Works Cited

Primary Sources

Alexander Fleming, holding a petri dish. *Science History Institute*, www.sciencehistory.org/historical-profile/alexander-fleming. Accessed 15 Jan. 2020. To be included in our page about Fleming's discovery, this is a picture from the 1930s of Alexander Fleming in his laboratory working on a petri dish of penicillin mold.

"Ayrton's Antiseptic Healing Cream." 1990s. *eHive*, ehive.com/collections/5254/objects/591300/chemical-ayrtons-antiseptic-healing-cream. Accessed 15 Jan. 2020. This is an image of Ayrton's Antiseptic Healing Cream created in the 1900s that can be found in the Health Museum of South Australia. It was included in our website as a type of medical method used prior to the discovery of penicillin.

Citric acid fermentation ranks in Pfizer's Brooklyn facility. 1920. *American Chemical Society*, www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicillin.html. Accessed 15 Jan. 2020. This photograph of a small factory, which eventually grew into a pharmaceutical giant, that produced the initial chemicals necessary for the production of penicillin will be included in our project to show the mass production process of penicillin.

Fleming, Alexander. "On the Anti-Bacterial Action of Cultures of a Penicillium, with Special Reference to Their Use in the Isolation of B. Influenzae." *British Journal of Experimental Pathology*, 10 May 1929. *US National Library of Medicine*, www.ncbi.nlm.nih.gov/pmc/articles/PMC2048009/pdf/brjexppathol00255-0037.pdf.

Accessed 14 Oct. 2019. This is a scientific journal written by Alexander Fleming, and it shows his extensive research on the function of penicillin. He tested the mold on many different bacteria to see which are affected by penicillin. This journal gave insight on Fleming's extensive research process and more context on how penicillin was discovered and researched.

---. "Penicillin." 11 Dec. 1945. Lecture. This Nobel Lecture written by Alexander Fleming was delivered by Fleming when he received the Noble Prize in Physiology or Medicine for his discovery of penicillin. In the lecture, Fleming begins by discussing the early days of penicillin and the choices he made about its name and his first publication. His lecture also contains information about his previous discoveries and the results yielded by the experiments he performed. Fleming also discusses how he discovered penicillin and the tests he conducted to isolate the antibiotic and produce it in a quantity that could be used for experimentation on living things. Furthermore, Fleming mentions penicillin's effect on more discoveries and advances in antibiotics. In addition, Fleming also discusses the consequences of using too much penicillin or not enough and the problems that will occur due to this. Fleming's lecture conveys his thoughts as he researched penicillin and its effects. It answers the question of Fleming's beliefs and his thoughts at the time of his discovery.

Howard Florey. *The Courier Mail*. Accessed 17 Nov. 2019. This is a photo of Howard Florey, a scientist who played a significant role in the development of penicillin into a successful antibiotic.

ICR. www.icr.org/i/articles/af/Chain_wide.jpg. Accessed 17 Nov. 2019. This is an image of Ernst Chain, a person who had a huge role in the development of penicillin.

Neushul, Peter. "Science, Government, and Mass Production of Penicillin." *Journal of the History of Medicine*, vol. 48, Oct. 1993, pp. 1-25, watermark.silverchair.com/371.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAAlowggJWBgkqhkiG9w0BBwagggJHMIICQwIBADCCAjwGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMuenWcbl-hg80lgCDAgEQgIICDbBG-Vqk7l15PVmFu82BSp0MhfoWXV6NOmwyDci0lSQZMuqOxS0CjwNFx1XSKrS96aNYJcO4bSdNlGgHdJOgKh4HKpbw6DnDnCNf_USOlw1aHxsrfQ13lVhiUDJ13EvgO3qQnP06qJV2dVMubpUAh7bE4Ad0Wl8i4WHX8rvk4oJK3wEpgCxCyHMHmI8l3kTsF0kUIAsLTts09Ox1EuOZNYASJFxcmkwWI2qRGfzBhiZiZ0I0IEAOySBcRSoIg4locyt23v1FNAFyXk7IvLW3dPOLgMScPhXzzQMHKWc91qH0QLLjIK4GZx1dEEhyOhde1zj7RrgtWfO-8qBbJF6GlocW8jL6y9djxTFXFSNV_cdgT9i6JzaSjEl6BY4uqRUfxFLy5377SvDFECqpTvFzNhIgZgF6HoBnBQ-fSty8BVzvPySkzZFBKlLoh0OJqlF2LROEAKc6poruNs5RqZTCVOQQTprho67Oyut_Xb7IrnGJIUJHlyK3nEjrRQc4IEnM7xQbNqeIDl80Et1kgqn8KH6RkTWc-PkxhiNYDMveYtTEouBSkz9I6MCyJocyYIMzbDu_JtJh2iElG0HFNGlIaHIjXVfJ8GsrDKisTitkWInr8KPqulAKQ3romrvBWa1leFRgRMrLYXZQwLkG6FA0KwmGD06uOQJ7KGFZ0jCh6eD6T_ehKRnSEniNmTo4RQ. Accessed 6 Oct. 2019. This scholarly journal from the Journal of the History of Medicine conveyed tons of information about the mass-production of penicillin. Many groups, such as the NRRL research group and the War Production Board, played major roles in the production of penicillin. They found good strains of penicillin and how to get the most units out of 1

ml. Due to the war, the government played a huge role in production of supplies. The -mass production of penicillin was mainly due to the government's huge role in production of supplies. In the end, a successful antibiotic industry remained and tons of saved lives.

