Annotated Bibliography

Primary Sources

Government Document

Federal Register, National Institutes of Health. *Recombinant DNA Research*. 7 July 1976, www.govinfo.gov/content/pkg/FR-1976-07-07/pdf/FR-1976-07-07.pdf. Accessed 13 Mar. 2024.

This source is a section of the Federal Register published by the National Institutes of Health that talks about the regulation of research on recombinant DNA molecules. I learned that it took three years for the NIH to regulate Boyer and Cohen's discovery and that the regulations have been amended several times over the years. I used this information in my Safety and Concerns page.

Interviews

Boyer, Herbert. "Recombinant DNA Research at UCSF and Commercial Application at Genentech." *The UCSF Oral History Program and the Program in the History of the Biological Sciences and Biotechnology*, The Bancroft Library, University of California, Berkeley, interview by Sally Smith Hughes, 1994, ia904701.us.archive.org/33/items/dnaresearchucsf00boyerich/dnaresearchucsf00boyerich.pdf. Accessed 2 May 2024.

In this 1994 oral history, Dr. Boyer discusses his recombinant DNA research and his biotech company called Genentech. I used a quote from this interview on my Safety and Concerns page and information from the interview to help me write text for my website.

Clem, Gary. *GMO Discovery's Impact on Agriculture.* Interview by Kye Smith, 8 Apr. 2024.

This interview is with Gary Clem who has been in the agriculture research equipment industry for over 50 years. I learned that GMOs made it possible to create Roundup-ready crops. I used this information in the Impact section of my project.

Gitschier, Jane. "Wonderful Life: An Interview with Herb Boyer." *PLoS Genetics*, vol. 5, no. 9, Sept. 2009, p. e1000653, https://doi.org/10.1371/journal.pgen. 1000653. Accessed 10 Jan. 2024.

From this online interview with Dr. Boyer. I learned about what he did compared to what Cohen did in their discovery and what the differences in their opinions are about the results of their research. I pulled quotes from it and used it in the Recombinant DNA part of my project.

Hardy, Pat. *GMOs' Impact on Agriculture*. Interview by Kye Smith, 12 Apr. 2024.

This is an interview with Pat Hardy, a Missouri farmer who has been farming since before GMOs were created. I learned the viewpoint of a farmer who has used non-GMO products and GMO products. I used quotes from this interview in the Impact section of my project.

PNAS. "50 Years of DNA Cloning: Stanley Cohen Reflects on the 50-Year Legacyof a Classic PNAS Paper on Recombinant DNA." *Science Sessions Podcasts,* PNAS, 18 Dec. 2023. https://www.pnas.org/post/podcast/50-years-dna-\cloning. Accessed 15 Jan. 2024.

In this podcast interview, Dr. Cohen discusses the recombinant DNA research that led to the paper published in the *Proceedings of the National Academy of Sciences* in 1973. This interview helped me understand the impact that the paper that Cohen and his colleagues published played on the discovery. I mainly pulled quotes from this podcast and used them in the Recombinant DNA portion of my project.

Journals

Berg, P., et al. "Potential Biohazards of Recombinant DNA Molecules." *Science*, vol. 185, no. 4148, July 1974, pp. 303–3, https://doi.org/10.1126/science.185.4148.303. Accessed 15 Mar. 2024.

This letter to the editor of *Science,* written by Berg, Boyer, Cohen and other scientists in 1974, is about the possible risks of recombinant DNA research. I learned what Boyer, Cohen, and other scientists thought were the hazards of their discovery. I used this article in the Safety and Concerns part of the project.

Cohen, S. N., et al. "Construction of Biologically Functional Bacterial Plasmids in Vitro." *Proceedings of the National Academy of Sciences*, vol. 70, no. 11, Nov. 1973, pp. 3240–44, https://doi.org/10.1073/pnas.70.11.3240. Accessed 15 Jan. 2024.

