the lowest number of daily newspaper readers compared to the other countries in this study, with only 43% of the population reading a daily newspaper (Newspaper Association of America, 2008). There are only three daily newspapers that circulate nationally: *USA Today*, the business-oriented *Wall Street Journal* and the *New York Times* (Stevenson, Scott, & Shaw, 2008). Both *USA Today* and the *New York Times* are elite newspapers, although *USA today* has undergone a degree of "tabloidization" over the years to include a more eye-catching design, shorter stories, and more color and visual material (Bird, 2008). Among the national newspapers, *USA Today* is the one that most closely represents an "intermediate" category and is therefore included in our study. There are only a few daily tabloids and these are confined to local regions, the biggest being the *New York Daily News* in the New York region. We therefore did not have a national tabloid to select from, and had to make an exception to include a regional tabloid for the US newspaper sample. The most scrupulous and sensational tabloids, that might be comparable to the UK redtops in terms of journalistic quality, are known as "supermarket tabloids". These are weekly magazines and are therefore not included in our sample. We chose the following three newspapers:

The New York Times: A major quality newspaper known worldwide for its in-depth news coverage (FACTIVA 2009). It has a daily science news section, a science editor and numerous science reporters. It has won several Pulitzer Prizes for its investigative journalism, including coverage of science topics, which is reflected in its readership: It increases 70-fold from lowest to highest educated and 30-fold from lowest to highest income. Its readers therefore have the highest income levels of all the newspapers in our sample. Its political orientation leans towards the left (Democrats).

USA Today: USA's largest national newspaper. Though it has a broadsheet format, it is famous for having a simple reader-friendly style and a colourful layout. Science stories tend to appear under the section "Your Life", which has a health focus. Whilst it does not have a designated science editor, it has a number of science and health reporters. Its readership has a level of education similar to Norway's quality paper *Aftenposten*: Readership increases 9-fold from lowest to highest educated. Reader income levels are comparable to France's *Le Figaro*, also increasing roughly 9-fold from lowest to highest income.

The New York Daily News: USA's fifth largest daily newspaper. Though it covers predominantly New York City and the metropolitan area, it is USA's largest circulating tabloid newspaper. It covers extensively on sport, entertainment and gossip news, but also includes a health section. It does not however have a science or health editor, or any in-house science reporters. Its readership is independent of education, but increases 6-fold from lowest to highest income.

Selection of newspaper articles

We accessed newspaper articles through the web services *Factiva* for French, UK and US newspapers and *Atekst* for the Norwegian newspapers. In order to capture a recent context, we limited the selection of articles to three recent years of publishing (July 2005 -July 2008). We included all types of articles published in print and limited the selection to items that contained the various forms of the word gene: "*gene* OR *genes*" for British & US newspapers, "*gène* OR *gènes*" for French and "*gen* OR *gener* OR *genet* OR *genene*" for Norwegian newspapers. From the result of this search, we then randomly selected fifty gene-related articles by picking items at regular intervals (total hits divided by 50). Articles that used 'gene' only as a name, e.g. in the title of a TV programme or for the actor 'Gene Hackman', were omitted and the next article was selected.

3.3.2 Coding procedure

Based on Paper I, we developed a coding manual (codebook) that described each frame by its association with typical key words, key phrases and metaphors (see Appendix 8.1.5). We recruited four external coders based on relevant academic background (scientific) and language skills. All five coders were fluent in Norwegian and English, and two were fluent in French. They all had university degrees in scientific subjects including archaeology, psychology and biology. They were aware of our research aims and that we were interested in possible differences in the use of frames in different newspapers, but we did not inform them of any specific hypotheses (to avoid possible bias in the analysis).

For the training session, we gave the coders a presentation of the five gene frames and showed examples of how different newspaper articles used these frames. We gave the coders a copy of the coding manual and instructed them on how to identify the five frames: The main criterion for coding a frame was that at least part of a sentence or quote conveyed the overall meaning of the gene (as summarized in the column "describing the gene as" in the coding manual in Appendix 8.1.5). The sentence(s) did not have use the word 'gene' explicitly, but could also refer to it indirectly. Not all framing features presented in the framing scheme needed to be present in order to identify a frame. For "homework", the coders analysed a practice article, using the coding manual as an aid. I gave them feedback at a follow-up meeting, where we discussed and clarified the meaning of the five frames.

Previous research has indicated that there can be several different frames in a single article (Matthes & Kohring, 2008; Petersen, 2001), which we also observed in Paper I. Often, the title reflects a different frame than the actual content (Condit et al., 2001). Coding for just the main frame can therefore ignore nuances in the text (Matthes & Kohring, 2008). To avoid 'forcing' the article into one frame category only, the coders were instructed to code up to three frames in an article and to rank them according to salience (prominence): The primary (dominant) frame carries the dominant or "preferred" meaning, and often appears in the title or early in the article. The secondary frame is less obvious and typically appears further into the text, either supporting the dominant frame or providing some journalistic balance. The tertiary frame has a similar function but is even less obvious.

We distributed the 600 articles among the coders, including myself, according to language skills. In order to visualize the coding, we also instructed the coders to highlight the parts of each article that accentuated a particular frame using a colour-coding scheme (similar to the colours used in Figure 4 in section 4.2). Doing so made it easier to recognize which frames were present, and to determine their order. We did not analyse the frames conveyed in images because the articles in the databases were text-based only.

In addition to coding for the five gene frames, we coded for the type of author, type of article, and topic. The coding results for each article were recorded in a coding sheet (see Appendix 8.1.6 for details).

3.3.3 Data analysis

Data preparation

In order to account for the presence of multiple frames within an article, we weighted the frames based on their salience. The secondary frame was weighted by half the value of the primary frame, and the tertiary frame was weighted by half the value of the secondary frame. Articles coded with two frames were therefore weighted as 2/3 belonging to the primary frame and 1/3 belonging to secondary frame; if three frames were coded, the article was counted as 4/7 belonging to the primary frame, 2/7 to the secondary frame and 1/7 to the tertiary frame. For each newspaper, we then computed the percentage of articles in each frame, which we call the “frame usage”. We acknowledge that assigning pre-determined weights to frames may seem somewhat artificial, especially in cases where the prominence of two frames is similar and difficult to judge. Alternatively, we could have asked coders to assign each frame a percentage presence (between 0 and 100), but we judged that to be more complicated and less reliable than asking them to provide an ordered list of frames.

Variables

Table 2 displays an overview of the dependent and independent variables considered in this study.

Table 2: Variables considered in study II

Dependent variable	**Frame usage**
Main independent variables	Reader income Reader education
Other independent variables	Type of author Type of topic Type of article

Statistical tests

The relationship between frame usage and reader income and education was analysed using Spearman correlations (n=12). We chose Spearman (rather than for example Pearson) in order to neutralize the effect of extreme values or large variances.

Whilst the frame usage captures the prominence of the five frames within our sample of gene-related articles, the above analysis does not take into account how frequent gene-related articles actually are in each newspaper as a whole. We decided to conduct an additional test: Based on our procedure for selecting articles, we estimated the total number of gene-related articles in each newspaper (please see Appendix 8.1.7 for details). This estimate was subsequently multiplied by the frame usage to obtain the overall percentage of each frame. As above, we then analysed for correlations with reader income and education. See Table 4 in the Results section 4.2 for a comparison of the results of these two tests.

The frequency of author types, article types, and topics in each newspaper were also analysed for correlation to reader income and education using Spearman correlations (n=12).[7] We used simple descriptive statistics to show the frame usage across the different types of authors, articles and topics.

[7] Some of the original categories in the coding manual were collapsed because they had too few cases: For author type, "member of public", "politician" and "other" were collapsed into "Other"; for topic, "politics" and "other" were collapsed into "Other"; for article type, "commentary by reader" and "commentary/column by journalist" were collapsed into "Commentary".

Inter-coder agreement

In order to assess inter-coder agreement, a random subset (44%) of the articles was re-coded by a different coder. For each doubly coded article, we used Cohen's kappa to calculate the agreement between coders, taking both the presence of frames and their order of salience into account. Full agreement thus implied that the two coders had coded the same frames in the same order, whereas the same frames coded with a different order resulted in partial agreement. Please see Appendix 8.1.8 for details.

The overall inter-coder agreement was 74% (kappa=0.64). To help understand and interpret the level of agreement and disagreement between the individual frames, we also present a table with the agreement for the dominant frame only (see the second table in Appendix 8.1.8). The symbolic frame stood out with the highest level of agreement between coders (94%), whereas the deterministic frame had the lowest (56%). The most common disagreement was between the deterministic and the materialistic frame.

3.4 Paper III

3.4.1 Overview

In this study we designed, tested and evaluated a teaching program in which upper secondary school students explored the meaning of the gene concept though systematic frame analysis of newspaper articles. The study therefore presents a practical application of the results in the first two papers.

Context

We conducted the study at an upper secondary school (for ages 17 to 19) in a sub-urban district of Oslo, Norway. The school has undergone a noticeable transformation during the past decade: Ten years ago, it was one of the least popular schools in Oslo, with serious social problems, high dropout rate and low grades. Today it is one of the most popular schools in the Oslo region, and enrols students with the highest grade point entry scores (at age 16) in Norway. It also has one of the best attendance rates in Oslo. Its success stems from a shift in pedagogical approach: The school now focuses on collaborative learning and close mentoring of both students and teachers, with extensive feedback throughout the year.

The school is currently being rebuilt and will by 2014 be physically integrated within an innovation park comprising a specialist cancer hospital, university research departments, and leading biotech companies within the field of cancer research (at the time of this study the school was in its original building). The overall aim of this collaboration is to bridge connections between school education, research and industry, in order to enhance student learning and strengthen the recruitment to life science. In this context, the school encourages projects like this study that foster interaction between university researchers, teachers and students.

Design

Because we were interested in the students' learning outcomes from the program, we chose a pretest-posttest design to assess what perceptions they had about genes before and after. To help design the teaching program, we tested out some preliminary ideas in another biology class prior to the study reported in Paper III. I call this a "pre-study", since the program reported in Paper III is essentially also a pilot. Due to space limitation, this "pre-study" was not mentioned in Paper III, but to give the full context and to make it clear why we made particular choices, I wish to describe the pre-study here.

Pre-study

Participants. A biology class with twenty-five students in their final year participated (18-19 years old, the equivalent of the last year of A-levels or the International Baccalaureate).

Procedure. The activity took place over six 45-minute long lessons at the end of the genetics syllabus. I myself carried out the activity in the classroom, and their teacher was present as observer. I had designed the activity in collaboration with my supervisor and the students' teacher. The first lesson began with a PowerPoint presentation of the five gene frames, showing examples from newspaper articles. The second lesson involved a series of classroom exercises where students were taught how to identify gene frames in a selection of newspaper articles using our framing scheme (for details of how students identified frames, see the explanation in section 3.4.3 below). In lesson three we split the class into five groups, assigning each group to a different topic in the genetics syllabus (GMO, diabetes, ageing, human evolution and lung cancer). Each person within each group received the same four texts on their topic: Two different newspaper articles, a passage from a textbook and a scientific abstract. The students coded each article at home and then compared their homework with the others in the group at the next lesson. In the last three lessons, each group prepared and delivered an oral presentation, explaining the different frames they found in their texts with examples, and what they had learned about the particular topic.

For measuring the impact of the activity on the students' understanding of media framing and of the gene concept, the students filled out a paper and pencil test before and after the activity. We based the questions on a newspaper article reporting on a gene discovery, and included both multiple choice and open-ended questions (we used a different newspaper article in the pre-test and post-test, yet with a similar format).

Result. Comparing the students' answers in the pre-test and post-test, we found some evidence that they had gained awareness of framing, but it was difficult to assess what they had learned about genes from the questions asked. It was difficult to construct questions for the paper and pencil test without probing for obvious answers. I also felt that the teaching style had come across as too authoritative and did not seem to engage the students adequately. Whilst the main classroom group work seemed engaging, it did not produce any written artefacts that could be analysed, so it was difficult to assess what they had learned from the group activity.

Conclusion. We decided to make several changes to both the teaching style, and how the activity was evaluated: To improve the teaching style, we decided it would be better to introduce the concept of framing and the five gene frames in a more interactive manner. In order to capture the students' free associations about genes beyond the limits of a questionnaire, we decided to use word association maps (simple brainstorms of the word gene) instead of a predefined question and answer test. We also opted to conduct a focus group before and after the activity to explore the students' understanding of genes in relation to the topics covered in the articles, and to uncover the reasoning behind their written remarks. We also redesigned the group activity so that it would produce written artefacts that could be evaluated.

The texts used in the pilot group work included scientific abstracts, which were in English. We had included these in order to show the students the differences between mass media reports and scientific reports on the same issue. However, the comparison between different genres was not within the scope of our goals, and the students found this very challenging. We therefore chose to focus exclusively on newspaper texts for the main teaching program as described in the next sections.

3.4.2 Participants

Thirty-four students (16 girls and 18 boys) participated in the study reported in Paper III. The students were in their final year of Norwegian upper secondary school, equivalent of the last year of A-levels or International Baccalaureate. They were from two parallel biology classes that were taught together for the purpose of this exercise. The classes had two different teachers that regularly conferred with each other on teaching methods and activities. One of the teachers served as our main contact person throughout the project, whom we also interviewed after the program.

Prior to the project, the teachers asked the students to volunteer for a focus group. Two girls and three boys were recruited and received a letter that outlined the study and presented the dates, times and activities they would be expected to attend. They were asked to sign a form of consent, declaring their agreement to attend both interviews. One of the boys withdrew from the group. The names of four focus group participants have been anonymised following the guidelines of the Norwegian Social Science Data Services.

3.4.3 The teaching program

Materials

The gene framing scheme. Based on the framing scheme previously developed by Carver et al. (2008), we developed a slightly more simplified scheme for the students. We also assigned a different colour to each frame and equipped the students with highlighting pens in corresponding colours. As described in further detail below, these pens were used to highlight the framing devices (words and phrases) that accentuated the different frames in a selection of newspaper articles. Each article thus became a colour map, which presented the students framing in a visual manner.

Newspaper articles. The criteria for choosing articles for analysis were 1) that the article clearly demonstrated the use of one or more of the five frames and 2) that the topic of the article was related to their biology curriculum. We chose news stories from both tabloid and broadsheet (elite) newspapers in order to provide some variety in article style and level of complexity. One set of articles (Collection I) was used for the initial classroom exercises; a second set (Collection II) consisted of four articles that were used for the subsequent homework and group work. The topics in Collection II included 1) intelligence, 2) genetic modification, 3) lung cancer and 4) obesity. The dominant frame of these articles was: 1) the evolutionary frame, 2) the materialistic frame, 3) relativistic and 4) deterministic frame, respectively. Collection II did not include an article with the symbolic frame, as this is generally non-scientific and therefore deemed irrelevant for the genetics curriculum. The students received a Word document with text-only versions of all the articles.

Reference coding. We colour-coded all the articles to provide a reference guide for teachers and students.

Word association maps. Before and after the program the students were asked to fill out a “word association map” (WAM) concerning the gene concept. The WAM consisted of an A3 sheet of paper with the word “genes” written in the middle, surrounded by two levels of empty boxes (30 in total). It contained the following instructions: “First, write down with words or short phrases whatever you associate with the word “genes” in the red circles. Use the blue circles extending from these to explain what you mean by the association. Think freely; there are no right or wrong answers.” For a picture of this, please see Appendix 8.2.1.

Lesson plan

We placed the teaching program at the end of the conventional teaching in genetics so that the students already had a basic understanding of genes with which we could build upon. The program took place on a Tuesday and Thursday in the same week (1.5 hours each time). I myself conducted all of the lessons, and the two teachers were present as observers (they did not intervene unless to maintain order in the classroom).

Day one:

1) Brainstorming session: I introduced the research project and asked the students to fill in the WAMs, individually. The completed WAMs were then collected, and I opened for a plenary discussion of the question; what is a gene?

2) Presenting the gene framing scheme: Building on the gene discussion, I gave a 25-minute interactive PowerPoint presentation about the five gene frames. For each frame, I showed the students an excerpt from a newspaper article and asked for comments about how the gene concept was portrayed, before showing them the framing devices corresponding to the particular frame.

3) Classroom exercise: The students were given Collection I of articles as well as a handout of the colour-coded framing scheme and a set of highlighting pens. They were then asked to identify the different frames by highlighting the relevant framing devices in the corresponding colour. I explained that not all framing devices needed to be present to identify a frame, and that the same article could contain more than one frame. In order to promote reflections, the students were encouraged to confer with the students they were sitting next to.

4) Plenary discussion: I asked the students how they had coded each article, before showing the reference coding of the same articles. Any differences in coding were discussed in relation to the framing scheme. The lesson ended with a description of their homework.

5) Homework: Each student received article Collection II and a short handout with instructions to code the four articles in line with the framing scheme and bring them to the next session.

Day two:

1) Recap of the gene framing scheme: The lesson began with a ten minute re-cap and brief discussion about the five gene frames.

2) Group work: The students were organized in nine groups of four. They were instructed to compare homework and come to an agreement regarding which frames were present in each article. In articles with more than one frame, they were asked to agree on which frames they regarded as the dominant, the secondary or the tertiary frame. They then coded a consensus version of each article, which was mounted on the blackboard next to the reference guide. By visually comparing the colour coding, it was thus easy to identify differences between the group works and the references guide.

3) Plenary discussion: The display of articles on the blackboard was used to spur a discussion about the different gene frames. I asked the groups about their particular choices of frames, pointing out interesting differences and asking them to explain these. I then initiated a general discussion about the implications of media framing.

3.4.4 Method of evaluation

The learning outcomes of the program were analysed using four different methods of analysis.

Evaluation of students' frame analysis

The results of the students' group work (Day two) were compared with the reference coding. The degree of similarity was used as a measure of the students' general understanding of media framing, as well as, their specific ability to identify the five frames. We also took notice of and evaluated the discussion that followed the group work.

Evaluation of WAMs

The WAMs were used as a brainstorming exercise at the beginning of the program, which was repeated for evaluation purposes four days after the program had finished. All of the entries in the WAMs were analysed for words, depictions and phrases related to the five gene frames. Entries that could not be related to any of the five frames were discounted. We compared the number of boxes representing each frame in the pre- and post-test WAMs from the students who were present at all sessions (n=17). We also made a qualitative comparison of the types of frames used in the pre- and post-test WAMs. The observed differences were used as an indicator of any change in the students' awareness and orientation towards different frames before and after the program.

Focus group interviews

Semi-structured focus group interviews were performed following standard guidelines by Krueger and Casey (2009). I myself organized and conducted a focus group interview with the same four students before and after the program. The interviews were structured around the four questions: 1) How do you define a gene? 2) How important do you think genes are for the development of diseases later in life? 3) If you read a headline "scientists have found the lung cancer gene", what does this make you think? 4) Imagine you took a gene test and found out you had "the diabetes gene", how would you react? In the first interview, I used the students' own WAMs (their free association to the word gene) as a point of entry for discussion. In the second interview, I also asked the students to tell me what they thought about the program and what they felt they had learned.

Both pre- and post interviews lasted about 30 minutes and were recorded using a digital audio recorder. I transcribed and analysed them with particular attention to the students' perspectives of the gene concept before and after the teaching program.

Teacher Interview

I also interviewed the main teacher about six months after the intervention. I conducted the interview at the end of the school year so that the teacher could regard the program in context of the whole biology curriculum. The interview lasted 45 minutes and was recorded with a hand-held digital audio recorder. I then transcribed and evaluated the interview, paying special attention to the teacher's opinion of how the program had affected the students' understanding of genetics.

4. Summary of results

4.1 Paper I

The aim of this exploratory study was to identify and describe the gene frames present in Norwegian and British national newspapers. Using an inductive frame analysis, we identified and named the following five distinct gene frames:

1. The *materialistic* frame presents the gene as a discrete physical unit. Key words include DNA, code, protein, identify, locate, isolate, transfer, specific.
2. The *deterministic* frame presents the gene as a definite causal agent for all biological characteristics, separate from environmental factors. Key words and phrases include "gene for", cause, control, culprit, blame, "responsible for" and "wired in genes".
3. The *relativistic* frame presents the gene as a partial predisposing factor involved in the development of biological traits. Key words include risk, chance, factor, association, susceptible, link, contribute, influence, "play a part in", "genes are involved".
4. The *evolutionary* frame presents the gene as a dynamic factor that interacts with internal or external environmental factors. Key words include interact, capacity, adapt, external influence, environment, change, evolve, evolution, replicate, reproduce, "depends on", "in combination with", "affected by", "triggered by".
5. The *symbolic* frame presents the gene as an abstract representation of inheritance, often used in a casual and unscientific manner e.g. "I must have inherited a taste for fashion", or as metaphors for non-biological information transfer, e.g. "Mazda has got Ford genes".

We produced a framing scheme with details of the framing devices associated with each frame, as shown in Table 3.

Table 3: The Gene Framing Scheme

Gene frame	Sub-frame	Describing the gene as	Key words, phrases & metaphors
Materialistic	–	A discrete physical unit	DNA, chromosome, identify, locate, isolate, deliver, transfer, specific, replace, inject, discover, code, protein, mutation. Metaphors: alphabet, book, map, code.
Deterministic	Classic	A definite causal agent	Gene for, cause, control, culprit, blame, disease-gene, responsible for, gene for, wired in genes, born with. Metaphors: computer program, recipe/instruction manual.
	Gene vs. environment	Contrary to environmental factors	Genes or environment, not down to our genes, genetic, environmental.
Relativistic	–	A predisposing factor	Risk, chance, factor, associated with, susceptible to, linked to, contribute, predispose, interfere, influence, play a part in, genes are involved
Evolutionary	Unit of selection	The central object of evolution	Being selected, make copies, replicate, reproduce, through generations, adapt, maladaptive. Metaphor: the selfish gene.
	Historical	A marker for evolutionary stage	Evolve, evolutionary relatedness, conserve, diversity, development, DNA record, gene bank, marker, extinction, change.
	Interactive	Interacting with the environment	Interact, complexity, dynamic, capacity, external influence, environment, depends on, in combination with, affected by, expression, triggered by, prevent, respond, turn on/off. Metaphor: like a switch or tap.
Symbolic	Rhetorical	An abstract representations of inheritance	It must be in the genes, good genes, gene pool, inherit, talent, “I inherited a shopping gene”.
	Metaphoric	A metaphor for information transfer	E.g. Mazda got “Ford genes”.

4.2 Paper II

The aim of this study was to find out whether newspapers catering for different audiences (with different socioeconomic status) frame the gene differently. Since the media has been widely criticized for promoting genetic determinism, and this tendency has been related to tabloid style reporting (Hubbard & Wald, 1993; Nelkin & Lindee, 2004), we hypothesized that the deterministic frame would be more common in newspapers with readers of low socioeconomic status (SES) than in newspapers with readers of high SES. On the contrary, we found no association between the deterministic frame and the SES of newspaper readers. Other key results were as follows:

- Newspapers with readers of high SES tended to write about genes in an evolutionary and materialistic perspective. This tendency remained for the evolutionary frame when adjusting for the total amount of gene-related articles in a newspaper (compare the two main columns in Table 4 below). Reader education was more strongly correlated than income.
- Newspapers with readers of low SES tended to write about genes with a symbolic frame, though this tendency disappeared when adjusting for the total amount of gene-related articles. Again, reader education was more strongly correlated than income.

