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Teaching Principles of Evolutionary Medicine through a Historical Lens

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Introduction

"Changes in human behavior patterns with cultural evolution throughout the millennia have had the greatest impact on the evolution of human diseases." [1] Migration, colonization, shifts from hunter-gatherer to agrarian societies, and the domestication of animals are some of the cultural changes that have had profound effects on the evolution of disease. Similarly, some infectious diseases have had profound effects on cultures throughout history.

Objectives and Rationale

My goal is to develop an integrated curriculum unit to use with my fourth grade students to teach events in history that were influenced by viruses and disease. We will work on the unit for four weeks and will combine both social studies and science.

The students will learn three main principles of evolutionary medicine. First, students need to understand how people develop immunity against infectious diseases. The second principle is the relationship between population size and disease spread. The third principle is the interaction between invasive and native species and how invasive species impact biodiversity. These three guiding principles will lay the foundation for this unit. In a world full of supergerms, MRSA bacteria and widespread antibiotic resistance it is important for students to understand how bacteria, viruses and human immune systems evolve.

Once the students have a working knowledge of these principles, we will examine how the Native Americans came to North America, and how the migration from Siberia to North America kept them isolated from many infectious diseases for thousands of years. We will also delve into the reasons why their isolated lifestyle made Native Americans more vulnerable to so many Old World diseases.

Next, we will examine the colonization of Virginia and the role that disease played for the English settlers, Africans and the Native Peoples. Beginning when the Old and New World's collided, the unit will introduce

factors that play a role in disease transmission and vulnerability and will focus on the importance of population density, diversity, the domestication of animals and agriculture. Students will understand how Europeans and Africans brought diseases that were new to the Native Peoples. They will learn how the lack of immunity hindered the ability of the Native Peoples to resist diseases. By studying maps and graphs of English and Native American populations over time, the students will be able to draw conclusions and make inferences to explain the shift in the populations. They will conclude that the English settlement was able to spread as a result of disease. It is important for the students to understand the importance of the first permanent English settlement and the implications of its survival. It is also important for my students to understand how the arrival of the English colonists was the beginning of the demise of the Native Americans.

The spread of Old World diseases haunted the Native American population for many years. Major outbreaks that impacted the Native Americans were diphtheria in 1614 and measles in 1618 in Peru and Mexico respectively. These two epidemics resulted in the death of 10-20 million Native Americans. A similar story would unfold in the United States of America beginning during its early colonization. In 1618, smallpox ravaged the Massachusetts Bay Native Americans. Disease took its toll and made the removal of the Native People easier for newcomers. Jared Diamond stated, "Far more Native Americans died in bed than on the battlefield— the victims of germs, not of guns and swords. Those germs undermined Indian resistance by killing most Indians and their leaders and by demoralizing the survivors." [2]

The theme of disease will reemerge during our Civil War unit later in the year. Connections will be made to the impact of measles during the Civil War and to the urbanization of Virginia during the post -Civil War era. By making these connections the students will understand how cultural evolution leads to the evolution of disease and changes history.

Numerous social studies objectives will be covered in this unit including: the colonization of Jamestown and Virginia, westward expansion, economic development and transition and advances in transportation and technology. The science objectives this unit will address are: ecosystems, natural resources and scientific investigations. Beyond the prescribed curriculum, my intent is for the students to develop an understanding of evolutionary medicine that can be applied to the world around them.

This unit will teach my students the importance of examining our history to learn about the present. While my students seem to really enjoy social studies, they often do not grasp the connection to their own world. From a teacher's perspective, it often is challenging to connect the social studies and science curriculum in a natural way. The connections that will be made in this unit will be meaningful and natural. More importantly, the students will develop their higher level thinking skills as they transfer their social studies knowledge and apply it to make sense of science concepts. For example, my students will understand that the Europeans were the invaders who displaced the Native Americans' population. My students will also make the analogy that in ecosystems foreign invaders often wipe out and displace native populations. One example is the Snakehead fish. This type of fish is not native to the Potomac River. Therefore it has no known predators and resides at the top of the food chain, thus preying on other organisms in the river. In addition to foreign species, there are also foreign diseases. MSX is a parasitic disease that was probably introduced to the Delaware Bay when Japanese oysters were introduced. MSX has spread and is also in the Chesapeake Bay. This parasite has been destroying much of the native oyster population that had no prior immunity to this disease.

Once the students have an understanding of evolutionary medicine concepts and have used them to look at historical events, they will be asked to apply this knowledge to their science curriculum. In this phase of the unit, the students will apply their newly learned concepts as they study ecosystems and conduct scientific

investigations. The students will understand how Old World pathogens inoculate native fauna and flora in the New World. Historical examples will be used to illustrate the connection between the spread of disease from Europeans and Africans to the Native Peoples, and the spread of an invasive species that displaces a native species. Students will examine specific examples of invasive species both from the past and today. One example such as how the introduction of Chinese chestnut trees brought a fungus, *Cryphonectria parasitica*, which was spread by woodpeckers and nearly wiped out the American chestnut species. [3] Another example is found in the Chesapeake Bay ecosystem. MSX and Dermo are invasive parasites that have destroyed 90% of the native oyster population. I would like my students to see how invasive species decrease biodiversity and create monocultures as well as understand that homogeneity is just as problematic to an ecosystem today as it was to the Native Americans. Teaching the basic understanding of disease transmission and species susceptibility will enable my students to apply three major principles of evolutionary medicine across disciplines and through time. The ultimate goal will be for the students to apply concepts to the world around them.