In 1973 this paper was published by Cohen, Boyer, and their colleagues right after their discovery. I learned the step-by-step process of their discovery, which helped me understand it more. I used an image of the paper title in the Recombinant DNA part of my project.

Mendel, Gregor. *Experiments in Plant Hybridisation*. 8 Mar. 1865, www.esp.org/books/bateson/mendel/facsimile/contents/bateson-mendel-3-peas.pdf. Accessed 3 Mar. 2024.

This is the text of two lectures that Gregor Mendel presented in 1865, which was published a year later in the *Natural Science Society* journal. Mendel describes his eight years of research on the transmission of hereditary traits in plant hybrids. I used a quote from this text on my Background page.

Newspapers

Anderson, Jack. "The DNA Research Argument." *Santa Cruz Sentinel*, 14 June 1978, p. 25, www.newspapers.com/newspage/63223612/. Accessed 5 Mar. 2024.

This is a newspaper opinion article published in 1978 a few years after Cohen and Boyer's discovery. I learned what people were concerned about after the discovery. I used this article in the Safety and Concerns section of my impact page.

Howard, Ted, and Jeremy Rifkin. "Recombinant DNA--A Modern Monster." *Oakland Tribune*, 28 Mar. 1978, p. 3, www.newspapers.com/image/735984179/. Accessed 11 Feb. 2024.

According to this 1978 newspaper opinion article, some people thought scientists were playing God because of the way that they could create new organisms. I learned of a viewpoint that some people had after the discovery of genetic modification. Similar to my other newspaper article, I used it in the Safety and Concerns part of my project.

Video

"Stanley Cohen and Herbert Boyer, Co-Recipients of 1996 Lemelson-MIT Prize." *YouTube*, YouTube Video, 27 Feb. 2009, www.youtube.com/watch?v=G3H-Uzts108. Accessed 2 Dec. 2019.

Boyer and Cohen discuss what they did in creating their breakthrough GMO discovery in this video. I learned about plasmids and also about Boyer and Cohen's process that they used to be the first scientists to genetically modify an organism. I used information and parts of this video throughout my project.

Websites

Berg, Paul. "Asilomar and Recombinant DNA." *NobelPrize.org*, 24 Aug. 2004, www.nobelprize.org/prizes/chemistry/1980/berg/article/. Accessed 13 Apr. 2024.

In this article on the Nobel Prize website, Dr. Berg, a chemist and DNA researcher, discusses the concerns about recombinant DNA technology during the 1970s. I used some quotes and information from this article.

"Humulin N, NPH, Human Insulin (Recombinant DNA Origin) Isophane Suspension." *Smithsonian Institution*, www.si.edu/object/humulin-n-nph-human-insulin-recombinant-dna-origin-isophane-suspension:nmah_1000967. Accessed 5 May 2024.

An image of the first biotech product approved by the U.S. government is included on this site. I learned that the first medical product based on rDNA was insulin. I used this information and the image in the Turning Points part of my project.

"Recombinant DNA in the Lab." *Smithsonian American Women's History*, womenshistory.si.edu/spotlight/birth-of-biotech/recombinant-dna-in-the-lab. Accessed 16 Jan. 2024.

This website contains images of some of the scientific equipment used in Dr. Cohen's lab. I learned what role each piece of equipment played in discovering how to create GMOs. I used it in the Splicing DNA part of my project.

Secondary Sources

Book

Lynas, Mark. *Seeds of Science : Why We Got It so Wrong on GMOs*. Bloomsbury Sigma, 2020, p. 60.

This book is about the history of GMOs and what some people think about them. I learned from this book that Boyer went on to create insulin to help diabetics. I used this information in the Transferring Between Species page of my project. The information also helped me better understand Boyer's work after discovering recombinant DNA.

Interviews

Borton, Katherine. *Basics of Recombinant DNA.* Interview by Kye Smith, 16 Jan. 2024.

