Microbiology 213 Social Issues in Biology- January 31, 2013
Please fill out the sign-up sheet and return it to me if you haven't yet.

What is Science: Evolution vs. Intelligent Design

The first session will consist of a viewing of the PBS Nova Film: "Judgment Day: Intelligent Design on Trial" and Discussion

This film is based on a 2004 court trial re: the teaching of evolutionary theory in the schools of Dover, Pennsylvania. The portion in which the trial itself is "filmed" uses actors to represent those participating in the trial. Actual films or videos of the trial were not available. (I have included a huge file of the actual Judge's decision. *If you have the time, take a look at it*).

In watching this film, please take notes if you can during the film and consider the questions below.

A contrarian view: read S. Fuller, Science's twin taboos. EMBO Reports 9:938-942 (2008). One of the people interviewed in the film is Steve Fuller whose article is one of the readings. Note what he says in the film and article. Do you understand what points he is trying to make or how that would change the nature of this discussion? How do you incorporate e.g. Newton's belief that his work illuminated God's work as an inspiration for doing science.

Primary Questions on the film:

Question 1: The film claims that "the nature of scientific inquiry is on trial." How so? What is science? How is it defined, particularly, in this film, e.g. by Kenneth Miller? Do you agree with his points, with regard to Evolutionary theory, or to science, in general? Is astrology a scientific theory? What distinguishes Evolutionary theory as science from Intelligent Design?

What follows are essentially different descriptions about science that have been used by various writers of the articles below in defense of evolutionary theory.

"a good theory is one that inspires new experiments and provides unexpected insight into familiar phenomena" (H.A. Orr)

"I would henceforth call [my] talk [not] why evolution is right [but] "Why evolution is probably right, and creationism is certainly wrong" (Steve Jones)

"Virtually all of science is an exercise in believing where we cannot prove." Philip Kitcher (a philosopher of science and strong defender of the theory of evolution)

"Even though our present evidence does not *prove* that evolutionary theory is true-….-evolutionary biologists will maintain that the present evidence is overwhelmingly in favor of theory and overwhelmingly against its supposed rivals." Philip Kitcher

Comment! Do you accept these statements or would you change them.

Question 2. Does it matter to society whether people accept evolutionary theory or not? Please think about this question and come prepared to offer reasons why you think the teaching of evolutionary theory or its acceptance by society is or isn't important for society. The population of the United States lags behind that of most other "Western" countries in its belief in

evolutionary theory? (e.g. Read the article given for this session.) What difference does it make? Do you see any way in which it is a problem for this country or not? What harmful consequences might there be?

J.D. Mills, E.C. Scott and S. Okamoto. **Public acceptance of evolution**. Science **313:**765-766 (2006).

Question 3. If "evolution does matter," should scientists be involved in finding ways to contribute to public understanding of the difference between evolutionary theory and other explanations of human origins?

J. Mervis. Tennessee House Bill opens Door to Challenges to Evolution, Climate Change. Science 332:295 (2011).

M.B. Berkman and E. Plutzer. Defeating creationism in the courtroom but not in the classroom. Science 331:404-405 (2011).

These articles indicate the many successes in various states of those raising criticisms of the teaching of evolution

H. A. Orr says: "Clearly a policy of limited scientific engagement has failed." Is there a "social responsibility" of scientists to participate. How?

Question 4. If scientists are involved what are the strategies for engaging in this public issue?

EurekAlert. Engaging prior learning on creationism and evolution may benefit college biology students. EurekAlert, AAAS (Publisher of Science Magazine) Nov. 2005.
Whether the study on which this news article is based seems solid or not, the idea of comparing e.g. evolution with intelligent design in the classroom is interesting. What do you think of this approach? If you think it sounds reasonable, why might it work?
(The following is not included in the readings for this session and is <u>not required reading</u>. It is the original study on which the news article is based. S. Verhey. BioScience **55:**996-1003 (2005).)

Other questions:

1. Notice who the funders for this film are. Any comments?
2. Do you think that the arguments made by scientists against specific criticisms made by Intelligent Design advocates are airtight: for example on the issues of the flagella or the immune system?
3. Are the makers of the show objective?
4. What is meant by the word <u>paradigm</u> in this context? What is your understanding of the word?

FYI: the book by P. Kitcher. "Evolution, Design and Faith" Oxford University Press (2007) presents both a discussion of the nature of science re: these debates and the implications or lack thereof of evolutionary theory for believers in religion. (This is not required reading.)

EMBO reports

viewpoint

Science's twin taboos

Is it premature to declare that the debates about the role of religion and race in science are closed?

Steve Fuller

In October 2007, the Nobel laureate and co-discoverer of DNA, James D. Watson, was hounded out of the UK during a book tour for comments he made to the effect that Western development aid to Africa was wasted because of the relatively low intelligence of its recipients (Milmo, 2007). He was subsequently forced to resign from one of the leading US biomedical research facilities, Cold Spring Harbor Laboratory in New York, which he had directed for 35 years of its most notable growth.

Almost exactly two years earlier, Michael Behe, a tenured Professor of Biochemistry at Lehigh University (Bethlehem, PA, USA), had testified under oath in the Third US Circuit Court that the scientifically credentialled form of creationism known as 'intelligent design' deserved a place in the public high-school science curriculum alongside neo-Darwinian evolution as an explanation for the origin of life. Not only did his side lose the case, but Behe himself has been subsequently subjected to personal vilification, abetted by the official—and continuing—dissociation of his department from his views (Lehigh University Department of Biological Sciences, 2007).

The rhetorical genius of Darwin lay in his refusing to take a clear stand on the matters that divided the creationists and racists of his day…

These two cases touch on the twin taboos of science: race and religion. It seems that science, especially biological science, cannot live with—or without—them. Together they define the limits of respectable public scientific discourse. To be sure, race and religion breach scientific respectability from opposite directions: racism makes a fetish out of the persistent diversity of the human population, whereas creationism overplays the importance of our common descent from a deity in whose 'image and likeness' we are supposedly created. Hence, racists and creationists propose alternative utopian visions for humanity: the former project an ideal world of well-bounded limited populations in ecological equilibrium, whereas the latter envisage that our ever-expanding numbers and greater mobility will permanently transform the planet for our collective benefit (Weikart, 2005; Noble, 1997). Their respective visions of history can be captured in a single phrase: evolution versus progress.

There used to be an entire science dedicated to debating creationism and racism on empirical grounds. It was called 'anthropology', named after the title of a 1798 work by the German philosopher Immanuel Kant (1724–1804), which was dedicated to how—and whether—the different races might embody the same Enlightenment ideal of a *Weltbürger* or 'world-citizen' (Kant, 1798). For much of the eighteenth and nineteenth centuries, the two positions travelled under the epistemologically sanitized labels of 'monogenesis' and 'polygenesis', respectively (Harris, 1968). Yet their proponents did not quite match up to the creationists and racists of today: there were religious and secular thinkers on both sides of the divide. On the one hand, the party of monogenesis was composed of New Testament promoters of the 'universal brotherhood of man' and Enlightenment optimists, such as the French philosopher Nicolas de Caritat, Marquis de Condorcet (1743–1794), pursuing human perfectibility. On the other hand, the party of polygenesis consisted of literal adherents to the multiple dispersals of human life postulated in the Old Testament as well as Enlightenment sceptics including the Scottish philosopher David Hume (1711–1776), who regarded 'humanity' as the brand name for a range of upright apes.

…discrimination on the basis of race has been overcome, whereas discrimination on the basis of religion has been intensified

The difference between monogenesis and polygenesis is epitomized in a question: are the diverse beings that pass for humans the result of one or multiple origins? I say 'pass' because, at the time, few denied for example the *prima facie* grounds for moral concern about the hereditary enslavement of Africans in Europe and the Americas. However, that shared concern did not necessarily translate into a belief that Africans and Europeans shared a common ancestry or at least an ancestry that was sufficiently strong to overcome their differences in appearance and mode of being.

The mindset of contemporary animal rights' activists provides a point of reference for these debates about slavery. Although the activists strongly object to the suffering endured by caged laboratory animals, most would stop short of according them civil rights because they doubt the animals' competence to take full responsibility for their actions. Similarly, it is one thing to justify the emancipation of slaves in terms of upholding universal human rights *à la* monogenesis, and quite another to justify it in terms of supporting the cultivation of life

under conditions where it is likely to flourish *à la* polygenesis. Do slaves suffer and revolt out of their God-given sense of natural liberty, which is shared by all humans, or out of their instinctive rejection of unnatural living conditions, which varies across animals?

The dispute between monogenesis and polygenesis gradually subsided as people eventually accepted the plausibility of a negotiated settlement, which was brought into effect by Charles Darwin (1809–1882) with the publication of *On the Origin of Species* (1859). Human races are environmentally reinforced genetic subdivisions or 'subspecies', descended from a common hominid ancestor, which itself descended from ancestors common to other species, ultimately going back to a primordial soup out of which life on Earth came into existence.

Darwin did not explicitly associate the emergence of life from the primordial soup with the creative efforts of God: the process could have been the result of a divine spark or, equally, of an entirely self-organizing process. Conversely, he not only refused to rank human races, but also stopped short of admitting that humans were the noblest species. Indeed, *The Descent of Man* famously ends with his declaration that he is happier knowing that he descended from baboons—not Caucasoids—rather than the fierce inhabitants of Tierra del Fuego whom he encountered on the *Beagle* (Darwin, 1871). If anything, the studied anti-racism of Darwin looks like the sort of 'species egalitarianism' that is nowadays associated with the animal liberation proponent Peter Singer (1999).

The rhetorical genius of Darwin lay in his refusing to take a clear stand on the matters that divided the creationists and racists of his day, and hence leaving the nature of humanity profoundly ambiguous. However, 150 years after the publication of *On the Origin of Species*, Darwinian diplomacy seems to be unravelling with the resurgence of both racism and creationism as potentially scientific propositions.

Anyone familiar with American legal history will be struck by the similarity between the rhetoric now used to 'separate' religion from science and that introduced a century ago to 'segregate' Blacks from Whites. In the case of race, the precedent was set after the abolition of slavery by the US Supreme Court in *Plessy v. Ferguson* (1896); a decision that was eventually overturned with *Brown v. Board of Education* (1954). In *Plessy*, the justices ruled that formal recognition of racial equality did not require that the races be given access to common facilities. The justices appeared to believe that racial equality was compatible with a caste system that restricts the mutual access of Blacks and Whites. At the same time, they also stressed that the provision of separate schools, wash rooms or rail coaches for Blacks and Whites did not *ipso facto* imply that Blacks would receive inferior facilities. This even led some Whites to complain that *Plessy* compelled the construction of facilities for Blacks that might be underutilized.

A similar segregationism with regard to religion was explicitly made in the Pennsylvania case mentioned earlier in this article:

Kitzmiller v. Dover Area School District (2005). Here, circuit court judge John E. Jones III expressly refused to pass judgement on the truth of intelligent design, ruling only on its status as science. Indeed, he suggested that intelligent design might be true in some other sense that might be taught outside the science class. Ironically, this line of argument—which is sometimes called the 'double truth' doctrine after the medieval scholastics—was the one used by the Roman Catholic Church against Galileo Galilei (1564–1642) to limit the reach of his scientific claims against theological interpretations of the Bible. After all, Catholic missionaries in China were promoting science as one of the fruits of their religion, while refusing to have it impinge on religion at home. Now, with *Kitzmiller*, the tables seem to have been turned. Just as the Church was happy to let Galileo conduct his research if he stopped promoting it as superior to Catholic doctrine, intelligent design can be taught as one wishes but not as science (Fuller, 2008).

…the separation of state and church has been pursued in the USA with a bloody-mindedness that now overlooks the distinctly positive impact of religion on the development of science

Despite the similarities, there is an obvious difference between the legal fates of racial and religious segregation in the USA: discrimination on the basis of race has been overcome, whereas discrimination on the basis of religion has been intensified. Yet in both cases, the consequences have been perverse for science, and have resulted in the coining of mildly euphemistic expressions such as 'genetic diversity' and 'intelligent design' to keep the issues represented by race and religion in the scientific debate. Interestingly, both strategies are compelled by virtue of traumatic historical events that have inhibited any role that race or religion might ever again play in science. I illustrate the point initially with race, followed by religion.

During their lifetimes and until the end of the Second World War, Darwin and Herbert Spencer (1820–1903) were regarded as the main promoters of the theory of evolution by natural selection, as popularized in the expression used by Spencer, "survival of the fittest". Both were, broadly speaking, *laissez faire* liberals, sceptical of the role that states might have in reversing natural dynamics. Confessing ignorance of the mechanisms of heredity and inclined to believe that natural selection would always ultimately trump artificial selection, both refrained from endorsing the original version of eugenics touted by the cousin of Darwin, Francis Galton (1822–1911).

Of course, this did not stop twentieth century developments in genetics, including their eugenicist applications, from being treated as extensions of the work of Darwin and Spencer. Back then, the difference between the two was seen to lie more in emphasis than in substance: Spencer focused on the implications of evolution for contemporary human concerns, whereas Darwin generally avoided any such talk. This made Spencer the most influential spokesperson for evolution in the final quarter of the nineteenth century, even including the public defender of Darwin, Thomas Henry Huxley (1825–1895).

