Canadian Newspaper Coverage of the Human Genome Project

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A Thesis Submitted to the Faculty of Graduate Studies in Partial Fulfillment of the Requirements for the Degree of:

MASTER OF ARTS

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Abstract

The Human Genome Project is largest biological undertaking in history. Completion of the project promises to change medicine, but it also poses a number of difficult ethical questions that have yet to be resolved. As a result, the project has attracted significant attention from the news media. Many researchers have explored the quality of science journalism, and have identified a number of deficiencies. But few have focused on how the media cover genetics, and fewer still have addressed coverage of the HGP. This study is a review of articles about the HGP published in 15 Canadian daily newspapers, one prestige American newspaper, a major science magazine and a major newsmagazine, between 1990 and 2000 inclusive. The review indicates Canadian newspapers paid a great deal of attention to the project. The quality of the coverage was similar to that uncovered by other researchers. But the findings suggest the HGP received more prominent coverage than the average story about science normally would. News articles in Canadian newspapers tended to be generally positive about the project. Features, opinion pieces and editorials, on the other hand, largely focused on the controversial aspects of the project. Both groups of articles were lacking in background and explanatory material. Canadian newspapers relied heavily on wire copy to cover the project. It is not clear precisely how these and other deficiencies affect readers. Media coverage tends to have a more profound effect on readers with little or no knowledge of a given subject. The news coverage reviewed in this study likely led to a distorted understanding of the project. Negative coverage of the project in features and opinion pieces may have elicited a negative reaction from readers who know little about it.

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INTRODUCTION

The Human Genome Initiative (HGI) is indisputably the largest collaboration in the history of biological science. Because of its concern with unlocking the secrets of our genetic code, the project is in essence the climax of almost an entire century of searching for answers about human nature, and hundreds more years of fascination with and wonderment about what makes us human.

The initiative is a collaborative effort by scientists the world over—geneticists, molecular biologists and others—to identify and characterize the genetic material that humans carry in every one of their cells—called Deoxyribonucleic acid, or DNA. The aim of the project is to develop a complete map of all human genes, the clusters of DNA that "code" for, or determine, everything from eye colour to propensity for genetic disease. Scientists also aim to determine the precise sequence of molecules in the string of some 3 billion molecules that make up DNA. The entirety of genetic material in a given species is called the genome, hence the title of the project. The initiative, officially begun in 1990, was to take at least 15 years to complete, require billions of dollars and the efforts of thousands of talented scientists. The end product, dubbed the "holy grail" of humanity, will be a large document "spelling out" the human genetic code.

Scientists involved in the project aim to understand human heredity, and use that understanding, in the long term, to alleviate human suffering from genetic disease. While the project garnered massive material and ideological support during the past decade, it also commanded much scrutiny and raised many ethical concerns. Average citizens, religious groups, scientists, even some geneticists have voiced concerns about various aspects of the project. At meetings leading up to the approval of the United States arm of the HGI, the Human Genome Project, (the name most commonly used to refer to the entire world-wide project), there were many dissenting voices opposing this massive undertaking (Davis 126; Kevles 24). Most of the critics took issue with the inordinate amount of resources that the project required, and they differed on what would be the most efficient approach to mapping the genome. Many of the dissenting voices were driven by ethical concerns. Some of these voices pointed to potential dangers of open access to the information gathered by the project. There were many questions: Who would have access to that information? Who would regulate its use, and how? Who would prevent misuse? Others wondered whether complete understanding of the function of all genes might lead to selective breeding—to a day when parents may choose to abort a fetus because it does not possess desirable genes. There are many more such concerns to be discussed in detail later.

While scientists set about their work, other members of society debated the benefits and the risks of the project as they were outlined in the popular media. It is widely accepted that the average adult receives most of his knowledge about scientific advances through the mainstream media (Nelkin 68). But there is little research that reveals how much information the public receives about the HGP, nor about the kinds of messages the media have presented about it. In an attempt to fill that void, this study explores the coverage of the project in major Canadian newspapers. In that regard, it is worth noting that science writers for the mainstream media face many challenges: understanding the research they cover, making science palatable to the general public, and doing all that while meeting tight deadlines. Scientists and communication researchers have criticized these writers for presenting incomplete pictures of science, for introducing errors, and for promoting unfair—or as the case may be, overly positive—characterizations of scientific advances. This study attempts to find out how science writers have covered the Human Genome Project, and by extension, how the public has perceived it. It is by no means a comprehensive one. The aim is to draw upon a sample of newspaper and magazine articles to identify some of the trends in coverage. While it may be possible to draw some conclusions about public perceptions from the data, those conclusions only provide a glimpse into how the public has received the HGP over the first 11 years of its existence.

HISTORY OF EUGENICS

The history of the Human Genome Project plays a large role in shaping media and public attitudes towards it (Kevles 34). That history is intimately intertwined with the eugenics movement. Many critics objected to the HGP because of that link to eugenics. In media coverage, as well as academic work about the implications of the HGP and genetic research in general, the history of eugenics often figures prominently (Hasian 144). A brief review of that history is therefore in order.

The word "Eugenics" is a derivative of a Greek expression meaning "noble in heredity" or "good in birth" (Kevles 5). According to Daniel Kevles, the word is the set of concepts, applied or theoretical, "Aimed at improving the quality of the human race through the manipulation of its biological heredity" (Kevles 4). The concept of eugenics dates back as early as Plato (Hasian 14). But eugenic ideas have never enjoyed as much success and attention as they did during the late 19th and early 20th centuries. British scientist Francis Galton, a first cousin of Charles Darwin, revived eugenic ideas at about 1865, and gave them their name. In his paper, "Hereditary Genius," Galton posited that humans could improve their stock by employing the breeding methods used in plants and animals (Galton 45). He also suggested intelligence was heritable (Galton 63). Supported by statistical study (Duster 12), Galton's ideas gained wide acceptance just after the turn of the last century (McLaren 16). Eugenics became a field of scientific inquiry, as well as a social movement, attracting British, American, German and Canadian scientists.

Today, scientists accept that a complex network of genes determine many aspects of human physiology and psychology. But during their time, most eugenicists attempted to fit various human traits such as intelligence into simple heredity models worked out by monk Gregor Mendel. Eugenicists often erroneously used Mendel's single gene model, in which traits are determined by and inherited through the transmission of one gene from one generation to the next. Erroneous and misleading data were the result. Nevertheless, many institutions sprang up to gather family histories and determine the heritability of human traits. Among them was an institution set up in Germany in 1918, which would later become the Kaiser Wilhelm Institute for Research in Psychiatry (Kevles 6). Early in the century, Galton established the Galton Laboratory for National Eugenics in London. Charles Davenport, originally from Britain, established a station for experimental study of evolution in 1904. He was inspired after meeting Galton and Karl Pearson, a student of Galton's and a leading proponent of eugenics in Britain (Kevles 6). Davenport also founded the Eugenics Record Office at Cold Spring Harbour in 1911 (Reilly 18-19). Davenport was a strong believer in the heritability of traits such as sanity, alcoholism, pauperism, criminality and feeblemindedness—despite his inability to show that these traits were in fact transmitted through genes. The Eugenics Record Office at Cold Spring Harbour undertook massive efforts to gather family data through house calls and mail-in surveys (Kevles 6; Hasian 31). In Canada, no major research institution dominated eugenic study. But eugenic ideas were already present before any of Galton's became popular. As early as 1890, Dr. Alexander Peter Reid, superintendent of the Nova Scotia Hospital for the Insane, said that, "Action had to be taken to stave off national degeneration" brought on by the genetically unfit (McLaren 23). In 1930, Canada also had its own Eugenics Society, as well as several prominent eugenicists, who promoted eugenic policies.

Such interest in eugenics was not accidental. In his book Backdoor to Eugenics, Troy Duster said that science both shapes and is shaped by the existing socio-economic and political environments (Duster 2). In Britain, there was dissatisfaction with the growing number of criminals, paupers and prostitutes who were considered part of a "social illness." There was also a public outcry about the heavy costs associated with the institutionalized care of the mentally and physically ill. In Canada and the U.S., race-based hostility grew over immigration policies (McLaren 48-49). Eugenicists promised the means with which to deal with everything from the feeblemindedness to pauperism, alcoholism and various other traits already believed to be hereditary and common among immigrants. Eugenicists concentrated their efforts on selling their ideas to governments. But the public also embraced those ideas, and eugenic language permeated every aspect of life. Speakers on the subject were many, and in very heavy demand (Hasian 37). Eugenics was more than a science that explained nature, Marouf Arif Hasian Jr. said. "It was a way of life, a perspective that informed a person's everyday social interactions" (Hasian 35).

Application of Eugenics

There were those who believed, as Galton and Pearson did, that positive eugenics was the most effective way to protect and improve the human gene pool. Positive eugenics is the promotion of reproduction of those considered to be fit to protect the "germ plasm," dubbed by eugenic pamphlets as "the most precious thing in the world" (Hasian 38). There was also a movement favouring so-called negative eugenics: the practice of preventing the propagation of those considered genetically inferior, and the elimination of their genes from the common gene pool (Kevles 10). Most eugenic policies implemented in Germany, Britain, the U.S. and Canada were based on negative eugenics (Kevles 10).

There were, however, some efforts in the vein of positive eugenics that are worth mentioning. In the United States, "Fitter Families" competitions, which became popular during the 1920s, provided incentives to individuals if they engaged in eugenic marriages (Kevles 10). Kevles says that in Britain and Germany, "eugenic claims did figure in the advent of family-allowance policies" (Kevles 9). In Canada, eugenicists distributed pamphlets espousing "eugenic" marriages (McLaren 76). These publications urged individuals to find partners of their own kind to preserve their pure lineages. Negative eugenic practices, meanwhile, became the means for the most inhumane treatment of human beings in the history of science, and unfortunately, in the name of science. Negative eugenics was practiced in the form of involuntary sterilization of thousands considered genetically defective. Those with mental disabilities, known as the feebleminded, formed the largest proportion of those sterilized. According to available documentation in the Americas, sterilizations were only carried out in some U.S. states, and two Canadian provinces, though the possibility exists that they occurred elsewhere (McLaren 91). As Angus McLaren described, "The sterilization of the feebleminded, it was argued, would prove to be a cheaper, more effective and humane method of restricting their breeding" (McLaren 93). The first sterilization law in the U.S., passed in Indiana in 1907, stated that any "confirmed criminal, idiot, rapist or imbecile" already in a state institution and whose condition was "unimprovable," would be subjected to involuntary sterilization (Reilly 33). State governments drew up this law, and 29 other laws, at the urging and with the help of eugenicists (Reilly 35). By 1956 alone, 58,000 Americans had been sterilized (Duster 30). In Canada, Alberta and British Columbia were the only provinces which legislated sterilization. McLaren says sterilizations also occurred in Ontario, without legislation, even after Alberta and British Columbia stopped the practice (McLaren 163, 169). Over four decades, Alberta sterilized more than 2,800 people—a significant record considering the province's small population (Reilly 105). Policy makers in Ontario (and Quebec) considered implementing laws like those in B.C. and Alberta—as they were increasingly urged to do—but did not due to opposition, especially from the Catholic church (McLaren 126). Germany also instituted sterilization laws in 1933 which forced the procedure on anyone "suspected of polluting the purity of German blood" (Shapiro, T. 40). Britain did not institute any sterilization laws (Reilly 104). It did however, adopt a bill in 1913 which gave a central body the authority to segregate the feebleminded from the rest of the population.

In addition to sterilization, governments used other measures to prevent the propagation of undesirables (Kevles 9-10). In both Canada and the U.S., immigration laws were tightened to ensure that no undesirables were allowed in. Under Canada's 1910 Immigration Act, the definition of undesirables became elaborate. It excluded "the mentally defective," which included idiots, imbeciles, the feebleminded, epileptics and the insane; "the diseased" included those afflicted with any "loathsome disease or a contagious or infectious disease" that may harm the public's health; and the "physically defective," including the "dumb, blind, or otherwise handicapped" (McLaren 56). There were also measures that restricted the marriage of undesirables. In 1914 in the U.S., 30 states amended or instituted new laws that rendered voidable any marriage of idiots, those with venereal disease and the insane. Some of these laws were based on the notion that the unfit could not make contracts and therefore did not know the meaning of marriage, but many of the states also justified their new laws on genetic grounds. The final example of negative eugenics is the most horrific: Adolf Hitler's attempts to cleanse the Aryan race by eliminating altogether people such as Jews and gypsies. Hitler had a respect for the sterilization programs in California, and is said to have been inspired by them (Kevles 10). Germany's ethnic cleansing regime will not be discussed in detail, but is rather raised here as the most extreme form of negative eugenics to be practiced in the name of protecting perceived genetic superiority. It also signaled the end of the popularity of eugenics.

The Demise of Eugenics

Even prior to the Second World War, eugenicists were increasingly finding it difficult to defend their "science." A large number of eugenicists were not even versed in the basics of human heredity, and viewed eugenics as a social and political movement rather than a science. A growing number of scientists also began seeing eugenics in a negative light because of the growing belief that the science was baseless (Kevles 11). Some scientists accused "laboratory" eugenicists of shabby and doubtful science. Others criticized eugenicists' disregard for environmental factors in their study of human heredity. Critics also denounced eugenicists' obviously racist approach. The human experiments and mass murder of millions in Germany dealt eugenics a final blow. Hitler's crimes became associated with eugenicists, because his aims—to purify the Aryan race—were too similar to what eugenicists were preaching. In Canada, those who had been loud cheerleaders of eugenics, and even of Nazi eugenic programs, began to distance themselves from eugenics (McLaren 148). The Canadian Eugenics Society was destroyed in light of the atrocities committed in Germany (McLaren 113-114, 148). As the criticism grew, a new generation of scientists—most notably plant and animal geneticists—began to distance themselves from eugenicists in the 1930s. This new group of scientists, called reform eugenicists, was more interested in rigorous methodology in the study of heredity, and was adamant about keeping scientific work free from racism and class biases (Kevles 12). The group included Julian Huxley, J.B.S. Haldane and Herman J. Muller. The growing legitimacy of their ideas attracted other scientists, including physicians such as

Lionel Penrose, who was adamantly anti-eugenics (Kevles 12). Penrose viewed the study of human heredity as potentially applicable in alleviating human suffering, and believed it would be useful in "preventative and therapeutic medicine" (Kevles 12). Many decades later, his dreams would be on the road to becoming reality.

While eugenics was still in its hey day, more rigorous scientists were making key discoveries which would later be fundamental to the development of the new genetics. For example, before World War I, geneticists working with fruit flies (Drosophila) had worked out the basics of gene linkage for a number of the fly's traits (some genes are always passed on to the next generation in conjunction with others, and are therefore 'linked'). This knowledge was key to understanding how some human traits are inherited. In 1936, the first discovery of linkage in humans was made—by J.B.S. Haldane and Julia Bell at University College London—between hemophilia and colour blindness (Kevles 14). The new generation of geneticists who emerged after the second World War drew on these findings to advance their knowledge. They also increasingly looked to advances in the fields of animal and plant genetics, biochemistry and molecular biology (Kevles 15). In 1953, James Watson and Francis Crick established the double-helical structure of the DNA molecule (Watson and Crick 737). Another crucial discovery came in 1956 when cytogeneticists Joe Hin Tjio and Albert Levan suggested that the human cell had forty-six chromosomes, a finding that was confirmed by C.E. Ford and John Hamerton that same year (Tjio and Levan 2; Ford and Hamerton 1021). Their work essentially launched the field of human cytogenetics—the study of human cells. Research on blood types provided geneticists with useful genetic markers with which other genes could be investigated and even assigned to their respective "home" chromosomes—the first few steps towards the mapping of the human genome (Kevles 12). These and other findings set the stage for one of the most ambitious scientific undertakings in the history of mankind—the Human Genome Project.

As the volume of genetic knowledge grew, scientists slowly showed that the study of human heredity, without eugenic aims, was valuable for its own sake and for its potential for alleviating human suffering (Kevles 18). Scientists also began realizing, that to understand any aspect of human biology, they must also understand its genetics. Following Watson and Crick's discovery, many scientists turned their attention to finding ways of manipulating DNA in an effort to understand its function. In the late 1970s, researchers discovered several important techniques, including new methods to sequence nucleotides. And in the 1980s, they developed ways to automate and speed these processes (Kevles 19). One of the most important discoveries came in 1973, when scientists discovered they could use restriction enzymes to cut out a piece of the human genome and splice it into another. Recombinant DNA, as it was called, opened up many possibilities, said Kevles, including that of isolating genes (Kevles 19). Scientists then found that restriction enzymes could be used to position genetic markers on human chromosomes to create what was called restriction fragment length polymorphisms or RFLPs (Kevles 20). Scientists, such as biologist David Botstein, saw that this technique could help simplify and speed mapping of genes. By the mid-1980s, this technique led to the discovery of hundreds of genes, including many which control disease (Kevles 20-21). With the discovery of oncogenes, which play a role in causing cancer, one scientist declared publicly that for cancer research to advance, scientists must map the entire genome. Renato Dulbecco made his plea in *Science* magazine in 1986, just a few days after a handful of scientists met to discuss the possibility of mapping the genome. The two events led to widespread discussion among biologists of the merits and risks of mapping the genome.

In the 1960s, scientists had already begun discussing the idea of searching for the so-called biological holy grail, or the "code of codes" because they increasingly saw the potential benefits of such an endeavour. In fact, Lancelot Hogben, who saw linkage analysis as key for building a gene map, was the first to propose the idea in the 1930s (Kevles 12). As scientists developed newer techniques, isolated laboratories around the world independently began the arduous task of putting together a map of segments of DNA they found interesting. Some laboratories chose to isolate a gene, determine its function, and then find its location on a chromosome. Other labs chose a chromosome, and began to scrutinize it closely to determine the gene sequence within it. But progressing in these ways was slow and frustrating. By 1992, only 2,000 genes had been mapped, and less than 1% of the genome's sequence had been determined (National Centre for Human Genome Research 11). Many scientists believed there had to be a better way. The answer had to be in collaboration, and in big spending—in a massive project the likes of which biology had never seen.

THE BEGINNING OF THE HUMAN GENOME PROJECT

In 1985, Robert Sinsheimer, Chancellor of the University of California, organized a conference at Santa Cruz aimed at establishing a concerted effort to map the entire human genome. Sinsheimer was among a growing number of scientists whose imaginations were captivated by the idea of a large mapping project. Biology had never engaged in "big science" endeavours that had, until then, been associated with physics or astronomy. Sinsheimer was apparently motivated by the desire to put his university on the map; an institute to sequence the genome at Santa Cruz would accomplish that goal (Wilkie 76). Attendees at his small conference did not make significant strides toward beginning the project, but they provided the starting point. The conference also raised the arguments against the project that still linger today. Some scientists at the meeting were skeptical about the idea for two reasons (Wilkie 76-77). One group believed the effort would not be worth the amount of money and labour it would require. Another was concerned that the project would result in human beings "knowing too much" (Wilkie 77). Despite this, Sinsheimer persisted. Fixated on the idea of a large genome-mapping project, he organized several more meetings to discuss it. Though momentum grew significantly over the years, many scientists felt daunted by the audacious goals of such a project. Part of their concern was the fact that it would cost about $1 to sequence each base—meaning the project would cost $3 billion in total—and take 15 years to complete (Wilkie 81). But more and more scientists began supporting the idea, persuaded that the benefits of such an endeavour would far outweigh any disadvantages.

While Sinsheimer was promoting his ideas, the U.S. Department of Energy was also looking to get involved in genome mapping (Wilkie 78). Scientists were suspicious of the DOE, and many felt the project would be safer in the hand of the National Institutes of Health. After much debate, the first major step in launching the HGP came in 1987 when both the DOE and the NIH received government funds to begin work on deciphering the human genome. Watson, the co-discoverer of the structure of DNA, was appointed the head of the National Centre for Human Genome Research at the NIH, and the project was partly underway by October 1, 1988, with the NIH in the lead (Wilkie 83). At a historic meeting at Cold Spring Harbour, the Human Genome Organization (HUGO) was founded to keep track of progress in the dozens of participating laboratories around the world. Several countries joined in: Japan, the UK, Italy, France and Germany. Canada joined the effort in 1992, with the allocation of $22 million of federal funds over five years. (Charbonneau, *Medical Post*, 16 June, 1992, p. 2). Officially, the start date of the worldwide Human Genome Initiative was set for October 1, 1990.

