Historical Analysis of Penicillin’s Development

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Introduction

The penicillin story, known by many today, is definitely a distorted version that does not accurately portray all the events. The general account of the penicillin discovery that most people are aware of is that scientist Alexander Fleming discovered bacterial zones of inhibition after coming back from vacation. Fleming deemed that the penicillin mold was the cause of the inhibition zones. This account presents two main problems: 1) This account was only published in 1944 and experimentation on penicillin was happening before then. In other words, Fleming’s preliminary experimentation is completely missing from this abridged version of the penicillin story. 2) Fleming is always credited more than scientists Howard Florey or Ernest Chain, people from Oxford University who had equally important roles in developing penicillin.

The first account of penicillin in Fleming’s notebooks was of a complete experiment in 1944, which happened nearly two months after Fleming returned from his vacation. There are no records of the date Fleming returned, no informal notes in his lab notebook, and no letters that explain the preliminary tests before the complete experiment. Research conducted by other scientists was already happening in 1944 as well. This paper attempts to thoroughly investigate the complex penicillin story by analyzing all the events, especially those pertaining to penicillin experimentation. Additionally when people recall the penicillin story, Fleming is the first that comes to mind and most, if not all, the credit is given to him. Scientists Howard Florey and Ernest Chain are overlooked for the most part. This phenomenon could explain the reason for the asymmetry between the upcoming biographies of the scientists. There is a significantly greater
amount of information on Fleming compared to Florey and Chain, which is probably a result of Fleming being more credited.

This paper aims at supplying the detailed events that the simplified account overlooks and, consequently, showing the contribution of other scientists who are not as well known. In doing so, it answers the following historical question: **Why is the story of penicillin’s development widely repeated as an account of accidental or inadvertent discovery by one man (Fleming, whose name we all learn and celebrate), which somehow miraculously turns into a wonder drug a dozen years later through the work of others whose names nobody cares to remember?**

Fleming’s Background and Early Experimentation

![Figure 1. Alexander Fleming in his lab (Alexander Fleming 2017).](image)

Alexander Fleming became one of the most important and well-known scientists of the twentieth century. He was born in Ayrshire, Scotland in 1881, and moved to London for further studies at Regent Street Polytechnic Institute. Fleming served in the army from 1900 to 1914,
and afterwards he joined the Saint Mary’s Hospital medical school. His initial career plans were in the field of surgery. Having passed the entrance exam for the Royal College of Surgeons, Fleming felt that the surgical career path would suit his skill set in human anatomy (Lax 2004, 9). He started researching in the Inoculation Department (department studying how foreign substances help produce an immunity) at Saint Mary’s and he became interested in bacteriology. Fleming worked in Almroth Edward Wright’s lab and learned about bacteriology. Fleming also coined the term ‘lysozyme’ for substances naturally produced in the body, such as mucus, which are capable of dissolving specific bacteria.

The country of Britain, militarily, was involved in World War I in the early 1900s. Fleming joined the army medical staff in France after the director of the medical services in the army, Alfred Keough, reached out to him. The load of patients was unmanageable: “An average of twelve-hundred patients a day was handled by the staff of clearing stations designed to help two hundred” (Lax 2004, 13). During his time there, Fleming examined the soldiers’ clothes and found that “…15 percent carries Staphylococci, 30 percent bore Tetanus bacilli, 40 percent had Streptococci, and that 90 percent of the samples grew Clostridium welchii” (Lax 2004, 15). After the war finished in 1918, Fleming returned to Saint Mary’s and became the assistant director of the Inoculation Department.

Fleming received his own lab at Saint Mary’s Hospital, in which he conducted his research. In 1928, after returning from a vacation, Fleming noticed a foreign greenish blue mold that was growing on the Staphylococcus aureus cultures in his lab. He thought that the mold must have come from surrounding research labs. Fleming saw zones of inhibition or areas in which the bacteria of interest, in this case Staphylococcus aureus, was killed. Fleming concluded that the substance from the Penicillium notatum mold, penicillin, must have lysed the bacteria.
Penicillin kills the bacteria by destroying the cell wall and stopping the replication process.