Table 4: Spearman correlations: Frame usage versus reader education and income

Correlation	**Frame usage**		**Total amount**	
(P value)	**Education**	**Income**	**Education**	**Income**
Gene articles			0.441 (p=0.15)	0.308 (p=0.33)
Evolutionary	0.699 (p=0.011)	0.517 (p=0.085)	0.643 (p=0.024)	0.483 (p=0.11)
Materialistic	0.692 (p=0.013)	0.615 (p=0.033)	0.510 (p=0.090)	0.399 (p=0.20)
Relativistic	-0.189 (p=0.56)	-0.154 (p=0.63)	0.049 (p=0.88)	0.021 (p=0.95)
Deterministic	-0.161 (p=0.62)	-0.427 (p=0.17)	0.427 (p=0.17)	0.175 (p=0.59)
Symbolic	-0.811 (p=0.0014)	-0.664 (p=0.018)	-0.049 (p=0.88)	0.175 (p=0.59)

Note: The education and income dependency of each newspaper was correlated with: 1) the frame usage, i.e. the proportion of sampled articles coded in each frame; 2) the total portion of gene-related articles, i.e. the portion of all articles in each newspaper, in all and per frame.

Figure 4 below visualizes the distribution of gene frames according to the SES of the newspapers' readers and the total amount of gene-related articles in each newspaper. For the exact percentages of frame usage per newspaper, please see the descriptive statistics in Appendix 8.1.4.

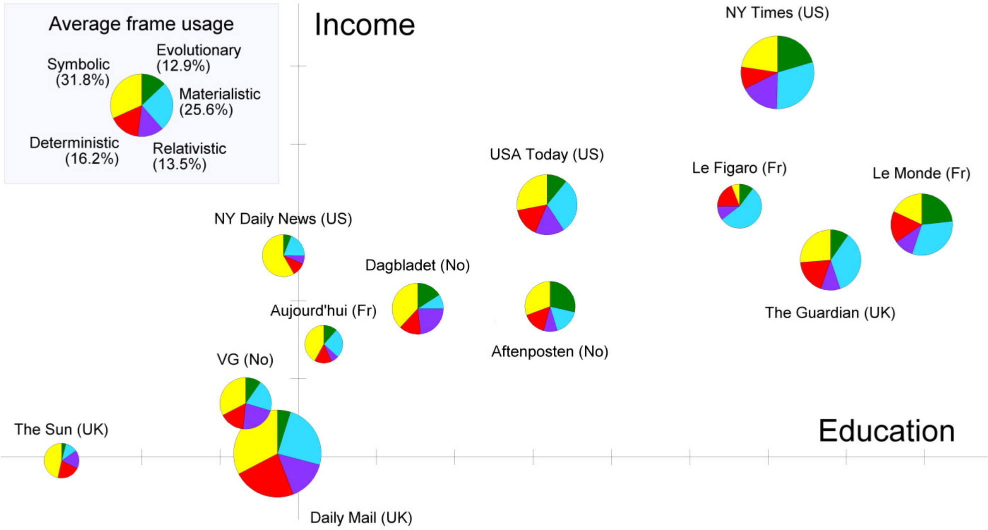

Figure 4. The upper left pie chart represents the use of the five gene frames in the total material of gene-related articles (n=600). The other pie charts represent the frame usage in the individual newspapers. The size of the pie chart represents the estimated percentage of gene-related articles in the newspaper; newspapers that have many gene-related articles have large charts, those that have few, have small charts. The area of each sector thereby corresponds to the estimated percentage of all articles in a newspaper that uses the particular gene frame. Newspapers are organized according to the socioeconomic status of their readers as measured by level of education and income; low status tabloids at the bottom-left, high status elite newspapers at the top-right. At the axis origin, readership depends on neither income nor education. Each tick on the axes represents a doubling in how much readership changes with education and income, respectively (see Section 3.3.1 for further explanation).

We also investigated the correlation between reader socioeconomic status and the percentage of each type of author, topic and article. For education (the more important variable), we found that:

- The elite newspapers had more articles written by science journalists (corr=0.64, p = 0.024) and scientific experts (corr=0.67, p =0.017), and fewer articles written by general journalists (corr = -0.76, p = 0.0045).
- Elite newspapers had more gene-related articles specifically concerning genetics (corr=0.74, p=0.006) and less concerning culture and society (corr=-0.56, p=0.06).
- The elite newspapers had a slight overrepresentation of commentaries, although this was not significant (corr=0.55, p=0.06).

Next, we explored the relationship between frame usage and the different types of authors, topics and articles. Figures 5, 6 and 7 show the frame distribution among these. For the specific percentages of frame usage, please see Appendix 8.1.9. Most notably, we found that:

- The symbolic frame was clearly overrepresented in articles concerned with Culture & Society (73.3% versus 31.8% in the sample overall) and with Sports & Cars (83.6% vs. 31.8%). It was seldom used by science journalists or scientific experts and was usually in the format of interview articles.
- The materialistic frame was overrepresented in articles about Genetics and General Science, and was most common in articles written by science journalists. It was also overrepresented in News & Briefs.
- The evolutionary frame was most common in articles written by scientific experts and was usually in the format of commentaries.

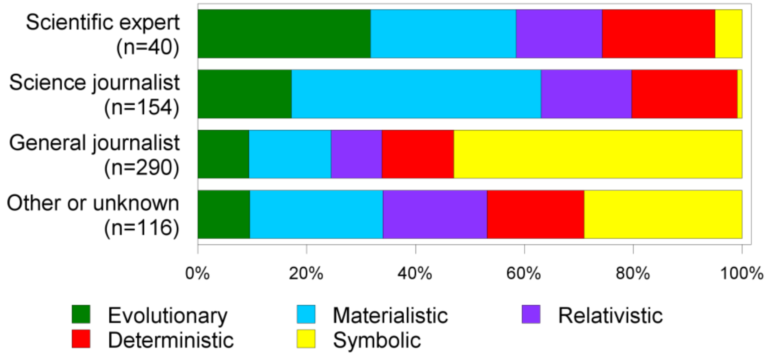

Figure 5. Frame usage (%) related to author type

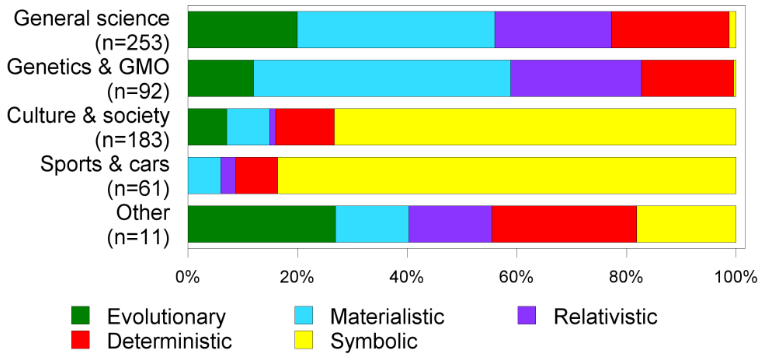

Figure 6. Frame usage (%) related to topic

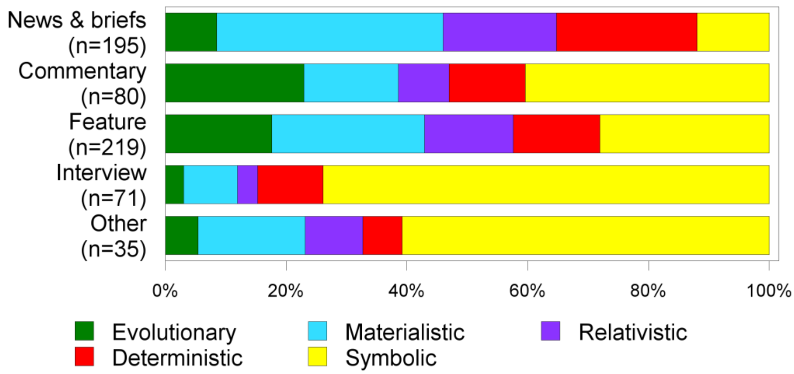

Figure 7. Frame usage (%) related to article type.

4.3 Paper III

In this study, we piloted and evaluated a teaching program where upper secondary school science students used our colour-coded framing scheme as a tool for systematic analysis of gene-related information in the media. The aim of this study was to investigate: (1) if the students were able to grasp the concept of media framing and recognize the five different gene frames in the presented media reports and (2) if the teaching program influenced their general understanding of the gene concept. In response to the first aim we found that:

- Results from the classroom group work showed that the students were able to identify the gene frames in newspaper texts with a high degree of accuracy. The classroom discussions and the post-test focus group interview also showed that they understood the meaning of the five frames.

In response to the second aim, we found that:

- The post-test word association maps and focus group interview showed a general shift from a (simple) deterministic to a more dynamic evolutionary understanding of gene-environment interaction.
- The teacher also believed the program had improved their understanding of gene-environment interaction, particularly in relation to the inheritance of common diseases.

In addition, the post-test interview revealed that the program had enhanced the students' general media literacy skills:

- The students had become more critical of various claims in the media, particularly of the deterministic frame.

5. Discussion

5.1 Reflections on methods

5.1.1 Reliability

Reliability refers to the likelihood that repeating the same procedure would generate nearly the same result (Priest, 2010). If, for example, the frame categories mean entirely different things to the different coders, the results would lack reliability. In Paper II for instance, the correct identification of frames rests on the assumption that all coders have the same understanding of what each frame means. One way of checking this is to have a portion of the material coded by two different coders and to calculate inter-coder agreement, which we did in Paper II. The overall inter-coder agreement is also a "test" for the reliability of the framing scheme (Paper I), since the level of agreement depends largely on the robustness of the frame categories and how easily they are to identify.

We found that the overall percentage agreement among the five coders was 74%, with a Cohen's Kappa score of 0.64. The Kappa score was lower than the percentage score because Kappa is a more conservative measure and takes into account agreement that occurs simply by chance. Kappa values range from 0 to 1 and there is considerable dispute in the literature over what counts as a good kappa value. For instance, Landis and Koch (1977) characterize values less than 0 as indicating no agreement, 0–0.2 as slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1 as almost perfect agreement. Downe-Wamboldt (1992) on the other hand considers a kappa of 0.8 to 0.9 the desired level, with 0.7 being the minimum standard. I therefore consider our kappa score of 0.64 as representing something in-between "substantial" and "below minimum standard" level of agreement: I consider it satisfactory.

The agreements between specific pairs of frames (displayed in Appendix 8.1.8) show some variation. There is for example a particularly high agreement for the symbolic frame (94% agreement for the dominant frame), which indicates that the coders found this frame easy to distinguish. The symbolic frame occurred most often in articles about sports, cars, culture or society, and tended to occur as the only frame in an article. This therefore indicates that the symbolic and deterministic frames occur in very different contexts, and strengthens our separation of the symbolic from the deterministic frame.

There was least agreement for the deterministic frame however (56% for dominant frame), and coders had particular difficulty distinguishing the deterministic from the materialistic frame. In an attempt to explain why this might be so, we wondered whether this was largely a result of the coders coding both frames in an article but assigning them different prominence. However, there were only four articles containing both the deterministic and the materialistic frame and where coders had ranked them differently. Most of the disagreement was in articles with just one frame, where the first coder had chosen the materialistic frame and the second coder has chosen the deterministic frame. We took an extra look at some of these articles and found that in most of them the phrases they had coded actually contained elements of both the materialistic and the deterministic frame, and were therefore slightly ambiguous. Here are some examples, where I have indicated which part of the sentence reflects a materialistic [MAT] and deterministic [DET] frame:

- “The blood test identifies the genes [MAT] that are active after Alzheimer's disease has broken out.” [DET]
- “By manipulating the genes [MAT] the body will produce substances that can improve performance” [DET]
- “Scientists have developed a genetic test [MAT] to detect colorectal cancer” [DET]
- “Progeria is not genetic and could not be "passed on" [MAT] to our children. It is, in fact, caused by [DET] an extremely rare gene mutation during conception.”

For such articles, the coders have chosen one of the two frames to represent the sentence/article. Since in most of these cases both frames could be detected, and are equally prominent, there is therefore a 50 % chance they will chose a different frame. This could therefore be a factor affecting the agreement between the deterministic and materialistic frame. This also brings to attention the general problem of weighting the frames in articles with more than one frame. In cases where it has been difficult to judge which of two frames is more salient, or if one frame is only slightly more salient than another is, it might be unfair to say that one is “twice” as prominent as the other. As mentioned in section 3.3.3, an alternative way of doing this could have been for the coder to decide on a percentage prominence (salience) of each frame ranging from 0 to 100 %, but we judged that to be more complicated and less reliable than asking them to provide an ordered list of frames.

Are the materialistic and deterministic frames so similar that we should have collapsed them into a single category? Whilst doing so might have increased inter-coder agreement, we do not think this would be a good idea because it would gloss over an important aspect of the meaning of the gene—namely, that the materialistic frame accounts for what genes *are* (structure), whilst the deterministic frame accounts for what genes *do* (function). This reflects an important demarcation in how we understand the gene, because it clarifies when we talk about molecular/physical structures as opposed to biological function. The difference may however be quite subtle and therefore difficult to detect, especially for coders not trained in biology.

The coders we used in Paper II all had scientific backgrounds, but in different fields (biology, psychology, archaeology). Whilst I myself did most of the coding in Paper I, parts of the material was also analysed by my supervisor who has a different background (medicine). Each coder's personal values, viewpoints and previous knowledge would no doubt have influenced how they interpreted each text (Jarman & McClune 2007). This is unavoidable in all research involving subjective interpretation and is largely beyond our control. I nevertheless argue that a certain degree of variation in coders' backgrounds is necessary to ensure a good balance in the interpretations, in order to minimize the risk of coder bias (e.g. repeatedly coding something in a peculiar way).

In Paper III, an important limitation concerns the researcher perspective. Since both my supervisor and I were involved in the development and evaluation of the framing scheme (Paper I and II), the study was generally motivated by this background (we were naturally interested in seeing that the teaching program had a beneficial effect). Moreover, I also acted as the facilitator of the teaching program, and I had little prior experience in teaching. Combined, the researcher perspective thus implies a bias in the implementation as well as the evaluation of the program. A more ideal research context would be that a teacher facilitated the implementation of an independently developed program while the researchers observed and evaluated. However, given that the aim of this study was to implement, test and explore a conceptually new teaching method, we believe that my active participation was both necessary and valuable for the implementation of the intervention.

5.1.2 Validity

Validity refers to whether you are measuring what you think you are measuring (Priest, 2010). A study with high reliability does not necessarily guarantee valid data (Van Gorp, 2005). For example, restricting a frame analysis to simply counting keywords or answering specific questions in order to identify each frame would increase the likelihood that different researchers categorize the data similarly, but they might also miss the implicit (latent) meaning of the text. In such cases, the data would not necessarily represent the frame. On the other hand, as McQuail (2005, p. 364) has pointed out, “The more one relaxes requirements of reliability, the easier it is to introduce categories and variables that will be useful for interpretation but ‘low’ in ‘objectivity’ and somewhat ambiguous” (original emphasis). To ensure that the frames identified in texts are meaningful representations of reality, the coding approach therefore has to strike a fine balance between adhering to pre-determined criteria for identifying categories and allowing for some contextual interpretation.

Did our coding approach produce valid results? In Paper I and II, we do not specify a stringent set of criteria for coding each frame; rather, we base it on the overall depiction (latent meaning) of the gene conveyed. Potter and Levine-Donnerstein (1999) note that for identifying latent content like this, the coders must provide subjective interpretations based on their own mental schema. However, we considered this the most appropriate way to identify the subtle features of each frame. Our framing scheme (Table 3 in section 4.1) contains examples of common features associated with each frame, yet allows the coders the freedom to consider other words, phrases or metaphors that might also contribute to the same depiction/meaning of a frame. I therefore recommend others to use the framing scheme as a *guide,* not a protocol for identifying frames. If we had attempted to include in our framing scheme every single framing device that we came across during the analyses, this would have resulted in a very large, unsystematic and overwhelming framing scheme.

I can also question the validity of the frame categories. The deterministic frame for instance includes claims that are outright misleading as well as those that are more scientifically correct. For example, most people would agree that the headline “Fat? It’s in your genes” is misleading, but the following statement is probably considered reasonable: “Cystic fibrosis, which afflicts about 30,000 Americans, is caused by a defect in a gene that controls the amount of salt and water that line the airways of the lungs”. Critics of genetic determinism in the media have tended not to make distinctions between such statements, though Condit et al. (1998) have suggested that a measure of the degree to which popular discourse makes such differentiation could be an important tool. This is because it can give an indication as to the level of sophistication a media outlet shows about genetic causation. Splitting the deterministic frame into two subframes—e.g. “misleading” or “deceptive” determinism and “reasonable” determinism—could therefore be considered in future studies using our scheme.

I expect that our separation of the symbolic from the deterministic frame presents the most questionable categorization in our framing scheme, since these two representations have mostly been considered as one and the same (deterministic/genetic essentialism) for almost thirty years in the literature. Most notably, Nelkin & Lindee (1995 and 2004) categorized symbolic and deterministic representations together as “genetic essentialism”. However, based on our finding that the symbolic and deterministic frames are easily distinguished, we argue that future studies of genetic discourse should take account of this distinction. We believe that symbolic phrases like “Mazda has many Ford genes” or “I have inherited the shopping gene from my Mom” entail very different meanings to the gene concept than a deterministic statement like “Researchers have found the gene for breast cancer”. The rhetorical sub-frame however, exemplified by statements such as “I must have inherited an Elvis-loving gene”, might resemble the deterministic frame more closely. Nevertheless, whilst this example uses the gene to explain a certain type of music preference, we expect that most people would probably agree that the preference is actually a result of culture, not genetics (although we cannot know exactly how readers mentally interpret such claims).

The coding scheme also made a categorical distinction between a relativistic frame, which presents the gene as a contributing factor, and an evolutionary frame, which presents it in dynamic interaction with the environment. This distinction may appear subtle, but was supported by the inter-coder agreement for these frames (see Appendix 8.1.8). Moreover, we found no correlation between the relativistic frame and socioeconomic status, whereas the evolutionary frame was significantly overrepresented in the elite newspapers. Our results thus emphasize the distinction between these two frames and support the validity of the coding scheme.

5.1.3 Generalizability

The aim of most research is to produce information that can be shared and applied beyond a particular study setting (Malterud, 2001). Can we, for example, assume that the five gene frames are present in the same form and proportion in national newspapers in other countries? The fact that we chose newspapers from different countries and different languages in Paper I and Paper II, and that we found associations between gene framing and SES across all countries in Paper II, gives some indication that the trends in gene framing occur independent of cultural or language traditions. However, we confined ourselves to the "West" in terms of media and culture, so we cannot know if these five gene frames are present in very different cultures, such as in the Asian or African media.

Perhaps the greatest limitation in Paper II is that we had only twelve newspapers (with 50 articles in each). This represents only twelve points in the graph (Figure 4 in Section 4.2) on which we base most of our statistical analyses. This is a relatively small number of data points, which limited the types of statistical analyses we could apply. The main reason for limiting ourselves to only twelve newspapers (600 articles) was that we had chosen a manual coding approach, which requires in-depth analysis of each article. Analyzing 600 articles qualitatively involves a large amount of work and represents an upper limit to manual framing studies. In addition, when designing the study, I had not anticipated carrying out the advanced statistical tests that we did. In hindsight, I should have decided at the onset which statistical tests we would use, and then designed the study in direct relation to this.

An obvious limitation in Paper III is that it involves a relatively small number of students in one specific school. We cannot know whether the teaching program will work in less privileged schools, or in other countries. We nevertheless argue that as a *trial*-teaching program, the relatively small number of students is acceptable. However, the context of the school —situated within an innovation park—may be so unique that it cannot be directly comparable elsewhere. The students in this school also achieve marks that are above average in Norway. There is therefore a possibility that lower-achieving students or schools would find the activity more challenging. Still, students who choose higher-level biology are overall a selected group, with particular motivations and competence in the field. Compared to other higher-level biology students, these participants, their thoughts and achievements, may therefore be quite representative.

Whilst the whole of this thesis has confined itself to the gene concept, I expect that the approaches and ideas that my co-authors and I have introduced can be transferred to other topics. Since other scientific topics and concepts have been found to be framed in different ways (Nisbet & Mooney, 2007), I expect that they also will be associated with different types of newspapers. In addition, if certain topics have a strong political connection—such as climate change—then the political orientation of the newspapers may also be an important factor. Similarly in schools, I expect that it is possible to design teaching programs that look at the media's framing of other scientific concepts or issues, using other framing schemes.

5.2 Implications of main findings

5.2.1 Specific comments to the Papers

The gene framing scheme

Paper I has shown that there is more diversity in gene representations than previous studies have suggested. Our framing scheme describes five distinct gene frames, three of which are "new" in the media studies literature; the evolutionary, the relativistic and the materialistic frame. The materialistic frame resembles much of what we see in classic scientific discourse. The evolutionary gene frame to some extent overlaps the "gene-environment interaction" frame proposed by Condit (2007), but also includes references to Darwinian evolution and changes in genes over larger evolutionary periods (which is why we chose to call it "evolutionary"). The relativistic frame also stems from the original "gene-environment interaction" frame, and though it indirectly implies that other genes or environmental factors might be involved in genetic causation, it does little to enlighten the reader about the underlying explanations. Further, we found the deterministic and symbolic frames to be categorically different, which is novel in the literature.

A surprising finding in Paper II was that, overall, only 16% of the 600 articles used the deterministic frame—much lower than we had expected. This indicates that there is, overall, much less genetic determinism in the media than previous studies have claimed. In particular, this contradicts work by Nelkin and Lindee (1995 and 2004), but supports work by Condit et al. (1998). The low amount of determinism may have resulted from our separation of the deterministic and symbolic representations. We found that 32% of the articles in our sample used the symbolic frame, which was the most prominent frame. If we had classified the symbolic and deterministic representations together in one single category, as Nelkin and Lindee (1995 and 2004) have done, that category would have contained a much larger proportion of articles.

Gene framing in relation to reader socioeconomic status

We found that a conventional classification of newspapers as elite, mid-range and tabloid, had limited value in an international context. In order to differentiate between newspapers addressing different segments of society, we therefore used the readers' socioeconomic status, measured by their level of education, as the key indicator. Adjusted for the overall level of education in each country, this approach offered a systematic way of ranking the newspapers.

In Paper II, we found that the deterministic frame was equally frequent in both tabloids and elites (there was no relation to reader SES). We had expected the deterministic frame to be more frequent in the tabloids since several authors have related genetic determinism to sensational reporting (Hubbard & Wald, 1993; Nelkin & Lindee, 2004; Nelkin, 1994). The symbolic frame, on the other hand, was strongly associated with lower-status newspapers, particularly in explicit tabloids like *The Sun* and the *New York Daily News*. The results thus indicate that previous accounts of genetic determinism in the tabloid media largely concerned symbolic representations of the gene, whereas actual accounts of genetic determinism in the tabloid media are probably much less.