Scientists predicted that within 15 years, they will have accurately and fully deciphered the entire structure of the human genome. DNA is composed of a "string" of an estimated 6 billion molecules that are paired up to form chromosomes, and scientists aimed to have "read" or sequenced them by the year 2005. They also expected to identify the location and sequence of the estimated what they had estimated to be some 50,000 to 100,000 genes contained within the 23 pairs of chromosomes (that estimate was later revised as the project progressed). Once a gene is mapped to a chromosome, its function can then be determined through further study. Genes function by producing certain proteins that ultimately determine traits as simple as eye color, or as complex as intelligence. When genes do not function properly, it is because they contain a "spelling mistake" or a mutation in their sequence of base pairs. As a result, the proteins these genes produce are defective and do not carry out their intended functions, possibly leading to genetic disease. The project would help identify these mutations, which could then be corrected or compensated for. The NIH promoted this aspect of the project in its publications: "Once genes have been pinpointed and isolated, researchers can then begin to understand the genetic errors that result in disease. Only this information can pave the way for new treatments and perhaps even cures for the many disease sufferers who, without it, have little hope" (National Centre for Human Genome Research 1). Despite the size of its ambitions, the project has achieved many of its goals. First, scientists produced a rough physical map in 1993 that provided researchers with the genetic markers needed to hunt for genes. The project's researchers have also identified some 200 genes related to specific diseases, including those affecting breast cancer and Lou Gerig's disease (Waterston and Sulston 53). Participants also completed the mapping of the genomes of model organisms, including a nematode and a fly. Most recently, in June 2000, the project also announced effective completion of the sequencing effort. At that point, 97% of the base-pairs had been sequenced—only 85% of which, however, had been mapped with 99.9% accuracy (Yamey 7). Scientists hoped the rest would be completed by 2003, two years earlier than anticipated. In its analysis of the latest data, published in February, 2001, the International Human Genome Sequencing Consortium estimated that the number of genes is more likely to be somewhere around 31,000 (Baltimore 815; International Human Genome Sequencing Consortium 860-921).

Although the media and scientists alike hailed the map announced in 2000 as a major breakthrough, there are clearly no immediate benefits, because much work remains to be done (Cordon and Watkins, 1223). But it is conceivable that within two decades, individuals could have their DNA tested to find out what mutations they carry, and therefore, what genetic diseases they might be at risk of developing. Some predict that medicine will become more personalized, tailored to each individual's genetic makeup. Scientists may eventually be able to "correct" defective genes by introducing the normal form of the protein into a human body so that everything functions properly—a process currently in the experimental stage called "gene therapy." Individuals who learn about their propensity for certain diseases, such as heart disease, diabetes, and even alcoholism—could then take preventive action to avoid them. Further, individuals might be able to test unborn children to ensure they are free of disease, or of other traits they consider undesirable, such as severe obesity or depression. While genetic testing already exists for a handful of diseases whose genes have been discovered (such as cystic fibrosis), the HGP will make it possible to test for hundreds if not thousands of genetic mistakes that could lead to disability or poor health. That is one of the main factors that make the HGP controversial.

HGP—Controversy

Since its inception, the HGP has sparked a great deal of debate and controversy, as already mentioned. Many people criticized its cost as well as its approach. But the HGP has mainly been controversial because of the ethical concerns it raises. Scientists involved in the project were not oblivious to these questions, and they took steps to address them right at the outset. The project dedicated 3%, and then later 5% of its budget to the study of ethical, social and legal implications. In Canada, that figure was even higher, at 12%, in the first phase of the study. Still, some ethicists, scientists and others are more concerned about issues of ownership and patenting of human genetic material. They also worry about issues of privacy that the HGP raises (Wilkie 121, 126). Others wonder whether the information the HGP provides might lead to the exertion of an unnatural degree of control over the kind of children we have (McGee 58). These issues can be discussed in three broad areas.

Ownership and Private Interests

The efforts of the HGP have, perhaps inadvertently, paved the way for the development of a mammoth biotechnology industry bent on reaping the financial rewards of genetic knowledge. Critics are unsettled by the practice of private companies taking ownership of genes they discover—an already widespread practice. These private companies hope that the stretches of DNA they patent turn out to be useful—for example, that they code for a specific disease. If so, companies can turn their attention to developing a cure that can then generate millions of dollars in profit. The way the HGP is structured necessitates the sharing of information publicly between all involved. Unfortunately, private companies do not participate in this practice, yet they benefit from the public effort's openness. The most visible example of the effects of private involvement came in the later years of the project, when one company threatened to render the HGP's years of work useless. Celera Genomics, a private company in the U.S., announced in 2000 that it planned to sequence the entire genome ahead of the public effort (McGee 25). It also planned to charge interested parties for access to its map. The company even admitted that it used some of the publicly available data to speed up its efforts. While a compromise was reached and the private and public projects announced their draft map together in June, 2000, Celera still plans to turn a profit by patenting a number of stretches of DNA. The involvement of private enterprise in scientific endeavors is not new. But when it involves ownership of something as personal as genes, controversy erupts. The real consequences of this kind of ownership will not be felt until cures are developed, and companies reap the rewards of their exclusive rights to such cures.

Genetic Privacy and Genetic Discrimination

The Human Genome Project is already making it possible for individuals to know more about their genetic makeup than they ever did before. The HGP has uncovered the location of many disease genes. This has made it possible for individuals to undergo genetic tests to determine if they might be at risk of developing one of these diseases, or of passing them on to their offspring. Scientists predict that the day will come when individuals will be able to order a genetic profile of themselves which would reveal everything from propensity to disease to expected life span. Critics believe readily available information about individual genetic makeup may provide new grounds for discrimination. Intimate knowledge about individuals will only accentuate differences between them, and, as Wilkie has said, such differences have been used in the past as a pretext for "unfair discrimination" (Wilkie 178). Marvin Natowicz defines genetic discrimination as that "against an individual or against members of that individual's family solely because of real or perceived differences from the 'normal' genome in the genetic constitution of that individual" (466). Discrimination may be exacerbated by the lack of the general public's understanding of basic genetic principles. There have already been instances, even before the HGP, when individuals who are carriers of a defective gene faced discrimination—as American blacks who carried a gene for sickle cell anemia did (Wilkie 106-107). It has been estimated that each one of us carries between five and eight deleterious genes, and we likely carry twenty genes that would cause genetic disease in offspring but not in ourselves (Shapiro, R. 277). But Paul Billings says that today, even innocuous genetic flaws are often perceived by social institutions as "extremely serious, disabling or even lethal," even if individuals carrying them are disease-free for the entirety of their lives (Billings et al. 481). With the tools provided by the HGP, employers and health insurance companies may increasingly rely on genetic information to determine a person's future health, and accordingly deny him or her jobs or insurance coverage based on that information (Bodmer and McKie 243). As Natowicz said, "because of economic incentives, it seems inevitable that, as more is learned about the genetic influence on disease, there will be a dramatic increase in workplace genetic screening and that widespread discrimination will result from its use" (467). Health insurance companies in the U.S. are already denying coverage to individuals with even a perceived genetic problem, and many of these cases have already been documented (Natowicz et al. 465). Some worry that genetic discrimination will lead to the creation of a new "genetic underclass" (Hasian 150). Legislators in Canada have yet to consider seriously the issue of discrimination based on genetic profile, despite warnings as early as 1992 from the federal privacy commissioner that they should (Philips 92).

Genetic testing poses other problems. Because the HGP is focused on finding genes, scientists will be able to test individuals for the presence of disease genes long before cures become available (Guyer et al 1151). Critics argue this is problematic—maybe even cruel—because someone who discovers he has a disease like Huntington's, for example, may not be able to do anything about it. There are other questions: Does that individual have the moral obligation to tell the rest of his family, even if the family does not wish to know? Who protects a person's right not to know the results of a genetic test? Unfortunately, these questions remain unanswered.

Eugenics—and Playing God?

Critics often suggest that information derived from the HGP might lead to an unnatural degree of human control of our children and ourselves. One day, it will become possible to test fetuses for a large number of diseases or undesirable traits, and possibly treat them before birth. Many critics, including religious groups, say that humans should not "play God" and alter the traits that nature provides—a theme often discussed in media reports. As Glenn McGee explained in his book, The Perfect Baby, there exists a feeling that, "biology is a part of the sacred tapestry of history, and there is something unnatural and immoral about meddling with its weave" (McGee 59). Critics say that the ability to test for undesirable traits in fetuses might also lead parents to choose abortion more often than they otherwise would. In an interview with *Minnesota Medicine*, geneticist Dr. Hymie Gordon highlights those concerns: "It will become possible to identify prenatally almost everything about an individual's biological potential. So what's going to happen? Are parents going to decide they don't want a baby because she eventually might have breast cancer, or because she eventually might have glaucoma?" ("Examining the Past" 14). Troy Duster, author of Backdoor to Eugenics, notes that "The elimination or prevention of the 'defective fetus' is the most likely consequence and ultimate meaning of a genetic screen" (Duster 128). This worries pro-life groups. Advocates for people with disabilities also have a problem with selective abortions—they do not believe in taking away the life of a fetus or a child to spare them a difficult life. The question is, who should decide what constitutes a justifiable abortion? Could society accept abortion of a fetus because it is found to carry genes that translate into below average intelligence? If not, who will decide what is acceptable? And if some parents choose to have an abnormal child, will that child be stigmatized for life? These questions are still being pondered and no clear answers are yet available.

"Playing God," argue some critics, is akin to what eugenicists were attempting to do early in the 20th century. Though most evidence is to the contrary, many of these critics say the Human Genome Project era has made eugenic aims popular again. Most media accounts of the HGP, especially of its ethical consequences, mention eugenics (Hasian 144). Robert Sinsheimer, who called the very first meeting on genome mapping, described gene therapy as the "new eugenics" which "could, at least in principle, be implemented on a quite individual basis. The new eugenics will permit, in principle, the conversion of all the unfit to the highest genetic level" (Fox Keller 289). Despite protests from the scientific community, some critics say that the logical consequence of having the knowledge and the tools developed by the HGP is eugenics. They argue that, "Like sterilization, the use of germ-line therapy becomes a means of ensuring that we have fewer generations of unfortunates" (Hasian 151). The stated purpose of genetic screening, selective abortions and gene therapy is the improvement of the human condition. But critics claim that with health costs rising everywhere, governments may enforce prenatal screening, for example, to avoid the costs of institutionalizing people with mental or physical disabilities (Duster 76). Duster suggested that while screening and gene therapy may not be intended overtly for eugenic ends, they do ultimately fit the definition of negative eugenics because they aim to eliminate undesirable genetic traits (Duster 112, 128). When most people think of eugenics, they immediately think of sterilizations and the Hitler regime. But in fact, when eugenics was popular early in the 20th century, different people had different interpretations of what it meant. But they all believed in the power of genetics as a determinant of human traits. That is one of the reasons that Marouf Arif Hasian Jr., author of The Rhetoric of Eugenics in Anglo-American Thought, says that eugenic ideas still exist today. While he dismisses critics who would stop genetic research altogether due to concerns about eugenics, Hasian concludes that,

> In the 1990s we are seeing a revival of eugenical discourse. With the advent of resource scarcity and shifting epistemic paradigms, we are witnessing a renewed interest in the possibility that human beings may in fact be inherently 'unequal,' at least as far as their genetic profiles are concerned (Hasian 2).

Hasian goes on to say that in the 1990s, Americans are facing problems—like homelessness and disease—similar to those faced by their ancestors a few generations earlier. And, as a result, he notes that, "genetic explanations are once again gaining in prominence" (Hasian 23). Wilkie says that a renewed emphasis on genetic makeup is slowly leading members of society, including scientists, to blame just about any problem on genetics, when in fact it may be due to cultural, economic or ethnic influences (Wilkie

179-180). Such attempts will be helped along by a genetic determinism (a reductionist approach to explaining human traits based on genetics alone) "borrowed and influenced by the HGP" (Wilkie 181). As Hasian points out, the public is "bombarded" with stories of HGP researchers who have discovered the latest genetic link to everything from musical talent to homelessness (Hasian 143). Genetic determinism, McGee argues, is thus difficult to avoid. Hasian suggests that genome-era science is just subtler in its eugenic aims, using language that distances it from its predecessor. As Hasian describes, "People are no longer predestined to be criminals—they may simply be 'predisposed' to commit crimes" (Hasian 153). Scientists speak less of improving the human "germ plasm" and saving racial purity, and more of "economic efficiency" and improving quality of life (McGee 51).

It is important to note here that geneticists and other scientists working on the Human Genome Project vehemently oppose any suggestion that their work and its consequences could amount to anything similar to the work of the early eugenicists. As mentioned, the HGP devoted a substantial portion of its funds to the study of the ethical and legal issues surrounding the project. As a result, several organizations developed to study these issues, including the Human Genome Organization's Ethics Committee, and the NIH-DOE's Joint Working Group on Ethical, Legal and Social Implications of Human Genome Research (also known as ELSI).

Scientists argue that their goals and those of the early eugenicists are fundamentally different. In a statement on eugenics and misuse of genetic information published in

1999, the American Society of Human Genetics said that geneticists aim to improve the health and lives of everyone. This is different from the aims of eugenicists:

> Galton used the word eugenics to characterize efforts to produce children who would be well born. However, he did not merely desire that as many infants as possible be born healthy. His real goal was to ensure that as large a fraction as possible of each generation would be the offspring of what he considered the best "stock" (American Society of Human Genetics 336).

In this statement, the society concluded that programs that would restrict reproductive freedom based on genetic information "are scientifically and ethically unacceptable and should be challenged" (ASHG 337). The society asserts that laws which implement genetic screening or funds provided for genetic services such as counseling and testing do not amount to the misuse of genetic information. The statement says that governments support these programs "in the interests of improving the odds that children will be healthy"—a far cry from eugenic aims (ASHG 337). The society adds in the statement that it,

> Deplores laws, governmental regulations, and any other coercive effort intended to restrict reproductive freedom or to constrain freedom of choice on the basis of known or presumed genetic characteristics of potential parents or the anticipated genetic characteristics, health or capacities of potential offspring (ASHG 335).

Other institutions and organizations have also taken the lead on ensuring genetic work does not impinge on the rights of individuals. For example, genetic counselors adopt a policy of neutrality when advising parents of their risks of having a child with a particular disease. They will neither support abortion nor oppose it. Instead, they give parents the information they need to make the decision on their own (Li 32). The ELSI organization has also developed a number of policy recommendations aimed at law makers. These address everything from protecting individual privacy to guarding against genetic discrimination. The organization has also considered a range of other issues, including the role of genetic counselors, to sensitizing health practitioners to the ethical and legal ramifications of genetic testing. ELSI has produced volumes of literature on these issues, with the ultimate aim of ensuring that genetic research is never misused (ELSI online).

Genetic scientists envision a future when people will have the ability to change the health status they were born with, a time when people do not have to die because of what is written in their genes. Critics, on the other hand, imagine a future when our genes are no longer ours, when we are at the mercy of employers or insurance companies, the private sector and maybe even governments. Either scenario piques our interest. And both scenarios are often taken to extremes by parties with a vested interest, almost always prompting media attention. There is no agreement on which scenario will prevail. Ethicist Thomas Murray asks, "Will mapping, or sequencing, in particular, somehow diminish our dignity? Will it somehow interfere with the moral standing of humankind?" His conclusion is optimistic: "If we could absorb Copernicus, if we could absorb Darwin, if we could absorb Freud, I have a feeling we will be able to absorb human genetics. . . . I think it is only a shallow and fearful concept of human importance that is threatened by this kind of knowledge" (Shapiro, R. 285). Given all the outstanding concerns about the HGP, that still remains to be seen.

INTRODUCTION

Over the past century, science has played an increasingly larger role in society, introducing advances in technology and solutions to age-old problems, including health ailments. Scientific advances have inarguably had a growing influence on public policy decisions and society at large. Researchers have, as a result, devoted a significant amount of time to studying how members of the public learn about scientific research and its applications. Many have concluded that the public does not have a sound understanding of the processes or results of scientific research. Parallel national surveys in Britain and the United States in 1988 have indicated that most adults have little basic scientific knowledge (Durant, Evans 11). Edna Einsiedel *et al.* describe scientific knowledge in Canada as "dangerously low" (Einsiedel *et al.* 85). Einsiedel's own survey, for example, revealed in 1990 that only about one-half of respondents knew that the Earth revolved around the Sun (Einsiedel *et al.* 85). The same survey showed that more than half of the respondents believed that early humans and dinosaurs co-existed. Einsiedel says that "while Canadians follow the lives of hockey players and other heroes of popular culture with profound interest, two-thirds can not name a single Canadian scientist," and fewer than half can identify one Canadian scientific achievement (Einsiedel *et al.*, "Science 85).

Despite the lack of scientific knowledge among the public, research has also shown that the public does value scientific knowledge, and that individuals are interested in learning more about scientific endeavours (Einsiedel *et al.* 108; Miller 57; Ubell 297). Jon D.

Miller found that 40% of American adults are highly interested in science and technology, and that half of these individuals can be described as an attentive audience (57). A survey of young adults in the U.S. showed that they were "strongly supportive" of science (Patterson 407). Most adults gather much of their scientific knowledge in high school and during post-secondary education. After schooling, the average North American adult then receives most of his information about science through the print news media. Landmark surveys conducted in the late 1950s by the U.S. Survey Research Centre and the National Opinion Research Centre suggest that once adults finish schooling, they acquire most of their subsequent knowledge of science and health issues from newspapers and magazines (Wade, Schramm 206, 209). Many other researchers have come to similar conclusions (Nelkin 68; Ubell 294). Dorothy Nelkin cites a more recent survey that also confirmed these findings. The survey, conducted by the United States National Cancer Institute, indicated that 63.6% of respondents received information about ways to prevent cancer from magazines, 60% from newspapers, and 58.3% from television. Only between 13% and 15% of those surveyed had spoken directly to their doctors about how to prevent cancer (Nelkin 68).

Because the media play such a large role in disseminating news about science and health, communications researchers have spent decades studying scientific journalism. These researchers have uncovered many flaws in the media's communication of science (Dornan 48). For example, print journalists often lack specialized scientific knowledge, and they face professional constraints that make it more difficult for them to convey a thorough picture of the scientific news they cover. Critics of science journalism, which include scientists, also cite lack of accuracy and the absence of depth and context as major shortcomings in newspaper accounts of science. How these shortcomings affect the public's perceptions and understanding of science is unclear. Researchers appear to agree that the media do have an influence on public perception, but that that influence is not pervasive. Several factors shape perception, among them an individual's social status and prior knowledge in a given field. This means that the media's coverage of a certain subject affects individuals differently. Several studies that will be discussed later have shown many specific instances where media coverage has far-reaching effects on perception. By extension, flaws in media coverage must also have an effect on the public's perception and understanding of scientific endeavours. Therefore, an analysis of popular media coverage of science, such as the one I have undertaken here, may provide some clues as to how a given subject is perceived by the public.