Fleming recorded the following observations in his notes: “On a plate planted with staphylococci a colony of mould appeared. After about two weeks it was seen that the colonies of staphylococci near the mould colony would degenerate” (Lax 2004, 18).

At this point, Fleming has discovered the active ingredient in the current penicillin antibiotic, which comes from the *Penicillium notatum* mold. He discovered the potential of this mold, and completed additional tests on the mold in his laboratory. Fleming grew the mold on other plates in four to five days. Then, he streaked various microbes (*Staphylococcus*, *Streptococcus*, *Diphtheria*, *B. anthracis*, *B. typhosus*, *B. coli*) on the plates. Fleming found that some microbes remained, whereas the growth of others were inhibited until several centimeters away from the mold (Table 1).

<table>
<thead>
<tr>
<th>Sensitive</th>
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<tr>
<td><em>Staphylococcus aureus</em></td>
<td><em>Enterococcus</em></td>
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<tr>
<td><em>Staphylococcus epidermis</em></td>
<td><em>Non-pathogenic gram-negative cocci</em> found in the mouth</td>
</tr>
<tr>
<td><em>Streptococcus</em> (hemolytic)</td>
<td><em>B. pyocyaneus</em></td>
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<td><em>Streptococcus</em> (viridans)</td>
<td><em>B. proteus</em></td>
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<td><em>Pneumococcus</em></td>
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<td><em>Gonococcus</em></td>
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<td><em>M. catarrhalis</em></td>
<td><em>B. typhus</em></td>
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<td><em>Diphtheria</em> group</td>
<td><em>B. paraptyphus</em></td>
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<tr>
<td><em>B. anthracis</em></td>
<td><em>B. dyssenteriae</em></td>
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<tr>
<td><em>Air-borne micrococci</em></td>
<td><em>Vibrio cholerae</em></td>
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<tr>
<td><em>Sandia</em></td>
<td><em>Pasteurella</em></td>
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| Actinomyces                      | *Brucella abortus* and melitensis         |
| B. welchii                       | *B. tuberculosis*                         |
| *Vibrio septique*                |                                           |
| *B. cedamatis*                   |                                           |
| *E. tetani*                      |                                           |
| *Sphaerochales*                  |                                           |

N.B. Those below the line have been added since my original paper in 1929.

*Table 1. Table showing bacteria and their sensitivity to penicillin (Fleming 1929, 88).*
Fleming also noticed how soluble the penicillin was in agar. Agar is the solid gel-like substance in bacterial plates. Solubility in agar is a useful property of penicillin, especially when testing the penicillin against bacterial colonies grown in agar plates. Additionally, he realized that only molds that were well isolated would be capable of inhibiting the bacterial species. Fleming stated that the penicillin should not be administered in small doses either. Fleming believed that if there is not enough penicillin to kill the bacteria, then the bacteria would become resistant to the treatment (Fleming 1929, 88-90).

Fleming referred to penicillin as being “...born in time of peace by a stray mold spore implanting itself on a microbial culture where it was not wanted, it reached maturity at the height of the greatest of all wars, when it was there to help the wounded soldier, and to do its part in preventing the awful miseries resulting from septic infections such as were seen in the last, and indeed in all, wars” (Fleming, quoted by Goldsmith, 1946, 49). Fleming was trying to show this one drug’s untapped potential to treat wounded soldiers and prevent infections. He needed to sell and convince people of the idea that penicillin was an important drug. Notably, Fleming also anticipated the problem of bacterial resistance. This is one of the most prominent issues in the medical field today. Other scientists could just as easily claim credit for the discovery of bacterial resistance in later decades. Why did Fleming not receive more credit for predicting the issue ahead of time, and why did he have to initially persuade people of the importance of penicillin? A possible reason could include that Fleming was not a well-known scientist in 1929. He was just starting to make his name in his field. It is in human nature to trust people of good credibility, and since Fleming was not widely known in 1929, people did not pay much attention to his ideas.
Fleming published a research paper in 1929 on “The Antibacterial Action of Cultures of a Penicillium, with special reference to their use in the isolation of B. Influenzae.” Fleming prepared multiple plates with *Staphylococcus Aureus* bacterial colonies, which were exposed to the air. Cultures of the *Penicillium notatum* mold were made from a broth at room temperature. The *Penicillium notatum* mold would be diffused into the air medium surrounding the plates, so the plates could take up the mold. Fleming described the *Penicillium notatum* mold as a “...white fluffy mass which rapidly increases in size” (1929, 226).