A particularly interesting feature about the symbolic frame is that its association with the tabloid newspapers disappeared when adjusting for the total amount of gene-related articles in the newspapers (Table 4 in section 4.2). In other words, although the tabloid newspapers have a higher proportion of articles in the symbolic frame, they do not have *more* such articles than the elite newspapers. This is because there appears to be a general tendency for the elite newspapers to publish more gene-related articles in total (although the correlation was not statistically significant). This indicates that, in total, there may be just as many symbolic articles in elite newspapers as in tabloid newspapers. The overall exposure of the symbolic frame for readers of tabloid and elite newspapers may therefore be the same. Future studies of science in the media might therefore also consider the distinction between the proportion and the total amount of articles in a particular frame, in order to gain a more nuanced picture of media framing.

The overrepresentation of the evolutionary frame in the elite newspapers was also present when adjusting for the overall number of gene-related articles (there was also still a correlation with the materialistic frame, though it was not statistically significant). This indicates that both the proportion of articles and the total amount of articles in elite newspapers tend to present the gene as a dynamic entity that interacts with the environment. This indicates that readers of elite newspapers more often than readers of tabloid newspapers encounter the evolutionary frame.

Overall, our key finding in Paper II is therefore that people of different socioeconomic status, who read different newspapers, encounter different pictures of what a gene is. This can have important implications for public understanding of science, which I will discuss further in section 5.2.2.

Gene framing in relation to editorial profile

We have focussed primarily on differences in gene frame use between tabloid and elite newspapers (as defined by the socioeconomic status of their readers). As Paper II indicates however, various features of a newspapers' editorial profile—such as the type of authors, topics and article formats—may also relate to frame use. Most strikingly, the symbolic frame was strongly overrepresented in articles about culture & society, and sports & cars (the non-scientific topics). This relationship emphasizes the non-scientific context of the symbolic frame and coincides with the finding that the tabloids report much less on scientific topics than the elite newspapers do. The three most serious newspapers—*The New York Times, The Guardian* and *Le Monde*—all have a daily science section and science editor, which naturally cover more science than the tabloids without such sections. It seems, therefore, that we can explain part of the differences in frame use between newspapers by the different topics covered by tabloids and elite newspapers.

Another important finding concerns the types of authors. The elite newspapers had more articles written by science journalists and scientific experts, which may also relate to the scientific profile of the newspaper (as outlined in section 3.3.1). However, this does not explain why the science journalists favoured the materialistic frame whilst the scientists favoured the evolutionary frame. I speculate that this has to do with the different level of scientific insight and complexity conveyed in these frames: The materialistic frame relates to the classic textbook definitions of a gene as a segment of DNA that codes for a protein, and perhaps science journalists believe this is the most "safe" and established way of describing the gene. Condit (2007) has said that journalists are "still rehearsing their high school lectures", which taught very simple models of causation. Scientists on the other hand, are keeping up to date with developments within genetics, increasingly seeing genes as dynamic parts of larger biological systems. The evolutionary frame encompasses recent gene perspectives from epigenetics and modern genomics—perspectives that are probably still confined to scientific circles and not yet part of common knowledge.

These findings indicate that differences in frame use between newspapers relate *both* to the socioeconomic status of their readers and to their editorial profile. The editorial profile adds another dimension to the list of possible factors that may influence framing.[8] Individual peculiarities of the newspapers may also play a small role. I believe these findings represent new and interesting insights into media framing that may also be relevant to the framing of science more generally.

Students' ability to identify gene frames in the media

Results from the group work in Paper III showed that the students were able to identify the gene frames in newspaper texts with a high degree of accuracy. There were only a few differences in opinion, which related mostly to the order of frames in articles. The differences in opinion probably reflect the qualitative nature of text analysis, rather than students' misconceptions of the gene framing scheme. As mentioned previously, there is always the possibility that two individuals will interpret the same text differently, simply because they have different background knowledge and opinions. I also regard these small differences in opinion as a positive aspect in Paper III, because it resulted in some interesting classroom discussions about the group work. For example, there was some debate over the presence of a symbolic frame in article 4 of the group work. One of the groups argued that the statement "Does this mean that obese people can lean back and just blame their genes?" was symbolic, because it seemed very "causal" and unscientific. However, because the article concerned obesity and referred to actual science, the other groups argued that it was deterministic, and eventually everyone agreed. Through active discussion, the students' therefore reflected on the meaning of the five frames and were able to come to a mutual agreement. They also began to question the overall quality and legitimacy of various claims in the articles, showing that they had become more critical readers.

[8] We were not able to present a multinomial model of how all the variables interact, because we had too few cases representing socioeconomic status (12) newspapers), and it is problematic to combine these with other variables when these are based on a different number of cases (600 articles).

Impact of teaching program on students' understanding of genes

The Word Association Maps showed that students predominantly perceived genes with a materialistic frame both before and after the program, though they recalled the evolutionary frame more often in the post-test. In the classroom discussion and the post-test focus group interview the students generally showed a greater awareness that both genetic and environmental factors are important in the development of traits. The teacher also believed the program had improved their understanding of gene-environment interaction, particularly in relation to the inheritance and development of various diseases and disorders. This is important because, as their teacher also suggested, understanding gene-environment interaction helps the students differentiate between different types of diseases (common or rare) and the relative role genes play in these. In other words, it gives them a more sophisticated understanding of genetic causation in relation to disease.

Still, the point of this teaching program has not been to argue that one gene frame is better than the other, but to show the students that the gene concept may have different meaning in different contexts. Equipped with an analytical instrument and an awareness of the five frames, the students can make their own judgments and comparisons of the science they encounter in the media.

5.2.2 Wider implications for science and society

This thesis has the potential to:

1. Promote scientific literacy via media literacy

Paper III indicates that, as the students became aware of the different meanings of the gene concept, they also started to question the overall quality and legitimacy of the claims in the articles. For example, in the post-test focus group interview, Alice remarked that knowing about the different gene frames can help people to avoid making uncritical remarks like "hey, they've found the gene that explains why I'm so fat!'. Such frame-awareness is particularly important for helping promote health literacy, so that people do not falsely believe that genes alone cause complex conditions, or use genetic explanations as an easy excuse for such traits or conditions. I believe therefore that knowledge of framing can help people make informed interpretations of media information, so that they do not simply take the dominant frame at face value. This links to what Norris and Philips (2003) have said about critical reading, and similarly what Potter (1998) has said about media literacy—that being aware of different meanings enables the reader to 'negotiate' with the text and make informed interpretations about which meaning is most useful, therefore not necessarily accepting the dominant frame.

For example, consider the two articles reporting on “the depression gene” at the end of the Appendix (section 8.3). These two articles frame the same story very differently: The *Daily Mail* article has a dominant deterministic frame because the title claims that the particular gene is a definite explanation for why some people get depressed. The title uses phrases such as “the gene that *rules”* and “scientists *prove* inherited trait”. The article in *The Guardian* on the other hand has a dominant relativistic frame, because the title says the gene is “linked to” depression, and that “researchers find inheritance *factor*”. *The Guardian* article also includes an evolutionary frame near the end, which explains how environmental factors might interact with genes in complex ways and flags that “biology is not destiny”. Without knowledge of the five gene frames, readers of the *Daily Mail* might be lead to thinking genes cause depression. Readers of *The Guardian* on the other hand might learn that lifestyle factors are also important for mental health. If The *Daily Mail* reader would be aware of the five frames, he or she could compare this representation with alternative ones, and make an informed interpretation of the text.

The students in Paper III had become particularly critical of deterministic headlines at the end of the teaching program. For example, after the teaching program the students in the post-test interview criticized the hypothetical headline “Scientists have found the lung cancer gene” for being too simplistic, acknowledging that there are most likely many different genes involved, as well as environmental factors. Before the program, they believed that the statement meant scientists had found the gene causing the cancer, without reflecting upon the real meaning. They had learned during the teaching program that headlines, because of their brevity and attention-grabbing role, might sensationalize a story and therefore not correctly reflect the content of the article. As seen in our frame analyses in both Paper I and Paper II, it is often the case that the headline and opening paragraphs will be framed differently than the rest of the article. Being aware of this process, which we call *frame dynamics,* is important in order to avoid being misled by overly deterministic headlines.

Being critical of headlines is even more important in cases where people simply read the headlines and opening lines and then gloss over the article, which is probably what happens most of the time. Work on framing effects has shown that the less thoroughly people read the main text, the more influence the headline has on their attitudes (Condit et al., 2001). Therefore, an increased awareness of the alternative ways a headline could be framed can help the reader make a more informed judgment of its appropriateness. Journalists and editors could also try writing more balanced headlines, though this can be more challenging. It is however possible to turn a deterministic headline into a relativistic one, as seen in the two depression articles mentioned above.

2. Have implications for how we teach and learn genetics

In Paper III, the teaching program made the students more aware of the interaction between genetic and environmental factors in the development of traits and disorders, which fills an important gap in knowledge: Previous studies have indicated that students lack knowledge about gene-environment interaction and that this is something science education should focus more on (Verhoeff et al., 2009). Making school students aware of the five gene frames, and in particular the evolutionary frame, can therefore help achieve this goal.

Regarding the placement of the teaching program in the biology curriculum, to increase the students' learning outcomes it might be wise to introduce it early on and then repeat short gene-framing exercises throughout the year. This way the students might remember the frames better and retain the knowledge longer. It can also help them see the gene concept in a wider perspective every time they encounter it throughout the year.

3. Increase our understanding of the knowledge gap within society

Awareness of the five frames may be even more important for people of lower socioeconomic status who tend to read tabloids only: Tichenor and collegues (1970) found that audiences with high socioeconomic status (SES) showed much stronger learning effects from health-related information in the media than did low-SES audiences. They believed this was because higher SES audiences were better educated, and that education is a powerful correlate with the acquisition of knowledge. Nisbet and Scheufele (2009) have recently suggested that this may in part be due to the fact that newspapers with science sections like that of *The New York Times,* tailor their content to highly educated audiences, so that these audiences receive more science. As a result, the different segments of society actually receive different *amounts* of science news.

In addition, we would argue that the *type* of science information also contributes to the knowledge divide: The results from Paper II show that newspapers catering to different segments of society communicate different aspects of the gene concept. Thinking broadly, if readers tend to stick to one type of newspaper for many years, then they will be repeatedly exposed to certain types of framing: People of lower socioeconomic status predominantly consume tabloid media and mainly encounter the gene as an abstract and intangible entity, often in a witty context. People of high socioeconomic status, on the other hand, more often encounter genes as physical structures of information that affect our lives in complex interaction with the environment. Given the large impact of media on the public understanding of science, these fundamental differences in gene framing in relation to SES may influence people's perception of genetics and contribute to an increasing knowledge gap in society.

4. Improve public health messages

The public lack knowledge of gene-environment interaction in disease development (Condit, 2007) and an important challenge will be to communicate this knowledge (Khoury et al., 2000). Trying to promote an understanding of gene-environment interaction in diseases such as cancer may encourage some people to modify their lifestyle factors. I believe that our gene framing scheme may be used by health professionals and communicators to guide public health interventions that involve genetic information. For example, anti-smoking campaigns that present just one side of the story—i.e. that smoking causes cancer—could induce overwhelming blame and guilt in an individual, making them believe that they are completely responsible for any eventual disease. It might be more appropriate and correct to incorporate the evolutionary frame in such health messages, conveying an understanding that both family history (genetics) and environmental factors such as pollution and smoking interact in complex ways. Reducing some of the environmental pressures can help slow disease progression, improve a condition, or avoid it altogether, which may encourage smokers to cut down or stop. Broader use of the evolutionary frame may therefore help achieve this goal.

5. Improve communication between doctors and patients

The different ways of perceiving the gene concept may also be relevant to medical practice. For instance, Prior (2007) investigated the different ways medical professionals, laboratory scientists and patients talk about "the gene for cancer". She found that when clinicians talk with their patients about cancer their language tends to display elements of genetic determinism, for example explaining that genes are like blueprints that instruct the human biological system on how to act. Prior wrote (p.988): "The medical professionals commonly attempt to translate their own knowledge... into a language that they assume can be better understood by their patients." Indeed, she found that the patients in her study also held a deterministic view, assuming genes determine destiny. The laboratory scientists on the other hand, talked about genes materialistically, as things that had to be "re-set, re-printed, copied and edited". Prior concluded that: "Clinicians, lab scientists and patients can all talk and exchange views about what is apparently the 'same thing' while holding different understandings of that thing" (p. 996).

Having different understandings of the same thing relates directly to the framing that goes on in people's minds (the 'audience frames' as described in section 1.3.1). Whilst professionals may consciously choose a certain frame from a repertoire of alternative frames stored in their memory, their patients may receive the same frame but not know of other frames with which to compare it. This can be potentially problematic in situations where health professionals refrain from (or forget) mentioning additional information that could help patients to understand diagnoses or treatment prognoses. It is in such cases that awareness of alternative frames can be advantageous for the public, because it can allow them to ask relevant questions and probe for further information.

6. Improve communication between scientists and journalists

As Condit (2007) has already suggested, awareness of the different gene frames among both scientists and journalists can help alleviate misunderstandings when scientists communicate with journalists about genetic-related issues. For example, the difference between the relativistic phrase "gene associated with prostate cancer" and the deterministic phrase "gene for prostate cancer" is significant in terms of meaning, yet subtle in terms of appearance. It is thus very easy for a journalist, striving for a catchy title, to shorten the "associated with" to "for", and perhaps this is done almost automatically without the journalist realizing it. If, however, the scientist was aware of the different gene frames, he or she could avoid using words that can easily be converted to determinism, or could quickly detect if a journalist changes the frame, and could thereby guide the journalist into making a more conscious choice of frame.

The general problems of communication between scientists and journalists probably relate to the general differences in how scientists and journalists work and think: Much in the same way as I have written this thesis, scientists write about their work in academic journals by starting with an introduction outlining the background and leading up to the research problem or question, followed by a detailed description of the methods of analysis, the results and ending with a discussion of the limitations and possible implications of the work. A journalist's news article on the other hand is like an "inverted" scientific paper, although it saves the limitations for the end: It begins with the conclusion and main findings, will often gloss over the study design or just mention it briefly, focusing mainly on the implications of these findings (often accompanied by a personal account of someone influenced by the research). Background information or limitations of the study are mentioned near the end, or not at all.

The news format relates to framing because information is organized in such a way that what the journalist thinks is most important will be made more salient, or noticeable. The main findings will therefore come first, followed gradually by less important information etc. Communication problems may arise because scientists and journalists have different ideas of what is most important for the audience to know about. I believe a mutual understanding of framing and the audience may help reduce this distance, because then the scientist will think more carefully about how to frame the information to suit a particular newspaper audience, rather than a journal editor (which is what they are most used to). Awareness of framing can also help scientists think about how to communicate the importance of their work whilst at the same time providing an accurate account, thereby being well prepared *before* they make contact with a journalist.

5.3 Future directions

An overarching aim of this research is to promote increased awareness about the different ways of communicating and understanding the gene concept. We believe that scientists, as well as journalists, teachers, school and university students, may benefit from a more diverse and analytic understanding of the gene concept.

Starting with high school education, we propose to develop the teaching program into an easy-to-use teaching pack with instructions, articles and materials. We could publish this online and create a website where teachers can comment on aspects that might be improved or changed. We also hope that teachers in other subjects will make use of the approach we have developed, by using our study as a model for how to teach about media framing in science class and adapting it to other topics.

At the university level, media framing could become part of science communication or media skills training courses, using examples of the five gene frames to illustrate the significance of framing. Such “transferable” skills are becoming increasingly important in the training of scientists, and there is a growing emphasis on including science communication modules in undergraduate and postgraduate science degrees worldwide (Stocklmayer & Gilbert, 2011).

Likewise, I believe journalist students would also benefit from learning about the media’s framing of science. How the media frame science could be integrated into a “science journalism” course or module in Bachelor, Master or PhD level media studies. At the present time, there are few courses in science journalism or science communication available in Norway, but I predict that the demand for such training will increase. For these courses to be successful, they should be based on solid research and knowledge within science communication.

We also propose further investigation into how awareness of framing may be useful in clinical communication. For example, most cancers have both a genetic and an environmental component. In cancer communication, it is therefore essential that patients understand the relative role of genes and other factors that can cause cancer, to help them come to terms with a diagnosis. It may also help physicians to communicate better with cancer patients if they are aware of the patient’s understanding. Perhaps framing should therefore also be incorporated into the training of medical and health professionals.

6. Conclusions

In response to the four research questions, I conclude that:

1. The gene is a diverse concept that is perceived through five different frames in the media: The *materialistic* frame sees the gene as a physical entity; the *deterministic* frame sees the gene as an absolute cause for trait; the *relativistic* frame sees the gene as a partial cause for trait; the *evolutionary* frame sees the gene as a dynamic factor that interacts with its environment; and the *symbolic* frame sees the gene as a symbol of cultural resemblance.

2. Newspapers catering for different audiences use different gene frames: Elite newspapers with highly educated readers, such as *The New York Times*, *Le Monde* and *The Guardian* have a particular tendency for using the evolutionary and materialistic frame, whereas tabloid newspapers with less educated readers, such as *VG* and *The Sun*, tend to use the symbolic frame. These differences also relate to the newspapers' editorial profiles. The deterministic and relativistic frames were equally frequent in tabloids and elites.

3. Upper secondary school students understand the concept of media framing and are able to use our gene framing scheme to identify the five gene frames in newspaper texts.

4. Awareness of gene framing improves students' understanding of the gene concept, particularly related to gene-environment interactions in disease development.

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8. Appendix

8.1 Supporting material for Paper II

8.1.1 Selection of newspapers based on education data

Norway

Top 10 Daily Newspapers[1]
Average daily readership figures:

1. VG	1,368,000
2. Aftenposten	729,000
3. Dagbladet	635,000
4. Dagens Næringsliv	298,000
5. Bergens Tidene	254,000
6. Adresseavisen	232,000
7. Stavanger Aftenblad	186,000
8. Dagsavisen	127,000
9. Fædrelandsvennen	117,000
10. Romerikesblad	114,000

Excluded:
Dagens Næringsliv (finance)
Dagsavisen (political)

Reader education
% readers in highest education category[2]:

1. Aftenposten	33,6
2. Dagbladet	23,6
3. Bergens Tidene	20,3
4. Adresseavisen	18,8
5. Stavanger Aftenblad	18,7
6. Fædrelandsvennen	16,2
7. VG	13,8
8. Romerikes Blad	13,3
(in population)	(16,8)

Selected:

Aftenposten
Dagbladet
VG

[1] Source: TNS Gallup, Forbruker og Media 08/2 (total pop: 4,0180,000; Base bef.:12+) http://online.gallup.no/gpcrapp/ (username: Lesertall, password: Lesertall). Please note that the readership figures reported in the article are slightly lower because they were taken from the same survey but from a sample including persons aged 15 and up. Also note that the readership figure for *Aftenposten* is for the morning edition (main edition). [2] Source: Percentages are taken from the category "University/college 4+

years" from the survey question "What is your highest completed education level?" Source: TNS Gallup, Forbruker og Media 08/2 (total pop: 4,0180,000; Base bef.: 12+) http://online.gallup.no/gpcrapp/ (username: Lesertall, password: Lesertall).

UK

Top 10 Daily Newspapers[1]
Average daily readership figures:

1. The Sun	8,031,000
2. Daily Mail	5,437,000
3. Daily Mirror	3,685,000
4. Metro	3,129,000
5. Daily Telegraph	2,060,000
6. The Times	1,498,000
7. Daily Express	1,598,000
8. Daily Star	1,484,000
9. Daily Record	1,212,000
10. The Guardian	1,165,000

Reader education
% readers in highest education category[2]:

1. The Guardian	23,18
2. The Times	13,11
3. Daily Telegraph	8,06
4. Metro	7,09
5. Daily Mail	2,95
6. Daily Express	2,75
7. Daily Mirror	1,25
8. The Sun	0,85
9. Daily Record	0,83
10. Daily Star	0.27
(in population)	4,38

Selected:

The Guardian
Daily Mail
The Sun

[1] Source: NRS July 07 – June 08, Weighted by population, all adults age 15+ (48,887,000)
[2] Source: From the category "Postgraduate Qualifications – Highest Obtained by informant" in the Survey NRS July 07 – June 08, Weighted by population, all adults age 15+ (48,887,000)

USA

Top 10 Daily Newspapers[1]

Average daily readership figures:

1. USA Today	6,865,000
2. The Wall Street Journal	5,148,000
3. New York Times	4,750,000
4. New York Daily News	2,695,000
5. The Los Angeles Times	2,176,000
6. New York Post	2,061,000
7. The Washington Post	1,717,000
8. Chicago Tribune	1,628,000
9. Houston Chronicle	1,228,000
10. The Arizona Republic	1,055,000

Excluded:

The Wall Street Journal (no education data available in ABC/NAA/FAS-FAX or Scarborough Research)

New York Post (no education data available in ABC/NAA/FAS-FAX or Scarborough Research)

Reader education

% readers in highest education category[2]:

1. The New York Times	58,7
2. The Washington Post	53,4
3. Los Angeles Times	42,1
4. Chicago Tribune	41,0
5. Houston Chronicle	39,4
6. USA Today	37,0
7. Arizona Republic	29,0
8. New York Daily News	23,4

Selected:

The New York Times
USA Today
New York Daily News

[1] Source: World Association of Newspapers; *World PressTrends* (2007), p. 742. These figures are from 2006, based on a survey by NADbase Report, Adults 8+ This was used as an initial reference since no single media survey in the U.S. includes data on all newspapers.

[2] Sources: Figures for USA Today and The Arizona Republic are from Audit Bureau of Circulations (ABC) Reader Profiles (2006), expired released reports; http://abcas3.accessabc.com/readerprofile/expired.asp Figures are for Morning Edition (Mon-Fri) under column "Reader Profile – Total Readers". The population figure is also from this.

