ALEXANDER FLEMING'S MIRACULOUS DISCOVERY OF PENICILLIN

Stacie L. Derderian *
Undergraduate Student, B.A. in Mathematics Program, Rivier College

1. INTRODUCTION

Antibiotics, chemicals produced by microorganisms that kill other microorganisms, were discovered by Alexander Fleming in 1928. Antibiotics kill bacteria by breaking down their cell walls (Sun, 2005). As a result, they are effective treatments for bacterial infections. Prior to the discovery of antibiotics, people with simple wounds and infectious diseases could not be treated. These people often died.

Alexander Fleming's background is very interesting because he was involved in many different things throughout his life. He was born on August 6, 1881, in Lochfield, Scotland and came from a large family (McGill, 2000). Fleming grew up in a sheep farming family (Ho, 1999). As a child, he spent much of his time outdoors. He was very interested in nature, asking himself how and why things worked the way they did. When Fleming was 14 years old, he went to London to go to school while working for a shipping company (McGill, 2000). He later entered medical school at St. Mary's Hospital of London (McGill, 2000). Early in his medical life, he became interested in bacteria (Sun, 2005). In 1906, Fleming earned his degree in bacteriology (McGill, 2000). He remained at St. Mary's as a researcher and teacher (McGill, 2000). He later joined the Army Medical Corps in 1914, when World War I began (McGill, 2000). During World War I, he was working hard to find a chemical cure for infection (McGill, 2000). In 1918, he discovered an antibacterial enzyme in tears and saliva called lysozyme (McGill, 2000). In 1943, he was elected Fellow of the Royal Society and knighted in 1944 (Sun, 2005). In 1945, Fleming was one of three scientists to receive the Nobel Prize in physiology and medicine (Penicillin). Furthermore, in his career, he received various honorable titles (Sun, 2005). One such honor was Emeritus Professor of Bacteriology granted by the University of London (Sun, 2005). Sadly, Alexander Fleming died in 1955 because of a heart attack (McGill, 2000). Fleming was buried in St. Paul's Cathedral with other heroes of Great Britain (McGill, 2000). Fleming was motivated by the desire to help mankind, which led him to look for antibiotics (Sun, 2005).

The political environment at the time Fleming discovered penicillin, in 1928, was unstable. Many wars were happening during the time Fleming discovered penicillin. Prior to World War I and II, in 1900, the Boer War broke out between England and the colonies in Southern Africa (Penicillin). After, World War I started in 1914 and ended in 1918. During World War I, Fleming saw many soldiers die (Penicillin). These soldiers did not only die from combat wounds, but also from blood poisoning (Penicillin).

World War II followed in the year 1939 and ended in 1945. During this period, soldiers were dying and could have lived if penicillin had been mass produced and easily obtained (Ho, 1999). Fortunately, by D-Day - June 6, 1944, there was enough penicillin to treat every soldier that needed it (Ho, 1999). Penicillin saved millions of lives by the end of World War II (Ho, 1999). It was used for more than battle wounds. For instance, during World War I, the death rate from pneumonia totaled 18% in the American Army (Penicillin). However, during World War II, the death rate from pneumonia fell to less

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than 1% (Penicillin). It is marvelous that penicillin was discovered around the time of the wars so that many peoples' lives could be saved.

In fact, at the time Fleming discovered penicillin society was plagued with people dying from many sicknesses and diseases. For instance, people were dying of pneumonia and blood poisoning, and women were dying during childbirth due to postnatal infections, and other bacterial infections (Ho, 1999). Strep throat, scarlet fever, diphtheria, syphilis, gonorrhea, meningitis, tonsillitis, and rheumatic fever also caused many deaths. So, it seemed that people would not have time to enjoy life and relax if they were sick or caring for the sick each and everyday. People would be wondering if they were going to live to see the next day.

Comparing the number one cause of death in 1900 to the number one cause in 1996 can help us understand what people were going through in their environment at the time penicillin was discovered. In 1900, the number one causes of death were pneumonia and influenza (Ho, 1999). However, in 1996, the number one cause of death was heart disease (Ho, 1999). From this, it seems that the number one cause of death in 1996 was not pneumonia or influenza because penicillin was available. This highlights what life and death were like for people before penicillin.

