THOMAS M. ZINNEN
2000–01 IFT Congressional Science Fellow

2001: A Sequence Odyssey

People enjoy food. Some people even think about food. But they may not think about it enough, or in the ways we wish they would. For example, ask a friend to give three examples of food that comes from stuff that's not alive, and be prepared for a response of silence, salt, and baking soda.

It's a revelation for many people that almost all our food comes from stuff that's alive: plants, animals or microbes. When domesticated, we call them crops, livestock, and cultures.

Recently, news of a completed or nearly completed sequence of a plant, an animal, and a microbe has flashed across the public airwaves, probably without penetrating too deeply into the public awareness. Now *Arabidopsis*, humans, and *E. coli* O157:H7 can be considered from a whole new point of view. Breakthroughs in genomics, like discoveries in recombinant DNA technology 25 years ago, are changing how we look at life and lead our lives. Since almost all of our food comes from living stuff, these new insights will eventually challenge how people think about food.

As IFT's Congressional Science Fellow, I attended the recent annual meeting of the American Association for the Advancement of Science. Genomics was a featured theme. The simultaneous but separate publication of the first draft of the human genome by two rival groups—Celera Genomics and the International Human Genome Sequencing Consortium—was the point of celebration.

Speaking to the 5,000 attendees, Celera's CEO Craig Venter noted how daunting the task of sequencing the 3 billion base pairs of DNA in the human genome had seemed in 1990. Now, Celera's capacity is 2 billion base pairs per month. At that rate, the sequencing of the human genome could be accomplished by one team of no more than 50 people every six weeks. At that rate, sequencing a bacterial genome takes a morning.

Sequencing may someday become as routine as computing in our daily business, at least in those businesses—such as food—that deal with living things.

At the same AAAS meeting, Francis Collins, the leader of the publicly funded consortium, shared several surprising insights:

• The genome is lumpy, not smooth: chromosome 19 is much more crowded with genes than chromosome 18.

• The number of human genes is only about 30,000, far fewer than the 100,000 that was the most commonly reported estimate. Yeast has 6,000; a fruit fly 15,000; the nematode *Caenorhabditis elegans* 20,000; and the crucifer plant *Arabidopsis* 25,000. We have fewer genes than cabbage soup with a fly in it.

• Humans are 99.9% identical at the DNA level, and most of our genetic differences are shared among all ethnicities and races. Thus, the definition of race and ethnicity is something that biological science cannot support, but is rather a social or cultural construct.

If human genomics is profoundly changing how we look at ourselves, consider what food genomics may bring: a better understanding of what the genes in crops, livestock, and cultures are, where they are relative to each other, what they do, and how they are regulated at certain times and in different tissues.

It is straightforward to anticipate new ways of detecting, monitoring, and tracing pathogens. Researchers will better understand the microbial ecology of the production field, the processing plant, the retail shelf, the kitchen counter, and the gastrointestinal tract.

That is in part what we can expect of genomics. But put it another way: what will the public expect of us? What knowledge will they expect from us about food? About food pathogens? About the ways food may interact with specific individuals? We will have to know and share new information about food products as demanded by our customers and our regulators.

For me, the most astonishing surprise in the results of the human genome sequencing was that more than 200 human genes are the result of horizontal transfer from bacteria. These genes have no known homolog or cousin or common ancestor in the fruit fly or in yeast. It seems that bacterial genes have breached the traditional boundaries and are now part of our "stuff." As Collins quipped, this sort of puts a new face on recombinant DNA, doesn't it?

It does. Researchers can ask if genomics uncovers any new risks unique to recombinant DNA technology, or genomic manipulation, or hybridization, or somaclonal variation, or any of the other half-dozen methods used to genetically modify crops and livestock.

Scientists are watching how the range of biotechnology opponents respond to the application of genomic manipulation. Some researchers believe that genomic manipulation will be accepted readily because it does not involve gene transfer across "species barriers." The irony is that genomics is showing that the species barrier concept has limited basis in biology.

Several years ago, the edge of research moved on from genomics to proteomics: the study of all the proteins made by a living thing. The best guess is that humans make about 90,000 different proteins from our 30,000 genes. But the impact of genomics continues because it has transformed how research in the life sciences is organized and funded. It is changing how we look at life, and it may even change how we think about food. ●