Figures for all other newspapers are from Scarborough Release (Tier 2 DMA, 2010), Average Comp % (Adults 18+) www.audiencefax.com

France

Top 10 Daily Newspapers[1]

Average daily readership figures:

1. l'Equipe	2,546,000
2. Le Parisien Aujourd'hui	2,269,000
3. Le Monde	2,066,000
4. Le Figaro	1,285,000
5. Liberation	906,000
6. Les Echos	700,000
7. La Tribune	451,000
8. l'Humanite	425,000
9. La Croix	404,000
10. France Soir	232,000

Excluded:

Niche newspapers:
Le Croix (catholic)
Les Echos (economics)
L'Equipe (sports)
L'humanite (strongly political)

Reader education

% readers in highest education category[2]:

1. Le Monde	71,2
2. La Tribune	68.7
3. Liberation	68,5
4. Le Figaro	61,6
5. Le Parisien Aujhourd'hui	34,2
6. France Soir	31.3
(in population)	(33,8)

Selected:

Le Monde
Le Figaro
Le Parisien Aujourd'hui

[1] Source: TNS SOFRES – EPIQ July 2007 – June 2008 (PQN, LNM Ensemble)
[2] Source: From the category "Enseignement superieur" (Higher Education) in the survey TNS SOFRES – EPIQ July 2007 – June 2008 (PQN, LNM Ensemble)

8.1.2 Raw data

Readers per educational group

Norway *Education*	*Persons ('000)* **Total**	*Persons ('000)* **Aftenposten**	*Persons ('000)* **Dagbladet**	*Persons ('000)* **VG**
Sum	*3829,794*	*716,982*	*620,571*	*1136,363*
0. Ubesvart	24,568	4,331	2,719	6,828
1. Grunnskoleutdanning	493,593	40,583	56,818	152,117
2. Videregående utdanning	1487,570	183,006	201,118	488,670
3. Universitet/-høgskoleutdanning med inntil 4 års varighet (1-4 år)	1092,491	233,946	197,507	309,139
4. Universitet/-høgskoleutdanning med mer enn 4 års varighet (mer enn 4 år)	731,572	255,116	162,409	179,609

UK *Education*	*Persons ('000)* **Total**	*Persons ('000)* **Daily Mail**	*Persons ('000)* **Guardian**	*Persons ('000)* **The Sun**
Sum	*48885*	*5347*	*1164*	*8030*
0. Don't know/Refused	1943	264	63	318
1. Less than O-level				
1.1. None of these	13116	1448	55	2543
1.2. GNVQ/NVQ	2868	222	17	694
1.3. Trade apprenticeship	1796	215	12	451
1.4. ONC/OND/City & Guilds	2601	342	16	536
2. O-levels or comparable				
2.1. BTEC,BEC,TEC or equivalent	1052	115	8	173
2.2. Other O levels/GCSE/CSE passes	5040	539	38	1147
2.3. 5+ O levels or equivalent	4000	456	44	753
3. A-levels or comparable				
3.1. Other teaching/nursing qualifications	1623	254	40	140
3.2. 1+ A levels or equivalent	3426	397	96	461
3.3. HNC or HND	1747	197	38	217
4. Qualifications requiring A levels	662	80	26	91
5. Professional qualifications	2179	266	111	108
6. First degree (BA/BSc)	4693	394	330	330
7. Postgraduate qualification (eg Phd,MBA)	2139	158	270	68

France *1000 Euro*	*Persons ('000)* **Total**	*Persons ('000)* **Aujourd'hui**	*Persons ('000)* **Le Figaro**	*Persons ('000)* **Le Monde**
Sum	*49844*	*2261*	*1283*	*2059*
1. Ecole primaire	4859	169	24	16
2. Collège (6ème à 3ème, CAP, BEP)	16187	729	164	173
3. Lycée (seconde à terminale)	11917	586	304	399
4. Enseignement supérieur	16881	777	791	1471

US *Education*	*Persons ('000)* **Total**	*%* **NY Times**	*%* **NY Daily News**	*Persons ('000)* **USA Today**
Sum	*219069,3*	*100,0*	*100,0*	*7080,1*
1. High School Grad or less	104455,6	18,2	48,3	2126,1
2. Some College	62212,4	23,9	29,3	2367,7
3. College Grad+	52401,3	57,9	22,4	2586,3

Readers per income group

Norway	*Persons ('000)*	*Persons ('000)*	*Persons ('000)*	*Persons ('000)*
1000 NOK	**Total**	**Aftenposten**	**Dagbladet**	**VG**
Sum	*3829,794*	*716,983*	*620,570*	*1136,363*
0. Missing	570,543	95,523	74,028	152,107
1. 0-300	470,933	58,738	54,009	111,982
2. 300-449	729,679	118,732	100,000	215,954
3. 450-599	553,017	87,600	80,085	168,612
4. 600-	1505,622	356,390	312,448	487,708

UK	*Persons ('000)*	*Persons ('000)*	*Persons ('000)*	*Persons ('000)*
GBP/Persons	**Total**	**The Guardian**	**Daily Mail**	**The Sun**
Sum	*49206*	*1148*	*4747*	*7821*
1. 4800	2046	19	153	312
2. 6000	3281	27	275	535
3. 7200	2968	33	312	424
4. 9600	3270	39	342	505
5. 14400	3482	48	344	543
6. 19200	3935	80	375	678
7. 24000	4490	98	470	770
8. 28800	4761	135	470	767
9. 33600	5087	118	504	823
10. 38400	4819	128	464	789
11. 43200	3782	99	336	592
12. 48000	3520	135	378	570
13. 52800	3765	190	327	514

France	*Persons ('000)*	*Persons ('000)*	*Persons ('000)*	*Persons ('000)*
1000 Euro	**Total**	**Aujourd'hui**	**Le Figaro**	**Le Monde**
Sum	*49958*	*2269*	*1287*	*2066*
0. Missing	6589	250	213	196
1. 0-9	2313	57	25	56
2. 9-12	3307	95	39	72
3. 12-18	6848	269	72	140
4. 18-36	19246	865	353	571
5. 36-42	4238	250	157	224
6. 42-60	4849	321	208	418
7. 60-	2568	162	220	389

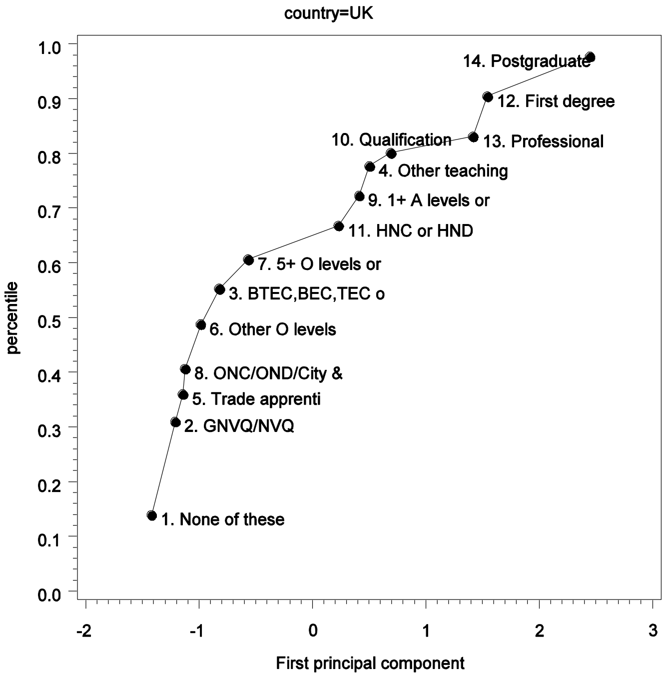
US	*Persons ('000)*	*%*	*%*	*Persons ('000)*
1000 USD	**Total**	**NY Times**	**NY Daily News**	**USA Today**
Sum	*219069,3*	*100,0*	*100,0*	*7080,2*
1. 0-50	115106,8	23,3	37,9	2350,8
2. 50-75	41394,6	14,5	17,0	1594,4
3. 75-100	30162,2	16,2	18,5	1232,0
4. 100-150	20509,0	19,1	14,0	1048,1
5. 150-	11896,7	26,9	12,6	854,9

UK data were obtained from the National Readership Survey (April 08-March 09, adults 15+, for readership figures, population and income data; July 07-June 08, adults 15+, for education data), US data for *The New York Times* and the *New York Daily News* were obtained from Scarborough release 1 (2008, adults 18+) and data for *USA Today* and population totals were from Scarborough ABC Reader Profiles (2003-2004, adults 18+), all Norwegian data were obtained from Forbruker & Media (08/2-MGI Univers ('000): 3 829,794, Base: Bef. 15+), and all French data from TNS SOFRES-EPIQ (2007-2008, PQN, LNM Ensemble, adults 15+).

8.1.3 Supporting analyses to assess order of UK education categories

The UK survey data came with a large number of educational categories for which a natural ordering was not immediately clear. We made a somewhat subjective assessment of the academic level of each of them to order them, and in the process decided to group several of them together. In order to evaluate this ordering, and in part to guide us, we made a principal component analysis of proportion of readers in each educational group for each of the newspapers (log-transformed) and extracted the first principal component. We then ordered the educational groups by the coefficients of the first principal component. The figure below shows the first principal component on the x-axis.

Along the y-axis is the average percentile in each educational group after ordering them: i.e. educational group 1. scored lowest and represents percentiles 0 to 27.9 (since they constitute 27.9% of the survey data), which gives an average value of 13.9, next is group 2. with 6.1%



of the data which then covers percentiles 27.9 to 34.0 (average 31.0), etc. Educational groups that are very close on the x-axis, are hard to distinguish based on the data alone.

This analysis was only used to assist in the grouping and ordering, but generally corresponded well with our assessment of the categories. The new groups are:

1: None of these; Trade apprenticeship; GNVQ/NVQ; ONC/OND/City & Guilds

2: Other O levels/GCSE/CSE passes; BTEC,BEC,TEC or equivalent; 5+ O levels or equivalent

3: HNC or HND; Other teaching/nursing qualifications; 1+ A levels or equivalent

4: Qualifications requiring A levels

5: Professional qualifications

6: First degree (BA/BSc)

7: Postgraduate qualification (eg Phd,MBA)

8.1.4 Descriptive statistics for newspapers

Newspaper	*Readers (1000)*	*Income dependency*	*Education dependency*	*Gene articles (%)*	*Evolutionary (%)*	*Materialistic (%)*	*Relativistic (%)*	*Deterministic (%)*	*Symbolic (%)*
France									
Aujourd'hui en France	2269	2.7	1.3	0.12	12	25	7	15	42
Le Figaro	1285	9.2	49.7	0.16	10	55	10	19	6
Le Monde	2066	7.9	249.4	0.31	23	32	10	17	18
Norway									
VG	1136	1.6	0.6	0.22	10	20	22	16	33
Dagbladet	621	3.7	2.9	0.21	16	9	23	14	38
Aftenposten	716	3.8	9.3	0.21	29	17	9	15	31
UK									
The Sun	7821	1.0	0.1	0.10	4	11	17	21	47
Daily Mail	4747	1.0	0.8	0.62	5	24	15	23	33
The Guardian	1165	5.7	111.3	0.30	10	35	10	19	26
USA									
NY Daily News	2552	6.0	0.9	0.15	6	19	6	10	58
USA Today	7080	9.4	9.0	0.30	11	30	16	16	28
NY Times	4562	30.3	69.6	0.44	20	30	17	10	23

Note: **"**Readers" refers to the average daily readership reported in National Readership Surveys. Income and education dependency is a factor of how over-represented the highest household income and education group are compared to the lowest. "Gene articles" is an estimate of the total amount of gene-related articles appearing in the newspaper in the search period 01.07.2005-01.07.2008. The percentage for each frame is the "frame usage", taking the frame dynamics of each article into account. The percentage for each author type refers to the proportion of articles authored by each.

8.1.5 Coding manual

CODING MANUAL

Developed by R. Carver & J. Breivik for the project

GENES IN THE MEDIA

Oslo, November 2008

Author

Look for information about the author in the article – If it is written by a specialist journalist (science, health or environment) it is sometimes stated underneath the title. If it is written by an external writer, information about them can also appear at the end. If no information is given, try googling their name or searching the Newspaper's website to find out. If you still cannot find information check the "Not known or anonymous" box. Also check this box if no name is given.

1. Non known or anonymous

2. Non-scientific journalist
   Those writing on general issues most of the time. Include business and political in this category.

3. Scientific journalist
   Those writing on science, health or environmental issues most of the time. They should have a specific job title as either science, health or environmental journalist, reporter or correspondent. Do not include fitness experts or sex therapists.

4. Scientist/expert
   This category includes academics or other experts in the reported topic – e.g. doctors, directors of research, teachers, scientific advisors, book authors.

5. Member of public

6. Politician

7. Other

Main topic

An article usually covers several topics but try to identify the most prominent one.

1. General Science

   Articles discussing broader scientific issues such as: climate change, environmental science, evolution, human evolution, diseases, psychology & behaviour, eugenics, science and religion, science education, science policy, science ethics, genetic literacy, public attitudes, public understanding of science. This category includes medical and health-related topics such as finding diagnoses and cures for diseases (e.g. human interest articles about a family coping with a disease).

2. Genetics

   The articles discuss research, knowledge, theories or ideas about genetics and/or genes but do not focus on medical applications per se. Issues include: stories about the Human Genome Project, history of genetic research, genetic screeing, biotechnology techniques (e.g. gene therapy, gene doping), genetically modified foods, plant breeding, animal breeding, cloning, stem-cell research, gene therapy.

3. Culture

   Anything of a general interest, not specifically to do with science. Topics include music, religion, crime, beauty, social issues, literature.

4. Sports and cars

5. Politics

6. Other

Type of Article

This distinguishes the type of news format (in norwegian, *sjanger*).

1. News & news briefs
Factual material reporting on recent events. Includes also short news briefs and fact files (only a few sentences long).

2. Commentary by reader
This includes all types of material sent in by readers of the newspaper; e.g. comments to articles, opinion pieces, debate entries, questions.

3. Commentary by journalist
Includes regular columns and editorial material.

4. Feature
More in-depth factual reporting. Includes longer reports, human interest stories, and background material.

5. Interview
An article specifically about a person, with their own views in focus.

6. Review
E.g. book or music review

7. Other

Gene frames

A gene frame is a particular way of perceiving or understanding the gene concept. Use the following Gene framing scheme to identify key features that help accentuate (a) particular frame(s). Colour-code the key features you find (see colour scheme below).

NB! Not all of these features are required to form a frame!

In consideration of the key features you have colour-coded, which of the following frames is *most obviously conveyed*? Do not tick, but indicate with the number 1 in the box. This is the dominant frame.

Are there any other frames present? Indicate whether there is a secondary and possibly a tertiary frame present. These tend to be less obvious. Sometimes secondary and tertiary frames provide some balance by voicing a different perspective (see Example 10), and other times they simply strengthen the effect of the dominant frame (see Example 3 & 6).

In the unusual case of not being able to identify any frame, or if there is some difficulty in identifying a frame or deciding the frame order, please make a comment in the space provided.

Colour coding scheme

Remember to colour code the features you find in the articles by highlighting with the appropriate colours in Word using these colours:

Materialistic (turquoise)

Deterministic (red) (or orange if using felt-tip pens on paper)

Relativistic (purple)

Evolutionary (light green)

Symbolic (yellow)

The Gene Framing Scheme

Gene frame	Describing the gene as	Key words, phrases & metaphors	Sample sentence
Materialistic	A discrete physical unit	DNA, chromosome, identify, map, locate, isolate, deliver, transfer, specific, replace, inject, discover, code, protein, mutation. Metaphors: alphabet, book, map, code, beads on string	"Injecting a key gene into patients could stimulate the production of insulin."
Deterministic	A definite causal agent	Gene for, cause, control, culprit, blame, disease-gene, responsible for, gene for, wired in genes, born with, no choice. Metaphors: computer program, recipe/instruction manual.	"BRITISH scientists have discovered a gene for prostate cancer that could revolutionise treatment for sufferers."
	Contrary to environmental factors	Genes or environment, not down to our genes, genetic, environmental.	"It may be genetic or diet or something else altogether."
Relativistic	A predisposing factor	Risk, chance, factor, associated with, susceptible to, linked to, contribute, predispose, interfere, influence, play a part in, genes are involved	"They have identified a variant gene which steeply increases the risk of baldness..."
Evolutionary	The central object of evolution	Being selected, make copies, replicate, reproduce, through generations, adapt, maladaptive. Metaphor: the selfish gene.	"Birds sing to maximise their chances of passing on their genes - by defining their territories and by attracting a mate."
	A marker for evolutionary stage	Evolve, evolutionary relatedness, conserve, diversity, development, DNA record, gene bank, marker, extinction, change.	"The American researchers looked at the DNA from all their ancestors, to establish the percentage of African and European ancestry in each individual."
	Interacting with the environment	Interact, complexity, dynamic, capacity, external influence, environment, epigenetic, depends on, in combination with, affected by, expression, triggered by, prevent, respond, turn on/off. Metaphor: like a switch or tap.	"The sheer complexity of the combination between genes, environment and training means that it is impossible to always achieve the ultimate super-physiology".
Symbolic	An abstract representationof inheritance	It must be in the genes, good genes, gene pool, inherit, talent.	"I inherited a shopping gene".
	A metaphor for information transfer	-	Mazda got "Ford genes".

Gene Metaphors

Here is a guide to how we defined various metaphors that helped describe the gene. There are of course many other metaphors but these were the most common we have found so far. Please feel free to add to our list and describe any new metaphors you may find (write this in the space at the bottom of the coding sheet).

Alphabet/book (materialistic)

The nucleotide bases (A, C, T, G) are **letters** in the alphabet; they are arranged in sequence to form various **words** (genes); the words are put together to form sentences (chain of amino acids) that give meaning (proteins, each having a particular function in the body).

Map (materialistic)

Each gene can be "mapped" onto a larger map of the human genome.

Code (materialistic)

This metaphor focuses on bits and pieces of DNA, specific genes, and fragments of codes. It makes reference to being able to read or decipher the genetic code; the idea that there are collections of autonomous genes carrying **bits of rewriteable code**.

Beads on a string (materialistic)

The great coiled DNA molecules of the chromosomes are seen as long strings on which discrete gene sequences sit like beads on a string. This view assumes that ONE protein is associated with (or coded by) ONE gene; a view which is considered 'old-fashioned' now.

Recipe/instruction manual/blueprint (deterministic)

The whole genome is a well-crafted blueprint/instruction manual for a living being. This metaphor places emphasis on the human genome as a whole rather than on genes in isolation. There is a **vision of DESIGN** in this metaphor: e.g. talking about being able to use gene therapy to "redesign unhealthy blueprints". The metaphor is seen as a 'development' of the code metaphor.

Computer program (deterministic)

Life is preprogrammed in the DNA digital code. Similar to the blueprint metaphor above.

Switch (evolutionary)

A gene is like a tap, the expression of which can be switched on or off.

Selfish gene (evolutionary)

This metaphor sees genes as '**self-replicating molecules'** that **ensure their survival** by means of phenotypic affects on the world. It draws on Dawkins' perspective of seeing the body as a mere survival machine for its genes (bodies are 'vehicles' for their genes) – genes help organisms survive for the sole reason that they may propagate into further generations – genes are seen as 'selfish' because of this.

Examples

Example 1
Dominant frame = Materialistic
Secondary = relativistic

Scientists complete Man's 'book of life'.
85 words
14 April 2003
Daily Mail
English
(c) 2003

HAILED as the most important discovery in history, the Human Genome Project - or 'book of life' - is completed today.

The world's top scientists have mapped 2.9billion letters of DNA code, which make up the human genome. They say it will provide the keys to diagnosing, treating and preventing cancer, heart disease and diabetes.

Already, it has helped search for **genes** involved in diabetes, leukaemia and childhood eczema.

Example 2
Dominant frame = Deterministic

Overseas news
Born to be gay
40 words
21 October 2003
The Sun
19
English

Homosexuals are BORN gay and have no choice in their sexuality, say researchers at University of California, Los Angeles. They found sexual identity is wired in our **genes** before birth.

(examples 3-10 omitted are omitted here because they take up too much space or are in Norwegian)

8.1.6 Coding sheet

Coder (initials)…………………………Newspaper………………………………………..

Date of article………………………….. Name of author……………………………...

Title of article……………………………………………………………………………

Author

1. Not known or anonymous ☐
2. Non-scientific journalist ☐
3. Scientific journalist ☐
4. Scientist/expert ☐
5. Member of public ☐
6. Politician ☐
7. Other ☐ State…………………………..

Main topic

1. General science (inc. health&med) ☐
2. Genetics ☐
3. Culture ☐
4. Sport & cars ☐
5. Politics ☐
6. Other ☐ State…………………………..

Type of article

1. News & new briefs ☐
2. Commentary by reader ☐
3. Commentary/column by journalist ☐
4. Feature ☐
5. Interview ☐
6. Review ☐
7. Other ☐ State…………………………..

Gene frame(s)

Dominant frame = 1
Secondary frame = 2
Tertiary frame = 3

Materialistic ☐
Deterministic ☐
Relativistic ☐
Evolutionary ☐
Symbolic ☐

Comments:

8.1.7 Estimating the total amount of gene-related articles per newspaper

The total number of gene-related articles per newspaper was estimated by multiplying the percentage of relevant gene-related articles in the screened sample by the total number of search hits (also non-relevant articles that matched the search criteria) for each newspaper. We divided this by the total number of articles in the database within the time period 01.07.05 – 01.07.08 to obtain an estimate for the total portion of gene-related articles in each newspaper. The table below displays the number of articles in the database and samples. The Norwegian database Atekst provided us with an exact number of all articles in the database for the designated time period, while in Factiva we had to search for the 5 most common words in French (de, le, la, et OR les) and English (the, be, to, of OR and) to estimate the total.

Newspaper	**# articles in database**	**# articles in search result**	**# articles reviewed**	**# irrelevant articles**	**% relevant in review**	**% relevant in database**
	N	n	$50+k$	k	$r=50/(50+k)$	$n \cdot r/N$
Aujourd'hui	92 511	115	53	3	94.34%	0.117%
Le Figaro	241 256	439	57	7	87.72%	0.160%
Le Monde	109 588	354	52	2	96.15%	0.311%
VG	129 932	339	60	10	83.33%	0.217%
Dagbladet	131 873	333	59	9	84.75%	0.214%
Aftenposten	232 173	536	56	6	89.29%	0.206%
The Sun	412 356	812	99	49	50.51%	0.099%
Daily Mail	87 982	703	64	14	78.13%	0.624%
Guardian	454 079	2973	109	59	45.87%	0.300%
NY DailyNews	108 732	1022	323	273	15.48%	0.145%
USA Today	59 302	1216	345	295	14.49%	0.297%
NY Times	254 537	2928	132	82	37.88%	0.436%

8.1.8 Calculating the inter-coder agreement

The table below shows the agreement (diagonal) and disagreement (off-diagonal) in percent of all doubly coded articles.

	Evo.	Mat.	Rel.	Det.	Sym.
Evolutionistic	**8.3**	5.2	1.5	4.0	0.9
Materialistic	5.2	**16.8**	2.2	7.1	0.3
Relativistic	1.5	2.2	**9.4**	2.5	0.3
Determinstic	4.0	7.1	2.5	**10.0**	2.1
Symbolic	0.9	0.3	0.3	2.1	**29.3**

If two coders give an article weights v_i and w_i in frame i, the agreement on that frame has weight $\min(v_i,w_i)$, and the total agreement for the article is made by summing this agreement weight over all frames. The agreement will be 1 if the two coders code exactly the same frames in the same order, 0 if there is no overlap in frames coded, and between 0 and 1 if there is partial agreement. If we subtract the agreement weight from the weights from each coders, we are left with residual weights corresponding to the disagreement: i.e. coding weights v_i and w_i result in residual weight $\Delta v_i=v_i-\min(v_i,w_i)=\max(v_i-w_i,0)$ and $\Delta w_i=w_i-\min(v_i,w_i)=\max(w_i-v_i,0)$ for the two coders. For each coder, these residual weights will sum to 1-agreement which represents the disagreement between the two coders on that article. The amount of disagreement on frame i versus frame j is found by distributing the total disagreement (1-agreement) between the frame pairs in proportion to Δv_i and Δw_j: i.e. $\Delta v_i \times\Delta w_j/(1\text{-agreement})$.

Kappa is then computed as (Agreement-Expected)/(1-Expected) where the Agreement refers to the average over all double coded articles and Expected is the average agreement found when the second coding is randomized, i.e. between random pairs of articles.

We do not distinguish between the first and the second coder in this, and so in the table we present the sum of the *i*—*j* and the *j*—*i* disagreements. Thus, the diagonal sums to 73.9%, the agreement, whereas the upper and lower triangles each sum to 26.1%, the disagreement.

The following table shows the inter-coder agreement for the dominant frame only. Bold numbers represent agreement, and the percentages are calculated per row (n=260).

