**Chapter 3 – Cell Function and Structure**

***Wonder Drug: How a chance discovery in a London laboratory revolutionized medicine***

**Driving Questions**

1. What structural features are shared by all cells, and what are the key differences between prokaryotic and eukaryotic cells?
2. How do solutes and water cross membranes, and what determines the direction of movement of solutes and water in different situations?
3. How do antibiotics target bacteria, and in what situations is antibiotic therapy indicated?
4. What are some key eukaryotic organelles and their functions?

**Story Abstract & Additional Information**

The story in this chapter utilizes the discovery of penicillin and its use (both historically and in the present day) in medicine to explain cell function and structure, and how antibiotics work.

Here are some of the key points in the story for this chapter.

**How the First Antibiotic Was Discovered**

* Alexander Fleming first noticed the bacteria-killing property of *Penicillium* *notatum* (a mold) in September 1928. Looking at a petri dish that contained the fluffy white mold, he saw that there was a zone around the mold where bacteria did not seem to grow.
* Experiments confirmed that the mold was capable of killing many kinds of bacteria, including *Streptococcus, Staphylococcus,* and *Pneumococcus.* Fleming published his results in 1929 in the *British Journal of Experimental Pathology*. He named the antibacterial sub­stance “penicillin,” after the fungus producing it, *Penicillium notatum*. It was the birth of the first **antibiotic**.
* Ironically, despite its remarkable killing pow­ers, penicillin was not immediately recognized as a medical breakthrough when it was first dis­covered. At the time, the idea that an antiseptic agent could kill bac­teria without at the same time harming the pa­tient was unheard of, so Fleming never considered that penicillin might be taken inter­nally. Nor was he a chemist, so he lacked the expertise to isolate and purify the active ingredient from the mold. While he found that his mold juice made a “reasonably good” topical antiseptic, he noted that “the trouble of making it seemed not worthwhile,” and largely gave up working on it.
* <http://nobelprize.org/nobel_prizes/medicine/laureates/1945/fleming-bio.html>

**Penicillin’s Early Use**

* In 1938, Ernst Chain, a German-Jewish biochemist, was working in the pathology department at Oxford University, having fled Ger­many for England in 1933 when the Nazis came to power. Both Chain and his supervisor, Howard Florey, were interested in the biochemistry of an­tibacterial substances. Chain succeeded in isolating and concentrating the active ingre­dient from the mold.
* With the beginning of WWII in 1939 and few other antibacterial medicines available, penicillin suddenly became the focus of re­search.
* At first it took up to 2000 liters of mold fluid to obtain enough pure peni­cillin to treat one person. The breakthrough that allowed it to be produced on a larger scale was a method for growing the mold on corn, a crop that the United States had in abundance.
* At first, all the penicillin harvested from U.S. production plants came from Fleming’s origi­nal strain of *Penicillium notatum*. But research­ers continued to look for more potent strains to improve yields. Then in 1943, Mary Hunt, a researcher, discovered a new strain of the mold―*Penicillium chrysogenum*―which produced more than 200 times the amount of penicillin as the origi­nal strain. Production of the drug soared.
* By the time the Allies invaded France on D-day, June 6, 1944, they had enough peni­cillin to treat every soldier that needed it. By the following year, penicillin was widely available to the general public and for the first time, doctors had a way to treat such deadly illnesses as bacterial pneumonia, syphilis, and meningitis.
* For his pioneering research, Alexander Fleming, along with Howard Florey and Ernst Chain, was awarded a Nobel Prize in 1945.
* <http://www.history.com/shows/modern-marvels/videos/inventions-of-war-penicillin>

**Penicillin’s Influence on Other Antibiotics**

* Most of the bacterial world falls into one of two categories: **Gram-positive** and **Gram-negative.** These names reflect the way bacterial cell walls trap a dye known as Gram stain (after its discoverer, the Danish sci­entist Hans Christian Gram). Fleming found that while penicillin easily killed Gram-posi­tive bacteria like *Staphylococcus* and *Strepto­coccus*, it had little effect on Gram-negative bacteria like *E. coli* and *Salmonella*.
* The discovery that penicillin was effective only on Gram-positive bacteria led other researchers in the 1940s to look for other antibiot­ics that could kill Gram-negative bacteria. The first such broad-spectrum antibiotic was strep­tomycin, discovered in 1943 by Albert Schatz and Selman Waksman at Rutgers University. In addition to killing Gram-negative bacteria, streptomycin was the first effective treatment for the deadly bacterial disease tuberculosis.
* <http://nobelprize.org/nobel_prizes/medicine/laureates/1952/press.html>

**Antibiotics Today**

* To those who first benefited from its healing powers, penicillin seemed like a wonder drug, and today antibiotics are some of the most widely prescribed drugs. But the overuse and misuse of them has led to antibiotic-resistance, which the Centers for Disease Control and Prevention calls “one of the world’s most pressing public health problems” (for more on antibiotic-resistant bac­teria, see Chapter 14).
* Fleming himself warned against this very danger. In a 1945 interview in *The* *New York Times*, he said that improper use of penicil­lin could lead to the survival and reproduction of virulent strains of bacteria that are resistant to the drug. He was right. In 1945, when peni­cillin was first introduced to the public, virtu­ally all strains of *Staphylococcus aureus* were sensitive to it. Today, more than 90% of *Staphy­loccocus aureus* strains are resistant to the an­tibiotic that once conquered this common microbe. In 2010, the American College of Physicians esti­mated that of the more than 133 million courses of antibiotics prescribed in the United States each year, as many as 50% are prescribed for colds and other viral infections for which they’re powerless.
* Because of the alarming growth in antibiotic-resistant superbugs, drug companies and re­searchers are trying to develop new antibiotics. One strategy they employ is to tweak the chemi­cal structure of existing antibiotics just enough that a bacterium cannot disable it. Another ap­proach is to look for antibiotics that target other bacterial weaknesses.
* <http://www.mayoclinic.com/health/antibiotics/FL00075>

**Additional information about other topics from this chapter includes:**

Read more about how antibiotics in this article are used.

<http://www.nlm.nih.gov/medlineplus/antibiotics.html>

Antibiotics can be harmful if mixed with substances like alcohol. This article from the Mayo Clinic describes the potential dangers:

<http://www.mayoclinic.com/health/antibiotics-and-alcohol/AN01802>

Do you need antibiotics? Consider these points from the CDC:

<http://www.cdc.gov/getsmart/antibiotic-use/know-and-do.html>