Background Evolutionary Medicine

Immunity

Immunity is the ability to resist infectious disease. There are two ways in which a person can become immune to a disease. First, there is innate immunity, which is the natural way the human body protects itself. The human body has anatomical barriers, such as the skin and mucus membranes. These are the first lines of defense to keep an infectious disease microbe out of the human body. The mucus membranes are found in any cavity that leads to the outside of the body. The cells that make up the mucus membranes produce mucus, which traps foreign substances that enter the body. Another form of innate immunity is endocytosis. When a foreign invader enters the body, a specialized human cell will surround the invader, ingest it and then dissolve it. If a foreign substance penetrates the human body, an immune response ensues. Defenders rush to the area of penetration. The influx of defenders results in inflammation, which is an attempt to destroy the invader. The last type of innate defense is antimicrobial protein. Macrophages or cells roam throughout our body looking for foreign protein. When such an invader is found, the macrophage transfers it to a helper T cell. The T cell in turn finds the white blood cells that can make the protein, or antibody, that attaches to the specific foreign protein, or antigen. The bonded antibody and antigen are on the surface of an invader such as bacteria. This process not only impairs the invader, but also marks it for attack. [4]

Acquired immunity results when an infectious disease enters the body and the human body produces antibodies. These antibodies can last for decades or forever. Over time the body builds up specialized B cells that fight infectious disease. If an infectious disease that has previously invaded the body invades again, the B cells that have been created and stored will immediately respond and attack. This process is called immune memory.

Population Size

The size of a host population is important in relation to the spread of an infectious disease. For some common Old World diseases such as, influenza, typhoid, measles, and smallpox, a certain population density was necessary for the disease to spread and be sustained. For example, if an infectious disease spreads and over

time, everyone becomes infected, some people will die while the rest of the population will recover and develop antibodies to the disease. The disease will die out when no one is left alive who is susceptible.

Disease load directly correlates to population size. There are three stages: hunter-gatherer, agricultural, and urban. With each stage humans become more vulnerable to a group of diseases, but the disease load is cumulative. For example, in the agricultural society the population would be susceptible to the diseases of the hunter-gatherer stage in addition to the diseases of the agricultural stage. Hunter-gatherer populations can get infectious diseases, but due to their nomadic lifestyle, hunter-gatherer cultures face a more limited disease load. In this kind of society, the group lives in one area for a short period of time, so they are not living in dirty conditions and amongst waste. However, they are still vulnerable and microbes that live on animals and in the soil will infect the people of this most primitive lifestyle at various times. [5]

As people move into agrarian societies and are no longer roaming the Earth foraging for food, the population expands. "Agriculture sustains much higher human population densities than does the hunting-gathering lifestyle on the average, 10 to 100 times higher." [6] Agricultural societies find themselves not only vulnerable to the diseases of hunter-gatherer societies, but also to a gamut of diseases that are associated with domesticated animals and a sedentary lifestyle. Farming communities become surrounded by disease carrying rodents seeking food stores and also by their own waste. The fecal matter can get into the water supply and is often used as fertilizer being spread by farmhands.

The disease load once again increases as people develop cities. The sanitation conditions can once again deteriorate as crowds of people live together. Infectious disease spreads easily when large numbers of people are living together under dirty conditions. People living in urban areas are vulnerable to the microbes that are found in soil and on animals in addition to the infectious diseases that become prevalent and are easily spread in urban environments.

Invasive and Native Species

Another basic principle of biology, which relates to evolutionary medicine is the dynamic that exists between invasive and native species. Native species are organisms that are indigenous to an area. Invasive species, as the name suggests, are organisms that invade the geographical area of a native. Invasive species can grow and spread rapidly. Over time, invasive species may take over the native species. Today, most of our weeds and hay grasses originated in Eurasia. Many of these species were indigenous to Eurasia. The greatest danger of invasive species is the fact that they have no known predators and they disrupt ecosystems. They also can carry many diseases that native species have never encountered.

The plight of the American chestnut tree is a great example of an invasive species introducing a new disease. This tree was not only an important natural resource used by Native Americans, but also a valuable resource for other cultures when making furniture, fence posts and train rails. The Chinese chestnut species was introduced in New York. Along with this tree came a fungus hidden in its bark. The first American chestnut tree died in 1904. The fungus spread its spores with the help of wind and woodpeckers over one thousand miles to the Southern Appalachians and by 1940 the American chestnut was almost wiped out completely. [7] The immigration and migration of living species that has been going on for years is stirring the pot and spreading microbes around the world. This movement of species is creating a more homogenous global environment with less and less biodiversity. [8]