		Coder 2				
		Sym	Det	Rel	Mat	Evo
	Sym	**77 (94%)**	4 (5%)	0	0	1 (1%)
	Det	2 (4%)	**27 (56%)**	1 (2%)	11 (23%)	7 (15%)
Coder 1	Rel	0	6 (17%)	**23 (66%)**	4 (11%)	2 (6%)
	Mat	0	11 (18%)	3 (5%)	**40 (66%)**	7 (11%)
	Evo	1 (3%)	4 (12%)	0	6 (18%)	**23 (68%)**

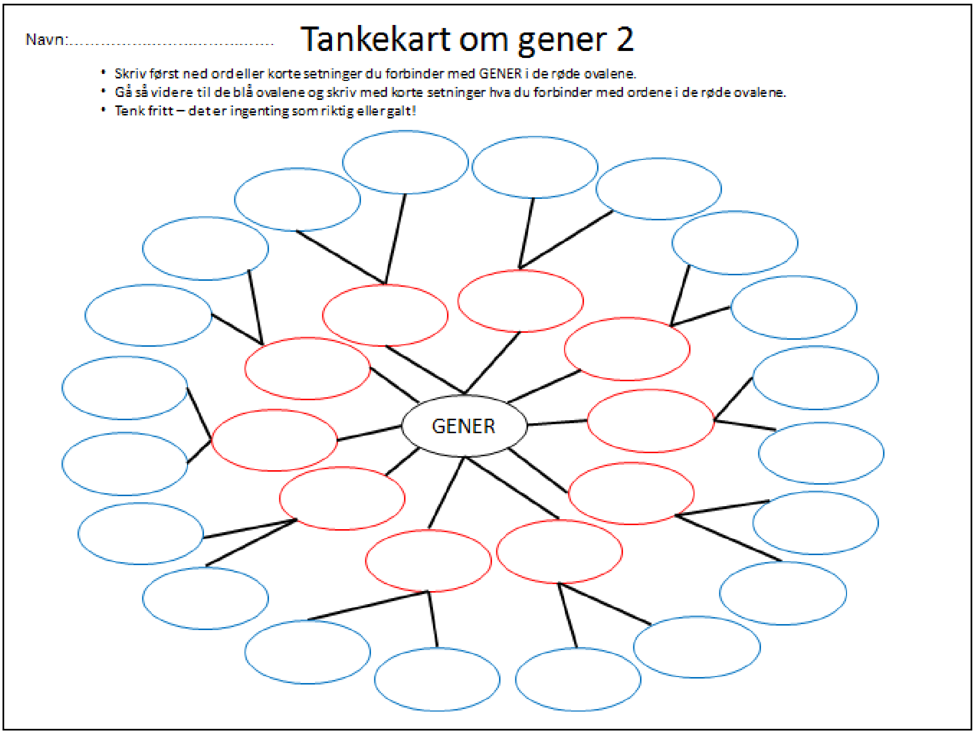
8.1.9 Frame usage related to topic, author and type of article

	Sym	Det	Rel	Mat	Evo	Total
Total	**190.8 (31.8%)**	**97.0 (16.2%)**	**81.2 (13.5%)**	**153.5 (25.6%)**	**77.4 (12.9)**	**600.0 (100%)**
Topic						
Culture & society	134.1 (73.3%)	19.6 (10.7%)	2.0 (1.1%)	14.2 (7.8%)	13.0 (7.1%)	183.0 (100%)
General science	3.3 (1.3%)	54.3 (21.5%)	53.9 (21.3%)	91.0 (36.0%)	50.5 (19.9%)	253.0 (100%)
Genetics & GMO	0.4 (0.5%)	15.5 (16.8%)	21.9 (23.9%)	42.2 (46.9%)	11.0 (12.0%)	92.0 (100%)
Sports & cars	51.0 (83.6%)	4.7 (7.7%)	1.7 (2.7%)	3.7 (6.0%)	0.0 (0 %)	61.0 (100%)
Other	2.0 (18.2%)	2.9 (26.4%)	1.7 (15.2%)	1.5 (13.4%)	3.0 (26.9%)	11.0 (100%)
Author type						
General journalist	153.7 (53.0%)	38.1 (13.2%)	27.0 (9.3%)	43.9 (15.1%)	27.2 (9.4%)	290.0 (100%)
Science journalist	1.4 (0.9%)	29.8 (19.4%)	25.6 (16.6%)	70.6 (45.9%)	26.5 (17.2%)	154.0 (100%)
Scientific expert	2.0 (5.0%)	8.3 (20.7%)	6.3 (15.8%)	10.7 (26.8%)	12.7 (31.7%)	40.0 (100%)
Other or unknown	33.7 (29.0%)	20.7 (17.8%)	22.2 (19.2%)	28.3 (24.4%)	11.1 (9.6%)	116.0 (100%)
Article type						
Commentary	32.3 (40.4%)	10.1 (12.6%)	6.7 (8.4%)	12.5 (15.6%)	18.3 (22.9%)	80.0 (100%)
Feature	61.5 (28.1%)	31.4 (14.3%)	32.2 (14.7%)	55.4 (25.3%)	38.5 (17.6%)	219.0 (100%)
Interview	52.5 (73.9%)	7.7 (10.8%)	2.4 (3.4%)	6.3 (8.9%)	2.1 (3.0%)	71.0 (100%)
News & briefs	23.3 (11.9%)	45.5 (23.3%)	36.6 (18.8%)	73.1 (37.5%)	16.5 (8.5%)	195.0 (100%)
Other	21.3 (60.8%)	2.3 (6.5%)	3.3 (9.5%)	6.2 (17.7%)	1.9 (5.4%)	35.0 (100%)

Note. Number of articles per frame is presented with decimals due to weighting of frames (see Methods). Based on n=600.

8.2 Supporting material for Paper III

8.2.1 Template for the Word Association Map (WAM)



8.3 Supporting material for discussion: Two different articles on depression

The gene that rules how you cope in a crisis; Scientists prove inherited trait means some of us sink and some swim

TIM UTTON

18 July 2003
Daily Mail

LIFE can throw up some tough situations, with divorce, bereavement or losing a job being among the most difficult to cope with.

And whether our reaction is to sink into depression or bounce back from adversity could be down to a single gene.

Scientists have found that our DNA makeup affects how well we deal with such major personal events.

The gene called 5-HTT has two versions, 'sensitive' and 'coping'. Those with the first are two-and a half times more likely to succumb to black moods, sadness and insomnia.

However, those born with the coping version tend to stay on an even keel after stressful events.

Experts said the study proves for the first time a direct genetic link between distressing events and emotional wellbeing.

Researcher Dr Terrie Moffitt, of King's College London, said: 'We believe the gene helps influence whether people are resistant to the negative psychological effects of the unavoidable stresses of life.' Katrina Kelner, deputy editor of the journal Science, which publishes the study's
results today, said: 'This is tremendously exciting.

'We now understand the biological basis of some people's ability to bounce back successfully from adverse life events.' Researchers looked at the lives of 847 people over five years and studied how well they coped with prolonged illness, bereavement, redundancy and relationship breakdowns.

Along with colleagues in the U.S. and New Zealand, they focused on those who had suffered more than one such stressful event. Among people with the 'sensitive' version of 5-HTT, 43 per cent developed depression feeling permanently sad for at least two weeks.

But only 17 per cent of those who had the 'coping' version fell into melancholy, the same level as people who have not suffered any stressful events.

The 5-HTT gene regulates the flow of serotonin, a chemical messenger in the brain that carries signals between nerve cells.

The 'sensitive' version is not as effective at controlling the compound, affecting a person's emotional state.

Each person carries two versions of the gene, one inherited from each parent, which can be told apart by their length. The 'coping' version is 'long' and the 'sensitive' is 'short'. Those most at risk from stress were those who had two 'short' versions. Tests showed they were almost three times more likely to think of or attempt suicide than those with the two 'long' 5-HTT genes.

In the King's study, 17 per cent of individuals carried two 'short' copies while 32 per cent carried two 'long' copies. The others ranged between the extremes, carrying one of each.

Genetic mutation linked to depression - Researchers find inheritance factor in succumbing to life's woes.

By Tim Radford Science editor.
18 July 2003
The Guardian

A common mutation in a single gene could make the difference between fighting back against life's assaults and sinking into clinical depression, according to research out today.

The discovery could one day help to provide early warning of vulnerability to mental distress.

According to the World Health Organisation, at any time 120 million people experience the lethargy, constant sadness and recurrent thoughts of death that are symptoms of depression.

It is now the world's fourth leading cause of "disease burden" - the time spent by humans living with a given disability or sickness.

"If current trends continue by 2020 depression will be the first cause of disease burden worldwide, and in the developed world will be second only to heart disease," said Terrie Moffitt, a psychologist at King's College London and the University of Wisconsin-Madison.

A lifelong study of 847 people born 30 years ago in Dunedin, New Zealand, has focused on a serotonin transporter gene called 5-HTT.

Serotonin is one of the "mood signals" in the brain. The gene comes in two forms, known as short and long. Everybody inherits one copy from each parent, so a person will have two short copies, two long copies, or one of each.

Prof Moffitt and co-author Avshalom Caspi report in the journal Science that they talked to the volunteers over a five-year period about stresses including unemployment, money worries, physical illness, abuse, and broken relationships. They also watched for signs of depression.

The subjects who had inherited the short version of the 5-HTT gene were more likely to experience depression when things went wrong than those with the long version.

Of those with at least one copy of the short gene who had also faced a number of stressful events 33% became depressed. Among those with two copies of the short variant, and who also had multiple troubles in life, 43% became depressed.

Of those who faced similar challenges with two copies of the protective version of the gene, only 17% became depressed.

"We are not reporting a gene that causes disease," Prof Moffitt said. "Instead, we believe the gene helps influence whether people are resistant to the negative psychological effects of the unavoidable stresses of life."

The 5-HTT gene is unlikely to be the only gene involved in depression. Another, not yet identified, could explain why women seem more vulnerable than men.

The research is a reminder that biology is not destiny: some people with the weak form of the gene survived their troubles without being depressed, and some people with the strong form succumbed. But it reinforces the idea that human outcomes depend on a cocktail of genetics, environment and personal history, the researchers say.

Working with their volunteers in New Zealand, the two scientists last year identified another genetic variation which seemed to make some men more resilient to abuse or unhappiness during childhood, when other abused boys with a different form of the gene became violent or abusive later in life.

Like the 5-HTT gene, both variations were common - and they could only be detected against a background of stresses. In effect, nurture could be used to identify nature.

"Once people get the idea that studying environmental risks is a powerful research tool, there ought to be more success in finding undocumented relationships between genes and all sorts of diseases," said Prof Moffitt.

She and her colleagues hope that other researchers will confirm their findings. "This new knowledge could advance efforts to develop a diagnostic test of vulnerability to depression."

9. Afterword

During this PhD, I have learned just as much about doing research as I have of the particular research topic in the thesis. In the beginning of the project, I shared an office with a variety of laboratory scientists working within gene therapy, stem cell and heart failure research. I thank these people for the scientific insights they have given me. At the same time, I also became part of a wider community of science educators and social scientists whom I met at regular intervals. I therefore feel as though I have been in the middle of "two cultures"; sitting right in the thick of a scientific community, whilst working and thinking like a social scientist.

Before embarking on this project, I was not aware of just how many countless "mini cultures" there are in science: in biology, there are dozens of different definitions of a gene, depending on subfield. The more I discovered, the more surprised I was. I have also learned that there are many mini cultures within the social sciences: When I first became part of the science education community in Norway, my theories and ways of looking at things from a science communication perspective seemed a little exotic for my fellow PhD students there.

Lastly, in the arduous but somewhat exiting task of writing scientific papers, I have come to learn that nothing can be 100% perfect; it depends on how you view it. I do not dare say how many edits we have had of the papers, all the changes in style, perspective and focus each one has undergone. If it were not for deadlines, these things could still be evolving. So many questions arose underway that we could not afford time or space to answer, and there were so many avenues we could have gone down.

I

II

Quantitative Frame Analysis of How the Gene Concept is Presented in Tabloid and Elite Newspapers

Rebecca B. Carver, Einar A. Rødland and Jarle Breivik

University of Oslo

Corresponding author:
Jarle Breivik (MD, PhD)
Department of Behavioural Sciences in Medicine
Institute of Basic Medical Sciences
Faculty of Medicine, University of Oslo
Pb. 1111 Blindern, 0317 Oslo, Norway.
Email: jarle.breivik@medisin.uio.no

Rebecca Bruu Carver (M.Sc.)
Department of Behavioural Sciences in Medicine
Institute of Basic Medical Sciences
Faculty of Medicine, University of Oslo
Pb. 1111 Blindern, 0317 Oslo, Norway.
Email: r.b.carver@medisin.uio.no

Einar Andreas Rødland (PhD)
Department of Informatics
Center for Cancer Biomedicine
University of Oslo
NO-0316 Oslo, Norway.
Email: einarro@ifi.uio.no

Abstract

Tabloid and elite newspapers differ in journalistic style and address different socioeconomic segments of society. Few studies have systematically investigated how these differences influence science communication, and the issue of genetics is particularly relevant. In this study we performed a quantitative frame analysis of genetic discourse in twelve national newspapers that address different audiences. We found that tabloid and elite newspapers use different frames when communicating the gene concept. The differences were related to the use of expert writers and choice of topics, and we discuss how framing of the gene concept is related to the newspapers' editorial profiles.

Keywords: Genetics, Framing, Newspapers, Science Journalism, Quantitative Analysis

Introduction

After general education, the mass media are people's primary source of scientific information (Bauer, 2005; Nelkin, 1995; Petersen, 2001). The media set the public agenda, both shaping and reflecting people's perception and opinion of science. In a world where scientific knowledge is increasingly important for political as well as individual decision-making, it is therefore essential to understand how the media communicate scientific information.

Previous studies of science in the media have tended to focus on elite newspapers as they are believed to represent the opinion-leading voices of society (Eyck & Williment, 2003; Nisbet & Lewenstein, 2002). Little attention has been given to tabloid newspapers despite their large audiences and significant impact on the public agenda (Maeseele & Schuurman, 2008). Current science communication research may therefore give a biased picture of the media, primarily emphasizing the elitist perspective (Crawley, 2007; Maeseele & Schuurman, 2008; Priest & Ten Eyck, 2003).

Tabloid newspapers have readers with lower socioeconomic status than their elite counterparts (Chan & Goldthorpe, 2007) and in many aspects represent the voice of the general public. They are also characterized by their tendency for sensational journalism and are widely criticized for distorting people's perception of science. Although comparative studies are limited, there are thus good reasons to assume that there are significant differences in how the tabloid and the elite media present scientific issues.

In order to communicate science, or any other issue, information has to be organized (Entman, 1993; Goffman, 1974; Nisbet & Mooney, 2007). In media and communication studies, this process is generally referred to as framing. Different frames are manifested by the presence or absence of certain key words, phrases, images and sources of information (Entman 1993, p. 52), which in combination underpin a particular meaning and invite a certain interpretation (Priest, 1994).

How the media frame messages about genetics is particularly relevant as it may influence people's understanding of health and disease. In this study we therefore perform a systematic frame analysis of genetic discourse in newspapers that address different socioeconomic segments of society. We apply and evaluate a previously described coding scheme and present a quantitative measure of how different newspapers frame the concept of the gene. These measurements are then analysed for correlations to the socioeconomic status of the newspapers, as defined by the readers' level of education and income. Finally, we discuss the overall trends and the relation of framing to the newspapers' individual editorial profiles, and draw lines to the general challenge of socioeconomic differences in science communication.

Framing the gene

The use of the word *gene* to describe the unit of inheritance was introduced by Danish botanist Wilhelm Johannsen more than a century ago (Johannsen, 1909; Roll-Hansen, 1989). It is derived from the Greek *genesis* (birth), or *genos* (origin), and was originally an abstract concept. Today we know that genes correspond to physical entities within the cells of all biological organisms, and the relationship between genes and the DNA molecule underlies our understanding of everything from genetically modified food and forensic investigations to prenatal diagnostics and cancer research.

We are in the midst of a biotechnological revolution (Gerstein et al., 2007), and the concept of the gene has gained an increasingly more central position in society. It has moved from the textbooks of biology and the occasional science pages of newspapers, into the business sections, the crime investigations, the health pages, as well as reports on politics and entertainment. The gene is part of the common vernacular and appears in the media on a daily basis.

Only a few studies have analysed how the gene concept is presented in the media. Nelkin and Lindee (1995) reviewed gene-related discourse in American popular culture during the 1990s. They concluded that the gene has become a powerful symbol of an entity that determines our lives and introduced the term "genetic essentialism" to represent this belief that we are governed by our genes. Conrad (2001) similarly examined the news coverage of genetics and mental illness in U.S. newspapers between 1987 and 1994. He found that the reports were characterized by the assumption that mental illnesses will be resolved through genetic research, and as a parallel to Nelkin and Lindee's concept of "genetic essentialism", he introduced the term "genetic optimism" to describe the dominating news frame.

The study by Nelkin and Lindee and the study by Conrad both implement genetic determinism as a key element in the media's coverage of genetics. This deterministic perspective implies that our lives are largely determined by our genes. It may be exemplified by statements such as “Scientists have found the gene for alcoholism” and “Your genes are making you fat”. Such deterministic claims involve a simplified and misleading representation of genetic causation and have been particularly related to tabloid style reporting (Hubbard & Wald, 1993; Nelkin & Lindee, 2004; Nelkin, 1994).

Criticism of the media for promoting genetic determinism has to some extent been countered by Condit, Ofulue and Sheedy (1998). Based on a systematic content analysis of American newspapers and magazines published during 1919-95, they found a more nuanced representation of genetic causation and a decrease in the propotion of deterministic claims. Condit (2007) later proposed that there are several “gene frames” in the media, and besides a “genes win frame” related to genetic determinism, she proposed a “gene versus environment frame”, which focuses on the conflict between genetic and environmental explanations, and a “gene-environment interaction frame”, which presents genetic causation as a dynamic process also involving environmental factors.

Building on the idea that there are several ways of framing the gene concept in the media, Carver, Waldahl and Breivik (2008) performed a systematic, deductive frame analysis of gene-related articles in British and Norwegian newspapers. The resulting framing scheme, which forms the basis for this quantitative study, comprises elements from Nelkin and Lindee’s (1995) as well as Condit’s (2007) perspectives, but also included some new elements.

Contrary to the concept of “genetic essentialism”, which combines symbolic and deterministic representations of the gene concept, Carver et al. (2008) found that these two perspectives could be clearly distinguished. The point may be illustrated by the differences between the phrases “Researchers have found the gene for breast cancer” and “I have inherited the shopping gene from my Mom”. Although both statements literally describe the gene as the causal agent, they differ in both context and meaning. Whereas the first phrase refers to actual research and uses the gene concept as a scientific term, the second phrase uses the gene concept in a casual and unscientific manner and describes a characteristic that most people would agree is more dependent on cultural than genetic inheritance. Although it is possible that the person actually believes that there is a single gene that determines the desire to go shopping, the context indicates that the utterance is meant as an informal and humoristic matter of speech to symbolize cultural belonging.

Based on these considerations, Carver et al. (2008) defined two separate frames: the *symbolic frame*, which uses the gene as a metaphor or a rhetorical device to indicate relationship, and the *deterministic frame*, which concerns actual genetic causation. The deterministic frame also includes discourse that presents genetic influence in opposition to environmental factors like “Forget your genes, it's the food you eat that makes you fat” and thereby comprises both the “gene versus environment” and the “genes win” frame proposed by Condit (2007).

Carver et al. (2008) also identified a gene frame which uses keywords like “chance” and “risk” or phrases like “linked to”, “involved in” and “predisposing for” to indicate genetic causation, e.g. “Genes increase risk of developing cancer” or “Some people have a genetic predisposition for putting on weight”. Contrary to the deterministic frame, this frame implies some level of uncertainty and dependency. It indicates that there are other factors involved, but gives no clues as to what this external influence might be. Carver et al. named this the *relativistic frame*.

The relativistic frame was further distinguished from discourse that explicitly presents the gene as an actor in an environmental context. This frame is similar to Condit’s (2007) “gene-environment interaction frame”, but Carver et al. (2008) chose to call it the *evolutionary frame* in order to signify its dynamic properties and relation to Darwinian explanations. This point is illustrated by claims like: “Women are attracted to tall men for flings as their looks are a sign of healthy genes” and “Comparison between human and ape DNA reveals that some human and ape genes evolved very swiftly”. The evolutionary frame also comprises aspects related to gene regulation, such as “It seems that only under dire circumstances - abuse, the strife of war, chronic stress - is the ‘depression gene’ triggered”.

Finally, Carver et al. (2008) identified a frame which underscores the physical properties of the gene. This *materialistic frame* is characterized by references to DNA, specific genes, chromosomes or proteins and is related to textbook definitions, which describe the gene as a physical entity that carries heritable information. It often appears in articles about genetic engineering that talk of identifying and manipulating genes, and may be used to support or strengthen other frames. A deterministic claim, for example, may appear as more powerful if the gene is pinpointed to a specific chromosome or produces a particular protein, e.g. “NPC is caused by a mutation in a gene on chromosome 18. Children with the disease have inherited two copies of the abnormal gene”.

Altogether, Carver et al. (2008) developed a framing scheme that classifies genetic discourse into five distinct gene frames (summarized in Table 1).

Research question and hypothesis

In this exploratory study we applied the framing scheme of Carver et al. (2008) as a tool for quantitative comparison of genetic discourse between different media. Our general research question was: Do tabloid newspapers (with readers of low socioeconomic status) use different gene frames than elite newspapers (with readers of high socioeconomic status)?

First of all, we wanted to explore the validity of the framing scheme and the distinctions between the five gene frames. We asked if the different frames could be consistently distinguished by independent coders and were particularly interested in the distinction between the deterministic and the symbolic frame. We also looked for patterns in how the frames were used separately or in combinations within the same article.

Based on the previous claims of a connection between genetic determinism and sensational style reporting (Hubbard & Wald, 1993; Nelkin & Lindee, 2004; Nelkin, 1994), we specifically hypothesized that the deterministic frame would be more common in the tabloids than the elite newspapers. Conversely, we predicted that elite newspapers use more scientifically advanced perspectives, like those comprised by the evolutionary and the materialistic frame.

Finally, we asked if possible differences in genetic discourse between tabloid and elite newspapers could be related to different editorial profiles, particularly concerning the use of expert writers, choice of topics and type of articles.

Material and Methods

Selection of Newspapers

In order to identify general trends, independent of journalistic niches and possible cultural biases, we decided to analyse major national newspapers from different countries. Newspapers from the US and UK were included to give a broad representation of the English context, whereas France and Norway represented different cultural and linguistic traditions within Europe.

The common characterization of newspapers as either tabloid or elite is based on poorly defined criteria and may reflect a newspaper's physical format as well as its journalistic style and tradition. We therefore decided to classify the newspapers by their socioeconomic status, and based on previous research (Chan & Goldthorpe, 2007), we chose reader education as the primary variable.

Readership survey data was accessed for each of the four countries (UK: National Readership Survey April 08-March 09 (readership, population and income data) and July 07-June 08 (education data), US: Scarborough release 1-2008 (*The New York Times* and the *New York Daily News*) and Scarborough ABC Reader Profiles 2003-2004 (*USA Today* and population totals), Norway: Forbruker & Media 08/2, France: TNS SOFRES-EPIQ 2007-2008).