A SHORT HISTORY OF SCIENCE JOURNALISM

Communications about science fell at one time on the shoulders of the scientists who conducted the research. Scientists communicated some technical information to the public through almanacs and calendars, but the most convenient method in this early period was personal correspondence via the postal services (Meadows 66). The letters served as a means to transmit information about scientific research and observation from individuals to groups and other individuals, who would then transmit this information by word of mouth (Meadows 66). Soon, some of these letters began appearing in journals. The first recognizable instances of scientific journalism emerged in 1665, in the form of two journals, the French *Journal des Scavans*, followed shortly by the British

Philosophical Transactions. Henry Oldenberg, secretary of the British Royal Society for the Improvement of Natural Knowledge, corresponded with scientists around the world and reported what he learned to members of the society (Fyrth and Goldsmith 113). He created *Philosophical Transactions* specifically to catalogue letters he received from scientists (Burkett 18). Original scientific research that was published in journals or communicated in letters was expected to eventually be published in books (Meadows 67). But soon, journals overtook books as the primary medium for the publication of major scientific research (Meadows 67). Scientific journals, which were at the time easily comprehensible by the literate laity, proliferated in Europe, and later in the United States. Historians estimate there were as many as 90 scientific journals around the world in 1800, and more than 10,000 by 1900 (King et al. 7). As newspapers and magazines emerged in Europe, they carried some of the journal articles in their own pages. But, as Warren Burkett describes, some of the greatest scientific innovations of the century—including the steam boat, telegraph and telephone—still only "received relatively bare mentions in the newspapers" (18). Scientists still undertook the bulk of scientific communication. They traveled to give lectures about their work, continued writing and editing their own journals, and published scientific pamphlets aimed at the general public. By the 19th century, science was evolving from the hobby of the independently wealthy into an acceptable, full-time profession (Friedman *et al.* xiv). Scientists began to specialize, and to move away from their earlier practice of helping to educate the public. As they formed national professional groups, scientists also abandoned their practice of holding public lectures, and their communications grew increasingly complex and specialized (Burkett 18-19). Soon, the mainstream media were covering science regularly (Burkett 20).

Newspapers in the late 19th century and early 20th, however, tended to embellish stories about science, or worse, make them up. Burkett describes a time when newspapers "gave laymen an impression of science focused on the bizarre. Stories of the odd, outlandish and impossible filled the popular press after the turn of the century" (Burkett 21). Nelkin says that in printing such material, the newspapers were responding to a public demand for "wildly lurid stories" (Nelkin 79). Some papers met that demand by covering scientific findings that never existed, such as sightings of bat-like humans on the moon. Yet simultaneously, newspapers noted Albert Einstein's theories of relativity and other genuinely important scientific developments. Some newspapers went further, like the *London Athenaeum*, which published transcripts of meetings of the Geological Society of London in the 1830s (Burkett 21; Nelkin 79). Newspapers in both Europe and the United States also published verbatim transcripts of lectures by prominent scientists of the period (Nelkin 79). But the bulk of serious writing about science in the mainstream press highlighted research and advances that had practical applications. Newspapers focused on disease prevention or home remedies. Industry and trade magazines, meanwhile, published articles on topics such as the latest farming techniques (Nelkin 79, Burkett 20).

The focus of science changed with the explosion of the First World War, and writing about science changed significantly with it. American scientists were an integral part of the war effort, developing material and technology, especially chemicals that would replace the German products that the U.S. had previously relied on (Burkett 21). With increased attention and funds from government, scientists provided more and more new findings, and journalists obliged with expanded and positive coverage of those endeavours. Burkett says that the war was key in persuading journalists and their editors to recognize "that the scientists deserved more serious attention" (21). Again, most of this expanded coverage entailed discussion of the application of science in people's daily lives. The experience repeated itself during the Second World War. Science played an even larger role in that war, and historians credit scientists with helping to win it. Scientists had developed penicillin, and had made advances in radar and electronic technology—all of which aided in the war effort (Burkett 23). Science also received much attention because it had helped develop the weapons of the Second World War, including the atomic bomb, which was key to Japan's surrender and the termination of the U.S. role in the war (Friedman *et al.* xiii). Following the war, scientists promised new advances in air transportation. Their work in biological research, says Burkett, promised to "make medicine a true science" (23). As a result of their role in the war, scientists received even more funding from governments. As Burkett says: "Big science had arrived, consuming large amounts of public funds and entering the political debate on public policy and financing, the natural field of journalism" (23). The media began to pay even more attention to the world of scientists.

With the significant leaps in scientific research following the Second World War, editors hired regular full-time scientific reporters to replace the freelance writers who had often provided the coverage until then (Burkett 22). Scientific journalism became a "distinct specialty," with its own professional organization, the National Association of Science Writers, which a dozen journalists had founded in the mid-1930s (Nelkin 83; Friedman *et al.* xiii). The post-war science writers were overtly positive in their coverage of scientists and their endeavours, much as their predecessors had been since the early 1900s. Nelkin says that journalists were "enamoured" of the progress science implied. They "conveyed an image of science as an economic resource, an instrument of progress, a servant of technological needs" (Nelkin 80). It was this positive tone that dominated in the work of the first syndicated science service, founded by Edwin W. Scripps in 1921. Working with the U.S. National Academy of Sciences, and the American Association for the Advancement of Science, Scripps produced stories with the stated purpose of emphasizing "the importance of scientific research to the prosperity of the nation and as a guide to sound thinking and living" (Nelkin 82). The service's articles conveyed images of science as a "new frontier," and scientists as pioneers who were "industrious, persistent and independent; all in all, they incorporated the most positive values of American culture" (Nelkin 82). The science service reached nearly seven million readers of more than 100 newspapers (Nelkin 81-82). Other scientific writers adopted the science service's attitudes, accepting their role as missionaries of science. The majority of scientific journalists at this time were non-scientists, which some blame for their awe-inspired attitudes.

In the 1960s and 1970s, scientific writing experienced further growth as newspapers scrambled to cover major scientific events such as the Soviet launch of Sputnik, and the attempts to put man on the moon (Friedman *et al.* xiv). Whereas their predecessors had essentially been cheerleaders for science, this generation of writers became more critical, more suspicious of authority—and that included scientists. Writers of the 1960s and 1970s were also generally better educated than their earlier counterparts, and became more investigative and adversarial (Nelkin 89). During this period, scientific writers began to criticize their own, calling for a more objective approach to covering science (Nelkin 89). These scientific writers were in part responding to the public's growing disenchantment with science, the costly space missions and development of atomic arsenals. Science had brought DDT and the green revolution, and had heralded medical advances that eliminated dozens of diseases from existence (Farago 67). But with those advances came new problems, such as the threats to the environment caused by new chemicals, and the exponential growth in world population (Farago 67). As scientists joined the debate over some of these issues, the public and the press questioned their objectivity (Nelkin, 89). Peter Farago describes the public reaction of the period in his book, Science and the Media: "The scientist emerges as the new bogeyman . . . despoiling the countryside for the creation of useless and dangerous wealth for a favoured elite" (68).

Journalists responded by eschewing their role as simple conveyors of facts, and began addressing the political and social consequences of science in their stories. This became especially the case in the 1970s, when journalists had also begun to increasingly report disputes over scientific work (Nelkin 89-90). In the conservative 1980s, Nelkin writes, science journalists briefly returned to the promotional style of writing as technology and big business boomed. But in the 1990s, with the exponential growth in scientific research, especially in the controversial field of genetics, journalists again became more critical. Nelkin says that the end of the Cold War "brought a search for new and newsworthy villains, scientists among them. Incidents of scientific misconduct, the costs of megascience, and bioethical dilemmas are sure to attract current media attention" (Nelkin, 90). But even as the media highlighted the negative aspects of scientific research, they generally still provided positive overall coverage, as they continue to do today (Nelkin 83; Einsiedel 99).

SCIENTIFIC JOURNALISM TODAY

In the past few decades, scientific research has grown exponentially. Just as a small measure of that growth, it can be noted that review articles on genetic disease alone in Medline, a medical database, increased sevenfold between 1986 and 1989 (Fox Keller 285). Newspapers have, of course, responded to that growth, devoting more resources and personnel to the coverage of science and health news. In the early decades of the 20th century, only a handful of the largest newspapers employed journalists dedicated to covering science or health stories. The situation has changed dramatically in the past two decades. In a 1994 survey of 105 Canadian newspapers, Mary-Anne Saari *et al.* revealed that nearly half of them employed a reporter who spent part of his time covering science or health (78). Most major newspapers now also allocate entire pages or small sections to news and features about science and health—though these newspapers form a small minority of Canada's daily newspapers (Einsiedel *et al.*, "Science Culture" 102).

Despite the increase in the number of journalists who write about science and the increased attention the field receives, advocates of improved popularization of science say it is not enough. Saari *et al.* conclude that:

> At a time when science is even more complicated to understand, the value of recent developments more difficult to assess, and public funding under greater pressure, the Canadian daily press is barely able to provide a critical source of public information. The commitment of staff by the Canadian daily press has never been weaker (78).

Media researchers have also said that the unique challenges scientific reporters face in doing their job also cause problems in the communication of science to the public. For example, scientific issues, on the whole, are more complex than those of politics or entertainment. Covering science, therefore, requires that journalists have either prior knowledge of science, or the skills to learn quickly. Researchers also cite lack of accuracy, depth, and context as some of the major shortfalls in the press's treatment of science. The consensus among several of these media researchers appears to be that newspapers are simply not an optimum medium for disseminating news about science. There are several reasons for this conclusion, which will be explored in some detail.

The Journalists

Reporters who cover science for newspapers today are not a homogenous group. They include those who cover medical and health news on a full-time basis, as well as those covering non-medical news areas such as the environment and engineering. Science news is also produced regularly by general reporters or by journalists who specialize in other areas who are occasionally assigned a science story. According to Saari's study, the majority of Canadian journalists who cover the beat on a full-time basis write for major newspapers with a circulation larger than 100,000 (Saari *et al.* 67). The study found that 70% of science writers who covered the hard sciences (excluding health) also worked for those large papers. Meanwhile, smaller newspapers emphasized health reporting. According to Saari *et al.*, some 42% of smaller Canadian newspapers did employ science writers, but nearly all of those writers focused on health. Even so, only about two-thirds of them actually devoted most of their time to covering the field (67).

One issue that has dominated discussions of the failures of scientific journalism is the type of education journalists who cover science have. Science writers in Canada (and elsewhere) come from a variety of educational and career backgrounds. Saari's study revealed that the vast majority of Canadian science writers held post-secondary degrees (73). But the survey also found that only 20% either held a science degree or at least took some science courses during their undergraduate education (74). Einsiedel found that the majority of the degrees science reporters hold are in the humanities (99). Nelkin says, however, that younger science journalists are more likely to have a formal science education (94).

There is a significant difference of opinion among researchers, scientists and journalists as to whether a science education is essential for a career in science reporting (Nelkin 94). Some scientists and researchers have argued that an education in science gives reporters a basic understanding of the scientific method and the necessary knowledge to avoid being misled (Saari *et al.* 74). These scientists and researchers have said that rampant errors and absence of context in today's science reporting can be attributed in part to journalists' lack of training in science. Einsiedel says that, "if there is one (reporting) beat where journalistic training alone may not be sufficient to carry the reporter through the news maze, it is the science beat" (99). Others have said that basic journalistic skills are more important than scientific knowledge, and that journalists with scientific training may tend to become too close to the people they are covering (Nelkin 95). Pierre Fraley says that because a writer cannot be trained to have knowledge in every branch of science, "many people believe that a feeling for the scientific method and an understanding of the philosophy and history of science might be more important than deep knowledge in any one field" (323). Proponents of this theory have suggested that journalists can easily pick up knowledge while performing their job and by learning to properly research the stories they write. Most have agreed, however, that some scientific knowledge—no matter the source—is key to doing the job well.

The Stories

> "They may not understand the theory of relativity but they will understand the importance of peer-reviewed journals, the concept of the double-blind study, the link between research and a country's economic performance. They will resist the urge to turn every modest research advance into a breakthrough, they will not demand black-and-white answers from scientists who deal in probabilities, they will not join in the mass hysteria which sometimes passes for health

reporting when it comes to infectious disease. They will understand that nothing is final in science, that every theory is permanently tentative. They will know that science can explain the machinery of life but not its meaning" (Bueckert, *Science Link*, May 1998, Online).

Dennis Bueckert, a science and health writer for The Canadian Press, wrote the preceding statement to describe what it is he attempts to impart onto the students who take his scientific writing course at Carleton University. Several media researchers have suggested that these values are not common among today's scientific journalists. These researchers have many complaints about science reporting in newspapers. They have maintained, for example, that the working conditions and professional pressures for scientific journalists conspire to produce scientific reporting of low quality. They complain that most stories about science are much too short and lack context. They also worry that journalists simplify concepts too much.

Competitive pressures top the list of constraints cited by critic as problematic. Those who work for the popular press must write articles that will appeal to wide audiences, and ultimately, help sell the newspapers they work for. The journalism profession is competitive, and scientific journalists must ensure they do not fall behind those at other newspapers. Journalists face competitive pressures within their own organizations as well. Reporters who write about science must constantly prove that their articles merit more prominent placement in the newspaper than other news articles (Farago 30). The "news hole" may only account for 30% of a newspaper's space, and science writers must compete with columns, editorials, features and other news for some of that space (Friedman, 21). As Peter Farago says, the journalist's "first task is not explanation, but selling, for he has to persuade his colleagues and superiors on the paper that the story needs to be published" (29). These pressures have major effects on the way journalists write science stories.

Studies have shown that these competitive pressures force reporters to oversell their stories to their editors, and to their audiences as well. In a landmark survey of scientific journalists, Jay A. Winsten documented the distorting influence that competitive pressures have on scientific reporting in the mainstream media:

> The journalist's ambition to make page one has a powerful impact on the selection and treatment of stories. Science reporters, based at preeminent publications, stated that competition for prominent display of their stories creates a strong motivation to distort their coverage (8).

Journalists who participated in Winsten's study reported writing "towards the limits of the permissible," to make their stories as strong as possible (11). That can mean describing scientific research, for example, as "groundbreaking" or of "vital importance," even if it is not quite so (Winsten 10). For example, a Reuters story, recently carried by *The Ottawa Citizen,* describes research into stem cells as offering hope for "future medical miracles" (Dunham, *Ottawa Citizen*, 4 May, 2001, online). In his discussion of how journalists cover medical news, Jim Sibbison says that stories "that say a salve performs miracles are more attractive than ones that say there may be flies in this particular ointment" (39). Winsten points out, as have other communications researchers, that attempts to "hype" or sensationalize a story have significant consequences: "the danger—sometimes realized—is that overemphasis on the 'strong' will distort the news and mislead. Sometimes the tone of the story—the emotional content of its words—misleads, even when each sentence is factually accurate" (11).

This is a problem that is exacerbated by journalists' attempts to establish the "newness" of their stories. Journalists naturally tend to highlight the immediacy of what they are reporting. Newspapers also tend to cover science through a series of unconnected, hard news stories. It is one of the top sources of criticism by the scientific community of the scientific reporting in the popular press (Winsten 6). These critics argue that in covering science, the tendency to emphasize newness is counterproductive because it distorts the way scientists actually work (26). As Sharon Friedman explains, "Science is portrayed as something made up of 'breakthroughs' every other day, rather than a long, laborious process. Scientific advances appear to be the products of individual researchers rather than of teams of scientists building on each other's work" (26). Scientific research findings are usually, at best, tentative, supporting one of several competing but equally tenable theories (Sibbison 36). Breakthroughs in scientific research, in fact, are quite rare. Sibbison explains that "the typical research study—inconclusive and in danger of being contradicted by a future, equally competent investigation—can come to seem, in the press, of much greater importance than the evidence warrants" (36).

Marianne Pellechia argues that emphasis on newness may also lead to the omission of important contextual detail: "it is perhaps easier to convey the newsworthiness or uniqueness of a particular finding if it is cast as a breakthrough or isolated event, rather than if it is contextualized as part of a larger body of research" (62). She adds that the resulting coverage ends up in "a trivialization and misunderstanding of specific research results, as well as of science in general" (64). Winsten says that a disjointed approach to covering news might work well for areas such as sports and politics, because the media tend to cover these areas on a regular basis and can assume prior knowledge among readers (21). But, he adds,

> Science news is different. With the occasional exception of a major, ongoing story, science news is scattershot. A particular line of research may make the news once or twice a year, or even less. Despite this, science stories often provide little or no context. Rather, the reporter presents a fragment of new information in isolation, and the next day moves on to something else (21).

The efforts to emphasize the new and to make stories as strong as possible are perpetuated by editors, who tend to have specific, set ideas about what the reader wants (Johnson 321). One study conducted in 1963 analyzing editors' evaluation of science stories suggested that editors tend to associate the value of a story with how exciting it is, and how much colour it contains, more strongly than do writers, scientists or readers (Johnson 321). June Goodfield says the motivation for both editors and writers is "not to give facts or create interest but to promote sensation" (16). In the coverage of scientific news, which is often about a new advance or technology, writers will usually then end up highlighting the positive more than the negative (Goodell 41; Einsiedel 99).

In addition to the constraints already mentioned, journalists face other limitations which even more directly affect the articles they produce. The news business is a fast-paced one, where journalists are constantly facing deadlines. This is especially true today since most journalists must also file throughout the day, as quickly as possible, to provide the latest to newspaper Internet sites. The time constraints mean that the majority of the time, journalists research and write their stories in the span of a few hours. As Farago says, "a multiplicity of ad hoc decisions are made in the heat of the moment, not infrequently, on insufficient evidence and less understanding, but on a great deal of intuitive experience" (Farago 29). Time limits also curtail journalists' ability to conduct research into the background of their articles or into similar or contradictory research, and make it more likely for them to make errors. Friedman says that, "Too much speed also can lead to superficial coverage and lack of interpretive or investigative reporting" (27).

Due to time constraints, science journalists must also often rely only on scientific sources for their stories, and often only the scientists directly involved in a particular story. For example, a recent article which appeared in *The National Post* on how stem-cell transplants help save leukemia patients quotes Dr. Mary Laughlin, who led the study, and no one else (Evenson, *National Post*, 14 Jun. 2001, online). Some media researchers have argued that the overrepresentation of the scientist's view in science articles is one reason why hard news about science is often generally positive in tone. This can be illustrated by an extreme example, a Reuters story which appeared in *The Calgary Herald* in 1993 announcing the completion of the first physical map of the human genome. The article dutifully reports, in the second paragraph, that the scientists involved likened their findings to "Louis Pasteur's 19th century discovery of bacteria or to the 1953 breakthrough by Watson and Crick in discovering the double helix structure of DNA" ("Scientists" A3). William Bennett says that the result of over-reliance on scientists, "is a disturbing overemphasis on the authority of science as a source of truth, rather than on its revolutionary potential as a way of thinking. The scientist comes off as an authority, and the validity of his work is justified by his standing, not the other way around" (127). Einsiedel suggests that with the constraints of daily news coverage, "it becomes easier for journalists without some background in the sciences to surrender to scientific expertise" (99). Nelkin agrees, suggesting that due to job constraints, journalists are "vulnerable" to scientific authority (123). She says the vulnerability is exacerbated as "Scientists and their institutions, increasingly motivated to enhance their influence over science and technology news, have become more sophisticated about how to do so" (123).

The constraints and limitations I have mentioned thus far force journalists to restrict their stories to the newest findings, and to rarely introduce dissenting views or refer to conflicting research. Often, even when they include details or background information, journalists place this material at the lower end of a story where it is liable to be cut out by editors if the story is too long (Friedman 23). Journalists have little time to devote to producing explanatory material, which takes time to compose. In a content analysis of science coverage in 100 American newspapers, Marilee Long found that writers who spend more time writing a story tend to include "significantly more explanation than did writers who spent little time composing their stories" (Long 126). Since most stories about science are hard news stories, they simply omit explanatory material. Critics, scientists among them, see this omission as another flaw in scientific journalism. Long found that the majority of the articles she studied contained 10% or less scientific explanation (125). The bulk of newspaper coverage of science is done in the form of news stories, which are so short that they do not allow the inclusion of anything more than the basic facts. This is why media researchers often suggest that hard news stories are not the best way for newspapers to cover science.

It is important to note, though, that many newspapers do sometimes publish features, a form of writing which eliminates or at least reduces the effects of time and space constraints on scientific reporting. Journalists who write these features may have a few days to work on them, instead of a few hours, and much more space in which to include explanatory as well as background detail. Communication researchers have discovered that unlike hard news articles, features are a better vehicle for writing about science, and that science journalists prefer to write those to hard news stories (Friedman 24). However, while science journalists at major prestige newspapers such as the *New York Times* do focus on writing features, the majority of smaller newspapers still largely rely on hard news, mostly produced by wire services (Friedman 20, 25).

