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Essays

Neuroethics and ELSI: Similarities and Differences

Henry T. Greely*

In the last four years “neuroethics” has become a term to describe the study of the ethical, legal, and social implications of new technologies from neuroscience. That field is strongly influenced by its predecessor, “ELSI,” the ethical, legal, and social implications of genetics. Both areas are the result of ongoing revolutions in scientific knowledge directly relevant to human life, both concern technologies that will have substantial effects on human societies, and both discuss possibilities that scare many people. Yet there is reason to think that neuroethics will expand in directions and develop in ways that are often significantly different from ELSI.

This article attempts to map some of the similarities and differences between these two fields. It first briefly reviews the history of both endeavors. It then describes ways in which the substantive questions explored by neuroethics are likely both to parallel and to diverge from those analyzed by ELSI. It ends by discussing the path forward for neuroethics and how its future will both be influenced by, but will differ from, that of ELSI.

I. HISTORIES

A. ELSI

ELSI has two connected meanings.¹ It is a field of study

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1. For people of a certain age, it also calls to mind “Elsie the Contented Cow” from advertisements for Borden’s Dairy Products. Elsie, introduced in 1939, was named by Advertising Age as one of the ten top advertising icons of the twentieth century. See AdAge.com, Top 10 Advertising Icons of the

but it is also a set of structures, including prominently two federal programs that have provided an unprecedented amount of funding for studying the ethical implications of a new technology.

People have been worrying about the implications of genetic technologies for decades. By the mid-1970s, scholars were publishing volumes of conference proceedings about genetics and the law;² by the early 1980s, a presidential commission issued two different reports on the implications of genetic engineering and humans³ and on genetic testing.⁴ The term “ethical, legal, and social implications” (or “issues”) seems to have first appeared in print (or at least in the Nexis database) with respect to genetics in 1990;⁵ the acronym ELSI

Century, http://adage.com/century/ad_icons.html (last visited Mar. 27, 2006).

2. See, e.g., NATIONAL SYMPOSIUM ON GENETICS & THE LAW, GENETICS AND THE LAW (Aubrey Milunsky & George J. Annas eds., 1976); NATIONAL SYMPOSIUM ON GENETICS & THE LAW, GENETICS AND THE LAW II (Aubrey Milunsky & George J. Annas, eds., 1980) (proceedings of a national symposium on genetics and law held in May 1980); NATIONAL SYMPOSIUM ON GENETICS & THE LAW, GENETICS AND THE LAW III (Aubrey Milunsky & George J. Annas, eds., 1985) (proceedings of a national symposium on genetics and law held in May 1984).

3. PRESIDENT'S COMM'N FOR THE STUDY OF ETHICAL PROBLEMS IN MED. & BIOMEDICAL & BEHAVIORAL RESEARCH, SPLICING LIFE: A REPORT ON THE SOCIAL AND ETHICAL ISSUES OF GENETIC ENGINEERING WITH HUMAN BEINGS (1982).

4. PRESIDENT'S COMM'N FOR THE STUDY OF ETHICAL PROBLEMS IN MEDICINE & BIOMEDICAL & BEHAVIORAL RESEARCH, SCREENING AND COUNSELING FOR GENETIC CONDITIONS: A REPORT ON THE ETHICAL, SOCIAL, AND LEGAL IMPLICATIONS OF GENETIC SCREENING, COUNSELING, AND EDUCATION PROGRAMS (1983).

5. See David Kramer, *Paper Describes DOE/NIH Genome Project, but Avoids Money Question*, INSIDE ENERGY/WITH FEDERAL LANDS (Platts, New York, N.Y.), May 14, 1990, at 6 (describing the first NIH-DOE five year plan for the Human Genome Project). The second use was in the main stream media, when the New York Times referred to Dr. Nancy Wexler as the head of the working group on ethical, legal and social issues. See Sandra Blakeslee, *Ethicists See Omens of an Era of Genetic Bias*, N.Y. TIMES, Dec. 27, 1990, at B9. Interestingly, the phrase does turn up earlier in Nexis in connection with the implications of *other* biomedical technologies. A 1983 article in Science about *in vitro* fertilization refers to its “ethical, legal, and social consequences.” Clifford Grobstein et al., *External Human Fertilization: An Evaluation of Policy*, 222 SCIENCE 127, 129 (1983). The phrase appeared in two newspaper articles from Australia, one about HIV policy, *Events of Interest Tonight*, ADVERTISER, Aug. 8, 1986 (“medical, ethical, legal and social implications”), and one that described a government committee, the National Bioethics Consultative Committee, then newly-appointed to study advances in medical technologies more generally. Philip Heyward, *New Group Seeks Consensus*

followed in 1991.⁶ This “acronym as noun” caught on, at least in the most directly relevant areas of bioethics and genetics, seeing off an early challenge from “genethics.”⁷

Where Controversy Rages, HOBART MERCURY, May 18, 1988 (“ethical, legal, and social issues”). I suspect its American usage stemmed more directly from the fairly broad coverage of the term in Canada in 1989 when the government, in the “Speech from the Throne” laying out its program for the year, called for creation of a royal commission to inquire into new reproductive technologies, citing “concern that these scientific advances will outpace our ability to deal with their moral, ethical, legal and social implications.” Governor-General Jeanne Sauve, *Speech from the Throne Touches on Wide Range of Issues*, TORONTO STAR, Apr. 4, 1989, at A20. In Canada the word “moral” stuck and for some years the Canadians talked about “MELSI.” It is interesting to speculate why the NIH-DOE working group adopted everything except “moral” from the Canadian phrase. I suspect it was to avoid religious connotations associated with “moral”: “ethical” seems more secular. In any event, the Canadians seem to have replaced MELSI more recently with GELS, which stands for “genomics ethical, legal, and social issues” or, much worse, by GE³LS, for “genomics ethics, environmental, economic, legal, and social issues.” Of course, the 1983 report on genetic testing by the President’s Commission *almost* used the term in its title, which referred to “ethical, social, and legal implications.” ESLI, however, would not have been as euphonious an acronym as ELSI.

6. “Three percent of the total budget, or an estimated \$ 90 million over 15 years, will be used to study ‘ELSI’ — ethical, legal and social issues.” Judy Foreman, *Working Out the Genome Project Ethics – In Advance*, BOSTON GLOBE, Feb. 4, 1991, at 25.

7. “Genethics” first appears in the Nexis database in 1983, in quotations, as a term used by then-representative Al Gore: “In a statement . . . Gore said that the new genetic technologies created a complex set of ethical questions—which he called ‘genethics.’” Michael Schrage, *Clergy Hit for Stance on Genes*, WASH. POST June 23, 1983, at C10. (The number of publications included in Nexis was quite small in the early 1980s and the database has very limited coverage before 1980; it cannot be relied upon to find the first use of a term from that era, but it is some evidence of the amount of its use.) The term appears seven more times in the 1980s, six of them in references, usually in reviews, to a book with that word in its title: DAVID SUZUKI & PETER KNUDTSON, *GENETHICS: THE CLASH BETWEEN THE NEW GENETICS AND HUMAN VALUES* (1989). One of the book reviews notes the creation at about that same time of a European coalition called the “Genethic Network,” which seems to have come and gone quickly. See Liebe F. Cavalieri, *Ethics in the Brave New World*, WASH. POST, Mar. 26, 1989 (Book World), at 9. From 1990 through 1994, genethics appeared fifteen times (six of them about a biotech company with that name) compared with twenty-six mentions for ELSI; by 2000 through 2004, the numbers were 101 uses of genethics to 157 for ELSI. Most of the “genethics” uses referred to either an Australian “GenEthics network” or a “genethics competition” in Australian schools; several of them, though, were from various reprintings of a column by William Safire. (The “ELSI” search was for “ELSI and genetics” as “ELSI” by itself picks up both a company whose stock exchange symbol was ELSI and a surprising number of women named Elsi.) “Genethics” is a more transparent term, with a more obvious meaning, than ELSI. I suspect it lost out in part because it was too similar to “genetics”; this both made the spoken term confusing and, perhaps

But “ELSI” as an activity can probably be dated to September 26, 1988, when it took its first step toward being not just an area of scholarly activity but a well-funded government program (or two). That day, Dr. James Watson was introduced as the first director of the National Institutes of Health (NIH) Office of Genome Research (which became the National Center for Human Genome Research (NCHGR) in 1990), a newly established unit of the NIH.⁸ The NIH was to share the work, and the funding, of deciphering the entire human genome with the Department of Energy (DOE), with NIH receiving roughly two-thirds and DOE roughly one-third of the funding. (The NIH share eventually grew to about eighty percent.) Watson, however, was to have oversight of sorts over both parts of the Project. He immediately made a commitment to what became ELSI:

At the press conference to announce his appointment, Watson declared that the ethical and social implications of genome research warranted a special effort and should be funded directly by NIH. . . . Remaining in character, he made the public commitment before conferring with Wyngaarden [the Director of NIH] or anyone else at NIH.⁹

Watson ultimately proclaimed that the Human Genome Project would devote three to five percent of its funding to studying the ethical, legal, and social implications of genetic technologies.

It has never been clear to what extent Watson’s pledge was motivated by his political assessment that the Project would be more likely to be funded with that commitment and to what extent it came from his own belief that the ethical issues were genuinely important. Watson has not said and, given his personality and history of frequent provocative comments, it is not clear how much credibility to accord whatever he might say about his motivations. The view of Robert Cook-Deegan, the historian of the early years of the Human Genome Project and a participant in its building, is that “[i]f there was a protective motive for Watson’s support [of ELSI], there was also a long-

more importantly, made it seem “too cute.” “Neuroethics” is not nearly as close in sound to its scientific parent, “neuroscience.”

8. See Larry Thompson, *Gene Pioneer Will Head Mapping Project*, WASH. POST, Sept. 27, 1988 (Health), at 7.

9. ROBERT COOK-DEEGAN, *THE GENE WARS: SCIENCE, POLITICS, AND THE HUMAN GENOME* 163 (1994). Interestingly, as far as I can tell none of the immediate news reports of Watson’s appointment mentioned his financial commitment to ethics research.

standing interest.”¹⁰

Whatever his reasons, his pledge got results. In 1990 both the NCHGR and the DOE created programs on the ethical, legal, and social implications of genetics.¹¹ The NIH established “the ELSI Branch” in its Division of Extramural Research and the DOE established its own ELSI Program in its Office of Energy Research. The NIH program concentrated on funding external grants, mainly to academics for conferences, working groups, articles, and books. More of the DOE funding was spent internally, largely at national laboratories that were part of the legacy of the Manhattan Project and the Atomic Energy Commission, including Los Alamos, Lawrence Livermore, Lawrence Berkeley, and Oak Ridge. From September 1989 to 1997, the two efforts were loosely coordinated by the National Institutes of Health-Department of Energy Working Group on Ethical, Legal, and Social Implications of Human Genetics Research (ELSI Working Group). The ELSI Working Group was abolished in 1997, but the separate NIH and DOE programs continued.