2. EXPERIMENTAL DISCOVERY OF PENICILLIN

The discovery of penicillin happened in 1928, by accident, when these political and societal issues were taking place. It all started out when Alexander Fleming was researching the properties of Staphylococci, a group of Gram-positive bacteria, which have a particular type of cell wall (Penicillin). Fleming was also pondering a hypothesis that his own nasal mucus had antibacterial effects (Ho, 1999). In July of 1928, Fleming left his lab work and went on a vacation (Ho, 1999). Before leaving, he left a culture plate smeared with Staphylococcus bacteria on his lab bench (Ho, 1999). He returned about a month later in August or early September and observed an interesting phenomenon (Sun, 2005). He noticed that many culture plates were contaminated with a mold that produced a yellow substance, which was inhibiting bacterial growth (Sun, 2005). Fleming took a closer look at a random plate (Sun, 2005). He noticed that the Staphylococcal colonies showed lysis, the destruction of bacteria cells, for some distance around the mold growth (Sun, 2005). Fleming (Sun, 2005, p. 2) reported, "But from the previous experience, I would have thrown the plate away, as many bacteriologists must have done before. It is also probable that some bacteriologists have noticed similar changes to those noticed [by me]… but in the absence of any interest in naturally occurring antibacterial substances, the cultures have simply been discarded… instead of casting out the contaminated culture… I made some investigations." Prior to leaving for vacation, Fleming was unaware that a spore of a rare variant mold called *Penicillium notatum* drifted onto the plate (Ho, 1999). Luckily, Fleming decided not to store the plate in a warm incubator and London was hit by a cold spell; this gave the mold an opportunity to grow (Ho, 1999). Later, as the temperature rose, the Staphylococcus bacteria grew very fast covering the entire plate except for areas surrounding the moldy contaminant (Ho, 1999). Seeing this interesting phenomenon was Fleming's "Eureka" moment (Ho, 1999). Fleming correctly deduced that the mold must have released a substance that inhibited the growth of the bacteria (Ho, 1999). Fleming named the active ingredient in the mold penicillin (Ho, 1999).

Fleming used some components of the Scientific Method when he discovered penicillin. Since Fleming discovered penicillin by accident, he did not ask questions and propose a hypothesis about the penicillin. On the other hand, he did design the experiment with the culture plates. He also collected data and organized his data into tables and graphs. Fleming developed plausible explanations for the data. He reasoned that a mold inhibited the growth of bacteria. He did not, however, devise a hypothesis for the penicillin experiment because when starting the experiment he was trying to prove a different antibacterial theory based on his own nasal mucus. Fleming also communicated his findings by writing a paper and speaking to other scientists. Hence, Fleming did indeed use some parts of the Scientific Method.

3. MATERIALS AND METHODS

There was a simple method of examining for inhibitory power (Fleming, 1929). First, a furrow was cut in an agar plate and filled with a mixture of equal parts of agar and broth in which the mold has grown (Fleming, 1929). Then, once this turned into a solid, cultures of various microbes were streaked at right angles from the furrow to the edge of the plate (Fleming, 1929). Staphylococcus was a suitable microbe on which to test the broth in the event because it was hardy, lived well in cultures, grew rapidly, and was very sensitive to penicillin (Fleming, 1929). The inhibitory substance diffused rapidly in the agar (Fleming, 1929). Before the microbes showed visible growth, the inhibitory substance spread out a centimeter in adequate concentration to inhibit the growth of a sensitive microbe (Fleming, 1929). With more incubation, portions of the culture closest to the fungus became transparent (Fleming, 1929). This portion of the culture was examined and it was found that most of the microbes were dissolved (Fleming, 1929). This showed that the anti-bacterial substance continued to diffuse into the agar at a high enough concentration to kill bacteria (Fleming, 1929). Therefore, this method demonstrated the bacteria-inhibitory and bacteriolytic properties of the mold culture (Fleming, 1929).

There was a way to determine the concentration of the substance with the greatest inhibitory power (Fleming, 1929). Serial dilutions of penicillin were made in fresh nutrient broth (Fleming, 1929). Then, all the tubes inoculated with the same volume of bacterial suspension were incubated (Fleming, 1929). Inhibition was assessed by comparing the opacity (cloudiness) of the broth (Fleming, 1929). If there was less opacity, there were fewer living bacteria. Thus, there was greater inhibitory effect from the penicillin.