Part of the problem is that smaller newspapers lack the financial flexibility to be able to produce and publish such features. This shortage of resources at some newspapers, along with the emphasis on turning a profit, has a detrimental effect on science journalism. Financial constraints often mean that newspapers cannot afford dedicated scientific reporters, and must therefore assign stories about science to general reporters. That means that those reporters cannot focus on properly researching science stories or keeping abreast of the latest developments. Financial considerations also mean that even if a newspaper does assign a dedicated science writer, it does not have the luxury of allowing that writer to spend too much time on one story.

Non-specialized reporters also find themselves struggling with the complexity of science, yet another constraint which makes scientific reporting difficult. The growing complexity of scientific advances, and the small number of journalists who possess sufficient training to understand them, leads to inaccuracies in reporting. Errors can also occur when journalists attempt to simplify concepts and make them tantalizing and understandable enough to ensure reader interest and comprehension. Journalists are often compelled to leave out entire concepts (leading to what some call "errors of omission") or to gloss over them, leading to a distortion of the facts. While critics decry the oversimplification of scientific concepts, there is evidence that readers find articles which contain simplified concepts more readable and enjoyable. G. Ray Funkhouser and Nathan Maccoby found that readers at all levels enjoyed more simplified versions of scientific stories (69). Based on their findings, Funkhouser and Maccoby give science journalists this advice:

> The results of this study suggest that a science writer use as simple a vocabulary as is consistent with the subject matter that he is presenting and that he make his

> points concisely and explain them by using examples rather than analogies. He might do well to use short sentences, activity words and concrete words. And it probably will help to use some non-science material (i.e., everyday life parallels, historical points, etc.) (69-70).

In other words, Funkhouser and Maccoby believe that those qualities detested by scientists and critics of scientific journalists might actually encourage reading and interest.

The Scientists

Many of the most vocal critics of scientific reporting in the popular press are scientists themselves, or media researchers who judge the writing from the perspective of scientists. Chris Dornan, who wrote a paper essentially defending scientific journalists, says that, "the interrogation of the communication process is most commonly conducted in light of the hierarchical dominance of the scientific camp" (51). There are several inherent problems with this, which I will briefly outline. The ultimate motivation of reporters is to attract readership, and sell more newspapers. Though many science writers believe in helping the public understand scientific research, they do not view it as their responsibility to act as educators, or as missionaries of science. In his survey of science journalists in the British press, Anders Hansen said that, "Fundamental to both popular and quality press journalists is a clear notion that the primary task of newspaper science coverage is neither to educate the public nor to make the public scientifically literate, but a rather more modest goal of supplying interesting, informative, and entertaining coverage" (127). Cristine Russell, an American national science reporter, describes a scientific writer's role:

> In addition to translating it for the reader, without all the technical jargon, we must point out if it is controversial or well regarded in the field. We have all heard from scientists who were hurt that we didn't use precisely their language in the story or that we included some criticism of their work, however justified. We need to make it clear that most science journalists are not agents or advocates for a given cause, but simply are trying to present a balanced story (Russell 92).

Further, to judge newspapers by scientists' standards is inherently problematic because at the core, the two fields are quite different—especially in their respective writing cultures. For example, in their writing for scientific journals, scientists first provide the reasons for conducting an experiment and the methodology, then they report their findings. In their writing about such research, journalists do the opposite (Dunwoody 12). Articles in scientific journals are often long and detailed, and scientists may take months to write them. Journalists clearly do not have either luxury (Dunwoody 12). Bennett points out that scientists are published in journals which demand that papers are reviewed by peers prior to publication. But, as Bennett explains, "the journalistic fourth estate operates according to a set of values that does not cheerfully tolerate this form of news 'management.'" Bennett adds, "Accustomed to reading and writing in one mode, scientists often find it difficult to adjust to the seeming unruliness of popular journalism"

(122). Journalists seek definitive answers, a final resolution of a problem. Scientists are more cautious and tentative, they discuss competing theories and caveats to their findings. Journalists write to sell newspapers, but also to inform and entertain the public. Scientists want to publicize their own theories, to advance their ideas and promote public (and financial) support for their work. Farago states that newspaper publishing "is innately not inimical to the presentation of scientific news and—more importantly—of the background ideas that give science its cohesive strength. Rather, possibly out of necessity, newspapers do not speak the same language as even a diluted and trivialized science would require" (35). Most critics of scientific journalism would agree.

Communication researchers and scientists, suggest some commentators, may simply be expecting too much of newspapers. Farago says that, "One does not expect a mini-scientific journal hidden within the bowers of a daily newspaper, especially when it is the paper's explicit policy not to cater specifically for those interested in science" (Farago 34). Sharon Dunwoody suggests that journalists cannot afford to include all the details that scientists want included in their articles. She says, "To burrow into methodological or theoretical detail is to lose them, for most of these readers will be interested primarily in what the researchers found and why it is important to their daily lives" (Dunwoody 13). Dornan bluntly points out that without journalists, scientists would have a tough time publicizing their work: "after all the studies, the content analyses, the ruminations and recommendations, what remains is the rarely spoken fear that *without* the narrative artifice that comes with press handling, science makes for unfortunately dreary subject matter" (62).

One final point raised by several researchers is that scientists themselves cannot be held blameless for some of the most criticized attributes of scientific journalism. Winsten and others report that scientists are increasingly barraging science writers with press releases and conferences to publicize what they themselves describe as "breakthroughs" and "miracle cures." The recent growth of for-profit biotechnology and drug companies has increased the amount of public relations material that science writers must sift through each day—adding another pressure to their jobs (Winsten 15, 17). In his recommendations, Winsten calls for a stop to the "public relations assault" on scientific journalists (22).

A WORD ON MEDIA IMPACT

Implicit in the study of the state of scientific journalism is the belief that somehow, the way the media treat scientific subject matter has some effect on how the public perceives it. The flaws that communications researchers have identified in science writing, therefore, must also have some effect on that perception. The nature of that effect is difficult to gauge. This difficulty stems from the fact that research has not yet yielded a definitive model of how the media affect public understanding and perception of science, or of any other subject. Despite that, it is important to outline here some of the research into the effects of the media, because it will inform the discussion on how media coverage influences public perceptions of the Human Genome Project.

The earliest researchers posited that the mass media's effects were pervasive and direct. The "silver-bullet" theory, say Wilbur Schramm and William Porter, was the belief that "The situation is like a shooting gallery: All that is needed is to hit the target, and the target falls down" (Schramm, Porter 172). Media researchers had essentially believed that what was printed in newspapers, or shown on television, or broadcast on radio, could easily alter an audience's beliefs. The belief stemmed, in part, from the notion that the proliferation of new sources of information (including radio, magazines, television) would have tremendous powers over consumers (Vipond 101). The "silver-bullet" theory was also reinforced in part by the belief that urbanization—and resulting isolation of the individual from family and community—had left individuals susceptible to messages they received from the mass media (Vipond 101). Communication researchers have since dismissed that theory as far too simple. Today, there is no clear, generally accepted model of how the mass media affect the public. But there appears to be agreement that the media must have some effect. As Joseph Klapper says,

> It must also be remembered that though mass communication seems usually to be a *contributory* cause of effects, it is often a major or necessary cause and in some instances, a sufficient cause. The fact that its effect is often mediated, or that it often works among other influences, must not blind us to the fact that mass communication possesses qualities which distinguish it from other influences, and that by virtue of these qualities, it is likely to have characteristic effects (Klapper, Process and Effects, 7).

Researchers agree that though the effects of the media are not as powerful as once believed, persuasion can occur through communication by the mass media (Klapper, "Mass Media," 288). They also believe that mass media effects on the public are mitigated by the public's influence on the mass media (Nelkin 69). Researchers also now agree that the people on the receiving end of media communication are actively involved—not passive as previously believed. Individuals, in essence, are the sum of their previous experiences. People gain these experiences through schooling, family and community values, and religious affiliation. They also gain them through interactions with society and exposure to other forms of mass communication and products of popular culture (Nelkin 65, 10). This background plays a large role in determining how individuals will interpret different messages. As David Berlo describes, "Meanings are learned. They are personal, our own property. We learn meanings, we add to them, we distort them, forget them, change them. We cannot find them. They are in us, not in messages" (Berlo 175). This all implies, then, that a single media product can, as Lawrence Grossberg says, "be read as telling a number of different stories" (196).

An individual's pre-existing attitudes and knowledge not only determine how he will interpret a message, but also what messages he chooses to receive (Schramm, Porter 177). Marshall McLuhan, in Understanding Media, points out that in reading newspapers, people actively pursue news that reaffirm their points of view: "The first items in the press to which all men turn are the ones about which they already know. . . . Experience translated into a new medium literally bestows a delightful playback of earlier awareness. The press repeats the excitement we have in using out wits, and by using our wits we can translate the outer world into the fabric of our own beings" (McLuhan 188). This has led researchers like Klapper to posit that the media are more likely to reinforce prior beliefs and predispositions rather than change or replace them (Klapper, "Mass Media," 302-303). If individuals tend to seek out information that reinforces their point of view, then they must also resist those messages that conflict with it (Klapper, "Mass Media," 303). This implies that those with some knowledge in a given area are less likely to be swayed by what they read in the news. It also implies that individuals who do not have knowledge or strong opinions about a given subject are more susceptible to the messages they receive (Nelkin 69; Gamson, Modigliani 33).

The same is true in the case of scientific reporting. Readers who have little or no knowledge about a subject—such as the Human Genome Project—are likely to be more profoundly affected by what they read than someone who has some knowledge. As Nelkin explains, "The press, as the major source of information, defines the reality of the situation for them" (68-69). Nelkin also suggests that the public may be more accepting of technology and its pursuit if it promises to improve their lives (70). She says that the media's focus on applications of science aids this acceptance. "Public acceptance of science appeared to be based on expectations of immediate applications, promising solutions for growing energy costs, effective new therapies, efficient ways to handle toxic wastes" (70). Nelkin suggests that some consumers will also sometimes change their habits as a result of news coverage. For example, the controversy over the depletion of the ozone, covered extensively by the media, led consumers to purchase fewer aerosol products. (Yet somehow, coverage of the risks of smoking does not appear to dramatically change smoker statistics.)

The way in which scientific issues are described also affects perceptions. Funkhouser and Maccoby found that "desirable reader effects such as information gain, enjoyment and attitude favourability are influenced by several, specific, manipulable textual variables" (69). Metaphors, for example, not only aid in understanding but play a role in persuasion. Nelkin states that,

> When high technology is associated with 'frontiers' to be maintained through 'battles' or 'struggles,' the associations of war imply that the experts should not be questioned, that new technologies must go forward, and that limits are inappropriate. But if instead the imagery suggests internal peril, crisis, or technology out of control, then we seek ways to 'rein in' the 'runaway forces' through increased government regulation and control (Nelkin 73).

Other researchers believe that the media tend to help set the agenda for the public rather than effect specific changes in opinion. Suzanna Hornig, in a study evaluating public responses to reporting on technological risk, says "the power of the media lies less in dictating opinion, however, than in . . . defining or 'framing issues,' and that media effects may be best understood as long-term and subtle influences on our understanding of the world" (Hornig 97). Gaye Tuchman wrote about the media's "framing" role, saying that, "frames turn non-recognizable happenings or amorphous talk into a discernible event. Without the frame, they would be mere happenings of mere talk, incomprehensible sounds . . . . The news organizes every reality and the news frame is part and parcel of everyday reality" (192-193).

Some researchers believe that the media can have especially strong effects when they report on technological risk. Allan Mazur asserts that, by covering scientific controversies, the media elicit a "conservative bias" from the public. Mazur states that when media coverage of a scientific controversy increases, "public opposition to the technology in question (as measured by opinion polls) increases; when media coverage wanes, public opposition falls off" (109). Mazur notes as an example that the number of people opposing the construction of more nuclear plants grew exponentially after widespread media coverage of the technology's risks. The public, argues Mazur, takes seriously suggestions that a given technology might be risky "particularly if the suggestion is repeated often enough" (114). William Gamson and Andre Modigliani arrived at the same conclusion in their analysis of attitudes before and after the nuclear accident at Three Mile Island in 1979 (33). This study also showed that people who had not paid attention to coverage of nuclear energy prior to the accident were more likely to have an anti-nuclear attitude after the accident (33). The general conclusion, summed up by Pellechia, is that newspaper coverage of science does have effects on public knowledge and perceptions. This coverage helps individuals make personal decisions and form opinions about scientific research (49). But it does not dictate opinion. Media coverage is just one of many sources that people draw on to construct their views of science.

METHOD

The literature I reviewed in the previous chapter clearly indicates that science writers face major obstacles in delivering scientific news to the general public. These include the professional constraints of time and space limits, as well as the pressures of competition and lack of resources. They also often include the limitations that journalists face due to lack of training and education in science. It has therefore become clear that popular newspapers are inherently not the ideal medium for the dissemination of scientific news. Part of the problem is that, unlike specialized magazines or journals, newspapers must assume that their readers have little or no knowledge about most scientific research (Nelkin 114). Journalists who write for these newspapers must, then, simplify their reportage and make it as interesting as possible to appeal to the lowest common denominator. As Nelkin explains, "complex issues are avoided, for many journalists doubt that their readers will work sufficiently hard to understand them" (Nelkin 113). Audience assumptions, adds Nelkin, also influence the format of the articles published in newspapers. Reporters must write short sentences, and keep their reports brief if they want to be read. Reporters and editors also feel that they must employ a certain style to appeal to every one of their readers. They use colourful language, anecdotes and humour to draw readers in, and might tend to "overestimate if not sensationalize" their story's significance (Nelkin 113). Audience assumptions also influence the types of stories that newspapers cover. A newspaper is more likely to publish a story on the genetic basis for musical ability, for example, than another on research into bone marrow transplants. Journalists also assume that a story about the ethical or social implications of scientific research will probably be more interesting to their readers than an article about the science itself (Nelkin 113). Editors may then reinforce this belief by giving more prominence to stories which go beyond the science.

National or "prestige" newspapers, on the other hand, likely have different audience assumptions and different ways of responding to perceived demands from readers. These newspapers likely assume that their readership is more educated than that of smaller popular newspapers. As a result, they are likely to be better venues for presenting science news. This is why I chose to include in this study not only small regional daily newspapers, but also national ones which claim to serve a specialized audience attentive to news about science. An analysis of the coverage of national newspapers will also highlight the differences in coverage produced by newspapers with ample resources, and by those without. As already mentioned, financial constraints force most newspapers to rely on general reporters, or on briefs culled from the news wires, for their science news. Along with the other constraints mentioned, financial limits also obviously affect the quality of science coverage. To clearly highlight the consequences of limited resources and other constraints faced by popular newspapers, I also chose to include *The New York Times*, *Maclean's*, and *Scientific American* in this study. I expect that an analysis of the coverage of these three sources will highlight the deficiencies in coverage provided by the average Canadian newspaper.

To collect the articles for this study, I conducted a wide search for pieces about the HGP published between 1990 and 2000 (inclusive) using available electronic databases, as well as microfiche. Because most databases are limited to a certain number of years, I searched several of them. These included Canadian NewsDisc, Canadian Business and Current Affairs, Canadian Periodical Index, Virtual Library, Infomart, and Lexis-Nexis. I also sought articles on the project through the database and print versions of the Canadian News Index, which led to articles in their original form on microfiche. I included the following newspapers in the search: *Vancouver Sun*, *Victoria Times-Colonist*, *Edmonton Journal*, *Calgary Herald, Saskatoon Star Phoenix*, *Regina Leader Post*, *Winnipeg Free Press*, *Ottawa Citizen*, *Toronto Star*, *Montreal Gazette*, *Halifax Chronicle Herald*, *St. John's Telegram*, *Charlottetown Guardian*, *Globe and Mail*, and *The National Post* (1998-2000 only). I also analyzed articles from the same period published in *The New York Times*, *Maclean's* magazine and *Scientific American* magazine. I found these articles using ProQuest—*New York Times* Ondisc, Lexis-Nexis, Canadian Periodicals Index, Medline, *Scientific American* Online, and Canadian Business and Current Affairs (as well as microfiche).

Where warranted, I contacted newspapers directly, as well as local libraries, for indexing information. My goal was to obtain as complete a set of articles as possible for the eleven-year period from each newspaper. However, this was impossible. Indexing for some newspapers—such as *The Charlottetown Guardian*—was incomplete or non-existent. In addition, the subjective nature of the process I used to choose the articles, which I will describe later, likely also led to the exclusion of articles which should have been included. While there is a quantitative aspect to the study, I have only included it to establish some basic trends, such as average length of the articles, and typical placement. It must also be noted that while *The National Post* only began publishing in 1998, I still include it in this study. Where warranted, I excluded articles published in *The National Post* from the quantitative analysis. Each time this was done, I noted it in the text.

My initial searches turned up a large number of articles, due to the fact that the Human Genome Project is mentioned in a wide variety of articles about genetics in general, as well as in articles about entertainment, and business. To narrow down the field, and to produce a sample that would yield meaningful results in this analysis, I established a number of criteria which the articles must meet to be included in the study. News articles were selected if they were concerned with events associated directly with the HGP: its progress, funding, personalities or any combination of these elements. I applied the same criteria to features, opinion and editorial pieces. But I still included these types of articles if they focused on a topic closely related to the HGP, such as gene therapy, so long as the apparent premise for writing the piece was the HGP itself, and the article addressed the project in more than a passing way. I specifically excluded book reviews, obituaries, entertainment and sports articles from this study. I also excluded letters to the editor because they were inconsistently indexed.

For the quantitative analysis portion of this study, I noted several aspects of each article, including date, page, section, and length. I also noted the source of each story, and whether it was produced by a local or foreign source. For the qualitative part of the study, I paid attention to the types of sources the articles quoted, the presence of explanatory material, and the premise of each story. I also noted whether news articles were predominantly positive, predominantly negative or neutral. I also recorded general observations on the language these articles used, the presence of multiple sources and of background material.

RESULTS

Numbers

As explained in the section on methods, the quantitative data I gathered in this study are meant to only be a guide to the general trends in newspaper coverage over the eleven years of the study. Since my sample is not comprehensive, it would be difficult to generalize too much from the numbers I arrive at here. Still, it is useful to attempt to determine whether newspapers focused their attention on hard news coverage of the HGP, or on other forms. The data will also be instructive in estimating the average length of news articles, and whether length varies according to newspaper size. Further, the data may reveal whether there exists a correlation between the size of a newspaper's readership and the frequency of articles about the HGP. I suspect that there is such a link. In this portion of the study, I will also attempt to determine how articles about the HGP were presented in Canadian newspapers, and whether they received prominent placement.

Canadian newspapers paid a significant amount of attention to the Human Genome Project throughout the eleven-year period addressed in this study. My initial searches of electronic databases for pieces containing the words "Human Genome Project" yielded hundreds of articles. A quick survey of these articles demonstrated that mention of the project has, over the years, become part of many media discussions of the field of genetics. Articles concerned with cancer and its hereditary nature, for example, often mention some aspect of the HGP. Virtually every report on the latest discovery of a gene included at least a passing mention of the project. The project also appeared in discussions of Canada's research capabilities, and in articles about university research in general. It was mentioned in business pages, in articles which were concerned with the growing biotechnology sector. The project also received attention in a large number of articles on a variety of non-scientific subjects, including politics—and even entertainment. The frequency with which the project was mentioned is reflective of a trend, documented by Nelkin, toward what she describes as a gene-centered culture (Nelkin and Lindee, 1-2). The broad exposure the project received over the eleven years of the study gives credence to a similar theory advanced by one of the very articles included in this study, a 1994 editorial from *The Globe and Mail*. It said that,

> We are becoming, in ways we don't quite yet appreciate, "geneticized." The way that the onrush of genetics influences human behaviour is not with an inflamed headline or a scoop. It is by repetition and accumulation. One story about finding a gene has very little impact. Ten thousand stories in 500 media outlets about finding the gene for this or that creates a public mind. What we are absorbing through our information pores is the certainty that genetic underpinnings of humankind will soon be in our grasp ("When Wisdom," *Globe*, 22 Dec. 1994, A22).