However, all of that changed with the rise and fall of the Nazis, and the unspeakable atrocities they carried out in the name of eugenics, which led to the subsequent stigmatization of the "survival of the fittest" policies. The post-war political climate was such that evolutionary theory was potentially held liable for the carnage caused by Hitler. The diplomatic solution, again to the advantage of Darwin, was to jettison Spencer as a "social Darwinist" (Hofstadter, 1944). The phrase had neutrally referred to the extension of the ideas of Darwin to human affairs, typically on the basis of what he himself had provided in *The Descent of Man*. Yet thereafter, 'social Darwinist' referred specifically to the overextension, and hence misuse, of those ideas. Spencer was the obvious target of this semantic shift, as he had been the most visible promoter of Darwin in the social sciences and politics, not least in Germany. The studied silence of Darwin on public policy left him as the only 'politically correct' nineteenth century ancestor to the post-war synthesis forged between natural history and Mendelian genetics. However, the conceptual cost of overcoming racism in this fashion was excluding by default any deep studies on *Homo sapiens* from modern evolutionary theory.

This point is epitomized in the influential 1950 United Nations Educational, Scientific and Cultural Organization (UNESCO) statement on "the race question" (Brattain, 2007). Asserting the biological unity of humanity, it portrayed claims to racial difference as little more than socially based 'ethnic' stereotypes ultimately grounded in unscientific prejudices. The coalition of distinguished social and natural scientists, who were involved in finalizing the statement, ensured its legitimacy. Nevertheless, it appeared shortly before DNA-driven breakthroughs in molecular biology revolutionized our understanding of genetics by providing a more fine-grained sense of both what unifies and what differentiates humanity. Two large-scale projects from the past 25 years, one devoted to sequencing the common human genome and the other to charting the course of human genetic diversity, represent the fruits of that revolutionary endeavour. It is the latter that concerns us here.

Even those scientists who continued to believe in God tended to conceive of the deity in more remote, sometimes irrational, terms…

The Human Genetic Diversity Project draws on an eclectic mix of genetics, archaeology and linguistics to follow the migration patterns of the peoples of the Earth (Cavalli-Sforza, 2000). Courtesy of IBM (Armonk, NY, USA) and *National Geographic* magazine (Washington, DC, USA), the project acquired a populist dimension in 2005, when it invited people who are interested in tracing their family histories to contribute personal information online in exchange for access to the collective knowledge base of the project. So far, more than 250,000 people worldwide have complied. However, the United Nations Permanent Forum on Indigenous Issues has recommended suspending the project because its results might be used opportunistically either to undermine affirmative action policies—if the disadvantaged indigenes turn out to be genetically similar to the dominant foreigners—or, in keeping with earlier racist policies, to 'repatriate' those who happen to have a large number of medically relevant alleles belonging to peoples normally resident elsewhere (Harmon, 2006).

No doubt the idea of genetic diversity taps into the heritage of *Rassenwissenschaft* ('race science') and *Rassenhygiene* ('racial hygiene'), an original stronghold of Darwinism and

perhaps the most exciting field of German biomedical science before the ascendancy of Hitler (Proctor, 1988). Its intellectual leader, Alfred Ploetz (1860–1940), promised no less than perpetual peace if the peoples of the Earth confined themselves to lands suitable to their respective genetic make-ups. For this he was nominated for a Nobel Prize—albeit in 1936, late in life and after the Nazis had come to power. A staunch anti-imperialist, Ploetz had called for a massive resettlement policy of the multiple ethnic groups of the newly amalgamated Second Reich as early as 1895, with each 'homeland' urged to design its own indigenous social security system, customized to the specific health needs of its people (Fuller, 2006).

The track record of atheism is limited to dispelling superstition and challenging dogmatism—it does not extend to promoting science

Originally, this proposal was made in the spirit of social democracy, even socialism, which by the 1930s had turned the Nordic countries into welfare states (Broberg & Roll-Hansen, 1997). However, it took a sinister turn in the wake of the defeat of Germany in the First World War in 1918, when it became incorporated into the campaign platform of the newly formed National Socialist Part. By contrast, the Human Genetic Diversity Project is operating in a political climate less prone to totalitarian abuse. An interesting witness here is the German born and trained Harvard evolutionist, Ernst Mayr (1904–2005), who remained active until his death. Without ever endorsing Nazism, he never failed to assert the relevance of biologically grounded racial differences for medical and perhaps even legal purposes (Mayr, 2002). Indeed, biomedical research provides growing evidence that race can be used by physicians as a marker to influence diagnostics and recommended treatments, and for preventive measures (Weigmann, 2006; Kahn, 2004). Yet, as long as 'politically correct' intuitions remain firmly anchored in the sentiments expressed in the original UNESCO document, there will be formidable barriers to allowing genetic diversity to explicitly inform policy-making.

A US-style exclusion of religion from science is inscribed in the constitutions of many modern states. Usually the difference between religion and science is reduced to the distinction between private and public knowledge. Moreover, in the USA and elsewhere, the legal separation of church and state has evolved from preventing a specific church dominating civil society to preventing the influence of religion altogether. The anchoring trauma here is the social discrimination originally suffered by wealthy, well-educated Christians in seventeenth century England who happened not to be members of the established church. They were compelled to start their own society, which over the next 150 years became the USA. The founders of this new nation resolved that never again would the same mistake be made: since 1791, the separation of state and church is derived from the first amendment to the US constitution, which states that "Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof…"

Indeed, the separation of state and church has been pursued in the USA with a bloody-mindedness that now overlooks the distinctly positive impact of religion on the development of science. This is a point that the original American settlers, as Puritan promoters of the Scientific Revolution, would have been the first to admit (Merton, 1970). The expression 'intelligent design' taps into that founding sentiment by recalling the strong analogy that the seventeenth century scientific revolutionaries, most notably Isaac Newton (1643–1727), drew between the machine-making capacities of humans and the creative agency of God. In effect, to see life as the product of intelligent design is to conceive of biology as divine technology. This eventually led the US founding fathers to conceptualize the 'mechanism of government' as literally a second creation (Cohen, 1995).

Certainly, intelligent design always had a heretical cast. It implied that the power of God exceeds human power only by degree and not by kind. Instead of upright apes, we are demigods. This explains the initial plausibility of what is now an ordinary feature of modern scientific reasoning—namely, model-building. After all, it is one thing to design a machine that works on its own terms, but quite another to think that the machine captures properties of the natural world to such an extent that it might be used as a basis for prediction and control. The scientific method honours that distinction as the difference between 'reliability' and 'validity' in laboratory experiments and computer simulations. Therefore, Behe (1996) might be wrong in claiming that the cell is "irreducibly complex" in the same sense as a mouse trap, all of the parts of which must be in place to work. But, to think that a cell might work like a mouse trap is very much in the spirit of the mechanistic worldview that launched modern science (Fuller, 2007).

…in the light of the ongoing success of both the Human Genome Project and the Human Genetic Diversity Project, we might need to revisit eugenics with a more positive frame of mind towards social experimentation

More generally, intelligent design theory taps into the vast majority of science that has been done under the assumption that nature is a unified, rational whole; and humans have been specially created to understand, manage and possibly improve it, if not to bring it to outright completion. The philosophical term of art for this quality of nature is 'intelligibility' (Dear, 2006). The assumption of intelligibility is shared not only by so-called young-Earth creationists, who claim on biblical grounds that the planet is only 6,000 years old, but also by physicists who continue to search for a grand unifying theory and biologists who seek a progressive direction to evolution. Darwin stands out in the history of biological science from his great predecessors—Carl Linnaeus (1707–1778), Georges Cuvier (1769–1832) and Jean-Baptiste Lamarck (1744–1829)—as well as his great successors—Gregor Mendel (1822–1884), Sewall Wright (1889–1988), Ronald Fisher (1890–1962) and Theodosius Dobzhansky (1900–1975)—in his failure to find his faith in God bolstered by his research, although his many decades of intellectual labour were originally motivated by a search for intelligent design in nature.

Given the recent strong public expression of atheism (Dawkins, 2006), the following question looms large: can the degree of human cognitive privilege implied in the idea of intelligent design be denied without undercutting the basis for the most inspiring theoretical projects in

science? Atheists, of course, say yes. However, in the *Critique of Pure Reason*, the cornerstone of modern Western philosophy, Kant answered with a resounding no, quickly adding that just because we need to postulate the existence of God to justify the pursuit of science, it does not follow that God actually exists (Kant, 1781). Kant had in mind Newton, whose exemplariness lay not only in the detail in which he worked out material motion in the known cosmos, but also in developing an artificial language—physics—that could lay reasonable claim to represent the divine standpoint, shorn of the partial subjectivity of his creatures.

However, Newton took a beating with the early twentieth century revolutions in relativity and quantum mechanics, which empirically undermined some of his fundamental conceptual assumptions. These developments, combined with the perverse uses to which the physical sciences were put in the two world wars, shook the faith of many in the intelligibility of nature. Even those scientists who continued to believe in God tended to conceive of the deity in more remote, sometimes irrational, terms than Newton or Kant would have deemed appropriate.

Yet atheism would hardly do as well as a background belief for science. The track record of atheism is limited to dispelling superstition and challenging dogmatism—it does not extend to promoting science. Consider Hume, the most intellectually substantial and attractive figure reasonably counted as an atheist—as opposed to simply a heretic or deist. His famed scepticism cut against not only theologians, who saw the design of nature as evidence for the existence of God, but also scientists, who followed Newton in thinking that they were on the verge of fathoming the inner workings of nature (Schliesser, 2008). The counsel of Hume was ultimately a therapeutic one, later echoed by that other icon of Anglophone analytical philosophy, Ludwig Wittgenstein (1889–1951), advising that we should lower our epistemic expectations and let go of the idea that some overall mastery of nature is to be had by either philosophical or scientific means.

Although such advice might put worried minds at ease, it does not explain the success of those who failed to heed it. After all, notwithstanding the post-war taboo on race, the revolution in molecular biology managed to bring genetics to the brink of bioengineering by the 1960s (Morange, 1998). Moreover, in the light of the ongoing success of both the Human Genome Project and the Human Genetic Diversity Project, we might need to revisit eugenics with a more positive frame of mind towards social experimentation. In the end, the question that continues to dog us is who exactly are 'we', the subject of this grand narrative that would unify our racial and religious differences. Once we get some agreement on that issue, race and religion will cease to be taboo subjects.

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doi:10.1038/embor.2008.175

Published online 19 September 2008

SCIENCE COMMUNICATION

Public Acceptance of Evolution

The acceptance of evolution is lower in the United States than in Japan or Europe, largely because of widespread fundamentalism and the politicization of science in the United States.

Jon D. Miller,[1]* Eugenie C. Scott,[2] Shinji Okamoto[3]

The concept of the evolution of humans from earlier forms of life is unacceptable to biblical literalists and causes concern even among some holders of less conservative religious views. Catholics and mainstream Protestants generally accept variations of a theological view known as theistic evolution, which views evolution as the means by which God brought about humans, as well as other organisms. Evolution is nonetheless problematic to some of these nonliteralist Christians, because it implies a more distant or less personal God (*1*–*3*). Efforts to insert "intelligent design" into school science curricula seek to retain the divine design of humans while remaining agnostic on earlier creationist beliefs in a young Earth and the coexistence of humans and dinosaurs (*2*, *4*).

Beginning in 1985, national samples of U.S. adults have been asked whether the statement, "Human beings, as we know them, developed from earlier species of animals," is true or false, or whether the respondent is not sure or does not know. We compared the results of these surveys with survey data from nine European countries in 2002, surveys in 32 European countries in 2005, and a national survey in Japan in 2001 (*5*). Over the past 20 years, the percentage of U.S. adults accepting the idea of evolution has declined from 45% to 40% and the percentage of adults overtly rejecting evolution declined from 48% to 39%. The percentage of adults who were not sure about evolution increased from 7% in 1985 to 21% in 2005. After 20 years of public debate, the public appears to be divided evenly in terms of accepting or rejecting evolution, with about one in five adults still undecided or unaware of the issue. This pattern is consistent with a number of sporadic national newspaper surveys reported in recent years (*6*–*10*).

A dichotomous true-false question format tends to exaggerate the strength of both positions. In 1993 and 2003, national samples of American adults were asked about the same statement but were offered the choice of saying that the statement was "definitely true, probably true, probably false, definitely false," or that they did not know or were uncertain. About a third of American adults firmly rejected evolution, and only 14% of adults thought that evolution is "definitely true." Treating the "probably" and "not sure" categories as varying degrees of uncertainty, ~55% of American adults have held a tentative view about evolution for the last decade.

