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# Innovation as a social bubble: The example of the Human Genome Project

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ABSTRACT

In this paper we present a detailed synthesis of the development of the Human Genome Project (HGP) from the mid 1980s through 2000, in order to test our hypothesis of "social bubbles", which claims that strong social interactions between enthusiastic supporters weave a network of reinforcing feedbacks that lead to widespread endorsement and extraordinary commitment by those involved, beyond what would be rationalized by a standard cost-benefit analysis in the presence of extraordinary uncertainties and risks. The HGP was initiated as a public project funded by government agencies, starting at a moderate pace. The progressive introduction of different actors and the development of various interests catalyzed the project, which eventually became eminent both in the public and private sectors. The competition between the public and the private sector played greatly in favor of both: the financial burden as well as the horizon of the public project were significantly reduced, the private project(s) gained from the hype of the public project, yet had to play an active and collaborative role in order to remain in the game. This is at the core of the social bubble hypothesis. To further our argument, we present quantitative analysis of the development of the biotech sector within the financial stock market. Lastly, we point to the fact that the hypes fueling the bubble during its growth have not been followed by real tangible outcomes over the short expected time horizons. Indeed, at the time of writing (May, 2011), the consensus of the scientific community is that it will take decades to exploit the fruits of the HGP.



> "And all this back and forthing over who did what and what strategy was used and which money was public and which was private is probably going to sink below the radar screen." (Francis Collins)[1]

> "The prevailing view is that the genome is going to revolutionize biology, but in some way, it's overhyped. In the end, the real insights are coming from individuals studying one gene at a time in real depth." (Gerald Rubin)[2]

## 1. Introduction

What if projects of large magnitudes do not just happen because they are important or even vital but because particularly favorable conditions inflate them to sizes that are out of proportion to any cost-benefit analysis? What are the catalysts, the driving forces of such large-scale scientific and technological projects? And more specifically: what are the major influences that motivate investment into such projects?

In order to tackle such questions, we have developed the "social bubbles" hypothesis, which recognizes that, in major projects, social interactions between enthusiastic supporters weave a network of reinforcing feedbacks that lead to widespread endorsement and extraordinary commitment by those involved in the project (Gisler and Sornette, 2009, 2010). The term "bubble" is borrowed from the financial economic literature in which a bubble is defined as a transient appreciation of prices above fundamental value, resulting from excessive expectations of future capital gain. Robert Shiller in Irrational Exuberance (2000) – published at the height of the dot-com bubble – proposed twelve factors that "propelled the market bubble", among them cultural and political changes favoring business success, challenging the role of specific judgment biases in finance. Similar characteristic scenarios have been described by Galbraith (1997), Kindleberger (2005), Sornette (2003) and Sornette et al. (2009), corresponding to five steps in the development of a typical bubble: (i) displacement, (ii) credit creation, (iii) euphoria, (iv) critical stage/financial distress, and (v) revulsion. The concept of a bubble implies implicitly a split from an underlying mechanism, some excess elements and the burst that may follow.

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[1] Francis Collins, interview with Leslie Roberts (19 August 1999; Roberts et al., 2001/291).

[2] Gerald Rubins, interview with Elizabeth Pennisi (February 2000; Roberts et al., 2001/291).

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The term "bubble" in a financial context is synonymous with market failure and systemic risks. In contrast, the social bubble hypothesis embodies a more positive vision: we propose that social bubbles provide an essential catalyzing element in the formation of major projects, which may lead to great innovations.[3] A social bubble is a phenomenon that develops in a social system during a technological or scientific project, in which the following symptoms should be simultaneously present:

- strong support for a specific idea/invention by different actors, including the public;
- credit creation via public and private investment;
- proliferation of ventures of all kinds;
- accelerated price growth of corresponding firms trading on organized stock markets;
- saturation of the idea and abrupt program termination (the exploration or development comes abruptly to an end, with open criticism).

Our focus is thus on the social interactions that lead to widespread enthusiasm and extraordinary commitment to the particular project. The basic idea (scientifically, technologically) of the project attracts a major group of people that are potent actors of the play (scientists, entrepreneurs, venture capitalists, the public via the government). Their enthusiasm leads them to ignore risk considerations; instead they focus on the expected returns of the invention or innovation. We expect to find these actors ready to throw in their reputation and time as well as their money, without weighing the consequences as viewed from a reasoned assessment.

The purpose of the present paper is to present an analysis of the Human Genome Project (HGP) in order to test our social bubble hypothesis. The HGP was a genuine innovation in the molecular biology sector that began formally in 1990, coordinated by the U.S. Department of Energy and the National Institutes of Health. The HGP was completed officially in 2003. It was one of the largest international scientific research projects, with the primary goals of determining the sequence of chemical base pairs which make up DNA and identifying and mapping the approximately 20,000–25,000 genes of the human genome from both a physical and functional standpoint (Watson and Cook-Deegan, 1991; Cook-Deegan, 1991, 1994; Gilbert, 1992; Hilgartner, 1994, 1997, 1998, 2004; Koonin, 1998/279; Jordan and Lynch, 1998; Roberts et al., 2001/291; Kieff, 2003; McElheny, 2010). It was launched on the rationale that, with all the genes identified and available in computerized data banks, genetic mapping[4] and sequencing data would utterly transform biology, biotechnology, and medicine in the next century (e.g. National Research Council, 1988).