Mrs. Borton is my science teacher who has an extensive knowledge of Biology and DNA. I worked with her to get a better understanding of DNA and how the process of genetically modifying an organism is conducted. I used the information from her in my Splicing DNA part of my project.

Cooper, Kevin. *Corn Borer*. Interview by Kye Smith, 23 Jan. 2024.

Mr. Cooper is my FFA teacher who has an extensive knowledge of agriculture and GMOs. I learned about the Corn Borer, how it affects crops, and how GMOs prevent it. I used this information in the Impact part of my project.

Lamkey, Kendall. *Herbert Boyer and Stan Cohen: Catalysts of GMO Technology*. Email to Kye Smith, 19 Feb. 2024.

This is an email interview with Dr. Kendall Lamkey, the Associate Dean for Facilities and Operation for the College of Agriculture and Life Sciences at Iowa State University, who has a PhD degree in plant breeding and genetics. I learned about his opinions on Cohen and Boyer's discovery and how it has impacted his field of research. I used this information in the Recombinant DNA part of my project and in the Impact portion.

Whitham, Steven. *Herbert Boyer and Stan Cohen: Catalysts of GMO Technology*. Email to Kye Smith, 4 May 2024.

Dr. Steven Whitham is a professor and researcher at Iowa State University with a PhD in plant pathology. With his email interview, I learned from someone who is directly involved with genetic modification about how the processes have changed in the last 50 years. I used quotes from the interview in my project.

Videos

"7 Reasons Why Gene Editing Is Dangerous and Unpredictable." *Www.youtube.com*, 20 Oct. 2022, www.youtube.com/watch?v=Au5HO7it9ng&t=88s. Accessed 12 Apr. 2024.

This video provides seven reasons why gene editing is not safe. I learned of the viewpoint of someone who is against GMOs. I used this information in the Safety and Concerns part of my project.

"GMOs and Food Safety: A Guide for Health Educators." 4 Aug. 2022, Www.youtube.com, www.youtube. com/watch?v=-RW5aRphVFw. Accessed 12 Apr. 2024.

This video talks about questions people have about GMOs. I learned from this video that scientists believe that GMO products are just as safe as non-GMO products. I used a clip from this video in the Safety and Concerns part of my project.

"Why Do We Use GMOs?" *Purdue University - College of Agriculture,* 12 Sept. 2016, ag.purdue.edu/gmos/ why-gmos.html#:~:text=Before%20GMOs%2C%20many %20common%20medicines. Accessed 15 Jan. 2024.

On this website, there is a video interview with Dr. Peter Goldsbrough, professor of botany and plant pathology at Purdue University. I learned about how GMOs affect resistance to herbicides. I used a clip of the video in the Impact part of my project.

Websites

Daynard, Terry. "A Brief History of the Hybrid Corn Industry." *Terry Daynard's Blog*, 25 Oct. 2019, tdaynard.com/2019/10/25/a-brief-history-of-the-hybrid-corn- industry/#:~: text=In%201916%2C%20Funk%20Brothers%20Seed. Accessed 19 Jan. 2024.

Daynard's blog is about the history of the hybrid corn industry. This gave me information about the Funk Brothers Seed Company that sold the first hybrid seed in 1916. I used the information in my Background page.

Entine, Jon. "Does GMO Corn Increase Crop Yields? More than 20 Years of Data Confirm It Does — and Provides Substantial Health and Safety Benefits." *Genetic Literacy Project*, 12 May 2023, geneticliteracyproject.org/2023/05/12/does-gmo-corn-increase-crop-yields-more-than-20-years-of-data-confirm-it-does-and-provides-substantial-health-and-safety-benefits/#:~:text=The%20analysis%20of%20over%206%2C000.
This website article is all about GMOs and their impact on yield. I learned about whether GMOs impact yield. I used this in the Impact part of the project.

