NBER Productivity, Innovation and
Entrepreneurship Program
Call for Research Proposals

Who Influences the Direction of Innovation? Evidence from CRISPR/Cas9

Grant Proposal for the Innovation Policy Group
Deadline: May 1, 2016

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Project Description

The diffusion of new technologies and their impact on the direction of scientific change is a central issue in the study of innovation. In this paper, we propose to examine how the introduction of a breakthrough research technology affects the trajectory of a scientific field. Specifically, we will look at the impact of the genome editing system CRISPR/Cas9, called the "biggest game changer to hit biology since PCR" (Ledford 2015). Introduced in 2012, CRISPR/ enables precise DNA editing and carries the potential to develop everything from blight resistant crops to targeted genetic drug therapies. We are interested in which scientists take up the mantle of this new technology, particularly in mammalian organisms where CRISPR/Cas9 provides the biggest incremental improvement. Are these new researchers? Researchers in adjacent scientific areas? Or perhaps it is just that existing researchers in these areas are made more productive or grow the size of their labs?

Clustered Regularly Interspaced Short Palindromic Repeats (CRISPRs) are distinctive sequences of DNA that were first noticed in bacteria as early as 1987. The CRISPRs, which consist of a repeated DNA sequence appearing between unique DNA sequences, were largely a curiosity until 2007. That year, CRISPRs' role in the bacterial immune system became well understood (Barrangou et al, 2007). Five years later, in 2012, scientists from UC Berkeley discovered that CRISPR when paired with an enzyme called Cas9, could be used to target and cut any identified DNA sequence in bacteria (Jinek et al. 2012). However, it was not until scientists at MIT and Harvard proved six months later (Cong et al. 2013, Mali et al. 2013) that CRISPR/Cas9 could be used to edit mammalian DNA that interest in the technique exploded. In a recent *Nature* article, a geneticist from Cornell with 30 years experience in the field, John Schimenti noted, "I've seen two huge developments since I've been in science: CRISPR and PCR… CRISPR is impacting the life sciences in so many ways" (Ledford 2015). Since 2012, the number of published papers mentioning CRISPR went from less than 200 per year to more than 600 per year in 2014 (Ledford, 2015). Likewise, patenting and financing of biotech companies involving the CRISPR technology has also exploded (Ledford 2015). In 2012, there were fewer than 25 patent applications mentioning CRISPR but by 2014 there were over 150 applications. New biotech firms founded around the CRISPR technology had raised over $150 million by the end of 2014.

To investigate CRISPR/Cas9's impact, we plan to use two datasets on genetic engineering research histories. The first comes from the biological resource center, Addgene, which identifies researcher experimentation with CRISPR/Cas9. Addgene, a non-profit company, was founded in 2004 to help scientists easily store, search for, and share plasmids[1] for use in biological research (Fan et al., 2005). The organization is a repository that helps facilitate the exchange of genetic material between laboratories by storing plasmids and their associated cloning data donated from academic labs all over the world. Addgene also performs quality control on all donated plasmids and can ship validated materials to academic laboratories worldwide for use in scientific research. Addgene has provided us their entire database of available plasmids and ordering records. The second, Web of Science, details publication histories for academics that produce papers in genetic engineering and are 'at-risk' for adopting CRISPR/Cas9.

Our data will allow us to understand the mix of scientists that contribute to this burgeoning area of science. For example, CRISPR/Cas9 could make incumbent mammalian researchers more productive and cause an increase in the rate of paper production. Or, researchers that previously worked with bacterial organisms could shift their focus to mammalian organisms as it becomes easier to work with them. Or new researchers (e.g. post-docs) could be enticed to enter the field of genetic engineering in greater proportions after the introduction of CRISPR/Cas9. Alternatively, shifts in the direction of research could be driven more by factors such as access to the informal knowledge needed to use CRISPR/Cas9, and thus is more related to geographic proximity or pre-existing scientific collaborations.

[1] Plasmids are DNA sequences that added to host cells to introduce new genes.

Most promisingly, our data allow us to look not only at who publishes in a field, but who *tried* to adopt the technology (irrespective of whether they succeeded and published in that area, or failed). That is, we can observe *experimentation* with a new technology. This will allow us to explicitly examine questions that have been central to innovation. For example, how much does the implicit knowledge around a tool influence adoption? Since Addgene distributes CRISPR / Cas9 widely, we can then determine the factors that make success more likely, such as: previous experience, quality of PI or institution, and location of institution.

The proposed project provides a foundation for an exciting set of novel research on how innovations are used in scientific communities and their influence on future directions of science in this new and rapidly changing setting.

Funding

We would like to request funding of $20,000 in the area of Innovation Policy. The funds will primarily be used to support a semester of PhD research assistance time to build the build and integrate the datasets and begin the analysis. The remainder will be used to fund travel to speak with genetic engineers from different communities to better understand the decision process to adopting CRISPR/Cas9 and for presenting the work at conferences.

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ACADEMIA

Assistant Professor (MIT, Sloan School of Management) 2013 –
- Teaching: Competitive Strategy, Experimental Innovation Lab (X-Lab)

PhD in Business & Public Policy (Berkeley, Haas) 2007 – 2012
- PhD Minor: Computational Science and Engineering (Big Data Option)

Masters in Statistics (Berkeley) 2010 – 2012

Masters in Computer Science (Berkeley) 2008 – 2012

Masters in Economics (London School of Economics) 2003 – 2004

Bachelors in Economics / Int'n Development (Queen's) 1997 – 2001

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RESEARCH

Moore's Law goes Multicore: Economic Implications

What happens after Moore's Law Ends? (with Leiserson et al.)

Effect of IP on Academic Science (with Mowery and Ziedonis)

Non-parametric clustering for data set matching (with Broderick et al.)

Synthetic Biology: CRISPR/CAS9 usage dissemination (with Zyontz)

How Wikipedia shapes Academic Research (with Greenstein and Fry)

Empirics of Patent Races and Patent Scope (with Kuhn and Roin)

How firms execute on their Strategy (with Sull, Hu and Kang)

BUSINESS

AMD (oncology diagnostics start-up with ~$2M funding) 2008 –
Business Advisor and on the Board of Directors

Lawrence Livermore National Laboratory 2008 – 2010
Technology Transfer & Commercialization Intern
- Work on next-generation nuclear power and on technology transfer

Bain and Company 2004 – 2007
Senior Associate Consultant (UK, South Africa & Australia)
- Advised corporate leaders of FTSE 100 companies
- Led a group of 10+ in a multi-million dollar improvement program

Previous Employers
United Nations (Poland), Canadian Embassy (Egypt), Canadian Parliament, Canadian Department of Foreign Affairs, World Bank

ACTIVITIES

Associate Member, Broad Institute - Genetics 2015 – 2016

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