The search for articles between 1990 and 2000 yielded 324 news, feature, editorial and opinion articles which fit the criteria set out for this study. Of those, 175 were news articles. Canadian newspapers considered several aspects of the HGP newsworthy. They carried items covering the project's overall progress, noted the many milestones reached by the scientists involved, and reported the development of new technology that helped the project along. Some newspapers marked the project's fifth anniversary, and noted the creation of the first genetic linkage map by French scientists in 1993. Newspapers also published articles on the funding, people, and ethical considerations of the project. For example, most newspapers published articles about the federal government's decision to allocate $22 million to researchers to create Canada's genome program in 1992. When genome scientists meeting in Vancouver called for increased attention to the project's ethical dilemmas, they made several headlines. In addition, journalists reported comments made about the project by notable people. For example, then-United States president Bill Clinton received wide coverage when he urged in 2000 that data from mapping the human genome be made public.

Hard news articles formed a slight majority of pieces collected for this study—some 50.9%. But newspapers did not limit their coverage of the project to news events. They also published dozens of features, opinion pieces and editorials over the eleven-year period of the study. The articles in this study included 69 features familiarizing readers with the project or some aspect of it—such as its potential for expanding the commercialization of genetic testing. These articles were sometimes accompanied by side bars which tackled everything from related cancer research to ethical implications of the project. My sample also included 65 opinion articles. These were written by in-house and syndicated columnists, or by scientists, ethicists and others with a stake in the project. A small number of newspapers also published editorials—15 in total over the study period—often following major news events related to the project, such as the announcement of a rough genome sequence map in 2000.

The number of articles about the HGP which appeared in Canadian daily newspapers varied considerably each year. In 1990, for example, I was only able to identify 12 articles eligible for this study. In 2000, when researchers announced a rough draft of the genome, I identified 134 articles (*The National Post*, which was excluded from this calculation, produced 13 articles in 2000). Between 1990 and 1994, an average of 16.4 articles were written about the project per year. In the final six years, newspapers increased their coverage as the project neared completion, publishing an average of 18.5 articles per year (this calculation also excluded *The National Post*, which produced an average of 6 articles per year). The average number of articles per newspaper per year appeared to increase with circulation size. For example: *The Toronto Star*, with an average weekday circulation of 453,034, produced an average of 3.09 articles per year over the eleven years of the study. *The Halifax Chronicle Herald*, with an average weekday circulation of 90,640, produced only 1.91 articles per year.

In *The New York Times*, a large "prestige" newspaper with a daily circulation of 1,086,294, I identified a total of 54 articles—an average of 4.91 articles per year. The average number of articles published by *The N.Y. Times* about the HGP appeared to increase in the second half of the project's lifespan, just as they did in Canadian newspapers. The average number of articles in the first five years of the project was 2.2 articles. In the final six years, it was 7.16. Of the articles I identified in *The New York Times,* 35% were hard news articles. Features, on the other hand, formed the majority of the articles. During the study period, *The N.Y. Times* produced 27 features, or exactly 50% of the complete sample. There were also four opinion pieces and three editorials included in the study.

Maclean's, a weekly magazine, produced 8 articles which were included in this study, an average of 0.7 articles per year. As for *Scientific American,* I identified 17 articles which fit the criteria I established at the beginning of this discussion. That is an average of 1.5 articles a year.

Placement

Communication researchers have repeatedly pointed out that one major challenge for science writers is persuading editors that their stories are worthy of prominent placement in their newspapers (Nelkin 108). Science news, obviously, must compete with other news of the day for space, placement and promotion within the paper. In the first two years considered in this study, the Human Genome Project was often not front-page news. News articles about the project often even failed to appear in the A sections of the newspapers. Despite this, the majority of the news articles in this study did appear in either the A or B sections, and 19 made it to the front page (three additional front-page stories appeared in *The National Post*). This is a higher proportion than that identified by other researchers who explored placement of science articles (Einsiedel 94). The difference is likely attributable to the enormity of the HGP endeavour and high media interest in it. Between 1990 and 1994, some 25 news articles were published in the A sections, and seven in the B sections of the newspapers in which they appeared. After 1995, news articles were more likely to appear in the A section, and more likely to land on the front page. In those final six years, 88 news articles appeared in the A section (a further 11 stories appeared in the A section of *The National Post*). In 2000 alone, no fewer than 15 articles included in this study hit page one (excluding *The National Post*, which had a further three). In *The New York Times*, 14 of the 20 news articles appeared in the A section, three of them on page one. None appeared in the B section.

Features on the HGP, on the other hand—like features on other subjects—tended to appear in later sections of the newspapers. However, 28 of the Canadian feature articles appeared in either the A or B sections (a further four appeared in *The National Post*). Some even made it to the front page, but those were relatively rare, and were often concerned with an anticipated news announcement coming the next day. Only two of the 27 features published by *The New York Times* appeared in the front section of the newspaper. The majority of these features—a total of 24, or 44.4% of the sample—appeared on the science pages. In Canadian newspapers, only 37 of the articles, or 12.1%, appeared on pages devoted to science or health. The placement of opinion pieces or editorials was not noted in this study, because they most often appeared on editorial pages, which are usually in the front section of the paper.

Magazines do not employ a consistent system in the presentation of stories which readily indicates their prominence. Therefore, I did not note the placement of articles in either publication. Magazines do, however, place important stories on their front page. *Scientific American* and *Maclean's* each put only one genome story on their front pages during the entire study period. In addition, *Maclean's* highlighted two genome stories with front-page "teasers," or small headlines. *Scientific American* did the same with three.

Length

A common complaint among those who study the coverage of science by the popular media is the lack of sufficient space allocated to such news (Friedman 21). This study suggests the complaint is also valid where coverage of the HGP is concerned. The average length of hard news articles between 1990 and 1994 was about 466 words. In the second half of the project's lifetime, that average rose slightly to 501.2 words (excluding those in *The National Post,* which averaged 656.6 words per article). The length of a news article appeared to increase with circulation size. For example, in *The Ottawa Citizen*, with a daily circulation of 140,909, news articles in the year 2000 averaged about 588 words. In *The St. John's Telegram*, circulation 33,007, the average length of a news article for the same year was about 472. While the difference may seem insignificant, stories published in *The Ottawa Citizen* were a full 25% longer than stories in *The St. John's Telegram.* News articles published in *The New York Times*, meanwhile, had a much higher average word-count than did those published in Canadian newspapers. The average length of news articles in that publication was 1,081.3 words. This could be due to several factors. First, *The New York Times* is much larger than its Canadian counterparts, allowing for longer stories. In addition, the newspaper has long employed several science and health reporters whose work is intended for dedicated science pages, and space is allocated accordingly.

Meanwhile, stories published in *Maclean's* were generally longer than those in the newspapers mentioned here. While many of the stories were well over 2,000 words long, the average word count for the entire 1990-2000 period was 1,729.2. As I collected most *Scientific American* articles in their original form, it was difficult to determine their exact length. Based on the articles I obtained via databases, it was clear that virtually all of the stories in *Scientific American* were well over 1,000 words, and as long as 4,000 words.

OBSERVATIONS

The First Five years

In the early years of the project, through 1994, newspapers appeared to limit most of their coverage of the project to hard news events associated with it. For example, in 1990, a geneticists' conference in Oxford provided an opportunity for journalists to write about the project. In 1992, most newspapers either wrote or picked up wire copy on Canada's decision to spend $22 million to create the Canadian arm of the genome project. These news articles generally concerned themselves with the news at hand, providing little background on the project, giving no hints as to how scientists were doing their work, and rarely addressing the controversial aspects of the project. These shortcomings appeared to be uniform across the spectrum of newspapers analyzed in this study. In fact, even *The Globe and Mail,* which generally provided better quality coverage than most other newspapers, reduced the story of new funding for the Canadian genome project to a 58-word brief.

Most of these articles, as well as others reporting milestones in the project's progress, were generally positive—throughout the study period—but particularly in those early years. Reporters focused on the project's promise to transform medicine and provide new treatments for genetic disease. These early stories were filled with wonderment about the "revolution" the project promised and the enormity of the endeavour. In their news coverage, journalists appeared to adopt the same positive tone as that exhibited by the scientists who were making a particular research announcement. This is likely due to the fact that a large number of news articles cited as sources only the scientists involved. As a case in point, consider one article which was picked up from syndicated news services by several Canadian newspapers in 1992. The article reported that scientists working on the Human Genome Project had produced the first two comprehensive maps of chromosomes Y and 21. One version of the article, which appeared in *The Montreal Gazette,* begins by saying that the advance offered "persuasive evidence that the extensive and widely heralded effort to analyze the entire human genetic blueprint is living up to its promise" (Angier, *Gazette*, 1 Oct. 1992, F6). The article goes on to say that in producing the map, "researchers have taken a major leap forward." This version of the article cites only one source: one of the scientists involved, saying only that "things are going good (sic)." The entire article is only 354 words long, just long enough to explain the basic details of the finding and briefly touch on its significance. The original story, as it appeared in *The New York Times*, was actually 1,047 words long, and it appeared on the front page. While it is still positive in tone, the version appearing in *The N.Y. Times* goes on to include interviews with two other scientists, one of whom cautioned against the belief that with this latest advance, the project was anywhere near done. The article also mentioned briefly that the project "has not been without critics" who decried its huge budget and intellectual merit (Angier, *N.Y. Times*, 1 Oct. 1992, A1). Few of the Canadian newspapers who carried this story used this extra background material. They simply cut it out. The Canadian versions were short, incomplete, and devoid of the tempering effect of additional interviews on the significance of the advance. (One exception was *The Ottawa Citizen*, which published the story in almost exactly its original form).

This kind of treatment of news events relating to the project appeared repeatedly in hard news coverage during the early years of the project. In 1993, for example, a Reuters story about the first complete genetic linkage map was widely circulated and published as a brief, usually shorter than 300 words. Once again, only one source was quoted: a scientist from the French academy where the map was developed. The article, written by an unidentified reporter, notes in the second paragraph that the map was likened by the scientists involved to "Louis Pasteur's 19th century discovery of bacteria or to the 1953 breakthrough by Watson and Crick in discovering the double helix structure of DNA" ("Scientists," *Calgary Herald*, 16 Dec. 1993, A3). The significance of the finding is explained in one paragraph, which says that the map would help researchers find genes for illness ten times faster than without a guide. The article did not explain how or why. A *London Daily Telegraph* journalist, Roger Highfield, adopts a similar tone in covering the same story. A version of Highfield's story appeared on the front page of *The Montreal Gazette* on Dec. 16, 1993. In it, he describes the findings as a "breakthrough," a word commonly used by journalists who cover science. In his second paragraph, Highfield reports that the achievement had been likened to "the development of the first charts for seafarers" (Highfield, *Gazette*, 16 Dec. 1993, A1). The article, which is about 360 words long, quotes two scientists involved in the project, and the editor of the journal *Nature*, all of whom lauded the research. A *Los Angeles Times* story picked up by *The Toronto Star* on the same subject was remarkably similar. However, a *New York Times* article published by *The Ottawa Citizen* on the subject showed significant differences. Though the version *The Citizen* published was still short (about 600 words), there was still more room for explanatory material than in other versions. The writer, Angier, tempered the enthusiasm for the finding early in the story, pointing out that the map was still preliminary and that researchers admitted it contained many flaws. She quotes the lead researcher saying that the map is "not perfect" (Angier, *Citizen*, 16 Dec. 1993, A8).

Throughout this early period, as mentioned briefly, news articles rarely contained explanatory material. In defining the project itself, few articles went beyond saying that it was a $3-billion international effort to map the human genome. Few articles provided details about how the mapping was done, and few defined even what a human genome was. Even when they did define the genome, journalists did it in vague terms. A story published by *The Toronto Star*, written by The Canadian Press, defined it as "the genetic material which determines a person's inherited traits" ("Insurers," *Star*, 29 Dec. 1993, B1). This is not an inaccurate definition; it simply does not provide the reader with much information. It was also the exception rather than the rule that articles would define such terms such as gene, chromosome, or physical map. When journalists did define these terms, they did it in a facile way: "Genes consist of tiny segments of the complex chemical called DNA" is the way one article explained genes ("Cancer," *Ottawa Citizen*, 9 Mar. 1994, A9). Articles picked up from larger newspapers or prepared by in-house science writers appeared to contain more, and better, explanatory material. For example, a 1993 *Los Angeles Times* story that appeared in *The Toronto Star* provided a more detailed explanation of a "physical map" than did other articles about the same subject:

> The physical map is an ordered collection of some 33,000 DNA fragments that contain the entire genome. It does not show the location of individual genes, but provides a series of guideposts that help geneticists navigate their way through the genome in their search for the individual genes that cause disease ("Human Gene Map," *Star*, 16 Dec. 1993, A2).

Larger Canadian newspapers also provided more sophisticated explanation of scientific concepts and methodology than did smaller ones, which generally relied on shortened wire copy. For example, a 1994 story published by *The Globe and Mail* explains at length how gene fragments are isolated. Mary Gooderham, identified as *The Globe*'s applied science reporter, explains that:

> A scientist studies pieces of tissue that might contain tens of thousands of genes, uses a couple of different kinds of automated machines to eliminate long

> repetitive strings of genetic material, called 'junk DNA,' then isolates a small portion of the gene, which usually consists of a few hundred DNA base pairs.
>
> The partial sequence is then copied to turn it into complementary DNA, or cDNA, and compared with a data base of known gene sequences to determine whether it is a new discovery (Gooderham, *Globe*, 24 Mar. 1994, A1).

Though not all stories published in *The Globe and Mail* provided such detail and technical information, a majority of them did.

In the first five years covered by this study, most Canadian news articles said little about the project's ethical implications. Despite the generally positive tone adopted by these early articles, not all ignored the project's "dark side"—as Bruce Philips described it in a piece for *The Ottawa Citizen* in 1993 (Philips, *Citizen*, 2 Sep. 1993, A19). This is not surprising, because the ethical questions surrounding the project have been raised, by scientists themselves, ever since the HGP was proposed in the 1980s. The articles which did expound on these problems tended to be hard news stories covering an event which raised these implications—for example, when a notable personality raised these issues, or when a conference of geneticists discussed them. Mention of these ethical and legal questions increased in 1993, when the number of news articles about the HGP suddenly increased due to a number of significant related events that year. One story in 1993 that focused on social implications of the project was prompted by comments that a leading German geneticist made in an article published in the scientific journal *Nature*. The news article, written by Tim Radford of *The Guardian,* appeared in at least three newspapers in

1993. In a version published by *The Calgary Herald*, Prof. Benno Muller-Hill is quoted suggesting that the HGP could lead to employers and insurance companies discriminating against those judged genetically inferior (Radford, *Herald*, 11 Apr. 1993, A2). Articles of this type, which addressed a news event relating to the controversial aspect of the project, appeared to generate sufficient interest to warrant their publication in several Canadian newspapers. For example, one such article written by The Canadian Press in 1993, appeared in four newspapers. The same year, yet another article by The Canadian Press, which reported that insurance companies were interested in genetic testing, appeared in five newspapers.

Journalists who wrote about the potential downside of the HGP generally raised similar problems: concerns about ownership (who owns the data and can it be patented?); privacy (who will have access to genetic testing results?); genetic discrimination (will employers and insurance companies misuse the data?); purifying the gene pool (will the project lead to the elimination of undesirables and the engineering of positive traits?). The language used in these articles was consistent with that used by most Canadian newspapers throughout the study period. For example, journalists often referred to possible eugenic applications of genetic testing, and invoked the Nazi past as an extreme example of such applications. In discussions of the implications for would-be parents and their offspring, journalists spoke of the possibility of an increased demand for "designer babies." When they wrote about the possible misuse of genetic tests, journalists called it "genetic discrimination." And when they wrote about the possibility that the rich would have preferential access to expensive techniques to improve their offspring, journalists wrote about a "genetic underclass." Interestingly, only a handful of articles actually mentioned that the HGP—both in Canada and the U.S.—had devoted a portion of their large budgets to the study of ethical and legal consequences of the project. One article that appeared in *The Toronto Star*, written by Michael Smith, said the funding was a way of resolving some of the pressing questions about the project (Smith, *Star*, 26 May 1992, A8). Despite the fact that some news articles addressed the ethical consequences of the project, the vast majority did not. These new articles were instead predominantly positive in tone.

Authors of opinion and feature articles, on the other hand, wrote some of the most damning condemnations of the project during the early part of its history. Some of the features provided journalists with the opportunity to explore more deeply the history of the HGP, the views of proponents and detractors, as well as the project's future implications—all elements that were lacking in the news coverage of the project. But many of these features tended to only focus on the controversial aspect of the HGP, providing little else in the way of information or explanation. The first long-form Canadian-written feature about the HGP in my sample appeared in *The Ottawa Citizen* in June of 1992, and was reprinted in *The Toronto Star* and *The Vancouver Sun*. This early feature, by *Citizen* reporter Shelley Page, focused almost exclusively on what had become the major contentious issues raised by the project. It began with a futuristic scenario involving Mary Anybody, who agrees to genetic testing as she applies for a job at a factory. Her genes, according to the scenario, reveal the possibility of coronary heart disease later in life, and to a predisposition to sensitivity to the chemicals used in the factory. She is told she cannot have the job—and that she also carries the Duchenne Muscular Dystrophy gene which she could pass on to her children. Page uses the scenario as the point of departure for a discussion about life after the HGP is completed. She begins this analysis by stating that "In the not-so-distant future, employers, governments, doctors and insurance companies will be able to peer into the secrets of our DNA" (Page, *Citizen*, 27 Jun. 1992, B1). Through interviews with ethicists and privacy advocates, she warns that people might become vulnerable to discrimination by potential employers, insurance companies, and society in general. She raises the possibility that parents would increasingly seek "designer babies" with desirable traits such as intelligence and good looks. Page asks, "What if a test turns up a birth defect like cleft palate or a tendency toward clinical depression?" "Do you abort the fetus to try again for someone more 'normal?'" While the article quotes Ronald Worton, then-head of the Canadian genome program, saying he wants to study the ethical implications of the project, it does not mention the funding allocated to the study of these issues. In 1993, *The Toronto Star* published its own award-winning package of articles, one of the most comprehensive included in this study. Written by Michael Smith, *The Star*'s science writer at the time, the main story differs substantially from Page's effort a year earlier in several important ways. First, it was accompanied by several other articles, written by Smith and others, which tackled various aspects of the project separately. Second, the article itself was clearly more balanced. While Page devotes nearly the entirety of her article to the discussion of the downsides of the HGP—but for a handful of lines about the advantages—Smith attempts to balance the two sides. He begins his article by outlining the two extreme views of the HGP. Then, he concludes just a few lines into the article that, "The truth probably lies somewhere in the middle—neither golden utopia nor Frankenstein horror" (Smith, *Star*, 10 Jan. 1993, B1).

Many of the rest of the features published by Canadian newspapers during the early years of the study were reprinted from other sources. They also tended to only appear in the larger newspapers, which have the space for them. In 1991, *The Edmonton Journal* published a feature written by Jim Detjen of Knight-Ridder Newspapers, under the title "Discriminating Genes" (Detjen, *Journal*, 24 Nov. 1991, D6). The feature essentially focuses on what it calls "the dark side" of knowledge made possible by the HGP. It lists a number of concerns, including those over discrimination, invasion of privacy, racism and determinism. While it explains what the HGP is and why it is beneficial, the article notes that "the moral issues raised are every bit as daunting as those raised by the study of the atom half a century ago" (Detjen, *Journal,* 24 Nov. 1991 D6). *The Edmonton Journal* ran another feature in 1993, this time written by Delthia Ricks of *The Orlando Sentinel*. This feature focuses on how the HGP's efforts in locating genes were crucial in the quest for cures for genetic disease. The article concludes that while the HGP has been instrumental in finding disease genes, cures were still far off. The article also discusses the negative implications of this for people afflicted with disease (Ricks, *Edmonton Journal* 6 Jun. 1993, C7).