"First Artificial Hybrid Was Obtained by Crossing Sweet William and Carnation in 1717 By– A) G.J MendelB) M.S SwaminathanC) P. MaheshwariD) Thomas Fairchild." *Www.vedantu.com*, www.vedantu.com/question-answer/first-artificial-hybrid-was-obtained-by-crossing-class-11-biology-cbse-5fba7c59ffe88b10a642f1b7. Accessed 7 Jan. 2024.
Thomas Fairchild's work with the first artificial hybrid is explained in this article. I learned what two plants he crossbred. I used the information in the Background part of my website.

Funk, Cary. "About Half of U.S. Adults Are Wary of Health Effects of Genetically Modified Foods, but Many Also See Advantages." *Pew Research Center*, 18 Mar. 2020, www.pewresearch.org/short-reads/2020/03/18/about-half-of-u-s-adults-are-wary-of-

health-effects-of-genetically-modified-foods-but-many-also-see-advantages/#:~:text=About%20half%20of%20U.S.%20adults%20(51%25)%20think%20GMOs%20are. Accessed 4 May 2024.

This website contains a survey about how U.S. adults feel about GMOs. I learned that around half of the adults in the U.S. think that GMO foods are worse for their health than non-GMO foods. I used a graph and information from this survey in the Safety and Concerns part of my project.

"GMO Crops, Animal Food, and Beyond." *FDA*, Sept. 2020, www.fda.gov/food/agricultural-biotechnology/gmo-crops-animal-food-and-beyond#:~:text=Corn%20is%20the%20most%20commonly. Accessed 15 Jan. 2024.

The Food and Drug Administration posted this article about GMO crops and animals. I learned the percentage of crops in the U.S. that contain GMOs. I used this information in the Impact part of my project.

A Half Century of Pioneering Innovation. Stanford Office of Technical Licensing, 2020, pp. 1–28, otl.stanford.edu/sites/g/files/sbiybj16766/files/media/file/stanford_otl_50th_anniversary_annual_report_fy2020.pdf. Accessed 13 Feb. 2024.

This source is an online booklet celebrating 50 years of innovation at Stanford, which contains the patent that Boyer and Cohen received for their discovery. I learned that it took over six years for Boyer and Cohen to receive their patent. I used the patent in the Transfering Between Species part of my project.

"Herbert Boyer and Stanley Cohen | Lemelson." *Lemelson.mit.edu*, 27 Feb. 2009, lemelson.mit.edu/award-winners/herbert-boyer-and-stanley-cohen#:~:text=By%20genetically%20engineering%20cells%20to. Accessed 19 Dec. 2023.

Cohen and Boyer's work and the process that they used to conduct it is explained in this website article. I learned about the impact that their work had on the world. This was one of my most important sources, and I used it throughout my project.

"Herbert W. Boyer and Stanley N. Cohen." *Science History Institute*, sciencehistory.org/education/scientific-biographies/herbert-w-boyer-and-stanley-n-cohen/#:~:text=Boyer%0and%20Cohen%2C%20as%20well. Accessed 22 Jan. 2024.

This source is all about Boyer and Cohen's research. I learned about the plasmids that they used. This is another one of my main sources that I used throughout my project.

"How GMO Crops Impact Our World." *U.S. Food & Drug Administration*, Apr. 2023, www.fda.gov/food/agricultural-biotechnology/how-gmo-crops-impact-our-world. Accessed 8 Dec. 2023.

Published by the FDA, this website is about why farmers use GMOs. I learned that one benefit that GMO crops offer is resistance to insect damage. I used it in the Impact part of my project.

King's College London. "The Structure of DNA: How Dr. Rosalind Franklin Contributed to the Story of Life | Feature from King's College London." *Www.kcl.ac.uk*, 11 Oct. 2016,

www.kcl.ac.uk/the-structure-of-dna-how-dr-rosalind-franklin-contributed-to-the-story-of-life-2#:~:text=The%20discovery%20of%20the%20structure. Accessed 8 Dec. 2023.
This website describes who Dr. Rosalind Franklin was and what she did with DNA. I learned that Dr. Franklin was the first scientist to X-ray DNA. I used the information in the Background part of my project.