Watson resigned as director of NCHGR in 1992 after a dispute with Bernadine Healy, then director of NIH, over NIH policies concerning gene patents. He was succeeded in 1993 by Francis Collins, a pediatrician and geneticist who had helped lead the team that in 1989 isolated the gene responsible, when mutated, for cystic fibrosis. Collins remains director of the organization, which in 1997 was promoted to the status of a full institute at the NIH, the National Institute for Human Genome Research. Under Collins, the ELSI program has continued to be very active under several different NIH directors. After Watson, the program has shown more interest in policy analysis and, recently, in creating Centers of Excellence in Ethics Research around the country.¹² The DOE ELSI program

10. *Id.* at 248.

11. This brief history is derived largely from three sources (as well as personal experience). See National Human Genome Research Inst., *The Planning and Evaluation History of the Ethical, Legal and Social Implications (ELSI) Research Program* [hereinafter *ELSI History*], <http://www.genome.gov/10001754> (last visited Mar. 29, 2006); COOK-DEEGAN, *supra* note 9; Kathi E. Hanna, *The Ethical, Legal, and Social Implications Programs of the National Center for Human Genome Research: A Missed Opportunity?*, in COMMITTEE ON THE SOCIAL & ETHICAL IMPACTS OF DEVELOPMENTS IN BIOMEDICINE, INST. OF MED., *SOCIETY'S CHOICES: SOCIAL AND ETHICAL DECISION MAKING IN BIOMEDICINE* 432 (Ruth Ellen Bulger et al. eds., 1995).

12. Glenn McGee has written an interesting analysis of the change in

also continues and has had remarkably stable leadership under Dr. Daniel Drell from June 1991 to the present. The DOE ELSI program has limited its focus to education about genetics, the privacy of genetic information, and employment consequences of genetics.

The Human Genome Projects at both NIH and DOE have consistently spent about three to five percent of their budgets on ELSI activities. The two agencies boast that they are running the largest bioethics project in the world. Over the last fifteen years, they have spent more than \$150 million, leading to hundreds of articles, books, conferences, and other research and educational activities on the ethical, legal, and social implications of genetics. Scholarship on these issues has proceeded in the United States without government funding, or, for some kinds of research—such as much legal research—without any funding at all, but the ELSI programs have certainly meant that more such research has been done and more researchers have been lured into the field. It is hard to know how to assess whether the financial investment in ELSI has been worthwhile; it is noteworthy, though, that since the American part of the Human Genome Project was created—with active ELSI programs from the beginning—public controversies about human genetics have not seriously threatened the Project's funding.

The Human Genome Project, of course, was not solely an American endeavor. It was pursued by researchers, and paid for by funds, from many countries, notably the United Kingdom, Japan, and France. Some ELSI work was supported by other countries, either individually or through regional organizations like the European Union. Canada, for example, has had an active program in “GE³LS” (Genomics Ethics, Environmental, Economic, Legal, and Social Issues), which has received substantial funding and has created a significant cadre of Canadian researchers expert in the area.

Genetics researchers from around the world created a voluntary association called the Human Genome Organisation

ELSI as a result of the Centers of Excellence in Ethics Research, arguing that Collins has, in effect, created publicly-financed ELSI think tanks, to the detriment of ELSI researchers not associated with those centers. Glenn McGee, “*Nanoethics: The ELSI of 21st Century Bioethics?*,” THE EDITORS BLOG OF THE AMERICAN JOURNAL OF BIOETHICS, Jan. 29, 2006, <http://blog.bioethics.net/2006/01/nanoethics-elsi-of-21st-century.html>.

(HUGO) in 1988 with the hope of using it to help coordinate the worldwide project. HUGO never did play the substantial role it initially envisioned, as international coordination seems to have occurred mainly as a result of talks directly between the agencies of the nations providing most of the funding and the researchers they funded. In 1992, HUGO created its own ethics group, initially called the Ethical, Legal, and Social Issues Committee, with very broad international membership. This HUGO committee, now called simply the HUGO Ethics Committee, has not funded research by others, as HUGO itself has been consistently financially strapped. It has, however, issued a number of useful and widely discussed policy statements, particularly under the leadership of Canadian law professor Bartha Maria Knoppers from 1996 to 2004.¹³

A few legal academics, such as George Annas and Alexander Capron, took part in some of the earliest discussions of ELSI issues. Initially these issues were dealt with in law schools, if at all, in “law and science” courses or a rare specialized seminar. Since the growth of ELSI, many more legal academics have become involved in research that involves genetics, and law schools are seeing more seminars or even courses on “law and genetics.” At this point, probably more than fifty active American law professors have published at least once on ELSI-related issues. Although this is a small fraction of the roughly 6,000 full-time American law professors, it is a significant number.

B. NEUROETHICS

The term “neuroethics” arguably was coined, and surely was popularized, by New York Times columnist (and wordsmith) William Safire.¹⁴ Safire chairs the board of the Dana Foundation, a private philanthropic organization with a special interest in mental health, neurological diseases, and neuroscience. He seems to have first used in the term in print, albeit with a hyphen, in a July 2001 column about human embryonic stem cell research, saying, in passing, “Disclosure:

13. See Hugo Genome Organisation Ethics Committee, Policy Statements, http://www.hugo-international.org/committee_ethics_info.htm (last visited Apr. 10, 2006) (giving an incomplete list of the policy statements).

14. Research by Paul Root Wolpe has shown that the term had been used on several occasions before Safire, but in specialized publications, with somewhat different meanings, and without any apparent notice being taken of it.

When not vituperating for a living, I head a foundation that supports research in brain science, neuro-immunology and immuno-imaging. We're exploring studies in neuro-ethics, surely a growing field."¹⁵ He returned to the now-hyphenless term more centrally in May 2002, devoting half a column to "the world of worry about unbridled science called 'neuroethics' [which] . . . deals with the benefits and dangers of treating and manipulating our minds."¹⁶

Personally, I find "neuroethics" less than ideal as a description for this field. It focuses entirely on "ethics" and ignores the legal and social issues that may be quite important. On the other hand, the term is catchy. Once applied, it has been impossible to dislodge—particularly as the broader alternatives, like "ethical, legal, and social issues in neuroscience" (ELSIN) or "neuroscience ethical, legal, and social implications" (NELSI), are hopelessly clunky by comparison.

Similar to ELSI, neuroethics has a "pre-history," a long period during which scholars and others worried about the possible implications of neuroscience—defined broadly—and society. It is little remembered today, but Huxley's novel *Brave New World* was more about psychological conditioning, sleep learning, and the effects of prenatal exposure to alcohol or oxygen on cognitive traits than it was about genetics.¹⁷ Philosophers, in particular, have a long history of interest in the mind, some of which spilled into neuroscience, with particular interest in issues of free will and personal responsibility.

In 1984, the late, lamented Office of Technology Assessment issued a thirty-six page background paper on the social implications of neuroscience,¹⁸ but the federal government did not follow it up. On July 25, 1989, Congress passed House Joint Resolution 174, declaring the 1990s "the

15. William Safire, *Stem Cell Hard Sell*, N.Y. TIMES, July 5, 2001, at A17. (The same language showed up without the hyphen in the version of the column published a few days later. William Safire, *Time To Move Ahead, Boldly*, MILWAUKEE J. SENTINEL, July 9, 2001, at A9.)

16. William Safire, *The But-What-If Factor*, N.Y. TIMES, May 16, 2002, at A25.

17. See ALDOUS HUXLEY, *BRAVE NEW WORLD* (Harper & Row 1969) (1932).

18. OFFICE OF TECH. ASSESSMENT, U.S. CONGRESS, *IMPACTS OF NEUROSCIENCE—A BACKGROUND PAPER* (1984).

Decade of the Brain,”¹⁹ followed by a presidential proclamation of the same in June 1990.²⁰ Although this announcement came at the same time as the development of ELSI inside NIH and DOE, no neuroethics movement resulted, nor, it appears, was one even contemplated. (Cook-Deegan does report, however, that other institutes of NIH watched the ELSI experiment at NCHGR very closely; it is possible that the National Institute for Mental Health (NIMH) or the National Institute for Neurological Disease and Stroke (NINDS) were among them.)²¹

The world of neuroscience had shown some previous interest in ethical and social issues. Since 1972, the Society for Neuroscience, one of the largest scientific societies in the world—its annual conference regularly draws around 30,000 participants—has had a Committee on Social Issues (sometimes called the Committee on Social Responsibility). Since 1983, this committee has sponsored a Social Issues Roundtable at the annual convention, including both panel discussions and occasional plenary talks.

To date, neuroscience has caught the attention of very few legal academics. Before 2000, only four law review articles appear in Lexis with the words “neuroscience” or “neuroimaging” in their titles.²² Only two more have appeared since then. The few legal academics interested in the brain (or the mind) were scattered into two very different fields—law and psychology and mental health law—which focused more on the rights of those facing possible commitment for mental illness. The Association of American Law Schools (AALS) publishes an annual directory of law faculty in which those faculty can choose to list themselves as working in various specialties. The number of faculty identifying themselves as working in Law and Psychology peaked at 128 in the 1995-1996

19. See H.R.J. Res. 174, 101st Cong. (1989) (stating “the President of the United States is authorized and requested to issue a proclamation calling upon all public officials and the people of the United States to observe such decade with appropriate programs and activities”).

20. Proclamation No. 6158, 55 Fed. Reg. 29,553 (July 20, 1990).

21. COOK-DEEGAN, *supra* note 9, at 241.

22. One was a Note by my then-student, Dr. Jennifer Kulynych, which, when published in 1997, should have, but did not, spark my interest in the field. Jennifer Kulynych, Note, *Psychiatric Neuroimaging Evidence: A High-Tech Crystal Ball?*, 49 STAN. L. REV. 1249 (1997).

academic year and is now down to roughly 116.²³ “Neuroscience” has never been listed as a specialty in the AALS directory and does not seem to have been the subject of any courses.

