Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2009 Volume V: Evolutionary Medicine

Human Population's Response to Re-emerging and Emerging Infectious Diseases

Curriculum Unit 09.05.02
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Rationale:

Individuals are required to make daily health decisions to promote healthy living. However, not all decisions are informed decisions because of the lack of knowledge in self treatment, in addition to limited access to healthcare providers to help make decisions. According to the U.S Census Bureau, 46 million people under the age of 65 years old went without healthcare in 2007 [1] . Without healthcare, ill patients will remain sick and/or contagious, which may possibly be extremely harmful to other individuals' health, yet beneficial for the survival of a horrible microbe.

On the other end of the healthcare controversy, those that receive healthcare benefits are at the same risk of making poor decisions compared to those without healthcare. When a patient is consulted by a doctor, many professionals and patients prefer prescription medication that may alleviate them of symptoms and not necessarily kill the disease causing pathogen. In some cases, patients are over treated with antibiotics, not realizing the adverse effects it could have on the human body's recovery process. 60% of patients suffering from a cold, cough, or sore throat symptoms go to the doctor and leave with a prescription for antibiotics. [2] The adverse effects of overusing prescribed medication would be the interference with the body's natural evolutionary defense mechanisms. Recently, there has been a growing awareness among the medical community that recognizes evolutionary biology as an important aspect for medically treating patients called Darwinian medicine.

The goal of this unit is to help inform high school students (grades 9-12) of human population response to microbial diseases through the development of medical treatment, while incorporating Darwinian medicine. This unit will use multifaceted approaches to understanding evolutionary biology by incorporating mathematics, history, and language arts skills. The unit will also identify unique ways of incorporating the arts (through dance, visual art, theatre, etc.) because of its role within my school's discipline.

As a class, students will formulate, from the unit's content, answers to the following questions: How do we prevent becoming ill by communicable microbes? Is it possible for humans to prevent microbial illnesses? Are medications safe to use? Should there be a limitation on the medication prescribed to patients?

Objectives:

At the end of this unit, students will be able to:

1. Define infectious disease.

2. Demonstrate how infectious diseases are transmitted from human to human contact (virology lab).

3. Observe the growth of bacterial populations and factors that inhibit the growth of bacteria.

4. Compare and contrast the pathogenic replication process when infecting a host.

5. Specify why humans are susceptible to disease from infectious microbes (transmission factors).

6. Define evolution.

7. Compare the evolution process of bacteria and viruses, in relation to human evolution.

8. Define genetic variability and explain the purpose of genetic variability (genetic evolution)

9. Identify different medical treatment for bacterial and viral infections.

a.Observe population trends and patterns when humans are exposed to medical treatments (i.e. antibiotics and vaccines)

10. Write about a scientist who contributed to the field of evolutionary biology and microbiology.

11. Evaluate and defend current treatments for various infectious diseases.

12. Support whether or not evolutionary biology is important in medical advancement in the treatment of infectious diseases and explain how universal healthcare plays a role in the treatment of ill patients.

Background Information:

Pathogens and Infectious Diseases

The word pathogen is a general term for any microbe (bacteria, virus, protozoan, prion, helminthes, or fungi) that causes disease within another organism. Each one of these microbes can affect their host which may or may not be beneficial to the organism. Microbes remain a threat to the health of humans worldwide.

When a disease is spread from one individual organism to another individual organism through various forms of direct contact, it is considered an infectious disease or a communicable disease. Infectious diseases still remains one of the leading causes of death in humans, primarily in babies, young children, elderly, and immunosuppresed and immunocompromised persons due to their vulnerable immune systems. [3] Worldwide infectious diseases include but not limited to: HIV/AIDS, tuberculosis, H1N1, cholera, influenza, malaria, and

African sleeping sickness. Emerging infectious disease can be defined as newly identified disease caused by a previously known organism; newly identified diseases caused by a previously unknown organism; the recognition of a new organism; a familiar organism whose geographic range has extended; whose host has changed, whose incidence has increased, or one that has changed to become more virulent or antibiotic resistant. [4]

Glossary terms: Host, pathogen, bacteria, virus, protozoan, prion, helminthes, fungi, immunosuppressed, immunocompromised, virulent, antibiotic

Transmission factors in the spread of infectious diseases

Factors that induce the emergence and reemergence of infectious diseases are: demographic factors, social and behavioral changes, changes in treatment and handling of water and food, climate changes, changes to environment, microbial evolution, human evolution, war, natural disasters (ex. hurricanes, tsunamis, flooding), and health care and technology advances.