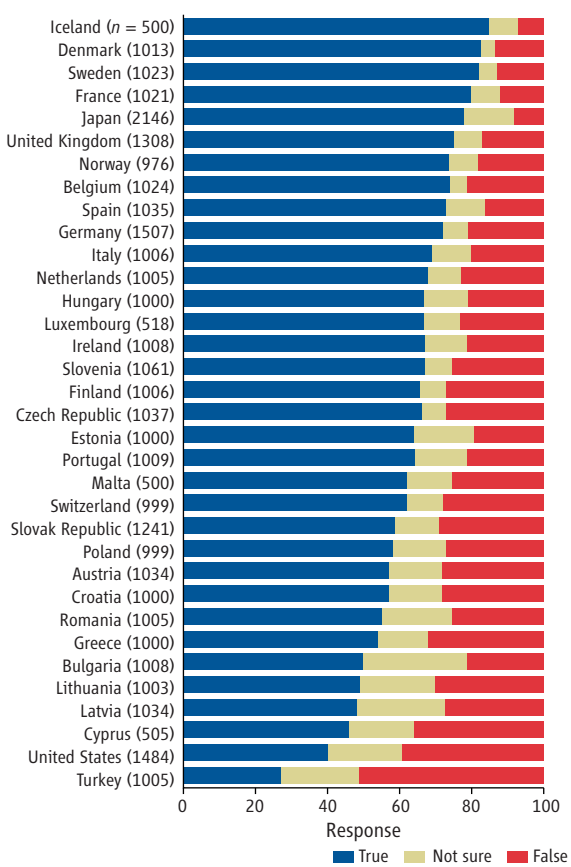
This pattern is different from that seen in Europe and Japan. Looking first at the simpler true-false question, our analysis found that significantly (at the 0.01 to 0.05 level by difference of proportions) (*11*) more adults in Japan and 32 European countries accepted the concept of evolution than did American adults (see figure, right). Only Turkish adults were less likely to accept the concept of evolution than American adults. In Iceland, Denmark, Sweden, and France, 80% or more of adults accepted the concept of evolution, as did 78% of Japanese adults.

A cross-national study of the United States and nine European nations in 2002–2003 used the expanded version of the question. The results confirm that a significantly lower proportion of American adults believe that evolution is absolutely true than adults in nine European countries [see fig. S1 in the Supporting Online Material (SOM)]. A third of American adults indicated that evolution is "absolutely false"; the proportion of European adults who thought that evolution was absolutely false ranged from 7% in Denmark, France, and Great Britain to 15% in the Netherlands.

Regardless of the form of the question, one in three American adults firmly rejects the concept of evolution, a significantly higher proportion than found in any western European country. How can we account for this pattern of American reservations about the concept of evolution in the context of broad acceptance in Europe and Japan?

First, the structure and beliefs of American fundamentalism historically differ from those of mainstream Protestantism in both the United States and Europe. The biblical literalist focus of fundamentalism in the United States sees Genesis as a true and accurate account of the creation of human life that supersedes any scientific finding or interpretation. In contrast, mainstream Protestant faiths in Europe (and their U.S. counterparts) have viewed Genesis as metaphorical and—like the Catholic Church—have not seen a major contradiction between their faith and the work of Darwin and other scientists.

To test this hypothesis empirically, a two-group structural equation model (SEM) (*12*, *13*) was constructed using data from the United States and nine European countries (see statistical analyses in SOM). The SEM allows an examination of the relation between several variables simultaneously on one or more outcome variables. In this model, 10 independent variables—age, gender, education, genetic literacy, religious belief, attitude toward life, attitude toward science and tech-



Public acceptance of evolution in 34 countries, 2005.

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nology (S&T), belief in S&T, reservations about S&T, and political ideology—were used to predict attitude toward evolution. The total effect of fundamentalist religious beliefs on attitude toward evolution (using a standardized metric) was nearly twice as much in the United States as in the nine European countries (path coefficients of –0.42 and –0.24, respectively), which indicates that individuals who hold a strong belief in a personal God and who pray frequently were significantly less likely to view evolution as probably or definitely true than adults with less conservative religious views.

Second, the evolution issue has been politicized and incorporated into the current partisan division in the United States in a manner never seen in Europe or Japan. In the second half of the 20th century, the conservative wing of the Republican Party has adopted creationism as a part of a platform designed to consolidate their support in southern and Midwestern states—the "red" states. In the 1990s, the state Republican platforms in seven states included explicit demands for the teaching of "creation science" (*1*). There is no major political party in Europe or Japan that uses opposition to evolution as a part of its political platform.

The same SEM model discussed above offers empirical support for this conclusion. In the United States, the abortion issue has been politicized and has become a key wedge issue that differentiates conservatives and liberals. In the SEM, individuals who held strong pro-life beliefs were significantly more likely to reject evolution than individuals with pro-choice views. The total effect of pro-life attitudes on the acceptance of evolution was much greater in the United States than in the nine European countries (–0.31 and –0.09, respectively) [see Statistical Analyses section of Supporting Online Material].

The same model also documents the linkage of religious conservative beliefs and a conservative partisan view in the United States. The path coefficient for the relation between fundamentalist religious views and self-identification as a conservative was 0.26 in the United States and 0.17 in the nine European countries. The path coefficient between pro-life views and self-identification as a conservative was 0.20 in the United States and 0.06 in the nine European countries. Because the two-group SEM computes path coefficients on a common metric, these results are directly comparable and the impact of fundamentalist religious beliefs and pro-life attitudes may be seen as additive (*12*, *13*).

Third, genetic literacy has a moderate positive relationship to the acceptance of evolution in both the United States and the nine European countries. This result indicates that those adults who have acquired some understanding of modern genetics are more likely to hold positive attitudes toward evolution. The total effect of genetic literacy on the acceptance of evolution was similar in the United States and the nine European countries.

Although the mean score on the Index of Genetic Literacy was slightly higher in the United States than the nine European countries combined, results from another 2005 U.S. study show that substantial numbers of American adults are confused about some of the core ideas related to 20th- and 21st-century biology. When presented with a description of natural selection that omits the word evolution, 78% of adults agreed to a description of the evolution of plants and animals (see table S2 in SOM). But, 62% of adults in the same study believed that God created humans as whole persons without any evolutionary development.

It appears that many of these adults have adopted a human exceptionalism perspective. Elements of this perspective can be seen in the way that many adults try to integrate modern genetics into their understanding of life. For example, only a third of American adults agree that more than half of human genes are identical to those of mice and only 38% of adults recognize that humans have more than half of their genes in common with chimpanzees. In other studies (*1*, *14*, *15*), fewer than half of American adults can provide a minimal definition of DNA. Thus, it is not surprising that nearly half of the respondents in 2005 were not sure about the proportion of human genes that overlap with mice or chimpanzees.

These results should be troubling for science educators at all levels. Basic concepts of evolution should be taught in middle school, high school, and college life sciences courses and the growing number of adults who are uncertain about these ideas suggests that current science instruction is not effective. Because of the rapidly emerging nature of biomedical science, most adults will find it necessary to learn about these new concepts through informal learning opportunities (*15*–*17*). The level of adult awareness of genetic concepts (a median score of 4 on a 0-to-10 scale) suggests that many adults are not well informed about these matters. The results of the SEM indicate that genetic literacy is one important component that predicts adult acceptance of evolution.

The politicization of science in the name of religion and political partisanship is not new to the United States, but transformation of traditional geographically and economically based political parties into religiously oriented ideological coalitions marks the beginning of a new era for science policy. The broad public acceptance of the benefits of science and technology in the second half of the 20th century allowed science to develop a nonpartisan identification that largely protected it from overt partisanship. That era appears to have closed.

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Supporting Online Material

www.sciencemag.org/cgi/content/full/313/5788/765/DC1

10.1126/science.1126746

Political warfare. Tennessee legislator Bill Dunn's bill labeling the teaching of evolution and climate change as "controversial" subjects mirrors efforts in seven U.S. states this year.

CREDIT: COURTESY OF THE OFFICE OF REPRESENTATIVE BILL DUNN

EVOLUTION IN THE SCHOOLS

Tennessee House Bill Opens Door to Challenges to Evolution, Climate Change

U.S. science educators are wringing their hands over what they characterize as a significant legislative victory for those who oppose the teaching of evolution.

Last week, the Tennessee House of Representatives overwhelmingly approved an innocuous-sounding measure allowing science teachers in the state to help their students "develop critical thinking skills." The legislation, which specifically mentions the teaching of "biological evolution, the chemical origins of life, global warming, and human cloning," is expected to become law next month after the state Senate embraces an identical version and the governor signs it.

Scientists say HB 368, and the corresponding Senate bill, SB 893, would actually have the opposite effect on critical thinking by introducing nonscientific beliefs into science classes and by undermining the principles of scientific inquiry. "These bills misdescribe evolution as scientifically controversial," say prominent Tennessee scientists, including medicine Nobelist Stanley Cohen of Vanderbilt University in Nashville, in a letter sent to legislators before last week's 70–23 vote. They write that teachers who are encouraged "to emphasize what are misdescribed as the scientific weaknesses of evolution … are likely to include scientifically unwarranted criticisms."

The bill's sponsor, Republican Bill Dunn of Knoxville, says scientists are deliberately distorting the intent of the legislation. He acknowledges that it is derived from a model bill crafted by the Discovery Institute, an organization based in Seattle, Washington, that questions evolution and promotes intelligent design. But Dunn says the bill would merely allow teachers to offer students "objective, scientific facts" during classroom discussions without fear of being "bullied" into silence by the scientific mainstream.

Dunn, a veteran legislator who this year helped the state's new governor push through various education reforms, including changes to teacher tenure laws, says most critics haven't bothered to read the bill. In particular, Dunn says, opponents have misinterpreted language about controversial teaching methods as an attack on evolutionary theory. "If you dare even question or call something controversial," Dunn says, "there seems to be this Pavlovian response. Only, instead of drooling at the mouth, they foam at the mouth." The "mean-spirited" criticism of his bill, he adds, has convinced him that "scientists are just as prejudiced and subjective as the average person walking down the street."

Online
sciencemag.org
Q&A with the bill's sponsor.

Scientists' fears that the bill would allow the teaching of creationism are unfounded, according to Dunn, who points to a clause that declares the legislation "shall not be construed to promote any religious doctrine." But Barbara Forrest, a philosophy professor at Southeastern Louisiana University in Hammond, who closely tracks the debate over teaching evolution, believes those words mean exactly the opposite. "The religious disclaimer is in every one of these bills," she says. "It's a dead giveaway that it IS a creationist bill. If it were truly only about teaching science controversies, they wouldn't need a disclaimer."

Tennessee isn't the only state in which so-called academic freedom statutes have been introduced in recent years (*Science*, 9 May 2008, p. 731). This year's tally alone is nine in seven states, according to the National Center for Science Education, an Oakland, California, group that tracks the debate. Although most died in committee, two bills—in Florida and Texas—are still pending. In 2008, Louisiana adopted a measure that allows science teachers to use supplemental material in exploring "the strengths and weaknesses" of evolutionary theory and other topics (*Science*, 23 January 2009, p. 451). Dunn says he asked Louisiana school officials this spring how many "problems" they have had since the bill was enacted and that their answer was "zero." Forrest says a bill will be introduced next week to repeal the measure.

Bart Gordon, the former chair of the science committee in the U.S. House of Representatives who represented a central Tennessee district for 26 years before retiring in January, agrees with Forrest that the bill is part of a disturbing trend among elected officials at the state and national levels. "It's an unfortunate statement of the times in Tennessee," says Gordon, who was a vocal advocate for better science education during his tenure in Congress. "Why don't people think that climate change is real? You asked me last year why I decided to retire. Well … ."

Dunn says he believes the bill, which he admits he did not write himself and introduced as a favor to a former colleague, will improve science education by stimulating classroom discussion. "You gather a whole bunch of facts and figure out what is happening—that's what science is," he explained during last week's floor debate. But his staunch advocacy of the measure—veteran Tennessee politics reporter Ed Cromer describes Dunn as "a person of faith who's very sincere and passionate about his beliefs"—has also come at a price.

"As I told a friend the other day," Dunn says, 'If I ever introduce another bill with the word 'evolution' in it, please shoot me.' I never expected things to get this nasty."

–JEFFREY MERVIS

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SCIENCE EDUCATION

Defeating Creationism in the Courtroom, But Not in the Classroom

Sixty percent of U.S. high school biology teachers are not advocates for either evolutionary biology or nonscientific alternatives.

Michael B. Berkman and Eric Plutzer*

Just over 5 years ago, the scientific community turned its attention to a courtroom in Harrisburg, Pennsylvania. Eleven parents sued their Dover, Pennsylvania, school board to overturn a policy explicitly legitimizing intelligent design creationism. The case, *Kitzmiller* v. *Dover*, followed a familiar script: Local citizens wanted their religious values validated by the science curriculum; prominent academics testified to the scientific consensus on evolution; and creationists lost decisively. Intelligent design was not science, held the court, but rather an effort to advance a religious view via public schools, a violation of the U.S. Constitution's Establishment Clause (*1*). Many scientists cheered the decision, agreeing with the court that the school board displayed "breathtaking inanity" [p. 765 (*1*)]. We suggest that the cheering was premature and the victory incomplete.