In general, there has been surprisingly little discussion of the ethical, social, and legal issues raised by advances in neuroscience.²⁴ What might be called, possibly with some hyperbole, the “modern era” in neuroethics almost certainly dates to 2002. The key event was probably a conference held in San Francisco in May 2002, entitled “Neuroscience: Mapping the Field.”²⁵ The conference was co-hosted by Stanford University and the University of California-San Francisco (UCSF) and was funded by the Dana Foundation. The main organizers were Dr. Zach Hall, then Associate Chancellor at UCSF and now the President of the California Institute of Regenerative Medicine; Dr. Judy Illes of Stanford; and Dr. Barbara Koenig of Stanford, now at the Mayo Medical School. The conference brought together more than twenty speakers and an audience of over 150. Its main themes were the implications of neuroscience for individuals, for social policy, and for clinical neuroscience, as well as issues associated with the dissemination of neuroscience discoveries.²⁶ Its speakers

23. ASSOCIATION OF AM. LAW SCHS., DIRECTORY OF LAW TEACHERS 2005-06 (2006); ASSOCIATION OF AM. LAW SCHS., DIRECTORY OF LAW TEACHERS 1995-96 (1996).

24. One notable exception is a book written by a political scientist. ROBERT H. BLANK, *BRAIN POLICY: HOW THE NEW NEUROSCIENCE WILL CHANGE OUR LIVES AND OUR POLITICS* (1999). This book contains chapters on a wide range of topics, including genetics and the brain, brain and behavior, intervening in the brain, brain grafting, and neurotoxicity. It does not, however, discuss imaging technologies in any depth, and Blank, now at Brunel University in the United Kingdom, does not seem to have published more on these issues. He has not been involved in more recent discussions of neuroethics.

25. Two other conferences in 2002 are worthy of note. On February 7, 2002, the University of Pennsylvania held a conference entitled “Ethics and the Cognitive Neuroscience Revolution.” It was smaller than the San Francisco conference, less broad in its coverage of neuroethics, and it produced no written output, but an argument could be made for its priority. In March 2002, Michael Gazzaniga, a cognitive neuroscientist at Dartmouth who had recently been named a member of the President’s Council on Bioethics, hosted a fifteen-speaker workshop in London on “Neuroscience in 2025.” This may not have had broad effects on the field, but it did mark my introduction to it, as Gazzaniga invited me to give the only talk at the workshop on ethical and legal issues.

26. My own contribution to the discussion included a much shorter and

included many, if not most, of those who have subsequently been viewed as working in neuroethics. The Dana Press, operated by the Dana Foundation, produced a useful volume of proceedings of the conference, called *Neuroethics: Mapping the Field*.²⁷

The period since 2002 has seen an increasing number of conferences, workshops, and publications dealing expressly with neuroethics. One notable workshop was held jointly by the Dana Foundation and the American Association for the Advancement of Science in September 2003, entitled “Neuroscience and the Law.” It brought together neuroscientists, law professors, judges, and practitioners and resulted in a book, again published by Dana Press, called *Neuroscience and the Law: Brain, Mind, and the Scales of Justice*.²⁸ In 2005, the American Society for Bioethics and Humanities, the leading bioethics society in the United States, established a “neuroethics affinity group” and plans are under way for the formation of some kind of “neuroethics society.” And 2006 has seen the publication of *Neuroethics: Defining the Issues in Theory, Practice and Policy*, a book edited by Judy Illes with contributions from many of the researchers active in neuroethics.²⁹

Unlike ELSI, there has been little governmental support for neuroethics. The main conferences were sponsored by private funding, especially from the Dana Foundation. Thus far, neither NIMH nor NINDS, two major sources of federal funding on neuroscience, have shown any interest in a general neuroethics program. The NIH has funded a few individual research projects, such as an RO1 project awarded to Illes. Other parts of the federal government have funded some efforts that have implications in the area. The National Institute for Justice, in the Justice Department, funded Michael Gazzaniga’s 2002 workshop in London; the National Science Foundation and the Office of the Science and Technology Policy, pursuant to specific congressional authorization, have

simpler approach to the question of this article. See Henry T. Greely, *Neuroethics and ELSI: Some Comparisons and Considerations*, in *NEUROETHICS: MAPPING THE FIELD* 83, 83-94 (Steven J. Markus ed., 2002) (outlining views on the likely legal, ethical, and social implications of neuroscience).

27. *NEUROETHICS: MAPPING THE FIELD* (Steven J. Marcus ed., 2002).

28. *NEUROSCIENCE AND THE LAW* (Brent Garland ed., 2004).

29. *NEUROETHICS: DEFINING THE ISSUES IN THEORY, PRACTICE, AND POLICY* (Judy Illes ed., 2005).

hosted a series of workshops on the use of neuroscience to improve lie detection, which have included some discussion of legal and ethical issues.

II. ISSUES

We now have over fifteen years of ELSI programs and a longer time of ELSI research. New issues continue to emerge, as well as new interpretations of (and even evidence about) older issues, but the broad outlines of the field seem fairly clear. Neuroethics is much newer, and its contents and borders are more obscure. Nonetheless, it seems useful to look at the issues explored by ELSI and being examined by neuroethics to see where, and how, the newer field is likely to build on the older—and where it will not. This section of the article starts with overviews of both fields and then analyzes first areas of similarity and then areas of divergence.

Before starting, two major differences between these first need to be noted. First, genetics studies characteristics that pass, strongly or weakly, from one generation to another. Neuroscience looks at characteristics of individuals (and their brains) that, except for any genetic roots they have, are no more likely to pass from one generation to another than any other trait that is influenced by environment, which, of course, includes the family as one key part. Second, neuroscience is likely, in many cases, to be more powerful than genetics, especially for issues of behavior. The genetic variations that a person is born with will sometimes influence his later behavior, but that influence will necessarily be mediated by years of both experience and chance. The size, shape, health, architecture, and patterns of neuronal activity that exist at any given time in a person's brain should be much more strongly connected to that person's behavior. They should, in fact, determine it. These two differences will explain much, though not all, of the differences in what issues ELSI and neuroethics examine—and how they approach them.

A. OVERVIEWS OF THE FIELDS

One can, of course, carve up the work in ELSI in many different ways. All of it proceeds from the revolution in genetics sparked by our understanding of DNA and our consequent ability to “read” the genetic code. The substantive research in genetics over the past thirty years has been

extraordinary and is, at least in its general outlines, well known. I will not discuss the science, but will focus on the research and its implications. I have found it useful to think about six major themes in the ethical, legal, and social implications of genetics: identity, uncovering the past, revealing the future, manipulation of genes and genomes, ownership and control, and effects on culture.³⁰

Identity issues include, prominently, the forensic uses of DNA but also the possible use of DNA for establishing “ethnic identity” and the controversy over human reproductive cloning, a form of assisted reproduction of particular interest only because of the almost complete genetic identity between the cloned and the clone. Genetics can uncover the past in ways ranging from the history of the human species and its migrations, to the genetic conditions of historic figures, to the genealogies—or genetic parents—of individuals. The most controversial area of human genetics is the use of DNA to predict the future: the future of living individuals with genetic variations linked to various diseases or traits, and the future of fetuses or even, through the process called preimplantation genetic diagnosis, embryos produced by *in vitro* fertilization. The proper uses of such predictive technologies, and the propriety of various users, such as insurers and employers or parents and governments, has occupied most of the attention of ELSI.

Manipulation of genes or genomes, through somatic cell gene therapy, intentional inheritable genetic modification (also known as germ-line gene therapy), or inter-specific genetic chimeras (part-human or, more commonly, agricultural), has also been widely discussed. Much ELSI research has focused on issues around patents—on gene segments, on genes, and on genetically modified organisms. Other significant issues of ownership and control have included questions of personal property, as in the famous *Moore* case,³¹ privacy, and forced disclosure of genetic information. Perhaps the most important, though not the most discussed, issues raised by the science of

30. See Henry T. Greely, *Ethical Issues in the “New” Genetics*, in 7 INTERNATIONAL ENCYCLOPEDIA OF THE SOCIAL AND BEHAVIORAL SCIENCES 4762 (Neil J. Smelser & Paul B. Baltes eds., 3d ed. 2001); Henry T. Greely, *Legal, Ethical, and Social Issues in Human Genome Research*, 27 ANN. REV. OF ANTHROPOLOGY 473, 475 (1998); Henry T. Greely, *The Revolution in Human Genetics: Implications for Human Societies*, 52 S.C. L. REV. 377 (2001).

31. *Moore v. Regents of the University of California*, 793 P.2d 479 (Cal. 1990), *cert. denied*, 499 U.S. 936 (1991).

genetics concern the broader effects of that science on human cultures. On the one hand, this includes the effects on human societies if the science of human genetics produces its hoped-for payoff in reducing disease and extending life. It encompasses our societies' understandings of the relationships between humans that are embodied in our concept of "race," as well as the family connections, clearly visible in DNA, with all of non-human life. Most profoundly, it speaks to the importance, great or small, of genetics in our lives—genetic determinism and, deeply still, genetic essentialism, the idea that, in some meaningful sense, we *are* our genomes (circling around, in a way, to the very first concern about identity).

As it reaches its fourth birthday, neuroethics is a rapidly expanding area for research, as is the field of neuroscience on which it depends. Neuroscience is in the early stages of a revolution, brought about by improvements in tools in several different areas. As this explosion of our understanding of the human brain is not nearly as widely known as the revolution in genetics, I will discuss some of its key features.

The most prominent changes have come from advances in neuroimaging. Conventional x-rays were almost useless for imaging living brains, both because of the enclosure of the brain in the dense and x-ray opaque skull and the soft consistency of brain tissue. Computerized axial tomography (CAT scans) allowed some imaging of the brain, but the real advances have come with a raft of other techniques, including positron emission tomography (PET scans), single photon emission tomography (SPECT scans), and, most notably, magnetic resonance imaging (MRI). All of these techniques can provide computer files packed with data about the structure of a brain, which can then be converted into visual representations of various brain cross-sections.

PET and SPECT scans, along with a variation of MRI called functional magnetic resonance imaging (fMRI), can show *activity* within the brain by tracing the location or concentration of various molecules, including glucose and deoxygenated hemoglobin. These technologies allow living brains to be observed, both as their shape changes over time and as they function, by watching the location and timing of glucose and oxygen consumption. These functional capabilities are allowing researchers to watch what areas of the brain are in greater or lesser use as test subjects use their brains—for

movement, for sensation, for emotion, or for thought. This has led to published research on the sites, within the brain, of passionate love,³² the sense of mystical union with God,³³ and the deepest level of Buddhist meditation,³⁴ among many more mundane examples.