Penicillin. *GET SCIENCE*, www.getscience.com/biology-explained/penicillin-wwii-poster-gallery. Accessed 17 Nov. 2019. These illustrations, in the form of ads, helped us understand how citizens and doctors learned about penicillin and their motivation to help the war through contributing to penicillin's advancement.

Portrait of Howard Florey and his team. 1940s. *The Royal Society*, pictures.royalsociety.org/image-rs-13329. Accessed 15 Jan. 2020. This photograph of the team at Oxford who worked on penicillin depicts the number of scientists who worked with penicillin and shows the importance of the project during the time period. It will be added to our website's mold to medicine page.

Ratcliff, J. D. "What about Those Miracle Drugs." *Evening Star*, 14 Oct. 1945, p. 8. *Chronicling America*, chroniclingamerica.loc.gov/lccn/sn83045462/1945-10-14/ed-1/seq-77/#date1=1920&index=3&rows=20&words=PENICILLIN+penicillin&searchType=basic&sequence=0&state=&date2=1950&proxtext=penicillin&y=11&x=13&dateFilterType=yearRange&page=1. Accessed 15 Dec. 2019. This article not only shows people's opinions from when it first came out, but it also supports penicillin's many significances. First, the author starts off by saying how many lives penicillin and other drugs that came after it have saved. He

wrote they "saved almost as many live as war destroyed." After, he wrote about penicillin and how it worked. Then, he wrote about a drug called streptomycin. It is a drug that kills microbes that even penicillin can't kill and it was discovered because scientists knew about penicillin used similar methods to discover it. Penicillin not only saves lives, but it has also given way to many live-saving drugs.

Schenley Labratories. *Thanks to Penicillin.... He Will Come Home!* 1944. *US National Library of Medicine*, www.nlm.nih.gov/exhibition/fromdnatobeer/exhibition-making-yellow-magic.html. This famous advertisement from the 1940's about penicillin was found on the website of the US National Library of Medicine. Advertisement played a big part in how penicillin got the name "wonder drug". The maker of this advertisement, Schenley Laboratories, played a big part in the mass production of penicillin. The drug was originally mass-produced for D-Day, but was soon made available to the public, as this advertisement shows. A message like this, must have meant a lot to the families of soldiers, and the significance of the advertisement is that it cemented the importance of penicillin in place. Connecting penicillin to the thought of soldiers returning home helped emphasize the importance of the drug to the rest of the world.

Science History. site.nhd.org/70634605. Accessed 17 Nov. 2019. This image shows Fleming in his lab, which is important because it helps contextualize the whole story.

Scientists meet at Peoria to discuss the penicillin project. *Northwest Herald*, www.nwherald.com/2018/06/17/illinois-bicentennial-for-75-years-peorias-ag-lab-has-changed-lives-with-wonderful-discoveries/a9ea6tr/. Accessed 15 Jan. 2020. This photograph

of scientists working to progress the mass production of penicillin in Peoria will be included in our website to convey the number of scientists that worked to further mass produce the antibiotic.

Squibb. "From Experience Comes Faith." *Evening Star*, 9 Dec. 1951. *Chronicling America*, chroniclingamerica.loc.gov/lccn/sn83045462/1951-12-09/ed-1/seq-160/#date1=1951&index=0&rows=20&words=penicillin&searchType=basic&sequence=0&state=&date2=1951&proxtext=penicillin&y=13&x=8&dateFilterType=yearRange&page=1. Accessed 15 Dec. 2019. This newspaper ad greatly supports one of penicillin's many significances. This ad is about how people need to learn to "try it and see", like scientists did with penicillin. The miracle discovery of penicillin set a precedent of following this motto.

Secondary Sources

Adedeji, W. A., editor. "The Treasure Called Antibiotics." *US National Library of Medicine*, 14 Dec. 2016, www.ncbi.nlm.nih.gov/pmc/articles/PMC5354621/. Accessed 29 Sept. 2019. The US National Library of Medicine is an almost 200 year old library that has thousands upon thousands of books and articles on anything related to medicine. This source is one of those many and shows how penicillin is a treasure to the world. Before penicillin, the average life expectancy of humans was 47 years. The middle age of modern times was the elderly of pre--penicillin times due to the lack of effective medicine. With the help of penicillin, the average life expectancy rose to 78 years and " infectious diseases now become the problem of elderly, cancer patients, transplant patients, surgical patients, patients on immuno-suppressive drugs and other at-risk groups in developed countries."

The barrier broken by the discovery of penicillin is apparent due to the massive increase in life expectancy.