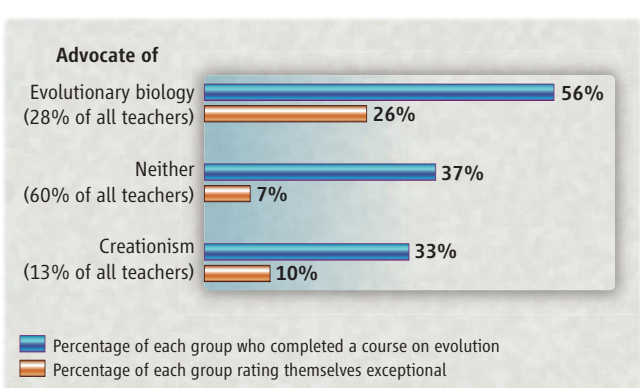
Systematic Undermining of Science

Creationism has lost every major U.S. federal court case for the past 40 years, and state curricular standards have improved (*2*). But considerable research suggests that supporters of evolution, scientific methods, and reason itself are losing battles in America's classrooms, where instruction in evolutionary biology "has been absent, cursory, or fraught with misinformation" [p. 21 (*3*), and (*4*)]. Extending this research, we have been investigating the evolution-creationism battle in state governments (*5*) and the nation's classrooms (*2*, *6*). Central to this research is the National Survey of High School Biology teachers, based on a nationally representative probability sample of 926 public high school biology instructors (*2*, *6*) (see the figure). [See supporting online material (SOM) for details.] The data reveal a pervasive reluctance of teachers to forthrightly explain evolutionary biology.

The data further expose a cycle of ignorance in which community antievolution attitudes are perpetuated by teaching that reinforces local community sentiment. For example, we ranked school districts from least to most socially conservative, and in the 15% most socially conservative school districts, nearly 4 in 10 teachers personally do not accept human evolution (compared with 11% in the least conservative districts) and, consequently, devote only minimal time to evolutionary biology in their classes [table A8.2 in (*2*)]. The next generation of adults is thus predisposed to share the antievolution views of their parents.

More promising data suggest that America's high schools contain thousands of outstanding, effective educators of evolutionary biology. We estimate that 28% of all biology teachers consistently implement the major recommendations and conclusions of the National Research Council (*7*): They unabashedly introduce evidence that evolution has occurred and craft lesson plans so that evolution is a theme that unifies disparate topics in biology (*2*).

At the opposite extreme are 13% of the teachers surveyed who explicitly advocate creationism or intelligent design by spending at least 1 hour of class time presenting it in a positive light (an additional 5% of teachers report that they endorse creationism in passing or when answering student questions). The boldness and confidence of this minority should not be underestimated. Although 29% percent of all other teachers report having been "nervous at an open house event or meeting with parents," only 19% of advocates of creationism report this ($\chi^2 = 5.1$, $P = 0.024$).



Self-reports of qualifications of teachers, classified by approach to teaching evolution. Based on responses from 926 U.S. public high school biology teachers. See SOM for survey details.

Some advocates of creationism insisted that they—not bench scientists—are the ones practicing proper science: A Minnesota teacher commented, "I don't teach the theory of evolution in my life science classes, nor do I teach the Big Bang Theory in my [E]arth [S]cience classes…. We do not have time to do something that is at best poor science." Others rejected the possibility that scientific methods can shed light on the origin of species. An Illinois teacher responded, "I am always amazed at how evolution and creationism are treated as if they are right or wrong. They are both belief systems that can never be truly or fully proved or discredited."

The Cautious 60%

But if mainstream science and the modern creationist movement each have their classroom allies, they still account for only about 40% of all high school biology teachers. What of the majority of teachers, the "cautious 60%," who are neither strong advocates for evolutionary biology nor explicit endorsers of nonscientific alternatives?

Our data show that these teachers understandably want to avoid controversy. Often they have not taken a course in evolution and they lack confidence in their ability to defend it (see the figure, see SOM for details). Their strategies for avoiding controversy are varied, but three were especially common and each has the effect of undermining science (*8*). Some teach evolutionary biology as though it only applies to molecular biology—completely ignoring macroevolution of species. At best, this approach sacrifices a rich understanding of the diversity of species. At worst it lends credence to the creationist claim that there is no evidence for one species giving rise to others.

Others defend the teaching of evolution as a necessary evil, using state examination requirements as a convenient means to disassociate themselves from

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the very material they are expected to teach. These examinations have only been recently introduced in most states. Yet, many teachers told us that they tell students that it does not matter if they really "believe" in evolution, so long as they know it for the test. One Michigan teacher tells students that they need to understand evolution because the biology curriculum "is organized *as if* evolution is true" [emphasis added].

Finally, a sizable number of teachers expose their students to all positions—scientific or not. Students should make up their own minds, explained a Pennsylvania teacher, "based on their own beliefs and research. Not on what a textbook or on what a teacher says." Many of these teachers might have great confidence in their students' ability to learn by exploration. But does a 15-year-old student really have enough information to reject thousands of peer-reviewed scientific papers? This approach tells students that well-established concepts like common ancestry can be debated in the same way we debate personal opinions.

The cautious 60% may play a far more important role in hindering scientific literacy in the United States than the smaller number of explicit creationists. The strategies of emphasizing microevolution, justifying the curriculum on the basis of state-wide tests, or "teaching the controversy" all undermine the legitimacy of findings that are well established by the combination of peer review and replication. These teachers fail to explain the nature of scientific inquiry, undermine the authority of established experts, and legitimize creationist arguments, even if unintentionally.

Courts, Standards, Preservice Teachers

Biology will be the only high school science class for 21 to 25% of U.S. high school graduates, and more high school students take general biology than any other science course (*9*). But many are not afforded a sound science education, which is problematic in a democracy dependent on meaningful citizen input on highly technical, but consequential, public policies. Research suggests several ways that scientists and scientific organizations can address this situation.

First, continued participation in federal law suits is essential, as federal courts have been shown to limit effectively the ability of state and local governments to endorse nonscientific alternatives to evolution (*5*). Likewise, the active role of scientists and scientific organizations has improved curricular standards in many states, and such reform has the potential to be especially effective in states having high-stakes science tests (*2*). But change due to improved standards is likely to be slow, because standards have the greatest impact on the newest teachers—those who were socialized in an era of standards-based education and who take standards and testing for granted (*2*). In addition, further improvements in state standards may be difficult because public opinion has been remarkably immune to outreach and public science efforts over the past three decades (*10*).

We suggest that increased focus be placed on preservice teachers (i.e., those preparing to be, but not yet, teachers). Teachers who are advocates for evolutionary biology are more likely to have completed a course in evolution than teachers who are ambivalent about evolution or who teach creationism (see the figure). Indeed, completing an evolution course is a powerful predictor of the classroom time devoted to evolution (*6*, *11*) and the likelihood that teachers will integrate evolution into their class as a unifying theme (*2*). Many nonresearch institutions lack the resources to offer a stand-alone evolution course regularly, however, and such institutions educate many high school science teachers. Requiring an evolution course for all preservice biology teachers, as well as provision of resources to provide such a course, would likely lead to meaningful improvement in secondary school science instruction.

In addition to their relative lack of evolution coursework, teachers in the ambivalent middle 60% also resemble those who endorse creationism in that few believe that they have an exceptional understanding of evolutionary biology (see the figure). Yet, unlike creationists, few of these ambivalent teachers hold a young-Earth belief system (e.g., that the universe is only about 10,000 years old) that would prevent them from becoming strong advocates for evolutionary biology. Therefore, improving the instruction they receive in evolution as undergraduates is essential. Outreach efforts such as webinars, guest speakers, and refresher courses—the types of efforts currently aimed at secondary school teachers—could be tailored and targeted for both preservice teachers and for biology and science education professors at teaching-oriented colleges. This two-pronged effort may help increase the percentage of new teachers who accept and embrace the findings of evolutionary biology. Better understanding of the field should provide them with more confidence to teach evolution forthrightly, even in communities where public opinion is sympathetic to creationism.

More effectively integrating evolution into the education of preservice biology teachers may also have the indirect effect of encouraging students who cannot accept evolution as a matter of faith to pursue other careers. Effective programs directed at preservice teachers can therefore both reduce the number of evolution deniers in the nation's classrooms, increase the number who would gladly accept help in teaching evolution, and increase the number of cautious teachers who are nevertheless willing to embrace rigorous standards. This would reduce the supply of teachers who are especially attractive to the most conservative school districts, weakening the cycle of ignorance.

Outreach efforts primarily benefit teachers who want to be helped, so expanding the corps of science teachers who want to be helped is critical. Thus, focusing on the preservice stage may be "the most effective way for scientists to help to improve the understanding of evolution" [p. 332 (*12*)]. Better-trained teachers will be able to more effectively take advantage of details in their textbooks and supplementary material published by the National Academy of Sciences and to put aside fear of reactions and pressures from members of their communities. It would also make them more critical advocates for high-quality standards and textbooks. Combined with continued successes in courtrooms and the halls of state government, this approach offers our best chance of increasing the science literacy of future generations.

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Supporting Online Material

www.sciencemag.org/cgi/content/full/331/6016/404/DC1

10.1126/science.1198902

Engaging prior learning on creationism and evolution may benefit college biology students

Article first appeared in an AAAS service called EurekAlert Nov 2005.

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http://www.eurekalert.org/pub_releases/2005-11/aiob-epl102605.php

Reading books sympathetic to and opposed to evolution supported increased acceptance of rationalist views

An educational intervention that included reading books sympathetic to and opposed to "intelligent design" (ID) prompted students in a college introductory biology course to report that they had become more accepting of evolution as an explanation for life, according to a study in the November 2005 issue of BioScience. The intervention, which was studied by Steven D. Verhey of Central Washington University, encouraged students to read parts of an ID-friendly, anti-evolution text, as well as an online refutation of the text and parts of a book presenting evidence for evolution.

Students in the study's two intervention streams read from "Icons of Evolution" by Jonathan Wells, which attacks evolutionary theory and is sympathetic to ID, and "The Blind Watchmaker" by Richard Dawkins, which supports the theory of evolution. Students in the intervention streams also read "Icons of Obfuscation" by Nic Tamzek, an online refutation of Wells' book, and discussed current thinking about the nature of science. Students in the two non-intervention streams read from and discussed "The Red Queen: Sex and the Evolution of Human Nature" by Matt Ridley, which describes evolutionary explanations for sexuality.

Verhey asked the 103 enrolled students to classify their beliefs about evolution and creationism before and after the course. Most of the 66 students who completed the survey had previously been exposed to both evolutionary and creationist accounts of life. Sixty-one percent of students in the intervention streams reported some change in their beliefs; most of these students were initially sympathetic to creationist explanations and moved toward increased acceptance of evolution. Only 21 percent of students in the non-intervention streams reported change in their beliefs.

Verhey's study was inspired by an influential theory of cognitive development advanced in 1970 by William G. Perry. Perry's theory holds that students pass through distinct modes of thinking. Verhey's intervention was designed to support students as they

progressed toward a more sophisticated cognitive mode by engaging them at the level of their initial understanding--including their initial ideas about creationism. Although alternative explanations are possible, Verhey maintains that his results suggest engaging prior learning "was an effective approach to evolution education."

BioScience is the monthly journal of the American Institute of Biological Sciences (AIBS). In an editorial commenting on Verhey's article, prominent evolution educator Craig E. Nelson asks how Verhey's "effective pedagogy" is to be reconciled with the strong stance of AIBS--and Nelson himself--against requiring the teaching of ID or creationism in high-school science classes. A large majority of biologists believe ID, which holds that evolution cannot explain life's complexity, is fundamentally unscientific. Nelson points out that teaching ID or creationism in a science class would be wrong unless these notions were critiqued scientifically and compared to evolutionary explanations. As many high-school teachers are not well prepared to rigorously contrast creationist and evolutionary accounts, Nelson writes that it would be "quite inappropriate to require such comparisons in high school." But encouraging active comparisons by college and university students will, according to Nelson, "help future teachers and other leaders understand why there is no contest scientifically between creationism and evolution."

MICROBIOLOGY 213. Social Issues in Biology: February 7, 2012

What is Science? Thomas Kuhn's "Structure of Scientific Revolutions"

Buy Thomas Kuhn's book "The Structure of Scientific Revolutions," (first published 1962), University of Chicago Press fourth edition- 2012 (available at the Harvard Coop course section) which includes an interesting Introduction and a 1969 postscript.

1. For background, read the following reviews of the new edition of Kuhn either before or after the book. (Or you can read the Introduction by Ian Hacking before or after if oyu have the time.)
D. Lehoux and J. Foster *Science* **338:**885-886 (2012)
Dr. Kaiser *Nature* **484:**164-166 (2012)

2. Read pp. 1-173 of the Kuhn book.

3. Read K. Popper, Normal Science and its Dogmas in "Criticism and the Growth of Knowledge," eds. I. Lakatos and A. Musgrave. Cambridge University Press. (1980) pp.49-58 (with an intro).

During the 20th century historians and philosophers of science challenged the view of science as a purely objective pursuit. Preceding Kuhn, Karl Popper, reacting against the positivist position, had proposed that the main defining feature of science was that hypotheses and theories are tested by a process of falsification. Only a falsifiable theory could be considered science. While Popper's proposal was accepted by many, Kuhn's book played a role in the critique of Popper's proposals and it initiated much larger debates and controversies that continue to this day. Many have questioned the specifics of Kuhn's thesis including how revolutions in science really take place. His book has also influenced academics in other fields who study the scientific process, leading them sometimes to using Kuhn to argue, at the extreme, that scientific "truths" are relative. Some scientists fear that these arguments hurt science and blame Kuhn for this presumed consequence.