Columnists and others interested in the project began expressing their opinions about it in print virtually as soon as it was underway. Larger newspapers tended to publish opinions written by in-house columnists, while smaller papers ran syndicated copy—though there were exceptions to both rules. In 1990, David Suzuki, a geneticist writer/broadcaster, appeared to be the only columnist writing about the project, though that soon changed. Two syndicated columns on the subject written by Suzuki that year appeared in a total of eight newspapers. In one of those pieces, Suzuki writes about the most recent advances in genetics, including the HGP, which he describes as biology's "Holy Grail." He adds that, "it's an exhilarating period in biology as DNA secrets seem about to be revealed to bring understanding and control over life's blueprint" (Suzuki, *Chronicle Herald*, 19 May, 1990, C2). Yet Suzuki adds a note of caution which was generally absent in news articles about the subject at the time. He points out that while the mapping of the human genome would bring deeper understanding of heredity and aid in diagnosing and preventing disease, cures and treatments "are not likely in the near future." This important point was often glossed over in early news articles, which tended to herald the project as a boon to the treatment of genetic disease. It was also glossed over in feature articles.

Most opinion pieces published between 1990 and 1994 focused on the controversy surrounding the project. In 1994, for example, when news articles excitedly reported that the project was ahead of schedule, opinion pieces tackled the myriad ethical issues that were surfacing as scientists churned out volumes of information about the human genome. One such piece, written by Jessica Mathews of *The Washington Post* and published in *The Montreal Gazette* on November 12, 1994, warns that scientists were producing information for which "society is almost completely unprepared" (Mathews, *Gazette*, 12 Nov. 1994, B6). Mathews adds that much of this information "will be perilous." Several newspapers opted for syndicated columns on the subject that were on the lighter side. An opinion piece published in *The Vancouver Sun* in 1993 took a humourous approach to questioning the morality of genetic screening of unborn children. The piece was originally written for *The New York Times* by Richard Liebmann-Smith, an editor at *American Health.* Liebmann-Smith tackles the issue of pre-selection of traits in children by heralding the "discovery" of several genes, including those "for athletic prowess (NBANFLNHLPGA), [and] for being entertaining and informative (NBCCBSABCPBS)" (Liebmann-Smith, *Vancouver Sun*, 11 Feb. 1993, A15). Despite the humour, there was a clear message—that society could go too far if it allowed parents to pre-select their children's traits.

Editorials were less frequent than opinion pieces, and fewer of them were written in the first phase of the project than later on. One of the earliest editorials, which appeared in *The Montreal Gazette*, does not mention the HGP by name. It was written in the wake of the federal privacy commissioner's report which warned that the widespread use of genetic tests could lead to discrimination. The anonymous author agrees, and calls on Parliament to protect the privacy of Canadian citizens: "Genetic testing should go on, but with proper controls . . . . Parliament should see that the balance is set and privacy respected before general access to testing data threatens it" ("Protect," *Gazette*, 1 Jun. 1992, B2). Another editorial, published by *The Globe and Mail* in 1994, took a decidedly grim view of the project—and not simply because of the implications widely discussed in news and opinion pieces. This editorial goes further, lamenting the lack of control over the genetic revolution—of which the HGP was a major part—and the fact that Canadians had not been consulted on whether they wanted to know what was in their genome:

> The first and most obvious thing the future will show is that no one was in charge. Scientists scattered across the face of the globe set to work understanding how nature would work. And this effort, by any conventional political standard, was out of control ("When Wisdom," *Globe*, 22 Dec. 1994, A22).

This editorial also raises the matter of genetic tests, but transcends the usual complaints about them to conclude that in the future, genetic knowledge will transform fate into risk analysis.

News coverage in *The New York Times* generally appeared to follow the same agenda as that identified in Canadian news articles. Many researchers lament newspapers' emphasis on hard news in covering science. It appears that *The N.Y. Times* has avoided this pitfall. As already mentioned, *The N.Y. Times* ran a larger number of feature articles, often appearing on the science pages, which explored news events about the HGP in depth. In addition, the average news article appearing in *The N.Y. Times* about the project was more than 1,000 words long, more than twice that of Canadian news articles. This longer format allowed journalists at *The N.Y. Times* to provide much more background information, explanatory material, and quotations from multiple sources. Angier's story about the genetic map developed by French researchers, first mentioned above, provides four sentences of explanatory material about maps. It says:

> The new compilation does not resemble a standard map. It consists of two elements: large collections of yeast cells growing on laboratory dishes, each cell enfolding a particular segment of a human chromosome and lists of 2,000 genetic markers, precise descriptions of biochemical patterns found on the different chromosome chunks.
>
> The markers serve as road signs, giving sense and direction to the otherwise inscrutable monotony of human DNA. They indicate how the segments would be aligned in the heart of the human cell, and they spell out the distance between road signs (Angier, *N.Y. Times*, 16 Dec. 1993, A1).

This is the level of detail that appeared to be the standard in news articles published by *The New York Times*. Not only were processes often described in detail, but scientific terms were also explained either in the text or in accompanying sidebars or diagrams. This type of material was even more plentiful in features, which were also much longer than those in Canadian publications.

While they contained more qualifying statements and alternate points of view, news and feature articles in *The N.Y. Times* also tended to generally be positive in their coverage of the HGP. But the newspaper did also publish articles which were predominantly negative. Unlike Canadian newspapers, when *The N.Y. Times* did consider negative aspects of the project, it did not focus on the legal and moral questions. That element was virtually non-existent in either type of article published in *The N.Y. Times* between 1990 and 1994. Instead, the newspaper appeared to focus on other negative aspects, which were in turn not covered in Canadian stories in this early period. These included the criticism that the HGP drained resources away from small but worthy research endeavours. An editorial published in 1990 about big science projects also addressed this subject, describing the HGP and the planned space station as "dubious extravaganzas" ("Big Science," *N.Y. Times*, 24 Jun. 1990, 20E). The project was also painted as intellectually questionable by critics quoted in *The N.Y. Times*. Journalists expanded on these issues in several large features published by the newspaper. Another issue that appeared to figure prominently was the growing interest of for-profit entities in the work of the project. One feature, by Lawrence Fisher, which appeared on the front page of *The N.Y. Times* was devoted entirely to that subject. That article, published in 1994, noted that the HGP had already created its first millionaire—Craig Venter, who would later play a major role in the unfolding HGP story. The article said that, "some scientists are uneasy—ethically and professionally—with the idea of their colleagues profiting from the research for which the government had paid" (Fisher, *N.Y. Times*, 30 Jan. 1994, A1). The ethical dilemmas typically covered by Canadian newspapers appeared in only one *N.Y. Times* article whose focus was Francis Collins, then-new director of the National Centre for Human Genome Research and the HGP. The article quotes Collins worrying about the project's privacy implications, possible eugenic applications, and its potential for helping design perfect babies (Kolata, *N.Y. Times*, 30 Nov. 1993, C1).

The Magazines, 1990-94

The two magazines I analyzed for this study did not publish as many stories as the newspapers did. Between the years 1990 and 1994, *Maclean's*, a weekly, published only two articles which fit my criteria. *Scientific American,* a monthly magazine, published six. These two publications provided coverage that was markedly different from that provided by newspapers. I would like to address these differences in a general way before discussing the actual content of each publication. Articles in these two magazines were far longer than those appearing in newspapers. As a result, the writers were able to include much more information and background material than newspaper journalists did. The articles in both magazines also included many more sources. This was probably due to the fact that magazine journalists have much more space in which to include such sources. In addition, journalists who write for magazines also have a longer time frame in which to research and write their stories. Both magazines published a larger number of side bars and graphics, which explained technical or methodological concepts related to the HGP. The magazines opted to publish mostly long-form features—rather than nearly always focusing on specific news events, as newspapers did. Often, even if an article was clearly written in light of a recent discovery, it would also address a wide variety of general information about the project. For example, in his article on the mapping of chromosome 21, John Rennie of *Scientific American* uses the opportunity to discuss how the HGP is progressing. He also presents to the reader an idea of how the HGP is changing the prevailing theories on how chromosomes function (Rennie, *Scientific American,* Jan. 1993, p.16). Articles in both publications allowed inclusion of several voices, and the discussion of opposing points of view. In an article published in *Maclean's* about patenting human DNA, for example, author D'Arcy Jenish interviews several experts on both sides of the debate (Jenish, *Maclean's*, 31 Aug. 1992, p. 38).

As mentioned, *Maclean's* published two articles in the first five years of the project. Both articles note that the HGP is promising in the search for cures for genetic disease. The first feature, nearly 3,300 words long, begins by explaining how genetic medicine, aided by the Human Genome Project "will revolutionize health care" (Fennell, *Maclean's*, 15 Jul. 1991, p. 32). Writer Tom Fennell describes how the HGP, once complete, will make it possible to test for a host of genetic diseases. The second article, written by Jenish, also mentions that "doctors eventually will be able to treat diseases by designing drugs based on knowledge of how genes work, or by injecting altered genes into patients" (Jenish, *Maclean's*, 31 Aug. 1992, p. 38). But a large portion of both articles is dedicated to discussions of controversial aspects of the HGP. Fennell describes the ethical concerns surrounding genetic testing in embryos. In his discussion, he raises some of the same concerns mentioned in the newspapers. He says, "some critics say that geneticists may some day be able to alter fetal cells to produce highly intelligent, physically perfect children for a price—while fetuses with the slightest imperfection will be routinely aborted" (Fennell, *Maclean's*, 15 Jul. 1991, p. 32). Fennell points out that finding cures will not be easy. But he also says that, "despite the painstaking work involved, scientists' understanding of how genes function is expanding rapidly" (Fennell 32). Meanwhile, Jenish's article focuses on the ethics of patenting human DNA. Specifically, it raises a subject that was rarely mentioned in the Canadian newspapers: the U.S. National Institute of Health's attempt to patent DNA sequences discovered by the HGP. Jenish adds that despite the controversy over patenting, Canadian scientists were still able to persuade the federal government to fund their involvement in the project. He concludes that, "almost everyone agrees that the NIH patent applications have thrown the whole issue into disarray—and it could be years before it is resolved" (Jenish 38).

Neither article, it seemed, delved too much into the science behind the project. Fennell describes, in a cursory way, how geneticists working on the project hope to find cures. He says,

> The code is embedded in a substance called deoxyribonucleic acid, the principal component in the nucleus of every human cell. As the genetic codes become understood, scientists say that by manipulating the four chemical substances that make up DNA, they will be able to cure many of the genetic diseases that plague mankind (Fennell 32).

Fennell also describes briefly how a pre-embryo is tested for genetic disease. As Jenish's article concerns chiefly the practice of patenting, he does not include any scientific explanation. He does define genes, though, as "tiny biological units that determine the development and characteristics of individuals" (Jenish 38).

Scientific American published eight articles, as mentioned, which covered a wide variety of subjects relating to the HGP. The articles addressed genetic testing, commercialization, informatics, and methodological aspects of the HGP. The magazine also addressed the project's progress, and how it was changing prevailing theories about chromosomes. In some ways, it is difficult to determine a precise subject for some of these articles because they contain so much information about so many facets of the HGP. As a result, it is also difficult to generalize about the tone of these articles, as at times they appear positive, and at others, negative. Some were not as difficult to classify. One article, published in 1991, focuses almost entirely on the controversial aspect of genetic testing made possible by the HGP. Another article is more positive in tone, concluding that even though the project has "plenty of findings," it did not receive the funding it deserved. What defines all of these articles, though, is the amount of scientific explanation they contained, and the scope of the information they included about scientific methodology. Relatively basic terms such as "DNA," "gene," and "genome" were left undefined—after all, the magazine caters to those with some scientific knowledge. Other, more complex terms and concepts were fully explained. For example, an article written by John Rennie in March, 1994 explains a technique called "primer walking" used in sequencing the genome. Rennie explains the technique as follows:

> Researchers can make primer molecules of DNA about 18 bases long that will bind to a unique location in the genome. With enzymes, they can extend a bound primer by several hundred more bases complementary to the genomic DNA. By sequencing the elongated primer, they can then determine the genome sequence. A sequence from the far end can serve as a primer for the next 'step' along the DNA (Rennie, *Scientific American*, Mar., 1994, p. 21).

While possibly incomprehensible to a reader with little or no scientific knowledge, the preceding statement presents a comprehensive description of the process to someone with basic knowledge of genetics. Another article by Rennie, this time published in the June 1994 issue, explains in detail how a genetic test is developed and conducted. This type of description was absent in popular accounts of genetic testing. Another element missing from newspaper coverage of the HGP was an adequate explanation of the difference between the various maps that scientists were periodically announcing. Rennie's Jan. 1993 article explains fully the difference between genetic linkage, physical and sequence maps. Writers for *Scientific American* appeared to place value on presenting not only all sides of a story, but also information on competing theories and previous research in a given area. For example, in Rennie's 1993 article, cited above, he highlights the differences in scientific opinion on the number of genes contained in the human genome. He reports that one scientist believed that HGP researchers are likely to discover more than the estimated 100,000 genes once the HGP was over. Rennie then quotes another genome scientist who believed that the estimate at the time was valid. In each case, Rennie also explains the premise behind each assertion.

Writers for *Scientific American* interviewed several sources for their stories, included background material, and explored competing theories—but they were not always immune from the type of language used by newspaper or popular magazine reporters. These writers also often took on the cheerleading role that newspaper journalists are often criticized for. For example, Rennie writes in his 1993 article that the HGP was an "undertaking tantamount to putting a man on the moon" (Rennie, *Scientific American*, Jan. 1993, p. 16). Rennie's 1994 article began by saying that "by all short-term measures, the Human Genome Project is succeeding beyond its planners' dreams" (Rennie, *Scientific American,* Mar. 1994, p. 21). He also said that scientists were finding genes with "astonishing speed" (Rennie 21).

The Final Six Years

Following a peak in the number of articles in 1993 and 1994, newspapers appeared to sharply curtail their hard-news coverage of the Human Genome Project in the mid-1990s. There were also fewer features and opinions on the subject than in 1993. Beginning in 1995, and continuing for several years, coverage became increasingly focused on how quickly the project was progressing, and on the latest predictions of when it would finally conclude. These types of articles continued to highlight the anticipated "revolutionary" applications of the project. One such article, published by *The Edmonton Journal* in 1995, marked the project's fifth anniversary by reporting that it had so far been cheaper and faster than originally planned. The article, picked up from the Knight-Ridder Newspapers service, said that the project had successfully identified at least 50 disease genes—a start toward "the Holy Grail of medical science—the ability to prevent or cure cancer, birth defects, Alzheimer's and other diseases by fixing damaged genes" (Boyd, *Journal*, 24 Sep. 1995, E6). This article was not front-page news. In fact, the article appeared on E6, in the science and medicine section. What did make the front page in 1995 was that for the first time, scientists involved in the project were saying that they would conclude their sequencing of the human genome in 2001 or 2002—much earlier than originally anticipated. The article credited the accelerated schedule to new technology that enabled scientists to create a much better linkage map to guide them in their search for genes. *The Globe and Mail* put the announcement on its front page on Dec. 23, 1995. This particular article was also one of the few in this study period that provided a significant amount of explanation about the way in which scientists go about mapping the genome ("Robot," *Globe* 23 Dec. 1995, A1). Of 29 sentences, seven provided explanatory material which included a definition of genetic markers and their role in mapping, and an explanation of PCR (polymerase chain reaction) technology. Few articles considered in this study could rival the 24% explanatory material that this article contained. Articles published in *The Globe and Mail* as well as some of the major Southam papers like *The Ottawa Citizen*, consistently contained more explanatory material than those of smaller papers. As suggested earlier, this is likely due to the fact that larger papers allocated more space and more resources to science writing.

Where technical information could rarely be found in articles written about the project in the first five years, newspapers were taking an interest in the later 1990s in obscure techniques that were helping to speed the project along. This interest actually began in 1994, when several newspapers picked up a Reuters report on a new "biological superchip" that would "decipher the human genome 1,000 times faster than conventional means" ("Superchip," *Calgary Herald*, 21 Sep. 1994, A2). The version of this article published in Canadian newspapers (without a byline) did not explain in any way how the superchip functioned—a common omission in these types of stories. An article published by *The Ottawa Citizen* in 1997 reported that two scientists had received a U.S. patent for a DNA sequencing technique that "could radically accelerate the Human Genome Project," speeding it up by a "factor of 10" (Willsey, *Citizen*, 4 Jul. 1997, A5). This article spoke of "gel electrophoresis separation techniques" and "matrix assisted laser absorption mass spectrometry"—terms the type of which never appeared in the early reporting on the subject. But again, the article failed to explain these terms or to shed light on precisely what these techniques accomplished. Articles in this period were more likely to define simple scientific terms like gene and genome than they were earlier in the project. An article published by *The Calgary Herald* in 1999 defined "genome" in this way: "The blueprint, known as the human genome, is inscribed on 23 pairs of chromosomes residing within the nucleus of nearly every cell in the body. Each chromosome, in turn, contains several thousand genes composed of DNA (Nelson, *Herald*, 16 Nov. 1999, A11). Definitions and explanations also sometimes appeared in sidebars or diagrams, which were more plentiful in the last six years of the study than the first five.

Meanwhile, the acceleration in the pace of the project prompted opinion and feature writers to warn that the research was proceeding too quickly. Some of these writers suggested that society was not yet prepared to deal with the ethical and legal consequences of knowing so much about the human genome. Jessica Mathews, of *The Washington Post*, says in an article reprinted by *The Montreal Gazette*: "at an accelerating pace, we will begin to be flooded with genetic information that can be as treacherous and unwelcome as it is sometimes lifesaving . . . . If the past is any measure, we won't be ready" (Mathews, *Gazette*, 22 Jun. 1996, B6). Opinion writers cited some of the same concerns as those mentioned in opinion pieces in the first part of the project. But they increasingly raised the spectre of eugenics and pondered the consequences of the increasing ability to control human traits. Writers of opinions and features declared that fictitious stories such as Mary Shelley's Frankenstein, Aldous Huxley's Brave New

World and GATTACA, a Hollywood film about a genetically engineered society, were becoming reality. A *Calgary Herald* reporter said in a feature article that "It's taken less than three generations for Huxley's visions to reach the realm of the possible" (Adams, *Herald*, 15 Mar. 1998, D1).

In the final two years of the study period, newspapers increased their hard-news coverage of the project. Just as opinion writers did, news reporters continued to focus on the project's rapid progress toward completion—until the announcement of a rough draft of the genome on June 26, 2000. In 1999, journalists marked a number of milestones toward the completion of the project, as headlines declared, "Scientists blueprint human chromosome," "Draft of human genome will be ready next year," "Human genome is a third of the way to being decoded," and "Catalogue of human blueprint near 90% complete." The most striking similarity among these articles was the almost complete absence of references to the ethical implications of the project (though a handful of other articles and features did continue to address the subject). These news articles now hailed the advantages of the HGP and its speedy conclusion, and painted a positive futuristic picture of how medicine would be revolutionized. The articles published during this period also appeared to adopt the enthusiasm of the researchers involved—often the only sources quoted. Journalists likened the project to the first landing on the moon. They called the mapping of the first chromosome a "breakthrough" that brings society closer to finding cures for genetic ills (Court, *National Post,* 29 Nov. 1999, A9).

But newspapers did appear to take an interest in the implications posed by the growing involvement of the private sector in genome mapping. Peter Calamai of *The Toronto Star* commented on the potential for commercialization of genetic research: "There is still a slim chance that some of the project's vast potential for public good could instead be diverted into bigger profits for pharmaceutical companies" (Calamai, *Star*, 15 Aug. 1999, F8). When they did mention the private industry's attempts to undermine the public project, journalists appeared to sympathize with the public effort. In his article reporting the mapping of chromosome 22 published by *The National Post*, Mark Court points out that "the British researchers have beaten rivals at a U.S. corporation who are trying to decode human genes and copyright the information so they can sell it. The Sanger Centre intends to make its revolutionary data available to all" (Court, *Post*, 29 Nov. 1999, A3).

Journalists also increasingly painted the mapping effort as a race between the public and private endeavours, as did the scientists involved. The resulting image was that of researchers frenetically trying to outdo one another. Calamai's article quotes molecular biologist Michael Smith (no relation to *The Toronto Star* writer) saying that the project "started out as a marathon. Now, it's more of a sprint" (Calamai F8). Calamai follows this assertion with this statement, describing the scene at the Sanger Centre in Cambridge, England: "A palpable sense of urgency does pervade at the centre. Staff bustle down the endless corridors. Workshops are divvying up responsibilities for various chromosomes. What drives the researchers is not only the challenge of a race but also a fundamental belief in the public mission of scientific research" (Calamai, F8). News articles focused so much on the horse race that other ethical considerations were all but ignored. Scientist Maynard Olson posits in a 1999 article that the "race" aspect of the story was eclipsing important debate on the project's social consequences:

> That competition, [Maynard] Olson says, has prompted "science by press release," in which the reaching of individual milestones such as chromosome 22 overshadows legitimate debate about the effort's results and possible effects (Nelson, *Gazette*, 2 Dec. 1999, B1).