"Alexander Fleming." *Science History Institute*, www.sciencehistory.org/historical-profile/alexander-fleming. Accessed 15 Sept. 2019. This article comes from the website of the Science History Institute, an organization that collects and shares the stories of innovators and of discoveries that shape our lives. The article contains information about Alexander Fleming, from his birth to his accidental discovery of penicillin. It discusses Fleming's experience in the scientific field as well his previous discoveries and research. Around the time of its discovery, Fleming did not realize that penicillin could be used to fight bacterial diseases but rather to treat wounds and surface infections. Penicillin was in fact extremely effective in treating small infections and was considered a great scientific breakthrough. However, the article emphasized that Fleming did not immediately grasp the importance of the antibiotic which was disadvantageous at the time as bacterial diseases threatened the population.The information of this source also answered questions that arose as preliminary research was collected including the antibiotics that were used to cure diseases before penicillin and the aftermath of its discovery. Before penicillin, there were medical barriers that limited the use of antibiotics which resulted in the loss of many lives. The discovery of penicillin broke these barriers and paved the path for the discovery of other antibiotics as well as further development of penicillin itself.

"Alexander Fleming." *Wikipedia*, 9 Oct. 2019, en.wikipedia.org/wiki/Alexander_Fleming. Accessed 14 Oct. 2019. This article was found on Wikipedia, and it very useful as a

context source. This article gave a lot of information on Alexander Fleming and his role in the discovery of penicillin. Apparently, He kept his laboratory quite mess, which resulted in the accidental growth of penicillin on one of his petri dishes. Fleming spent many month researching it and calling it mold juice, until he was able to publish into a scientific journal. His article didn't gather a lot of attention, and he also doubted penicillin's function. Due to this, penicillin was left alone for a bit until Howard Florey and Ernst Chain found Fleming's journal and furthered his research. This resulted in the mass-production of penicillin and penicillin's standing today. Knowing this has helped fill in the tiny gaps in my knowledge of the discovery of penicillin.

Arnaud, Celia Henry. "Penicillin." *Chemical & Engineering New*, 20 June 2005, cen.acs.org/articles/83/i25/Penicillin.html. Accessed 15 Sept. 2019. This is an article from Chemical & Engineering News, which is a new website that is published by the American Chemical Society. The ACS is a non-profit organization based in the United States that works towards advancements in the field of chemistry. Their article about penicillin has a lot of information on how penicillin was made into a safe antibiotic for humans. It shows how scientists figured out how to mass produce penicillin and synthesize it for different uses. Once penicillin was known to be an effective antibiotic, many countries, especially the United States, played a part in funding the mass production of penicillin. Countries wanted to use penicillin to help decrease casualties during war. Knowing how penicillin, a mold that accidentally made, was turned into a mass produced antibiotic which is sought after by all countries helps clarify the story of the discovery of penicillin. It clarifies what happened after scientists figured out that

penicillin had potential to be a life-saver. The context of the topic is way clearer due to this article.

Barret, Mike. "Penicillin's first patient." *Mosaic Science*, 14 May 2018, mosaicscience.com/story/penicillin-first-patient-history-albert-alexander-AMR-DRI/. Accessed 15 Sept. 2019. This source is an article written by Mike Barret, the professor of biochemical parasitology at the Wellcome Centre for Molecular Parasitology at the University of Glasgow. In this article, Barret writes about how Alexander Flemming discovered penicillin, but Howard Florey, Ernst Chain and Norman Heatley were the ones purify it into a medicine. The most enticing piece of information was about penicillin's first patient, Albert Alexander. Barret writes that Alexander developed sepsis and he was very ill by the time he was treated with penicillin. The thing the shocked everyone was the rate of his short-term recovery. Alexander still died due to a shortage of penicillin, but the effects on his body gave scientists hope. This event sparked the mass-production of penicillin for war. Barret writes "thousands of Allied soldiers were surviving battlefield wounds and being treated for sexually transmitted infections, including gonorrhoea." This document not only helps with historical context, but also to show the barrier in the medical society that was broken when penicillin was turned into medicine.

Bernhardt, Thomas G. "How Penicillin Acts like TNT for Bacteria." *Howard Hughes Medical Institute*, 9 Apr. 2019, www.hhmi.org/news/how-penicillin-acts-like-tnt-for-bacteria. Accessed 29 Sept. 2019. Written by Thomas Bernhardt, a professor of microbiology and immunobiology at Harvard Medical School, this article shows new data that has been

revealed about the effects of penicillin. Bernhardt and his fellow scientists conducted research about ways to prevent the spreading of bacteria that has become too strong and insensitive to current antibiotics. As a result, forty years after the discovery of penicillin, scientists recently learned more specific information about the functions of penicillin and how it treats patients. Furthermore, using this discovery, they hope to further develop more antibiotics that are stronger to fight these newly approaching bacterial diseases that have been resistant to current medicine. Penicillin continues to serve as an extremely resourceful antibiotic in modern medicine. Forty years ago, the antibiotic broke the barriers the world faced in medical development and even today, it inspires further development of medicine and antibiotics.

Bloodletting . History. This illustration demonstrated the practice of bloodletting that was used before the discovery of penicillin.