Then, Fleming studied the properties of the *Penicillium notatum* mold to better understand the substance. For example, he tested how varying the temperature would affect the mold. He found that the mold is produced at the fastest rate at room temperature rate (twenty degrees Celsius) and can destroy the *Staphylococci* bacteria in approximately six days (Fleming 1929, 228). Nutrient broth was the most effective medium for producing penicillin. Figure 2 shows how the penicillin created zones of inhibition in which the *Staphylococci* bacteria died. The upper half of the plate with the penicillin has a significantly smaller number of bacteria spots compared to the lower half of the plate. Figure 3 is mucus from an individual with a cold. When six drops of penicillin were added to the plate, the white spots representing the cold-causing bacteria died. The penicillin was added to the bottom half of the plate, which is why it has less bacteria spots.
Figure 2. Image of Staphylococcus bacteria and penicillin on plate (Fleming 1929, 228).

Figure 3. Image of cold causing bacteria and penicillin on plate (Fleming 1929, 228).
Table 2. Bacteria and their inhibition zones under different conditions (Fleming 1929, 229).

Table 2 lists different microorganisms and the size of the inhibition zone for each of them under different conditions. As a general trend when the penicillin was boiled, it was less effective. This trend can be seen with the decrease in inhibition zone size, across all the microbes, with boiling. The penicillin was most effective against gram-positive bacteria species that had the greatest inhibition zones. Such species included *Pyogenic coccus*, *Staphylococcus pyogenes*, *Diphtheroid bacillus*, *Streptococcus*, and *Pneumococcus*. The greatest inhibition zones for each species across all the experiments were 24mm, 35mm, 30mm, and 30mm respectively (Fleming 1929, 229).
Gram-positive bacteria are highly sensitive to the penicillin compared to the gram-negative ones. For example, only 0.2% of penicillin is needed to completely inhibit *Pyogenic cocci* bacteria. Fleming found that only a small amount of penicillin was necessary to affect this gram-positive bacterial species because of its sensitivity. Penicillin can be used to kill *Streptococcus pyogenes* and *Pneumococci* species in a dilution of 1 in 800 (Fleming 1929, 235).

Figure 4. Various concentrations of penicillin with B. Subtilis on a plate (Penicillin 1944).

Figure 4 shows an image from one of Fleming’s penicillin experiments. The cylinders represent penicillin of various concentrations that have been spread on the plate. The penicillin of greatest concentration has the greatest zone of inhibition around it. The bacteria that was spread on the plate was *B. Subtilis*.

Many other important conclusions came from Fleming’s preliminary experiments. He determined that the penicillin reaches its peak effectiveness seven days after it has been made and when it functions at twenty degrees Celsius. Penicillin typically degrades in four weeks. Penicillin is easily accessible as it can be filtered out from the *Penicillium notatum* mold. High pH (above 7) and high temperatures (above 115 degrees Celsius) denatures the penicillin and
lowers its functionality (Fleming 1929, 237). One characteristic of penicillin that makes it applicable to the drug development field is that it is not toxic to animals in large doses. Low toxicity is an important characteristic for effective drugs. Fleming envisioned penicillin being used as an antiseptic or an injection against gram-positive bacteria. Obviously, Fleming had a crucial role since he discovered the source of penicillin itself.