Many other technologies are also contributing to the neuroscience revolution. Electroencephalograms and other methods of measuring electrical flows within the brain are becoming more detailed and precise. Transcranial magnetic stimulation is permitting an experimenter to make temporary changes in the function of chosen brain tissues, stimulating or repressing neuronal function. Implanted microelectrodes and other devices are allowing the direct sensing and stimulation of small numbers of, or even individual, brain neurons. New drugs are providing new ways to heal, or to enhance, human brains. And, of course, the neuroscience revolution is in part the same as the genetics revolution. Our improved knowledge of genes and their functions has included greatly increased knowledge of genes that are important to the brain and how the brain is affected by their normal and abnormal expression. Huntington's disease, fragile X syndrome, Tay-Sachs and related diseases, and some cases of Alzheimer's disease are the subjects of both genetics and neuroscience and so have become topics for both ELSI and neuroethics.

Stemming from advances in neuroscience, neuroethics appears to be developing along three major lines. One branch of neuroethics looks at ethical issues raised in the process of neuroscience research. The work by Judy Illes and colleagues on the serious problem of unexpectedly incidental findings during neuroimaging is a good example of this strand.³⁵ A

32. Andreas Bartels & Semir Zeki, *The Neural Basis of Romantic Love*, 11 NEUROREPORT 3829 (2000); H. Fisher, A. Aron & L.L. Brown, *Romantic Love: An fMRI Study of a Neural Mechanism for Mate Choice*, 493 J. COMP. NEUROLOGY 58 (2005).

33. Andrew Newberg et al., WHY GOD WON'T GO AWAY (2001) [hereinafter Newberg et al., WHY]; A. Newberg et al., *Cerebral Blood Flow During Meditative Prayer: Preliminary Findings and Methodological Issues*, 97 PERCEPTUAL & MOTOR SKILLS 625 (2003) [hereinafter Newberg et al., *Cerebral*].

34. Newberg et al., WHY, *supra* note 33; Newberg et al., *Cerebral*, *supra* note 33.

35. See Judy Illes et al., *Ethical and Practical Considerations in Managing Incidental Findings in Functional Magnetic Resonance Imaging*, 50 BRAIN & COGNITION 358 (2002) (discussing various ethical dilemmas arising from brain imaging); Judy Illes et al., *Incidental Findings in Brain Imaging*

second strand looks at the neuroscience of ethics—how human brains make ethical decisions. There is substantial research in this area as well as the broader area of how human brains make decisions at all, which is sometimes called neuroeconomics. Work by Oliver Goodenough and Kristin Prehn on neuroimaging during normative decisions is a good example of these kinds of research.³⁶

The third strand of neuroethics, which is likely to be the largest, looks at how existing or plausible discoveries and technologies in neuroscience are likely to affect societies, including their laws. This comprises at least four areas. The first is the consequences of improved prediction of mental illness, neurological disorders, or personality traits. A second concerns the possibility of using neuroscience techniques to determine a person's competence. "Mind reading" is the third, which is plausible through the use of neuroimaging and similar technologies to associate detectable forms of brain activity with mental states, such as lying, bias, or the subjective experience of pain. The final area is human brain "enhancement" through neuroscience technologies. My own work has surveyed these issues and analyzed some of them.³⁷

Research, 311 SCIENCE 783 (2004) (discussing ethical issues that have arisen incidentally from brain-imaging research); Brian S. Kim et al., *Incidental Findings on Pediatric MR Images of the Brain*, 23 AM. J. NEURORADIOLOGY 1674 (2002) (discussing incidental abnormalities found in brain MR imaging studies).

36. See Oliver R. Goodenough & Kristin Prehn, *A Neuroscientific Approach to Normative Judgment in Law and Justice*, 359 PHIL. TRANSACTIONS ROYAL SOC'Y LONDON B 1709 (2004) (examining developments in neuroscience that provide insight into brain processes involved in normative judgment). The entire November 2004 publication of the *Philosophical Transactions of the Royal Society of London, Series B*, is devoted to "Law and the Brain," with a focus on neuroimaging and normative decisionmaking.

37. See, e.g., Henry T. Greely, *Prediction, Litigation, Privacy, and Property: Some Possible Legal and Social Implications of Advances in Neuroscience*, in NEUROSCIENCE AND THE LAW, *supra* note 28, at 114 [hereinafter Greely, *Prediction, Litigation, Privacy, and Property*] (exploring the social and legal consequences that neuroscience could bring); Henry T. Greely, *The Social Effects of Advances in Neuroscience: Legal Problems, Legal Perspectives*, in NEUROETHICS: DEFINING THE ISSUES IN THEORY, PRACTICE, AND POLICY, *supra* note 29, at 245 [hereinafter Greely, *The Social Effects*] (examining how developments in neuroscience will affect law and the legal system); Henry T. Greely, *Premarket Approval Regulation for Lie Detection: An Idea Whose Time May Be Coming*, 5 AM. J. BIOETHICS 50 (2005) (discussing the development of technically assisted lie detection and its use inside the

Neuroscience will share some of the issues examined by ELSI research, allowing it to build on that work as appropriate. The area that seems most likely to be strongly similar is prediction; areas of lesser but still substantial overlap include manipulation, the privacy area of ownership and control, cultural impacts, research uses, and enhancement. Other questions, however, such as those of identity, uncovering the past, patents, personal property, source of ethics, competence, and mind reading, exist largely in either ELSI or neuroethics, but not in both.

B. PREDICTION: THE STRONGEST LINK BETWEEN NEUROETHICS AND ELSI

The correspondence between neuroethics and ELSI is strongest in prediction. Genetics can predict—sometimes powerfully, sometimes weakly—a person's future health and other traits. There has been great concern that insurers, employers, and others might use this information against people. Neuroscience will similarly be able to predict the future diseases or traits of people, again strongly or weakly, with the potential for similar consequences.³⁸ For living people, neuroscience predictions may well have a broader effect than genetic ones; for embryos or fetuses, however, genetic prediction will probably remain much more powerful.

For living people, neuroscience has an advantage over genetics in that it can look at the present condition of the brain, which should allow it to make a greater number of strong predictions than genetics. The genetic variations a person has (apart from mutations acquired during life, which are mainly important in cancers) are established when her zygote is formed by the meeting of egg and sperm. Making strong predictions from the genetic variations inherited at that earliest moment leaves out all the consequences of time, chance, and experience.³⁹ A thirty-year-old woman has had

courtroom as well as in other disciplines).

38. The two fields will sometimes cover exactly the same technologies. For example, genetic tests can already be used to predict Huntington's disease, an uncommon, progressive, and deadly neurological disorder usually diagnosed in middle age, raising not only issues of discrimination but when, to whom, and how such tests should be offered. As Huntington's disease is a neurological disease, these ELSI issues are also neuroethics issues.

39. This refers to the traditional predictive uses of genetics, in which inherited genetic variations are correlated with various outcomes. It turns out, however, that not only is the sequence of a gene important in how the

thirty years and nine months during which other factors may have affected her inherited genetic tendencies. On the other hand, neuroimaging of the same woman can reveal the structure and function of the brain as it has been affected by those years; other tests may reveal real-time levels of various crucial molecules. There is no opportunity for intervening causes; behavior will be a function of how that brain and its neurons work. Her genetic inheritance will be one part of how her brain and neurons work and, in some cases, like Huntington's disease, it will be a determinative part. But in most neurological diseases, mental illnesses, or behavioral traits, genetics will play a smaller part. The "penetrance" of the genetic variations—the percentage of people with a particular set of such variations (the "genotype") who have the disease, illness, or trait (the "phenotype")—will be fairly small. It seems likely that the "penetrance" of the structural, functional, or biochemical aspects of the brain that are used to make predictions can be much higher.

For example, for a very small number of people, genetic tests can already predict a near certainty of future Alzheimer's disease in either early-onset or late-onset forms. Genetic tests can provide weak predictions of somewhat heightened risk (well under fifty percent) for about one-third of the population.⁴⁰ On the other hand, neuroimaging of amyloid plaques or tau protein tangles of people in their sixties, or even their fifties, may well lead to successful prediction of which elderly people are going to be diagnosed with Alzheimer's disease.⁴¹ Neuroimaging should actually be able to see the

body (and the brain) functions, but so is when and how a gene is used—when it is "expressed" through the production of proteins or RNA. Some of those changes are themselves inherited, not through changes in the sequence of the DNA but through various modifications to it. These modifications are called "epigenetics." Expression of genes, however, is also very often affected by subsequent events or signals. If one considers this kind of "expression analysis" as genetics, it may have the same kind of temporal advantages for predictions as neuroscience. (Currently, however, direct study of the expression of genes in the brain requires fresh samples of brain tissue, a distinct disadvantage when studying live humans.)

40. See, e.g., L.M. McConnell, B.A. Koenig, H.T. Greely & T.A. Raffin, *Genetic Testing and Alzheimer Disease: Has the Time Come?* 4 NATURE MED. 757, 758 (1998) (discussing the current inadequacy of genetic testing to accurately predict Alzheimer's disease, noting that just over a quarter of Caucasian adults have the appropriate genetic make-up for mere diagnostic testing).

41. See, e.g., H. van Dyck, *Neuroimaging in Alzheimer's Disease:*

progression of the disease from asymptomatic levels to deadly ones, thus extending all the problems of prediction to a much larger group of people.

Genetic tests can predict some other, relatively rare, neurological conditions, but although genetic associations are believed to exist, researchers have not found genetic variations that allow strong predictions about common mental illnesses, such as schizophrenia, bipolar disorder, obsessive-compulsive disorder, various addictions, or depression. Genetics may ultimately be able to make such predictions, but experience thus far makes it plausible that, at least for most people, these diseases will prove such complicated mixtures of environmental influences, variations in multiple genes, and luck that only weak predictions will be possible. The ability of neuroimaging to see both the structures of the brain and the functioning of its parts holds out the possibility that it may be able to make strong predictions about who will develop these disabling illnesses. Increased knowledge from non-imaging neuroscience technologies may also lead to useful predictions.

An estimated twenty-two percent of adults suffer, in any given year, from mental health disorders,⁴² thus again potentially expanding the number of people against whom such predictions could be used. The stigma that continues to follow mental illness makes the possibility of discrimination even stronger. Of course, for mental illnesses as for neurological diseases, if the ability accurately to predict the disease brought with it an ability effectively to *treat* the disease, people would happily endure the risks of prediction. If, however, neuroscience follows the same path as genetics, good predictions will exist long before any good treatments, which, in both areas, makes the balance of costs and benefits of such predictions—at least for the individual involved—ambiguous.

