Science, Industry and Wealth Creation

By Susanne Goldstein

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Introduction

The evolution of technology and its impact on wealth can be observed in the evolution of science as a source of technological innovation. Until the late 19th century, science and industry "might have lived in other worlds."[1] Basic scientific experiment, as practiced originally by Galileo, was seen as a way of explaining the natural sciences for the pure means of uncovering the mysteries of the world we live in. Science was not "expected to be commercially successful or self-sustaining."[2] Technological innovation, on the other hand, was solely the craft of artisans and inventors.

But in the late 19th century, scientific knowledge helped solve some very serious industrial challenges (specifically around the preservation of food), solidifying scientific research's place as the backbone of technological development and the practical application of science as a vehicle for economic growth. With this came the Second Industrial Revolution, where the lion's share of innovation was done by scientific researchers instead of artisans. What had been a visible world of levers and gears shifted to the invisible world of atoms, molecules… bacteria, viruses and genes."[3] It is this evolution from visible to the invisible, and the eventual transition to a knowledge culture on which this paper will focus. I will use research in human genetics as an example of the next evolution of science-industry relations and its effects on wealth creation and social issues.

The Evolution of R&D

Over the past century, the coupling of scientific research and industry had grown into the very important contemporary function of research and development (R&D). R&D serves an important role in our economy. It is projected that over $283.8 billion was spent on R&D in 2003.[4] R&D has become such an important part of our technological advancement that 70% of the funding comes from non-government sources.[5] One could argue that R&D is the result of the evolution of the partnership between science and industry that began in the Second Industrial Revolution. Rosenberg & Birdzell contend that it was the desire for financial rewards from innovation that spurred the economic growth in the West. They continue, explaining that this "evolution depended upon wide diffusion of the power to undertake and use innovations, coupled with ample rewards for success and penalties for failure."[6] Because of this need for a diffusion of power, the structure of R&D

[1] Rosenberg & Birdzell, "How the West Grew Rich" 1986 Basic Books p243
[2] Ibid p 255
[3] Ibid p 252
[4] Web Site National Science Foundation, Cited Feb. 29, 2004 URL: http://www.nsf.gov/sbe/srs/infbrief/nsf04307/start.htm
[5] Ibid.,
[6] Ibid., Rosenberg & Birdzell p266

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evolved into a spectrum of defined activities from basic research to full commercialization (see figure 1).

Basic research is defined as "the work of scientists and others who pursue their investigations without conscious goals, other than the desire to unravel the secrets of nature.[7]

Applied research is aimed at gaining knowledge or understanding to determine the means by which a specific, recognized need may be met. In industry, applied research includes investigations oriented to discovering new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.[8]

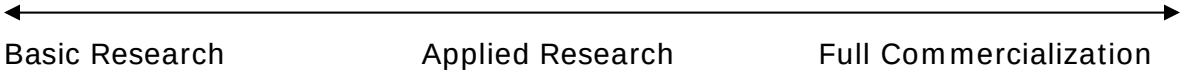

Figure 1: The R&D Continuum[9]

Fully commercial research exists exclusively for the purpose of commercializing and making profit from technological and scientific innovation.

All of these types of R&D are important to our economic growth. But in general, it is fair to say that corporations are not particularly interested in performing basic research because it lacks any potential for profit. For that reason, most basic research is conducted by the government at federally funded research centers or universities.

The Human Genome Project

The mapping of the human genome provides a fascinating backdrop against which to understand the link between scientific research and the creation of wealth. The Human Genome Project (HGP), which formally began in October 1990 as a $3 billion project cosponsored by the U.S. Department of Energy (DOE) and National Institutes of Health (NIH), set out to "discover all the estimated 30,000 to 35,000 human genes and make them accessible for further biological study."[10]

[7] Web Site International Consulting Inc., Cited Feb. 29, 2004, URL http://www.intra-con.com/r_d.htm
[8] Web Site National Science Foundation, Cited Feb. 29, 2004 URL: http://www.nsf.gov/sbe/srs/seind96/ch4_defn.htm
[9] KSG, Roger Porter's Class "The Business and Government Relation in the US", Fall 2003
[10] Web Oak Ridge National Laboratory Cited Feb. 29, 2004, URL http://www.ornl.gov/sci/techresources/Human_Genome/project/hgp.shtml

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The initial impetus of the project could fall under the rubric of basic research, as the goal was to unravel the makeup of human life. But the ambitious project became one of the most contested battles in scientific history.

Dr. Francis Collins was director of the National Human Genome Research Institute. NHGRI acted at the lead for the international research effort. With government funding, Collins et al, set a 15-year plan to map the entire genome.

With a decoded genome, scientists, medical researchers and many others felt that they would have a roadmap by which to solve a vast number of human problems. Many considered the decoding of the genome a "public good," one that is "*non-rivalrous*, meaning that it does not exhibit scarcity, and that once it has been produced, everyone can benefit from it, and is *non-excludable*, meaning that once it has been created, it is impossible to prevent people from gaining access to the good."[11] With the genome in the public domain, no person or organization could exclusively benefit financially from the data uncovered during the scientific discovery process.