Aside from the question of whether all the details of Kuhn's descriptions can be applied to science generally, I, personally, have found the book to be rich with insights into the scientific process. Not only do I think that these insights are useful, at the least, in musing about the science we do, but also in considering many of the issues we will discuss this semester.

As you read the book, please be thinking about the set of issues/questions I have listed below. For each of these, do you find Kuhn's explanations compelling or do you see problems with them? Come prepared to talk on either "side." There is practically no biology in this book. Why? As you read through the book, can you think of examples (e.g. paradigms) from biology/genetics/molecular biology that would fit into the discussion?

Can you relate Kuhn's ideas to aspects of the discussions we had about "what is science" in talking about Evolution vs. Intelligent Design? Also, see comments on creationism in the Science magazine review of the new edition.

Questions to discuss in the class:

1. What is "normal science?" (A brief summary of what is a paradigm is necessary here.) What do "normal scientists" do? How does normal science make it difficult for new paradigms to emerge? Does normal science resist "novelty?" Is this a good thing for scientific progress? Can you seek novelty? How does normal science result in paradigm changes? The Karl Popper article for today says pretty strong things about Kuhn's idea of "normal science." Those of you who are doing science or will do science in the future, how do you view this concept. **I will ask some of you to prepare an argument that supports Popper's comments about normal science and criticizing Kuhn's, and I will ask others to prepare an argument supporting Kuhn's position and criticizing Popper's.**

2. What are anomalies and their relationship to normal science. Anomalies can be treated in different ways by scientists. How so? Why? What is their relationship to paradigm shifts.

3. How does a paradigm shift (conversion?) take place? What are the factors that Kuhn says make successful acceptance of the shift (or cause resistance to the shift)? Make a list of these factors which might include the scientific, personal, social, political and the psychological (others?). These would include features of the paradigm itself and other extraneous factors. Would you add any of your own?

4. What does it mean to talk about fields of research that are paradigm based or non-paradigm based or pre-paradigmatic? Examples?

5. Explain Kuhn's use of the term "incommensurability" of competing paradigms. (pp.98-100; 103-104) is one place where this is discussed. Do you have any problems with this characterization?

6. Kuhn mentions scientific positivism, verificationism and falsificationism (Karl Popper). Do you know what these terms mean. Do you agree with his critique of each individually as a critique of the description of how science is done? Do you see problems with falsificationism.

7. The book actually begins with a critique of the education of scientists. Are the science education and texts that he criticizes something you have experienced or is it different from what he describes? If some of his criticisms (also throughout the book) of the education of scientists are accurate, should the education of scientists be changed?

8. Perhaps most disturbing to many is the idea summarized on p. 170 that "We may…. have to relinquish the notion….. that changes of paradigm carry scientists and those who learn from them closer and closer to the truth." What does he mean by this? Does he

believe in progress? Do you agree or disagree? **Again, I would like members of the class prepared to take one side or the other.**

9. As indicated above, come with some thoughts about paradigm changes in biology. Kuhn talks of some of the big paradigms, but he also allows one to think in the same terms of smaller "paradigms." So, don't restrict yourself to just major paradigms of biology.

10. Do you think that science (biology) has changed in ways that don't fit with Kuhn's "structure?"

Finally, do Kuhn's ideas challenge any of your own beliefs about science? Do you disagree with his ideas? If that is the case, come with arguments for why you think some of his analysis is incorrect? And, do you think it makes any difference whether or not people accept his views of science? Which people? Scientists? The Public? Journalists?

FYI: Read Interview with Harvard physicist Lisa Randall, Boston Sunday Globe, October 23, 2011. Some of Randall's descriptions of science seem to reflect the changes that have taken place in the thinking about "what is science."

Microbiology 213
Social Issues in Biology
February 14, 2013

Science, Race and Eugenics

This is the first of a few sessions that will include at least some discussions of issues of race and science. This session focuses largely on historical examples. There have been repeated controversies during the last two centuries over the use of science to make arguments about presumed human races. This has led to often bitter debates between scientists.
The required book, S.J. Gould's "Mismeasure of Man," should be available at the Harvard Medical Coop or probably easy to find otherwise. I will be lending copies of my book "Making Genes, Making Waves".

Readings:

1. S. J. Gould. **The Mismeasure of Man** (revised and expanded). Norton paperback. (1996). Please read pages **51-61, 74-104 and 176-204 and** pp. **264-269** on Sir Cyril Burt (up to "Correlation …..)
   Read packet of brief articles on very recent reactions to the history of Louis Agassiz in Cambridge, MA and in Switzerland.

Stephen Jay Gould was a paleontologist/evolutionist who made major contributions to his field and was a popularizer of evolutionary biology. He testified at court trials in defense of the teaching of evolution in evolution/creation conflicts. But, he was also a critic of research which claimed scientific support for theories of racial and gender inequality. **The Mismeasure of Man** is a summary of much of his criticisms. The issues he dealt with have long engendered a contentious debate amongst scientists and some of Gould's work has itself been recently criticized, including in readings for today. I have been giving readings from Gould for many years and I think it is an important book worth reading in its entirety. We may be reading a couple of short sections in subsequent sessions.

One of the themes that runs through this book is that scientists' personal biases and those of the society around them can influence their research and that this is of particular concern when the research relates to societal questions.

With regard to Louis Agassiz, I am including recent material that reports on public reactions to the revelations about him in Cambridge and in Switzerland. Are the reactions and changes made or suggested re: the Agassiz name warranted, reasonable? **I will ask individual students to take one side or the other on this question?**

Recently, an article (for today's reading) has argued that Gould himself was biased and that this bias influenced his scientific analysis of Samuel Morton's data. As one discussion point for this class, I would like you to consider Gould's section on Morton and the article included that criticizes Gould's analysis of Morton (see Readings 2 below). **What conclusions do you draw about the validity of Gould's claims? (I will ask students to take different positions on this controversy.** It may be useful to look at the video link I have included.)

Overall, as you read Gould, think about his critiques in terms of the issues we have

discussed in the earlier sessions (see e.g. p.54). Were researchers such as Agassiz, Morton, Goddard, etc. doing science? Do you consider these cases represent good science, bad science, or just science? Why might Burt have gone to such extremes in concocting data in his identical twin studies? Gould himself repeatedly states that non-objective factors are just as prevalent in all the science we do. Are his arguments convincing? **What factors might have influenced their science**, their assumptions even to the point of apparently committing fraud in the case of Burt? Are we free of such influences today? **What factors might have influenced or provoked Gould's critique?**

Be prepared to discuss each example of research and theories offered by the various scientists Gould cites.

On p. 269, Gould says that Burt's work has "affected millions of lives." What is he referring to?

Other themes that come up in Gould:

His repeated point that quantitation in science is often misused as the ultimate objective criteria. (first brought up on p. 58)

In page 77-78, issues arise as to why certain scientific subjects are studied.

The failure to consider alternative hypotheses for data also comes up.

On page 186, be sure you understand the "two false implications" that he describes.

I have not required reading of the section on factor analysis in the Gould book as I thought there was already a substantial amount of reading and this would require significantly more work and I'm not very good at it.

2. J. E. Lewis *et al.* **The Mismeasure of Science: Stephen Jay Gould vs. Samuel George Morton on Skulls and Bias.** *PLoS Biology* **9:** Issue 6 e1001071 pp.1-6 (2011). Plus two commentaries on the paper- Hawks and Horgan). Plus a video, if you want to put in the time, which includes the skulls! A confusing video of commentary by one of the authors: http://www.youtube.com/watch?v=emDuNjVs7f8&feature=channel_video_title

This paper is the one referred to above that criticizes Gould. It involves a re-analysis of Morton's work and comes to different conclusions from Gould and draws certain conclusions about Gould and perhaps objectivity in science (?). The two commentaries make strong statements on opposing sides of this issue**. I will assign certain people to make the best case for Gould and criticize this paper and others to make the best case for the Lewis et al. paper.**

3. a)Figure (cartoon) of the Kallikak family from a widely used psychology text published in the early 1960's. b)L. Zenderland. (1998) **Measuring Minds: Henry Herbert Goddard and the Origins of American Intelligence Testing.** Cambridge Univ. Press. Cambridge, England. (paperback), pp. 352-353. and c)discussion of Goddard's Regrets.

4. J. Beckwith. Chapter 7 "Their Own Atomic History" in **Making Genes, Making Waves: A Social Activist in Science.** Harvard University Press, Cambridge (Hardback) pp. 98-115 (2002).

This is my brief summary of and take on the eugenics movement in the early part of the 20th century.

Did you learn about eugenics in any of your previous courses? Were they science courses?

How much blame for the consequences of this movement, if any, should be put on the shoulders of the scientists involved? What could they or might they have done differently?

Why do you think that most geneticists believed in eugenics ideas, at least early on?

Some would argue that this 20th century eugenics movement gave the word "eugenics" a bad reputation and that there is a good eugenics. What does that mean? Are there arguments for the eugenics being made today that resemble the ideas put forth ~100 years ago?

5. D. Wahlsten. **Leilani Muir versus the Philosopher King: Eugenics on trial in Alberta.** Genetica **99:**185-198 (1997).

This article describes the history of the formation of the Eugenics Board in the Canadian province of Alberta, its long life and the story of Leilani Muir mentioned in my chapter above.

p. 187 Do you know what pellagra is and the history of discussions of the origin of the disease?

Magistrate Murphy (1927) says that "science is proving" the hereditary basis of the human traits (feeble-mindedness, etc.) they are basing their sterilization decisions on. Where does she get this from?

p. 195. This is the second court case appearing in this course in which science is at issue. What is your reaction to the parts of the decision presented? I have not looked this up, but I suspect that more scientists were involved in testimony. What is the current status of science in the judicial system?

Heritability and Society from Twin Studies to GWAS:Need for a New Paradigm

: Crisis in Biology?

Twin studies have been one of the workhorses of both human behavioral genetics and medical genetics since the very first twin study in 1924. However, in the case of human behavioral genetics, there have been very strong threads leading back to the eugenics movement in the early 20th century. In particular, many of the researchers using twin studies have focused on intelligence, using IQ tests and other standard tests to determine the heritability of intelligence. Over the last 40 or 50 years, many of these scientists have received financial support for their work from the Pioneer Fund. This Fund started in the 1930's with leaders who, from the start were associated with the eugenics movement, and even praised the Nazis' anti-semitic Nuremberg Laws. The Fund gave grants to researchers who used twin studies to claim genetically based differences in intelligence between blacks and whites. This is not to say that this research would not have been done without Pioneer Fund support, but the NIH stopped funding this kind of research in the 1960s for many years and, it is known that at least one prominent researcher in twin studies, went to the Pioneer Fund for support, when his grant was turned down by NIH.

Research on twins and IQ that has made racial suggestions, has had significant social impact. In 1969, Arthur Jensen, a psychologist on the University of California, Berkeley faculty published an article in the Harvard Educational Review in which he argued that twin studies led to the conclusion that differences in IQ between blacks and whites was genetically based and could not be eliminated. From this conclusion, he suggested that compensatory education programs for minorities would not work. The article received enormous media attention and was read into the Congressional Record as part of the debates over ending such educational programs during the administration of President Nixon. IN 1994, Richard Herrnstein, Harvard psychology Professor and Charles Murray, political scientist and major advisor to the Republican Party, published the book "The Bell Curve" which greatly amplified Jensen's arguments and called for policies reminiscent of the eugenics era. Nearly all of the researchers on IQ and twins cited in the book were supported by the Pioneer Fund. The book has sold more than 300,000 copies. In 2011, in Germany, a leading political figure, Thilo Sarrazin, argued, on the basis of twin studies (mostly from the United States), that Germany should stop and reverse immigration of Muslims as they were diluting the quality of the German gene pool.

For some people, a major bone of contention over the conclusions from the twin studies is the meaning and misunderstanding of the term heritability which is calculated from such studies. The articles that follow will deal largely with what heritability does and doesn't signify written both by critics and practitioners of these studies. These discussions raise questions about current searches for mutant genes that are responsible for either human health problems or human behaviors. A consideration of the significance of heritability calculations may inform the current discussions in the quest for finding the "missing heritability" that has dogged such searches. This session ends with a review of this dilemma that harks back to our discussion of "paradigms" in science.

1. E. Sober. 2001. Separating nature and nurture. In **Genetics and Criminal Behavior**, eds. D. Wasserman and R. Wachbroit. Cambridge University Press, Cambridge. Pp. 47-78.

Please be prepared to present the essentials of Sober's argument. This reading goes into depth on the concept of heritability which is central to the reports of Sir Cyril Burt (covered in Gould) and many other studies that continue to the present day. To me, Sober's is one of the best available in explaining the concept, its problems and it uses and potential misuses in twin and family studies. I think the concepts are clear without a full understanding of the math. Sober here goes into detail on the meaning of heritability and what is or isn't learned from studies such as those done with identical twins. Often heritability is taken to mean inherited, which, Sober (and others), makes clear it doesn't. With the mistaken interpretation of heritability, such studies are given a genetic determinist slant. The concepts of gene-environment interaction and gene-environment correlation are important for seeing the complexity of interpretation particularly in genetic studies of human behavior. Can you see why? Are these arguments new to you? Are you aware of examples of the misrepresentation of heritability studies that have had social implications?