But the predictive power of neuroscience may be even wider than neurological diseases or mental illness and may go far beyond what genetics can do. Personality traits and cognitive abilities are, after all, a function of how the brain works. Some of these may have some genetic associations, but those have proven so complex as to be unknown, at least except

Relevance for Treatment, 3 CURRENT PSYCHIATRY REP. 13 (2001); C. Wu et al., *Amyloid Imaging: From Benchtop to Bedside*, 70 CURRENT TOPICS IN DEVELOPMENTAL BIOLOGY 171 (2005).

42. Mental Health InfoSource, *Mental Health Information and Statistics*, <http://www.mhsource.com/resource/mh.html> (last visited March 3, 2006).

in the most extreme cases. Some forms of intelligence, for example, seem to have genetic associations, but genetics can predict only the pathologically low levels of intelligence that are called mental retardation—and only a small percentage even of that. On the other hand, various mental skills or personal characteristics might be predicted, or revealed, by neuroscience testing. Of course, in general if one wants to determine a person's math skills, a math test is a better method than an fMRI. Such predictions might be helpful in connection with educational or career counseling for children, although a prediction of skills may also end up as a burdensome limitation, particularly if it is imperfect.

But such predictions could also be helpful in quite different cases of predicting future behavior, where the behavior either cannot be tested for directly or the subject of the test has reason to conceal it. Consider predictions about a criminal's future dangerousness or the likelihood that someone is, or will become, a sexual predator or a sociopath. Although genetic associations have occasionally been put forward for such traits, most notoriously in the alleged (and false) propensity to violence of men with one X and two Y chromosomes,⁴³ they have failed. It is much more plausible that neuroscience predictions will be more accurate—or that they will be wrongly taken as more accurate. The implications of those predictions, for the criminal justice system among other things, may prove much more substantial than those of genetic predictions. But the effects may reach beyond the justice system. Claims of

43. For a discussion of the early studies, see P.A. Jacobs et al., *Aggressive Behaviour, Mental Subnormality and the XYY Male*, 208 NATURE 1351 (1965). For a discussion of how the study was discredited, see Deborah W. Denno, *Human Biology and Criminal Responsibility: Free Will or Free Ride?*, 137 U. PA. L. REV. 615, 620-22 (Dec. 1988). A more scientifically legitimate "violence gene" has subsequently been identified. A defect that makes inoperative the gene called MAO-A has been shown to lead to men with below average intelligence and a history of violent behavior, sexual assault, and arson. This mutation, however, has been found only in the Netherlands and there, only in one family. Avshalom Caspi et al., *Role of Genotype in the Cycle of Violence in Maltreated Children*, 297 SCIENCE 851 (2002) (reporting results of the study); Erik Stokstad, *Violent Effects of Abuse Tied to Gene*, 297 SCIENCE 752 (2002) (commenting on the study). It cannot "explain" violence. Another gene, called SRY, is found in almost all people who commit violent crimes; people without that gene are highly unlikely to commit violent crimes. This is the gene most directly involved in making those who carry it male. Although maleness is strongly associated with violence, that particular genetic test does not seem very useful.

genetic connections to sexual preference, though highly publicized, have not been proven. It seems plausible that neuroscience testing might be more successful than genetic tests in predicting the eventual sexual preferences of children, adolescents, or adults, although it is not clear whether they would be accurate as other, already existing, tests.⁴⁴ One can imagine parents, or others, seeking that kind of information, perhaps to attempt interventions.

Although neuroscience is likely to do a better job than genetics of predicting brain-related characteristics of living people, it probably will not be as important as genetics for predicting the characteristics of “future people”—fetuses and embryos. Those kinds of predictions give rise to some of the most controversial issues in ELSI, including state-sponsored eugenics and parental choice about their children’s genetic traits. Part of the reason for the weakness of neuroscience is the other side of its strength with living people; with a fetus or an embryo, there is little or no accumulation of the effects of environment and chance. To the extent that brain-related traits are functions, at all, of post-birth events whose marks are visible to neuroscience but not to genetics, they cannot be predicted successfully before birth. There is another, more fundamental reason, however. The embryo and fetus lacks, at first, any structure of a brain; for much longer it lacks any discernible brain function. To the extent neuroscience predictions rest on brain structure and function, they are impossible unless that structure or function can be detected.

The weakness of prenatal neuroscience is relative, not absolute. It is possible, for example, to get structural images of the brains of later term fetuses through MRI. It is possible that those screening technologies could be used to pick up some gross abnormalities in the developing brain, from anencephaly (a fatal condition where a child is born without a cerebrum) to possibly some forms of mental retardation or cerebral palsy. At this point it is not clear what conditions could be detected using fetal MRI or at what stage of development they could be seen. It is at least possible that neuroscience methods might

44. The penile plethysmograph, for instance, is a crudely straightforward test that involves measuring a male subject’s physical arousal as he is presented with a variety of sexual images depicting men, women, and children. Jason R. Odeshoo, *Of Penology and Perversity: The Use of the Penile Plethysmograph on Convicted Child Sex Offenders*, 14 TEMP. POL. & CIV. RTS. L. REV. 1, 9 (2004). It is commonly used in sex offender treatment programs. *Id.* at 7-8.

ultimately lead parents to decide to abort some fetuses with serious structural brain problems.

C. AREAS WITH LESSER BUT SUBSTANTIAL OVERLAP

Neuroscience predictions seem likely to raise ethical issues quite similar, but not quite identical, to the concerns that stem from genetic predictions. Other uses of neuroscience will raise issues somewhat less similar to those raised by genetics with respect to manipulation, privacy, cultural impacts, research ethics, and enhancement.

1. Manipulation/Intervention

Most of the discussion of genetic manipulation in humans has centered on so-called gene therapy,⁴⁵ where properly functioning copies of genes are transferred in order to cure genetic diseases in living people, called somatic cell gene therapy, or to prevent genetic diseases in future generations, called germ line gene therapy or inheritable genetic modification. (There has also been substantial controversy about moving genes from one non-human species to another non-human species for agricultural purposes; this seems unlikely to happen significantly in neuroscience, except in laboratory research where it should not be controversial.) After some early concerns about the idea of modifying a person's genome, the idea of somatic cell gene therapy to cure disease has not been controversial, although research ethics issues about how to carry out these investigations remain. The idea of somatic cell gene therapy not for treating disease or disability but for enhancing abilities beyond normal, however, does remain controversial.

Neuroscientific "manipulations," perhaps better termed "direct interventions," are likely to follow a similar path. The idea of intervening directly in people's brains, by electronic implants or other intrusive methods, will evoke discomfort, particularly to the extent, parallel to genetic essentialism, that

45. The term "gene therapy" is not a good one as there have not yet been any clinically accepted therapies as a result of this technique of gene transfer. "Gene transfer research" would be a better term for it, but this article will use the more widely understood term "gene therapy." And, ironically, as the field of gene transfer research has developed, far more research has gone into using gene transfer to combat diseases that are not caused, substantially or at all, by inherited genes, such as cancer and AIDS.

the brain is perceived as a person's "essence." This is parallel to the uneasiness prompted by other intrusive interventions in the brain, whether eventually dismissed as medically inappropriate, like prefrontal lobotomies,⁴⁶ or remaining in some clinical use, like electro-convulsive therapy. As long, however, as the neuroscientific interventions are for the purpose of curing or alleviating disease or injury, their intrusions will be uneasily accepted, as, indeed, we currently accept such implanted brain devices as cochlear implants for deafness and deep brain stimulation for the treatment of Parkinson's disease. Neuroscience interventions for enhancement, however, will be quite controversial and are discussed below.

There seems to be no likely neuroscience equivalent to concerns over germ line gene therapy. Such genetic intervention is controversial because it may be transmitted to future generations; neuroscience interventions do not have the same potential for passing down to the families of their recipients.

On the other hand, the issue of human/non-human chimeras has already become more controversial in neuroscience than in genetics. Transferring human genes into non-human organisms is the most important technique of the biotechnology industry: find a human gene for a therapeutic protein (insulin, erythropoietin, granulocyte-macrophage colony stimulating factor), move it into non-human cells (*E. coli*, yeast, Chinese hamster ovary cells), and let those cells pump out commercial quantities of the human protein. That this creates cells that are, genetically, part human and part non-human, has not caused concern, or even attracted much notice. Of course, moving a large number of human genes into a non-human creature (particularly a near relative like one of the great apes) or moving genes from a non-human species into humans would be likely quite controversial.

In neuroscience, when Irv Weissman, a Stanford researcher, proposed to transplant human brain stem cells into fetal mice, he sparked a substantial controversy.⁴⁷ Senator

46. It is worth remembering that the invention of the prefrontal lobotomy, now generally viewed as a tragic and barbaric mistake, led to the award of the Nobel Prize in Medicine and Physiology to Egas Moniz of Portugal in 1949.

47. See generally Henry T. Greely, *Defining Chimeras . . . and Chimeric Concerns*, 3 AM. J. BIOETHICS 17 (2003) (discussing the definition of "chimera" and how a better definition will enhance understanding of ethical issues of

Brownback introduced legislation to make such research a felony;⁴⁸ President Bush, supporting that legislation in his 2006 State of the Union address, called “creating human-animal hybrids” one of “the most egregious abuses of medical research”;⁴⁹ and even the National Academy of Sciences panel on human embryonic stem cell research guidelines called on researchers to use special caution when transplanting human stem cells into the brains of non-human animals.⁵⁰ The potential value of such human/non-human chimeras for research into human brain cells makes it likely that this debate will continue.

2. Privacy

Genetic information has sparked worries about privacy for two different reasons. One is the concern about the negative ways genetic information might be used against the person tested. The other is a less instrumental concern, a feeling of invasion of an especially personal, private, or important aspect of a person. Privacy feels particularly important in the genetic context because genetic information is not generally obvious but is instead usually “hidden.” (Of course, not all genetic information is hidden; a person’s sex is almost completely determined by genes, as are various superficial characteristics

cellular and genetic transplantation between animal species); Mark Greene et al., *Moral Issues of Human–Non-Human Primate Neural Grafting*, 309 *SCIENCE* 385 (2005) (discussing controversial findings that resulted from implanting human brain cells into mice in the larger context of brain-cell implants between various animals); Phillip Karpowicz et al., *Developing Human-Nonhuman Chimeras in Human Stem Cell Research: Ethical Issues and Boundaries*, 15 *KENNEDY INST. ETHICS J.* 107 (2005) (discussing transplantation of human brain cells into prenatal nonhumans and related ethical concerns); Jason Scott Robert & Françoise Baylis, *Crossing Species Boundaries*, 3 *AM. J. BIOETHICS* 1 (2003) (exploring the moral boundaries involved in the emerging field of combining human and nonhuman animals at the genetic and cellular level); Henry T. Greely, *Outline of Talk to NAS Panel on Human Embryonic Stem Cells*, 7-13 (Oct. 13, 2004), *available at* <http://dels.nas.edu/bls/stemcells/Greelyoutline.pdf> (discussing Weissman proposed experiments).