The transmission of infectious disease is through physical contact, sexual contact, food and water, blood transfusions, airborne/ droplet, insects and arthropods, and zoonoses.

Glossary terms: evolution, arthropods, zoonosis

How pathogens affect human hosts

DNA and RNA Viral infections

Viruses are nonliving particles that contain genetic material (nucleic acid) within protein layered coat (or lipid protein coat) called a capsid. Viruses are considered nonliving because of its inability to perform cellular functions. Viruses do not grow, do not move, cannot reproduce without a host cell (known as obligate intracellular parasites) nor can they metabolize. Viruses can affect both eukaryotic and prokaryotic celled organisms. When a virus enters the host, it will only be able to replicate once it finds and recognizes the host's cell receptors. The virus attaches onto the cell (similar to lock and key mechanism) and uses the enzymes and organelles within the cell to replicate; therefore, infecting the human host.

The method of for viral replication within the host's cell is different among the RNA viruses and the DNA viruses. Within the RNA virus replication process, the virus enters the host cell and translates new viral proteins immediately using the mRNA of the hot cell. Some viruses like HIV contain enzyme reverse transcriptase to make DNA from the RNA. Viruses that carry the enzyme reverse transcriptase are called retroviruses. On the contrary, the DNA viruses uses DNA to make mRNA, which is translated into viral proteins. The two methods of replication within a virus are the lytic cycle and the lysogenic cycle.

The lytic cycle is when the virus invades the host cell, produces new viruses, and immediately ruptures the host cell (lysis) when the viruses are released from the host's cell. The steps to the lytic cycle are as follows:

1. The virus attaches to a cell and injects its DNA.
2. The viral DNA circularizes.
3. The viral DNA continues the lytic cycle or enters the lysogenic cycle.
4. In the lytic cycle, new viruses are made.

5. The cell lyses, which releases the viruses. [5]

The lysogenic cycle different from the lytic cycle because it allows the viruses to hide in the host cell for a period of time before the viruses emerges from the cell. The steps to the lysogenic cycle are as follows:

1. The virus attaches to a cell and injects its DNA.
2. The viral DNA circularizes.
3. Viral DNA integrates into the host DNA.
4. The viral DNA is replicated when the host cell replicates its own DNA and divides.
5. The prophage may leave the host DNA and enter the lytic cycle. [6]

Major viral infections include: Herpes virus (HSV 1, HSV 2, chickenpox, shingles), Hepatitis (A, B, C, D, E), HIV/AIDS, influenza, polio, measles, West Nile Virus, HPV (Human Papillomavirus), HTLV (Human T-lymphotrophic virus), Epstein- Barr virus, SARS, Ebola virus, and Marburg virus.

Glossary terms: eukaryotic, prokaryotic, enzymes, DNA, RNA, prophage, retrovirus

Bacterial infections

Bacteria are living organisms that are single celled without a nucleus. The structure of bacteria varies depending on shape, size, and composition. Some bacteria are rod shaped bacteria (bacilli), sphere shaped (cocci), chains of cocci (streptococci), clusters of cocci (staphylococci) and spiral shaped (spirilla). Cell walls of the bacteria might consist of peptidoglycan, which creates a more complicated cell wall that may be difficult to penetrate. The genetic material within a bacterial cell is not encapsulated within a nucleus.

The method in which bacteria reproduce is through a process called binary fission. Bacteria reproduce asexually in which the DNA replicates itself and the two strands separate from one another to create two identical daughter cells. In some cases, a bacterial cell can take in DNA from its outside environment through a process called transformation. In other instances, bacteria can undergo a process called conjugation where bacteria bind together and transfer DNA from one cell to another cell using sex pilli.