Typhoid Fever

Typhoid fever is a disease of humans caused by the bacteria *Salmonellatyphi* and is spread through the contamination of food or water. S *typhi* only lives in humans in the intestinal tract or in the bloodstream. The first symptoms of typhoid fever include severe headache, body aches, weakness and constipation. Later, a fever and some red splotches will appear usually around the abdomen. The stomach becomes tender and the spleen may swell. Hair loss and bronchitis are other common symptoms. The bacteria get into the bowels and are excreted with bowel movements. In about 25% of the people the bacteria also appears in their urine. [9]

In some cases, the bacteria may be able to reside in the gallbladder of a host, enabling such a person to be an asymptomatic carrier of the disease. [10] This was the case with Mary Mallon, who became known as "Typhoid Mary". In the early 1900's, Mary Mallon cooked for several families in New York City. She was a carrier and was determined to be the source of the outbreaks. Typhoid Mary was quarantined for the rest of her life since she refused to stop cooking and repeatedly ended up killing her employers and members of their families.

Today, the industrialized parts of the world rarely encounter typhoid fever. The modern methods of treating drinking water and waste have greatly reduced the contamination cycle. Unfortunately, third world and developing countries continue to face this disease.

Smallpox

Variola virus causes the human disease smallpox, and it has affected human populations for thousands of years. Humans are the only natural host for smallpox. Fortunately, smallpox was eradicated from the United States in 1949, and the last naturally occurring case in the world appeared in 1977 in Somalia. [11]

Smallpox has a higher mortality rate and spreads more easily in large population densities. But, smallpox is also sustainable in small, densely populated rural populations. Smallpox can be contagious when the infected person begins to exhibit symptoms. However, it is most contagious when the rash is present. The contagious stage lasts until the last scab falls off, which could be three weeks. There are three ways the virus is transmitted: 1) through infected droplets in the respiratory tract 2) from the pus in a sore or 3) from dried scabs. The scabs and sores can contaminate clothing and bedding. Touching these items can make the virus airborne, but the virus cannot travel long distances without a host. [12]

The most obvious symptom of smallpox is the skin rash with lesions that hold pus. The virus enters the body through the respiratory system, but quickly travels to the lymph nodes and then to the blood. From the blood it has access to the internal organs. The virus then invades the blood for a second time and the infected person develops a high fever, a headache, stomach and muscle pains and vomits.

Measles

The strain of the measles virus that affects humans is generally mild. However, when a population has no prior exposure to the disease measles it is much more dangerous. This reveals that historically the virus used to be more serious to humans. A virus called rubeola causes measles. This disease begins in the upper respiratory system and its symptoms include a fever, runny nose and cough. Eventually, the immune response to this virus causes a skin rash. [13]

Diphtheria

Diphtheria has been around at least since the time of Hippocrates, who described the disease in 4 th century B.C. This disease threatened the colonies at various times. From 1735-1740 an epidemic spread throughout New England. It mostly affected children. This infectious disease is caused by a bacterium and affects the upper respiratory system. Symptoms include a sore throat, low fever, and an extra membrane forms over lesions that develop in the upper respiratory tract. The growth of the extra membrane may cause swallowing problems and/or suffocation. The lesions produce a toxin that spreads through the lymph system and the blood to other organs. [14] Once the toxin spreads throughout the body, it may cause paralysis and heart failure.

