Letters

Ownership of the Human Genome

In "Who owns the human genome?" (Research News, 24 July, p. 358) Leslie Roberts quotes Walter Gilbert as making the astonishing assertion that scientists can map and sequence human DNA, place their findings in a manual, obtain a copyright on that knowledge, and charge their colleagues users' fees for the data contained therein. In my book *Cloning and the Constitution* (*1*), I specifically address the question of whether researchers can acquire proprietary control over such information, concluding that the Constitution forbids the result. Congress, of course, does not own the human genome; nor is there any way under American law for Congress to stake out hegemony over our double helix and transfer a portion of this hegemony to others. The key lies in appreciating the play of the First Amendment. My notion is that the biological universe and our preceptions of that universe comprise an idea marketplace. Debate over competing theories of this biological reality lies at the core of free expression and presupposes universal access to the reality under investigation. As Congress lacks power to punish dissemination of these theories, so Congress lacks power to carve out segments of that idea marketplace and put them in the hands of any person or group to be allocated as these persons see fit. Gilbert can prepare his manual and sell it to willing buyers, but he cannot rely on a franchise from the Congress to protect the sanctity of his product against the discoveries of other scientists and the manuals they publish containing those discoveries. Shakespeare would be entitled to clothe Hamlet's speeches in copyright dress, but Congress could not hand Einstein $E = mc^2$ on a patent platter and similarly cannot (even if it wanted to) hand the human genome to Gilbert. Our genetic constitution belongs to us.

IRA H. CARMEN
Department of Political Science, University of Illinois at Urbana, Champaign, Urbana, IL 61801-3696

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The article "Who owns the human genome?" raises issues about the conduct of research and the dissemination of information that must be clearly formulated if they are to be resolved sensibly. I am concerned that some comments reflecting fears of or distaste with patent and other proprietary rights may stem from a misunderstanding of the role these rights play in furthering public policy goals. Much of the confusion arises because we actually have two separate systems for promoting research and stimulating innovation in this country, both very successful.

One, the private investment system, involves a grant of limited monopoly, usually a patent, for usable research results, which gives the owner a chance to recoup a return on research investment and provides an incentive to make such an investment. The public benefits from the products developed and marketed and from the information that is disseminated when the patent is published. Although publication is slower than in academic channels, it provides a substantial public benefit when compared with the alternative of maintaining secrecy.

The academic system is used primarily when research is funded from philanthropic or public sources. Rapid publication, free exchange of ideas, and extensive collaborative networks are characteristic of this system, which does not directly foster the development and testing of products.

Both systems have been extremely effective at generating creative, innovative research. In my view, it is a mistake to regard either system as superior on moral, ethical, or scientific grounds. On practical grounds, each serves the public effectively for its intended purpose. Furthermore, the two systems complement and extend one another. Research conducted in one system does not damage or limit research conducted in the same general area in the other.

Over the past decade and a half, the level of public support for the academic research system has decreased, and many researchers have turned to the private investment system as a way of maintaining an active lab momentum (research activity). At the same time, the industrial sector has become more attuned to the value of basic research for opening up new product opportunities.

Most of those who conduct academic research would agree that the public interest in a robust, effective academic research system would be severely damaged if the system were to be allowed to atrophy or if too many of its practitioners opted for the private investment system. By the same token, the public interest would be severely damaged if the private investment system were rendered less effective by restrictions designed to limit its scope. I see nothing inherently wrong with commercial activity regarding the human genome, if such activity can lead to alleviation of disease and suffering, as it surely must if the activity is to persist. However, as a matter of public policy, we might conclude that human genomic data are best developed, analyzed, or disseminated by the academic system.

If we want to make a policy decision that the public is better served by conducting human genome research in the academic system, then the solution is to support that system by allocating the necessary resources to it, not to damage the private investment system by restrictive legislation.

LORANCE L. GREENLEE
Greenlee and Associates 5370 Manhattan Circle, Boulder, CO 80303

World Population: Still Ahead of Schedule

Twenty-seven years ago *Science* published a remarkable article, "Doomsday: Friday, 13 November, A.D. 2026," in which it was predicted that world population in the year 2026 would go to infinity (*1*). This startling conclusion was the result of careful analysis of population data going back thousands of years. The article presented an equation that permits computing the population for any given time or the time corresponding to any given population. The equation is

$$\text{Population} = \frac{1.79 * 10^{11}}{(2026.87 - \text{time})^{0.99}}$$

The article attracted wide attention. Not only was it mentioned in *Time* (*2*) and the *New York Times* (*3*), it became probably the only article from *Science* ever to be the subject of three Pogo cartoon strips (*4*).

The article was subjected to severe criticism, but the authors held their ground and with sprightly and entertaining argumentation demonstrated the flaws in the logic of their critics (*5*).

Although the "doomsday equation" fit surprisingly well estimates of human population in the past, there were doubts about how well the equation would fare in predicting human population in the future. A small group of scholars have followed the doomsday equation over the years.

In 1975 Serrin noted that most predictions made at the same time as that of von Foerster *et al.* had ranged from 3 billion to 3.5 billion (*6*). But the doomsday equation, which had predicted a human population of 3.65 billion people in 1975, was closer to the number being reported by the Population Reference Bureau—3.97 billion. The human reproductive capacity had outperformed all estimates and had jumped to a lead of 320 million.