Glossary terms: conjugation, transformation, asexual reproduction

Prion infections, Protozoan infections, Helminths infections, Fungal infections

Other infections include prion infections, protozoan infections, helminth infection, and fungal infections. Prions are protein particles that do not have a genome and can cause fatal neurological degenerative diseases. Example prion diseases are Creutzfeldt-Jakob disease, otherwise known as CJD. Protozoans are parasitic organisms such as amoebae, flagellates, and ciliates that can cause disease in humans. Protozoans can remain in the soil and water for long periods of time and later be digested by humans. An example protozoan disease is malaria. Helminths are parasitic worms that consume nutrients within the body of the person infected. Helminths include roundworms, hookworms and guinea worms to name a few. An example helminth infectious disease is uncinariasis. Funis are not all harmful. However, fungi can cause infectious diseases such as athlete's foot and yeast infections. Fungi reproduce by spores and people who suffer from a weakened immune system are at a greater risk of infection.

Evolution and genetic variability

The origins of viruses are unknown but there are a few hypotheses that exist on its evolutionary development and genetic variability. One hypothesis is that viruses were naked pieces of nucleic acid that could enter a cell through damaged cell membranes and later, due to evolution, developed a protein coat to bind to healthy. Many viruses evolve rapidly and spread quickly due to the simple design of the viruses. Due to the rapid evolutionary process among the virus, the immune system of individuals cannot always recognize the new invader due to slower evolutionary response. However, the immune system can recognize older viruses that have existed and the body has its line of defense for protecting the individual based upon gene selection.

Bacteria also evolve rapidly to adapt to its environment through mutations of the genetic material. Humans undergo mutations as well but not as frequently as bacteria mutations. It is important to have mutations so that the less favorable traits within the organism are slowly eliminated, while the preferable traits remain allowing genetic variability. The goal in preserving the most preferable traits is to help a population reproduce and sustain. Within the human population, while there are still some traits that are not favorable, the human body has evolved significantly to keep the traits that allow humans to become more successful in reproduction and survival.

Human Body Line of defense

Immune Response

The human body has two forms of immune protection: innate and acquired immunity. Innate immunity is a nonspecific defense mechanism that consists of skin, mucous, cilia, sneezing, and diarrhea as the first line of defense. Other defenses include endocytosis, inflammation, and antimicrobial proteins. On the other hand, acquired immunity consists of production of antibodies and immune memory, where cells specialize in helping the body create proteins that defends the body against invaders.

Glossary: endocyosis, innate immunity, acquired immunity, antibodies

Fever

Through research, it has been suggested that fevers are evolutionary responses of the human body to fight infections. Fever is an example of human adaptation to its environment. Fever is considered to be a primitive immunological response [7] which allows the body temperature to increase slightly to kill any infectious microbe. The body has the ability to go back to normal temperature.

Iron Withholding

Iron is an important part of the blood in humans. However, iron is also an important part in the survival of pathogens. Pathogens will obtain iron from the host to maintain its survival. The body can prevent the pathogens from obtaining the iron within the human system. The human body is able to bind the iron to iron binding proteins, which will in turn lower the amount of free iron available to pathogens. Lowering the iron levels will keep low levels of infections.

Diarrhea and vomiting

Connections have also been made that diarrhea and vomiting are also evolutionary responses to eliminate toxins from the body. Diarrhea and vomiting are the body's first line of defense within the immune system. Through diarrhea and vomiting, water is lost from the body, in addition to healthy calories. Although, these essentials are lost, harmful toxins are forcefully flushed out of the system to prevent infection.

