

# Annotated Bibliography: CRISPR

*Andie Bisk*

## Part I: Source Analysis

**Guerrini, Christi J., Evan Spencer, and Patricia J. Zettler. "DIY CRISPR." *North Carolina Law Review*, 2019, 8 May 2019.  
[https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3365421](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3365421)  
#**

1. This article is written by Christi J. Guerrini, Evan Spencer, and Patricia J. Zettler, and published in the *North Carolina Law Review*, student-operated academic journal that publishes "outstanding legal scholarship" to the Carolina Law community. While the journal does not publish only scholarly articles, this specific article is considered to be a scholarly source (I think it was published in a different academic journal that was peer reviewed but I could not find it, so I am not actually counting this source as one of my legit scholarly articles, and instead this will be considered as an "article of my choosing").
2. The purpose of this article is to present qualitative interviews with 40 practitioners of "citizen science/DIY biology" which is a different terminology for biohacking. It also provides a detailed account of the government oversight (both internal and external) to regulate applications of CRISPR technology, and how citizen science tiptoes around these regulations by creating their own methods of self-regulation. The authors point out the concern that citizen scientists using CRISPR for human applications is potentially very risky (and often times illegal) due to its nature of

human experimentation for results. Because it is an article written by people with a background in law, they offer insight on how to improve oversight capacities of the government to crack down on illegal citizen science.

3. This source lends credibility to my argument on government regulation of the sciences with regards to biohacking and CRISPR technology because it was written by professors who teach law and have experience in navigating how government regulation works and how it can be used to curb the dangers included under the umbrella of citizen science. This article is important because it will act as a bridge between my first and second conversations, and provides me with information regarding government procedures (which I lack a background in). Because the article was written by experts in the field of law, I can trust that their information and research presented is reputable and accurate.
4. The main limitation I found within the source is not being able to deduce whether it is truly a peer-reviewed scholarly article, or whether it is simply an academic paper written by experienced professionals in the field. While I do not deny that the authors can be considered credible sources, there are limits with which I can claim accuracy within the paper as I cannot confirm that it has been peer reviewed or not. Additionally, the article itself mentions that its analysis has several limitations regarding its focus on citizen science, and points out that it only discusses applications of DIY CRISPR, and does not go into any other type of citizen science, and the topic of CRISPR in this article is limited only to its possible human applications and cannot be applied to another

field of usage. It also discusses that it is only focused on US laws and scientific regulations, and this cannot be applied to another country's scientific norms and institutional rules. However, I plan to discuss biohacking solely in the US, so this limitation will not have an effect on the information I present.

*Article Information page from Database*

The screenshot shows the SSRN article page for "DIY CRISPR". The article is from the *North Carolina Law Review*, 2019, 60 Pages, posted on 8 May 2019. The authors listed are Christi J. Guerrini (Baylor College of Medicine; University of Houston Law Center Intellectual Property and Information Law Institute), Evan Spencer (University of Houston Law Center), and Patricia J. Zettler (Ohio State University (OSU) - Michael E. Moritz College of Law). The date written is April 4, 2019. The abstract begins: "Although scientists have been manipulating genomes since the 1970s, the recent discovery of Clustered Regularly Interspaced Short Palindromic Repeats ("CRISPR") has expanded the possibilities not only for what gene editing might accomplish, but also who might accomplish it. Because CRISPR is relatively easy, efficient, and inexpensive, it is accessible to individuals — known as "citizen scientists" — who work in nontraditional laboratory settings and may not have formal scientific training. Prompted by concerns about human applications of CRISPR, the United States is co-hosting a series of international summits on human gene editing, while organizations around the world race to issue their own reports and recommendations. For the most part, however, these efforts have focused on the use of CRISPR by professional scientists working in institutional settings who are already subject to layers of formal and informal oversight. They have largely..."

On the right side of the page, there is a section titled "Here is the Coronavirus related research on SSRN" with a "View the research" button. Below that is a "Paper statistics" table:

DOWNLOADS	ABSTRACT VIEWS	RANK
117	985	250,535

There are also 54 references and PlumX Metrics (represented by a colorful icon) shown on the page.