The effects of private sector involvement in the project continued to be a major theme in news coverage of the HGP in 2000. Early that year, journalists reported every announcement that came from either the public or private side, sometimes even concluding that one or the other would be the "winner" of the race. Newspapers also covered efforts by politicians to bring the public and private scientists together to make a joint announcement. And when the negotiations failed, newspapers provided wide coverage of the politicians' response: a statement by then-U.S. president Bill Clinton and British Prime Minister Tony Blair urging scientists to make genome information public. That statement unleashed a torrent of news, feature, opinion and editorial articles which lauded its spirit. The only condemnations came from the business pages and some editorials, which criticized the leaders for making a statement that sent biotechnology share prices tumbling. Finally, when the two sides agreed to announce their findings together, journalists described it as a "face-saving draw" in a "bitter race."

Opinion writers joined news writers in paying attention to the private sector involvement in the project, warning of the dangers this posed. Gwynne Dyer's column on Craig Venter and his company Celera Genomics was published in at least six newspapers in 1999. In it, Dyer, a London-based syndicated writer, says that the most important issue of 1999 and of a number of years to come is Venter's attempt to "pre-empt the government-funded Human genome Project and hijack the human genetic code for private profit" (Dyer, *Vancouver Sun*, 17 Dec. 99, A21). Dyer warns that if Venter is allowed to patent stretches of DNA which have no function, fewer people would benefit from the research into the genome. He says that, "the bigger question is whether anybody has the right to do what Venter proposes: patent this basic scientific information, legally prevent the publicly funded project from distributing it for free, and instead make it available only 'on a subscription basis'" (Dyer A21).

Because coverage of the announcement on June 26 and the days leading up to it was so widespread and extensive, it serves in my opinion as a useful point of comparison between the different types of publications I analyzed in this study. I will therefore describe this coverage in some detail. Canadian newspaper articles published in the period leading up to the final joint announcement on June 26, as well as those covering the event, had several attributes in common. They lauded the "bold," "ambitious" and "mammoth" achievement and compared it to other major feats such as the first landing on the moon and the invention of the wheel. They described the accomplishment as the opening of "the book of life" and the "cracking" of a code. Reporters enthusiastically wrote of the revolutionary effect the map would have on medicine, and the "avalanche" of new drugs sure to come as a result. Stories published days in advance of the announcement painted futuristic scenarios in which medicine had changed dramatically for the better. A sample of headlines illustrates the tone: "DNA code cracked open: Mapping of human genome heralded as start of medical revolution," "Scientific team crosses genetic frontier" (Knox, *Montreal Gazette*, 26 Jun. 2000, A1; Cohen, *Globe and Mail*, 27 Jun. 2000, A10). Larger, more sophisticated newspapers did the same. *The Globe and Mail*, in its front-page story the day prior to the announcement, describes the future like this: "In the doctor's office of the near future, patients will present a smart card bearing their total individual genetic map. One swipe will reveal everything that makes you who you are" (Campbell, *Globe*, 26 Jun. 2000, A1).

While journalists and their newspapers obviously shared an enthusiasm for the impending announcement, a majority did point out, at least briefly, that the tangible benefits of the map would not flow for some time yet. Many articles noted that the map was in fact only a "rough draft," for it had not been sequenced in its entirety to the required accuracy level. Some journalists went as far as suggesting that the timing of the announcement itself was arbitrary, a decision likely prompted by political and market pressures. It appeared that dedicated science writers were more likely to make these points than general reporters. Some of the journalists who wrote these stories for Canadian newspapers were not science writers, and were instead political reporters stationed in Washington. The few Canadian science writers who covered the story, such as *The Ottawa Citizen*'s Tom Spears, were much more cautious in their tone. Spears asks in the second paragraph in his story: "So why are they calling it only a 'good start?'" Then he says, "Because decades, perhaps even centuries of work still lie ahead in unwrapping what it all means" (Spears, *Citizen*, 27 Jun. 2000, A10). The article focuses chiefly on this aspect of the announcement, and the ethical consequences of mapping the genome. Near the end of the story, Spears did say that, still, this was a day for celebration for the research community. Some articles also mentioned, at least briefly, the ethical and legal questions raised by the project. Yet most of the news articles about the announcement were rather positive. After making the passing references to limitations of the rough draft and perhaps to the ethical problems with the project, journalists then went on to write stories that were largely about the myriad benefits the finished map would bring.

That positive tone did not go unnoticed by Simon Jenkins, a *Times of London* columnist who humorously admonishes drug companies and science journalists for their "congenital hysteria" (Jenkins, *Calgary Herald*, 28 Jun. 2000, A17). In one version of his column, published by *The Calgary Herald,* Jenkins goes on to say that,

> The real challenge to science is not public understanding or ethical policing, it is the degenerating skills of reporting and analysis. What is abused is our power of imagery, wonder and a sense of proportion. To say that genetic mapping is 'more important' than inventing the wheel is crass. To compare it with reaching the Moon may be more immediate, but where did that blind alley lead? (Jenkins A17).

The point of this opinion piece was that while the rough map is an "impressive work of scientific cartography," it is only the mapping of the "highways" of the human genome, not the "byways" (Jenkins A17). And in that he was correct. Several other opinion and feature articles made the same point. Marni Jackson, writing for *The Globe and Mail*, said on June 27 that the map was just the beginning.

> I don't want to be a spoilsport about the greatest scientific breakthrough since Galileo, but let me point out two things: First, as the scientists themselves keep reminding us, this is a map, not an operating manual. . . . Maps are useful, of course, because they do what science has always done best—they measure. They orient. But they don't interpret or imagine (Jackson, *Globe*, 27 Jun. 2000, R2).

Editorials also took a similar approach. *The Globe and Mail* published an editorial in the fall of 2000 following an Angus Reid survey of Canadians regarding their views on the HGP. The editorial suggested it might be a couple of centuries before a map is in place which would help scientists understand the function of genes which interact with one another—and even then it may not offer cures for genetic ailments ("If You Were Given," *Globe*, 5 Sep. 2000, A16). Ironically, even newspapers which provided restrained coverage of the HGP published an article on June 26 which threw that caution to the wind. The *London Sunday Times* story, picked up by several newspapers, reported that humans would, as a result of the HGP, "soon" live twice as long as they do today—and "have the potential to live for 1,200 years" (Rufford, *Ottawa Citizen*, 26 Jun. 2000, A1). The article quoted a leading British scientist, John Harris, saying medical advances brought on by the HGP would create a race of "immortals."

In *The New York Times*, coverage also appeared to wane in the mid-1990s, then pick up again in 1998, likely for the same reasons outlined above. In 1995 and 1996, *The N.Y. Times* appeared to briefly rely on wire services (mostly The Associated Press) to keep readers apprised of the relatively minor news the HGP generated. These articles were generally short (under 400 words) though they still contained material which explained the significance of each milestone they covered. During this period, as with Canadian newspapers, *The N.Y. Times* produced several articles concerning technology that was helping speed up the project. A large feature in 1996 written by Gina Kolata documents the role of computers in the mapping of the human genome (Kolata, *N.Y. Times*, 11 Jun. 1996, C1). Another such article, written by Nicholas Wade, updates readers with the latest technology (Wade, *N.Y. Times,* 10 Mar. 1998, F5). Soon enough, just as Canadian newspapers did, *The New York Times* closely followed what was dubbed a race between the public and private efforts to map the genome. Wade writes in 1998 that the HGP "unexpectedly became a race last month" when the project "acquired a rival" in Venter (Wade, *N.Y. Times*, 23 Jun. 1998, F3). The article goes on to describe how the HGP was forced to reconsider its approach in light of the rivalry. In another article on the subject, Wade does not appear optimistic that the public effort would prevail. He writes that "the odds of success at this point are not overwhelming" regarding the project's stated goal of sequencing the human genome by 2005. He adds that, "At the end of this month, the project will be halfway through its planned 15-year course, yet only 3% of the genome has been completed" (Wade, *N.Y. Times*, 10 Mar. 1998, F1). (This article, like nearly all others in *The N.Y. Times*, provided comprehensive explanation of how mapping and sequencing is done, and was accompanied by an explanatory side bar which defines terms ranging from DNA and cloning to sequencing and mapping.) An opinion piece by a critic of the public project, William A. Haseltine, also declared in *The N.Y. Times* that the HGP is losing the race and should abandon its wasteful effort to sequence the entirety of the genome. Haseltine, the CEO of Human Genome Sciences, described how private companies like his had found better and cheaper ways of deciphering the genome: "Sometimes, it's smart not to compete . . . there is good reason that the Federal Government should end its effort: decoding the entire genome doesn't add significantly to the information we already possess" (Haseltine, *N.Y. Times,* 21 May 1998, A33).

News and feature articles in *The New York Times* continued to all but ignore the HGP's ethical implication. Instead, *The N.Y. Times* focused on organizational problems within the HGP, and on the implications of private sector involvement. Andy Valvur, an opinion writer, did attempt to touch on the reductionist thinking that appeared to be encouraged by the HGP, by being funny:

> With thousands more yet to be discovered, you can just imagine what is out there, or in there. I know I can:
>
> The Line Dancing Gene.
>
> The Loves British Cuisine Gene.
>
> The Tendency to Body Pierce Gene

> The Prone to go on TV Talk Shows and Embarrass Yourself Gene. (Valvur, *N.Y. Times*, 15 July 1997, A19)

The New York Times provided superior coverage of the 2000 announcement of the rough draft. An editorial set the scene a day earlier by dampening any unrealistic expectations. While scientists and other newspapers compared the mapping to the first walk on the moon, *The N.Y. Times* said that,

> Deciphering the human genome has been likened to discovery of the periodic table of elements, which accelerated chemical research, to the first detailed description of the human anatomy, which facilitated subsequent advances in medical treatments. Some practical results may come in a matter of years. . . . But for lots of diseases, scientists must first identify the gene or genes involved and then find a way to intervene therapeutically. That will not be easy ("Last Lap," *N.Y. Times*, 26 Jun. 2000, A16).

The next day, while most Canadian newspapers published one or two stories relating to the announcement, *The N.Y. Times* published seven. *The New York Times* also added a chronology, and two diagrams which explained the types of analysis used in mapping, and defined terms relating to the HGP. Of the seven articles, one described the difficulty of treating genetic diseases because many of them are controlled by more than one gene. Another described the human genome itself. The rest of the articles included one which features an interview with James Watson, co-discoverer or the DNA double helix and formerly head of the HGP; one which explores how the HGP was already making research easier by allowing scientists easy access to information about genes that would have otherwise taken individual researchers years to determine; and another article which looks into whose DNA it was that the genome project had deciphered. The "main" story written by Wade, much like the editorial the day before, focuses on the challenge that lies ahead for researchers. This article is comprehensive, and it includes information about the ethical questions posed by the HGP. Wade raises the possibility that genome knowledge may be used to bolster racial and ethnic prejudices and provide temptation to "optimize one's offspring" (Wade, *N.Y. Times*, 27 Jun. 2000, F1). On the problems genetic testing poses, Wade says that, "probably almost everyone possesses many gene variants associated with adverse health effects. This information could be used to the individual's detriment, if not kept confidential, and could be psychologically devastating if diagnosis runs ahead of treatment and the physician has no therapy to offer" (Wade F1).

The day following the announcement, *The New York Times* published an editorial which focuses on the fact that no cures were immediately forthcoming from the mapping of the genome. It said that the map would bring a deeper level of understanding of genetics to research and medicine and may, much later, aid in treating health problems like cancer.

> What is often lost in the excitement is how long the process of discovery may take. Everyone expects some medical breakthroughs, in the form of drugs or diagnostic tests based on the new genetic understandings, to emerge in the next

five to ten years, but no one can say for certain just what the breakthroughs will be ("After," *N.Y. Times*, 28 Jun. 2000, A26).

The New York Times, it is clear, provided much more comprehensive coverage of the announcement than did Canadian newspapers. The coverage touched on virtually every aspect of the project in long, well-written pieces produced mostly by the newspaper's science writers.

The Magazines, 1995-2000

Maclean's appears to have all but ignored the project between 1995 and 1997, mirroring the slowdown in coverage which appeared in the newspapers as well. The magazine stepped up its coverage in 1999 and 2000, publishing a total of five articles. In 1998, the magazine published what amounts to an opinion piece by one of the most vocal critics of genetic engineering, the biotechnology industry and the Human Genome Project. Jeremy Rifkin's article sets out the major arguments against commercializing genetic research. He says that, "the entrepreneurial scramble has picked up substantial momentum, thanks to the quickened pace of mapping and sequencing the approximately 100,000 genes that make up the human genome" (Rifkin, *Maclean's*, 4 May, 1998, p. 49). Rifkin also questions the benefits stemming from genetic research. He writes that while the genetic age is bringing new advances in medicine, "at what cost?" he asks. "What will it mean to live in a world where babies are genetically engineered and customized in the womb, and where people are increasingly identified, stereotyped and discriminated against on the basis of their genotype? What are the risks we take in attempting to design more 'perfect' human beings?" (Rifkin 49). An article by a regular writer for the magazine in January, 2000 is much more positive. While author Mark Nichols makes a passing mention of the ethical questions the project raises, he mostly focuses on the benefits. He says that, "a new world of healing is within the sights of mainstream researchers" (Nichols, *Maclean's*, 10 Jan. 2000, p. 44). During 2000, *Maclean's* articles also paid some attention to the ensuing "race" between the public and private efforts to map the genome. Nichols mentions it in his Jan. 10 article. A brief published in the March, 2000 issue also reports that the threats posed by a "profit-minded entrepreneur bent on patenting genetic knowledge" (Venter), prompted Blair and Clinton to make a statement regarding public access to genome information ("Can Anyone," *Maclean's*, 27 Mar. 2000, p. 61).

For its coverage of the June, 2000 announcement, *Maclean's* published two articles. The main piece, written by Mark Nichols, emphasizes that much work must still be done before any real benefits can be reaped. He says, "the world learned that with one Herculean task almost complete, formidable labours lie ahead before the decoded genome can yield widely forecast health benefits" (Nichols, *Maclean's*, 10 Jul. 2000, p. 46). Though the piece included ample information about the project and the race to the finish line, it was short on technical information—as were most *Maclean's* articles. The second piece, written by Andrew Phillips, focuses on the controversial aspects of the HGP. Phillips highlights all the typical concerns, including those over patenting, genetic privacy and creation of designer babies: "Who wouldn't want a brighter, prettier, stronger kid? The trouble is that it raises a host of moral issues, not to mention the unknown consequences of rewriting the human gene code" (Phillips, 10 Jul. 2000, p. 36). Phillips concludes that as society attempts to deal with these moral issues, it must walk a fine line.

He says that too much regulation would slow down research, and too little regulation would leave it open to abuse.

Scientific American published a total of nine articles during the final phase of the study, five of them in the year 2000. Many of the attributes observed in the early articles were also present in the later ones, including the advanced level of explanation and the number of accompanying diagrams and sidebars. For example, one article written by Tim Beardsley for the March 1996 issue explains fully the differences between the various maps to be generated by the HGP. Beardsley explains, for instance, that a genetic map is "essentially a diagram describing how thousands of known marker sequences in the chromosomes separate and recombine between human generations" (Beardsley, *Scientific American*, Mar. 1996, p. 100). Such a detailed description of a map was largely absent in most (but not all) popular newspaper accounts of mapping achievements.

Several articles published by *Scientific American* in the last six years of the study took a long view of the project, addressing its various aspects, good and bad. A feature written by Tim Beardsley in 1996 took stock of the project's progress, addressing the improvement of sequencing techniques and the benefits expected to flow from the project. It also explored in detail the ethics of genetic testing, commercialization of research, genetic privacy, and gene therapy. Between 1998 and 2000, *Scientific American* also stepped up its coverage of the HGP. In 1998, the magazine published two articles which highlighted the personalities of two scientists involved in the race to the finish line: Francis S. Collins, head of the public effort, and Craig Venter, head of the private enterprise. Unlike profiles written for the popular media, these two articles did not shy away from addressing technical matters and defining the scientific concepts which each scientist identified with. In his February, 1998 article, Beardsley writes about Collins' proposal to use single nucleotide polymorphisms or "SNPs" in the tracking of genes (Beardsley, *Scientific American*, Feb. 1998, p. 28). In his August 1998 article, Beardsley describes in detail the whole-genome "shotgun cloning" technique which Venter preferred for sequencing (Beardsley, *Scientific American*, Aug. 1998, p. 30).

Scientists like Collins also had a chance to communicate directly with readers of *Scientific American.* One example is an article written by Collins, head of the public effort, in December 1999. In it, Collins and co-author Karin G. Jegalian discuss how geneticists will proceed when the genome is mapped. The authors also answer a series of questions often asked about the project, such as, "will understanding of the human genome transform preventive, diagnostic and therapeutic medicine?" (Collins and Jegalian, *Scientific American*, Dec. 1999, p. 86). In their answer, the authors predict that by 2010 or 2020, gene therapy will be commonplace, and that by 2050 "many potential diseases will be cured at the molecular level before they arise" (Collins and Jegalian 86). William A. Haseltine, chairman of the board of the private Human Genome Sciences, and critic of the public genome project, also wrote such an article in 1997. Haseltine uses the opportunity to defend the mapping methodology that his company used, a method which had been criticized by the mainstream genome scientists. In this way, readers with enough knowledge in the area can judge for themselves whether his approach is preferable to that of the HGP.

In the magazine's coverage leading up to and including the announcement in June 2000, the writers set their sights ahead, to what happens to the study of genetics beyond the conclusion of the HGP. These articles introduced proteomics, the study of proteins, as the next focus for scientists seeking cures for genetic disease. Following the June announcement, the magazine published a package of two lengthy articles about the project in its July issue. One of these pieces, by staff-writer Carol Ezzell, focuses almost entirely on proteomics, and on who is expected to be at the forefront in this new research area. The second article, by Kathryn Brown, addresses the actual announcement. This article tempers any enthusiasm by downplaying the achievement, saying that much work still remains (Brown, *Scientific American*, Jul. 2000, p. 50). It reviews the various elements of the HGP, including its controversial side, history, and its race with the private sector. The resulting article is a comprehensive account of the HGP, its challenges, and future. The article is accompanied by diagrams which explain the differences between the sequencing methods of the public and private efforts, as well as a graphic which summarizes genome research on model organisms.

DISCUSSION

There were many common trends in the coverage of the Human Genome Project provided by Canadian newspapers during the period studied. The typical story was associated with a news event, was relatively short, depended on scientists as the only sources, and provided little background or explanatory material. There was a clear uniformity among newspapers in the type of stories they covered and in how they framed them. When I compared articles written by different newspapers on the same news event, I found a remarkable similarity in the type of information that was included or excluded, in the people interviewed, and the general approach. Some of that could naturally be explained by the fact that many of the newspapers borrowed much of their coverage from the same foreign sources. Even when newspapers wrote their own stories, or used different wire services, the coverage was still quite similar. This was consistent throughout the study period and across the entire sample of Canadian newspapers reviewed here.

