



Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2014 Volume IV: Engineering in Biology, Health and Medicine

Emerging and Reemerging Infectious Diseases

Curriculum Unit 14.04.11
by Andrea Zullo

Introduction

The following unit was developed with the understanding that diseases are an ever evolving crisis whose continuous ebb and flow through history helped to shape humans as a species. Human response to outbreaks has led to innovations in sanitation, modern medicine, and scientific discovery. Understanding transmission and developing treatments have allowed humans to gain a form of mastery over what was previously thought to be an unstoppable force. However, as humans respond to diseases, diseases reply with new out breaks and re-emergence of pathogens that devastate populations and upset the tentative balance we have fought hard to win. This unit provides students and teachers the chance to explore the arms race between humans and emerging infectious pathogens.

At the time this unit was conceived, several potential dangerous pathogens were emerging in the global population. While this unit focuses on these outbreaks and several notable outbreaks in recent history, there is room to utilize current discoveries to keep this unit up to date and relevant in the classroom. Furthermore, as with all emerging diseases, time is required to fully understand the nature of their transmittance and origin. As such, information included in this unit may be outdated. It is highly recommended that the materials provided in this unit are supplemented by current research and articles in order to provide the most up to date picture of the emerging diseases discussed.

This unit touches five major topics areas and necessary background information. While the scope of this unit is very broad and may take between four and six weeks to complete, each of the topic area can be reduced to form five mini-unit or lesson plans. This particular unit was developed for high school students in either biology or biomedical science courses. The materials and activities in this unit plan can be scaled down to accommodate younger students or can be extended to build a strong science enrichment program.

Rationale

I am a high school teacher at Hyde Magnet School of Health Science and Sports Medicine. Hyde is a small, science based magnet school that focuses on preparing students to enter into careers that are founded in health science and sports medicine. This unit is written to be included at the end of the sophomore biology course in the fourth quarter. It will provide students with an opportunity to explore the concept of epidemiology and microbiology while also introducing students to various career opportunities in this field.

Subunit One: Bacteria and Virus Overview

This initial subunit addresses the background information necessary to understand the anatomy and physiology of bacteria and viruses. At the end of this subunit, students should be able to identify the major structures of bacteria and viruses and the differences and similarities between them.

Bacteria Anatomy, Morphology, and Arrangement

In this portion of the subunit, students will learn about the basic anatomy and structures that are common with bacterial pathogens. In addition, students will learn about differences in the peptidoglycan cell wall and capsule of bacteria species and how this structure is important for identifying the bacteria. Students will also learn basic morphology and arrangement of bacterial species, a key feature to identifying the infectious agent. It is recommended that students use the biology texts issued by their districts or sample microbiology text books to assist them with this portion of the unit.

Bacteria are microscopic, prokaryotic organisms known to cause several debilitating, contagious diseases. Bacteria are ubiquitous and, while often depicted in a negative light by media, are not all harmful. Most living organisms live in synergy with bacterial cells and receive many benefits from their mutual interaction. Humans are covered in native flora which provides us with several important health benefits.²⁴ However, not all bacteria are beneficial. Several bacterial species are known to cause debilitating or deadly diseases.

Bacteria possess many of the same cellular traits that students are familiar with from introductory biology units, however, it is worth reviewing the function of basic organelles. Students should also be reminded of the meaning of prokaryotic and the key differences between this formation of cells and the eukaryotic cells. There are also parts of bacteria cells that students may not have been exposed to in prior units (see Figure 1).

In addition to the cell membrane, bacteria possess two additional external structures called the cell wall and the capsule. Students may be familiar with the concept of a cell wall if they have already studied plant cells. It is important to note that the bacterial cell wall is made of a substance called peptidoglycan, not the cellulose found in plants, and is found in one of two types. Bacteria with a very thick cell wall are considered to be Gram Positive, while thin cell walls indicate Gram negative species.²⁴ The cell wall provides several advantages to the bacteria, including the regulation of turgor pressure from interactions with the environment.

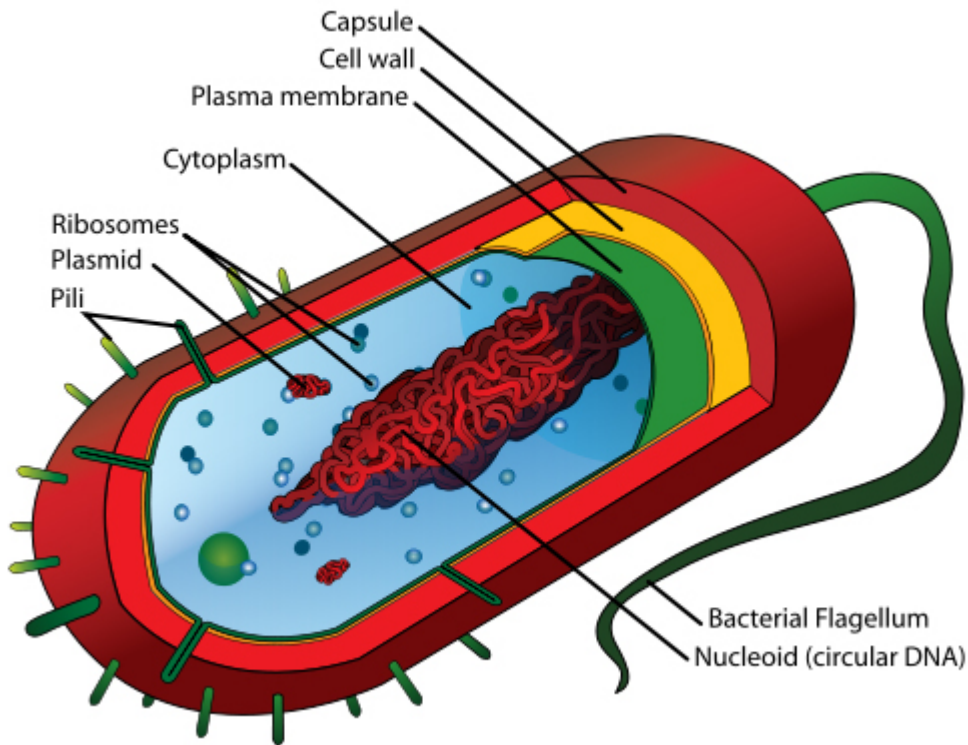


Figure 1. A sample prokaryotic cell with major parts labeled. Retrieved: http://en.wikipedia.org/wiki/Bacteria#mediaviewer/File:Average_prokaryote_cell-_en.svg

The cell capsule is found mostly in Gram negative species, although there are a few notable Gram positive species that do have one present. The cell capsule is a virulence factor in most pathogenic bacteria species.²⁴ This structure prevents phagocytosis and desiccation of the bacterial cell and allows it to adhere to surfaces aiding in the formation of biofilms or fomites.²⁴

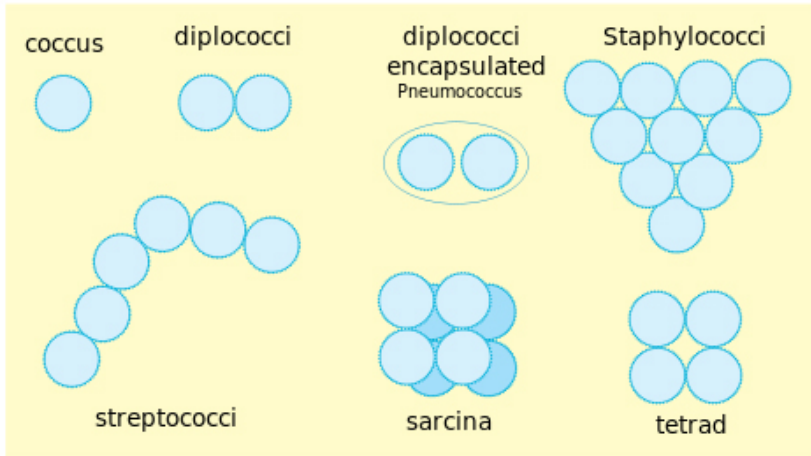
Additional external structures of bacteria include the pili—short hair like structures found projecting outward that assist in movement through a rowing motion—and the long whip-like flagella. Students should become familiar with several flagella arrangements, including peritrichous, lophotrichous, and amphitrichous morphologies.²⁴