Medicinal treatment of infectious diseases

Antibiotics and vaccines

Antibiotics affect only bacteria by inhibiting cell activities. The first antibiotic discovered was penicillin, which is naturally created from fungi and bacteria. Although, antibiotics are beneficial in killing bacteria, they are able to respond to environmental changes through genetic mutations, and develop new strains that are resistance to the antibiotic administered. Antibiotics can interfere with the body's natural abilities to prevent infection and create harmful bacteria. Antibiotics are typically overprescribed to patients feeling symptoms of a cold or flu, which do not kill viral infections that may be the cause of the symptoms or discomfort. Thirty billion dollars are spent in the United States for the treatment of antibiotic resistant infections. [8]

Vaccines are effective in preventing a viral infection and are specific to certain viral infections. A vaccine is a harmless virus or toxin that triggers the immune system to respond by creating antibodies. The body creates antibodies against the weakened form of the virus so if the body does become exposed to the true virus, the body will be able to defend itself. There has been concern about the overuse of vaccinations and its connection to autoimmune diseases and humans' ability to fight other viral infections..

Prescription drugs

When prescription drugs are administered, it has the ability to interfere with the body's natural evolutionary response to its environment. The use of over the counter prescription drugs, like Tylenol or aspirin, to alleviate the symptoms of a fever can be extremely harmful. If it is recognized that the fever is a sign of infection and the body's way of fighting the infection, why would one want to reduce the fever? Using prescription drugs could be dangerous leading to secondary infections or dangerous health conditions particularly in pregnant women and children. Antipyretics are examples of harmful drugs administered to pregnant mothers and children.

Next, using iron pills could be harmful in some instances, although many may find iron pills beneficial for their health. It is important to respect the human body's response to lower the iron rate so that the body can naturally defend itself. If the body's process is interfered with, it could increase virulence levels of certain pathogens and allow bacteria to grow rapidly.

Overall, individuals should be able to recognize the body's evolutionary mechanisms for protection against illness and disease. Some of the body's natural defenses include mucous, anxiety, coughing, and sneezing. Our body's natural evolutionary responses to protect us against pathogenic organisms are often mistaken and treated using unnecessary medications. The use of medicines to prevent defensive responses like diarrhea or vomiting or coughing could be harmful in the process of eliminating toxins and/or pathogens from the human body. In other instances, medicines can be over prescribed, causing the pathogen to rapidly evolve into new strains with increased virulence levels.

Scientists who've contributed to microbiology and evolutionary biology

Girolamo Francastoro (1478-1553) identified diseases as transmissible and invisible airborne particles; incorporated poetry with science

Antoin Van Leeuwonhook (1632-1723) found bacteria in microscope with a simple lens (1676)

Louis Pasteur (1822-1895) confirmed the Germ Theory and developed the pasteurization process (1862)

Robert Koch (1843-1910) developed Koch's postulates by testing the blood and of cows and found rod shaped bacterium (Anthrax)

Lady Mary Wortley Montagu (1689- 1762) developed variolization (engraftment) where the virus is taken and scraped onto the skin to create immunity

Edward Jenner (1749-1823) developed vaccinations using cowpox microbe to help create human immunity

John Snow (1813-1858) is known as father of epidemiology due to his work in solving the cholera outbreak in Soho, England

Alexander Flemming (1881-1955) discovered penicillin from penicillium

Martinius Beijerinck (1851-1931) isolated the first virus

Ignaz Semmelweis (1818-1865) discovered hand washing as an important step in gynaecological examinations

Joseph Lister (1827-1912) is known as the "father of antiseptics" for recognizing and introducing chemical sterilization and sterile surgery

Florence Nightingale (1820-1910) recognized clean hospitals are necessary in preventing illness (sanitary design)

Dimitri Ivanovski (1864-1920) discovered the tobacco mosaic virus that caused disease in plants

Rosalind Franklin(1920-1958) used x-ray crystallographer to understand the	molecular structures of DNA, RNA, viruses, coal and graphite
Charles Darwin (1809-1882) provided evidence that species evolved over time	and from a common ancestor
Jean Baptiste Lamark (1744-1829) supported the idea that evolution followed	natural laws
Ernst Mayr (1904-2005) renowned taxonomist, naturalist, and explorer who has	contributed to evolutionary biology
Barbara McClintock (1902-1992) known for her research in corn cytogenetics to	demonstrate genetic fundamentals