National Geographic Society. "Genetically Modified Organisms | National Geographic Society." *Education.nationalgeographic.org*, National Geographic Society, 20 May 2022, education.nationalgeographic.org/resource/genetically-modified-organisms/.
I learned the basic process of GMOs from this National Geographic website. I did not necessarily use it in my project, but I used this site to build a basic understanding of the process of GMOs.

Olby, Robert. "Gregor Mendel | Biography, Experiments, & Facts." *Encyclopædia Britannica*, 27 Nov. 2018, www.britannica.com/biography/Gregor-Mendel. Accessed 21 Jan. 2024.
In this encyclopedia article, the author discusses Gregor Mendel and what he did. I learned what knowledge Gregor Mendel gained in breeding plants and what he did in his experiments. I used the information in the Background section of my website.

"Paul Berg." *Science History Institute*, sciencehistory.org/education/scientific-biographies/paul-berg/. Accessed 15 Feb. 2024.
This website from the Science History Institute discusses Dr. Paul Berg and the work that he did with recombinant DNA. I learned what Berg did and the impact that he had on the

development of GMO technology. I used the information in the Background part of my project.

Peikes, Katie. “GMO Food Labeling Has Been Required in the U.S. For a Year. Have Consumers Noticed?” *Nebraska Public Media*, 6 Feb. 2023, nebraskapublicmedia.org/en/news/news-articles/gmo-food-labeling-has-been-required-in-the-us-for-a-year-have-consumers-noticed/. Accessed 3 May 2024.

In this online article, the author discusses GMO food labeling. I learned that in 2022 the U.S. Department of Agriculture started mandating the labeling of food that is genetically modified or contains GMOs. I used this information on my Safety and Concerns page.

“Professor Herbert Boyer | Biographical Summary.” *WhatisBiotechnology.org*, www.whatisbiotechnology.org/index.php/people/summary/Boyer#:~:text=Serving%20as%20Genentech. Accessed 23 Jan. 2024.

From this website about Herbert Boyer, I learned what he did after discovering GMOs and about his groundbreaking work with insulin. I used the information in the middle part of my project.

A Timeline of Genetic Modification in Modern Agriculture. www.fda.gov/media/135276/download?attachment. Accessed 15 Jan. 2024.

This PDF was issued by the FDA and gave me a basic understanding of what events took place before and after GMOs were developed. It also gave me examples of GMO

products. I used the information throughout my project and in the Timeline that I created using Canva.

U.S. Food and Drug Administration. “Science and History of GMOs and Other Food Modification Processes.” *Science and History of GMOs and Other Food Modification Processes*, Apr. 2023, www.fda.gov/food/agricultural-biotechnology/science-and-history-gmos-and-other-food-modification-processes. Accessed 25 Jan. 2024.
Published by the FDA, this website contains a timeline of events that affected GMOs. I learned about events that led up to GMOs and about Gregor Mendel. I used this source throughout my project but especially in the Background.

Wieczorek, Ania, and Mark Wright. “History of Agricultural Biotechnology: How Crop Development Has Evolved | Learn Science at Scitable.” *Nature.com*, 2012, www.nature.com/scitable/knowledge/library/history-of-agricultural-biotechnology-how-crop-development-25885295/.
This website is all about GMOs and about Thomas Fairchild’s work. I learned what type of plants he worked with. I used the information in the Background part of my project.

Images

“3 Big Ways GMOs Support the Environment.” Croplife International, 2021. gmoanswers.com/.

“Adapting Corn Production to Climate in Alabama.” *Alabama Cooperative Extension System*,

August 23, 2018 www.aces.edu/blog/topics/crop-production/adapting-corn-production-to-climate-in-alabama/.

Bertrand, Savannah, et al. “No-till Farming Improves Soil Health and Mitigates Climate Change | Article | EESI.” Www.eesi.org, 28 Mar. 2022, www.eesi.org/articles/view/no-till-farming- improves-soil-health-and-mitigates-climate-change.