Some bacterial species can form structures called endospores. Endospores are resistant encapsulations that allow for bacteria cells to survive hostile environments. Endospores are not reproductive, but may allow a bacteria to survive in an otherwise dangerous environment until conditions become suitable for it to reactivate into a vegetative or reproductive state.²⁴ There are even cases of endospores being revived after millions of years of hibernation.²

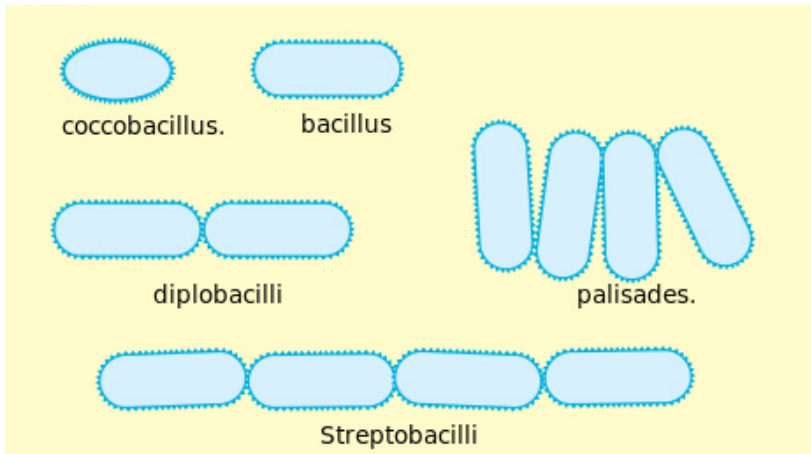
Students should also be exposed to the three common morphologies of bacterial cells—cocci, bacilli, and spirillum. In addition to being able to recognize common morphologies, students should also be familiarized with the arrangements that these forms take. Specific morphologies have particular arrangements that are common. Bacterial species will favor one arrangement over others and these two pieces of information together can be important in the diagnostic identification of bacteria. Students should be exposed to staining techniques that allow them to identify the morphology and arrangements of certain bacteria. This will allow them to dissect some bacterial names and identify bacteria from slides or to construct what certain bacterial

colonies should look like given the name (see Figure 2).

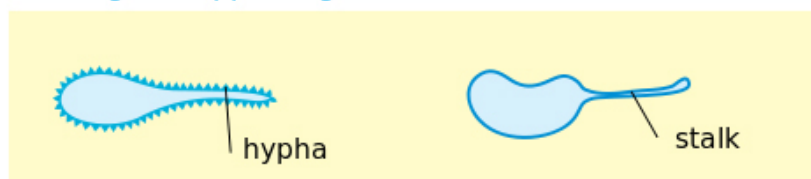
Cocci



Bacilli



Budding and appendaged bacteria



Others

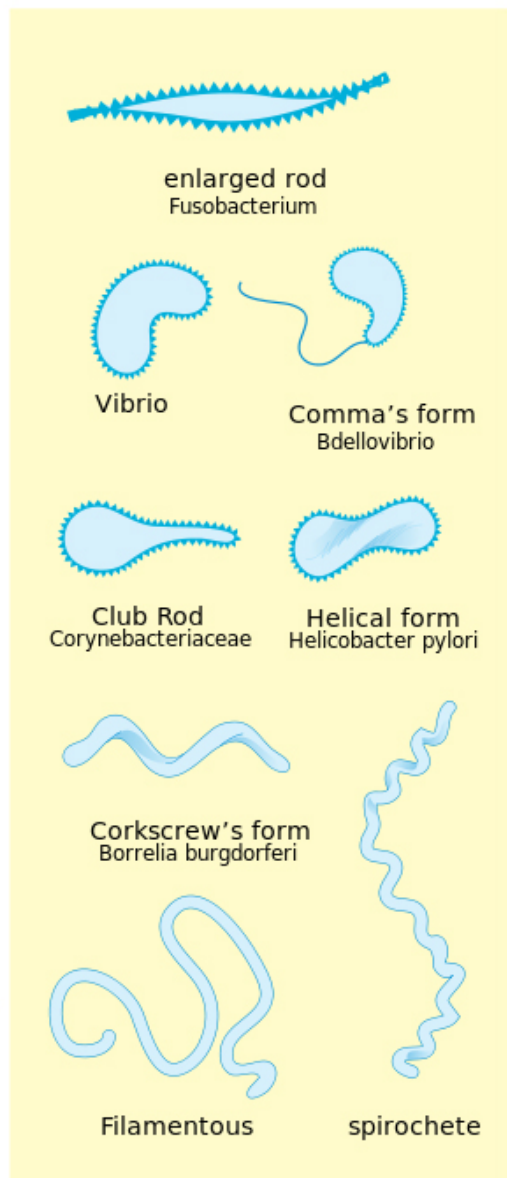


Figure 2. A diagram of bacterial morphology and arrangements. Retrieved: http://en.wikipedia.org/wiki/Bacteria#mediaviewer/File:Bacterial_morphology_diagram.svg

It is important to note, however, that there are several other bacterial morphologies that students might encounter outside of the big three. Coccobacillus bacteria, for example, are more oblong than a normal coccus, but do not have the length associated with the rod shaped bacillus bacteria. Examples of coccobacillus species include the re-emerging bacterium *Bordetella pertussis*, the causative agent of whooping cough.

In addition, I have loosely grouped spirillum into one class when, in reality it should be divided into three subgroups: vibrio, spirillum, and spirochete. Vibrio morphologies, as seen in the bacterium *Vibrio cholerae* are comma or curved rods. These bacteria do not have the exaggerated spiral shape that is often associated with the spirillum grouping. Spirillums are often bacteria that are characterized by thick, rigid spirals. Common

examples of this bacterial morphology are *Spirillum volutans* and *S. minus*. The last classification within this grouping is the spirochetes. Spirochetes are often thinner and more flexible than spirillum. They also exhibit a higher volume of curl than is seen in the more rigid, thicker bacteria. Examples of spirochetes include the causative agent of Lyme's disease, *Borrelia burgdorferii*, and *Leptospira*.

Bacteria Staining Protocols

Two staining protocols commonly used in microbiology labs to identify bacteria morphology, arrangement and, structure, are simple staining and negative staining. Simple staining is, as the name implies, relatively easy to perform. This type of staining is ideal for a laboratory class and can be modified to suit every facilities particular constraint and needs. Simple stains are performed using one basic (positively charged or cationic) stain such as methylene blue or safrinin. ²⁴ These stains color the cell because they have a slight positive charge to their chromophore—the name for the grouping of the compound that contains the color. Bacterial cells are slightly negatively charged. When introduced to a basic stain like safrinin or methylene blue, the stain readily binds with the cell proteins, essentially staining it the color of the chromophore. ²⁴ As a result, cells stained with basic stains are the color of the dye itself.

It is important to note that heat fixing is crucial for developing a good simple stain. Heat fixing is used to stick bacterial cells to the slide. If this technique was not used, the stained cells would be washed off the slide when the excess dye is removed. Heat fixing requires passing a bacterial smear over a flame. The flame will cause some of the proteins to stick to the slide as they are heated with only a small amount of distortion to the organism. ²⁴ Too little heat, and the cells will wash off the slide. Too much heat will cause a great amount of distortion, drastically changing their perceived morphology and arrangement or destroying the cell entirely. ²⁴

After heat-fixing, students can apply the simple stain of their choice to the slide. The stain will sit according to the protocol, usually around one minute to ensure strong saturation, and then is rinsed off using sterile or distilled water. After, the slide should be blotted with bibulous paper to remove excess moisture. At this point, the slide can be observed.