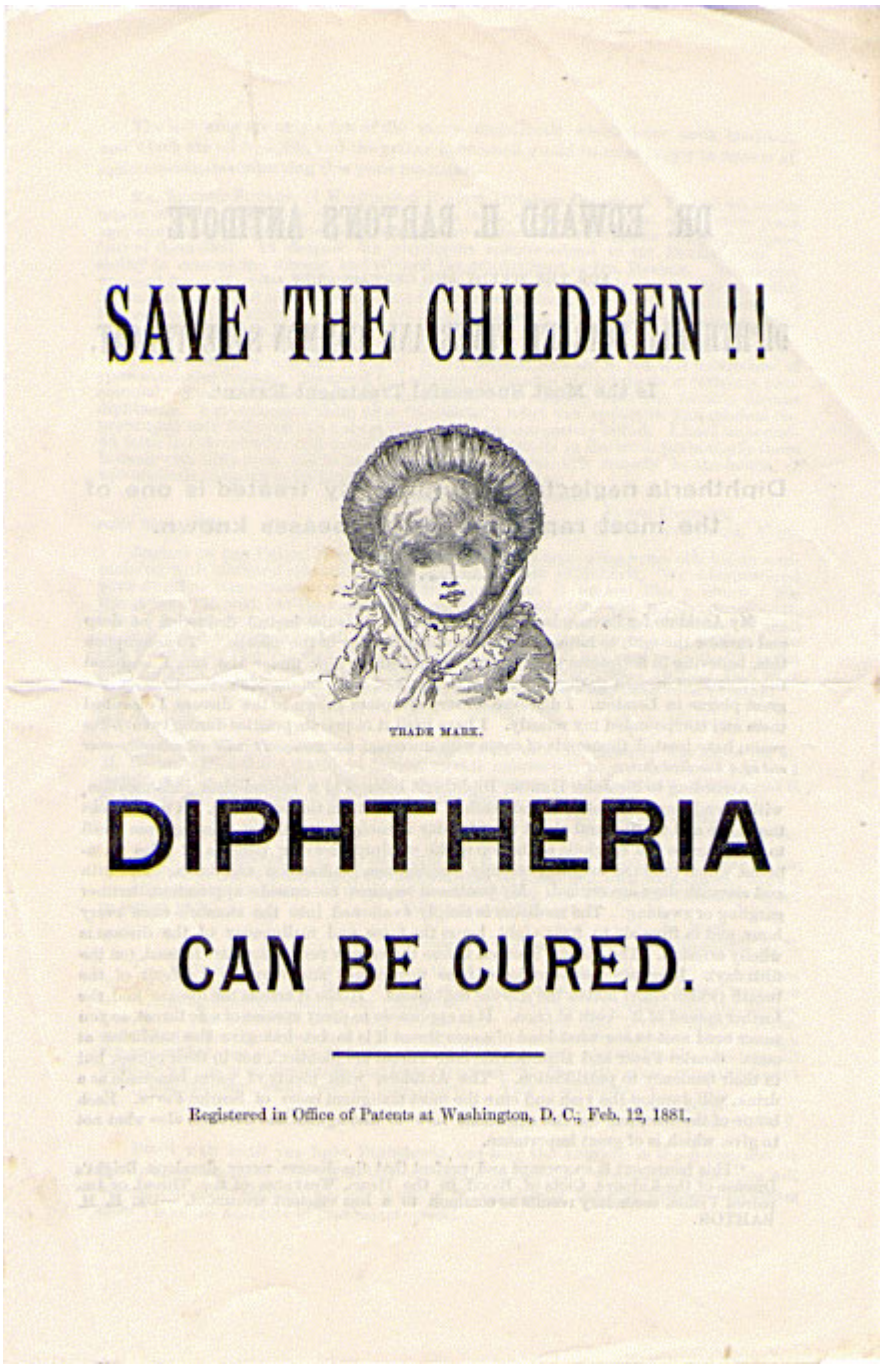


Figure 1 [15]

Yellow Fever

Yellow Fever is an arbovirus, or a type of virus carried by biting arthropods, which infects both non-human and human primates. Several types of mosquitoes carry

yellow fever and there are three types of transmission: sylvatic, intermediate, and urban. The sylvatic transmission cycle occurs when humans encroach into the jungle. In this type of transmission mosquitoes usually carry yellow fever from infected monkeys to humans. Intermediate transmission usually occurs when humans live or work near the jungle. In this cycle, yellow fever is transmitted via mosquitoes to humans either from monkeys or from humans. In urban transmission, the virus is spread from human to human through a mosquito vector. [16] The *Aedes aegypti* mosquitoes are best able to live in villages, therefore transmitting the virus from one infected person to another. [17]

The virus originated in West Africa, but during the slave trade the virus made it across the ocean to the New World. A mosquito carrying the virus could not survive the entire journey to the Americas, but given a food supply and water supply, the mosquito could survive long enough to lay eggs in the water containers onboard the ship. When these mosquitoes hatched they too carried yellow fever. This cycle enabled yellow fever to cross the Atlantic Ocean to the Caribbean Islands. The virus established itself in the warm climate of the islands. Later, it eventually reached port cities in North America. Since the seasons change in North America, the mosquitoes that transmit the disease could only survive during the warmer months. This meant that an outbreak of yellow fever could only strike during the warmer months and could only last until the first frost killed off the mosquitoes.

Historical Context

The Old World is defined as Europe, Africa and Asia, including the nearby islands before the 15 th century. The New World refers to the Americas and Australasia. When people first emigrated from Siberia and came to the Americas, they crossed a land bridge, made of frozen tundra where the Bering Strait is today. These immigrants are believed to be the ancestors of modern Native Americans.

The small size of the groups that crossed the land bridge likely limited the number of parasitic and infectious diseases that made the journey with these people. The frigid conditions along the trek across the frozen bridge prevented the survival of some pathogens, which are typically accustomed to warmer climates. This frozen trek also weeded out the weaker individuals and only the strongest people survived this difficult migration.

The Native Americans' nomadic life style prevented them from acquiring many diseases. Basically, prior to Columbus' discovery of the Americas the Native Americans were exposed to a few "hunter-gatherer" diseases such as chagas, leishmaniasis and amoebic dysentery. The Native Americans' lifestyle of small groups living in isolation resulted in a relatively "disease free paradise". The populations simply were not large enough to sustain and spread most infectious diseases. While this isolated lifestyle served the Native Americans well for a long time, it would ultimately leave them extremely vulnerable to disease later on.