48. See Human Chimera Prohibition Act of 2005, S. 659, 109th Cong. (2005).

49. President George W. Bush, State of the Union Address (Jan. 31, 2006), *available at* <http://www.whitehouse.gov/news/releases/2006/01/20060131-10.html>.

50. See COMMITTEE ON GUIDELINES FOR HUMAN EMBRYONIC STEM CELL RESEARCH, NAT’L RESEARCH COUNCIL, *GUIDELINES FOR HUMAN EMBRYONIC STEM CELL RESEARCH* 50, 55 (2005).

like skin color, eye color, and hair color.) Information about an individual derived from neuroscience seems likely to be at least as sensitive. It is equally susceptible to use against the person tested; it is at least equally personal, private, and important; and equally hidden—or hideable. And both genetic and neuroscience information will have substantial legitimate uses that will make protecting the information all the more difficult.

3. Cultural Effects

The likely cultural impacts of genetics include its consequences for health, for our views of race, for our relationship with non-human life, and for genetic determinism or essentialism. Neuroscience certainly may have effects on society similar to those of genetics through changes in human disease and age of death, although the details may differ. The long-term social consequences of, for example, a substantial extension of the age of high mental functioning, could be extensive. Like genetics, neuroscience might also affect our views of race. Neuroscience seems likely to provide yet more proof of the irrelevance of “race” to mental ability, although, at the same time, one would have to be alert to possible racist misuse of any small variations that might be found.

It is less clear whether or not neuroscience will raise cultural issues similar to those of genetics on other points. Genetics establishes common links—common genes and DNA sequences—between humans and other living things. It might (or might not) cause us to accord more respect to other living things. It remains to be seen what neuroscience tells us about the mental lives of other species and what conclusions we will draw from its findings. The most common forms of life on earth—microbes—obviously will not share our mental world, nor will fungi, plants, or most small or simple animals. But, as we come to understand the brain activities that mean planning, pleasure, or pain in humans, will we or will we not find similar activity in the brains of octopi or whales, of dogs or cats, of monkeys or chimpanzees? And how would either answer affect our relationship to those species?

The last area of possible deep cultural significance from genetics involves the relationship between individuals and their genomes. One version of this relationship has been called “genetic determinism,” the idea that our genes determine our lives. As *Time* magazine once quoted James Watson, “We used to think our fate was in the stars. Now we know in large

measure, our fate is in our genes.”⁵¹ For almost all of us, Watson was wrong. Unless we are unusually unlucky and are born with completely penetrant, untreatable, and serious genetic disease, genes are only one component—sometimes large, often small—in our fates. Much ELSI discussion has focused on the falsity of genetic determinism and the dangers an exaggerated view of genes’ power could pose. It is possible that a neuroscience determinism, accurate or inaccurate, could arise. On the other hand, although our genomes are fixed ninth months before our birth, we know that our brains change, and are changeable, throughout our lives. The complex and plastic nature of our brains makes them a less plausible, though still not impossible, source of determinism than our genes.

“Genetic essentialism” is somewhat different from genetic determinism. Genetic essentialism asserts that our individual genomes are, in some important sense, our true, essential selves. The ELSI literature contains some discussion of genetic essentialism, but it has never seemed a serious threat. Such a view would mean that identical twins, who share the same genome, were, essentially, the same person, something anyone who has known identical twins is likely to reject. It also rejects any role for experience or chance in the making of our individual essence, which is also unlikely to be accepted, as everyone will have lived through experiences that seemed to be fundamentally important to his or her nature. Genetic essentialism, in any non-trivial sense, is just not plausible.

Neuroessentialism, however, seems much more plausible. If we could successfully transplant my brain into your body, would the resulting person be me with a new body or you with a new brain? I believe almost all of us would say it was me with a new body—that the “essence” of the person is the brain, not the body. My views on this may be influenced by many decades spent in settings—as a student, an attorney, and a professor—where the brain was particularly valued, yet I suspect the same reaction would be very widespread, if not universal. Neuroethics may well have to deal with a widespread public acceptance of neuroessentialism, where ELSI never had to deal with a broad belief in genetic essentialism. It is not at all clear whether that will raise

51. Leon Jaroff, *The Gene Hunt*, TIME, Mar. 20, 1989, at 62, 67.

ethical, legal, or social problems.

4. Research Ethics

ELSI has engaged, and neuroethics will engage, issues of research ethics, but with different emphases. ELSI has been concerned with many different questions of research ethics, but three areas have received particular attention. One group of issues has revolved around the creation of large DNA repositories. These repositories have provoked concerns about the consent necessary when people are giving permission to use their genetic material (and their personal health information) for an indefinite amount of future research on undetermined (and perhaps undreamt of) issues and about the confidentiality of that material and information. A second set of problems deals with research on human populations and what kinds of consent or consultation may be appropriate from the group as a whole, as opposed to individual members of the group participating in research. A third set of research questions, related to those of ownership, deals with whether research subjects are fairly treated if they receive no financial benefits while researchers create valuable products from their DNA and health information.

These have some possible analogues in neuroethics. Some databases of MRI and fMRI data are being created for general use of researchers, raising issues of consent by the research participants and the confidentiality of their information. These databases are not very advanced in neuroscience and, as far as I know, there is not (yet) much individual health or other personal information associated with them, but this could become a concern.

The issues around population research seem less related to neuroethics but not irrelevant. Geneticists often look at particular ethnic or cultural groups in medical research because some groups will have a much greater burden of a particular genetic disease. Populations, like families, are more likely to share some genetic variations with each other than with outsiders. Finding genetic variations linked to the disease is easier in populations (or families) in which the disease is common. This could also lead, however, to harms to the entire group through stigmatization and discrimination. Neurological diseases, mental illnesses, or personality traits seem much less likely to be usefully studied in particular ethnic groups as there seems no *a priori* reason to think that any causes of such

phenotypes (other than genetic causes) are likely to be concentrated within the group. Still, the risks that neuroscience research might harm a population (ethnic or otherwise) cannot be dismissed. Some group-based research might occur, seeking environmental or other causes if a brain-related phenotype were particularly common in a group, which could potentially lead to harm. Perhaps more plausibly, more general research on brain-related traits could cause harm; consider, for example, the possibility of an exaggerated public reaction to a study that said that based on neuroimaging, “female brains” are not as good as “male brains” at mathematics.

It is unclear how strong the issues of financial fairness may be in neuroethics. As discussed below, it seems unlikely that patents on brain structures will be significant, unlike patents on genes. Although we hope neuroscience will lead to successful treatments, and successful treatments are likely to mean profitable products, without the sense (accurate or not) that part of a discrete individual’s body—his genes—have been used to make that profitable product, the ethical concerns may not be as great.

This uneven relationship runs the other way as well. The biggest research ethics issue in neuroethics has been incidental findings. When researchers perform MRIs for research, they typically look for effects across the entire brain. It is disconcertingly common to see unexpected odd things in the brains of research subjects, even young and healthy subjects. Some studies report finding abnormalities of uncertain importance in the brains of as many as forty percent of research subjects. Most of the time those incidental findings have no apparent medical significance, or at least none known to the researchers. What to do about those findings, both in investigating them and in telling the subjects about them, is unclear.

The issue of returning information about medical risks has been occasionally raised in ELSI, but it has not taken a central position.⁵² Traditional genetics research has focused on a few “target” genes. The ability did not exist to look at a vast number of the subject’s genes for abnormalities, so any findings

52. See Henry T. Greely, *Human Genomics Research: New Challenges for Research Ethics*, 44 *PERSP. BIOLOGY & MED.* 221, 225-26 (2001).

of abnormalities were not “incidental” but were part of the planned research—and presumably issues of follow-up and disclosure were anticipated. As microarrays, cheap sequencing, and other new technologies make it possible to look at hundreds of thousands of genetic variations at once, genetics research is having to confront these same issues of incidental findings.⁵³ Here neuroethics may help inform ELSI.

5. Enhancement

Questions of human biological enhancement arise in both genetics and in neuroscience, but in significantly different ways. Enhancement issues are deeply interesting, whether in genetics, neuroscience, athletic-performing enhancing drugs, or cosmetic surgery.⁵⁴

In genetics, issues of enhancement arise from one of two mechanisms: prenatal selection or gene transfer (either somatic or, more commonly, germ line).⁵⁵ The first method is limited to selecting among possible children based on their genetic variations and the traits associated with them, through fetal testing, abortion, or, for parents using *in vitro* fertilization methods, preimplantation genetic diagnosis and selective

53. Within the past year I have been a member of one working group convened at Stanford to make recommendations on incidental findings in genetics research and have spoken to a second working group, at the University of Minnesota, on the same topic.

54. I have analyzed some of these issues in detail recently. See, e.g., Henry T. Greely, *Disabilities, Enhancements, and the Meanings of Sports*, 15 STAN. L. & POLY REV. 99 (2004); Henry T. Greely, *Regulating Human Biological Enhancements: Questionable Justifications and International Complications*, U. TECH. SYDNEY L. REV./SANTA CLARA J. INT'L L. (joint issue) (forthcoming 2006). Other useful discussions include: ALLEN BUCHANAN ET AL., FROM CHANCE TO CHOICE: GENETICS AND JUSTICE (2000); CARL ELLIOTT, BETTER THAN WELL: AMERICAN MEDICINE MEETS THE AMERICAN DREAM (2003); MAXWELL J. MEHLMAN, WONDERGENES: GENETIC ENHANCEMENT AND THE FUTURE OF SOCIETY (2003); PRESIDENT'S COUNCIL ON BIOETHICS, BEYOND THERAPY: BIOTECHNOLOGY AND THE PURSUIT OF HAPPINESS (2003); SHEILA M. ROTHMAN & DAVID J. ROTHMAN, THE PURSUIT OF PERFECTION: THE PROMISE AND PERILS OF MEDICAL ENHANCEMENT (2003); Francis M. Kamm, *Is There a Problem with Enhancement?*, 5 AM. J. BIOETHICS 5 (2005); and Michael J. Sandel, *The Case Against Perfection*, ATLANTIC MONTHLY, Apr. 2004, at 51

55. One might also view as “genetic” the use of drugs produced through genetic engineering or genetic knowledge, such as the use of Epogen (a biotechnology-produced version of the natural protein erythropoietin) for boosting an athlete's red blood cell count. The source of the drug in genetic technologies, however, does not seem to distinguish it substantially from drugs produced in other ways, such as anabolic steroids.

implantation. These methods raise important ethical and constitutional issues of parental control over reproduction.⁵⁶ The second method can be used in living people (as well as in fetuses, embryos, eggs, or sperm) for either somatic cell gene therapy or germ line gene therapy, but has the disadvantage that it has not been shown to be possible, let alone safe and effective.