Negative staining, unlike simple staining, uses dyes that have a negative charge. Many of the stains used in negative staining are also called acidic staining. They have a negative charge to their chromophore. ²⁴ The stain and the cell repel each other. As a result, students are left with a slide that looks like a negative of a film strip—the background is stained black while the cell itself is not. This staining technique is also referred to as indirect staining, because of the way it stains the slide and not the cells. The most common negative stain is nigrosin. Negative staining is an excellent tool for studying morphology and arrangement because no heat fixing is required to set the cells on the slide and so the highest degree of preservation is observed. ²⁴

To create negative stained slides, students will need to add a drop of nigrosin to the edge of one slide. Into the drop, mix a loop of suspended culture and agitate to break up large clumps. Using the end of another slide, students will draw the nigrosin-culture mixture across the side. Slides are usually observed after the film air-dries. It is very important to note that negative stained slides are not rinsed with water after the smearing process. Rinsing with water would remove the dye and the cells, leaving clean slides.

These are just two of the many staining techniques used in laboratory to observe morphology and arrangement of bacterial cells. We will learn another staining technique called Gram Staining in subunit four.

Virus Structure

Viruses, unlike bacteria, are not composed of cells. Instead, they are pieces of single or double stranded DNA or RNA surrounded by repeating protein subunits called capsomeres to form a polyhedral or a helical capsid structure. ²⁴ While many human pathogens are polyhedral virus crystals, it is important to expose students to the multitude of viral shapes including the 'spider-like' T4 bacteriophage shape with tail fibers and tail sheath and the *filovirus* family with their long, Sheppard's crook formations.

Students should also be exposed to the lytic and the lysogenic replication cycles of viruses and how the basic components of virus structure allow it to infiltrate host cells and hijack their cellular machinery (see Figure 3).

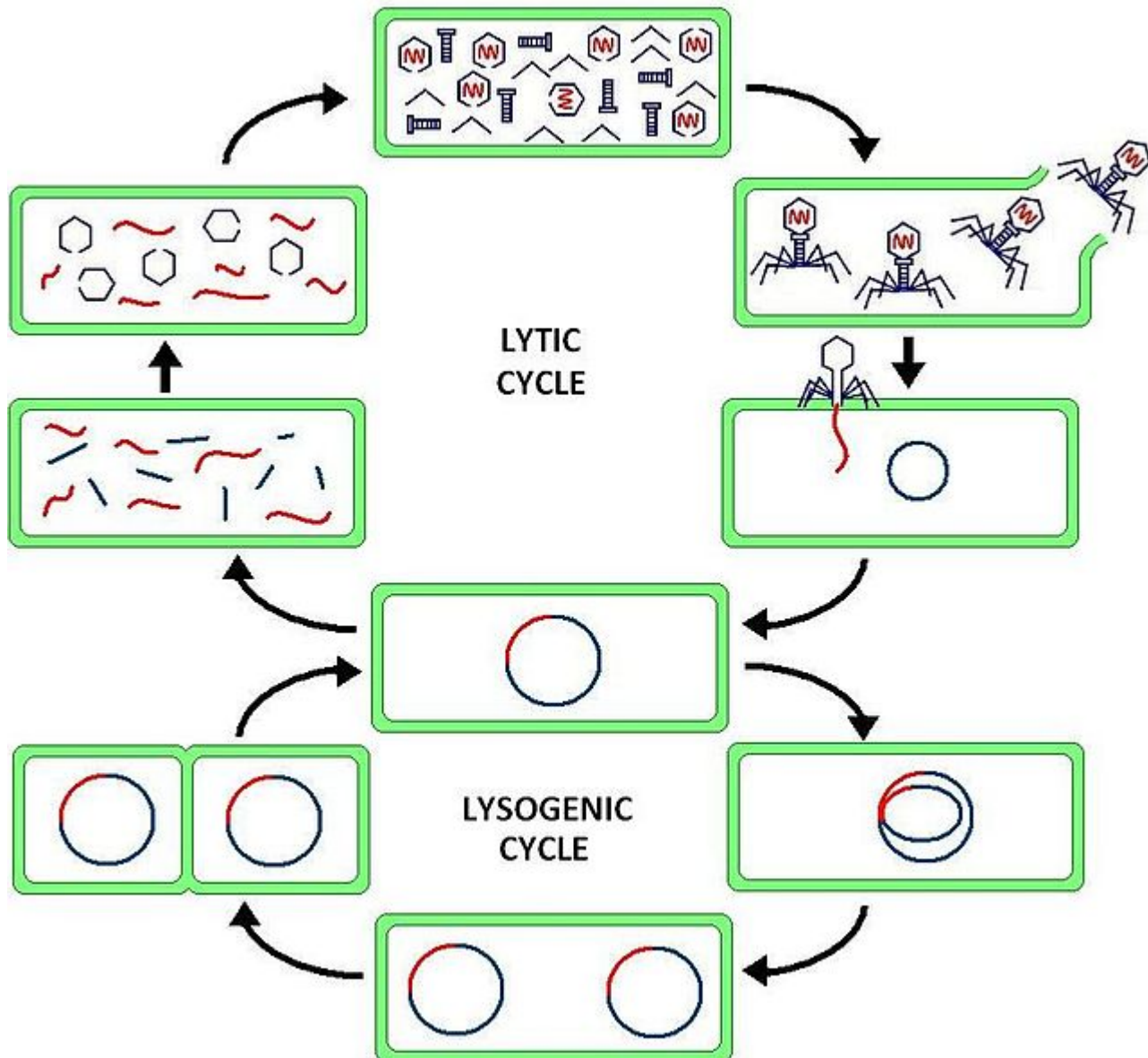


Figure 3. The viral lytic and lysogenic cycles. Retrieved: http://en.wikipedia.org/wiki/Lytic_cycle#mediaviewer/File:Phage2.JPG

Viruses are relatively immobile—they do not actively seek out hosts. Instead, they passively move through the human body until they encounter a host cell with receptor membrane proteins that trigger it to attach. If the

virus is a bacteriophage, it will inject the genetic information directly into the host cell. Some enveloped viruses have similar receptor molecules and will "merge" with the host membrane as if it were a liposome, entering the bacteria at that point. ²⁴ Once the viral information enters into the host cell, it will hijack the ribosomes and synthesize viral proteins in a replication process. The viral particles self-assemble inside of the host cell and will lyse or burst out upon completion. If the virus is an envelope virus, it will cloak itself in the cell membrane of the host as it rips its way out.

The lysogenic cycle follows the processes of attachment to the host cell and injection, but once inside the cell, the viral genetic material inserts into the host cell's DNA. This stage is referred to as the formation of a prophage. Prophage refers to the combination of the viral and host genetic information. ²⁴ At this point, the virus enters a latent stage where the host cell replicates, incidentally replicating the viral material as well. This latent, shadow stage can last several weeks to years as is seen in the case of the HIV retrovirus. As the cells proliferate, so does the viral material until there is a chemical signal that causes it to undergo spontaneous induction. At this point, the viral DNA exits the host DNA and enters into the lytic cycle.

There are several major differences between the lytic and the lysogenic cycles. The lytic cycle, while rapid, affects one cell at a time. While the number of cells infected increases with the viral load, there is a noticeably logistic growth to this type of infection within the host body. The lysogenic cycle will infect one cell and then 'hibernate', taking a long time for this cycle to undergo completion. However, the virus passively replicates as host cell turnover can, in effect replace a large amount of the cell tissue with the newly infected cells as they proliferate. Then, once spontaneous induction occurs, multiple cells burst releasing a dauntingly large viral load into the host.

Recommended teaching strategies for this subunit allow students to explore the structures of viral and bacterial pathogens and the important difference between them. One recommended teaching strategy is to allow students to study preserved slides of various bacteria and identify their morphology and arrangement. Students will have the added advantage of learning to focus microscopes under oil emersion (100x oil emersion objective lens) and manipulating slides on a light microscope. It is also recommended that students be allowed to build model viruses and label the structures.

Subunit Two: Epidemic Outbreaks—A Historical Model

The second subunit focuses on providing students with a historical prospective on epidemics and how these epidemic events shaped the way humans respond to pathogen outbreaks. This subunit focuses on the events of the black plague, otherwise known as the bubonic plague, outbreaks during the 6th century, the late middle ages, and more recently in the 2013 outbreak in Mandritsara, Madagascar. The events of these outbreaks are briefly outlined below.