**Hather, Gregory J., et al. "The United States of America and Scientific Research." *PLoS ONE*, vol. 5, no. 8, Public Library of Science, 16 Aug 2010, p. e12203, doi:10.1371/journal.pone.0012203.**

1. This source is a scholarly article written by Gregory J. Hather, et al. and was published in the *PLoS ONE* journal, which is an open-access peer reviewed academic journal.
2. The purpose of this article is to provide an objective analysis utilizing solely quantitative research to measure the state of scientific research in the US (from the 1960s to the present) in comparison to the EU and China (since 1996)— with regards to

federal research funding (FRF) and with US gross domestic product (GDP), as well as industry research spending. This article provides concrete evidence that US federal contributions to scientific research has slowed in recent years, and continues to generate most of its funding towards basic research, while the actual industry is shifting towards a focus in developing products that years of research have gone into. The article points out that although the US has a strong system of university-backed research compared to the EU and China, it is falling behind to China and the EU in the race to create new scientific innovations that have the potential to improve the lives of the public. The article points out that it is important for the US government to consider how the US will continue to excel in the sciences, and continue to produce exceptional research in the years to come (without increasing the allotted federal budget— which will most likely not change in the near future).

3. I chose this source due to its detailed research on US federal spending specifically on scientific research, and its decline in the past couple of decades. This idea is important as it fits into my second conversation explaining why many non-scientists (and even some accredited scientists) are turning to biohacking as a way to test extreme experiments that would generally not get approval by the government, nor would they ever receive funding for such experiments (although the article never mentions biohacking). I plan to use this information to formulate my argument that decreasing federal spending and high levels of regulation are causing people to turn to extreme measures in

order to test questions we have about the extent one can go to achieve perfection through body augmentation and DNA editing technology. Additionally, because this is a scholarly article written by authors affiliated with top research institutes (such as the Seattle Children's Research Institute and the Natural Environmental Research Council, as well as several top universities like McGill University and the University of Washington), I can trust that the information is provided by experts in the field, and is accurate, reliable, and has been peer reviewed (because it was published in an academic journal, and explicitly states that it was peer reviewed) by other experts in the field. The article's research was also funded by the NIH, which is a highly credible research facility in the US.

4. The authors point out that there are limitations within the data analysis due to issues with the comparability across regions. They point out that the data does not measure the skill level necessary to acquire a doctoral degree, the value of the patents granted, or the actual originality of the papers published in the various regions studied, and that these qualities will differ between the US, EU, and China. They also mention that the data is purely qualitative because qualitative data provided for this study would be too subjective to be considered an accurate measure to be used for analysis. This article also holds limitations for me because it is a piece that is solely concerned with federal spending comparisons between the US, EU, and China, and can only be used for data about these issues. However, it will still be a valuable

resource that will allow me to explore the challenges of needing federal funding and regulation to go through with a legal scientific study, and why biohackers are straying away from this.

*Article Information Page from Database*

The screenshot shows the PLOS ONE article page for "The United States of America and Scientific Research". The page includes the PLOS ONE logo, navigation links (PUBLISH, ABOUT, BROWSE), a search bar, and a "RESEARCH ARTICLE" label. The article title is prominently displayed, followed by the authors' names: Gregory J. Hather, Winston Haynes, Roger Higdon, Natali Kolker, Elizabeth A. Stewart, Peter Arzberger, Patrick Chain, Dawn Field, B. Robert Franza, Biaoyang Lin, Folker Meyer, Ural Ozdemir, Charles V. Smith, et al. The publication date is August 16, 2010, and the DOI is https://doi.org/10.1371/journal.pone.0012203. On the right side, there are statistics: 53 Saves, 21 Citations, 14,290 Views, and 22 Shares. Below the statistics are buttons for "Download PDF", "Print", and "Share". The article content is organized into sections: Article, Authors, Metrics, Comments, and Media Coverage. The "Abstract" section is visible, starting with "To gauge the current commitment to scientific research in the United States of America (US), we compared federal research funding (FRF) with the US gross domestic product (GDP) and industry research spending during the past six decades." An advertisement for "CALL FOR PAPERS: LIVER DISEASES" is also present on the right side.

**Riley, Margaret Foster. "Federal Funding and the Institutional Evolution of Federal Regulation of Biomedical Research." *Harvard Law & Policy Review*, vol. 5, no. 2, July 2011, pp. 265-287. EBSCOhost, [search.ebscohost.com/login.aspx?direct=true&db=aph&AN=67026608&site=ehost-live&scope=site](http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=67026608&site=ehost-live&scope=site).**

1. This source is a scholarly article written by Margaret Foster Riley, and was published in the *Harvard Law & Policy Review* journal, which is a peer reviewed academic journal.
2. The purpose of this article is to examine the institutional evolution of government regulation of biomedical research and innovation, and whether federal funds allotted to the industry

have caused this evolution to occur. Riley explains that federal funding has played a vital role in the (recent) eventual dominance of academics in the industry, and that regulations have not changed to accommodate for this new influx, even though the current academic model for research has been modified. Riley exhibits the gaps in government oversight and works to prove that the current IRB model is not as effective in regulating biomedical research as it once was because it does not deal with many of the new conflicts of interest that have appeared in recent years. In addition, incentives for research are becoming more profit based rather than based on science.