Bud, Robert. *Penicillin: Triumph and Tragedy*. This book confirmed a lot of the information we had gathered from our research on penicillin about the pre-penicillin era, the discovery as well as the rapid growth in demand for the antibiotic. In addition, the book provided new information about the use of penicillin in animals and the results of these experiments. Furthermore, the book also provided essential information about the new diseases that are now arising in the world which are becoming resistant to antibiotics such as penicillin. The author discusses how the importance of penicillin is slowly decreasing but nonetheless emphasizes the revolutionary changes in medicine production that came about due to the discovery of penicillin.

Calver, Tom. "75 Years of Penicillin in People." *University of Oxford: Oxford Blog*, 12 Feb. 2016, www.ox.ac.uk/news/science-blog/75-years-penicillin-people. Accessed 14 Oct. 2019. This article, written by Tom Calver, was found on the Oxford Science Blog, a blog for the University for Oxford, where penicillin was further developed after its discovery. The article contains essential information about the discovery and advancement of antibiotics and their impact on society for almost the past century. The article discussed the efforts of the team of scientists working at Oxford to explore penicillin furthermore and expand their knowledge about penicillin and its benefits. After performing trials on both animals and people, the team of scientists faced the issue of producing penicillin on a large scale. The article discussed the scientists' efforts to persuade the US government and industry to industrialize penicillin. Their efforts were achieved and penicillin was available in sufficient quantities for medical support for the D-Day invasion. Penicillin was then made available to US pharmacies for purchase by civilians for treatment which introduced ordinary citizens to the benefits of antibiotics.

Carrol, Andrew. "Here Is Where: Penicillin Comes to Peoria." *HistoryNet*, www.historynet.com/here-is-where-penicillin-comes-to-peoria.htm. Accessed 14 Oct. 2019. HistoryNet is made by the world's largest publisher of history magazines. They wrote this article about where penicillin was mass-produced. Howard Florey and Ernst Chain had to contact the USDA to get penicillin mass-produced. When they went to America, they packed tons of penicillin and even smeared penicillin into their coat pockets as backup. They, along with some other scientists, researched many ways on how to get the best penicillin yield and they succeeded by finding a strong strain on a

over-ripe cantaloupe that they found at a grocery store. After getting the penicillin off, the scientists ended up eating the cantaloupe. Due to the cantaloupe strain, they were able to mass-produce enough penicillin for D-Day. This article helped fill in bits of context.

Columbus, Christie. "In a world with no antibiotics, how did doctors treat infections?" *The Conversation*, 29 Jan. 2016, theconversation.com/in-a-world-with-no-antibiotics-how-did-doctors-treat-infections-53376. Accessed 29 Sept. 2019. The Conversation is a non-profit online forum where academic experts can share information about different topics to enlighten the world. This article shows how the world survived without modern antibiotics, and it isn't good. People had to use gory techniques, such as bloodletting, to have a chance at surviving an infection that could be easily cured. The side-effects to some of those techniques are more dangerous than the infection itself.The author says "thankfully, in 1943, penicillin supplanted these treatments and remains the first-line therapy for all stages of syphilis." Bloodletting and consuming mercury rarely worked to treat infections because they were treatments based on a myth. There was always a barrier stopping people from living healthy lives because there was no good option to treat illnesses. The discovery of penicillin broke that barrier by becoming an exceptional solution for many previously deadly diseases.

"Discovery and Development of Penicillin." *American Chemical Society*, www.acs.org/content/acs/en/education/whatischemistry/landmarks/flemingpenicillin.html. Accessed 15 Sept. 2019. This article is by the American Chemical Society, which is a non-profit organization with the goal of furthering studies in the field of chemistry. The

was a multi-page source that gave a complete breakdown of the entire history of penicillin. It gave information about how it was made to how it was first used commercially. The information in the article further reinforced all the information that was found in the rest of the sources. It filled in most of the pieces of historical context and gave a bit about the historical significance by showing the effects on the medical field and patients in general.

"Discovery of Penicillin." *Wikipedia: The Free Encyclopedia*, 8 Sept. 2019, en.wikipedia.org/wiki/History_of_penicillin. Accessed 15 Sept. 2019.

Dunn, William. "Penicillin's Discovery and Antibiotic Resistance: Lessons for the Future." *US National Library of Medicine*, 29 Mar. 2017, www.ncbi.nlm.nih.gov/pmc/articles/PMC5369031/. Accessed 15 Sept. 2019. This source is from the US National Library of Medicine and the Sir William Dunn School of Pathology, where a lot of the initial research about penicillin was done. This source gave a lot of information of the involvement of the United States in the production of penicillin. The United States was the first country to fund the mass production of penicillin for use in war. The author also wrote about the the post-production era of penicillin, which consists of threats of diseases becoming resistant to penicillin and the search for new antibiotics. This source helped fill in more pieces of this story such as threats of the future and the involvement of the US.

Encyclopedia Brittanica, editor. "Penicillin." *Encyclopedia Brittanica*, Encyclopedia Brittanica, inc., 14 June 2019, www.britannica.com/science/penicillin. Accessed 15 Sept. 2019.