Bubonic plague is a disease associated with the bacteria *Yersinia pestis*, a Gram negative coccobacillus often found in single cells, but occasionally seen in strepto- (chain like) formations. *Yersinia pestis* is a zoonotic pathogen, like many other emerging infectious diseases. This means its natural host species is not humans but it has developed the ability to operate within a human host, often with devastating effects. Other examples of zoonotic diseases include the HIV virus and Ebola,

Yersinia pestis is transmitted through the natural reservoir of wild rats by flea bites. As the flea bites the host, the bacteria are transmitted through the regurgitated liquid infecting rodents. Non-infected fleas pick up the bacteria by biting infected rats and vice versa. This disease is introduced into human populations when an infected flea bites a human host. ¹¹

The bacteria will enter the host through the skin and cause sudden onset of high fevers and buboe, from which the disease receives its name. These buboe often occur in the groin but may also appear in any lymphatic vessel. In early outbreaks, *Y. pestis* caused death in 30-50% of Europe's population. ¹¹ It is important to note that the census of this time is unreliable and these numbers are the best prediction of historians. There are three varieties of plague caused by *Y. pestis*, each with varying symptoms and mortality rates.

The first type of plague is the common bubonic plague (30-75% mortality rate) characterized by aches, high fever, and the characteristic swellings of lymph nodes. It was likely that patients suffering from the bubonic form of the plague died within the first week. Pneumonic plague had a significantly higher (90-95%) mortality rate than the bubonic form and was characterized by bloody sputum and respiratory distress. The final form of the plague, septicemic plague, was the least common and the most deadly with a 100% chance of mortality. ¹⁷ Sufferers of septicemic plague were often spotted with dark purple patches as their bodies underwent consumptive coagulation, providing the alternative name of "Black Death". The high mortality rate was assisted by a second aerosol mode of transmission where healthy individuals in contact with those infected were able to breathe in the exhaled bacterium and develop the disease. ¹¹

The response to the first pandemic outbreak of plague in the 6th century, or the Justinianic plague, caused wide spread pneumonic and septic forms in addition to the buboe. While there is no consensus of the plague's origin, it swept through the Mediterranean and is reported to have caused as many as 10,000 deaths per day as it decimated Constantinople, although these numbers are thought to be highly exaggerated due to the hysteria and lack of accurate census. ¹¹ Bodies were buried in mass graves and left in the streets and in homes to rot. Because the plague ran so quickly through the population, it burned itself out—lacking hosts to continue the transmission cycle—and fell into a stage of hibernation. There were several small outcroppings of the plague after the Justinianic plague, as there were small outcroppings before but it wasn't until the Middle Ages that another large pandemic arose. ¹¹

These same events were mirrored in the 1330s as plague once again reared in the East along the ship trade routes from China through India, Syria, and Egypt into Eastern Europe. Much like the Justinianic plague, the disease was transmitted from flea to person and eventually through aerosol between infected hosts and healthy humans. The plague caused mass hysteria as it seemingly jumped through the air to infect whole families and whole blocks of cities. Doctors lanced buboe and practiced bloodletting, or bathed patients in rosewater to cleanse them of what was assumed to be 'foul vapors' or evil spirits. ¹¹ The affected thought the plague was a punishment from God and prompted many to engage in flagellation and join the monasteries in order to seek salvation. Those left to cart out the dead wore the long beaked plague masks stuffed with flowers and herbs as a way to stifle the bad vapors and prevent them from coming into contact with the disease. By the mid 1350s, the plague burned through Europe, leaving an estimated 25 million—one third of Europe's population—buried in its wake. ¹¹

As improvements in sanitation were made, the threat of contacting these diseases decreased. Advances in modern medicine and a better understanding of the causative factors behind these diseases reduce the impact of plague outbreaks when they do occur. While most students look at the bubonic plague through the

lens of history, there are in fact still outbreaks occurring in modern times. For example, in December 2013, a re-emergence of the pneumonic plague was reported in the upper part of the island infecting 84 and killing 32. In the year before, there were 60 reported deaths from the plague—attributed mostly to a decline of sanitation and treatment options as a result of the region's increased political turmoil. ¹³

One teaching strategy that is highly encouraged for this experiment is an infectious pathogen lab. The lab exposes students to transmission and R_0 (pronounced R naught), or the reproduction rate of a virus. This is usually measured by the number of people an infected individual transmits the virus or bacterium of interest. For example, R_0 for the measles (rebeola)—a highly contagious, viral outbreak that can be spread through aerosol—can range between 12 to 18 people depending on the particular infectious strand in that outbreak. ¹⁶ That means for every person who develops measles, they are likely to spread that pathogen to over a dozen people before it is no longer virulent. To provide some prospective, most flu viruses have an R_0 slightly over 1. In this lab, students model an outbreak system using an R_0 of 2. For laboratory instructions, please visit the lesson plan and resource sections at the end of this document.

Teaching strategies for this unit also include the creation of a word wall featuring key vocabulary. As seen in the previous unit, microbiology and pathology is terminologically dense and may require many exposures to frequently encountered words in order to garner a more complete understanding. It is highly recommended that students are introduced to common epidemiology and pathology terminology. Students should be encouraged to define the words using context clues presented by the textual readings that they are using for the unit.

Students should also discuss the relevance of the terminology to the plague unit to both the currently studied plague and other emerging infectious diseases. For example, students should be able to identify the host, pathogen, symptoms, and reservoir of any bacterial or parasitic infection and extrapolate information to decide whether a disease is emerging or re-emerging or whether it should be considered a local outbreak, epidemic, or pandemic.

Students also have a unique opportunity to compare a relatively well known historical outbreak pattern with an emerging outbreak. Students can identify key factors that have altered the impact of this outbreak in Mandrisita, including how the change in infrastructure, the breakdown of medical and sanitation practices, and how political turmoil can impact the spread of infectious agents.

Subunit Three: A Survey of Current Emerging Infectious Diseases

The third subunit is a survey of current emerging or re-emerging infectious diseases. The background information in this section is intended to provide examples of six key emerging infectious diseases, in addition to the re-emergence of *Y. pestis* outlined in subunit two above. As previously stated, the background information may become outdated as scientists gain a better understanding of the infectious agents being addressed. It is highly recommended that current research be used to supplement any presentation of these materials.

SARS: Severe Acute Respiratory Syndrome

SARS, or severe acute respiratory syndrome, emerged in Asia in February 2003 and spread worldwide before the outbreak was later contained that year. The causative agent for SARS is a coronavirus SARS-CoV, a zoonotic virus that moved into human populations from infected avian populations. ¹¹ This disease presents with dangerous respiratory complications in addition to myalgia and fever. If the infection is left untreated, the virus may cause viral pneumonia and, in some cases, death.

While the outbreak is credited as occurring early in the year 2003, the first signs of emergence were in late November 2002 when a farmer was brought into First People's Hospital of Foshan to be treated for respiratory distress. ^{8,11} The patient died shortly after being admitted into the hospital. The hospital and Chinese government failed to report the novel virus to the World Health Organization, This delay in notification allowed the virus to spread slowly through China as a 'flu outbreak'. ⁸ By the time it started to make worldwide news, there were already numerous deaths.

In February 2003, an American business man flying from China to Singapore started to show symptoms of respiratory distress. ^{8,11} He was admitted into The French Hospital of Hanoi, Vietnam where he died as did his attending doctor Carl Urbani who reported the case to the WHO and Vietnamese government. ^{8,11} By this time, SARS had spread globally, with cases occurring in the United States and Eastern Europe. ^{8,11}

Shortly after, on March 29th 2003, there was a super-spread event. Sixteen individuals who lodged the 9th floor of the Hotel Metropole in Hong Kong were infected with SARS-CoV. ^{8,11} They subsequently traveled to Canada, Singapore, Taiwan, and Vietnam spreading the disease to more people. By July 31st, 2003, the SARS pandemic was considered to be under control, though no vaccine was developed to prevent future outbreaks.