How many have a background in which you have studied in classes the concept of heritability? Did you learn anything new here?

Other questions to think about:

p. 37 "whether a scientific question should be pursued depends on what the consequences for human welfare would be of pursuing it?" What does this mean? What is human welfare?

p. 61, 62 Why is the issue of controlling for "trait-relevant" environmental variables important. How do you choose which one to assess?

p. 68, 70 How would you test whether the equal environments assumption is correct or not?

p. 71 gene-environment correlation

p.73 Be sure you understand what Sober is trying to say with the redhead example

Sober's clear explanation of the problems is important today because much of the expectations of geneticists that they would readily find genes for many human traits have encountered enormous difficulties. They and the media now talk about the puzzling gap between findings of strong heritability of a trait and failure to find the genes that could account for it. **(I suggest that if you want to read more about the problems with the attempts to show a genetic basis for IQ score difference between social classes and racial groups, look at some of the early chapters of R.E. Nisbett's "Intelligence and How to Get It" just out in paperback. It is popularly written but academically sound and heavily referenced.)**

2. E. Turkheimer, A better way to use twins for developmental research. LIFE Newsletter, volume 2, #1, pp. 2-5 (2008).

Microbiology 213
Social Issues in Biology
March 28, 2013

"Mapping Fate" and its Consequences

The major reading for today is the book by **Alice Wexler, Mapping Fate:A Memoir of Family, Risk, and Genetic Research. Univ. of Calif. Press(1995)** available in the section for this course in the Harvard Coop. This book has also provided some of the stimulus for the theatrical production that is being developed. The play, currently composed of four story lines, includes one about the Wexler family and Huntington's Disease. There is also a set of short readings on privacy and genetic discrimination listed at the end of this hand-out.

The book has a number of themes running through it. It starts off as a memoir of family experiences with Huntington's, then moves into the role of the Wexler family's role in promoting the search for the Huntington's gene. It provides an example of an unusually powerful impact of the family on research much of which was done in an unusually cooperative manner at that time (see particularly Chapter 13).

What are the advantages or disadvantages 1)of such cooperation and 2)of interest group fostering or having an influence of research directions? The Wexler's not only started this group, they also at certain stages influenced the research itself. How? The role of Nancy at various points is fascinating (e.g. p. 196). Why?
What were the conflicts between the Wexler and Guthrie groups?

The names of several people appear in this book whose names we have already met in previous sessions of the course. **Can you name some and their different roles? Also notice the mention of eugenics a couple of times.**

What do you make of the short inserts in italics that keep appearing in the book.

The anguished and angry discussions of the family over whether or not Alice and Nancy will be tested raises a number of issues about the impact of genetic testing or even the idea of being tested. **What are these issues? How serious might they be? (See the additional readings.)**

More generally, what are the potential risks and benefits from genetic testing? Include fetal testing particularly relevant to Huntington's which is mentioned. What do you think of the Wexler sisters deciding not to take the test. (From relatively recent personal knowledge, I know that both of them decided not to take the test.) Think about whether you would you take the test if you were from a family with the same history? (Consider the different thoughts the family members present.)

p.. 272 According to the author, most doctors feel that individuals should be informed of their genetic status. Alice refers to this as coercion. What do you think?

The Huntingtin protein has been widely studied, but, so far as I know, it hasn't led to any successful treatments. That's not surprising as it is a long haul to get from the protein to discovering treatments and the successes so far are not numerous. **What ones do you know of and how do they work?**

Additional readings on Huntington's, genetic discrimination and genetic privacy issues.

In 1989, at a press conference debuting of the Human Genome Project (HGP), Jim Watson (head of the Project) announced that several percent of the ~60 million dollar budget

would be devoted to supporting research and efforts to anticipate the potential dangers of the advances achieved by the Project. He established a Working Group on Ethical, Legal and Social Implications of sequencing "the" human genome. This Group (of which I was a member for the first five years and which was chaired by Nancy Wexler (!)) established the type of research questions that would be examined and held its own hearings on issues of immediate concern. One of these was the issue of genetic "discrimination" in insurance. Research supported by HGP in this area was important in the ultimate passage by the U.S. Congress of the Genetic Information Nondiscrimination Act (GINA) in 2008. Overall, the establishment of ELSI was historical in that it was the first time the initiation of a research project was accompanied by efforts to explore its potential risks to society.

Below is a set of articles that gives examples of genetic discrimination, that discuss the effectiveness of GINA and that raise issues of genetic privacy. Three of these focus on a recent Science article that explores how easy it is to deduce from a genome sequence the identity of the person. While much of this material reflects concerns about the lack of privacy, the last article co-authored by George Church offers some challenges to these concerns. Consider all of this material together (looking on Huntington's as only one type of concern) and be prepared to discuss the pros or cons of a law like GINA or of giving up the idea of privacy. As one issue not discussed, should genetic information be privileged by protection over other medical information, a practice termed "genetic exceptionalism?"

If not GINA, what is the solution?

C. Erwin. Legal update: living with the Genetic Information Nondiscrimination Act. Genetics in Medicine 10:869-873 (2008).

A.Harmon. Insurance fears lead many to shun DNA tests. The New York Times Feb. 24, 2008 and letters written in response (March 2, 2008)

Y. Bombard et al. Engagement with genetic discrimination: concerns and experiences in the context of Huntington disease. European J. Hum. Genetics 16:279-289 (2008).

M. Gymrek et al. Identifying personal genomes by surname inference. Science 339:321-324 (2013),

L. Rodriguez et al. The complexities of genomic identifiability. Science 339:275-276 (2013).

_____ (Editorial) Genetic Privacy Nature 493:451 (2013).

J. Lunshof et al. From genetic privacy to open consent. Nature Rev. Genetics April 2008 10.1038/nrg2360

Guide for the March 7 session of Micro 213: Social Issues in Biology

For the 3/7 session, Roberto Kolter will lead a discussion centered around the seminal discovery of the double stranded structure of DNA. The events leading to this key discovery serve as wonderful case study of many extremely interesting and important social issues in science. Thus, during the discussion we hope to address several of these, e.g. the influence of personality in the scientific process, the treatment of women in science, and moral and ethical aspects of data acquisition. The particular series of events, and in the personalities involved, have been extensively analyzed and represented in numerous writings, movies, theater pieces, and documentaries. Needless to say, we will only be able to cover a minute amount of this material. Importantly, the following week, we will be reading from and discussion a theater piece on the subject "Photograph 51" by Anna Ziegler. The readings for the 3/7 discussion will be from two sources:

1) Watson's "The Double Helix" - this is a rather short account and should be read it its entirety.

2) Brenda Maddox's "Rosalind Franklin: The Dark Lady of DNA". This second book is more substantial and thus the required reading will only be from chapter 6 (page 87) up to chapter 13 (page 213). There is absolutely no harm in scanning/reading pages 1-86! And... If you get totally enthralled and feel like reading the whole book, please do!

Please be prepared to discuss in depth the key points that, in your opinion, led to the strained relationship between Watson & Crick and Franklin as well as the working relationship between Wilkins & Franklin. Know the details and form an opinion on the process by which the data in support of the double helix came to be known to all these scientists. In addition, be prepared to discuss what role gender played in how the events evolved. Please **make sure to be ready to cite specific sections of both books** in support of your arguments.

Should you become fascinated by the subject matter, please feel free to consult these other sources:

A) The Third Man of the Double Helix: The Autobiography of Maurice Wilkins

B) What Mad Pursuit: A Personal View of Scientific Discovery by Francis Crick

C) DNA: Secret of Photo 51 (A NOVA documentary available in DVD and YouTube)

D) The Race for the Double Helix (A 1987 movie by BBC available in DVD and online)

Microbiology 213
March 14, 2013 (No class on March 21)
Communication of Science through Theatre

The readings for today's class are two plays: "Photograph 51," which presents much of the story of the discovery of DNA we talked about last time and "The Edge of the Map," experimental theatre based on some of the issues raised in Micro 213 and developed by Calla Videt with a cowriter and Harvard undergraduate students.

Both scripts are in this week's file as well as an "outline" file which is for casting and design purposes. You should consider the questions listed below while you are reading the two entire scripts. You need not read the "outline file."

Tentative schedule for Thursday, March 14

1:00-1:30 Actors present Photograph 51 short excerpt, Discussion

1:30-2:30 The class does a reading of The Edge of the Map, Discussion

2:30-3:00 Watch short video(s) Mnemonic (and Copenhagen); Discussion

3:00-4:00 General class discussion (Individual filmed interviews with Calla will be going on in a separate room during this time)

Discussions will include the following questions/topics:

Photograph 51:

Does this play present any perspectives different from last week's readings?

1. Did the play make you feel differently about any of the issues?
2. In Photograph 51 the playwright takes "poetic license" with actual events and introduces Don Caspar as a contemporary during the "double helix" period, which he was not. Moreover, the playwright imbues the Franklin-Caspar relationship with romantic undertones. Discuss how you feel these approaches help or hurt the play impacts you. Discuss why.

The Edge of the Map

Note that Leilani Muir has been renamed Isabelle in this version.

General Questions:

1.Do you think that the plays/excerpts for today's class served to communicate scientific ideas well? Did you think that particular styles of the play in each case enhanced that communication? Were there any scientific concepts that could be better presented?

2, How are scientists represented?

3. How are conceptual ideas balanced with narrative ones?

4. What themes are being tackled in what way and with what implications?

5. Have you seen any other plays that had significant scientific content? Did you think that they effectively communicated the science? What plays?

Microbiology 213
Social Issues in Biology
March 28, 2013

Prenatal Screening, Gene Therapy/Genetic Enhancement and Society

Today's readings represent a selection of papers and book chapters that give views on the benefits and problems associated with various genetic approaches that are allowing or present in the future more and more choices to be made by parents concerning what their children will be like. These include, prenatal screening and abortion, genetic enhancement using "gene therapy" techniques and even synthetic biology. There are a variety of perspectives on whether the genetic advances that allow these choices are beneficial or not. How informed does the basic science researcher have to be in this area? What role should geneticists play in these discussions?

To my mind, these readings are all related to some extent. After having read them all, what developments, if any, do you think to be of particular concern? Why and can or should anything be done to deal with these concerns?

I expect everyone to do all the readings and be able to comment on them, as usual. However, I am asking 8 students in the class (names indicated below) to take positions on particular issues and, while reading everything, they should concentrate on the set of articles that they are reading for their presentations. The pairs of students that are named below to argue various positions can work individually or together.

Readings:

Part I:

1. Excerpts from Rayna Rapp's <u>Testing the Women, Testing the Fetus.</u> Routledge, NY. 1999. Pp. 3-8; 66-93; 185-190.

Rapp is an anthropologist who has spent many years observing and participating in interactions between pregnant women and their families and medical professionals, mainly genetic counselors. Her experiences reveal much complexity and diversity in the population in dealing with genetic information. There are a variety of issues to think about here: 1)Should genetic counseling be non-directive- can it be non-directive? 2)How does different cultural/ethnic/class background influence attitudes towards screening and reproductive decisions? 3)How is normality defined or should it be? 4)How do we deal with issues of science literacy in areas like this where scientific information is being communicated? 5)What other issues does this reading raise for you?

2. A. Asch. Prenatal diagnosis and selective abortion: a challenge to practice and policy. Am. J. Public Health. 89:1649-1657 (1999). PLUS T. Lee. You probably won't like James Watson's ideas about us. Ragged Edge. Mar/Apr. p. 16 (1998). R.S. Cowan RS. 2009. Moving up the slippery slope: Mandated genetic

screening on Cyprus. Am J Med Genet Part C Semin Med Genet 151C:95–103 (2009).

The Asch article raises questions that arise from the development of new genetic tests, presenting a significant point of view within the community of people with disabilities. Does this influence your thinking about prenatal testing, etc.? Asch is trained in social psychology. Do you think Watson's ideas may be widely shared or more acceptable if less inflammatory language were used? Note Watson's comments in The Ragged Edge and a quote from a recent biography of Watson by Victor McElheny, in which we hear of his retort to a woman who said she would proceed with a pregnancy, knowing that she would bear a child with a deformity: "I'd hate to be the child you brought into the world." **For these readings, I am asking *Chris and Reshma* to defend Asch's position and *Seth and Homan* to offer a critique of it. Various stances could be taken in the critique from comments like Watson's or more limited positions. This brings up the issue of the history of eugenics and eugenics today. In that context, are there potential general implications of the Cyprus screening program for the future. Include that issue in your discussion.**

Readings: Part II

The following remaining articles deal mainly with the issue of genetic enhancements with the more futuristic version of it that discusses the synthetic biology engineering of "post-persons."

3. P. Shanks. In Biopolitical Times on Website of Center for Genetics and Society. "Pushing the Bioethics Envelope to Serve Neo-Eugenic Purposes." February 24, 2011. D. Sharp. In Biopolitical Times. "Writing your Baby's Synthetic Genome: Genetic Engineering for the Facebook genome." March 22, 2012.