Subsequently, Dr. Cecil G. Paine was performing preliminary testing of penicillin treatments in humans. He was a pathologist at the Royal Infirmary, and in the 1930s he treated a few patient cases with penicillin obtained from the *Penicillium notatum* mold. One patient was a six-year-old girl who was diagnosed with ophthalmia neonatorum, a condition in which the eyes of the newborn acquire an infection from the birth canal (Wainwright 1986, 46-47). Dr. Paine’s notes are displayed in Figure 8. She is described as having “both eyes swollen and full of pus”.

```
On admission
Both eyes swollen and full of pus
Culture diphtheroid
Penicillin hourly
22.12.30 Both eyes clear
Home
Lot AB Zinc
TID
8
```
Figure 8. Dr. Paine’s notes on six-year-old girl case (Wainwright 1986, 47). The upper image is typed notes and lower image is handwritten notes.

Penicillin was given to the patient hourly and in eighteen days she was discharged from the hospital (Wainwright 1986, 47). The penicillin was able to kill the bacteria causing the infection and treat the patient’s swollen eyes.

Dr. Paine also treated another eye case, however this was for an adult. A piece of stone had entered the patient’s right eye. The stone came in contact with the cornea sclera junction, and it became stuck in the iris. An inflammatory response occurred and caused swelling of the eye. Samples were taken from the patient, which revealed the presence of *Pneumococci*. Dr. Paine administered penicillin to the patient over the course of forty-eight hours. The doctor’s records state that the eye visually looked better. Additional samples were taken from the patient to ensure the death of the bacteria. The stone was then removed, and the patient had a full recovery with
restored eyesight (Wainwright 1986, 48). He was temporarily blinded by this infection and penicillin restored his eyesight in only two days.

Florey and Chain Experimentation

Roughly a decade later, in 1938, Howard Florey expressed interest in the case of penicillin. Florey was another scientist who researched penicillin and its potential as an antibiotic therapy. He was born in Adelaide, Australia during 1898, and attended Adelaide University. Oxford University, subsequently, gave him a Rhodes Scholarship in 1922. After completing higher degrees, he returned to Oxford and became a pathology professor. He developed an interest in penicillin after reading about Fleming’s published research. In 1939, Florey worked with his colleagues, including Ernst Chain, at Oxford University to conduct further testing on penicillin and extract it from its mold (Lax 2004, 25-30).

![Figure 5. Image of Sir Howard Florey (Goldsmith 2014).](image)

Sir Ernst Boris Chain had Jewish ancestry and he lived in Germany for his early life. His father was in the field of chemistry, and consequently Chain graduated in chemistry and physiology from Friedrich Wilhelm University in 1930. He then obtained his doctorate degree from Berlin’s Charité Hospital. In 1933, Chain moved to England due to the rise of the Nazi
Party. He worked in several England institutions in the following order: University of College London Medical School, Cambridge University, and Oxford University (Lax 2008, 65).

Asymmetry can be seen in the biographies of the scientists. (Fleming’s biography is considerable larger than the biographies of the other two scientists.) This may speak to the fact that Florey and Chain are less widely recognized for their roles in the development of penicillin, and there is less information about them in this context. It is ironic how Florey and Chain are not widely recognized for their work with penicillin, especially because without them penicillin would not have become extracted and turned into a drug.

Florey conducted extraction experiments on penicillin at Oxford University in 1939. The only source of funding he received for his research was 350 pounds from the Rockefeller Foundation (Goldsmith 1946, 158). The penicillin was extracted with the use of organic solvents such as ether and amyl acetate. However, the organic solvents tend to have a pH of 2 and penicillin denatures at room temperatures with this pH. Thus, this process had to be completed at low temperatures. Afterwards, a second extraction was performed to retrieve the penicillin alone (Abraham 1941, 3). The final product had 500 units of active penicillin ingredient per mg, which was significantly more than the current standard of 40-50 units per mg.
On May 25 1940, Florey also performed an experiment with Ernst Chain testing the antibacterial activity of penicillin. In this experiment, the test subjects were eight mice. All the mice were infected with a strain of *Hemolytic streptococci*—bacteria from the *Streptococcus* family, which is known for causing strep throat. Four of the mice were given penicillin, and the other four served as controls. The mice were kept overnight, and by 4:00 AM the four control mice died. As expected, the four mice with penicillin survived even with the bacteria strain (Florey 1942, 122). This experiment supports the idea that penicillin has antibacterial properties. However, the mice would tend to excrete the penicillin quickly, which meant they needed more frequent doses of penicillin. A larger supply of penicillin was needed for in vivo experiments.