Cohen, S. N., et al. “Construction of Biologically Functional Bacterial Plasmids in Vitro.” *Proceedings of the National Academy of Sciences*, vol. 70, no. 11, 1 Nov. 1973, pp. 3240–3244, www.pnas.org/content/70/11/3240, https://doi.org/10.1073/pnas.70.11.3240.

Digital, G. L. P. “Only Conspiracy Theories Left to Challenge Science Consensus That GMOs Are Safe.” *Genetic Literacy Project*, 7 Feb. 2017, geneticliteracyproject.org/2017/02/07/only-conspiracy-theories-left-challenge-science-consensus-gmos-safe/. Accessed 9 May 2024.

“DNA Double Helix Isolated on Green Background Stock Illustration.” *Adobe Stock*, stock.adobe.com/images/dna-double-helix-isolated-on-green-background/135293052. Accessed 2 May 2024.

“European Corn Borer.” *Gardenia*, www.gardenia.net/pest/european-corn-borer. Accessed 11 Feb. 2024.

Funk Brothers Seed Company, and National Agricultural Library U. S. Department of Agriculture. “Funk’s G Hybrids : Here Are the Reasons You Can’t Afford to Be without Funk G / Funk Bros. Seed Co.” *Internet Archive*, Bloomington, Illinois : Funk Bros. Seed Co., 1947, archive.org/details/CAT31368463/page/n21/mode/2up. Accessed 21 Jan. 2024.

“How GMOs Are Regulated in the United States.” FDA, 19 Apr. 2023, www.fda.gov/food/agricultural-biotechnology/how-gmos-are-regulated-united-states.

Jones, Mark. “The Invention of Recombinant DNA Technology.” *Medium*, LSF Magazine, 12 Nov. 2015, medium.com/lsf-magazine/the-invention-of-recombinant-dna-technology-E040a8a1fa22.

“No-till Farming for Climate Resilience | USDA Climate Hubs.” *www.climatehubs.usda.gov*, www.climatehubs.usda.gov/hubs/international/topic/no-till-farming-climate-resilience.

Olby, Robert. “Gregor Mendel | Biography, Experiments, & Facts.” *Encyclopædia Britannica*, 27 Nov. 2018, www.britannica.com/biography/Gregor-Mendel. Accessed 21 Jan. 2024.

Peterson, Kristina. “Washington Threatens Battle over Mexico’s Plan for a GMO Corn Ban.” *Wall Street Journal*, 1 Dec. 2022, p. A2.

Rosen, Aliza. “What to Know about the Updated COVID-19 Vaccine for Fall/Winter 2023 | Johns Hopkins | Bloomberg School of Public Health.” *Publichealth.jhu.edu*, 14 Sept. 2023, publichealth.jhu.edu/2023/what-to-know-about-the-updated-covid-19-vaccine-for-fall/winter-2023.

Wetterstrand, Kris. “Recombinant DNA Technology.” *National Human Genome Research Institute*, 7 May 2024, www.genome.gov/genetics-glossary/Recombinant-DNA-Technology. Accessed 8 May 2024.

“Who Discovered It?” *How Does Genetic Engineering Affect Mankind?*, 8 Oct. 2016, howdoesgeneticengineeringaffectmankind.wordpress.com/who-discovered-it/.

Wilkinson, Linda. “A Garden for Thomas Fairchild | Spitalfields Life.” *Spitalfields Life*, 18 Nov. 2014, spitalfieldslife.com/2014/11/14/a-garden-for-thomas-fairchild/.

Wilson, Matthew. “Thomas Fairchild: The Man Who Created the First Hybrid Plant — and Changed Science.” *Financial Times*, Financial Times, 17 Mar. 2017, www.ft.com/content/ 64451cc4-07f3-11e7-ac5a-903b21361b43.