Ernest Everett Just determined the factors for successful fertilization an development of the ovum

Dr. James Earl King Kildreth identified cholesterol as allowing HIV to penetrate	the cell
Lynn Margulis biologist known for her theory of how eukaryotic cellular	organelles developed and her ideas within the endosymbiotic theory

Dr. Turner evolutionary biologist at Yale University

Dr. Eloy Rodriguez investigated self medication of primates and environmental biology

Other current scientists who have contributed to the study of biology are: Rita Colwell, Susan Wessler, Susan Wiliams, Pedro Villegas, Nettie Marca Stevens, Guillermo Zavala, Kenneth Olden, Ida Stephens Owens, Clifton Doodry, Lydia- Villa-Komaroff, Martha Zuniga, George Langford, Cynthia Kenyon, James Hildreth, Carlos Bustamante, David Burgess, Kogo Mensa-Wilmot, and Mari Carmen Garica.

Strategies

The big idea of the unit is that infectious diseases continue to emerge and infect humans due to the microbes' evolutionary response to change in their environment. Humans are not at a great advantage to reproduce as quickly as a microbe due to their more complex nature. Within this unit, teachers must be able to help guide students to an understanding of why infectious diseases are continuing to emerge and what we can do to help prevent a future infection through the exercise of wise decision making. The key ideas to address within the unit are: 1. Bacteria and viruses are not the same but can cause an infectious disease within a human; 2. Bacteria and viruses reproduce and function differently which may make it slightly difficult in developing treatments and cures for any disease; 3. Humans may be susceptible to diseases however; humans have evolved to defend itself from invading microbes to prevent diseases; and 4. Medical treatment of certain diseases may interfere with the body's natural defense mechanisms.

Throughout the unit, teachers should emphasize the scientific inquiry process through various hands on activities and labs. Students will follow the scientific method to investigate a science question (problem statement) and write lab reports that communicate their results from the lab. In addition, mathematical associations are incorporated so that students are able to analyze data and compare the growth of bacteria, viruses, and humans, which relates to the spread of infectious diseases. The classroom timeline of scientists allows the students to recognize the faces behind the science and visualize the scientific process, which includes trials and errors, necessary in the advancement of all sciences. Also, the timeline of scientists helps in encouraging young minds to continue practicing science and maintain their curiosity.

In order to develop a unit that is inclusive of the arts (i.e. music, dance, theatre, visual arts, creative writing), students will have opportunities to demonstrate biological processes through their respective arts by either drawing, creating a story, or acting. Student responsibility for acquiring knowledge is quintessential for student learning rather than teacher instruction. Discussion groups and debates, which may be inclusive of scientific literature, should be frequently incorporated within the units to allow students to share their reasoning. From the discussion, teachers should be able to facilitate by identifying and addressing any misconceptions. It would be even more beneficial if the students took on the facilitator's role during discussions. A sample lesson format has been identified below using the 5 E's learning model (engage, explore, explain, elaborate, and evaluate).

In order to capture student interest and engage them with the curriculum unit topic, it is suggested that a simple activity is presented to encourage a small group discussion. A video on a current infectious disease would be helpful in exciting students and stimulating their thinking about infectious diseases. After the movie, a guided whole group discussion would be beneficial for students to share their ideas and thoughts to one another. Another useful approach to a video would be a KWL chart, in which students are part of a whole group discussion on what they know about the subject already (W), what they want to know (K), and what they've learned after the discussion (L). The KWL chart is very beneficial to the teacher in preassessing student understanding before teaching. Other options include a small laboratory demonstration or a critical reading activity to replace the video.