The movement of human populations and contact across long distances leads to the spread of disease. When

the Europeans colonized the Americas, the Native Americans had no memory, or stored B cells to fight Old World diseases. They essentially had no acquired immunity for Old World diseases. Acquired immunity occurs when an organism, a human in this case, is exposed to a virus or a bacterium. The person will either get sick and die or recover. If the person recovers, the body produces antibodies to that particular pathogen, thus "acquiring" long-term immunity. Native Americans lack of exposure to infectious disease resulted in a lack of knowledge in regards to disease and contagiousness. "One warrior could not understand how one could pass this damaging ailment (smallpox) when a battle wound couldn't be passed on." [18] Since the Native Americans were not exposed to the diseases of the Old World, the Native Americans faced high mortality rates upon contact. It is believed that there were about 20 million Native Americans living in the New World in 1492, and about 95% of them died over the next two centuries. [19]

The transatlantic journey not only brought English colonists, but also diseases from the Old World that would decimate the population. One such colonist, Reverend Robert Hunt became ill on the ship and suffered for weeks. One of his symptoms was a high fever. He was the only colonist who showed signs of sickness on the journey. During the journey, hygiene was important. The bedding was aired out daily and the below decks were washed with vinegar. [20] This most likely contributed to the overall health aboard the ship. The three English ships, the Godspeed, the Discovery, and the Susan Constant arrived in Jamestown, Virginia in the summer of 1607. The weather was hot and humid. The new colonists constructed an enclosed fort on a peninsula on the banks of the James River. It is believed that typhoid fever was the main disease that struck the Jamestown colony, and Reverend Hunt carried the disease across the ocean to the New World. The new colony would face starvation and high rates of disease and death throughout its early years.

The mortality rate during these early years was staggering. During the first year, the colony's population went from one hundred eight to thirty-eight. Then during the most difficult time, the Starving Time — the winter of 1609, the population went from five hundred to sixty in six months. The situation was so dire that colonists resorted to eating leather, rats and even the corpses of their fellow fallen comrades. Between 1619 and 1622, after 3,570 new settlers joined the colony, the population was 4,270. Within the three-year period beginning in 1619, about 3,000 colonists died. But, why was there such a high mortality rate?

There are numerous factors that contributed to the plight of the English colony. First, they arrived in the summer and many pathogens prefer warmer climate. Second, the site chosen for the settlement was surrounded by brackish water, which gave rise to mosquitoes and a poor supply of drinking water. The colonists initially drank the brackish water directly from the James River. Later, they dug shallow wells, but the salt water managed to seep into the drinking supply. Third, the colonists faced starvation. Nutrition has a negative impact on susceptibility to disease. Similarly, infection increases the level of starvation. A fourth reason is that the settlers had dirty living conditions. The last reason is the enclosed fort, which provided protection from the Native Americans, but the tight quarters contributed to the spread of infectious disease.

It has also recently been discovered that a severe drought coincided with the starving time. Scientists examined the tree rings of cypress trees and concluded that the drought lasted seven years and was the worst spell in 800 years. A drought would also explain the increased conflict that occurred between the Native Americans and the colonists. If the fresh water supply was drying up and there was more competition for food, it makes sense that there would be more fighting amongst the people. Additionally, since the James River is brackish, a drought most likely reduced the amount of fresh water entering the river thus increasing the salt content. The water quality certainly played a part in the poor health of the colonists.

It is difficult to know exactly what types of diseases struck the Jamestown colony because most fast killing

diseases do not affect the skeletal system. Archaeologists study the bones of human remains in an effort to determine history. Some of the information about the types of diseases comes from archaeological research and some comes from primary source accounts. John Smith kept a detailed journal, but it is believed that some of his accounts were biased. However, journal entries have shed light on the signs and symptoms of the diseases that affected the English settlement. From the accounts of Reverend Robert Hunt's sickness, it is believed that typhoid fever was one disease that infected the colony. Malnutrition was also responsible for death in the colony, and probably made the colonists more susceptible to other diseases as well.

As the Jamestown colony survived, it became more dependent on subsistence farming, the first epidemiological transition: the shift to an agricultural subsistence economy began. Along with subsistence farming came the domestication of animals. Living amongst animals opened up new avenues for disease to infect humans. Subsistence farming created larger, more permanent settlements, limited food variety and poorer nutrition resulted, sanitation problems occurred and infectious disease increased. Clearly these problems came about with the emergence of subsistence farming. This transition extended through the 18 th century.

Smallpox is an example of a disease that evolved from a disease of animals. Recent evidence suggests that the smallpox virus is very closely related to viruses that infect rodents. [21] The smallpox virus of humans is also very closely related to the cowpox virus, which infects cows. This very close relationship led to the realization that an infection of the cowpox virus can elicit an immune response in humans and provide protection against the smallpox virus. The discovery of this relationship was key in the development of modern day vaccines. In the 1700's, Edward Jenner, an English physician, observed that milkmaids seemed to be more resistant to smallpox. He took the pus from a cowpox lesion and experimented with a vaccination for smallpox. In 1796, Jenner proved his cowpox vaccination prevented infection. [22] In 1806, Thomas Jefferson sent Jenner a letter to congratulate him. In 1807, Jenner received a wampum belt and a thank you letter from the chiefs of the five Nations of North American Indians. Smallpox killed hundreds of thousands of Native Americans. Jenner was most proud of his wampum belt. It would take one hundred eighty-two years from the time Jenner published his pamphlet to eradicate this deadly disease from the world. That year was 1980.