Florey and Chain also conducted experiments on the effects of purifying penicillin. He set up an experiment with four mice. Each mouse was injected with 20 mg of penicillin. One mouse was given penicillin containing 250 units per mg of active ingredient and the other three were given 325 units per mg (Florey 1942, 121).
Figure 7 is an image from penicillin experimentation. The image has been photographed through a microscope, and it shows the crystalline structure of purified penicillin. Florey found that purifying the penicillin and extracting more of the active ingredient decreased its toxicity level. When he tested with leukocytes (human white blood cells), he noted that the highly purified penicillin did not pose a greater threat compared to the standard penicillin (Florey 1942, 121).

Low toxicity levels help the penicillin be more applicable to human treatments. From his testing, Florey concluded that the most purified form of penicillin has the potential to completely eradicate *Staphylococcus aureus*. Fleming claimed the mold “...produced something which was much more powerful in retarding the growth of many of the common microbes, and yet it did not appear to do any damage to human cells. At that time, this was unique. We called it Penicillin” (Fleming, quoted by Goldsmith, 1946, 150). He believed that penicillin had the perfect balance between antibacterial properties and low toxicity to animal tissues.

Florey achieved the purification of penicillin, and Chain helped to test it in model organisms. Purification and extraction of the drug makes it more accessible. Testing the drug in animals and recording their response is a good indication of how humans will react to the drug. Both of these milestones were important to achieve for the commercial use of the penicillin drug.

Commercial Production of Penicillin

Florey’s next step involved making the penicillin production happen at a larger scale to produce immense quantities of the penicillin. He, along with other Oxford researchers including Chain, attempted to utilize the media to further increase the popularity of penicillin. In 1940, they published accounts of penicillin treating humans in a magazine: *The Lancet*. They stated that “...enough evidence, we consider, has now been assembled to show that penicillin is a new
and effective type of chemotherapeutic agent, and possess some properties unknown in any antibacterial substance hitherto described” (Chain 1940, 226). The Oxford team’s intent was to spark interest in the British government for mass producing penicillin by making them aware of penicillin’s potential. Although, the British government neglected the team’s publication because only a small number of people were actually utilizing the drug at that time. Offers for funding did not come out of the publication either. Chemical companies inquired about the technical aspects of the treatment, however they still focused on their own products.

On February 12 1941, Albert Alexander was the first patient who was treated with purified penicillin developed from Oxford University. Alexander was a 43-year-old policeman who developed a dangerous infection while pruning roses. The infection started affecting different parts of his body including the eyes, face, and lungs. His body was not responding to typical drugs used at the time because the bacteria were developing resistance to them. Other alternatives were being considered, which included penicillin.

Two hundred units of penicillin were given to him and within twenty-four hours his temperature dropped and his infection stabilized (Wainwright 1986, 52). The penicillin was remarkable in quickly improving Alexander’s health. However, there was a limited supply of penicillin so the hospital staff tried to extract it from his urine. After five days, there was no more available penicillin resulting in Alexander's death on 15 March (Wainwright 1986, 52). If there had been additional supplies of penicillin, his life could have been saved. This case emphasized the continuous need of having sufficient quantities of penicillin.

Hence, Florey decided to take imitative and travelled to the United States. Originally, penicillin was produced in a way which did not require heavy equipment. For example, Florey used old dairy equipment to make the penicillin. Then, the mold grew in hospital bedpans and
the liquid containing the penicillin was filtered with a parachute silk (Lax 2008, 53). However, this method was not an efficient way to mass produce the penicillin. Instead, Florey looked into possible partnerships with American companies to produce vast quantities of penicillin with their advanced equipment.

Florey’s goal was to find a partner company that would be willing to mass produce penicillin as a drug. Accordingly, Florey approached companies such as Merck, Squibb, Lily, and Pfizer. Alfred Richards, vice president of medical affairs at the University of Pennsylvania, was familiar with Florey and helped him by arranging meetings with the pharmaceutical companies (Lax 2008, 115).