After completing the engagement activity, the next step would be for students to explore one or more of the concepts discussed in the engagement activity. Students may investigate a specific infectious disease, its symptoms, transmission, and the current treatment methods for the disease. Providing the opportunity for students to acquire knowledge through their own investigation is imperative for their learning. The assignment should be a long term assignment that provides adequate time for researching and asking questions. Also, it is suggested that students not only explore the content involved with microbiology but the scientists involved in the development of the microbiology and evolutionary biology field. Students will have the option of choosing one or two scientists who have contributed to the field of evolutionary biology and/or microbiology, in order to create a classroom timeline that presents the many faces behind past and current scientific work and processes involved in our current scientific discoveries. The timeline should request for students to investigate the lives of the scientists and the actual processes involved in their development of new scientific theories, ideas, and discoveries. The activity may be differentiated based upon student learning abilities by either providing resources that may assist in research, developing research guidelines, and creating student groups. (A list of scientists has been provided). In order to create a more challenging research opportunity, students may be required to complete a more formalized and in depth bibliography that coincides with their research topic.

While students are working on their independent research assignments, class time should be lent towards instruction through lecture, laboratory, and discussion, which allows explanation and elaboration. Students need to be informed of the definition of an infectious disease and how an infectious disease is transmitted. The best way to illustrate the concept of an infectious disease transmission would be the virology lab, where students mimic the passing of body fluid and infectious disease. The lab clearly illustrates the fact that anyone can be at risk of acquiring an infectious disease and disease can spread rapidly. The lab introduces the concept of transmission factors and it investigates transmission rates. Students can use the mathematical approach to predict the number of students to become infected over a period of time or use ratios to understand how quickly the disease spread. To go further, students can apply the mathematical understanding to reading human population growth curves to identify where human populations have been impacted by infectious diseases (examples include bubonic plague, smallpox, HIV/AIDS, tuberculosis, and influenza).

Also, students need to be able to identify what are the causes of an infectious disease. Students should be able to distinguish between a bacteria and virus, while knowing that they reproduce at a much faster rate than humans making humans vulnerable to some bacteria and viruses. Bacteria and viruses also evolve a lot faster due to their reproductive abilities, which encourages high genetic variability. Teachers may choose to have students read within the textbook how viruses and bacteria reproduce. It may be necessary to differentiate the instruction by using more or less detail when describing the replication process. Students who are part of a more advanced biology course could further investigate fungus, prions, protozoan, and/ or helminths. However, the focus of comparing reproduction of the bacteria to the virus is to show that viruses and bacteria are not exactly the same because they do not share similar characteristics in regards to replication, structure, and function. Therefore, if the bacteria and viruses are not similar, then, they must be treated differently when trying to eliminate.

In reference to treatment and cures of infectious diseases, students need to understand that not all treatments work effectively in killing the pathogen and must be specific to the microbe it is killing. This concept can be illustrated through another hands on lab called the bacteria inhibition lab, which allows students to observe the growth of bacteria populations, while identifying the factors that inhibit the growth of bacteria, such as antibiotic use. Students may grow bacteria in petri dishes and use different mechanisms to prevent the bacteria from growing. Viruses, compared to bacteria, require a completely different treatment, which needs to be addressed within the student discussions or lecture. It would be beneficial for the students to have a classroom speaker, who would be able to discuss the different treatment options available and the current medical treatment research as an elaboration piece. It is equally important for students to understand that humans have evolved to develop their own mechanisms of self defense that prevents microbes from harming us. Students should be able to identify natural evolutionary responses that prevent us from becoming ill.

Finally, all students should be able to synthesize their independent research projects, labs, lectures, discussions, videos, and readings to evaluate whether or not genetic variability and evolution is valuable to humans and if all medical treatment options are beneficial to humans or not. Students should be able to debate on the current use of medicine for treating patients, while answering the following essential questions:

1. Is it possible to prevent becoming ill by a microbe?
2. How often should prescription medicine be used to treat an illness?
3. Should there be a universal healthcare to help those who are ill? And prevent others from becoming ill?
4. Should doctors be required to have a background in evolutionary biology in order to accurately treat patients?