The first approach and the germ line version of the second approach will have implications for future generations. And all of the genetic approaches are only as powerful as the strength of the connections between particular genetic variations and desired traits. Except for a few, usually uncommon, diseases, those connections are currently weak or nonexistent; although reasonably strong connections to cosmetic traits (such as hair color, eye color, skin color, and nose shape) seem likely to come soon, it is not clear when or if we will ever have strong connections to other, more important traits.⁵⁷

Neuroscience enhancement is likely to involve both pharmacological enhancements (“steroids for the brain”) and various kinds of implanted interfaces between the brain and electronic devices (“neuroelectronic interfaces”). Some of these already exist. Caffeine, alcohol, Prozac®, Ritalin®, Provigil®, and other drugs—some traditional and others approved by the FDA—are among many of the legal compounds that are sometimes taken to affect brain function, not just by the ill, but by normal, healthy people. Cochlear implants use electronic signals to stimulate the auditory nerve so that some of the deaf can hear; technologies under development pick up signals from a quadriplegic person’s brain and use them to allow that disabled person to operate a computer. These may well expand in the near future to be useful to healthy people.⁵⁸

Neuroscience enhancement issues do not implicate decisions about childbearing, but some of their hardest questions may involve questions of government control over

56. See John A. Robertson, *Procreative Liberty in the Era of Genomics*, 29 AM. J. L. & MED. 439 (2003).

57. See Henry T. Greely, *Seeking More Goodly Creatures*, 6 CEREBRUM 49, 51-53 (2004); Henry T. Greely, *Human Genetic Enhancement: A Lawyer’s View*, 17 MED. HUMANITIES REV. 42 (2003) (reviewing MAXWELL J. MEHLMAN, *WONDERGENES: GENETIC ENHANCEMENT AND THE FUTURE OF SOCIETY* (2003)).

58. See Greely, *The Social Effects*, *supra* note 37, at 255-56.

parental decisions about *childrearing*, whether in the government's power to prevent parents from using neuroenhancement techniques on their children or in the parents' power to refuse neuroenhancement methods demanded by the government. Neuroscience enhancement will not pass in any direct biological way from one generation to the next, thus avoiding any issues of a biological "caste" system (what Mehlman referred to as a "genobility").⁵⁹

On the other hand, it seems likely that neuroscience enhancements will be more common and more powerful than genetic ones. The link between the present functioning of the brain and characteristics, primarily behaviors, that we will view as enhancements will be much more direct than links between genetic variations and behavior. And, to the extent neuroscience enhancement takes the form of healthy people using (legally or illegally) pharmaceuticals that were developed for, and are widely marketed to, sick or disabled people—such as possible memory-enhancing pills prescribed for dementia—controlling those technologies will prove very difficult. And, of course, neuroscience enhancements will, by definition, involve the brain, which, as the discussion above of neuroessentialism indicated, may in fact be of unique importance to our sense of our own personhood and of our species' humanity.

D. DIVERGENT ISSUES

Many issues of concern to ELSI do not seem likely to be significant questions for neuroethics. These include questions of identity, revealing the past, patents, and personal property. At the same time, many neuroethics issues, such as the neuroscientific basis (if any) for ethics, questions of competence, and the problems of mind reading, have little or no parallel in ELSI.

Genetics raises important questions of identity, not only through the forensic use of DNA to identify the source of human cells and tissues, from crime scenes, disasters, and elsewhere, but also, at least in some approaches, ethnic identity.⁶⁰ Also, human reproductive cloning attracts special

59. Cf. MEHLMAN, *supra* note 54, at 108-20.

60. See Henry T. Greely, *Genetic Genealogy: Genetics Meets the Marketplace*, in REVISITING RACE IN A GENOMIC AGE (Barbara Koenig & Sandra Lee eds., forthcoming 2006); Kimberly TallBear, *Native-American-DNA.com: In Search of Native American Race and Tribe*, in REVISITING RACE IN A GENOMIC AGE, *supra*.

interest among various forms of assisted reproduction only because of the genetic identity between the cloned baby and the DNA donor. Neuroscience seems to have nothing to add in those areas.

Genetics can also use DNA to reveal the past—the past of famous individuals, like Thomas Jefferson or Abraham Lincoln;⁶¹ the pasts (and futures) of many living people through paternity determinations; the pasts of ethnic groups;⁶² or the past of humanity as a whole.⁶³ Neuroscience can do none of that. At its most speculative, neuroscience might help clarify the history as perceived by living people by assessing the accuracy or authenticity of memories, but it is not clear that such a method is even conceivable.

Patents arising from genetic technologies, whether patents on genes, on living organisms, or on human biological materials, have been a major source of ethical, legal, and political debate.⁶⁴ It seems unlikely that anything similar to patents on the composition of matter that is a gene will come out of neuroscience.⁶⁵ Some neuroscientists may end up patenting the use of certain patterns of brain activity in screening or diagnosis, but those kinds of patents, although causing some concern, have been less controversial in genetics and are likely to have similar consequences in neuroscience.

The ownership of the actual physical “things” that make up genetic samples or other human biological materials has remained controversial and surprisingly unsettled. The *Moore* decision⁶⁶ is only law in California and a few states that have

61. See, e.g., David M. Abbey, *The Thomas Jefferson Paternity Case*, 397 NATURE 32 (1999); Eugene Foster et al., *Jefferson Fathered Slave's Last Child*, 396 NATURE 27 (1998); Eric S. Lander & Joseph J. Ellis, *Founding Father*, 396 NATURE 13 (1998); Victor A. McKusick, *Advisory Statement by the Panel on DNA Testing of Abraham Lincoln's Tissue*, 7 CADUCEUS 43 (1991).

62. The story of the Lemba, a southern African tribe that apparently has substantial Jewish ancestry, is one fascinating example. See Nicholas Wade, *DNA Backs a Tribe's Tradition of Early Descent from the Jews*, N.Y. TIMES, May 9, 1999, at A1.

63. See LUIGI LUCA CAVALLI-SFORZA & FRANCESCO CAVALLI-SFORZA, *THE GREAT HUMAN DIASPORAS: THE HISTORY OF DIVERSITY AND EVOLUTION* (Sarah Thorne trans., Addison-Wesley Publ'g Co. 1995) (1993).

64. For a good summary of the issues, see THE NUFFIELD COUNCIL ON BIOETHICS, *THE ETHICS OF PATENTING DNA: A DISCUSSION PAPER* (2002).

65. See Greely, *Prediction, Litigation, Privacy, and Property*, *supra* note 37, at 114.

66. *Moore v. Regents of the University of California*, 793 P.2d 479 (Cal.

expressly followed it, and even that decision can be read narrowly. Although there may still be tough questions of the relative rights of researchers and research subjects to ownership and control over “things” produced in research, neuroscience seems unlikely to raise issues of personal property. The relevant research materials in neurosciences will be information, produced by neuroimaging and other technologies, but will not often be physical pieces of brains (or cerebrospinal fluid).

Moving to neuroethics issues, research into the basis in the brain for human ethics has an equivalent, but not in ELSI. The overlapping fields of sociobiology, evolutionary psychology, and behavior biology look for, among other things, genetic or evolutionary explanations for human ethical judgments.⁶⁷ ELSI researchers have largely ignored these fields, probably because discoverable links between genetic variations and the broad and often amorphous behavioral characteristics that constitute human ethical and moral responses seem somewhere between distant and highly improbable.

Neuroscience is likely to play a substantial role in our understanding of, and assignment of, competence or, more broadly, free will. Although it seems unlikely that neuroscience will so completely overturn our views of human free will as to change the criminal justice system (and our ethics) fundamentally,⁶⁸ it may certainly provide a better understanding of what it means to be competent as well as what is useful evidence in specific cases. Although there have been some ill-fated efforts to use genetic defenses to criminal responsibility, the connection between inherited genes and current competence does not seem very useful. People with very strong genetic evidence of lack of competence—people with severe mental retardation from a genetic cause—will not need to add genetic evidence to their overpowering behavioral evidence. Weaker connections between genes and, for example,

1990), *cert. denied*, 499 U.S. 936 (1991).

67. See, e.g., EDWARD O. WILSON, *SOCIOBIOLOGY: THE NEW SYNTHESIS* (1975); *THE ADAPTED MIND: EVOLUTIONARY PSYCHOLOGY AND THE GENERATION OF CULTURE* (Jerome H. Barkow et al. eds., 1992); Owen D. Jones & Timothy S. Goldsmith, *Law and Behavioral Biology*, 105 COLUM. L. REV. 405 (2005). But see DAVID J. BULLER, *ADAPTING MINDS: EVOLUTIONARY PSYCHOLOGY AND THE PERSISTENT QUEST FOR HUMAN NATURE* (2005) (providing a detailed critique of Evolutionary Psychology).

68. See Stephen J. Morse, *New Neuroscience, Old Problems*, in *NEUROSCIENCE AND THE LAW*, *supra* note 28, at 157, 158-81.

violent behavior seem unlikely to be sufficiently strong as to be convincing. A nice example of the difference might be the difference between a genetic test showing that a particular person is predisposed to develop the disease and an MRI showing, in that person's brain, the accumulation of the amyloid plaques, tau tangles, and neuronal death that defines the disease.

Finally, some of the most far-reaching ethical, legal, and social implications of neuroscience arise from the possibility that it may help us "read minds." By neuroscientific determination of patterns of neuronal activity, we may be able to know, or at least make a powerful guess about, what a person is perceiving, what emotions that person is feeling, whether she is lying or telling the truth, or even what she is thinking. Genetics might, at most, be able to tell us whether a person has a predisposition to be happy or sad, or has strong or weak sensory organs, but it cannot say anything about an actual state of mind.