By 1980 the climate of public opinion regarding population had changed dramati-

cally. From concern about "the population bomb" in the late 1960s and the environmental movement of the early 1970s, arguments by revisionist writers began to appear saying that population was coming under control and was no longer a matter of serious concern.

Nevertheless, the Population Reference Bureau reported that world population in 1980 was 4.414 billion. The equation had predicted 3.969 billion. Hence, 20 years after the equation was proposed and after many years of family planning efforts, the equation had proven to be drastically conservative. We were then 445 million people ahead of schedule!

Just how far ahead of schedule we were can be seen by looking at what would have happened if a nuclear war had occurred between the United States and the Soviet Union in 1980 and had destroyed seven-eighths of the populations of both countries. Such an event would have removed about 425 million people from the world population. Thus a nuclear war would merely have served to put us back on schedule.

In the past 7 years the press has reported the success of family planning efforts in China and elsewhere. But given that in 1980 world population was ahead of the historical trend by almost twice the population of the United States, how much progress have we made? The Population Reference Bureau now estimates that world population in mid-1987 was 5.026 billion. However, the Worldwatch Institute says that world population passed 5 billion in July 1986. The equation predicts a population of 5 billion in 1989. As we head into the equation's fourth of six and one-half decades, we are comfortably ahead of schedule.

The current discussion of world population growth lacks a firm foundation. Optimists say that the rate of population growth is diminishing. Pessimists say that more action is urgently needed. The layman or policy-maker is left wondering whom to believe. The doomsday equation has so far provided a useful benchmark for judging what progress we have been making in controlling population growth. It seems that we have not been doing as well as we thought.

STUART A. UMPLEBY
Department of Management Science, George Washington University, Washington, DC 20052

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Math Anxiety

Constance Holden (News & Comment, 8 May, p. 660) and Sanford L. Segal (Letters, 24 July, p. 350) assert, respectively, that female math anxiety is on the wane and that female math anxiety may have been a fiction all along. Since I was among those who originally formulated the problem of female math avoidance as having to do with anxiety (*1*), your readers may be interested in my reflections on the subject.

My staff and I did not tell the students we attracted to the Wesleyan Math Anxiety Clinic, which I codirected in the mid-1970s, that they had "math anxiety." Rather they told us, and not by means of any paper and pencil tests. (We did not use the much quoted Mathematical Anxiety Rating Scale questionnaire. We found it neither useful among our very sophisticated math avoiders nor predictive of their particular problems.) Instead, our counselors and math instructors conducted intake interviews (we called them "math autobiographies") among hundreds (and elsewhere thousands) of students, walking them back through their earliest to their most recent recollections of sweaty palms, stomach upset, and panic.

We did not claim that math anxiety was peculiar to females but found, rather, that while some males admitted fear of math, fear was more debilitating to females. One study (*2*) quoted in my book found a correlation between women students' final grades in an introductory college-level math course (at Ohio State University) and their levels of anxiety; but no such correlation existed for young men. Boys who measured high in math anxiety scored across the board on finals.

The existence of math anxiety among females was supported by the response of current and former students to this new explanation of their difficulties. Operationally, the concept was productive in that it gave counselors and math instructors some new techniques to employ in helping previously unsuccessful math students succeed (*3*).

In the environment at the time, lay people and math instructors alike believed that students had to have a special talent—one not generally distributed over the population and one that was particularly underrepresented in females—to do even elementary college-level math. My interviews of mathematics instructors in the period from 1974 to 1978 revealed that they thought our math avoiders to be quite simply "dumb in math" or lazy; in any case not worthy either of research or of special recruitment. Better, I thought at the time, to believe ourselves "anxious," even "traumatized," than "dumb." At least we can do something about the emotional static that intrudes on concentration. We can do nothing about our brains.

As long as the college math community was letting math avoiders slip through, someone had to help. Reformulating the problem as one of anxiety rather than incompetence was the first—and indeed a most constructive—step.

As a feminist who really believes that once all barriers are removed women will show themselves to be equal to men in all mental endeavors, I would be the first to welcome any evidence that female math anxiety is on the wane, so long as it is not replaced, yet again, with circumstantial evidence—the kind served up year after year by some researchers—of female inferiority.

SHEILA TOBIAS
Department of Political Science, University of Arizona, Tucson, AZ 85721

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Feline Navigation

No wonder "El Blanco" Glassauer (cover, 14 Aug.) is no longer with us. Any object with red on the starboard and green on the port side is bound to run into something as it moves around at night! It is an "eye-catching" cover.

JON AMY
Department of Chemistry, Purdue University, West Lafayette, IN 47906

Erratum: In the Research News article "New family of growth factor genes identified" by Jean L. Marx (7 Aug., p. 602), the researcher Mitchell Goldfarb of Columbia University College of Physicians and Surgeons was incorrectly given the first name Martin.

Erratum: In figure 1 (p. 528) of the Report "Identification of a family of muscarinic acetylcholine receptor genes" by T. I. Bonner *et al.* (31 July, p. 527), the entire deduced amino acid sequence of the human M2 receptor and the sequences corresponding to the third cytoplasmic loops of all the receptors were omitted. A correction appears on page 1628.