Craig Venter felt differently. Venter had been a scientist at the National Institutes of Health. He was disappointed in the amount of time it was taking the federal project to get through the genome. In 1998, he founded Celera Genomics, a private corporation in genome research, and announced that Celera would decode the human genome faster and more economically than the publicly funded consortium of scientists.[12] Venter's motivations were clear; he believed that if his company successfully mapped the genome, he had the "right to sell information he discovered fair and square."[13] Venter's firm, Celera, put money, time and technology toward creating robots and supercomputers that could chart the genome quickly, and within year, pulled ahead of the public genome project.[14]

As both initiatives moved forward, the battle between who would "own" the data from the genome became fierce. The intensity of the debate was magnified by the dollars at stake for the potential winners, which was "a huge amount of money that can be made by understanding how human genes work in normal people and how they misfunction in people that have diseases"[15]

Biology and the study of the "invisible" sciences, it seems, has turned into a focal point of economic growth. Pharmaceutical, biotech, mining, agriculture, and food processing companies are all in position to greatly benefit from the discoveries made through new scientific research.

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[11] Web Site Word IQ, Cited Feb. 29, 2004, URL http://www.wordiq.com/cgi-bin/knowledge/lookup.cgi?title=Public_good
[12] Web Site Edge, Cited Feb. 29, 2004, URL http://www.edge.org/3rd_culture/bios/venter.html
[13] Web Site: NewsHour, Cited Feb. 29, 2004 URL: http://www.pbs.org/newshour/extra/features/jan-june00/genome.html
[14] Ibid.
[1515] Web Site: NewsHour, Cited Feb. 29, 2004 URL: http://www.pbs.org/newshour/bb/health/jan-june00/genome_sharing_3-16.html

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Venter's intention was to file genome patents to ensure the proprietary nature of the work the Celera Genomics was doing. But, as Forbes Magazine's Matthew Harper contests, "the gold rush to patent individual gene sequences will probably yield very little in the way of profits. And that is a good thing, because the development of life-saving medicine depends on genes being accessible to as many companies as possible.[16]

There is stark disagreement on who should actually benefit from the mapping of human genetics. It seems that the apparatus that has fueled innovation to date (scientific and industrial collaboration) may pose some vexing social dilemmas as we move more and more into a knowledge age.

So where do we go from here?

It seems that as we continue to evolve from the industrial revolutions (first and Second) to the new Knowledge Revolution, we must carefully consider how science and industry should interact. Rosenberg & Birdzell indicate that decentralized organization is key to continued technological innovation and therefore economic growth. The question remains, when is it appropriate to interrupt this innovation for the sake of the public good?

Certainly, the partnering of science and industry in the genome project has raised many ethical questions. The Gattaca-esque prediction of a world of genetic prejudice – where genetic perfection will be superior to genetic defect, and regular imperfection may mark a person as inferior – is a particularly scary thought. So much so that before leaving office, President Clinton signed an executive order "protecting federal employees from genetic discrimination in the workplace."[17] So hopefully, we will all be protected from discrimination in the case where genetically we have an 'uncrossed T' in our genetic code. But when is far too far?

The desire for new products and superior processes of the Second Industrial Revolution brought us to a whole new level of scientific discovery, innovation and wealth. As these methods have matured into the Knowledge Revolution of the late 20th century, we must consider whether profit should be the ultimate driver, or a means to a different kind of wealth – perhaps the social kind. As Els Torreele, PhD comments in his paper *From Louis Pasteur to J. Craig Venter: When Biomedical Scientists Become Bio-Entrepreneurs,* "In the transition from the industrial era to the knowledge-based global economy, research is increasingly considered the motor for innovation and progress.[18] The question remains, is the decentralized model of organization still appropriate? Is free market competition appropriate in all areas of research? And if we continue to let a market economy drive innovation, how can we set policy to ensure that public needs are met?

[16] Web Site Forbes Cited Feb 298, 2004, URL: http://www.forbes.com/2002/06/26/0626targets.html
[17] Web Site: NewsHour, Cited Feb. 29, 2004 URL: http://www.pbs.org/newshour/extra/features/jan-june00/genome.html
[18] Web Site: Neglected Diseases, Cited Feb. 29, 2004 URL http://www.neglecteddiseases.org/3-3.pdf

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We all know that it is the prospect of profits that attracts investors to fund R&D. If the preponderance of R&D dollars are going to continue to function as part of a market economy, perhaps we must find ways to tie research to economic imperatives. AIDS, for example, AIDS is now an economic as well as health issue. By tying the economic impact of widespread disease to long-term profitability and economic growth, we might be able to create an economic imperative for stopping disease. Perhaps it is possible to convince well-funded firms to pursue R&D strategies that will help the public good.

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