MERS: Middle Eastern Respiratory Syndrome

MERS , Middle Eastern Respiratory Syndrome, is a novel coronavirus outbreak. Like SARS, MERS-CoV affects the pulmonary system of those who it infects causing severe respiratory complications. MERS-CoV was first reported in Saudi Arabia in 2012 and has since developed into media-worthy proportions in 2014. ²⁶ As of the time this paper is being scripted, 288 people have died from the virus and 830 confirmed cases, mostly in Saudi Arabia. This virus has been documented in several countries including the United Kingdom, Italy, the Philippines, Egypt, and Iran. ²⁶ While a majority of patients are asymptomatic, those who do show symptoms face a 30% mortality rate. ²⁶

MERS is another zoonotic virus spread from camels to humans. Recently, there is some evidence that MERS may be airborne, increasing ease of transmission between hosts. ²⁶ Similar to the SARS virus, there is currently no vaccine available and treatments aim to eliminate the symptoms of MERS rather than MERS itself.

Ebola

Ebola is, arguably, one of the scariest emerging and re-emerging diseases known. Ebola, and its sister virus Marburg, are part of the *filovirus* family. There are multiple strains of Ebola three of which are fatal to humans and nonhuman primates and one strain (Reston) which as of yet is not fatal to humans. Ebola is a hemorrhagic virus presenting initially with flu like symptoms but rapidly progressing into hemorrhaging, rashes, damage to the liver, and coagulopathy. ¹¹ Patients entering the terminal stages of Ebola present with profuse bleeding

from the inside the mouth, expectant from the lungs, and from the anus. Diffuse bleeding send the body into shock, leading to death in over 80% of cases in the most virulent strain. ¹¹ In total, the infection can run its course between two to three weeks time.

Ebola, and viruses like Ebola are considered 'hot viruses' and often pop up in populations and quickly burn out as they run out of hosts to support the virus. Like the previous diseases discussed, Ebola is a zoonotic disease. Transmission is initially spread by contact with infected body fluids of animals like chimpanzees, fruit bats, antelope, or porcupine. ¹¹ This wide range of animal hosts has made it difficult to pin down the natural reservoir for this virus. ¹¹ Once Ebola transmits into the human population, it is transmitted from person to person through contact with infected body fluids. There have also been documented cases of sexually transmitted Ebola from males to females up to seven weeks after a man has recovered from the illness, indicating longevity of the virus even after the patient is asymptomatic. ²⁰

Most recently, the CDC announced an outbreak of Ebola on March 25th, 2014 in several southeast districts of Guinea. Initially, a total of 86 cases were reported with 59 deaths. ⁶ The *Zaire ebolavirus* strain was indicated as the culpable pathogen. ⁶ By April 23rd, 2014 the virus spread to Liberia. ⁶ As of July 20th, 2014, the Guinea Ministry of Health has reported a cumulative death total of 314 patients out of the 415 suspected and confirmed cases. ⁶

There is currently no vaccine available for this virus although several are being developed. Part of the reason why viral vaccines are so difficult to produce is the mutability of viruses. Viruses replicate very quickly and, without the same methods to check for accurate DNA replication, often acquire mutations. This allows for the virus to quickly evolve resistance from the vaccine as its genetic information mutates. ¹⁹ In 2012, two companies that were working on an oral Ebola vaccine were informed that they needed to halt work because funding had been cut to the programs. Since Ebola tends to burn out quickly, and it is often easily contained using relatively simple protocol, it is more likely that the consumer base for an Ebola vaccine is relatively small. This makes producing the drug expensive without the payout that many pharmaceutical companies look to gain. ¹⁴ Another vaccine being developed more recently in 2014 uses surface proteins from the Ebola capsid to invoke an immune response. However, this vaccine is only in a pre-clinical evaluation. After pre-clinical evaluation, it must go through a series of clinical trials, putting an Ebola vaccine several years away. ²¹

Poliovirus and Poliomyelitis

Polio is considered to be one of the first diseases that mankind eradicated. Polio is a viral infection caused by a virus called poliovirus, a member of the picornaviridae family. ¹¹ This virus causes poliomyelitis—a transmittable disease that may enter into the central nervous system and cause paralysis of both voluntary and involuntary muscles. Interestingly, a majority of infected hosts are asymptomatic and do not express the paralysis that it is associated with. A quarter of those infected may have flu like symptoms and some stiffness which resolves over several weeks. Only 1% of people who are infected with the disease actually develop any sort of paralysis. ^{7,10} As patients age, so too does death rate as the virus spreads into the respiratory muscles causing suffocation. ^{9,11}

The height of the polio epidemic was in the late 1940s through the early 1950s. ¹¹ According to CDC records, over 35 thousand people were crippled yearly by the virus, many of them children. ^{7,10} Quarantines were used to separate the ill from the potentially infected and travel between cities was often restricted to prevent the

spread of the virus. ⁴ There is no cure for polio, only supportive measures aimed at reducing some of the symptoms. Most treatments included a combination of pain killers and physical therapy along with braces. ^{9,11} As the disease traveled towards the lungs, respiratory distress was reduced with respirators or negative pressure ventilators like the iron lung. ¹¹

It wasn't until the early 1960s when Dr. Albert Sabin developed the oral polio vaccine that the United States began to recover. ¹¹ By 1979, polio was eliminated from the United States. ^{7,10} Nine years later, the CDC, WHO, UNICEF and several other national organizations and governments band together to form the Global Polio Eradication Initiative (GPEI). ¹⁰ Outlined in their plan are four pillars: immunization of infants with the oral polio vaccine, providing supplementary immunization, surveillance for wild poliovirus in populations, and campaigns aimed at targeting any poliovirus outbreaks. ¹⁰

Currently, the CDC reports that GPEI has reduced the amount of polio outbreaks to 99% with the Americas, Europe, South East Asia and the Western Pacific marked as polio free. ^{7,10} There are currently only three countries where polio outbreaks happen with frequency—Afghanistan, Nigeria, and Pakistan. ⁷

MRSA and other Drug Resistant Bacteria

When Alexander Fleming discovered one of his *Staphylococcus aureus* petri dishes was contaminated with mold, he did not know that he had discovered the next line of defense against disease. What Fleming discovered was a secretion called penicillin, a compound that had antibiotic effects that killed bacteria. Antibiotics work by preventing the formation of bacterial cell walls or by preventing the bacterial cells from reproducing.

By the late 1960s, antibiotics were prescribed for a wide range of previously uncontrollable infectious diseases. ²² In addition, improvements in the sanitization infrastructure in major cities had improved dramatically, further eliminating conditions that contributed to the spread of bacteria and viruses. Penicillin and other antibiotics were so promising in controlling disease that in 1967 the United States of America Surgeon General William Stewart declared that, "We have basically wiped out infection in the United States."

²²

Not too long after that bold statement, a strain of penicillin resistant staph was found in a patient. Now, almost all strains of staph are resistant to penicillin. Other forms of antibiotic resistance have been noted in dozens of species of bacteria indicating that bacteria are keeping pace with our medical developments.

Antibiotic resistant bacteria, like MRSA or methicillin-resistant *Staphylococcus aureus*, are a serious health concern. Often, resistant forms of bacteria are acquired as nosocomial infections—secondary infections developed after entering into a hospital. ²³ Sometimes, infections are acquired by coming into contact with an infected person outside of the hospital. These infections can spread unchecked through a patient and are notoriously difficult to treat because the drugs that are most effective no longer work. ²³ While many cases of resistant bacterial infections occur in patients that have weakened immune systems, anyone who has come into contact with these bacteria can be susceptible. ²³

MRSA and other antibiotic resistant bacteria have evolved as a response to the flood of antibiotics. If used correctly, antibiotics can kill bacterial infections. However, many people misuse or overuse prescriptions, exposing bacterial populations to the drug without entirely removing the population. As a result, bacteria that are naturally resistant survive the infection and recolonize the host in a secondary infection.^{23,24} These bacteria are spread from person-to-person and cause further infections. Constant exposure to antibiotics has driven an evolutionary arms race between antibiotic and bacterium, creating these super-bugs.⁵

Teaching strategies and resources for this sub-unit include exposing students to news paper articles about each of these diseases. Creating an Infectious Emerging Disease wall with the lifecycle of the virus or bacterium, transmission, hosts and reservoirs, and any other pertinent information may be a helpful activity for teaching students about these diseases. With the large number of emerging or re-emerging infectious

diseases available, it may be worthwhile to assign this subunit as an individual research project.