One meeting, which took place on October 8 1941, allowed Florey to meet Dr. Coghill. Dr. Coghill was part of the staff at the Department of Agriculture, and he was studying the applications of a thick liquid, called corn-steep liquor, that was formed from milling corn. Corn-steep liquor increased the yield of *Penicillium notatum* mold by tenfold. Penicillin, however, needs to be exposed to the air when it is produced. When penicillin is exposed to the air with corn-steep liquor, it results in foaming. A company called Squibb introduced a chemical called glycercyl monoricinoleate to prevent the foaming (Lax 2008, 104).

After the Pearl Harbor bombing during World War II, immediate action needed to be taken to address the outbreak of infections faced by the soldiers at the battlefront. The survival rate from infections for soldiers in the war was around 4 out of 100 (Masters 1946, 50). Lax described the situation as follows: “The main floors of the building, parceled into high-ceilinged, ornate, and once elegant rooms, were now wards filled with soldiers razed from high fevers brought on by infection” (2004, 13). Many soldiers got infections that spread amongst other people quickly. Additionally, doctors would remove the bandages to tend and treat the wounds.
There was a wait time before the troops were operated on by the surgeons. The average wait time was approximately fourteen hours (Ligon 2004). During the wait time, the wounds were exposed to the pollutants in the air, which led to infections. In extreme cases of infection, amputations had to be done.

Sulfonamides were the current standard of treatment for infections. Sulfonamide drugs are made with sulfur and they can be used as antibiotics. This class of drugs destroys dihydrofolic acid, which is the acid employed by bacteria to make proteins (Ross-Flanigan 2015, 1). However, bacteria gained resistance against sulfonamides, as Fleming had warned in the early stages of testing. He correctly predicted the risk of antibiotic resistance, although people neglected his ideas back in 1929. It is paradoxical because today Fleming is one of the first people we associate with the penicillin discovery, but when he alerted people of the antibiotic resistance issue nobody listened to him. People did not readily accept his theories because Fleming was not well-known or credible throughout 1929.

During the final months of 1941, soldiers contracted a common disease known as syphilis. Doctors would treat syphilis patients with a drug called Salvarsan. Treatment with Salvarsan typically lasted one year, and the compound was quite toxic. Healthcare professionals administered the drug to the patient via a glass syringe. Salvarsan came in a powder form, and the drug had to be diluted with 600 cubic centimeters of water. The treatment posed many threats to the patient. For example, if the doctor administering a large amount of the drug did not inject it properly, then the substance could enter the tissues. A substantial amount of the drug could damage the tissues leading to arm amputations or in extreme cases, death. (Lax 2008, 13). Such therapies pose great threat to the patients because the life of the patient depends on how carefully
and accurately the doctor injects the drug. Penicillin had the potential to be a more appropriate treatment in these scenarios.

Hence, Merck agreed to initially produce one kilogram of penicillin. The production process had to be done carefully in order to produce a stable form of penicillin. The process involved fermentation, isolation, and purification. In 1942, the penicillin production done by Merck gradually increased and the drug was shown to be effective against certain categories of infections including streptococcal, staphylococcal, gonococcal, and syphilis (Lax 2008, 110). Producing penicillin in larger quantities made it more effective as a treatment and increased the potential of it being developed into an injectable antibiotic.