3. This source is credible in its explanations of law and government oversight because it was written by a professor of law who has experience and expertise in the field and is knowledgeable on the given subject. While many sources may touch on the idea of how government regulation and federal funding affects how biomedical science is researched and treatments are approved, because this was written by an expert of law, Riley is able to offer valuable insight that is not present in sources written by someone without this level of expertise. Because she is an expert in the field, her paper is considered highly reputable and can be trusted to provide accurate and reliable information.
4. Because this article was written by a professor of law, the article is filled with advanced law jargon that I (a freshman with absolutely no experience studying law) do not completely understand. Scholarly articles are written for other scholars in the field, so Riley does not need to address jargon utilized because she

assumes that anyone reading her article has the necessary background to comprehend her paper and understand her main argument. Because I lack this background in law (and my paper is not a piece that focuses strictly on government oversight procedures), I am limited in what I am able to use in my paper from this source. However, it provides excellent background in how federal funding is regulated in the biomedical industry, and how it has acted as the basis of authority in what can constitute an experiment and what is considered to adhere to appropriate ethical standards.

*Article Information Page from Database*

<b>Federal Funding and the Institutional Evolution of Federal Regulation of Biomedical Research.</b>	
<b>Authors:</b>	Riley, Margaret Foster <sup>1</sup>
<b>Source:</b>	Harvard Law & Policy Review. Jul2011, Vol. 5 Issue 2, p265-287. 23p.
<b>Document Type:</b>	Article
<b>Subject Terms:</b>	*MEDICAL research *FEDERAL regulation *EVOLUTIONARY theories *FEDERAL aid to medical research *FINANCE *HUMAN biology *LEGISLATIVE oversight *RESEARCH
<b>Geographic Terms:</b>	UNITED States
<b>NAICS/Industry Codes:</b>	541712 Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)
<b>Abstract:</b>	The article focuses on the institutional evolution of the <b>federal regulation</b> of biomedical research in the U.S., as well as the <b>federal</b> funding on the evolution. It defines biomedical research as a basic scientific research into human biology and its applications, clinical treatments and medical procedures. It explores the history and evolution of the biomedical research enterprise in the United States through the 1970s. It examines the effect of the Bayh-Dole Act on the enterprise and how funding has been refocused. More specifically, it describes the gaps and functioning of <b>federal</b> oversight over medical research.
<b>Author Affiliations:</b>	<sup>1</sup> Professor of Law, University of Virginia School of Law
<b>ISSN:</b>	1935-2077
<b>Accession Number:</b>	67026608

**Samuel, Sigal. "How Biohackers are Trying to Upgrade their Brains, their Bodies— and Human Nature." *Vox*, 15 Nov 2019,**



**<https://www.vox.com/future-perfect/2019/6/25/18682583/biohacking-transhumanism-human-augmentation-genetic-engineering-crispr>.**

1. This source is a current popular article published online by *Vox*, written by Sigal Samuel.
2. The purpose of this article is to inform the public about what biohacking is, and the various reasons why people from all walks of life are gravitating towards the movement. The article is formatted to include “9 questions about biohacking you were too embarrassed to ask,” a common formula that *Vox* writers use to present novel ideas and events in a way that directly connects with their audience. This format assures them that they are not the first to have basic questions about popular topics such as this, and thoroughly answers these questions in a way that makes sense and stays away from subject-specific jargon that may complicate the piece. This article provides an introductory explanation of what biohacking is, as well as providing several concrete examples of ways people are carrying out these experiments. It also touches on the fact that it is not always backed by strong scientific research, is completely unregulated by the government (which can be considered a pro or con depending on whom you ask), and has the potential to be incredibly dangerous. This article is important because it provides a decent (but basic) introduction to a multifaceted and polarizing topic that much of the public may know very little— if anything at all— about.
3. Samuel’s article is valuable towards my argument because it provides a decent explanation on the basics of biohacking

technology and discusses both the arguments of supporters and critics. Additionally, Samuel is a credible, educated, and award-winning author who has been published numerous times in other popular news outlets such as *The Atlantic* and has made appearances on BBC and CBC, which are championed as reputable media corporations. Due to her experience in the field of journalism, I can trust that she reports facts that have been thoroughly researched (although her piece is not supposed to be completely objective), and can ensure that her article's purpose is not supposed to push one sort of ideal, but rather is supposed to introduce a topic from all angles. I chose this source due to its comprehensive explanation of the ins and outs of biohacking, as well as its potential to bring me into my second conversation detailing why one may turn to biohacking rather than relying on government-regulated scientific research done by an accredited scientist.