Yellow fever affected American history numerous times over the years. Since Africans had previously been exposed to yellow fever, they were more resistant to the disease. Native Americans worked the field and did chores for Europeans, but so many were dying from yellow fever. Europeans noticed that the Africans were not coming down with yellow fever as frequently as the Native Americans. This made Africans more desirable as a source of labor and increased slave trade in North America. [23] Yellow fever also shut down the government in Philadelphia in 1793. Of the 40,000 residents, 4,044 died in a four-month span. [24] The presence of yellow fever around the Mississippi Valley was one factor that Napoleon considered when he agreed to sell the Louisiana Purchase. The large American outbreak took place in 1878 in Memphis, Tennessee. During an eleven-week span following the first case, Memphis faced 17,000 cases. Five thousand of which were fatal. African Americans were not as resistant to this strain. [25]

Strategies

Many different strategies will be used throughout the entire unit. The students will learn about immunity and population size/disease load through role-play. I will guide the students through simulations to explain innate and acquired immunity. For the lesson on invasive and native species, the students will set-up several different scientific investigations. One of these investigations will demonstrate how invasive species take over the habitat of native species by having students grow grass in a foil pan. Chickweed will then be introduced. Students will note their observations. The second one will demonstrate how a disease can harm the native species more than the invasive species. My class will plant three pans using identical methods. One pan will have grass, one will have chickweed, and the third pan will have a mixture of grass and chickweed. Then the same amount of the same type of disease will be introduced to each pan. The students will make observations throughout these two experiments.

Next, the students will watch a video clip about the land bridge. The students will then have a discussion about the implications of the migration on the Native Americans' immune system and their vulnerability to disease. The students will now have a strong foundation to better understand the impact of the arrival of the English colonists and the Old World diseases that came with them. The students will use a graphic organizer to predict the pros and cons of the English colonization for the English and the Native Peoples. These charts will provide me with their level of understanding at this stage in the unit.

A mapping activity depicting where English and Native American populations lived in the Eastern part of Virginia will be completed. This activity will visually show the students how the populations were changing over time.

The *starving time* will be explored for two days since this is a focal point of this unit. Following a teacher led discussion the class will write a journal entry from a colonist's point of view. The following day, the students will learn about the drought and write a journal entry from the Native Americans point of view. Having the students take on the point of view of the colonists and the Native Americans will be challenging, but meaningful. Since fourth graders are learning about author's purpose and point of view, this strategy would support their standards as well as critical thinking skills.

Over the next four days, the class will learn about diptheria, measles, typhoid, smallpox, and yellow fever. The students will make a flip-book to help them remember the important features of these diseases.

The students will spend two days preparing virus/bacteria playing cards. The students will engage in an Infectious Disease card game. This will teach the students about the diseases in a fun way and will help them understand and synthesize much of the information they learned previously in this unit.

The final activity is for the students to complete a writing assignment. They will choose one of the diseases from this unit and write an informative paper about the disease including how the disease impacted one of the various cultural groups in early America. By having the students write an essay about one disease, it will allow for choice and empower them to show what they have learned from this unit.

Activities

Day 1

The students will explore the first principle of evolutionary medicine, immunity, by acting out endocytosis and acquired immunity.

Day 2

Disease load and its relation to population size will be explained to the class. Students will represent the three different levels of disease load. The lowest level as seen in hunter-gatherer societies will be represented by a few students holding a few books. The next level existed in agrarian societies. This level will be depicted with more students holding the original load of books plus several more. The highest level of disease load exists in cities. A large group of students will represent this echelon. The students will hold the same amount of books the previous groups held plus additional books. This activity should help the students to understand disease load using visual and kinesthetic modalities.

Day 3

Invasive and native species will be explored through a series of scientific investigations. These investigations will be set up, then monitored and observed throughout the duration of the unit.

Day 4

The class will view a video clip about the migration from Siberia to North America. The closeness of Russia and Alaska will be noted using a globe and a map. The students will then complete questions related to the video clip.

Day 5 and Day 6

The colonization of Virginia will be introduced. The journey to the New World and choosing a site for the colony will be discussed. The students will complete two T charts thinking about the pros and cons for the Native Americans migration and the English colonists migration. These will be discussed.

Day 7

A mapping activity created by the Virginia Historical Society will be used to illustrate the population change in Virginia over time. Initially the students will see many locations where Native People lived and a few locations where the English settled. This will change as time elapses.

Day 8 and Day 9

For two days the unit will focus on the starving time. This was a critical period for the colonists with implications for the future of America. Students will write a journal entry from a colonist's viewpoint. The latest discovery of a severe drought will also be shared and the student's will write another journal entry from the Native Peoples' point of view.

Day 10

John Smith's "no work, no eat program" that led to subsistence farming for the Jamestown colony will be viewed through an evolutionary medicine lens. The students will understand how the shift to agrarian life will help the settlers to survive, but over time will take the colonists to the second level of disease load.

Day 11

Students will begin to learn the nature of some of the common diseases that affected Native Peoples throughout the Americas. The students will make a flipbook of the diseases. As they learn about a disease, they will include key information in their book. Today students will learn about typhoid.

Day 12

Measles and diphtheria will be the focus of today's instruction. The students will continue to add to their flipbooks.

Day 13

Smallpox will be added to their books.

Day 14

Today the students will learn about yellow fever. This will be the last disease added to their books.