Subunit Four: Diagnosis, Testing, and Treatment for Emerging Infectious Diseases

This subunit focuses on the diagnostic tests, and treatments for identifying and studying infectious pathogens. This subunit focuses on several bacterial and viral diagnostic tests used in the lab to identify and treat infections.

In both bacterial and viral infections there is typically an immunological response by the host cell. When host organisms interact with foreign agents, there is an adaptive immune response. The body will produce antibodies targeting the agent as not-self and tagging it for infection. The presence of the antibody immunoglobulin M (IgM) produced by the immune system appears in patient serum after contact with infectious pathogens. ²⁵

Aseptic Technique

All of the techniques listed below should be completed aseptically in order to prevent contamination. Before the transfer and preparation of slides, the surface area of the work surface should be wiped down with surfactant. After, a burner is lit to prevent bacteria from settling into the environment while working. All work should be completed in the area of the burner to limit contamination. Any loops used in the transference of bacteria must be flamed until red hot and then cooled. To remove bacteria from capped tubes, pass the cap quickly through the flame and then quickly flame the mouth of the tube. This heats up the air inside of the tube and pushes out any bacteria or fungal spores that might enter during the transference process. ²⁴ Bacteria can be removed using the sterile loop and then the tube re-flamed and re-capped.

If students have been progressing through the subunits in order, they have already been exposed to simple staining technique and negative stains. These two techniques, while not in and of themselves diagnostic, allow students to gain an understanding of the basic shapes of bacterial colonies. If subunits are being completed out of order or selectively, the protocols for simple staining of slides is listed above in subunit one.

Gram Staining

Gram staining is the first type of diagnostic testing that students will be exposed to. Gram staining is a procedure that exposes bacteria fixed on a slide to a series of stains in order to characterize their cell walls. Bacterial cells with thin cell walls stain red and are considered Gram Negative. Bacterial cells with thick cell walls stain blue and are considered Gram Positive. If the facility is properly equipped, students can practice Gram Stain technique on pre-fixed bacterial cells. Otherwise, a virtual gram stain lab is available and is included in the resources portion of this document. Gram staining capitalizes on the cell wall type to differentiate between bacterial species. ²⁴ It is important to let students know that not all bacteria respond to Gram staining and that this is one of a few diagnostic techniques available to identify bacterial types. ²⁴

Media: Nutrient, Differential, and Selective

Media often refers to the substance on which a bacterial colony is grown and maintained. There are many

different types of media, all with different purposes. Nutritive or general agar is the most common for students to have come into contact with. This media is usually composed of some sort of agarose gel complete with all of the nutritive elements needed to support the growth of the bacteria colony. This media allows all bacteria to grow and is often used in labs in order to maintain culture collections. While this media isn't necessarily diagnostic, looking at the bacteria colony characteristics on this type of media can yield some diagnostic evidence. For example, *Pseudomonas aeruginosa* often grows with fluorescent colonies that give off a grape odor. These preliminary characteristics are often key evidence for identifying *Pseudomonas* infections.

Altering the basic composition of the media by either adding or subtracting elements can greatly impact the way bacteria grow on the media. This principle is used to identify specific types of bacteria either by selecting for the bacteria type or differentiating the growing culture. Selective media is media that has an inhibitor agent added to prevent the growth of certain bacteria. ²⁴ Often, inhibitor agents select for either gram positive or gram negative bacteria. Common inhibitor agents used in selective media include high concentrations of salt, low or altered pH, missing amino acids, or specific antibiotics embedded into the media. ²⁴

Differential media, unlike selective media, relies upon the biochemical composition of the bacteria to interact with additives in order to cause a measurable, observable change to the media. Often times, differential media includes pH indicators and dyes that allow for metabolic reactions to be observed. ²⁴ Often, a specific sugar is added to the media. If the bacterium metabolizes that particular sugar, it decreases the pH of the surrounding area. ²⁴ This decrease in pH causes a color change

For this unit, only two selective and differential plates will be studied—Eosin Methylene Blue (EMB) and Mannitol Salt Agar (MSA).

EMB plates are selective for Gram Negative bacteria. The inhibitor agent methylene blue prevents the growth of any thick cell walled Gram Positive bacteria. There are several differential properties of EMB. Coliform bacteria like *Escherichia coli* grow with a metallic green sheen. Bacteria that metabolize the lactose sugar found in EMB, like *Enterococcus* species, grow with fish-eye colonies spotted with a dark center.

MSA plates are selective for Gram Positive bacteria and differential between species of *Staphylococcus*. The high concentration of salt in the media prevents the growth of Gram Negative bacterial species and the pH indicator allows for the identification of bacteria that metabolize mannitol sugar. This agar is useful for differentiating between *Staphylococcus epidermidis*, a resident bacterium found on the skin and in the eyes and *S. aureus*, a potentially devastating pathogenic bacteria that can have multi-antibiotic resistance.

Antibiotics

After performing differential diagnostic tests, like those listed above, pathologists are able to narrow down the infectious agent causing the disease. Antibiotics are medicines that are developed to treat bacterial infections. Antibiotics can be naturally derived, semi-synthetic drugs that are altered to increase their effectiveness against bacteria or decrease their toxicity to the host, or completely synthetic drugs. ²⁴

There are two major effects an antibiotic may have on a bacteria cell. First, antibiotics might kill the cell directly, either by preventing the formation of a vital component of the cell's structure like the cell wall as is the case with penicillin. We term these types of drugs bactericidal or bacteria killing antibiotics. ²⁴

The second way an antibiotic can be used to clear an infection is to be bacteriostatic—or to prevent the

bacteria cell from multiplying. ²⁴ For example, the antibiotic tetracycline prevents the protein synthesis needed to make proteins required in binary fission. Sulfa drugs prevent the formation of new bacterial DNA. ²⁴ As a result, the unmitigated growth found in bacterial infections is now stymied, allowing for the host's immune system to remove the bacteria cells that are already present without needing to deal with new growth.

It is important to know what type of infection the patient has in order to select the correct antibiotic to treat it. Some antibiotics are broad spectrum and treat many different bacterial infections. ²⁴ This might be a good course if the particular agent causing the infection is unknown and intervention is required to save the patient's life while doctors work to identify the pathogen. However, over use of broad spectrum antibiotics may kill other, healthy, bacteria and may actually increase the amount of antibiotic resistance seen in certain species. ²⁴ Specialized antibiotics, called narrow spectrum antibiotics, work on specific types of bacteria—for example, vancomycin is a narrow spectrum antibiotic prescribed to treat *S. aureus* infections, but it is ineffective against Gram negative infections. An excellent laboratory exercise to study antibiotic sensitivity in different bacteria species is listed in the lesson plan section for subunit four.

The previous set of diagnostic tools and treatments were specific for bacterial infections. Viruses have a different mode and means of infection in their hosts. As a result, the diagnosis and treatment options for viral infections differ greatly than those of bacterial infections. Below is a general explanation of how viral pathogens are diagnosed and treated.