Based on the newspapers' percentage of readers in the highest education category, we selected one elite, one mid-range and one tabloid newspaper from each country (Table 2).

Selection of articles

Newspaper articles were accessed in text-only format through the web services *Factiva* for French, UK and US newspapers and *Atekst* (Retriever) for the Norwegian newspapers. In order to capture the current context, the selection of articles was limited to three recent years of publishing (July 2005 -July 2008). We included all types of articles published in print and limited the selection to items that contained the various forms of the word gene: "*gene* OR *genes*" for British & US newspapers, "*gène* OR *gènes*" for French and "*gen* OR *gener* OR *genet* OR *genene*" for Norwegian newspapers. From this search result, we then randomly selected fifty gene-related articles by picking items at regular intervals (total hits divided by 50). Articles that used 'gene' only as a name, e.g. in the title of a TV programme or for the actor 'Gene Hackman', were omitted, and the next article was selected.

Frame analysis

In media communication, frame analysis is the process of exploring underlying meaning in discourse by systematically identifying patterns in the use of certain words, phrases, images and sources of information. Such key items in a text are generally referred to as framing devices (Entman, 1993), and in combination they define a particular frame.

Inductive frame analysis is the process of defining new frames by identifying and categorizing the related framing devices. It is usually based on qualitative assessment and results in a framing scheme, which may be used as a reference for further studies. Deductive frame analysis, on the other hand, applies an already established framing scheme to identify the presence of particular frames in a material. A previously defined framing scheme may thus be applied to quantify the occurrence of particular frames in a sample.

In this study we applied the framing scheme developed by Carver et al. (2008) as basis for a quantitative frame analysis of gene-related newspaper articles. From this scheme, we developed a coding book that defines the five frames by characteristic examples, their overall depiction (meaning) and their association with typical framing devices as summarized in Table 1.

Four coders were recruited based on relevant academic background and language skills. They received the coding book and were trained in identifying the five frames. The main criterion for coding a frame was that a sentence or quote conveyed the overall meaning of the gene, e.g. depicting it as a physical entity or a relative risk factor. Not all framing devices presented in Table 1 had to be present to identify a frame, and the sentence did not have to explicitly contain the word 'gene'. It could also refer to it indirectly.

In line with other studies, Carver et al. (2008) found that a single article may include more than one frame. Coding for just the dominant frame can thus ignore important nuances in the text (Matthes & Kohring, 2008). In order to avoid 'forcing' the article into a single category, the coders were therefore instructed to code for up to three gene frames in each article and to rank them according to salience (prominence). The dominant frame is typically the one expressed in the headline and opening paragraph (Kitzinger, 2007), whereas the secondary and tertiary frames are less prominent and usually found in the latter parts of an article (Petersen, 2001). We could have asked the coders to assign each frame a percentage presence (0-100), but judged that to be more complicated and less reliable than asking them to provide an ordered list.

The material was distributed between the coders (the four recruited coders plus the first author) based on language skills. In order to visualize the coding, the coders were instructed to mark the individual framing devices with different text-highlighting colours. Each of the five frames was assigned a specific colour (as in Figure 1). The coders' basis for determining and ranking the frames in an article could thus be easily recognized and were kept electronically for documentation.

Additional coding

In addition to coding for the five gene frames, the coders were instructed to identify the type of author, the type of article, and the topic of each article. Types of authors included 1) general journalist, 2) science journalist, 3) scientific expert or 4) other. Types of article included 1) feature article, 2) news & briefs, 3) commentary, 4) interview or 5) other. Types of topics included 1) general science (and medicine), 2) genetics, 3) culture and society, 4) sports and cars, and 5) other.

Data analysis

In order to account for the presence of multiple frames within an article, the frames were weighted based on their salience. The secondary frame was weighted by half the value of the primary frame, and the tertiary frame was weighted by half the value of the secondary frame. Accordingly, when only one frame was present in an article, this frame was weighted by a factor of 1. When two frames were present, the primary frame was weighted by 2/3 and the secondary by 1/3, and when three frames were present, the primary frame was weighted by 4/7, the secondary by 2/7, and the tertiary 1/7. For each newspaper, we then computed the percentage of articles in each frame, hereafter called the "frame usage".

In order to make reader income and education comparable across the countries, we calculated a factor that measures the income and education level of each newspaper's readers relative to the rest of the population. The categories were arranged in increasing order and described in terms of population percentiles (lowest educated as 0th percentile, highest educated as 100th percentile). We then estimated the change in readership frequency with increasing income or education using log-linear regression[1]. The resulting indexes (as shown in Table 2) represent the ratio of readership at the 100th percentile compared to the 0th percentile as estimated by the regression curve. For example, *Le Monde* has an index for reader income of 7.9, which indicates that readers with high income read *Le Monde* roughly eight times as often as readers with low income.

The relationship of frame usage to reader income and education was analysed using Spearman correlations. We chose Spearman (rather than for example Pearson) in order to neutralize the effect of extreme values or large variances. Given the small number of newspapers (n=12), correlations must be fairly strong in order to be statistically significant ($p<0.05$).

The frame usage captures the prominence of the five frames within our sample of gene-related articles, but does not take into account how frequent gene-related articles are in each newspaper as a whole. Based on our procedure for selecting articles, we therefore estimated the total number of gene-related articles in each newspaper.[2] This estimate was subsequently multiplied by the frame usage to obtain the overall percentage of each frame. As above, we then analysed for correlations with reader income and education.

The frequency of author types, article types, and topics in each newspaper were analysed for correlation to reader income and education using Spearman correlation (n=12).

Validation of coding scheme

The articles were coded for up to three gene frames, which were ranked by their relative salience. Of the articles, 66% had only one frame, 22% had two frames and 12% had three frames. The symbolic frame stood out by rarely appearing in combination with other frames. Only 6% of the articles that used the symbolic frame also contained other frames. In contrast, the four other frames usually appeared in some kind of combinations, but there were no clear patterns in which frames appeared together or in which order of salience.

In order to assess inter-coder agreement, a random subset (44%) of the articles was re-coded by a second coder. Cohen's kappa was calculated, taking account of the coding of multiple frames in an article. Full agreement thus implied that the two coders had coded the same frames with identical ranking of salience, whereas the same frames coded with different rank order resulted in partial agreement[3].

The overall inter-coder agreement was 74% (kappa=0.64). In order to explore the level of inter-coder agreement and disagreement between the individual frames, we focused on the coding of the dominant frame (Table 4). The symbolic frame stood out with the highest level of agreement between coders (94%), whereas the deterministic frame had the lowest (56%). The most common disagreement was between the deterministic and the materialistic frame, whereas there was particularly little disagreement between the evolutionary and the relativistic frame.

Results

Correlation between gene frames and socioeconomic status

The primary results are presented in Figure 1, which illustrates the use of the five gene frames relative to the newspapers' percentage of gene-related articles and the socioeconomic status of the readers. The most apparent trend was that the symbolic frame was the most frequent gene frame in newspapers with readers of low education (corr= -0.81, $p = 0.0014$), whereas the evolutionary and the materialistic frame were the most frequent gene frames in newspapers with readers of high education (corr = 0.70, $p = 0.011$ and 0.69, $p = 0.013$ respectively). Similar, but weaker correlations were seen for reader income. Further comparisons between tabloid and elite newspapers therefore refer to differences in reader education.

The primary difference between tabloid and elite newspapers may be illustrated by the two extremes: *The Sun* (UK) had the lowest educated readers and used the symbolic frame in 47% of all gene-related discourse, whereas the evolutionary and the materialistic frame comprised 15%, combined. Conversely, *Le Monde* (Fr) had the highest educated readers and used the symbolic frame in only 18% of all gene-related discourse, whereas the evolutionary and the materialistic frame comprised 55%.

The correlation between elite newspapers and the evolutionary frame remained significant also when adjusting for the percentage of gene-related articles in the newspapers, (corr = 0.64, $p = 0.024$), whereas the correlation with the materialistic frame became somewhat weaker (corr = 0.51, $p = 0.09$). As for the symbolic frame, the correlation with tabloid newspapers almost disappeared entirely when adjusting for the percentage of gene-related articles in the newspapers (corr = -0.05, $p = 0.88$).

Relative to the total number of articles (not just gene-related articles) the elite newspapers thus used the symbolic frame just as often as the tabloids newspapers. This effect could be related to a higher percentage of gene-related articles in elite newspapers (corr = 0.44, $p = 0.15$). The primary trend in the material was therefore that the elite newspapers tended to write more articles that used the evolutionary and the materialistic frame, whereas the symbolic frame dominated in the tabloids.

Contrary to expectations, we found no overrepresentation of the deterministic frame in the tabloid newspapers. In total, this frame accounted for only one sixth of the gene-related discourse and appeared with similar frequency in *The Sun* (ultra tabloid) as in *Le Monde* (ultra elite). Similarly, there was no correlation between socioeconomic status and the relativistic frame.

Relation to topic, author and type of article

How the five gene frames were used in relation to different topics, types of authors and types of articles is presented in Table 3. Although the majority of articles in our sample (n=600) concerned general science or genetics, there was also a substantial fraction of articles concerning non-scientific topics. Elite newspapers had more gene-related articles specifically concerning genetics (corr=0.74, p=0.006) and less concerning culture and society (corr=-0.56, p=0.06), whereas for general science (corr=0.22, p=0.5) and sports & cars (corr=-0.42, p=0.2) there was no clear trend.

Nearly half of the articles were written by general journalists, a quarter by science journalists, and a smaller fraction were written by scientific experts. The elite newspapers had more articles written by science journalists (corr=0.64, p = 0.024) and scientific experts (corr=0.67, p =0.017), and fewer articles written by general journalists (corr = -0.76, p = 0.0045).

Most of the articles were news and briefs or feature articles, followed by commentaries and interviews. The elite newspapers had a slight overrepresentation of commentaries, although this was not significant (corr=0.55, p=0.06).

In accordance with its contextual definition, the symbolic frame was clearly overrepresented in articles concerned with non-scientific topics and very rare in articles about general science or genetics (Table 3). It was seldom used by science journalists or scientific experts and was most common in interviews. The materialistic frame was most common in articles written by science journalists, whereas the evolutionary frame was most common in articles written by scientific experts and was usually in the format of commentaries or feature articles. The differences in frame usage between the newspapers could thus be related to different editorial profiles, including selection of topics and formats, as well as the use of expert writers.

Discussion

Strengths and limitations of coding scheme

In this study we have explored differences in how tabloid and elite newspapers frame the concept of the gene. We used a predefined coding scheme that categorized genetic discourse into five gene frames (Table 1). The strengths and limitations of this coding scheme are reflected by the inter-coder agreement and disagreement between the different frames (Table 4) and call for further discussion of the different categories.

There was particularly high agreement related to the symbolic frame, which also stood out by rarely appearing in combinations with the other frames. This frame uses the gene concept in a non-scientific manner to signify relations or belonging and was easily distinguished by both context and meaning. It was also clearly distinguished from the deterministic frame, which refers to actual science and implies a direct causal relationship between genes and traits. This distinction is important as previous studies have combined symbolic and deterministic discourse under the term "genetic essentialism" and have criticized the media for misleading public perceptions of genetics.

We, on the other hand, believe that symbolic phrases like "Mazda has many Ford genes" or "I have inherited the shopping gene from my Mom" entail very different meanings to the gene concept than a deterministic statement like "Researchers have found the gene for breast cancer". Although we do not know how readers mentally interpret the symbolic gene frame, it seems clear that it is not intended as a claim that our lives are determined by genetics. Based on our finding that the symbolic and deterministic frames are easily distinguished, we argue that future studies of genetic discourse should take account of this distinction.

The deterministic frame, as defined by Carver et al. (2008), is in itself an ambiguous category. As has also been argued by Condit et al. (1998), there is a distinction between making a deterministic statement about traits that are closely related to a particular genetic mutation (like cystic fibrosis) and phenomena that are obviously governed by complex interactions between genetic and environmental factors (like obesity). In order to get a more nuanced picture, future studies may therefore consider a coding scheme that distinguishes between what we may call "reasonable" and "deceptive" determinism.

The inter-coder agreement also demonstrated a clear distinction between the relativistic and the evolutionary frame. Even though they both present genetic causation in a non-deterministic manner, they represent very different ways of communicating the gene concept. A relativistic statement like "Scientists have identified a genetic factor that is linked with a 20% to 30% increased risk of developing bowel cancer" gives some sense of complex causation, but does little to enlighten the reader about underlying explanations.

The evolutionary frame, on the other hand, concerns interactions and mechanisms. It presents genes and environmental factors in concert and may appear too complicated for the general audience. Yet, even simple phrases like "most people carry the genes of many races" or "there are genes that allow learning" convey profound biological insight. Particular attention should therefore be devoted to the variations, limitations and applications of the evolutionary frame.

The distinction between the deterministic and the relativistic frame was also quite clear. Importantly, however, this border is easily crossed. A relativistic statement like "Scientists have discovered a variant gene that leads to a sizable extra risk of Type 2 diabetes" may very easily be converted to the headline "Scientists have discovered the gene for diabetes". Such deterministic conversions may take place during the journalistic process or perhaps also in the mind of the reader. Although a relativistic framing of the gene concept may be regarded as scientifically and semantically correct, the effect is not necessarily very different from that of a clear-cut deterministic statement. The relativistic to deterministic conversion of genetic discourse may thus be a subject for further investigation.

The least clear distinction appeared between the deterministic and the materialistic frame. These two frames are closely related and may appear together in the same sentence: "NPC is caused by a mutation in a gene on chromosome 18." They may thus be difficult to distinguish, and one may argue that they should be regarded as one frame. Still, the notion that genes are physical structures is highly fundamental and independent from the concept of genetic determinism. Indeed, we found the materialistic frame in combination with both the relativistic and the evolutionary frame, and it also appeared alone. Although the materialistic frame is often related to other frames and may be difficult to distinguish, we therefore believe that it represents an important dimension in genetic discourse and should be considered in future studies.

Combined, the five gene frames encompass several fundamental aspects of genetic discourse. They define boundaries and transitions in a complex and important field of science communication and are conceptually easy to recognize. Although the categories are not always unambiguous, and should stay open for discussion, we believe this coding scheme offers an applicable tool for systematic analysis of gene-related communication.

Framing and socioeconomic status

Few studies have systematically investigated differences in how the elite and tabloid media present scientific issues. In this study, we have quantified such differences using the framing of the gene concept as an indicator. In order to identify the general trends and control for possible cultural biases, we chose to analyse major national newspapers from four Western countries. The selected newspaper are dominating actors also in the digital media market, and we believe the material of 600 randomly selected, gene-related articles gives a representative picture of current trends in public genetic discourse.

We found that a conventional classification of newspapers as elite, mid-range or tabloid had limited value in an international context. In order to differentiate between newspapers addressing different segments of society, we therefore used the readers' socioeconomic status, measured by their level of education, as the key parameter. Adjusted for the overall level of education in each country, this approach offered a methodological way of ranking the newspapers. Still, there may be other differences in readership demographics between the countries, and the statistical correlations should be interpreted with some caution.

The most striking finding (Figure 1) was the overrepresentation of the symbolic frame in tabloid newspapers. This frame uses the gene in a non-scientific and often humoristic manner, and coincides well with an editorial profile that aims to entertain rather than to inform. Importantly, however, the overrepresentation of articles using the symbolic frame could be explained by the low number of other gene-related articles in the tabloid newspapers. Relative to the total number of articles (not just gene-related articles) the elite newspapers used the symbolic frame just as often as the tabloids. The tendency for using the gene as a symbol of relationship thus appears as a widespread phenomenon in the media. In line with the perspective of Nelkin and Lindee (1995; 2004), one might say that the gene has evolved out of its scientific domain and has become a versatile icon in popular culture. Still, we believe that this casual use of the gene concept should be clearly distinguished from the ideas of genetic determinism.

Contrary to expectations, we found no overrepresentation of the deterministic frame in the tabloid newspapers. When symbolic representations are categorized separately, there is thus little evidence for linking genetic determinism to tabloid journalism. There is also little evidence linking determinism to particular author types. Even if we exclude the symbolic frame from the results, the science journalists and scientific experts used the deterministic frame just as often as general journalists. Overall, the deterministic frame only accounted for one sixth of the genetic discourse, and as discussed above, some of these deterministic claims may be considered reasonable. The results thus suggest that previous accounts of genetic determinism largely concerned symbolic representations of the gene, whereas actual claims of genetic determinism are less common in public discourse.

The overrepresentation of the evolutionary and the materialistic frame in the elite newspapers were present also when adjusting for the overall number of gene-related articles. Whereas tabloids predominantly use the gene as a playful symbol, the elite newspapers tend to present it as a molecular and interactive entity. Our key finding is therefore that people of different socioeconomic status, who read different newspapers, encounter very different pictures of what a gene is.

How these differences in gene framing affect the readers' understanding of genetics, we do not know. Do people who get their scientific information from tabloids think of genes merely as a figure of speech, something abstract and intangible, or do they also perceive them as physical and interactive entities? Do they realise from the context that the "shopping gene" implies something fundamentally different than the "cystic fibrosis gene", or does the dominant position of the symbolic frame also influence people's understanding of scientific and medical information? These questions may be explored by studying people's reception of texts that use different gene frames and may give further insight into public understanding of genetics.

Relation to editorial profile

The use of particular gene frames was clearly related to topic. Most obviously, the symbolic frame was strongly overrepresented in articles about culture & society, and sports & cars (the non-scientific topics). This relationship emphasizes the contextual characteristics of the symbolic frame and also underlies the primary differences in the gene framing between tabloid and elite newspapers. How the gene concept is presented in different media may thus be seen as a reflection of their editorial profile.

The materialistic and evolutionary frames were both overrepresented in elite newspapers, but were clearly related to different types of authors (Table 3). Whereas the science journalists preferred the materialistic frame, the scientific experts preferred the evolutionary frame. It is thus primarily the science journalists that drive genetic discourse in a molecular and "reductionistic" direction, whereas the scientific experts promote a more systems-oriented perspective. This difference may be related to the coverage of different topics, but may also suggest that the science journalists are lagging behind current genetic paradigms. Our results, and the underlying framing scheme, may thus serve as a means of reflection in the field of science journalism.

Looking at the frame usage of individual newspapers, there were also interesting connections to the editorial profiles. The *Daily Mail* scored low on reader education and income, but had an exceptionally high percentage of gene-related articles. This deviation from the general trend may be related to the newspaper's particular attention to females and health. Yet, in accordance with the low socioeconomic status of its readers, the *Daily Mail* often used the symbolic frame and hardly ever used the evolutionary frame.

Le Figaro stood out as an elite newspaper with relatively few gene-related articles, but which predominantly used the materialistic frame. This distinctive characteristic may be related to the newspaper's business-oriented profile and use of science journalists. Similarly, *Aftenposten* had the highest usage of the evolutionary frame, which may be related to the newspaper's strong attention to public debate, including numerous essays and commentaries by scientific experts. Finally, the *New York Daily News*, which is known for its extensive coverage of sport, entertainment and gossip, had an exceptionally high proportion of articles using the symbolic frame.

Overall, there thus appears to be good correspondence between the newspapers' socioeconomic and editorial profile, on one hand, and their use of the five different gene frames, on the other. One might say that we have mapped the "gene profile" of the newspapers.

Conclusion

In this study we have investigated how tabloid and elite newspapers frame the concept of the gene. First, we demonstrate that the applied framing scheme offers a reproducible method for analysing the underlying meaning of genetic discourse. This scheme comprises five distinct categories and incorporates several fundamental issues concerning the understanding of genetics. In particular, we demonstrate a clear distinction between the symbolic frame, which uses the gene in a casual and non-scientific manner, and the four other gene frames. Nonetheless, we emphasize that these categories are open for discussion and should be regarded as a pragmatic tool for structuring the different meanings of the gene concept.

Second, because we distinguished between the symbolic and the deterministic frame, we found that actual deterministic claims only accounted for one sixth of the gene-related discourse and were as frequent in elite as in tabloid newspapers. Previous criticism of the (tabloid) media for promoting genetic determinism may therefore be exaggerated.

Third, we show that tabloid and elite newspapers present very different pictures of what a gene is. These differences in how the gene concept is communicated to different segments of society may have implications for people's understanding of genetics. They play into the general socioeconomic barriers in science communication and may be further explored by studying how people of various levels of education interpret the different gene frames.

Finally, this study shows that the general characteristics of a media outlet may be reflected by the framing of a single scientific concept. How often each gene frame was used by a newspaper was not random and could be related to its overall editorial profile. These results draw attention to the important role of framing in science communication and provide a basis for further investigations.

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Table 1: *Gene framing scheme*

Gene frame	Depiction	Keywords & phrases	Metaphors	Examples
1.Symbolic	An abstract representation of relationship	"it must be in the genes"		"Fashion has always been in my genes" "Mazda has many Ford genes"
2.Deterministic	A definite causal agent	"gene for", cause, control, culprit, blame, disease-gene, responsible, born with, no choice, "genes or environment"	like a computer program recipe/instruction manual	"Scientists have found the gene for breast cancer" "It's either because of genes or diet"
3.Relativistic	A predisposing factor	influence, disease risk, chance, factor, associated with, susceptible to, linked to, contribute, predispose		"Genes double risk of breast cancer" "The genes linked to type 2 diabetes were recently shown to play a role in prostate cancer"
4.Materialistic	A discrete physical unit	DNA, chromosome, identify, locate, protein, mutation.	alphabet, book, map, code, beads on string	"Genes are digital codes written on DNA molecules" "The key gene was injected into the muscle cell"
5.Evolutionary	A dynamic agent interacting with the environment	interact, in combination with, expression, genes and environment	like a switch or tap the selfish gene	"Many genes have survived millions of years of evolution, but small changes have sometimes led to dramatic differences between related species." "Mother's food turns genes on and off"

Note. Adapted from Carver et al. (2008)

Table 2*: Newspaper information*

Newspaper by Country (pop. base)	**Daily readership**	**Reader Education Index**	**Reader Income Index**	**Scientific profile**
US (219,069,300)				
The New York Times	4,562,142 (2.1%)	69.6	30.3	Major quality newspaper, known worldwide for its in-depth news coverage; it has a daily science news section, a science editor and numerous science reporters.
USA Today	7,080,100 (3.2%)	9.0	9.4	Broadsheet with a degree of tabloidization; no designated science section or science editor, though the section "Your Life" has a health focus; it has several science and health reporters.
New York Daily News	2,551,719 (1.2%)	0.9	6.0	USA's largest circulating tabloid newspaper; focus on sport, entertainment and gossip news; includes a health section, but does not have a science or health editor, or any science reporters.
UK (49,206,000)				
The Guardian	1,148,000 (2.4%)	111.3	5.7	Respected newspaper, particularly for its science reporting; has a science editor and numerous science correspondents, and a daily news section dedicated to science; weekly technology supplement.
Daily Mail	4,747,000 (9.6%)	0.8	1.0	Mid-market tabloid catering especially to a female audience; it has a weekly health supplement; science editor; numerous health and science reporters; weekly section on body and health.
The Sun	7,821,000 (15.9%)	0.1	1.0	Red-top tabloid, renowned for its sensationalist style, its focus on sports and celebrities; it has a designated health editor, but no science column or section.