Coverage of the HGP was predominantly "event-oriented." Newspapers generated most news stories from announcements of a new "milestone" or benchmark in the project's progress, or a new related innovation or advance. The majority of these stories tended as a result to be generally positive in tone no matter when they were written. In other words, while many of them mentioned the negative side of the HGP, this aspect was not emphasized as much as the positive side. This is not a novel finding. In her analysis, Edna Einsiedel came to similar conclusions about science articles in the Canadian media, saying that these findings, "confirm the image of science as remote, elitist, consentient and a collection of 'success stories' " (98). My findings are also consistent with Einsiedel's 1990 national survey of Canadians, in which they were asked to decide whether a sample of science and technology stories were predominantly positive, negative or about the same. Some 45% of those consulted said they were predominantly positive, while 5% of the respondents said they were generally negative (Einsiedel 99). The positive tone could partly be attributed to the fact that overall, news stories about the HGP appeared to rely heavily on the scientists involved in a particular event, and few others, as sources. News articles also failed to include information that tempered the findings they reported. Once again, science writers of larger newspapers appeared more cautious in that regard, as the examples outlined above illustrate. When news articles did mention the ethical consequences of the project, the language they used throughout the study period was uniform, with journalists sharing exact phrases, such as "designer babies" and "raising the spectre of eugenics."

News articles tended to be quite short throughout the period of the study. They contained little background material on the project. The vast majority of news articles failed to provide information on previous findings relating to the HGP. For example, stories which celebrated the latest achievement, such as the mapping of a chromosome, did not mention previous efforts to map other chromosomes or produce a physical map of human genes. The newspapers also failed to differentiate between the different types of maps that the HGP had produced. This omission and others like it was likely a function of the brevity of the articles. Other researchers have suggested that the lack of background material may also be blamed on the pressure journalists are under to persuade editors and the public that what they are covering is newsworthy. Pellechia suggested that, "It is perhaps easier to convey the newsworthiness or uniqueness of a particular finding if it is cast as a breakthrough or isolated event, rather than if it is contextualized as part of a larger body of research" (Pellechia 62).

Despite the slightly longer stories that newspapers published in the second half of the project, and despite an increase in the coverage of the HGP, explanatory material was still as scarce as it had been in the first few years of the study. This appeared to be more of a problem for smaller papers, which relied on wire copy and general reporters, rather than for larger ones. There were more articles in the later years of the study which addressed methodological aspects of the HGP, but they generally continued the practice of glossing over the practical side of genetic work. For example, virtually none of the articles covering the announcement of the latest maps pointed out that scientists must re-sequence their stretches of DNA four times to claim they have a working draft, and up to eleven times before they can claim they have a polished one (Jones, *Vancouver Sun*, 20 Apr. 2000, A15). Most articles failed to explain adequately how scientists were actually carrying out the mapping of the human genome, and this did not improve with time. This observation is consistent with that of other researchers. In her study of science coverage in three major U.S. newspapers, Pellechia also concluded that "coverage has not become more rigorous with the passage of time . . . . Contextual factors and methodological details are still frequently omitted" (Pellechia 61). These articles also contained few definitions of scientific terms. Those which did provide definitions simplified them to such an extent that they shed little light on the subject at hand.

News articles published throughout the study period also reflected journalists' tendency to report science news as definitive, despite protests from the scientific community (Einsiedel 100). As a result, few articles contained the caveats or qualifications scientists often attach to their work, such as the need for peer review and further study. Journalists who omitted such detail were again likely motivated by the desire to demonstrate their story's newsworthiness (Pellechia 62). Journalists also tended to quote few sources in the articles analyzed for this study. The sources the journalists did quote in the typical news story were generally the scientists involved in the work leading to each announcement or event. Often, articles contained only one such source. This dependency was not evident in articles published by larger newspapers, such as *The Globe and Mail* and *The Ottawa Citizen*, both of which relied largely on dedicated science writers to report on HGP news. Einsiedel also made the same observations, noting that "the predominance of scientists as sources also suggests some amount of scientists' control over the media agenda" (100). I must note that many of other the problems I cite here also appeared more often in smaller newspapers rather than larger ones. For reasons already discussed, newspapers like *The Globe and Mail* and *The Ottawa Citizen* provided superior coverage because they had the resources, the writers, and the space to do so. These newspapers claim to have a captive audience which is interested in more specialized science news. Smaller newspapers are forced to appeal to everyone, and face a number of constraints which affect the quality of the pieces they produce or pick up from other sources.

It must also be noted here that coverage of the HGP in Canadian newspapers appeared to be heavily influenced by the agenda of foreign newspapers and wire services. Nearly 40 per cent of the articles reviewed here originated in the U.S. and England. That means that many of the problems I have cited so far can in part be attributed to these original sources. However, the newspapers themselves are not blameless, as they often edit wire copy and shorten it drastically to fit their needs, a practice which introduces errors and significant omissions. Despite an increase over the study period in the number of stories newspapers produced in-house about the project, foreign sources continued to form a large proportion of the stories published in Canadian newspapers. Einsiedel posited that especially in the Canadian context, foreign stories reinforce among the public the remoteness of science (98). Unlike Einsiedel's findings (98), this study indicates that newspapers did attempt to find the "local" story of the HGP throughout the eleven years. Journalists wrote several features and news articles which attempted to "bring the story home" by highlighting the work of local scientists or university departments involved in the HGP.

In general, those journalists who wrote features tended to focus on the controversial aspect of genome mapping. Many of the stories were remarkably similar in tone, and presented the issues in very similar ways. These articles very often contained futuristic anecdotes which were used to illustrate the confounding questions that the project poses. The articles almost always focused on genetic discrimination by employers and insurance companies as the most practical example of how the project might adversely affect society. These articles also often suggested parents might one day be able to order desirable traits in their unborn children. They often discussed the ramifications of widespread genetic testing and asked questions such as: who has the right to know?, how does an individual cope with bad news following a screen?, should people have a right not to know?, and who tells the children and when? These articles also tended to rely on very similar sources. Often, the point of view of scientists was balanced with those of the same lawyers or ethicists who presented the opposing side in other similar stories. And since these articles were longer than news stories, they often contained more context, providing historical accounts of the founding of the HGP and other background material. Despite the extra available space, these articles did not offer substantially more explanatory material, and also lacked comprehensive definitions and descriptions of how the mapping effort proceeded.

Opinion pieces also tended to focus on the negative side of the HGP. While occasionally some opinion writers dismissed as unfounded people's fears about the project, the vast majority questioned the benefits of the HGP and the applications it made possible. These pieces often suggested the genetic revolution would lead to a subtler form of eugenics. They warned that people with the means would go about improving their children, while poor people evolved into a genetic "underclass." Many of them called for public debate on the ethical questions, or for legislative means to prevent genetic discrimination. Editorials throughout the study period looked at broader issues, such as privacy considerations and the lack of controls on the scientists mapping the genome. They, too, called for government intervention in protecting individuals. Many lauded the work of scientists, but cautioned that HGP findings would not bring revolutionary cures in the short term.

For reasons already discussed, the coverage provided by *The New York Times* was significantly different from that of Canadian newspapers in many ways. There were more news stories on average per year than in Canadian newspapers. The majority of the articles collected from *The N.Y. Times* were features which explored the HGP and news events associated with it in detail. These articles most often appeared in the science section of the paper. Ironically, though it is considered a "prestige" newspaper, *The N.Y. Times* went to great lengths to explain scientific concepts and methodologies, much more than most Canadian newspapers. While clearly attempting to appeal to readers who have basic knowledge of genetics, *The New York Times* appeared to also be ensuring that the average reader is not alienated by articles that are too complex. The newspaper balanced the two demands by providing basic definitions in a separate side bar, which readers could choose to consult or not. *The N.Y. Times* news stories, written by full-time science writers, were longer, providing more room for background, definitions and much more explanatory material. These articles were also often accompanied by explanatory diagrams or sidebars. While they too tended to be predominantly positive in tone, these news articles often included tempering statements from scientists or others with alternative points of view. These differences are attributable to the fact that *The N.Y. Times* had several full-time science and health writers. These reporters also had more resources and time than their Canadian counterparts to research and write about major events associated with the HGP. *The New York Times* is read widely by a large cross section of people. But it also serves an audience which is attentive to science news, which expects quality reporting. As a result, the newspaper must balance its coverage by providing intelligent reportage, as well as in some ways appealing to the lowest common denominator. The same could be said for *The Globe and Mail,* and to some extent, *The Ottawa Citizen.* Another reason for the superior coverage in *The New York Times* is the fact that the HGP was officially based in the U.S., providing American reporters with ease of access and an impetus to write about the project. News articles in *The N.Y. Times* did not place as great an emphasis on the ethical implications of the project as did Canadian articles, and it is not clear why. Instead, they focused on criticism that the project was too large and wasteful. They also often addressed the implications of private sector involvement in human genome research.

Finally, coverage in the two magazines, as mentioned in the observations, differed from that of newspapers. Neither publication published articles about the HGP at the same frequency as newspapers did. Both *Maclean's* and *Scientific American* appeared to follow, though, the same pattern of coverage. Both magazines also devoted much more space to their articles about the HGP. That meant more room for background information and for a variety of sources. In some ways, *Maclean's* coverage was similar to that of newspapers'. This is not surprising, as *Maclean's* is a popular magazine aimed at the general public. Though *Maclean's* included far more information in its articles than newspapers did, this extra information was not generally explanatory (also true for newspaper features). Instead, journalists used the extra space to include more voices, and provide context and history. *Maclean's* also appeared to avoid any discussion of the actual science involved in the HGP. Its writers appeared to prefer to address the project either in terms of its potential benefits or the ethical questions it poses.

Meanwhile, articles published by *Scientific American* tended to be quite long, and very general in scope. They provided much more explanation than articles in any of the other publications. This magazine caters to a reader who has more than a cursory knowledge of science, or at least an avid interest. Terms such as "gene" and "DNA" need not be defined in such a context. But as mentioned, the magazine went to great lengths to explain more complex terms. Articles also invariably included ample methodological information—which was absent in virtually all Canadian sources I studied here. This is not surprising. A magazine devoted specifically to covering science would be expected by its readers to provide information that is broader and more technical than that provided by newspapers. Articles in this magazine also often included information about competing theories or research. But as mentioned earlier, articles published in *Scientific American* were not immune from the positive tone that characterized the majority of news articles I have analyzed. Some communication researchers believe that dedicated science writers become too close to the subjects they write about, and are therefore more likely to sympathize with scientists. It is not clear whether this is what is at play here, but it is one possibility. Analysis of the articles in *Scientific American* makes it clear that journalists who have more space and time produced better quality science writing—but these were not the main factors, as coverage in *Maclean's* demonstrates. One must not forget that *Scientific American*, unlike popular newspapers or *Maclean's*, is *mandated* to deliver science news. One would only expect it, then, to be better at it.

CONCLUSION

This study has shown that over the first ten years of its existence, the Human Genome Project generated a significant amount of coverage in popular Canadian newspapers. The HGP likely commanded regular attention, even from the smallest newspapers, due to its ambitions, its sheer enormity, and the large ethical questions it raises. Larger Canadian newspapers, which often relied on their own science writers, produced the largest number of articles about the project. Smaller newspapers relied almost exclusively on foreign-produced wire copy to cover the project. Coverage in both large and small newspapers tended to focus on events or announcements associated with the HGP. As a result, articles about the project focused more on facts surrounding specific events rather than on scientific concepts or background information related to the project. This observation was consistent with that of other researchers exploring Canadian newspaper coverage of scientific issues (Einsiedel 98).

For several reasons already discussed, many communication researchers have concluded that newspapers are not the ideal medium for disseminating scientific news. The findings in this study suggest the same is true for coverage of the Human Genome Project. News articles about the HGP exhibited most of the same general problems often associated with general scientific reporting. The series of articles published in each Canadian newspaper about the HGP formed a mass of unconnected bits of information. Each article stood alone, unrelated to others published about the project either before or after. News articles were short and included few sources. Definitions of scientific terms were cursory. Methodological, contextual and historical information was almost always glossed over, if not omitted altogether. Journalists covering the project also tended to treat each finding as definitive, eliminating mention of any caveats the scientists themselves might have attached to their work. Furthermore, as in other studies (Pellechia 61), it appeared here that the coverage did not improve over time. While articles became slightly longer in the second half of the eleven-year period, they did not include appreciably more scientific explanation (though they did appear to include more accurate definitions of scientific terms). Canadian newspapers also relied heavily on outside sources for their news about the HGP. These sources included wire and syndicated copy, gleaned mostly from sources such as *The New York Times* and the Reuters news agency. Some of the problems observed in the Canadian coverage of the HGP might, therefore, be blamed on these foreign sources. But, as illustrated by the examples cited earlier, Canadian newspapers themselves are not blameless. Foreign articles which might have included background information and alternate points of view in their original form were often drastically cut by the Canadian newspapers which reprinted them. Methodological and contextual information was often simply eliminated.

Popular newspapers appeared to be of two minds about the HGP. Nearly all of the news articles analyzed in this study were predominantly positive in tone. They focused on specific news events, such as the completion of a map of a chromosome. Journalists relied almost exclusively for their sources on the scientists involved in a given announcement. Few of these articles were long enough to include interviews with scientists who have an alternative point of view, or to include information about competing theories. News writers hailed each announcement as a "breakthrough" and a "boon" to the search for cures for genetic disease. Meanwhile, the majority of features, opinion pieces and editorials tended to be negative in tone. These articles focused almost entirely on the dangers posed by the availability of so much information about the human genome. Although feature articles provided journalists with ample space in which to address aspects of the project often ignored in news articles, they tended to instead focus on the moral and legal problems that the HGP raised. Opinion articles and editorials followed suit, sounding the alarm about the HGP's broader implications for humankind.

How do all these factors affect readers? Although, as Nelkin says, we live in a geneticized culture, the public's scientific knowledge is still less than satisfactory (Einsiedel *et al.* 85; Durant, Evans 11). The problem can be blamed, in part, on the quality of science writing in newspapers and magazines (which are the average adult's main sources of scientific information). It follows, then, that the quality of writing observed in this study may similarly contribute to a lack of understanding about the Human Genome Project among the public. The coverage provided by most (but not all) Canadian newspapers is incomplete, and one would expect that the knowledge readers glean from such coverage would also be lacking. Since there was no continuity in the coverage, and the articles included little background information, readers might be hard-pressed to explain how the project proceeded, or precisely how it could aid in improving human health. They would also have trouble providing a chronology of major events related to the project. On the basis of the coverage analyzed in this study, it may be impossible for a reader to explain the differences between the different genetic maps produced by the HGP. It would also likely be difficult for a reader to explain how each map brought researchers closer to developing cures for genetic disease. In his book How Superstition Won and Science Lost, John C. Burnham describes the disjointed coverage of science, such as that observed in this study, as the bits-and-pieces approach. Burnham suggests that this type of coverage distorts science and misleads the public. He notes that the dissemination of facts—the primary function of newspaper articles about science—does not alone improve the understanding of science (Burnham 232). The fact-based focus of news articles has a direct effect on public attitudes and actions, Burnham adds. He notes that the authors of a 1972 report for the U.S. Food and Drug Administration found that "most Americans did not have a systematic approach to health, but rather used a 'rampant empiricism' based on isolated facts and personal 'experience'" (Burnham 230). The bits-and-pieces approach also leads to a mystification of science, reinforcing the belief that it is remote and even magical in some way (Burnham 233). The way newspapers covered the HGP, then, may also lead to an obfuscation and mystification of the science behind the project.

The bits-and-pieces approach, says Burnham, affects readers in different ways. The effect is determined partly by the level of pre-existing knowledge that a reader has about a given subject. Readers with little knowledge of a scientific area are more likely to be mystified by the science and view it as remote. Well-informed readers are less likely to do so (Burnham 232). Previous knowledge also has a significant effect on how readers use newspaper coverage to construct their opinions. Readers who already have well-formed opinions would be less likely to read articles which contradict those opinions, and more likely to seek out news and features which confirm them. Those readers with little knowledge about the HGP would be the most likely to be affected by the quality and tone observed in the articles in this study. The newspapers, in essence, frame the subject for readers with little knowledge, by setting out the major areas of concern. William Gamson and Andre Modigliani suggest that readers without experience with the risks associated with a particular science or technology are more likely to develop strong negative opinions following newspaper coverage of those risks. It follows, then, that such readers are more likely to also become concerned about the ethical and moral questions raised by the HGP than those who lived through the controversy over recombinant DNA in the 1970s. Allan Mazur also observed that as the coverage of the risks associated with science increased, public opposition to that science also increased (Mazur 109). One might expect, then, that as journalists paid more and more attention to the ethical consequences of the HGP, public opposition grew proportionally. I could find no surveys which suggested such a trend during the periods in which newspapers intensified their coverage. One survey conducted in the year 2000 indicated that the Canadian public had, like newspapers, two minds about the HGP. An Angus Reid survey conducted among 1,500 adults in the year 2000 indicated that 90% of respondents said they think the HGP will improve health and quality of life. Yet two-thirds of the respondents also said they feared the genetic testing of fetuses ("Human Genome Project" Online). The positive news coverage provided by newspapers may have some effects because, as Nelkin described, readers are more accepting of technology if it promises to improve their lives (Nelkin 70). However, such positive coverage may also give novice readers an erroneous impression that science is a series of "success stories" (Einsiedel 98). This type of coverage, says Einsiedel, also promotes an image of science as a remote activity. This may be exacerbated due to the fact that much of the news about the HGP comes from foreign sources. Einsiedel said that this has a specific effect on Canadian readers, whose images of science as remote may be further reinforced by the geographic separation from the research undertaken by the scientists involved with the HGP (Einsiedel 98).

The problems already mentioned apply to most, but not all newspapers included in this study. The coverage of the Human Genome Project provided by some of the larger newspapers was superior in quality. These newspapers included *The Globe and Mail* and *The Ottawa Citizen*, and to some extent, *The Toronto Star*. These three newspapers were the largest analyzed in this study, and they provided more complete coverage of the project than did the other newspapers. Readers of these newspapers probably have a better sense of the HGP than readers of smaller newspapers. Though at times all three large newspapers used wire and syndicated articles, each also employed science or health writers who produced original copy about the HGP. While these newspapers were also still somewhat limited by space, they provided slightly better contextual information and explanation than did the smaller newspapers. These three operations have ample resources which allow them to employ dedicated science writers, who are in turn more likely to produce quality copy than non-specialist writers. Because they are better financed, these newspapers can also allocate more space to scientific news. Prestige newspapers assume that while they serve the general public, they must also cater to an educated audience which is attentive to scientific news. All these factors help explain the differences in HGP coverage between the larger and smaller newspapers. The attributes that separate prestige newspapers from the others were even more pronounced in *The*

New York Times. That newspaper had more resources, employed more science writers and allocated more space to scientific news than even the largest Canadian newspapers. Articles in *The New York Times* about the HGP were much longer than those in all other newspapers and they included a great deal more scientific explanation and alternate points of view. Analysis of *Maclean's* articles, though, illustrated clearly that more resources, space and time does not always translate into better coverage of the HGP. While the magazine's journalists wrote longer stories and included more voices than did newspaper articles, they still excluded scientific information, good definitions and references to previous or competing research. Based on my analysis here, a better vehicle for transmitting scientific news is *Scientific American*. But articles about the HGP in this magazine obviously cater to a more specialized audience which must have at least some basic knowledge of genetics and the HGP.

The consensus among critics of science writing is that sound scientific knowledge among the public is desirable. The HGP is one of the largest scientific endeavours ever undertaken by humankind. The vast resources dedicated to its completion, the enormity of its accomplishments, and the promise it holds to change medicine should be reason enough to promote public understanding. This study indicates that the newspaper audience is likely aware of the project, its possible benefits and potential downsides. But the readers of these newspapers do not likely have a complete picture of the science behind the HGP, nor are they likely to understand exactly how the project might help cure genetic disease. It is debatable whether the public needs to know every small detail associated with work on the HGP. But it is clear that the coverage provided by Canadian newspapers is not of the quality necessary to give the public a clear understanding of the project, its goals and implications for society.

The conclusions I arrive at here are tentative at best, because they are based solely on the coverage provided by Canadian newspapers. A more accurate picture of how media coverage of the HGP helps shape public perceptions could be accomplished through focus groups or surveys. It could also be achieved by including analysis of television and radio coverage of the HGP. In these ways, researchers could determine more precisely how the deficiencies in media coverage affect understanding among individuals. Surveys could give researchers a better sense of how individuals view the project following exposure to media coverage, and how prior knowledge affects their opinions. Also, a careful content analysis of perhaps a smaller sample of newspapers might provide more specific information on the common themes, and the kind of contextual and scientific information articles may contain or lack.

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