Fey, Paul. "The mold in Dr. Florey's coat The story of the penicillin miracle." *National Library of Medicine*, 5 Feb. 2005, www.ncbi.nlm.nih.gov/pmc/articles/PMC546436/. Accessed 15 Jan. 2020. This review of *The Mold in Dr. Florey's Coat* was a very helpful way to understand the book better and the information in it. It gave a mini summary of the book which helped refresh my memory, and it was helpful to see what an expert thinks of a source that I want to use. The author's words helped me make sure that the information was sound, and it also gave me more resources to use. Lastly, the review showed me a new way to look at and use the information in the book.

Florey and Chain Experiment. *BioNinja*, ib.bioninja.com.au/standard-level/topic-6-human-physiology/63-defence-against-infectio/penicillin.html. Accessed 15 Jan. 2020. This illustration of the experiments conducted on mice by Florey and Chain shows the results and how they were beneficial to the further development of penicillin.

Frith, John. "Syphilis – Its early history and Treatment until Penicillin and the Debate on its Origins." *JMVH*, jmvh.org/article/syphilis-its-early-history-and-treatment-until-penicillin-and-the-debate-on-its-origins/. Accessed 29 Sept. 2019. The author of the article, Dr. John Frith, is an allergist-immunologist who received his medical degree from Michigan State University College of Osteopathic Medicine and has been in practice for more than 6 years. The article contained information about syphilis, a dangerous disease that spread severely during World War II. Early treatment of syphilis was administered on patients but these treatments were not effective as a cure and alternatives proved to have grave side effects

that harmed the lives of patients. The article discussed the emergence of penicillin as a possible treatment for syphilis and its usage on patients. The anitibiotic, in its beginning stages of development, was used to treat four patients that were infected with syphilis through administering it as an injection. Penicillin proved to be a very effective cure to patients who were suffering from the primary or secondary stages of syphilis and it had very few side effects that didn't prove to be significant. The discovery of penicillin was a significant discovery at its time which was beneficial to World War II soldiers who were suffering with bacterial diseases. The antibiotic broke the medical barriers that citizens faced at the time as the development of medicine was limited to simple cures.

Gaynes, Robert. "The Discovery of Penicillin — New Insights After More Than 75 Years of Clinical Use." *Centers for Disease Control and Prevention*, May 2017, wwwnc.cdc.gov/eid/article/23/5/16-1556_article. Accessed 15 Sept. 2019. The author of the article is Robert Gaynes, a professor at Emory University School of Medicine in Georgia. He is an infectious disease specialist who received his medical degree from the University of Chicago Pritzker School of Medicine and has been in practice for more than 20 years. In the article, Gaynes discusses the evolution of penicillin, including its discovery, rise to popularity, its benefits to the population as well as the large scale production of the antibiotic. The article also contains information about the use of penicillin during World War II to help cure soldiers that had suffered during the war. The article also discusses the popularity of the antibiotic as nations struggled during the war to mass produce penicillin to treat their fallen soldiers. In addition, Gaynes explains the research and involvement of several other scientists who worked with Alexander Fleming

to further the medical benefits and production of the antibiotic. The article discussed the recognition the scientists received and how their work was a breakthrough in medicine that contributed to the exceptional health of many patients. Furthermore, the article discovery of penicillin revealed the difficulty of discovering new antibiotics and the limitations of these medicines.

---. "The Discovery of Penicillin-New Insights after 75 Years of Clinical Use." *CDC*, May 2017, wwwnc.cdc.gov/eid/article/23/5/16-1556_article. Accessed 14 Dec. 2019. The information in this website helped us solidify our argument. We were looking for a less obvious significance than the fact that penicillin saved lives because it would make our project more meaningful. This article from the CDC gave us two new significances of penicillin and gave us some new contextual information. England refused to allow other countries to get their hands on the penicillin spore, especially Germany, but Fleming had already sent out his spore to many people. One landed in the hands of a German scientist, but they weren't able to grow the spore. Eventually Germany was able to grow penicillin, but the Allied air raids saw to the end of that. Additionally, this source showed that the discovery of penicillin set two major precedents of US involvement in drug production and not ignoring accidental discoveries. Penicillin also helped scientists discover a bunch of other antibiotics because they followed the same method to grow penicillin which resulted in them finding other life-saving antibiotics.

"Howard Walter Florey and Ernst Boris Chain." *Science History Institute*, 4 Dec. 2017, www.sciencehistory.org/historical-profile/howard-walter-florey-and-ernst-boris-chain. Accessed 14 Oct. 2019. This information was found on the website of the Science

History Institute, which is a non-profit organization with the goal of preserving science history. This article provided thorough information on the history of Howard Florey and Ernst Chain, the two scientist that made mold into medicine. Florey was australian and Chain was an immigrant to England. They met at Oxford and became friends while researching antibacterial substances. They started researching penicillin and were able to test it. When they were ready to mass-produce it, Britain said no. Luckily, Florey had American connections, which led research to a USDA laboratory in Peoria, where they were able to mass-produce it. This information was missing from my knowledge of penicillin, which is why this article was very important for context.