These two articles indicate additional interest among some scientists and bioethicists in genetic enhancement. The following articles expand pro- and con-positions on some of these ideas.

4. Buchanan, D. W. Brock, N. Daniels and D. Wikler. Excerpt from Chapter 4, "Why not the best?" in *From Chance to Choice: Genetics and Justice*. Cambridge University Press pp. 156-196 (2000).

This chapter, as the book it is part of, is co-written by four moral philosophers, who overall take a favorable view of genetic enhancements. What do you think of their arguments?

5. N. Agar. Why it is possible to enhance moral status and why doing so is wrong. J. Med. Ethics. March 2013. 39:67-74. T. Douglas. The harms of status enhancement could be compensated or outweighed: A Response to Agar. J. Med. Ethics. March 2013. 39:75-76.

An entire issue of this journal was devoted to this topic.

6. S. Lumenello. Perfection Complex: an interview with political philosopher Michael Sandel. Colloquy (Harvard GSAS Alumni Quarterly) Fall, 2007.

pp.2,3,10,11; C. Elliott. The mixed promise of genetic medicine. NEJM 365:2024-2025 (2007).

These two pieces talk about the future impact of genetics and genetic testing, although with somewhat different perspectives and touching on different issues. I thought it would be particularly interesting to sum up this session with a discussion of what the future looks like. Sandel is more worried about how society will handle human genetic information. Elliott is, in part, responding to Sandel. Do you agree with either of their views? Do you think there is anything to worry about? If so, come prepared to talk about those issues or to argue why you don't agree with either of the authors.

For readings 4, 5, and 6, I am asking *Michael and Toria* to present rationales for supporting the more libertarian approach of Chance to Choice and that of others that support the use of new technologies and *Amanda and Huadi* to represent the variety of criticisms of raised by Agar, Sandel and Elliott as well as your own. Who might benefit from these "procedures" or who might suffer. What do you think are the most salient problems, if any. Do not consider just the moral/ethical/social/political consequences of the ideas <u>but also</u> indicate how feasible you think it will be to do genetic enhancements or successfully generate persons (or post-persons) with rewritten genomes in the future. For the latter question, consider whether the discussions we had about the Weiss and Buchanan article in an earlier session, etc. are relevant.

Microbiology 213
Social Issues in Biology
Class for Thursday, April 4, 2013

Science Meets the Powerless: Communication and Exploitation?

Please buy and read in its entirety the book "**The Immortal Life of Henrietta Lacks" by Rebecca Skloot**. Published in 2010 and in paperback in 2011. May still be at the Harvard Coop on the course site, but widely available.

Please consider and think about the following issues as you read the book. Make sure to cite specific passages of the book that you think are relevant to the point you want to make.

1. **Section of book on past medical research practices generally that seem repugnant to us today: history and evolution (including some of the extra reading below)**

   What was the state of ethics in medical research at the time that some of these events (e.g. the Tuskegee Syphilis "Study") took place? Do you think that some of the practices were largely widely approved? Do we learn here of instances where such practices were opposed? When did this happen? How have practices changed over time during the history reported here? What policy changes have taken place? Have they been effective? Can you relate this discussion to any of the topics we have talked about in previous classes?

   Do you think that these issues are gone now or is it difficult to anticipate further evolution of mores/ethics etc.

   How has this history affected the attitudes of groups toward medical research? Do these attitudes seem reasonable given the history?

   Read and take into account the 3 articles below in considering these questions.
   M. Walter, "First Do Harm" Nature 462:148-152 (2012).
   H. Epstein. "Lead Posoning: The Ignored Scandal" The New York Review of Books. March 21 (2013), 7 pages.
   D. Normile. "The Promise and Pitfalls of Clinical Trials Overseas." Science 322:214-216 (2008).

2. **The taking of Henrietta Lacks' cells for research purposes**

   Do you find any faults with the taking of Lacks' cells for cancer research? Should she have been informed? Would it be required that she be informed today? How do you deal with contrast between the poverty of the Lacks family and the amount of money, fame, etc. that some scientists or companies earned? Should people be paid for their cells? What are the pros and cons of paying people for their cells: the economics, ethics and the effects on research?

   For this question, also read: R.D. Truog, A.S. Kesselheim and S. Joffe. "Paying Patients for Their Tissue: The Legacy of Henrietta Lacks. Science 337:37-38 (2012).

3. **What role did racism, its history, the attitudes of that time play this story?**
   What indications are given in the book of degree of racism in society ~1951.

4.The nature of communication between medical/scientific researchers and the black community, poor people or the public, in general.

This is one of the most important issues in the book, at least for me.
There are a number of scientists in the book who had contact with either Henrietta or later her family and particularly Deborah. There are differences in how effective they were (or wanted to be) in these communications. Examine these various interactions, both positive and negative. Do these reflect any problems for the relationship between researchers and the public, in general, or groups within society, in particular?

5. **Other questions of interest**
   Would you point to any heroes in this story either related to the Lacks' or in other incidents covered in the book?
   What do you think was the story referred to on p. 167 where African-American children were screened for a genetic predisposition to criminal behavior?
   You might be interested to look up the history of Alexis Carrel who is mentioned several times in the book.
   What do you think of the press coverage of the potential of HeLa cells?
   Does the problem with HeLa contamination of other cell lines tell us anything about scientific research?

6. **Read: R.Skloot. "The Immortal Life of Henrietta Lacks, the Sequel. The New York Times Sunday Review Section, March 24, 2013.**
   This article brings up the issue of privacy of genetic information again. Do you think that this particular instance is problematic?

Microbiology 213
Social issues in Biology
April 11,2013
Genes and Anti-Social Behavior: How scientific ideas move from the lab to influencing social norms

(The reading below by Morris et al. begins with a brief history of previous work on genetics and criminal behavior, including the XYY case. If you would like to read more detail on the XYY male story, you could read Chapter 8. "The Myth of the Criminal Chromosome," of my memoir that I lent you "Making Genes, Making Waves: A Social Activist in Science" pp. 116-134. Not required.)

The following sets of readings cover the history of arguments for a correlation between biology and criminal behavior emanating from scientists. In particular, the history is reviewed quickly in the Morris et al. article. These claims start with a brief reference to Cesare Lombroso in the 19th century. (If interested, you can read more about him in Stephen J. Gould's book "Mismeasure of Man.") They include the important role of these claims during the heyday of the eugenics movement in the U.S. They continue with the XYY story beginning in the 1960s. The Brunner et al. and Caspi articles represent the most widely known recent examples exploring the issue of genes and anti-social/criminal behavior.

In going through the first 3 sets of readings, I would like you consider generally the question of how a piece of research moves from the lab to the journal to the public and to whatever social impact it might have. In particular, consider the following questions:

1. Is the science solid? Why? why not?
2. Does the way in which the paper is written- particularly the Introduction and Discussion- influence the way it is ultimately received publicly? Point to specific portions of the paper that support any comment here.
3. These are both articles published in Science. Does the science of the paper seem to warrant publication in this journal? If not, why does Science accept it?
4. Does the journal do anything to attract media attention to the article? What? You may not know all of the factors here, some of which we will talk about in class.
5. The conclusions of the Caspi et al. paper are still widely cited and still used in courtrooms. Is this appropriate? Why? Why not?
6. Why do some scientific ideas- e.g. the XYY criminal chromosome- stick around so long after they have been refuted?
7. Finally, do you think that genes for anti-social behavior exist and will be found?

1. **H.G. Brunner et al. Abnormal behavior associated with a point mutation in the structural gene for monoamine oxidase A. Science 262:578-580 (1993)**.

V. Morell. Evidence found for a possible 'aggression gene.' Science. **260:**1722-1723 (1993).

N. Angier. Study finds a genetic flaw that may explain some male violence. New York Times, Oct. 22, 1993.

G. Cowley and C. Hall. The genetics of bad behavior. Newsweek Nov. 1, 1993, p. 57.

B. Breathed, Outland. Boston Sunday Globe Comics. Oct. 31, 1993.

E. Felsenthal. Man's genes made him kill, his lawyers claim. Wall Street Journal, November 15, 1994, pp. B1,B5.

Note the date of publication of the paper. Note the dates of the media reports. How does it get into the press so quickly? (And even into a cartoon!)

2. A. Caspi et al. (2002) Role of genotype in the cycle of violence in maltreated children *Science* 297, 851-4.

E. Stokstad. Violent effects of abuse tied to gene. Science 297:752 (2002).

Z, Prichard et al. No evidence for interaction between MAOA and childhood adversity for antisocial behavior. Am. J. Med. Gen. 147:228-232 (2008).

T. Ngo. Professor looks into 'murder' gene in justice system. Arizona State Univ. publication. April 26, 2011.

E, Feresin. Lighter sentence fo murderer with 'bad genes'. Published online 30 October 2009 | Nature | doi:10.1038/news.2009.1050

AND NEWTOWN! G. Kolata. Seeking answers in genome of gunman. New York Times. December 24, 2012.

Compare the findings presented in Caspi et al. (2002; the first study presenting a gene-environment interaction for criminal/antisocial behavior with maltreatment) and that of Prichard et al. (2008). What do you think of the conclusions and the recommendations of the Caspi study? Do they follow from the findings? Are they appropriate? What are some of the possible reasons for the dramatically different findings presented in the two studies? Methodological? Statistical? Cultural? What are the implications? (Reference to other conflicting studies is described in the Morris et al. article.)

3. C. Morris, A. Shen, K. Pierce, J. Beckwith. 2007. Deconstructing Violence. *Gene Watch* Volume 20 Number 2, pp. 3-10, March - April 2007.

Are the premises and methods investigating links between behavior and genetics sound? How does social context inform this study? If the Caspi et al. conclusions were to become well established, what do you think the social implications would be? Would genetic screening be a good idea? Who should be screened? How should the screening information be used?

4. K.A. Taylor. On the explanatory limits of behavioral genetics. Chapter 5 p. 117-137 (especially pp. 132-137

M. Baron. Crime, genes and responsibility. Chapter 8. Pp. 201-218 (esp. 201-206, 213-218(

P. v, Inwagen. Genes, statistics and desert, Chapter 9. Pp. 225-242.

PDF files of these three essays are in the Week 10 readings on the course site. They are from the book "Genetics and Criminal Behavior." Ed. D. Wasserman and R. Wachbroit. Cambridge Univ. Press. (2001).

There three essays are by philosophers. Each of these chapters focuses on different issues related to the social, ethical and legal implications of information about the relationship between genes and criminal behavior. Give a critical look at their arguments and be prepared to argue for or against their soundness. (Forgive Inwagen's glib description at p. 230 of a described behavior as "genetically determined." That statement serves, within his analysis as a whole, only as a premise assumed for the sake of argument.)

Microbiology 213, April 18,2013
Race and Genetics into the 21st Century

During the class, I will call on students to talk about some of the questions raised.

As last week's session may have indicated, there is an ongoing debate over studies on race and genetics. How people look at data and how seriously they take arguments on one or another side may be influenced by their social perspectives. Do you have any reason to think that this is the case again in today's readings?

1. A brief history of the idea of race

S.J. Gould. **The Mismeasure of Man** . Norton paperback (1996). Page 398 (beginning with 2d paragraph) through page 412. (read from your copy of the book)

This excerpt gives some history of the origin and development of the concept of human races. Keep the question of the meaning of race in mind during the discussion of the papers below. Is race a valid term to use for human populations? How do you define race or would you? Why is it useful to define race?

2, The Human Genome and Race as of 2000:

In 2000. as the U.S.Govt. celebrated the nearly complete sequence of the human genome leaders of the two research groups spoke to the press, saying the following:

Craig Venter- "There is no basis in the genetic code for race."
Eric Lander- "There is no scientific evidence to support substantial differences between groups."
Aravinda Chakravarti "The differences we see in skin color do not translate into widespread biological differences that are unique to groups."
…. And Bill Clinton "I'm happy that today, the only race we are talking about is the human race."

As a result, the NY Times headline reporting on the achievement was: "Do Races Differ? Not Really, Genes Show."

Yet, just two years later, scientists and others began to debate again whether there was a reality to the idea of race. The next paper played an important role in that debate.

For sections 3 and 4, I would like you to observe the transfer of information from the researcher to the journal to the media and the social implications of its representation to the public. How does this process take place at each step?

3. Use of human genetics to distinguish "groups" (2002-now) and its relevance to Race

I. N.A. Rosenberg et al., Genetic structure of human populations. Science 298:2381-2385 (2002). M.C. King and A. Motulsky. Mapping Human History. Science 298;2342-3 (2002) N. Wade Gene Study Identifies Five Main Populations. NYTimes Dec, 20, 2002.

First, read the Rosenberg *et al.* paper. Note in the same issue of Science the news article featuring the Rosenberg et al . article (this time written by scientists), then the report by Wade in the New York Times and its focus on race; this was a harbinger of a much broader interest in genetics and race both in the public and amongst scientists. Does the Rosenberg et al. paper say anything about race? Why not?

I ran into one of the co-authors of the Rosenberg et al. paper several years ago. One of the first things he said to me was "We were naïve when we published that paper." What do you think he meant?