France (49,958,000)				
Le Monde	2,066,000 (4.1%)	249.4	7.9	Well-respected elite newspaper, renowned for its coverage of culture and politics; it has a daily science section, a science editor and numerous science journalists.
Le Figaro	1,285,000 (2.6%)	49.7	9.2	Well-respected newspaper with a focus on economics; it also has a daily science section, a science editor and science correspondents, and a weekly supplement with articles from The New York Times.
Aujourd'hui en France	2,269,000 (4.5%)	1.3	2.7	Largest national daily newspaper in France with a focus on celebrity news and sports; no science or health section, but has health reporters and sporadic health-related news.
Norway (3,829,794)				
Aftenposten	716,982 (18.7%)	9.3	3.8	Norway's leading elite newspaper with a broad editorial profile; it has a weekly supplement with a science section; some science journalists write for this, occasionally larger science features; no science editor.
Dagbladet	621,571 (16.2%)	2.9	3.7	Tabloid newspaper with a somewhat academic reputation; particular focus on culture and debate; no designated science section; increasing attention to health and life style.
VG	1,136,363 (29.7%)	0.6	1.6	Classic tabloid newspaper with sensational headlines and celebrity gossip, yet respected for its critical journalism; no science section; increasing attention to health and life style.

Note. Values for reader income and education indicate how much readership increases from the lowest to the highest income/education level.. For example, the factor of 9 for *USA Today* indicates that the highest educated persons in the population read the newspaper 9 times as often as the lowest educated persons. Readership percentages are relative to the population base (all adults 18+ for US; all adults age 15+ for the other countries). For data sources, please see the section Selection of Newspapers.

Table 3: *Frame usage related to topic, author and type of article (based on n=600)*

	Sym	Det	Rel	Mat	Evo	Total
Total	**190.8 (31.8%)**	**97.0 (16.2%)**	**81.2 (13.5%)**	**153.5 (25.6%)**	**77.4 (12.9)**	**600.0 (100%)**
Topic						
Culture & society	134.1 (73.3%)	19.6 (10.7%)	2.0 (1.1%)	14.2 (7.8%)	13.0 (7.1%)	183.0 (100%)
General science	3.3 (1.3%)	54.3 (21.5%)	53.9 (21.3%)	91.0 (36.0%)	50.5 (19.9%)	253.0 (100%)
Genetics & GMO	0.4 (0.5%)	15.5 (16.8%)	21.9 (23.9%)	42.2 (46.9%)	11.0 (12.0%)	92.0 (100%)
Sports & cars	51.0 (83.6%)	4.7 (7.7%)	1.7 (2.7%)	3.7 (6.0%)	0.0 (0 %)	61.0 (100%)
Other	2.0 (18.2%)	2.9 (26.4%)	1.7 (15.2%)	1.5 (13.4%)	3.0 (26.9%)	11.0 (100%)
Author type						
General journalist	153.7 (53.0%)	38.1 (13.2%)	27.0 (9.3%)	43.9 (15.1%)	27.2 (9.4%)	290.0 (100%)
Science journalist	1.4 (0.9%)	29.8 (19.4%)	25.6 (16.6%)	70.6 (45.9%)	26.5 (17.2%)	154.0 (100%)
Scientific expert	2.0 (5.0%)	8.3 (20.7%)	6.3 (15.8%)	10.7 (26.8%)	12.7 (31.7%)	40.0 (100%)
Other or unknown	33.7 (29.0%)	20.7 (17.8%)	22.2 (19.2%)	28.3 (24.4%)	11.1 (9.6%)	116.0 (100%)
Article type						
Commentary	32.3 (40.4%)	10.1 (12.6%)	6.7 (8.4%)	12.5 (15.6%)	18.3 (22.9%)	80.0 (100%)
Feature	61.5 (28.1%)	31.4 (14.3%)	32.2 (14.7%)	55.4 (25.3%)	38.5 (17.6%)	219.0 (100%)
Interview	52.5 (73.9%)	7.7 (10.8%)	2.4 (3.4%)	6.3 (8.9%)	2.1 (3.0%)	71.0 (100%)
News & briefs	23.3 (11.9%)	45.5 (23.3%)	36.6 (18.8%)	73.1 (37.5%)	16.5 (8.5%)	195.0 (100%)
Other	21.3 (60.8%)	2.3 (6.5%)	3.3 (9.5%)	6.2 (17.7%)	1.9 (5.4%)	35.0 (100%)

Note. Number of articles per frame is presented with decimals due to weighting of frames (see Methods)

Table 4: *Inter-coder agreement for dominant frame*

		Coder 2				
		Sym	Det	Rel	Mat	Evo
Coder 1	Sym	**77 (94%)**	4 (5%)	0	0	1 (1%)
	Det	2 (4%)	**27 (56%)**	1 (2%)	11 (23%)	7 (15%)
	Rel	0	6 (17%)	**23 (66%)**	4 (11%)	2 (6%)
	Mat	0	11 (18%)	3 (5%)	**40 (66%)**	7 (11%)
	Evo	1 (3%)	4 (12%)	0	6 (18%)	**23 (68%)**

Note. Bold numbers represent agreement; percentages calculated per row; n=260.

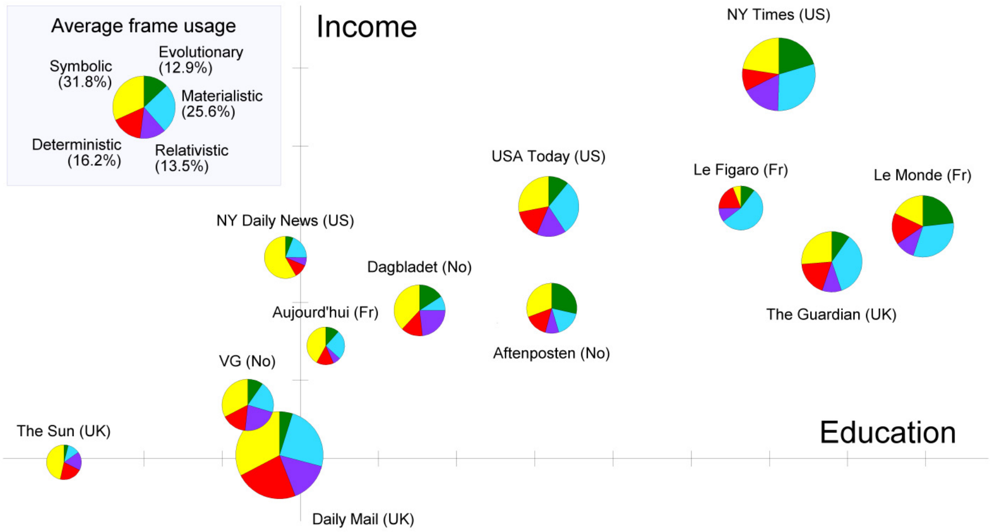

Figure 1. Newspaper gene framing relative to reader income and education. The upper left pie chart indicates the overall use of the five gene frames in the material of gene-related articles (n=600). The other pie charts represent the frame usage in the individual newspapers. The size of the pie chart represents the estimated percentage of gene-related articles in the newspaper; newspapers that have many gene-related articles have large charts, those that have few have small charts. The area of each sector thereby corresponds to the estimated percentage of all articles in a newspaper that uses the particular gene frame. Newspapers are organized according to the socioeconomic status of their readers as measured by level of education and income: low status tabloids at the bottom-left, high status elite newspapers at the top-right. At the axes' origin, readership depends on neither income nor education. Each tick on the axes represents a doubling in how much readership changes with education and income, respectively (see Material and Methods).

Footnotes

[1] We ordered the categories by increasing household income or education and used a linear regression model of the log odds ratio of readership per category for the newspapers compared to the general population. The median percentile per category was used as regressor. If p_i is the percentage of readers and q_i the percentage of the population in category i, we thus use the model $\log(OR_i) \sim Q_i$ where $OR_i=[p_i/(1-p_i)]/[q_i/(1-q_i)]$ and the median percentile $Q_i=q_1+...+q_{i-1}+q_i/2$, and where category i was given weight q_i to account for its size.

[2] The total number of gene-related articles per newspaper was estimated by multiplying the percentage of relevant gene-related articles in the screened sample by the total number of search hits (also non-relevant articles that matched the search criteria) for each newspaper. We divided this by the total number of articles in the database within the time period 01.07.05 – 01.07.08 to obtain an estimate for the total portion of gene-related articles in each newspaper. The Norwegian database Atekst provided us with an exact number of all articles in the database for the designated time period, while in Factiva we had to search for the 5 most common words in French (de, le, la, et OR les) and English (the, be, to, of OR and) to estimate the total.

[3] For each doubly coded article, we computed the agreement between the coders. If the two coders gave an article weights v_i and w_i in frame i, the agreement on that frame has weight $\min(v_i,w_i)$, and the total agreement for the article is made by summing this agreement weight over all frames. The agreement will be 1 if the two coders code exactly the same frames in the same order, 0 if there is no overlap in frames coded, and between 0 and 1 if there is partial agreement. Cohen's kappa is then computed as (Agreement-Expected)/(1-Expected) where the Agreement refers to the average over all double coded articles and Expected is average agreement found when the second coding is randomized, i.e. between random pairs of articles.

III

Frame analysis in genetics class:

A model for teaching media literacy in science education

Rebecca B. Carver, Eline F. Wiese and Jarle Breivik

Corresponding author:

Rebecca Bruu Carver, Department of Behavioural Sciences in Medicine, University of Oslo, Pb. 1111 Blindern, 0317 Oslo , Norway. E-mail: rebecca.carver@medisin.uio.no

Coauthors:

Eline Fatima Wiese, Faculty of Education, Østfold University College, NO-1757 Halden, Norway Email: eline.f.wiese@hiof.no

Jarle Breivik, Department of Behavioural Sciences in Medicine, University of Oslo, Pb. 1111 Blindern, 0317 Oslo , Norway. E-mail: jarle.breivik@medisin.uio.no

Abstract

After completion of formal education, the mass media represent people's primary source of scientific information. Besides the traditional attention to scientific knowledge, national curricula are therefore increasingly emphasizing critical and reflexive engagement with media content as a key objective of science education. Despite this curricular emphasis, there are few models for teaching media literacy in science class.

Here we apply recent advances in science communication and frame analysis to meet this challenge. Based on a previously described scheme for classifying genetic discourse, we developed a pilot teaching program for upper secondary school biology. Thirty-four students from two parallel classes were taught how the gene concept may have different meanings in different contexts. They were then challenged to recognize these 'gene frames' in media texts. Learning outcomes were evaluated with a pre- and post-test design involving word association maps and focus group interviews, as well as analysis of the students' group work.

We found that the students fully grasped the idea that there are different ways of framing scientific issues. They were able to recognize the different gene frames and actively engaged in discussion about their effects and meanings in particular contexts. This multi-dimensional perspective was also reflected in the students' own use of the gene concept, and we observed a shift from an oversimplified deterministic view to a more dynamic and evolutionary understanding of genetic causation. We thus conclude that frame analysis of genetic discourse represents an effective tool for teaching media literacy while also promoting better understanding of science.

Keywords: media literacy, framing, genes, science education

Introduction

Scientific knowledge is rapidly evolving, and what the students learn in school today may be outdated tomorrow. The focus of modern science education has therefore shifted from simply teaching scientific content, towards a model of life-long learning (Falk, Storksdieck, & Dierking, 2007; Rennie, 2011). In order to stay up-to-date on important issues like health, environment and biotechnology, students must be able to extract scientific knowledge from the information they encounter in daily life. They should be able to seek out different sources of scientific information and critically evaluate what they are reading (Jarman & McClune, 2007; Jarman, McClune, Pyle, & Braband, 2011; McClune & Jarman, 2010).

After formal education, the mass media represent people's primary source of scientific information (Falk et al., 2007). Media literacy, meaning the ability to critically and reflexively engage with media content, has thus become a key learning goal in science education (McClune & Jarman, 2010). In the UK, the English National Science Curriculum expects students at Key Stage 3 (ages 11-14) to 'gain an appreciation of how science is represented and sometimes misrepresented in the media' (Qualifications and Curriculum Authority, 2007, p. 212). In the US, The National Research Council has proposed that year 12 students should be able to 'Read media reports of science or technology in a critical manner so as to identify their strengths and weaknesses' (National Research Council, 2011, chapter 3, p. 18). In Norway, where this study was based, the National Curriculum in upper secondary school biology (age 18-19) states that students should 'discover new knowledge in biology from different sources and evaluate information and claims in the media on an academic basis' (Grønlien, Ryvarden, & Tandberg, 2008, p. 379).

However, despite the explicit emphasis on media literacy in science curricula, relatively little research exists on how to use informal learning sources, like the media, in science education (Jarman & McClune, 2007; Jarman et al., 2011; McClune & Jarman, 2010; Stocklmayer & Gilbert, 2011). Previous research shows that whilst science teachers commonly use newspaper stories to highlight the relevance of particular topics, they lack the tools or skills needed to teach the students how to critically analyse these reports (Jarman & McClune, 2002; Kachan, Guilbert, & Bisanz, 2006). Even top achieving students have been found to perform poorly when asked to interpret everyday media reports of science (Norris, Phillips, & Korpan, 2003; Pettersen, 2005). There is therefore a need for new teaching concepts that can equip teachers and students with tools for critical analysis of science in the media.

In this study we therefore present and evaluate a new concept for teaching media literacy in science education. Based on a previously described scheme for classifying genetic discourse into five different gene frames (the symbolic, the deterministic, the relativistic, the evolutionary and the materialistic frame), we have developed a pilot teaching program for upper secondary school biology. In brief, the students were presented the hallmarks of five frames and then challenged to recognize these in a sample of media reports. We investigated if the students were able to grasp the concept of media framing, if they recognized the different gene frames and if this intervention influenced their understanding of genetics.

Frame Analysis

To be media literate implies the ability to recognize the underlying meanings in a communicated message (Potter, 1998). In media and communication studies, such underlying meanings may be systematically identified by the method generally referred to as frame analysis. According to Entman (1993, p. 52), 'to frame is to select some aspects of a perceived reality and make them more salient in a communicating text'. Kitzinger (2007) has compared the way journalists frame news stories to the process of taking and editing a photo: First you select the perspective, you decide what to focus on, what to include and what to leave out. Then you may edit colours, shading, contrast or other effects to emphasize certain aspects of the image. The same story or phenomenon may thus be framed in different ways that convey very different meanings.

The features that characterize a frame are referred to as framing devices. These may be particular words, phrases, stereotyped images, sources of information, and sentences, which 'provide thematically reinforcing clusters of facts or judgments' (Entman, 1993, p. 52). As an illustrative example, Williams, Kitzinger and Henderson (2003) studied the debate on stem cell research in the UK media and found two very different ways to frame the concept of the pre 14-day embryo: The proponents often prescribed the embryo with scientific terminology like 'blastocyst' and 'microscopic', and metaphors like 'florescent frogspawn'. The opponents on the other hand, used words like 'tiny', 'human', 'precious', often coupled with pictures of foetuses with fingers and toes (which do not appear until later in development). Whereas the first frame gives support to stem cell research by drawing attention to the embryo's technical properties and scientific potential, the second frame strengthens the opponent's viewpoint by emphasizing the embryo's human potential and our moral obligation to protect it. Alternative framing of a scientific concept may thus have profound impact on how an issue may be perceived by the audience.

Frame analysis is increasingly applied in the field of science communication (Reis, 2008) and involves two principally different, but related methods: Inductive frame analysis is used to define new frames and is largely based on qualitative methodological approaches. Such studies may start with a preliminary set of 'hypothetical' frames derived from a literature analysis, followed by a close reading of texts to identify the framing devices associated with the potential frame. Matching features are seen as confirmation of the category, whereas non-matching features may suggest a new frame. The resulting framing scheme is then presented as an overall depiction of each frame with a list of the related framing devices.

Deductive frame analysis, on the other hand, is largely quantitative and uses an already established framing scheme as the basis for investigation. The challenge is thus to identify the presence of the predefined framing devices in a particular text, for example a newspaper article. The same article may have more than one frame present, and usually there will be a dominant frame, which has the 'highest probability of being noticed, processed, and accepted by the most people' (Entman, 1993, p. 56). The dominant frame is often expressed in the headline and opening or closing paragraph (Kitzinger, 2007), whereas less salient frames are typically embedded further into the text (Petersen, 2001).

Inductive frame analysis involves complex synthesis of unstructured information. It requires a high level of analytic thinking and does not easily lend itself to secondary school education. Deductive analysis however, is basically a matter of pattern recognition and may to some extent even be computerized (Matthes & Kohring, 2008). Still, it utilizes the sophisticated insight embedded in the already established framing scheme and represents a powerful tool for critical media analysis. In this study we therefore apply deductive frame analysis as an educational tool for teaching students critical analysis of gene-related articles in the media.

Framing the Gene

The gene has become one of our most important scientific concepts. It forms the foundation for the on-going revolution in biotechnology and concerns everything from personalised medicine and early diagnosis of cancer to genetically modified organisms and evolutionary biology. Accordingly, it implies profound scientific ethical and political issues. Because the gene is so central to contemporary society (Miller, 2004), it also has a key role in science education. It occurs in numerous topics in the science curriculum and may also appear in relation to other subjects like social science, physical education and religion.

The gene concept is also prominent in the media. It appears in relation to topics ranging from science and health to celebrity gossip and crime investigations, and has been subject to several media studies. Nelkin and Lindee (1995) reviewed gene-related discourse in American popular culture during the 1990s and concluded that the media has an overall tendency to give a deterministic and misleading representation of the gene concept. Condit, Ofulue and Sheedy (1998), on the other hand, found that there are several ways of representing the gene concept in the media, and Condit (2007) later proposed that there are different 'gene frames'. Building on this idea, Carver, Waldahl and Breivik (2008) performed a systematic, inductive frame analysis of the gene concept and found that genetic discourse could be divided into five distinct categories:

The *symbolic* frame uses the gene as a rhetorical device to symbolize relationships and generally concerns characteristics which are regarded as more dependent on cultural than genetic inheritance, e.g. 'I have inherited a shopping gene from my Mom'. It is often written with a humoristic and unscientific tone, and may also use the gene concept as a metaphor to signify transfer of information or technology, e.g. 'Mazda has many Ford genes'.

The *deterministic* frame presents the gene as a direct cause for biological traits, e.g. 'They found sexual identity is wired in our genes before birth'. It is often characteristic of sensational headlines like: 'Researchers find the gene for breast cancer' and 'Fat? It's in your genes'. The deterministic frame also includes representations of the nature-nurture controversy, which assumes that traits are caused *either* by genetic *or* environmental factors, e.g. 'Culture, not genes, is supposed to be what makes people different'.

The *relativistic* frame presents the gene as a contributor or risk factor in the development of biological traits, e.g. 'Genes increase risk of developing cancer' or 'Some people have a genetic predisposition for putting on weight'. It uses keywords like 'chance' and 'risk' or phrases like 'linked to', 'involved in' and 'predisposing for' to indicate genetic causation. The relativistic frame indicates that there may be other causes involved, but does not mention these explicitly.

The *evolutionary* frame presents the gene as a dynamic factor that interacts in an environmental context, and may be related to evolution in a larger historical perspective, e.g. 'Comparison between human and ape DNA reveals that some human and ape genes evolved very swiftly' or to the Darwinian perspective of biology, e.g. 'Women are attracted to tall men for flings as their looks are a sign of healthy genes'. The evolutionary frame also comprises matters of gene expression, e.g. 'Curcumin, a compound in the bright yellow seasoning, may deactivate genes which cause the heart to enlarge and scar'.

The *materialistic* frame describes the gene as a physical entity that carries heritable information, e.g. 'genes are digital codes written on DNA molecules'. It often relates to genetic engineering and typically describes the gene as something that can be identified, isolated, removed, replaced, inserted or transferred, e.g. 'A researcher illicitly inserts his genes into an embryo in the laboratory'. The materialistic frame often occurs in combination with other frames, and can, for example, strengthen a deterministic frame by pinpointing a trait to a specific chromosomal location, e.g. 'NPC is caused by a mutation in a gene on chromosome 18'.

Together, the five different gene frames imply a comprehensive scheme for analysing genetic discourse. This scheme was recently evaluated and substantiated by a deductive frame analysis of 600 gene-related articles form a wide range of international newspapers (Carver, Rødland, & Breivik, in press). The different gene frames represent an applicable tool for exploring fundamental aspects of genetic discourse, and in this study we used the gene framing scheme as the basis for a teaching program in upper secondary school biology.

Description of Teaching Program

Materials

Gene framing scheme. Based on the framing scheme previously developed by Carver et al. (2008), we developed a slightly more simplified scheme for the students (Table 1). We assigned a different colour to each frame and equipped the students with highlighting pens in the corresponding colours. As described in further detail below, these pens were used to highlight the framing devices (words and phrases) that accentuated the different frames in a selection of newspaper articles. Each article thus became a colour map, which presented the students' frame analysis in a visual manner.

Newspaper articles. The articles that the students were asked to analyse were selected based on the following criteria: 1) that the article clearly demonstrated the use of one or more of the five frames, 2) that the topic of the article was related to their biology curriculum. We chose news stories from both tabloid and broadsheet (elite) newspapers in order to provide some variety in article style and level of complexity. One set of articles (Collection I) was used for the initial classroom exercises; a second set (Collection II) consisted of four articles that were used for the subsequent homework and group work. The topics in Collection II included 1) intelligence, 2) genetic modification, 3) lung cancer and 4) obesity. The dominant frame of each of these articles was: 1) the evolutionary frame, 2) the materialistic frame, 3) relativistic and 4) deterministic frame, respectively. Collection II did not include an article with the symbolic frame, as this is generally non-scientific and therefore deemed irrelevant for the genetics curriculum. The students received a Word document with text-only versions of all the articles.

Reference coding. All articles were colour-coded by the first author (herein called the facilitator) to provide a reference guide for teachers and students.

Word association maps. Before and after the program the students were asked to fill in a 'word association map' (WAM) concerning the gene concept. The WAM consisted of an A3 sheet of paper with the word 'genes' written in the middle, surrounded by two levels of empty boxes (30 in total). It contained the following instructions: 'First, write down with words or short phrases whatever you associate with the word 'genes' in the red circles. Use the blue circles extending from these to explain what you mean by the association. Think freely; there are no right or wrong answers.'

Participants

The school. The study was performed at an upper secondary school (ages 17 to 19) in a sub-urban district of Oslo, Norway. This school has undergone a noticeable transformation during the past decade: Ten years ago the school was one of the least popular schools in Oslo, with serious social problems, high drop-out rate and low grades. Today it is one of the most popular schools in the Oslo region, and enrols students with the highest grade point entry scores (at age 16) in Norway. It also has one of the best attendance rates in Oslo. Its success stems from a shift in leadership and pedagogical approach: The school now focuses on collaborative learning and close mentoring of both students and teachers, with extensive feedback throughout the year.

The school is currently being rebuilt and will by 2014 be physically integrated within an innovation park comprising a specialist cancer hospital, university research departments, and leading biotech companies within the field of cancer research (at the time of this study the school was in its original building). The overall aim of this initiative is to promote collaboration between school education, research and industry, in order to enhance student learning and strengthen the recruitment of young talents to life science. In this context, the school encourages projects like the current study that foster interaction between university researchers, teachers and students.