How does Antibiotic Resistance Occur. *Pharmaceutical Microbiology*, www.pharmamicroresources.com/2017/10/understanding-antibiotic-resistance.html. Accessed 15 Jan. 2020. This illustration, found on the website of Pharmaceutical Microbiology, shows the process of which antibiotic resistance occurs which is an essential issue now regarding penicillin. It will be included in our future of antibiotics page to emphasize the importance of antibiotic resistance.

Kardos, Nelson. "Ernst Chain: a great man of science." *US National Library of Medicine*, Aug. 2013, www.ncbi.nlm.nih.gov/pubmed/23793259. Accessed 14 Oct. 2019. The National Center for Biotechnology Information website, where this source was found, is part of the US National Library of Medicine, a library that contains thousands of books related to medicine. The article contains information about Ernst Chain, a British biochemist who aided the development and production of penicillin. Chain was born and educated in Germany until he was forced to flee to England where he became part of the Oxford

research team that was exploring penicillin. Working with Norman Heatley and Edward Abraham, Chain was able to isolate and produce sufficient amounts of penicillin to be tested on mice. As a result, these scientists, along with Alexander Fleming, received the Nobel Prize in Physiology or Medicine for their work in the development of penicillin as a therapeutic agent. Furthermore, the article discussed Chain's development of engineering methods to extract penicillin which were then used by the US to commercially produce penicillin which proved to be of great significance to the Allied war effort. In addition, Ernst Chain's involvement in the development of penicillin led him to work to develop new antibiotics that were very significant to medicine as they were industrially mass produced by many Eurporean countries. Chain's introduction of penicillin to the medical industry proved to be very beneficial to the British as the antibiotic was used significantly throughout the course of the war.

Khond, Sonali. Interview. 12 Jan. 2020. This interview was way more helpful than I expected it to be. The interviewee is a family friend of my family so it was very easy to meet and do the interview. She gave me a lot of important information on how penicillin is used in practice and alternatives to it. Antibiotic resistance is a big problem now, but I didn't know how it was affecting people in real life. This interview gave me a lot of information on that and on medicines that were created after penicillin started the "Golden Age" of antibiotics. It sparked the discovery of medicine stronger than itself that have helped millions. Penicillin not only broke a barrier, but it started a domino because how many medicines were discovered because of it.

Lax, Eric. *The Mold in Dr. Florey's Coat*. New York, John Macrae. This book helped put all the information into perspective. Everyone thinks that Fleming had the biggest hand in making Penicillin, but Florey and Chain actually did most of the work. They were the ones the actually made it into a usable medicine and kickstarted its mass production process. It also gave information on how the scientist that actually made the drug didn't get any money from it. The drug companies that were the ones that got the patent on the production process and reaped the benefits. It was an all-around informative biography that put the story into perspective and helped us understand the significance of penicillin.

"The Legacy of U.S. Leadership in Global Health." *Youtube*, uploaded by NASEM Health and Medicine Division, 19 Sept. 2017, www.youtube.com/watch?reload=9&time_continue=83&v=gttMbcj3Xm4&feature=emb_logo. Accessed 15 Jan. 2020. This video showed the United States's involvement in medicine since the discovery of penicillin and proved to be very important to our significance as it contained essential information such as where the United States contributes to global health as well as what types of infections and diseases are battled with by organizations of the United States.

Markel, Howard. "The real story behind penicillin." *PBS News Hour*, p. 1. *PBS*, www.pbs.org/newshour/health/the-real-story-behind-the-worlds-first-antibiotic. Accessed 15 Sept. 2019. The article was written by Howard Markel, who is the George E. Wantz Distinguished Professor of the History of Medicine at the University of Michigan and Director of the University of Michigan's Center for the History of Medicine. The article contains information about Fleming's discovery and includes Fleming's own thoughts

from his letters. The article also discussed the other scientists Fleming collaborated with to arrive at the discovery of penicillin. In addition, the article also discussed the patients the antibiotic was tested on and the outcome of the testing. Furthermore, the use of penicillin during times of war was also described in the article as it treated numerous wounded soldiers. This answered the previous questions from preliminary research about the first use of penicillin on humans and the outcome of the testing.

Mason, Barbara, and John S. Mailer, Jr. "Penicillin: Medicine's Wartime Wonder Drug and Its Production at Peoria, Illinois." *Northern Illinois University Libraries*, www.lib.niu.edu/2001/iht810139.html. Accessed 14 Oct. 2019. Written by Barbara Mason and John S. Mailer Jr, this article was published on the website of the Northern Illinois University Library which contains essential information about discoveries and topics of interest in the state of Illinois. The article contains information about penicillin's story and details about its development and impact on modern medicine. In addition, the article also discusses medicine before penicillin and contains information about the research that was conducted by scientists other than Fleming to develop penicillin to treat infection. The article also included an excerpt from a journal written by Fleming. This journal entry provided quantitative and qualitative data about the discovery and also explained how Fleming discovered penicillin. In addition, the article contains information about the use of penicillin during the war and how the production of penicillin in the United States was essential. Penicillin was first chosen to be naturally fermented in Illinois and was then used in hospitals around the country to treat soldiers which showed

the importance of the antibiotic and the benefits of its production in the United States to the American population of soldiers.