Alexander Fleming is the name that everyone associates with penicillin, and he is the scientists who has received the most credit for this discovery. One of the reasons for this is an intervention by Sir Almroth Edward Wright, the professor from Saint Mary’s Hospital whose lab Fleming worked initially at. On 27 August 1942, Wright wrote a letter to *The Times* magazine detailing the importance of Fleming’s contributions in the penicillin discovery. In his letter Wright said, “he (Fleming) is the discoverer of penicillin and was the author also of the original suggestion that this substance might prove to have important applications in medicine” (Macfarlane 1985, 198). Although, Wright had his own justifications for writing this letter that brought Fleming fame. He believed that the letter would not only increase the publicity for penicillin, but also improve the reputation of Saint Mary’s Hospital (Macfarlane 1985, 199). If the hospital had a high reputation, then there would be more opportunities for funding. This one letter resulted in *The Times* accrediting Fleming as the brain behind the penicillin discovery. *The Times* increased Fleming’s credibility and helped people see the worth of the penicillin discovery. As a result, people would believe him about the benefits of penicillin more easily. At
the same time, Fleming had negative views about all the publicity he was receiving from the press. On September 2 1942, he wrote a letter to Florey saying “Although my work started you off on the penicillin hunt, it was you who have made it a practical proposition, and it is good that you should get the credit. You are lucky to be in Oxford to be out of range of reporters. They are persistent lot, and I have not been able to dodge them completely” (Fleming, quoted by Macfarlane, 1985, 200). Ironically, Fleming himself recognized Florey’s contribution, but the press only publicized Fleming’s name.

Case Studies and Wartime Applications

Anne Miller was treated with purified penicillin from Oxford University. Miller had contracted a deadly streptococcal infection in 1942. She was in the New Haven hospital for almost one month. Her temperature was recorded to be 107 degrees Fahrenheit (Saxon 1999). Blood transfusions, surgery, and sulfonamides were not successful so doctors had to turn to another option: penicillin. Purified was injected and her temperature dropped significantly overnight. By the next day, her physician, Dr. John Bumstead, reported that Miller was able to eat with no difficulty and was no longer feeling delirious (Saxon 1999). A single drug, penicillin, extended her life an additional 57 years. Penicillin controlled the streptococcal infection using its antibacterial properties. In Miller’s case, a greater amount of penicillin was able to be produced because Florey worked with American companies to mass produce the antibiotic. In 1943, a two-year-old girl from New York who had blood poisoning. The hospital staff claimed that she only had seven hours to live, and they obtained a sufficient supply of penicillin for her treatment. She recovered in a matter of a few hours (Wainwright 1986, 54).
Such case studies helped to perfect the dosage and delivery of the drug. The trials also advanced penicillin’s progression from a discovery to a safe and applicable treatment. Penicillin had widespread applications, especially in World War II. The survival rate of military troops increased to 50 out of 100, and decreased the death rate cause by pneumonia from 18% to 1% in World War II (Masters 1946, 53). Treatments would consist of regular penicillin injections which were more effective and efficient. According to medical teams, thirty to forty cases were successfully handled per day (Ligon 2004). There were many posters during World War II that promoted penicillin because of its beneficial effects. Figure 9 is a poster depicting a healthy soldier who is feeling better because of the penicillin that saved his life.

Figure 9. Poster promoting penicillin from World War II (Quinn 2013).
Penicillin had another successful application in the wartime context on June 6, 1944 otherwise known as D Day. As part of the D Day battle, 156,000 troops from the Allied Powers (United States, Britain, France, Soviet Union, and China) arrived to free Western Europe from German control (Beevor 2009). They fought on five beaches aligning the coastline of Normandy. Many soldiers were suffering with infections and a condition known as gangrene. Gangrene is a medical condition in which a large amount of blood is lost leading to organ and muscle damage.

Pfizer helped produce 2 million doses of penicillin using 25,000 metal gallon tanks (Lax 2008, 120). The large supplies of penicillin were sent to the troops participating in the D Day fighting. Penicillin inhibits infectious bacteria and therefore helps prevent the onset of gangrene. In fact, in the D Day Museum in Portsmouth there was a display of a book titled The Use of Penicillin in Treating War Wounds (Figure 10). The display contained the original book written by Dorothy Hansell, a Voluntary Aid Detachment nurse who served during the D Day battles. She described penicillin as being “a miracle drug” because of its impact on the lives of many soldiers. In addition, penicillin treated burns for the seriously ill. According to Lax, penicillin is a symbol of British pride because people around the world were relying on this British invention (Lax 2008, 120).
Recognition from the Medical Community

Fleming, Florey, and Chain all received the Nobel Prize for Physiology and Medicine in 1945. Each of the scientists gave banquet speeches upon receiving the Nobel Prize. The speeches revealed personality traits of the scientists.