ELISA

Enzyme-linked immunosorbent assays (ELISA) are commonly used to measure the titer of either antibodies or antigens in a solution. This assay was used to screen for HIV and other emerging infectious diseases like West Nile Virus. ELISA tests coating the wells of the microtiter plate with the antigen that researchers are testing for. The patient's serum is introduced. ²⁴ If that patient has been exposed to the viral factor in the recent past, they should have IgM antibodies for that factor. If it has been a long time since exposure IgG antibodies may be the ones to react. Antibodies that are responsive to the antigens bind together. After, the remaining serum can be removed from the well, leaving the antigen-antibody complex behind. ²⁴ At this point, animal antibodies that have been conjugated with an enzyme are added. These antibodies bind to the human antibody-antigen complex. ²⁴ A second rinse removes excess animal antibodies from the well. Finally, a color substrate is added, which interacts with the attached enzyme. ²⁴ As a result of this cascade, there is a color change that can be measured, indicating that the patient has come into contact with that viral substance. This protocol is for an indirect ELISA—an ELISA test that looks for the presence of antibodies against a specific antigen instead of looking for the antigen itself in the patient's serum. ²⁴

Detection with Nanowire Tubes

Similar to ELISA, but much more sensitive, is a possible immune response detection based on identifying changes in current flow using semi-conducting nanowires or carbon nanotubes. ¹² The way this process works is by lining a conducting tube with antibody receptors. If the corresponding antigen is found in the patient's serum sample, the antigen will attach to the antibody. At this point, there is a decrease in the conductance of the tube, similar to when a person stands on a running hose. ¹² As long as the antigen ligand attaches, there is a measurable result that can indicate presence of the antigen in the patient's blood serum.

Vaccines

Vaccination has become a staple of preventing infections. Vaccines themselves are designed to prime our immune response in order to respond quickly to an infection. Most vaccines are made up of three parts: an antigen of interest, an immune potentiator, and finally a delivery carrier. ²⁴ These three compounds work together to create an immune response in the body. Current vaccines are used to prevent a wide variety of diseases, including polio and pertussis. However, as mentioned in subunit three, there are often factors that impede the development of vaccines. First, vaccines are expensive to create and host through clinical trials. ¹² In the case of the Ebola vaccine, not only is the vaccine expensive to manufacture and put through trials, but there is a relatively small number of clients who would use the vaccine. This limit on returns decreases the attractiveness of the vaccine to manufacturers. Vaccines are also difficult to deliver to underdeveloped countries where they are needed most. Finally, the delivery method of vaccines and the current adjuvants needed to invoke immune response are very limited. ¹²

Currently, a new nanoparticle delivery method using biodegradable polymers such as poly (lactic co-glycolic acid) and poly (glycolic acid) are being examined as a more effective drug delivery method. Nano-particles are small enough to be able to interact with cells and have the advantage of activating two types of immune response—antibody and cellular response. This ensures that there is a stronger immune response and increased response to the vaccine.

There is a lot of controversy over the use of vaccines in children. According to current vaccination schedules, most children should receive about nineteen injections in their first two years of life—a number that parents think is too many. The number of injections, coupled with the drastic reduction or complete eradication of measles, pertussis, and polio outbreaks in the United States have many questioning the need for these vaccines anymore. ¹

Vaccines can also have damaging side effects. Some case studies have been made that link vaccination with the rise in autism or other chronic diseases. The polio virus discussed in subunit three was linked to causing vaccine-associated paralytic polio in a handful of children yearly. ¹ This infrequent side effect was deemed acceptable when more than 16 thousand children were suffering from the crippling effects of the poliovirus. However, since polio is now considered to be eliminated from the United States, many feel that this risk is no longer acceptable. ¹

It is very likely many students will have their own opinions about vaccination. Students should be allowed to explore this topic and potentially clear up any misconceptions they have. A recommended teaching strategy for this subunit is to allow students to create either a position paper about vaccination or to host a debate on the topic.

Subunit Five: Media Influence on Outbreaks

The last subunit of this program is dedicated to the influence of media on outbreaks of diseases. As quickly as an emerging infectious disease can spread, panic and hysteria can spread just as quickly. Many students might remember the avian flu or the swine flu hysteria. It seemed like a constant media blast covering outbreaks and spread of the disease, in addition to the death toll. More recently, there has been frequent

news coverage of the MERS outbreak and the new Ebola outbreak in Africa.

And, just like the diseases that they cover, these media reports can spread panic. In a recent document released by the Office of Transnational Issues evaluating the containment and control of the SARS outbreak, the media was contributed to increasing the transmission of diseases and inhibiting effective quarantine. This is especially true with sensationalist media reporting and reports that contain rumors and speculation.³

Media coverage of an outbreak may increase the perceived threat, especially if significant airtime is dedicated to the disease. In two separate studies, readers rated the seriousness of diseases and other epidemiological factors.²⁵ Diseases that were highly represented in the media were rated as more severe than diseases that were not as often portrayed. In addition, the participants felt that the diseases that were more often discussed in media posed a higher risk to their communities.²⁵ In a follow up experiment, the diseases were stripped of their names and were presented as a list of symptoms. In this follow up experiment, participants usually rated the less discussed diseases as being more severe—demonstrating that media influence heavily swayed perception of diseases.²⁵

In one study, social media was used as a resource to increase information spread within social circles without initiating physical contact. This Information Dissemination Network can help to inhibit the spread of disease while also allowing for those who are sick to reach out for assistance.¹⁸ Scoglio, one of the members of the team, also indicated that people may be more willing to follow advice from individuals they trust rather than impersonal news broadcasts.¹⁵

Recommended teaching for this subunit include exposing students to different forms of media—newspaper clippings, online articles, and even television news reports—and having students analyze the tone of the broadcasts. They can decide if the media piece is providing valuable information to the public and if they are presenting the information in a tone that is unbiased and collected. Students can also hold a debate about the effectiveness of media in assisting disease containment.

Sample Lessons

Each subunit includes suggested activities and teaching suggestions, as listed above. Below, I have included a more in-depth lesson idea for each section.

Subunit 1 Activity: Bacteria research project.

Students can take class time to research different bacteria structures, morphology, and arrangement. Students can be assigned a bacterial pathogen or they can choose one that interests them. Students should research morphology and arrangement, Gram-reaction, natural reservoir, transmission, symptoms, methods to kill the bacterium, and any other important information they see fit. Students can either present their research in a slide show or fill out a teacher generated template to create a classroom book on bacteria.

Subunit 2 Activity: Transmission Lab.

This laboratory experiment also exposes students to the inherent problems of identifying patient zero. Each

student has a numbered cup containing either distilled water or a cup of sodium hydroxide. Students 'exchange fluids with a classmate by pouring all of the liquid into one of the cups and then splitting the amount equally again, keeping a log of who they exchanged with. After exchanging twice, phenolphthalein can be used to identify which cups are "infected" with the sodium carbonate. Using their logs, students can try to trace back to patient zero.

Subunit 3 Activity: Public Outreach.

Students should research one emerging or re-emerging infectious disease and write a paper, create a presentation, or develop a poster and handouts that inform the New Haven community about the causative agents and risks of that disease. Students should also provide methods for staying safe and reducing the risk of infection.

Subunit 4 Activity: Antibiotic Disk Sensitivity Lab.

Large petri dishes should be seeded with a lawn of different types of bacteria. Students will carefully place antibiotic disks on the lawn, making sure that they are not too close to the edge or each other. Students should allow the disks to incubate for 24 hours. After, measure the zone of inhibition (the clear area) around the disks and compare with a sensitivity table to determine if the bacteria are sensitive, intermediately sensitive, or resistant to that antibiotic.

Subunit 4 Activity: Debate. Are vaccines helpful or harmful?

Divide students into two groups and have them research the pros and the cons of vaccination. Using proper debate format, have students discuss vaccine controversies. After, students can write short position paper stating their own opinion about the subject.

Subunit 5 Activity: Analysis of Media Broadcasts.

Using a graphic organizer, students can watch and read several news broadcasts about different emerging infectious diseases. Students can then try their hand at creating their own broadcasts or reports about a current emerging infectious disease. After, students can peer-review the articles on their accuracy and professionalism.

Appendix A: Standards

New Haven Standards

DINQ.1: Identify questions that can be answered through scientific investigation.

DINQ.2: Read, interpret, and examine the credibility and validity of scientific claims in different sources of information

DINQ.4: Design and conduct appropriate types of scientific investigations to answer different questions

D.31: Describe the similarities and differences between bacteria and viruses

D.32: Describe how bacterial and viral infectious diseases are transmitted, and explain the roles of sanitation, vaccination, and antibiotic medications in the prevention and treatment of infectious diseases

D.39: Describe the difference between genetic disorders and infectious diseases.