The public HGP, the International Human Genome Sequencing Consortium (IHGSC), brought together scientists at 20 institutions in six countries: France, Germany, Japan, China, the UK and the U.S., including the Wellcome Trust Sanger Center (now Sanger Institute), Hinxton, Cambridgeshire, UK; the Whitehead Institute/MIT Center for Genome Research, Cambridge, MA, USA; the Washington University School of Medicine Genome Sequencing Center, St. Louis, MO, USA; the Joint Genome Institute, U.S. Department of Energy, Walnut Creek, CA, USA; to name but a few.[5]

The private faction, on the other hand, is much more difficult to fully identify. This is due to the fuzzy concept of genomics as such, the definition of genomics used to be and remains to be imprecise. Moreover, not all firms that are interested in genomics have directly taken part at or profited from the Human Genome Project. Nevertheless, with Cook-Deegan (1991) it can be stated that private investment in genomics was virtually nil when the public Human Genome Project was launched.

In the early 1990s, the first genomic startup firms appeared; companies such as *Human Genome Sciences* (HGS), *Hyseq*, *Mercator Genetics*, *Millennium Pharmaceuticals*, *Myriad Genetics*, and *Sequenom* were created. *Incyte* shifted from doing contract research for *Genentech* and turned its attention to genomics; *Collaborative Research* changed its name to *Genome Therapeutics* to reflect its emphasis on genomics. These first ferments of private interests later proliferated to more than 300 firms, which had significant aspects of their business plan based on genomics. These firms were not necessarily contributing to the mapping and sequencing process, which was the target of the public project. Rather they played a major role in developing technology serving sequencing or commercializing genomics products.

Not all genomics companies were startups, though. Some firms moved into genomics from other lines of business. Large and established firms such as *Perkin-Elmer*, *Hewlett-Packard*, and others, have developed technologies for both the public and private genome laboratories (Chandrasekharan et al., 2009). And not all firms had the same strategies and targets. Some firms (e.g., *Genome Express*, *SeqWright*) are service firms that do DNA sequencing or conduct DNA-based analyses sent to them by research laboratories. Some of them also do DNA forensics or genetic testing (e.g., Myriad Genetics). Some firms make instruments (e.g., *Applied Biosystems* (initially *Perkin-Elmer Cetus*, then *PE*, and later *Applera*)). Others develop analytical software intended for whole-genome analysis, mining DNA sequence databases, or interpreting data on very large numbers of probes or gene expression arrays (e.g., *Affymetrix*, *Gene Trace*, *SuperArray*, Sequenom, Hyseq) (Cook-Deegan et al., 2000). We can observe that more and more of the biotech industry endorsed and rode the HGP bandwagon, as it developed, the distinctions hence blurring.

Financial aspects associated with the HGP helped put in perspective its development and the enormous size of the required efforts. Indeed, the costs of the HGP were initially estimated at about $3 billion, a sum that engendered great concern, raising fears about "big science" and the effect that a project of this magnitude might have on other areas of biological research (DeLisi, 1988; Roberts, 1990/248). This figure of $3 billion had come up in an early dis-

[3] Concepts such as 'creative destruction' (Schumpeter) or 'paradigm shift' (Perez) go in a similar direction. Perez (2002, 2009) holds that processes of destruction and reemergence result in huge successes that can induce an atmosphere of excitement at last. Technological innovations are followed by financial ones; the world of finance itself being among the pioneers in adopting the new paradigm, especially in organization, equipment, transport and communications. It rapidly invents, learns and diffuses new ways of providing venture capital, of attracting new investors and new capital to the market and of leveraging, handling, hedging and spreading risk.

[4] Genome mapping is the creation of a genetic map assigning DNA fragments to chromosomes.

[5] The others were Baylor College of Medicine Human Genome Sequencing Center, Department of Molecular and Human Genetics, Houston, TX, USA; RIKEN Genomic Sciences Center, Yokohama-city, Japan; Genoscope and CNRS, UMR-8030, Evry Cedex, France; Genome Therapeutics Corporation (GTC) Sequencing Center, Genome Therapeutics Corporation, Waltham, MA, USA; Department of Genome Analysis, Institute of Molecular Biotechnology, Jena, Germany; Beijing Genomics Institute/Human Genome Center, Institute of Genetics, Chinese Academy of Sciences, Beijing, China; Multimegabase Sequencing Center, The Institute for Systems Biology, Seattle, WA; Stanford Genome Technology Center, Stanford, CA, USA; Stanford Human Genome Center and Department of Genetics, Stanford University School of Medicine, Stanford, CA, USA; University of Washington Genome Center, Seattle, WA, USA; Department of Molecular Biology, Keio University School of Medicine, Tokyo, Japan; University of Texas Southwestern Medical Center at Dallas, Dallas, TX, USA (no longer in operation); University of Oklahoma's Advanced Center for Genome Technology, Department of Chemistry and Biochemistry, University of Oklahoma, Norman, OK, USA; Max Planck Institute for Molecular Genetics, Berlin, Germany; Cold Spring Harbor Laboratory, Lita Annenberg Hazen Genome Center, Cold Spring Harbor, NY, USA; and Gesellschaft für Biotechnologische Forschung mbH (GBF) – German Research Center for Biotechnology, Braunschweig, Germany.