Some of you may be familiar enough with this work and the STRUCTURE program to understand at least roughly how the analysis in this report was achieved. If not, **were you able to figure out roughly how it was done? T**he two **following papers just below** should help. (Everyone in the class should read them anyway. There is more to them than the technical points.) Wade's article is an example of media coverage. Evaluate it.

II. M.W. Feldman and R.C. Lewontin. "Race, Ancestry and Medicine" pp. 89-101; D. Bolnick. "Individual Ancestry Inference and the Reification of Race as a Biological Phenomenon" pp. 70-85. both are chapters in Revisiting Race in a Genomic Age, eds. B.A. Koenig, S.S.-J. Lee and S.S. Richardson. New Brunswick, NJ. Rutgers University Press. (2008).

Did they help you understand the Rosenberg et al. paper? Note a coincidence concerning one of the chapters' authors.Did they change your view of the meaning/significance of the findings? How did they choose the optimal number of groups to divide peoples into. One question here is how one might use science to tell us whether one can define races biologically. **I would like some to argue for the biological idea of race and some against. How do we define race.**

The second major question is: if one believes that the Rosenberg et al. paper lent itself to misinterpretation, are there ways in which the authors could have presented their paper differently that might have avoided some of the ways in which it was extended to the concept of race? **Come prepared either to argue that the paper need not have been changed or that it should have been.**

If you had read the paper when it was published, do you think that you would have been concerned about what its effects might be?

III. (The article cited at the end of this paragraph is is not included on the course site and is only mentioned for your information). Much more recently, the group of Sarah Tishkoff has shown that a significant limitation to the data used by Rosenberg et al. was that it did not have anywhere near a good sampling of populations from different regions. This was particularly the case for Africa where the samples available to Rosenberg et all came only from a small number of regions of Africa. Tishkoff et al. wentto Africa and obtained a much broader array of samples. The result was that when they used the same Structure program to analyze their data, they discovered that rather than sub-Saharan Africans constituting one group they constituted , it showed 14 groups- groups that were sometimes as distant from each other as the other 4 geographical groups were from each other. This is really not at all surprising- why not? Does this influence one's thinking about biological race? (**M.C. Campbell and S.A. Tishkoff.. The evolution of human genetic and phenotypic variation in Africa. Current Biology 20:R166-R173 (2010).**

IV. J.J. Vitti, M.K.Cho. S.A. Tishkoff and P.C. Sabeti. Human evolutionary genomics: ethical and interpretive issues. Trends in Genetics. 28:137-145 (2012).

What do you think of these guidelines for those writing on issues in this field that relate to race. Would it have helped Rosenberg et al.? Are they sufficient? Anything else you would add?

4. Genes, Evolution and "Cognitive Function?" Science and the Media

This set of readings follows articles published in 2005 that attracted media attention and what followed. Read carefully and critically the one article that I have chosen for this session. Consider the **Science** news article itself and the media coverage and whether they fairly represented the science. Do you see social implications in the article, in the media coverage?

The Scientific Article

P.D. Evans *et al. Microcephalin,* a gene regulating brain size, continues to evolve adaptively in humans. Science 309:1717-1720 (2005).

Read this paper critically. I am only including one of two research papers from the same lab since they are similar. Think about the following questions:

1)What is your evaluation of the speculations made by the authors? Consider the data presented, what is known about the effects of the mutations on gene function or brain function, and what is known about when these polymorphisms arose.

2)Do the authors favor a particular interpretation of their data?

3)Do you think the speculations are warranted? Are there other equally reasonable interpretations of their data? Are there any limits on speculation in scientific papers that scientists tend to accept?

4)After you have read about the coverage below, can you think of ways that it could have been written differently to avoid what followed?

The Science News and Views article accompanying the Evans *et al.* paper

M. Balter. Are human brains still evolving? Brain genes show signs of selection. Science 309:1662-1663 (2005).

Does this Science news article fairly represent the work; the scientists' views? Science usually has a news article on only one scientific article in an issue, if any? Why was this one featured? What is the impact of featuring it?

Resulting Media Coverage

R. Kotulak. Two evolving genes may allow humans to become smarter; researchers say brain shows signs of continuing development. Baltimore Sun. 9/9/2005.
M. Inman. The New Scientist. Human brains enjoy ongoing evolution. 9/9/2005
N. Wade. Brain may still be evolving. New York Times 9/9/2005
V. Griffith. The Financial Times. Human brains still growing larger 9/9/2005

Other coverage: **a)**Chosen as one of **Discover Magazine's** top discoveries of 2005

b)here's a quote from **John Derbyshire, columnist: *National Review Online*, Nov. 2005***:*** "Our cherished national dream of a well-mixed and harmonious meritocracy…may be unattainable."

c)here's an excerpt from the **New Scientist, September 17, 2005** "Whatever advantage these genes give, some groups have it and some don't. This has to be the worst nightmare of people who believe strongly there are no differences in brain function between groups," says anthropologist John Hawks of the University of Wisconsin in Madison.

1)Do you feel that these news reports exaggerated what the scientists said in their papers or that it was perfectly reasonable speculation and correct interpretation of that speculation?

2)Do you feel that there is potential social fall-out from the speculations/news reports? If you do, and you consider the fall-out of some concern, what might you have done differently if you were part of the scientific team? Nothing? Drop out of the project? Suggest alternative interpretations? Suggest altering the paper in some way? How? If the representation has social fall-out, who bears responsibility for making sure no harm is done?

The Story Falls Apart

Then, in December of 2006, **Science** published another news article following-up by reporting studies that falsified the suggestion that the microcephalin polymorphisms might be involved in cognition, etc. Studies reported no correlation with intelligence or head circumference, as well as criticizing the approach used to suggest evolutionary selection had taken place.. There was no significant media coverage of this article and the falsifications. I did find one piece from the Australian Broadcasting Corporation and one from the Wall Street Jourbal..

M. Balter. Brain man makes waves with claims of recent human evolution. Science 314:1871-1873 (2006); J. Skatssoon. Australian broadcast- Researchers bust head size-intelligence link. August 2, 2006; Head Examined: Scientist's Study Of Brain Genes Sparks a Backlash. Antonio Regalado. Wall Street Journal. Jun 16, 2006. pg. A.1

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Look at abstracts of papers that test predictions of Evans *et al.* which are included in the material for this week. (Timpson et al. Comment on Papers by Evans et al., ….. Science **217:**1036a (2007).; J. P. Rushton et al. Biology Letters **3:**157-160 (2007).; Mekel-Bobrov et al. Human Molecular Genetics **16:**600-608 (2007).)

Are there some lessons to be learned from this story about how the authors, the journal and the media handled it? And how to handle the retractions?

Do a Google search on J. Philippe Rushton. He was (dies recently) President of what Fund? What does this Fund do? Why might he have been interested in this subject? Notice reference to him in Vitti et al.

Microbiology 213
Scientists in Wartime
April 25, 2013

Please buy the book "American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer by K. Bird and M. Sherwin., Knopf, New York (2005).

1. From "American Prometheus," read the short preface and Chapters 13-26. Then read ONLY Pages 31-35 of the short Oppenheimer biography in the PDF file Oppenheimer.pdf (from a University of California, Berkeley Website, http://ohst.berkeley.edu/oppenheimer/exhibit/) which gives a brief description of his loss of security clearance.

I recommend that, when you've got a chance, you read the entire book. In addition to what you've read for this session, the book presents a fascinating history of the ferment and excitement in physics in the 1920's and 1930's. Overall, the book also presents significant parts of the social and political history of the country during much of Oppenheimer's life. It is a very rich book.

Be prepared to recount the part of Oppenheimer's history in these chapters. More broadly, consider the role of different scientists in discussions of morality, ethics, politics of this science. Notice the discussions among scientists about their concerns over the development of atomic weapons. Some refused to participate, others participated in such discussions while they were doing the research, others spoke out and suggested sharing atomic secrets with the Russians. Note how many reacted after the use of atomic weapons in Japan. What role should scientists play, what role did they play, what were the effects of their actions, etc.? (On page 549, the authors state "With Oppenheimer's defrocking [1954], scientists knew that in the future they could serve the state only as experts on narrow scientific issues.") In Chapter 24, what do you think of Oppenheimer's views on the importance of science.

What were the different attitudes of scientists towards development of atomic weapons?

What did they do about it?

How and when did their discussions on ethics start?

Did they have special knowledge that made it reasonable for them to try to influence policy? Should the Russians have been invited in?

What do you think of the battle over secrecy where "the rules of science had trumped the principles of military security."

What do you think of Bohr's conception of "the communitarian nature of scientific inquiry?"

Do you get the occasional sense of the scientists' enthusiasm for the development of the bomb purely as a scientific problem? Is it understandable or disturbing?

What do you think the scientists would have done if they had obtained information earlier that led them to think that the bomb would be used in Japan to deter the Russians?

2. J. Conant. Last of the outspoken scientists. Boston Globe, April, 2005.
J. Rotblat. A Hippocratic oath for scientists. Science 286:1475 (1999).

These readings connect to two of the people who are characters in the Oppenheimer book. What role did they play? The Conant article follows the death of Phillip Morrison, who was part of the Manhattan Project. Do you agree with the thrust of her article? What do you think of Rotblat's proposal?

3. Other examples of scientists' interactions with the military.
E.C. Hayden. Bioengineers debate use of military money. Nature 479:458 (2011).
Articles about Harvard Professor Louis Fieser and napalm.

The first article describes a current controversy in science over military uses of biology. Different scientists have different positions on the issue. Where might the different positions come from? In some fields, specific societies of researchers uch as the American Psychological Association and the American Anthropological Association have debated at meetings motions that condemned the use of their fields for certain specific military or war-related ventures- e.g. APA and Guantanamo and AAA and Vietnam.

The second reading (2 articles in one file) describe Professor Fieser and his responses to the use of napalm in World War II and in the Vietnam War. Here one scientist had different reactions to military uses of his science in the case of two different wars. Why?

The third (**I will send to you by Monday)** is a brief recounting of the story of Nobel Prize winner Fritz Haber and his contributions to war and the startling, ironic connection between his work and the gas used in the concentration camps to kill Jews and others. There is a play about Haber- "Einstein's Gift" by Vern Thiessen and a book by Dan Charles.

Microbiology 213
May 2, 2013
Social Activism in Science: The Recombinant DNA Debate and Science Activists

I. Read pages 1-67; 83 to the middle of page 90 of J. Beckwith "Making Genes, Making Waves: A Social Activist in Science" Harvard University Press (2002).

Here, I've been complaining all semester about scientists going to the media, holding press conferences, etc and contributing to misrepresentation of science. Did we (me and my colleagues) do the same thing?

The last section on the situation in my lab during this period may give a sense (perhaps) extreme of what the societal environment was like and how it invaded the lab. Any comments?

Please come prepared with your comments, criticisms and any questions you want to ask me.

II. The Recombinant DNA Controversy

P. Berg et al. Potential biohazards of recombinant DNA molecules. Science 26 July, 1974, p. 303
V. K. McElheny. "Watson and DNA: Making a Scientific Revolution." pp. 220-237. Perseus Publishing, Cambridge (2003).
N. Wade. Genetics: conference sets strict controls to replace moratorium. Science **187:**931-935 (1975).
P. Berg and M. F. Singer. The recombinant controversy: Twenty years later. Proc. Natl. Acad. Sci. USA, **92:**9011-9013 (1995).
D. Nelkin. Threats and promises: negotiating the control of research. Daedalus Spring, 1978 191-210.

This is an instance where leading scientists got together and proposed a moratorium on the use of a particular research technique (recombinant DNA) and ultimately came up with guidelines for carrying out the research. It involves several different perspectives among scientists. Among those who first proposed the moratorium, some continue to point to it as an important instance of social responsibility, while others think it was a mistake. Other scientists felt that it was an elite group of scientists who established the moratorium and guidelines and there should have been more public involvement. Finally, some scientists wanted the discussions to include the prospects of human genetic engineering (e.g.me). In some cases, the public also got involved in discussions of the issues. The debates were pretty fierce at times as you may sense from the excerpt from the biography of Watson. These readings may give you a sense of the different perspectives in the controversy. The calling of the Asilomar Conference likely reflects the environment in which activism among researchers and science students began to flourish in the late 1960's.

There are a number of important questions that arise. There are those who argue that it is a mistake and a dangerous precedent 1)to stop a scientific project that may provide great societal benefits and 2)to air the issues publicly. What do you think?

III. Scientists who acted: Why?

Arthur Galston. Science and social responsibility: a case study. Annals of the NY Acad. Sci. **196:**223-235 (1972)
M. Meselson. Averting the hostile exploitation of biotechnology. CBWCB **48:**16-19 (2000)
American Society for Cell Biology. Statement on Public Service Award to Matt Meselson, (2002)
T.O. Baldwin. Engaging the Public. ASBMB Today. April 2010.
S. J. Gould. Pp. 351-353 in The Mismeasure of Man.
M. Thompson. Students on Front Lines of Public Engagement. ASBMB Today Sept. 2011.

These are instances of scientists or science students who became concerned about certain issues and, by the very nature of the issues, took very different approaches. How do you evaluate these different approaches? What do you think of Gould's praise of "debunking?"