4. RESULTS

There were nine major results from the research of penicillin. First, a specific type of Penicillium produced a powerful antibacterial substance in culture (Fleming, 1929). The antibacterial power of the culture reached its maximum when incubated at a temperature of 20°C (68°F) over seven days (Fleming, 1929). After ten days, the antibacterial power diminished until it had almost disappeared in four weeks (Fleming, 1929). Second, the best medium for the production of the antibacterial substance was nutrient broth (Fleming, 1929). Third, the active agent was filterable and the name penicillin was given to filtrates of broth cultures and mold (Fleming, 1929). Fourth, the active agent was not destroyed by boiling for five minutes (Fleming, 1929). On the other hand, in alkaline solution, boiling for one hour reduced the power, and autoclaving for 20 minutes at 115°C (239°F) destroyed it (Fleming, 1929). The agent was insoluble in both ether and chloroform (Fleming, 1929). Fifth, the substance was active against Diphtheria bacilli and on pyogenic cocci (Fleming, 1929). Other bacteria such as the coli-typhoid group, the influenza-bacillus group, and the enterococcus were insensitive to the substance (Fleming, 1929). Sixth, penicillin was non-toxic to animals in large doses (Fleming, 1929). Its doses did not interfere with the leucocytic function more than ordinary broth (Fleming, 1929). A seventh result was that penicillin was suggested to be an efficient antiseptic for application to, or injection into, areas infected (Fleming, 1929). An eighth result was that the use of penicillin on culture plates rendered many bacterial inhibitions, which were not evident in ordinary cultures (Fleming, 1929). Lastly, the value of penicillin as an aid to the isolation of B. influenza, a virus, was demonstrated (Fleming, 1929).

5. DISCUSSION AND CONCLUSION

Fleming showed that Penicillium species produce a very powerful antibacterial substance, which affects the growth of a variety of bacteria (Fleming, 1929). The least sensitive bacteria are the Gram-negative bacilli while the most susceptible are the pyogenic cocci (Fleming, 1929). The inhibition is almost specific to microbes (Fleming, 1929). The inhibitory substances are hardly ever strong enough to withstand a slight dilution with fresh nutrient material (Fleming, 1929). So, penicillin is not inhibitory to the original Penicillium used in its preparation (Fleming, 1929). Hence, penicillin can withstand additional penicillin, which is important because it needs to be kept to a certain concentration in the body in order to attain complete effectiveness.

Additionally, in regards to infections with sensitive microbes, penicillin seems to have advantages over antiseptics (Fleming, 1929). Penicillin was found to be more powerful than carbolic acid and can be applied to infected surfaces undiluted since it is non-irritant and non-toxic (Fleming, 1929). A good sample of penicillin will fully inhibit Streptococcus pyogenes, Staphylococci, and pneumonococcus in a dilution of one in eight hundred (Fleming, 1929). Therefore, if someone puts penicillin on a dressing, it will still be effective even when diluted eight hundred times (Fleming, 1929).

6. IMPACTS

There are five important impacts of the discovery of penicillin on society. One impact is now bacterial infections are not troublesome (Sun, 2005). Penicillin forever altered the treatment of bacterial infections and was recognized as the most life-saving drug in the world (Ho, 1999).

A second impact is that penicillin also has use in bacteriological media because it inhibits unwanted microbes in bacterial cultures (Fleming, 1929).

A third impact of the discovery of penicillin is that this discovery triggered the Age of Antibiotics, further research on antibiotics by scientists around the world, and advancement of medicine (Sun, 2005). For instance, penicillin brought about the greatest search in medical history (Penicillin). People began to think if there is one antibiotic, then there must be many more; and many more would be found (Penicillin). Antibiotics are not only produced by certain fungi but are also derived from bacteria particularly Actinomycetes (Penicillin). Nonetheless, without discovering penicillin, many other antibiotics would probably never have been discovered (Penicillin).

A fourth impact is a man-made negative impact. Misuse or overuse of penicillin results in microbial resistance; the germ has taught itself to outsmart its killer. With the convenience of penicillin, patients and doctors may have become too quick to rely on a pill, disallowing the human body to heal itself naturally or alternatively. Taken to an apocalyptic extreme, this could mean eventually all antibiotics lose their effectiveness and humans begin to die from common infections.

A fifth major impact of the discovery of penicillin is that it saves millions of lives worldwide, including the soldiers that were in World War II (Sun, 2005). Alexander Fleming's discovery initiated a large pharmaceutical industry by the middle of the 20th century (Ho, 1999). This industry churned out synthetic penicillin (Ho, 1999). Penicillin conquers some of mankind's most ancient scourges, including tuberculosis and gangrene (Ho, 1999). Penicillin is vital because everyday it saves countless people from dying. Thus, Alexander Fleming's discovery of penicillin is an extremely important scientific, historical discovery.

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* **STACIE L. DERDERIAN** is a senior at Rivier College. She is pursuing a Bachelor of Arts Degree in Mathematics and a Minor in Spanish. Stacie has written a poem entitled "What Should I Do?" *Typically Unusual*, the online Rivier magazine, has published this poem. She has worked as a library assistant and a math tutor at Rivier College. Stacie has also served as a Reading Buddy at an elementary school in Nashua, NH. In the past, she volunteered for various community services, such as "Penny Pickers" of Nashua. Stacie enjoys swimming, gymnastics, and playing the clarinet.