Mercury. *Wikipedia*. This image demonstrated the form of mercury once used to treat the disease, syphilis.

Microbiology Society. "The History of Antibiotics." *Microbiology Society*, microbiologysociety.org/members-outreach-resources/outreach-resources/antibiotics-unearthed/antibiotics-and-antibiotic-resistance/the-history-of-antibiotics.html. Accessed 29 Sept. 2019. The Microbiology Society is a website that promotes the public understanding of microbiology and medicine. It is one of the largest organizations with a worldwide membership based in universities, hospitals, and research institutes. The article published by the website contains information about antibiotics that were used in the late 19th century and early 1900s. Information about observations scientists made of antibacterial chemicals was also included in the article to convey the small amount of knowledge scientists had about the early development of antibiotics. Fleming's discovery of penicillin was especially emphasized in the article as penicillin proved to be an extremely successful antibiotic at the time. Furthermore, the article also contained information about the mass production of penicillin and its usage throughout World War II in Europe. The discovery of penicillin was a breakthrough in medicine that proved to be extremely effective in treating fallen soldiers on the battlefields as well as citizens of Europe in hospitals. The article revealed the conditions in the world before penicillin and the importance of the antibiotic to those who were struggling from bacterial infections. The large barriers that the world faced before proper medicine and antibiotics were

successfully broken through the discovery of "the wonder drug" as penicillin was referred to by the end of the World War II.

Ogbru, Omudhome. "Penicillin(Antibiotics)." Edited by Jay W. Marks. *MedicineNet*, www.medicinenet.com/penicillins-injection/article.htm#what_are_the_uses_for_penicillin_antibiotics. Accessed 14 Jan. 2020. This website gave us a list of medicine made after penicillin. This is important because it proves our point about penicillin creating a Golden Age of antibiotics

"Penicillin Mechanism." *News Medical Life Sciences*, 23 Aug. 2018, www.news-medical.net/health/Penicillin-Mechanism.aspx. Accessed 29 Sept. 2019. Written by Susan Chow, a former research scientist who holds a PhD in cell and molecular biology from Dartmouth College, "Penicillin Mechanism" discusses the function of penicillin in the body and the antibiotics' effects on human cells. The article also contains information about similar antibiotics that are used to treat bacterial infections in a similar manner to penicillin. Also mentioned was the behavior of bacteria and the spreading of bacterial infections in the body which showed the necessity of antibiotics as well as provided a framework of the functions of antibiotics that would be used to treat infections. The article also discussed how bacterial resistance to antibiotics has been growing and emphasized how this has resulted in a worldwide threat to public health. Since the discovery of penicillin, antibiotics have become weaker and bacteria has been able to fight the presence of certain antibiotics in the body. The article provided information about the aftermath of the discovery of penicillin and the impact the

antibiotic has had on the world. At its time, penicillin was considered an extremely effective antibiotic that could be used to cure diseases that were deadly and incurable.

Penicillin on Petri Dishes. *Past Medical History*. Accessed 17 Nov. 2019. This image shows pencillin growing on petri dishes which provides a basic demonstration of the antibiotic.

"Penicillin Opening of an Era." *Agricultural Research Service: US Department of Agriculture*, 3 May 2018, www.ars.usda.gov/midwest-area/peoria-il/national-center-for-agricultural-utilization-research/docs/penicillin-opening-the-era-of-antibiotics/. Accessed 14 Oct. 2019. This article was found on the website of the Agricultural Research Service, an official website of the United States government. The article contained information about large scale commercial production of penicillin after its development. The antibiotic was produced during the war in the United States and the article stated that British scientists were referred to the US production lab as the war drained the country's industrial and government resources. Furthermore, the article discussed how production methods and samples of penicillin were transferred to research groups and private industry as well. Soon after, the production of penicillin was quickly scaled up in time for use on soldiers during the war.

Quinn, Rosewell. "Rethinking Antibiotic Research and Development: World War II and the Penicillin Collaborative." *US National Library of Medicine*, Mar. 2013, www.ncbi.nlm.nih.gov/pmc/articles/PMC3673487/. Accessed 6 Oct. 2019. The US National Library of Medicine is the website for a library that has thousands of books related to medicine. This article contains information about the development and use of

penicillin during World War II. The article discusses the effect of penicillin on humans and how it came to be used during the war. The article also discusses how military leaders used their resources to further the development and usage of penicillin and have mobilized the large scale production of penicillin to assist their troops and soldiers. Furthermore, the article discusses penicillin's significant usefulness in military medicine and how the production of penicillin increased drastically during the war. The article emphasized the importance of penicillin during the war and showed how its mass production benefitted soldiers and armies. Penicillin became a significant medical resource to militaries fighting on both sides of the war.