4. This source is limited, however, due to the article not being a totally objective piece, and Samuel often subtly inserts her opinion into the article (mainly through her word choice in how she chooses to explain various ideas). By introducing biohacking experimentation using defamiliarization techniques to present these concepts in an unfamiliar way, she moderately explains the information in a way that makes the audience lean towards her side of the argument (that paints biohacking as unusual and dangerous) without even realizing that they are doing so. While I do actually agree with her argument, the purpose of my piece is not to paint biohacking as a terrible effect of unregulated science, but rather as an uncouth new facet of

biotechnological innovation that has come about due to scientific experiments taking decades to be approved, and the overall extreme expenses of life-saving medicines developed— although it is important that I recognize and explain the dangers of biohacking.

*First Page of Article*

# How biohackers are trying to upgrade their brains, their bodies — and human nature

9 questions about biohacking you were too embarrassed to ask.

By Sigal Samuel | Updated Nov 15, 2019, 12:10pm EST

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Even if you haven't heard the term "biohacking" before, you've probably encountered some version of it. Maybe you've seen Twitter CEO Jack Dorsey extolling the benefits of **fasting intermittently and drinking "salt juice" each morning.**

Maybe you've read about former NASA employee Josiah Zayner **injecting himself with DNA using the gene-editing technology CRISPR.** Maybe you've heard of Bay Area folks engaging in **"dopamine fasting."**

Maybe you, like me, have a colleague who's **had a chip implanted in their hand.**

These are all types of biohacking, a broad term for a lifestyle that's growing increasingly popular, and not just in **Silicon Valley**, where it really took off.

Biohacking — also known as DIY biology — is an extremely broad and amorphous term that can cover a huge range of activities, from performing science experiments on yeast or other organisms to tracking your own sleep and diet to changing your own biology by pumping a

**Zhang, Sarah. "A Biohacker Regrets Publicly Injecting Himself with CRISPR." *The Atlantic*, 20 Feb 2018, <https://www.theatlantic.com/science/archive/2018/02/biohacking-stunts-crispr/553511/>.**

1. This source is a current news article published online by *The Atlantic* and was written by Sarah Zhang.
2. The purpose of the article is to exhibit how the biohacking movement is creating waves in the realm of biological innovation and research and the dangers that lurk behind these experiments. The article is formatted into an interview transcript with one of the infamous and notoriously polarizing leaders of the biohacking movement: Josiah Zayner. Zhang uses guiding questions to probe Zayner for the types of responses that will give her audience a more comprehensive look into why these biohacking experiments are taking place, and what sort of role Zayner has played in order to push the movement into the extremes that subsequently led to an Ascendance Biomedical CEO injecting himself with an untested Herpes treatment over Facebook Live. This article is important because it showcases Zayner's reasonings behind why he still sells DIY-CRISPR kits to the public despite expressing fears over how the biohacking movement is spiraling out of control and has the potential to seriously injure someone. Zayner's biohacking experiments include such stunts as injecting himself with CRISPR to theoretically enhance his muscles in front of a live-streamed event. Before the article's publication, the public had little knowledge on Zayner's motivations behind his publicity stunts, or on his opinions of the biohacking movement.
3. Zhang's article is valuable towards my argument due to her

credibility as a writer for *The Atlantic*. Because *The Atlantic* is a popular (and credible) news source, its writers are educated (and surely have a college degree), although they may lack the subject expertise about a given topic. While *The Atlantic* tends to have liberal leanings, I found that this article was objective, and Zhang focused the interview solely on Zayner's opinions rather than inserting her own opinion into the matter. I chose this article because Zhang's interview allows for a never-before-seen insider-view on Zayner's motivations and reasoning for his viral experiments. It addresses many of the questions I have about why biohacking exists and what the implications of their unregulated experiments may be from the point of view from a scientist on the forefront of the movement.