III. ELSI AND NEUROETHICS ALONG THE PATH AHEAD

ELSI is both a set of intellectual issues to be explored and a federally-financed program (or two) with substantial funding. Neuroethics is highly unlikely to be the subject of a similar program, but it will be—and already has been—a beneficiary of the ELSI programs. And nascent programs in "nanoethics" provide another useful comparison.

In the United States, the government-funded ELSI programs were the product of three factors: a major scientific initiative funded by federal agencies, the ready availability of money to spend on ethics, and a need for political cover on the issues involved.⁶⁹ The Human Genome Project was the "big science" project of its generation, an expensive, high profile, and long-term research enterprise. With funding projected at \$3 billion over fifteen years, the idea of spending a few percent on ethics was easy to swallow, particularly as budgets for the Project were generous throughout the late 1990s and technology lowered the costs of doing the research. And, as Cook-Deegan's history of the creation of the Project so clearly

69. I suspect the same factors were involved in ELSI programs set up by other countries, but I know too little about those programs, and the history of the Human Genome Project in those countries, to speak to them.

points out, public concern about genetics, reflected in Congress, made it crucial that the Project sponsors address, or appear to address, the ethical issues.⁷⁰

Neuroethics lacks all three factors. There is no Human Brain Project. The Decade of the Brain came and went without a correlative “big science” project, and it is difficult to see something like the Human Genome Project developing in neuroscience. Part of the appeal of the Human Genome Project was that it had concrete goals—first mapping, then sequencing the “entire” human genome.⁷¹ The National Human Genome Research Institute is able to argue to extend those goals to understanding the functions of that sequence. In theory, one might be able to propose mapping the connections and functions of all 100 billion neurons in the human brain, but both the science and the technology seem completely inadequate to address those goals, even leaving aside questions of whether such a map and such functions would be uniform across different people and their brains.

The National Human Genome Research Institute played the major funding and coordinating role in the Human Genome Project, although with substantial contributions (and a little competition) from the Department of Energy. Neuroscience, and hence neuroethics, has no one major funding agency behind it. The NIH provides a huge part of the funding for neuroscience, but at least three different institutes play major roles: the NINDS, the NIMH, and the National Institute on Aging (NIA). And each is roughly the same size; for fiscal year 2006, the President requested budgets for them of \$1.5 billion, \$1.4 billion, and \$1.1 billion respectively. The lack of a

70. See COOK-DEEGAN, *supra* note 9, at 248.

71. In spite of happy press releases, the Human Genome Project did not, and will not, exactly achieve those goals. First, it is hard to say what “the” Human Genome is. There are about 6.4 billion human beings alive today. Each one has two genomes, one inherited from each parent, plus millions of variations caused by mutations since conception in particular lineages of cells. Except for identical twins, each of those two genomes is unique (and the millions of variations caused by post-conception mutations exist even in identical twins). Even if one accepts a narrow definition of “the human genome” as a complete sequence of at least one copy of each of the twenty-four chromosomes (one through twenty-two plus the X and Y), the Human Genome Project still fell short. About twenty percent of the genome, a portion called the “heterochromatin,” is technically quite difficult to sequence and contains few, if any, genes. It is unclear when, if ever, these roughly 600 million base pairs will be sequenced. See Lincoln D. Stein, *Human Genome: End of the Beginning*, 431 NATURE 915 (2004).

dominant institutional sponsor is another drawback for neuroethics.

Even if some “big science” project were plausible, budgetary realities make it politically unlikely. The short period of federal budget surpluses in the late 1990s has disappeared. Although federal spending has increased substantially in the last five years, the increases have come largely in defense, national security, and entitlement programs, like Social Security and Medicare. “Demographic realities”—code for the aging of my baby boomer generation—mean that the entitlement programs will consume ever larger amounts of the federal budget. On any realistic assessment, unless politically unpopular tax increases are adopted, huge federal deficits stretch into the indefinite future. And, at a more specific level, after the unprecedented doubling of the NIH budget from 1998 to 2003, NIH appropriations are dropping in inflation-adjusted terms. Multi-billion dollar brain projects are not currently imaginable.

Finally, there just is not the level of public concern about the implications of neuroscience that drove the political demand for an ELSI program. That could change. The reasons for public interest and concern are substantial, but public knowledge about the advances of neuroscience is very limited. It is conceivable that early neuroethics work might lay a foundation for more public concern and hence could result in political pressure for some neuroethics funding. On the other hand, to the extent that neuroethics research comes directly from health-related research—unlike the Human Genome Project—any public concerns will be undercut by the huge public hope for treatments and cures.

Interestingly though, there may be another nascent federal bioethics program, in the ethical, legal, and social implications of nanotechnology, irresistibly named “nanoethics.” Nanotechnology does not have the kind of concrete big science project that ELSI had, but it has had substantial federal funding, amounting now to about \$1 billion each year. According to an October 2005 article in the *Chronicle of Higher Education*,⁷² the National Science Foundation (NSF) awarded twenty-one large grants between 2000 and 2005 to research

72. See Jeffrey Brainard, *National Science Foundation Promotes Research on Impact of Nanotechnology*, *CHRON. HIGHER EDUC.*, Oct. 21, 2005, at A27.

nanotechnology. Each of those grants was required to devote some attention to the social consequences of the technology, although those efforts were limited. Between 1997 and 2004, the NSF division of social and behavioral sciences also awarded grants directly for nanoethics, but they totaled about \$10 million. In October 2005, the NSF awarded four more nanoethics grants, the two largest of which involved \$6.2 million to Arizona State University and \$5 million to the University of California-Santa Barbara; in each case, the funds are allocated over five years, so the average annual spending for all four grants is probably around \$4 million.⁷³

Nanoethics is, if not big science, at least a well-funded and new scientific field. It also has some public and political pressure, based on concerns about environmental risks (the gray goo,⁷⁴ among others) and threats to privacy. It will be interesting to see how it develops.

Neuroethics cannot follow the funding path of ELSI, nor could it follow the path of nanoethics if that field succeeds in obtaining substantial federal funding. Where should the field look for funding for conferences, books, research, fellowships, salary support, and the other monetarily demanding aspects of modern research? (Salary support is particularly important to researchers with positions in medical schools, the homes of many bioethics centers, as their salaries are often contingent on grant support.)

Some federal support should be sought. Squeezing new funding from the NIH may be akin to squeezing blood from a turnip in its current budget situation, but the neuroscience funding institutes might be lobbied to set aside a small amount of their research funding for neuroethics. Even 0.1% across the three institutes would be about \$3 million each year, which could be allocated through a grant application process. The social and behavioral sciences division of NSF may be another useful, if small, source.

But neuroethics will have to look beyond the federal

73. *See id.* The estimate of annual spending is mine. A recent article on the Bioethics Blog states, based on a slide shown at a presentation, that the federal government is spending \$42.6 million per year on nanoethics, although it adds parenthetically that "I am now told that much of this is for 'education.'" McGee, *supra* note 12. That number seems implausibly high.

74. "Gray goo" is the term used to describe an apocalyptic scenario where uncontrollable and self-replicating nanomachines wipe out life on Earth. The term, and probably the concept, originated in ERIC DREXLER, *ENGINES OF CREATION* (1986).

government, probably to foundation support. Thus far, the Dana Foundation has been the major funding source for neuroethics research, as it has supported several major conferences or workshops along with several books and other publications. Broader financial support needs to be sought from foundations, including large foundations that are not focused on the brain. Foundation funding also has the advantage that it may be free of some explicit or implicit strings attached to federal funding.

Between federal funds, foundation funds, and researchers who are self-funded—whose research is inexpensive and whose salaries are covered by so-called “hard money”—neuroethics may be able to survive, and even thrive, financially, but it seems unlikely that funding will ever come close to the levels provided by ELSI.

Fortunately, it will not need to because of at least three ways in which neuroethics benefits from ELSI's legacy. First, ELSI has produced a cadre of legal, ethical, and social science researchers interested in and capable of doing research on the social implications of biological technologies. ELSI's money drew them into the general area and trained them as practitioners; neuroethics can live to a large extent off that inheritance. Second, ELSI has provided the financial support necessary for the increased size and numbers of bioethics centers. ELSI grants help pay the overhead and provide a critical mass of colleagues. Centers with grants under the Centers of Excellence in Ethics of Research program have the security of several years of reliable funding, not dependent on individual researchers' success in grant applications. And third, ELSI has expanded the market for bioethics. Journalists, government officials, and even the public have become accustomed to the word “bioethicist.” Books and articles by bioethicists and about bioethics are in greater demand. And universities, think tanks, and other possible employers value bioethics more highly because of ELSI. Neuroethics will surely benefit from all of these legacies of ELSI.

CONCLUSION

“It is always hard to predict things, especially the future.”⁷⁵

75. This line is usually attributed to the Danish physicist Nils Bohr, but

Neuroethics is a child, or at least a stepchild, of ELSI. As geneticists and neuroscientists—and all parents—know, children are both like and unlike their parents. I have tried to predict some of the ways in which neuroethics will develop, but I do so with sincere humility. I know I will be wrong in many of my predictions; I just don't know which ones. One prediction, though, I put forward with great confidence. Like ELSI before it, neuroethics will discuss fascinating and important issues . . . and those people fortunate enough to be involved in it should have a lot of fun.

tracking it down turns out to be quite difficult. In an earlier article, I wrote:

I had initially thought that this was a quotation from Lawrence Peter ("Yogi") Berra. On examining a book of his quotations, this appears to be, as he would put it, "one of those things I said that I never said." YOGI BERRA, *THE YOGI BOOK OR I REALLY DIDN'T SAY EVERYTHING I SAID* (1998). Data base search of news articles over the past 25 years reveals this quotation, or slightly variant forms of it, attributed most often to Berra, but also to Casey Stengel, Mark Twain, and even Confucius. It is most credibly attributed to the Danish physicist, Nils Bohr, in several news articles quoting other physicists. Erika Wayne, one of Stanford's excellent research librarians, did find the following version attributed to Bohr: "It is very difficult to make an accurate prediction, especially about the future." The quotation was used as one of several epigrams in GEORGE ANASTAPLO, *THE AMERICAN MORALITY: ON LAW, ETHICS, AND GOVERNMENT* viii (1992), but without any citation. A concerted search has been unable to find any good source for the quotation, in spite of all the resources of the Internet.

Henry T. Greely, *Trusted Systems and Medical Records: Lowering Expectations*, 52 *STANFORD L. REV.* 1585, 1591-92 n.9 (2000).