Ridgewell, Harry. "200 million lives saved - but prognosis for penicillin is not healthy." *WikiTribune News*, 29 Nov. 2018, www.wikitribune.com/wt/news/article/28091/. Accessed 29 Sept. 2019. WikiTribune is a news platform with the goal of spreading the most factual and high-quality news that they can. This article by them is about how many lives have been saved by penicillin. 200 million live have been saved by penicillin and 15 percent of Allied soldiers were saved by penicillin. After the boom in use of penicillin, Alexander Flemming notes ""When I woke up just after dawn on September 28, 1928, I certainly didn't plan to revolutionize all medicine by discovering the world's first antibiotic, or bacteria killer. But I suppose that was exactly what I did." Many people are scared that many diseases will become resistant to penicillin, but there is hope that if anti-biotics are used and prescribed correctly, then bacterias will stop becoming resistant to them. Penicillin has saved millions of lives and will continue to save lives, if it is used correctly

Roser, Max. "Life Expectancy." *Our World in Data*, 2013, ourworldindata.org/life-expectancy. Accessed 15 Jan. 2020. I got census data from this cite to support our significance

Sample of Penicillin Mold. 18 Apr. 2012. *Smithsonian*, www.si.edu/newsdesk/photos/sample-penicillin-mold. Accessed 15 Jan. 2020. Found on the Smithsonian website, the picture of a mold of penicillin will be an useful image to include in the context slides of our website.

Schwartz, Penny E. Albert Alexander's daughter holding up a picture of Albert Alexander. *The Press-Interprise*, 2 Nov. 2012, www.pe.com/2012/11/02/redlands-local-artists-share-childhood-bond/. Accessed 14 Jan. 2020. Picture of Albert Alexander's daughter holding up a picture of Albert Alexander.

"7 Ways Penicillin Has Cured the World for 90 Years." *React*, 29 Sept. 2018, www.reactgroup.org/news-and-views/news-and-opinions/year-2018/7-ways-penicillin-has-cured-the-world-for-90-years/. Accessed 30 Sept. 2019. ReAct is a network specifically geared towards spreading awareness about antibiotics and how to prevent antibiotic resistance. This source shows seven major ways that penicillin has helped the world over almost a century. It has helped with pneumonia, child care, surgery and more. Nowadays, people take antibiotics for granted, but in the past, antibiotics were a gift. Life expectancies increases and diseases became less and less deadly. The immense change created by the discovery of penicillin is unimaginable.

Tertiary Sources

Slinn, Judy. Review of *Penicillin: Triumph and Tragedy*. *US National Library of Medicine National Institutes of Health*, Jan. 2009, www.ncbi.nlm.nih.gov/pmc/articles/PMC2629146/. Accessed 15 Jan. 2020. This book review was an essential source as it revealed information that I didn't take note of when I first read the book. The book review contained information about penicillin's mass production and how most of the antibiotic that was manufactured was unpatented. The book review also included information about the international reach of penicillin and antibiotics that were being produced during the time of penicillin's development and distribution.

Thankker, Naina. Videoconference interview. This interview conducted via skype with Dr. Naina Thankker provided us with essential information about the significance and legacy of penicillin. After the distribution and usage of penicillin throughout the world, scientists utilized the methods used to produce penicillin to develop more medicine that proved beneficial to society. This interview helped us better understand the new antibiotics that have come from penicillin and their benefits in the medical world today.

Ventola, Lee. "The Antibiotic Resistance Crisis." *US National Library of Medicine National Institutes of Health*, Apr. 2015, www.ncbi.nlm.nih.gov/pmc/articles/PMC4378521/. Accessed 29 Sept. 2019. The US National Library of Medicine is the website for a library that has thousands of books related to medicine. The author of the article, C. Lee Ventola is an influential medical writer who has 43 publications and 121 influential citations about medical topics such as antibiotics and health care. The article contains information about the antibiotic resistance crisis that emerged worldwide as bacterial infections once

again became a large threat. The article discussed the history of antibiotics which, the article mentioned, really began with the discovery of penicillin in 1928. Furthermore, the article also provided additional information about Fleming's words about antibiotic overuse and the growing demand for newly developed antibiotics such as penicillin in society. This article emphasized the importance of antibiotics in the medical world and the impact of their resistance on the citizens' health. Specifically, the resistance of penicillin, which was seen as a breakthrough in medicine, changed the way penicillin was viewed by the world.

Wong, Szu Shen. "Syphilis and the use of mercury." *The Pharmaceutical Journal*, 8 Sept. 2016, www.pharmaceutical-journal.com/opinion/blogs/syphilis-and-the-use-of-mercury/20201679.blog?firstPass=false. Accessed 17 Dec. 2019. Written by Szu Shen Wong, a lecturer of pharmaceutical sciences at Keele University, this source provided important information about the medical methods used to treat infections and diseases before penicillin. Specifically, the use of mercury and other elements to treat severe diseases such as syphilis. In addition, the source also included information about the consequences of using mercury to treat syphilis. The article showed the lack of effective medical techniques to effectively cure infections and bacterial diseases before penicillin. The discovery of penicillin broke the tremendous barrier the world faced regarding the lack of effective medicine.