Fleming discusses his strong beliefs about destiny and how fate leads to the ultimate consequences: “We all know that chance, fortune, fate or destiny-call it what you will has played a considerable part in many of the great discoveries in science” (Fleming 1945). He preferred to conduct his research and make his own decisions. This personality quirk could explain why he was the one who discovered penicillin in the first place. He wanted to be in control of his research and follow his intuition, which helped him land the biggest accidental discovery of his
life. Making judgments about the experimentation was not difficult for Fleming because he had a passion for the field of bacteriology. Fleming was simultaneously humble and recognized the contributions of other researchers in the development of penicillin into a drug (Fleming 1945). The humbleness made it easier for people to accredit Fleming and view him as one of the heroes of the 20th century.

Florey gave appreciative remarks at the beginning of his speech. He explains how he enjoyed interacting with different scientists in the field, which could explain his collaborations with other researchers such as Chain. He feels that working with multiple people increases the chances of success. Fleming had an opposing view because he preferred to be in control of his research. Looking back, Fleming’s view may have been better for an initial discovery, although Florey’s collaborative approach was more appropriate for making penicillin into the efficacious drug treatment it is. For example, the mass production of penicillin required international collaboration between America and England. Florey perceives science as a way to solve the global problems faced by mankind. His view could clarify why he was one of the major hands behind the development of commercial penicillin, which could be used by people all around the world. In addition, Florey feels people should be rewarded for their knowledge and hard work. He followed this belief when he persisted to find partner companies willing to mass produce the penicillin. Florey had certain qualities that made him successful in commercializing penicillin (Florey 1945).

Chain dedicated a greater time to talk about what the Nobel Prize achievement means to him. He was grateful to the Nobel Prize Committee for giving him the award without taking his race or nationality into account, especially since he had been discriminated for his Jewish background before. He also recognized Florey’s contribution in developing penicillin showing
his willingness to cooperate with others. Chain was already motivated about science and he claimed that “the recognition of my work in this singular manner has naturally given me enormous encouragement.” His passion for science is what drove him to complete all the penicillin tests he performed within animals (Chain 1945). Similar to Florey, Chain greatly values collaboration with other experts in the scientific field. Chain has a huge enthusiasm for science and a large amount of respect for the Nobel Prize Committee.

Conclusion

Penicillin revolutionized the field of antibiotic treatments. It saved millions of lives and many people at the time of the twentieth century highly regarded this drug. People viewed penicillin as a miracle drug and they were impressed with how effectively it addressed a major concern of the time: bacterial infections. The whole story of penicillin has been brought down to a simple event. However, completing an analysis of the penicillin development has allowed me to discover the complex story hidden underneath. Today penicillin is used as an antibiotic to treat infections. Penicillin can be taken orally or through injection. In 2010, 7.3 billion units of penicillin were consumed (Lax 2008). People should take a greater appreciation for the penicillin antibiotic as it had great implications for humans, and there were multiple researchers that had to come together to develop the drug.

Through the essay, I tried to answer the historical question of why the story of penicillin was simplified down to one event of Fleming’s discovery by providing a complex account of events that the simplified version tends to overlook. The complex account hints at the contributions of the other researchers and attempts to explain why Fleming was the scientist who received the greatest recognition. This paper has also revealed the manner in which history of
medicine papers are written. Often times, the account will honor one person with the credit at the expense of the others. Macfarlane states that “there would have to be a…focus for the public gratitude for the gift of penicillin, and it was natural that one name rather than several should become the focal point” (1985, 201). Fleming was given the credit, and he was viewed as the hero in the eyes of the people. He was probably accredited and chosen to be the “focal point” because, as Wright stated in his letter, he initially discovered the penicillin. The other scientists, including Florey and Chain, who were not honored as much played a critical role in the drug research process. Without them, penicillin would not have been made into a commercially available drug. In writing of the history of medicine, all the authors’ credit is at stake for the sake of simplifying the account and turning it into one that is remembered by people.
Works Cited


*Penicillin. A Brief History* with plates. 1944.