Day 15 and 16

Students will make their infectious disease cards to go with activity #2. These cards will resemble Pokemon® cards, but will have disease characters.

Day 17

The Infectious Disease card game will be played. (See activity #3)

Day 18 -20

Students will create informative essays about the role infectious disease played in early America. These will follow the writing process including brainstorming, writing a first draft, editing, and writing a final draft.

Activity 1

The first investigation involves setting up two foil pans. Everything will be held constant. Both pans will be the same size and will have the same kind and amount of soil. One pan will have grass seed and the other will have a mix of grass seed and chickweed seed. Both pans will have a grid made of string elevated above the growing area. This will aid the students for observation purposes.

A second experiment will be set up to show the disease resistance of native and invasive species. Three foil pans will be set up the same way. One will have grass and the one will have chickweed and the third pan will have a mixture of grass and chickweed. Once these are established, a fungus will be introduced to each pan. Again a grid system made with string will be in place. The students will make observations and use the grid

system to quantify the area of grass and chickweed.

Activity 2

The students will create a flipbook to use to record information about the five diseases of which this unit focuses. A piece of construction paper and two sheets of printer paper will be used to make the book. Fold all three sheets of paper in half, the hamburger way. Holding the construction paper vertically and opened, place a folded sheet of printer paper on each half. The fold should be on the top. Glue the back of the printer paper to the construction paper. Cut the front half of each sheet of printer paper into thirds. There will be six sections: "infectious disease", "diphtheria", "typhoid", measles", "yellow fever" and "smallpox". On the outside of the flap, students will write the aforementioned headings. Inside each flap, students will write key facts about each disease.

Activity 3

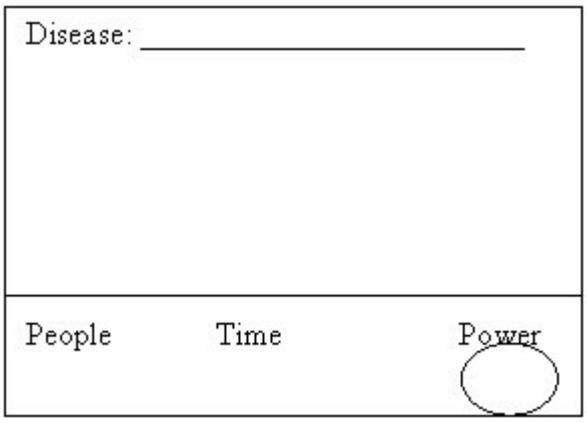
In preparation for the Infectious Disease card game, the students will draw the name of a disease from a jar. Given pictures of the bacteria and viruses, the students will use a template and draw their bacteria or virus character. Each student will draw four cards. Once the characters are drawn, each student will choose a host from the host jar and a year from the time jar. The disease, the host and the time will determine the value for each card. Once the cards are complete, the students will play the card game. The game will be played like war. Students can play individually or they can team up with a partner.

Power Chart for Card Game

(Figure 2)

Yellow Fever	Native Amer. & English	1878	100
Yellow Fever	Native Amer. & English	1793	75
Smallpox	Native American	1617	75
Diphtheria	Native Amer./Eng./African	1735	50
Smallpox	Native Amer./Eng./African	1696	20
Smallpox	Native Amer./Eng./African	1633	20
Typhoid	Native Amer./Eng./African	17^{th} Cent.	20
Any disease	Any group	any, but present	20
Any disease	Any group	present	0

Template for playing card (Figure 3)



Appendix A: Implementing District Standards

Virginia Studies

VS.3 The student will demonstrate knowledge of the first permanent English settlement in America by

?. describing the hardships faced by settlers at Jamestown and the changes that took place to ensure survival
a. describing the interactions between the English settlers and the native peoples, including the contributions of Powhatan to the survival of the settlers.

VS.4 The student will demonstrate knowledge of life in the Virginia colony

VS.8 The student will demonstrate knowledge of the reconstruction of Virginia following The Civil War by

1. describing the economic and social transition from a rural, agricultural society to a more urban, industrialized society, including the reasons people came to Virginia from other states and countries;

Science

4.1 The student will plan and conduct investigations

a. distinctions are made among observations, conclusions, inferences and predictions
b. hypotheses are formulated based on cause-and-effect relationships
c. variables that must be held constant in an experimental situation are defined
d. appropriate instruments are selected to measure linear distance, volume, mass, and temperature
e. appropriate metric measures are used to collect, record, and report data
f. data are displayed using bar and basic line graphs
g. numerical data that are contradictory or unusual in experimental results are recognized
h. predictions are made based on data from picture graphs, bar graphs, and basic line graphs.

4.5 The student will investigate and understand how plants and animals in an ecosystem interact with one another and the nonliving environment.