4. The limitations of the article surround the fact that the article is a popular news article that was not peer reviewed, and was published by media cooperation that tends to lean toward the liberal ideology. Additionally, while Zhang has experience writing articles detailing new scientific breakthroughs (as well as providing scientific news such as current COVID-19 pandemic), she is not a scientist and (most likely) does not have any educational expertise in the field, despite being an experienced writer who tends to cover scientific stories. Therefore, I plan to use this source specifically for Zayner's perspectives on the biohacking movement, and the ethical and safety concerns that have arisen, rather than using it for its limited scientific explanations of CRISPR technology and the methodology of the experiments being done.

Q Popular Latest *The Atlantic*

SCIENCE

# A Biohacker Regrets Publicly Injecting Himself With CRISPR

“There’s no doubt in my mind that somebody is going to end up hurt eventually.”

SARAH ZHANG FEBRUARY 20, 2018



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## Part II: Response

I began my research process by recalling a multi-episode Netflix documentary called *Unnatural Selection* that introduced me into the world of CRISPR-Cas9. The technology is used both as a facet for valuable gene therapy research, as well as a potentially dangerous technology to hypothetically create a better human and to perfect the imperfect. The compounds can be readily purchased by just about anyone with \$2000 dollars to spare. I remembered that this documentary followed and interviewed ex-NASA scientist Josiah Zayner who created a website that sells biological equipment, samples, and DIY-CRISPR kits for very low prices on

the website *the-odin.com*. I became incredibly uncomfortable and concerned when I learned that one could purchase an entire “genetic engineering home lab kit” for only \$2000, with no college degree or scientific accreditations required.

This brought me to several important questions that I needed to research. First: “what is biohacking?” Second: “why has biohacking become a popular trend?” Third: “why are people turning to biohacking rather than trusting the research done by scientists at credible universities and research institutes (that are often backed by federal funding)? What was the draw towards biohacking?” The easiest part of the research process was simply researching all there was to know about the biohacking movement and learning about some of the planned medical innovations (such as cures for deadly diseases like HIV). I found tons of information that discussed biohacking. I also discovered several sources detailing how scary Josiah Zayner’s experiments are and how they tend to be a provocative publicity stunt in order to get people talking about the potential of biohacking to create scientific change.

The most difficult part of the research process, however, was trying to find scholarly articles about my topic. Because biohacking is such a new movement, and scholarly articles can take years to get peer reviewed and published, I was unable to find actual academic journal articles about the topic. However, I instead turned to academic journals as a source for a second conversation. I researched how science is regulated and funded by the US Government. I used this information to create and support an argument to justify why people are turning to biohacking for

answers to medical and medicinal questions, and why this has the potential to be incredibly dangerous to those involved. It opened up the important philosophical question of who should have access to this technology, and whether an educational degree truly equates to natural intelligence.

Through this research, my perspective on the topic has shifted from being completely against and disgusted with biohacking experiments (and perplexed with Josiah Zayner's ideologies), to trying to bridge an understanding as someone who is very pro-regulation and ethics into the reasoning of why people are turning to biohacking, and the future implications of such actions. I have gained insight into Zayner's beliefs, and although I do not agree with his actions, I can understand and respect why he wants to push these provocative experiments as a wake-up call to the government to push scientific experiments to be faster and approve more experiments that test the bounds of human intelligence in the realm of scientific research. It also helped me to understand that there are people who cannot afford a college education and are frustrated with the slow-paced experimentation and testing processes of novel biotechnologies and have decided to take these methods into their own hands (despite not having the educational background). Biohackers are not always doing these experiments for personal gain but are trying to prove that the tools necessary to create medicines for deadly illnesses are out there. By not being bound to ethical codes and stuffy corporate procedures, they are able to develop these products faster than the NIH and FDA ever could. While I still do not agree with their unwillingness



to adhere to ethical codes, and the dangerous (and often lack of scientific research of their experiments), I can appreciate why biohackers do what they do.

The popular conversations I have explored mainly touch on the biohacking movement and the reasoning for creating an underground subculture that goes against the status quo of needing federal funding and regulation in order to create scientific innovations. The scholarly conversations about my topic stem from how federal regulation slows the process of scientific innovation, and how the US is falling behind to other countries due to our government's unwillingness to increase funding and speed up clinical trials for lifesaving medications. These two ideas fit together because it shows a direct cause and effect relationship. Due to the slow pace of regulated scientific research, this biohacking movement has surfaced where common people (who often do not have a scientific educational background) are taking matters into their own hands in order to try to produce innovations that either have the potential to cure deadly diseases, or for unethical personal gain to correct the imperfect— under the guise of wanting to create a better human.