The classroom context. Thirty-four students participated in this study (16 girls and 18 boys). The students were in their final year of Norwegian upper secondary school, equivalent of the last year of A-levels or International Baccalaureate. They were from two parallel high-level biology classes (Bio 2), which for the purpose of this exercise were taught together. The classes had two different teachers that regularly conferred with each other on teaching methods and activities. One of these teachers served as our main contact person throughout the project and was also interviewed after the program.

Focus group participants. Prior to the project, the teachers asked the students to volunteer for a focus group. Two girls and three boys were recruited and received a letter which outlined the study and presented the dates, times and activities they would be expected to attend. They were asked to sign a form of consent, declaring their agreement to attend both interviews. One of the boys withdrew from the group. The names of four focus group participants have been anonymised following the guidelines of the Norwegian Social Science Data Services.

Lesson plan

The teaching program was placed at the end of the conventional teaching in genetics. The students had thus already gained a basic understanding of the gene concept, and our intervention represents a supplement to the ordinary curriculum. The actual program took place on a Tuesday and Thursday in the same week and comprised a double lesson (1.5 hours) each day. The facilitator led all of the lessons, and the two teachers only intervened to maintain order in the classroom.

Day one

1) Brainstorming session. The facilitator gave a short introduction to the research project and asked the students to fill in the WAMs, individually. The completed WAMs were then collected, and the facilitator opened for a plenary discussion of the question: What is a gene?

2) Presenting the gene framing scheme. Building on this discussion, the facilitator gave a 25-minute interactive PowerPoint presentation about the five gene frames. For each frame she showed the students an excerpt from a newspaper article and asked for comments about how the gene concept was portrayed. The students were then explained how each frame corresponded to the different framing devices and were presented the complete framing scheme. The facilitator also explained that not all framing devices must be present to identify a frame and that the same article may contain more than one frame.

3) Classroom exercise. The students were given Collection I of articles as well as a hand-out of the colour-coded framing scheme and a set of highlighting pens. They were then asked to identify the different frames by highlighting the relevant framing devices in the corresponding colour. In order to promote reflections, the students were encouraged to confer with the students they were sitting next to.

4) Plenary discussion. The facilitator asked the students how they had coded each article, before showing the reference coding of the same articles. Any differences in coding were discussed in relation to the framing scheme. The lesson ended with the assignment of homework.

5) Homework**.** Each student received Collection II of articles and a handout with instructions. They were instructed to code the four articles in line with the framing scheme and asked to bring the results to the next session.

Day two

1) Recap of the gene framing scheme**.** The lesson began with a ten minute re-cap and brief discussion about the five gene frames.

2) Group work. The students were organized into nine groups of four. They were instructed to compare homework and come to an agreement regarding which frames were present in each article. In articles with more than one frame, they were asked to agree on which frame they regarded as the dominant, the secondary or (if applicable) the tertiary frame. They then coded a consensus version of each article, which was mounted on the blackboard next to the reference guide. By visually comparing the colour coding, it was thus easy to identify differences between the groups and the reference guide (Figure 1).

3) Plenary discussion. The display of articles on the blackboard was used to spur a discussion about the different gene frames. The groups were asked about their particular

choices of frames, pointing out interesting differences and asking them to explain these. The facilitator then initiated a general discussion about the implications of media framing.

Program evaluation

Learning outcomes and the participants' perspectives were evaluated using four different methods:

Evaluation of students' frame analysis

The results of the students' group work (Day two) were compared with the reference coding. The degree of similarity was used as a measure of the students' general understanding of media framing, as well as, their specific ability to identify the five frames. We also took notice of, and evaluated, the discussion that followed the group work

Evaluation of WAMs

The WAMs were used as a brainstorming exercise at the beginning of the program and were also repeated for evaluation purposes four days after the program had finished. All the entries in the WAMs were analysed for words, depictions and phrases related to the five gene frames. Entries that could not be related to any of the five frames were discounted. We compared the number of boxes representing each frame in the pre- and post-test WAMs from the students who were present at all sessions and who had completed both WAMs (n=17). We also made a qualitative comparison of the types of frames used in the pre- and post-test WAMs. The observed differences were used as an indicator of a change in the students' awareness and orientation towards different frames before and after the program.

Focus group interviews

Two semi-structured focus group interviews were performed following standard guidelines by Krueger and Casey (2009). The first author organized the focus group interviews with the same four students before and after the program. The interviews were structured around the four questions: 1) How do you define a gene? 2) How important do you think genes are for the development of diseases later in life? 3) If you read a headline 'scientists have found the lung cancer gene', what does this make you think? 4) Imagine you took a gene test and found out you had 'the diabetes gene', how would you react?

In the first interview we used the students' own WAMs as a point of entry for discussion. In the last interview, we also asked the students of their overall opinion of the program and what they had learned from the activity. Both pre- and post-test interviews lasted about 30 minutes and were recorded using a digital audio recorder. They were then transcribed and analysed with particular attention to the students' perspectives of the gene concept before and after the teaching program.

Teacher Interview

We interviewed the main teacher about six months after the intervention. The interview was conducted at the end of the school year so that the teacher could regard the program in context of the whole biology curriculum. We were primarily interested in her opinion of how the program had affected the students' understanding of genetics. The interview lasted 45 minutes, was recorded with a hand-held digital audio recorder and was transcribed and evaluated by the first author.

Results

Students' group work

Figure 1 demonstrates how the colour-coded articles appeared on the blackboard. The students had been informed that the same article could have more than one frame, and seven of the nine groups had ordered frames according to salience. Two groups (3 and 4) only agreed on the dominant frame and simply encircled the article with the particular colour.

Overall, there was good correspondence between the students' coding and the reference guide (Table 2). Of 36 coded articles, 31 (86%) were assigned the correct dominant frame. All nine groups identified the evolutionary frame in Article 1, but three of the groups believed that there were also other frames in this article. Article 2 was unambiguously identified as materialistic frame by all nine. Article 3 comprised a relativistic, as well as, an evolutionary frame, and four of the groups identified both frames in the correct order. Four groups identified only one of the frames, whereas one group missed completely and coded the article with the deterministic and materialistic frame. Article 4 comprised three different frames: deterministic, relativistic and evolutionary. All but one group identified the dominant frame, and two groups identified all three frames in the correct order.

The group work ended with a plenary discussion where the students were asked to explain their coding of the articles. The discussion centred on the discrepancies related to Article 3 and 4. Some of the students said they had used the wrong colour by accident, whereas others defended their alternative coding. Group 2 were the only ones who had identified a symbolic frame in Article 4. They argued that the statement ‘Does this mean that obese people can lean back and just blame their genes?’ was symbolic, because it seemed very causal and unscientific. The other groups argued that because the article concerned obesity and referred to actual science, this sentence should be coded as a deterministic frame.

The discussion also concerned how the different gene frames may affect people's understanding of disease. The students generally agreed that the deterministic frame might cause misunderstandings, for example when the media report about the ‘gene for lung cancer’ or the ‘obesity gene’. They argued that these conditions are most likely due to both environmental and genetic factors, and that it would in these cases be better to use the evolutionary frame.

Word association maps

The majority of the boxes in both the pre- and post-test WAMs reflected the materialistic frame (n=158 and n=143 respectively), exemplified by words such as ‘DNA’, ‘chromosomes’, ‘molecule’, ‘proteins’, ‘building blocks’, ‘codes’ and phrases such as ‘Cloning – copy of our DNA’, ‘Mutations can happen when genes are coded’, and ‘we have different variants of each gene’. The second most prominent frame was the deterministic frame (n=71 and n=72 in pre- and post-test WAMs respectively), exemplified by words such as ‘traits’, ‘good genes’, ‘bad genes’, ‘inherited disorders’, and phrases such as ‘genes decide how you look’, ‘the blue eye code lies in the genes’ and ‘we get traits from our parents’. Very few boxes represented the symbolic or the relativistic frame.

The most noticeable difference between the pre- and post-test, was an increase in the number of boxes that could be related to the evolutionary frame. This frame was reflected in words like ‘evolution’, ‘natural selection’, ‘biodiversity’, ‘expressed genes’, and by phrases such as ‘inheritance – interacts with the environment’, ‘genes + environment’, ‘influenced by the environment’, and ‘many genes can influence a trait’. The number of such entries doubled from 26 in the pre-test to 52 in pre- and post-test, whereas for the other frames there was little or no difference.

Student focus group interviews

Pre-test: The interview began by asking the students to elaborate on the entries in their respective WAMs. Two of the students had written ‘a bit of DNA’ and were asked to explain what they meant by this. Sam replied ‘it’s a bit of DNA that codes for a protein or trait’, and Alice added that genes ‘decide who you are’. She then continued: ‘I mean, how I look...what I have inherited...after all, I am created by a combination of genes that give me a detached or attached ear lobe, or a large or small nose.’

The next topic for discussion was the role of genes in the development of various traits and diseases. The students were asked how genes are related to diseases:

Jane: Genes can decide whether you will get hereditary diseases such as Alzheimer's and stuff.

Sam: I think more about dominant and recessive genes, in relation to who you get them from, and if both parents have to be carriers for the disease.

Interviewer: Some of you have written the words ‘recessive’ and ‘dominant’ in the brainstorms. Are you thinking about disease then?

Sam: Everything … eye color.

Jane: I think of brown hair, and disease.

Sam: We have had some kind of crossover forms in biology, where we were working on just that.

Overall, the students conveyed an impression that genes are the main cause for many diseases, but they also gave more complex responses. When asked how they would react to finding out they had a ‘diabetes gene’, Alice argued that it might be possible to manage the condition by changing one’s lifestyle. Sam, on the other hand, assumed that if you have the genes, there is little you can do to stop the disease. He would therefore carry on his life as usual.

The students were then asked to comment on the headline ‘Scientists have found the lung cancer gene’.

Harry: I would think straight away that they had found the gene that codes for the main bacterium…

Interviewer: The cancer?

Harry: Yes, and that they have managed to do something scientific with it.

Jane: I think they have found a fault or a weak point.

Alice: I think lung cancer is what you make of it; if you smoke, or your environment, but you have to have a starting point of course. But they probably are doing a lot of research on how to get rid of this gene.

Jane: I watched a documentary about two twins where one was healthy, never smoked and went skiing regularly, whilst the other smoked a lot…but then both of them got a heart attack with one day difference between them.

Interviewer: What did this make you think?

Jane: That it was decided by our genes!

Although Alice showed some reflection about the role of the environment (smoking) in lung cancer, none of the students actually questioned or criticized the deterministic frame.

Post-test: The post-test interview started by asking the students about their overall opinion of the teaching program:

Harry: I thought it was good, especially the PowerPoint.

Interviewer: Do you usually have PowerPoints?

Harry: Yes, but the way you did it, with the colours and stuff, that was good because then you could visualise it and make connections...

Sam: I think it was pretty cool the way it was set up with the five ways to look at genes, and that there was such a clear difference between them. I have come across the different perspectives before, in biology class and in the media.

Interviewer: So you've seen the frames before?

Sam: Yes, I have sort of noticed them. I probably didn't think much about it then, but at least I have seen that there is a difference there.

...

Alice: I learned lots, and it was great to see the different perspectives. This is useful to know because then we don't become like those cynical people who say 'hey, they've found the gene that explains why I'm so fat!' – no, they have probably exaggerated.

Interviewer: What frame would that have been?

Alice: Deterministic.

As in the pre-test, the students were asked to comment on the headline 'Scientists have found the lung cancer gene'. Harry answered: 'I would think that this is utter nonsense. It could be that they have found a gene that has something to do with lung cancer, but I don't think there is just one gene directly for it. It's probably a combination of different genes'.

They were also asked if the program had influenced their impression of how genes are presented in the media:

Alice: Yes, very. I may not analyse everything I read word for word each time, but I will at least think about it…. together with what we already know from the biology course.

Jane: I will think about how they portray it this way and that way.

Sam: I really see the relevance of this when I read media articles in relation to the biology book. I have subconsciously had a different view of genes and genetic engineering when reading the media because they portray it as dangerous, while I personally believe that it is not so dangerous - you can use genetic engineering for many good things.

Towards the end, the students were again asked to define a gene:

Interviewer: After participating in this activity, have you formed a new definition of a gene?

Sam: I felt that I had a pretty clear picture beforehand too...

Jane: It's still a molecule.

Sam: I'm more interested now in the differences between genotypes and phenotypes and stuff like that - how it works.

Interviewer: How genes are expressed?

Sam: Well, how DNA becomes proteins ... how it all works really.

Overall, the students adhered to the materialistic definition of a gene, but were noticeably more reflected in their discussion about genetic causation. Sam, who expressed a distinct deterministic perspective in the pre-test, clearly demonstrated an emerging scepticism: 'Yes, it is genes and environment... I don't think too much about genes because it isn't easy to say for sure that it is due to inheritance'.

Teacher interview

The teacher was asked to reflect on how the program had influenced the students' understanding of genetics:

'A very positive thing here is the interplay between heredity and environment—it's easy to overlook this by just reading the textbook—there is only a tiny section that states "...and remember that both genetic and environmental factors are usually involved". Students do not really get any good examples to help them understand this, but when they analyse these newspaper articles they get very specific examples…'

… 'The textbook portrays a very limited picture when it comes to genetic diseases—they tend to mention dominant or recessive diseases with monohybrid inheritance. They are in the textbook to show examples of inheritance, but they are not typical diseases as you say, so it's not that useful... We are not just

educating doctors or biologists, we want to give them all the knowledge they will need later in life, so that they will not simply believe that cancer is only genes, or only environment. It is important that we signal that it is probably both.'

The teacher was overall positive to the program and believed that the intervention had a significant impact on the students' understanding of genetics. She regarded the gene framing scheme as a helpful tool for understanding genetics in general and suggested that it may be introduced at the beginning of the curriculum. She also expressed that the program had been an eye-opener for her own understanding of genetics and that she would implement it in her own teaching strategy.

Discussion

In this study we have described and evaluated a teaching program where upper secondary school biology students explore the meaning of the gene concept through systematic analysis of newspaper articles. The results indicate that the intervention was successful both in terms of teaching critical reading skills and in broadening the students understanding of genetics. However, before we discuss the implications of these findings, we will emphasize two important limitations:

First, this study was conducted in a special context. The participating school is at the centre of an innovative and extensively promoted collaboration between the City of Oslo, the Oslo Cancer Cluster Innovation Park and the University of Oslo. Both the school management and teachers may thus have been particularly receptive to this kind of activity. The school's results are also consistently at the top of national rankings, and the students who volunteered for the focus group interviews were most likely more motivated. Still, students who choose high-level biology are overall a selected group, with particular motivations and competence in the field. Compared to other high-level biology students, the participants, their thoughts and achievements, may therefore be quite representative.

The second limitation concerns the researcher perspective. Two of the authors were previously involved in the development and evaluation of the framing scheme (Carver, Waldahl, & Breivik, 2008; Carver, Rødland & Breivik, in press), and the study is generally motivated by this background. Moreover, the first author acted as the facilitator of the teaching program. Combined, the researcher perspective thus implies a bias in the implementation as well as the evaluation of the program. A more ideal research context would be that a teacher facilitated the implementation of an independently developed program while neutral researchers observed and evaluated. However, given that the aim of this study was to implement, test and explore a conceptually new teaching method, we believe that the active participation of the researcher was both necessary and valuable for the implementation of the intervention.

Overall, we found that the students quickly grasped the idea that there are different ways of framing a scientific issue. Although they did not know about the concept of framing beforehand, it was easily illustrated by sample articles, and the students did not have problems evaluating media content. The introduction of media analysis in science class thus appears as unproblematic from the perspective of the students, and the ideal situation would be if science and English teachers (Norwegian in our case) could work together on this kind of interdisciplinary program. We believe that such an approach would strengthen the relevance of both subjects, but will require teachers who are motivated to work across the traditional school subjects.

The applied framing scheme has been previously tested by independent coders (Carver et al., in press) and although it remains open for debate and modifications, it represents an applicable tool for analysing genetic discourse. This study shows that it is also a useful instrument in science education. As demonstrated by Table 2, the students were able to differentiate between the five gene frames and classified sample articles with a high degree of accuracy. Importantly however, the goal of the teaching program is not the classification *per se*, but the thought process and debate that accompanies it. The students were provided with an instrument and a vocabulary that enabled them to engage with the media content in a systematic manner. As they became aware of the different meanings of the gene concept, they also started to question the overall quality and legitimacy of the claims in the articles (such as criticizing the media's use of the deterministic frame). This ability to negotiate between different frames or perspectives is a key aspect of media literacy (Potter, 1998), and enables the reader to make independent and informed decisions about an issue.

Regarding the students own use of the gene concept, we saw an overall shift from what may be characterized as a simplified deterministic frame towards a more insightful evolutionary frame. This effect was particularly evident in the focus group interviews and the classroom discussion, but was also seen in the brief notes in the WAMs. Whereas the pre-test WAMs and focus group interview were dominated by the molecular aspects of genetics and a deterministic relationship between genotype and phenotype, the post-tests reflected a higher degree of uncertainty concerning genetic causation and emphasized gene-environment interactions. This latter perspective, related to gene-expression and the genotype-phenotype connection, is particularly difficult to teach (Forissier & Clement, 2003; Lewis & Kattmann, 2004; Venville & Treagust, 1998) and poorly presented in standard textbooks of biology (Gericke & Hagberg, 2007; Gericke & Hagberg, 2010). Science textbooks have been widely criticised for placing too much emphasis on single-gene disorders and not enough on complex disorders such as cancer or obesity (Dougherty, 2009; van der Zande, Waarlo, Brekelmans, Akkerman, & Vermunt, 2011).

Recently, it has also been argued that high school biology curricula should teach more about the interactions between genes and environmental factors (Dougherty, 2009; van der Zande et al., 2011; Verhoeff, Boerwinkel, & Waarlo, 2009; Verhoeff, Waarlo, & Boersma, 2008). The teacher in our study also made remarks in that regard and thought that the intervention had broadened the students understanding of the relationship between genes and environment. Introducing this teaching program in genetic education may thus help both teachers and students to meet this challenge.

The evolutionary frame is particularly characterised by its integration of genes and environment, and should arguably receive a more central position in the curriculum. Still, the point of this teaching program is not to argue that one gene frame is better than the other, but to show the students that the gene concept may have different meaning in different contexts. Thereby the students can make their own judgments and comparisons. For example, when asked if the program had changed his definition of the gene, Sam said: ‘It’s still a molecule’, but then went on to problematize the genotype-phenotype relationship. By combining and switching between different frames a student can thus knowingly construct his or her own multi-dimensional picture of what a gene is.

In conclusion, we show that a systematic approach to how the gene concept is presented by the media, not only increases the students’ level of media literacy, but also their level of scientific literacy. The different frames communicate different aspects of the gene, which in combination give a deeper understanding of genetics. The pre-established framing scheme represents a compact synthesis of accumulated knowledge and was easily adapted to a teaching program. We therefore conclude that deductive frame analysis of media content represents a new and effective approach to help students understand the complexity of genetics, and may also be applicable to other scientific issues.

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Table 1. *The gene framing scheme*

Gene frame	Describes the gene as	Keywords or phrases	Metaphors	Examples
Symbolic **(yellow)**	An abstract representation of inheritance	"it must be in the genes"		"Fashion has always been in my genes" "Mazda has many Ford genes"
Deterministic **(red)**	A definite causal agent	"gene for", cause, control, culprit, blame, disease-gene, responsible, born with, no choice, "genes or environment"	Like a computer program Recipe/instruction manual	"Scientists have found the gene for breast cancer" "It's either because of genes or diet"
Relativistic **(purple)**	A predisposing factor	influence, disease risk, chance, factor, associated with, susceptible to, linked to, contribute, predispose		"Genes double risk of breast cancer" "The genes linked to type 2 diabetes were recently shown to play a role in prostate cancer"
Evolutionary **(green)**	A dynamic agent interacting with the environment	interact, in combination with, expression, genes and environment	Like a switch or tap that can be turned on or off The selfish gene	"Mother's food turns genes on and off"
Materialistic **(blue)**	A discrete physical unit	DNA, chromosome, identify, map, locate, code, protein, mutation.	Alphabet, book, map, code, beads on a string	"Genes are digital codes written on DNA molecules" "The key gene was injected into the muscle cell"

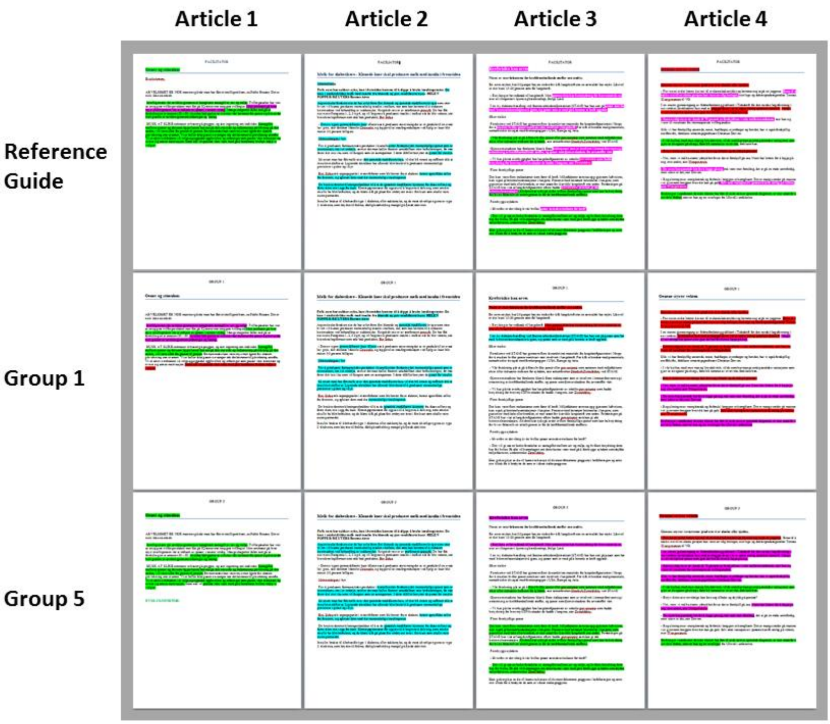
Notes. Adapted from Carver et al. (2008). We assigned a specific colour to each frame in order to make the frame analysis more visual.

Table 2. Reference coding versus students coding of articles.

	Reference coding	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9
Article 1	Evo	Rel Evo Det	Evo Rel Det	Evo	Evo	Evo	Evo	Evo	Evo Det	Evo
Article 2	Mat	Mat	Mat	Mat	Mat	Mat	Mat	Mat	Mat	Mat
Article 3	Rel Evo	Det Mat	Rel Evo Det	Rel	Rel	Rel Evo	Rel Evo	Rel Evo	Rel	Evo
Article 4	Det Rel Evo	Det Rel	Det Symb	Det	Det	Det Rel Evo	Rel Det	Det Rel Evo	Det	Rel

Notes. Frames listed in order of salience. Evo: Evolutionary, Mat: Materialistic, Rel: Relativistic, Det: Deterministic, Symb: Symbolic.

Figure 1. Illustration of colour-coded articles from the group work



Each colour designates the words and phrases that accentuate a particular frame. Each article thus became a colour map which makes it easier to compare the groups coded.