4.8 The student will investigate and understand important Virginia natural resources. Key concepts include:

b. animals and plants;

Endnotes

1. Barnes. *Diseases and Human Evolution* (Albequerque, NM: University of New Mexico Press, 2005): 1.
2. Jared Diamond. "The Arrow of Disease". Discover, vol. 13 no. 10 (1992)
3. Herman J. Viola and Carolyn Margolis. Seeds of Change (Washington, DC: Smithsonian Institution Press, 1991): 235.
4. Randolph M. Nesse and George C. Williams. Why We Get Sick: *The New Science of Darwinian Medicine.* (New York, NY: Vintage Books, 1994): 39-40.
5. Jared Diamond. *Guns, Germs, and Steel: The Fates of Human Societies* (New York, NY: W.W. Norton & Company, 2005): 204.
6. Diamond, 205.
7. William McNeill. *Plagues and Peoples*. (New York, NY: Anchor, 1977): 235.
8. McNeill, 232.
9. Barnes, 289-291.
10. Barnes, 291.
11. http://www.bt.cdc.gov/agent/smallpox/overview/disease-facts.asp (accessed 7/27/10)
12. Barnes, 223.
13. Barnes, 192.
14. http://textbookofbacteriology.net/themicrobialworld/diphtheria.html (accessed 7/27/10)
15. Courtesy of owner, William H. Helfand and the National Library of Medicine
16. www.nc.cdc.gov/travel/yellowbook/2010/chapter-2/yellow-fever.aspx (accessed 7/27/10)
17. Barnes, 301-302.
18. Viola, 193.
19. Diamond, 211.
20. Gordon W. James. "The First Epidemic in English America." *The Virginia Magazine* of *History and Biography* 71 (1963): 5-6.
21. Yu Li, Darin S. Carroll, Shea N. Gardner, Matthew C. Walsh, Elizabeth A. Vitalis, and Inger K. Damon. "On the origin of smallpox: Correlating variola phylogenics with historical smallpox records." PNAS Vol. 104 No. 40 (2007): 15787.
22. Bryn Barnard. *Outbreak Plagues that Changed History* (New York, NY: Crown Publishers, 2005).
23. Michael B.A. Oldstone. *Viruses, Plagues, & History* (New York, NY: Oxford University Press, 1998.)
24. Oldstone, 46.
25. Oldstone, 49.

Annotated Bibliography

Barnard, Bryn. *Outbreak Plagues That Changed History*. New York: Crown Publishers, 2005. This is a book written for children, but it is very informative and interesting.

Barnes, Ethne. *Diseases and Human Evolution*. Albuquerque, NM: University of New Mexico Press, 2005. A very informative book about evolutionary medicine written for a general audience.

"CDC Smallpox." Small Pox Disease Overview. www.bt.cdc.gov/agent/smallpox/overview/disease-facts.asp (accessed July 27, 2010).The CDC website provides reliable information about diseases that is easy to understand.

"Centers for Disease Control and Prevention ." Traveler's Health Yellow Book. www.nc.cdc.gov/travel/yellowbook/2010/chapter-2/yellow-fever.aspx (accessed July 27, 2010). This website provides accurate information about diseases.

Diamond, Jared. "The Arrow of Disease." *Discover*, October 1, 1992. http://discovermagazine.com/1992/oct/thearrowofdiseas137 (accessed July 28, 2010). This article is a nice companion to Jared Diamond's book, Guns, Germs,and Steel.

Diamond, Jared. *Guns, Germs, and Steel: The Fates of Human Societies, New Edition*. New York: W. W. Norton, 2005.This is a fascinating book and an interesting read.

James, Gordon W. "The First Epidemic in English America." *The Virginia Magazine of History and Biography*, January 1963: 3-10. http://www.jstor.org/stable/4246912 (accessed July 8, 2010). This article was very helpful and provided accurate historical information specific to Jamestown.

Li Yu, Darin Carroll, Shea N. Gardner, Matthew C. Walsh, Elizabeth A. Vitalis, and Inger K. Damon. "On the origin of smallpox: Correlating variola phylogenics with historical records ." PNAS 104, no. 40 (2007): 15787-15792. www.pnas.org/cgi/doi/10.1073/pnas.0609268104 (accessed August 10, 2010). This article is from a professional science journal and is difficult to understand for a general audience.

Margolis, Herman, and Carolyn Viola. *Seeds of Change: Five Hundred Years Since Columbus*. Washington, DC: Smithsonian, 1991. This was a very interesting read, but it is not the most current resource.

Mcneill, William H. *Plagues and Peoples.* New York: Anchor, 1977. This is a very informative book. It is a classic and many other readings refer to McNeill's work.

Nesse, Randolph M., and George C. Williams. *Why We Get Sick: The New Science of Darwinian Medicine*. 1 ed. New York: Vintage, 1996. This book provides a great overview of evolutionary medicine. This book addresses many topics and is easy to understand.

Oldstone, Michael B. A.. *Viruses, Plagues, and History*. New York: Oxford University Press, USA, 1998. This is a very useful book full of insightful information.

Ramenofsky, Ann. "Native American Disease History: Past, Present and Future Directions." *World Archaeology* 35, no. 2 (2003): 241-257. http://www.jstor.org/stable/select/3560225?seq=1 (accessed June 27, 2010). This article was very closely related to my unit.

Todar, Kenneth. "The Microbial World Homepage." The Microbial World. textbookofbacteriology.net/themicrobialworld/diphtheria.html (accessed July 27, 2010). This website was useful and had nice images along with text about many diseases.