D.45: Explain how technological advances have affected the size and growth rate of human populations throughout history

Common Core State Standards

ELA-Literacy.RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions

ELA-Literacy.RST.9-10.2: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept provide and accurate summary of text

ELA-Literacy.RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text

ELA-Literacy.RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words

ELA-Literacy.RST.9-10.9: Compare and contrast findings presented in a text to those from other sources, noting when the findings support or contradict previous explanations or accounts

Appendix B: Web Resources for Students and Teachers

CDC- The Centers for Disease Control and Prevention website is an excellent website for researching current and past emerging infectious diseases. www.cdc.gov

WHO-- The World Health Organization website provides a global perspective on currently breaking diseases. www.who.org

Students should also be exposed to as much primary literature and media as possible, surrounding current emerging infectious diseases.

Appendix C: Bibliography

1. Bronfin, Daniel. "Childhood Immunization Controversies: What Are Parents Asking?" *The Ochsner Journal* (2008): 151-156. This article discussed several very important concerns about vaccination in children.
2. Cano RJ, and Borucki MK. "Revival and Identification of Bacterial Spores in 25- to 40-Million-Year-Old Dominican Amber." *Science* (1995): 1060-1064. An interesting article detailing the revival of ancient bacterial endospores.
3. Central Intelligence Agency. "SARS: lessons from the first epidemic of the 21st century." http://www.pdhealth.mil/downloads/cia_sars.pdf. This article provides an analysis of the SARS outbreak, including effectiveness in the containment process and media influence.
4. Centers for Disease Control and Prevention. "A Polio-Free U.S. Thanks to Vaccine Efforts." Centers for Disease Control and Prevention. <http://www.cdc.gov/Features/PolioFacts/> (accessed July 20, 2014). This website outlines some of the protocols in place for polio vaccination.
5. Centers for Disease Control and Prevention. "Antibiotic resistance FAQ." Centers for Disease Control and Prevention. <http://www.cdc.gov/getsmart/antibiotic-use/antibiotic-resistance-faqs.html#define-antibiotic-resistance> (accessed June 11, 2014). This website provides information about antibiotic resistance as seen in MRSA.
6. Centers for Disease Control and Prevention. "Ebola Hemorrhagic Fever: Outbreak of Ebola in Guinea, Liberia, and Sierra Leone." Centers for Disease Control and Prevention. <http://www.cdc.gov/vhf/ebola/outbreaks/guinea> (accessed July 27, 2014). This website was critical in the outlining of the current Ebola outbreak and is updated regularly.
7. Centers for Disease Control and Prevention. "Our Progress Against Polio." Centers for Disease Control and Prevention. <http://www.cdc.gov/polio/progress/index.htm> (accessed June 11, 2014). This website explains the global progress in the eradication of polio.
8. Centers for Disease Control and Prevention. "SARS Response Timeline" Centers for Disease Control and Prevention. <http://www.cdc.gov/about/history/sars/timeline.htm> (accessed June 10, 2014). This website explains the outbreak timeline for SARS.
9. Centers for Disease Control and Prevention. "Vaccines and Immunizations: Polio Disease in Short." <http://www.cdc.gov/vaccines/vpd-vac/polio/in-short-both.htm> (accessed June 11, 2014). This website describes the vaccination process for polio.
10. Centers for Disease Control and Prevention. "Who We Are: CDC and the Global Polio Eradication Initiative." Centers for Disease Control and Prevention. <http://www.cdc.gov/polio/who/index.htm> (accessed June 11, 2014). The CDC summary of the GPEI and results.
11. Dobson, Mary. *Disease: The Extraordinary Stories Behind History's Deadliest Killers*. Quercus Books, 2008. This high school friendly text provides insight into many of the emerging infectious diseases covered in this paper.
12. Fahmy, Tarek M. , Demento, Stacey L., Caplan, Michael J., Mellman, Ira, and Saltzman, Mark. "Design opportunities for actively

targeted nanoparticle vaccines." *Nanomedicine 3* (2008): 343-55. A research paper that outlines the role of nanoparticle delivery systems for vaccines.

13. Guardian News and Media. "Bubonic plague outbreak kills 32 in Madagascar." theguardian.com.

<http://www.theguardian.com/world/2013/dec/20/bubonic-plague-outbreak-deaths-madagascar> (accessed January 5, 2014). This article discusses details about the recent outbreak of plague in Madagascar.

14. McGrath, Matt. "Little Chance for Ebola Vaccine." BBC News. <http://www.bbc.com/news/science-environment-19112510> (accessed July 25, 2014). This article explores some of the problems with creating a vaccine for the Ebola virus.

15. Nauert, Rick. "Can Social Media Prevent the Spread of Disease? - Psych Central News." Psych Central.com.

<http://psychcentral.com/news/2012/11/28/can-social-media-prevent-the-spread-of-disease/48226.html> (accessed June 12, 2014). This article explores the role that social media plays in preventing the spread of contagious diseases.

16. Nelson, Kenrad E., and Williams, Carolyn. *Infectious Disease Epidemiology: Theory and Practice, 3rd edition*. Jones & Bartlett Learning. 2013. This book details several globally threatening emerging infectious diseases.

17. Pietrangelo, Ann. "The Plague: Types, Causes & Symptoms." Healthline. <http://www.healthline.com/health/plague#Types2> (accessed July 12, 2014). This website outlines the symptoms of plague and the three different types.

18. Sahneh, Faryad Darabi., Chowdhury, Fahmida. N., Scoglio, and Caterina. M. "On the Existence of a Threshold for Preventative Behavioral Responses to Suppress Epidemic Spreading." *Scientific Reports*, (2012). This study looks at the way behavior may suppress the spreading of emerging infectious diseases.

19. Senthilingam, Meera. "Ebola Outbreak: Is it Time to Test Experimental Vaccines?" CNN.

<http://www.cnn.com/2014/07/25/health/ebola-outbreak-experimental-vaccines/> (accessed July 25, 2014). This article outlines possible protocols for an experimental Ebola vaccine.

20. Sullivan, Nancy, Yang, Zhi-Yong., and Nabel, Gary J. "Ebola Virus Pathogenesis: Implications for Vaccines and Therapies." *Journal of Virology*, no. 77 (2003): 9733-9737. This resource further explores the possibility of the creation of a Ebola virus vaccine.

21. Thompson, Dennis. "As Ebola outbreak spreads, vaccine remains years away." CBSNews.

<http://www.cbsnews.com/news/as-ebola-outbreak-spreads-vaccine-remains-years-away/> (accessed April 20, 2014).

22. Upshur, Ross. "Ethics and Infectious Disease" *Bulletin of the World Health Organization* 86 (2008): 577-656. This article discusses ethics in epidemiology and the rise of antibiotic resistant bacteria.

23. U.S. National Library of Medicine. "MRSA : MedlinePlus Medical Encyclopedia." U.S National Library of Medicine.

<http://www.nlm.nih.gov/medlineplus/ency/article/007261.htm> (accessed July 28, 2014). This article briefly describes MRSA symptoms and treatment.

24. Willey, Joanne M., Sherwood, Linda M., and Chris J. Woolverton. *Prescott's Microbiology, 7th ed.* McGraw Hill, 2008. This comprehensive textbook outlines methodology for microbiology students and provides important background information for understanding epidemiology.

25. Young. M., Norman, G., and Humphreys, K. "Medicine in the Popular Press: The Influence of the Media on the Perceptions of Disease." *PLoS ONE* 3 (2008): e3552. This article looks at how the media may influence the perception of diseases in three studies

using psychology and medical students.

26. Zabludovsky, Karla. "Deadly MERS Virus May Be Airborn, Study Says." Newsweek.

<http://www.newsweek.com/deadly-mers-virus-may-be-airborne-study-says-260619> (accessed July 27, 2014). This article explores a new development in the MERS virus outbreak.

<https://teachersinstitute.yale.edu>

©2019 by the Yale-New Haven Teachers Institute, Yale University

For terms of use visit <https://teachersinstitute.yale.edu/terms>