Classroom Activities

Lesson 1: Virology lab

Objectives:

1. Demonstrate how infectious diseases are transmitted from human to human contact

Essential Question: How are infectious diseases spread from individual to individual

Materials:

Plastic cups (1 per student)

Calgon water softener or NaOH

Phenolphthalein pH indicator

Droppers

Index Cards

Procedure:

Teacher Procedure-

1. Prepare the basic solution of NaOH or Calgon water softener by mixing it with water, creating a 1/8 diluted solution.
2. In each of the student's cups, pour 10 mL of the basic solution into one plastic cup.
3. In the remaining plastic cups, place 10mL of water.
4. Pass cups to students in the classroom with one index card.

Student procedure-

1. Each student is responsible for finding three different students in the classroom to share fluids.
2. The student must use the dropper to remove some of their liquid in the cup and pour into the other person's cup. The partner must do the same thing. The person that receives fluid must write the name of whom they received the fluid from.
3. Once the student has swapped fluids with three classmates, the teacher will use the pH indicator to determine who is infected with an infectious disease. Students with a color change of pink are positive for the infection.

Post activity:

1. List the students infect and uninfected.
2. Determine the ratios of the infected and uninfected individuals.
3. Using a map, solve for the individual who was originally infected.
4. Discuss the method in which disease are transmitted.
5. Discuss the ways that the human body might protect itself against a pathogen.
6. Describe any errors in the transmission process.
7. Identify the variables that should have been controlled in the experiment.

Lesson 2: Timeline of important scientists

Objectives:

1. Recognize the scientists who've contributed to the field of microbiology and evolutionary biology

Essential question: How have scientists contributed to the field of microbiology and evolutionary biology?

Materials:

Computer (internet)

Library

Organizational guide to research (Optional)

Grading rubric

Procedures:

1. Using list of scientists provided, students will select a scientist who has contributed to the field of microbiology and/or evolutionary biology .
2. Students will research their scientist by identifying the following:
   a. Date of birth
   b. Place of birth
   c. Schooling
   d. Life as a student
   e. Life as a researcher
   f. Discussion of scientist's research
   g. Evaluation of how the scientist contributed to the field of biology
   h. Portrait of the scientist
3. Students will create a poster on the scientist providing all the information mentioned in step 2. Teacher may modify the list accordingly.

Post activity:

1. Students will present in class their posters and hang the posters in the classroom by date of discover/research.

2. Students will write a response on:
a. What it means to be a scientist?
b. How to think like a scientist?
c. Why is science important? What has been learned from the project?

Lesson 3: Bacteria Inhibition lab

Objectives:

1. Observe the growth of bacteria populations and the factors that inhibit the growth of bacteria including antibiotics

Essential question: How do bacteria grow? How can we inhibit the growth of bacteria using natural substances?

Materials:

E.Coli K12

Petri dishes with agar

Antibiotic disk

Spices (ex. Cinnamon, garlic, red pepper)

Incubator

Q tips

Procedure:

1. Students will use the Qtip to swab Petri dishes with E.Coli K12 (total of two dishes). Note: Students must wear all safety materials before performing lab which includes apron, gloves, and goggles.
2. On the bottom of the petri dish with the agar, using a marker, divide the petri dish into two or three separate but equal sections.
3. In one section, place one antibiotic disk.
4. In the second and third section, choose a spice to place on top of the agar.
5. Leave one section without any spices or antibiotics (control group).
6. Let the dishes sit in the incubator for 24 hours.
7. Measure the ring around the placement of the spices and antibiotic called the zone of inhibition- area where bacteria did not grow.

Post activity:

1. Student lab report to demonstrate the proficiency in the steps of the scientific method
2. Discussion on what was observed and learned within the lab:
   a. Discuss procedural process and observation of petri dishes after incubation.
   b. Best spice for inhibiting bacteria growth
   c. Worst spice for inhibiting bacteria growth
   d. Compare antibiotic use to spices.
   e. Connect the lab to real world -How could this lab be beneficial and applicable in real life situations?

Lesson 4: Debate on medicinal treatment of patients suffering from infectious diseases

Objectives:

1. Evaluate the use of medicine (antibiotics, vaccines, and prescription drugs) as treatment options for patients.

Essential Question: How does evolution play a role in the medical treatment of patients with infectious diseases?

Materials:

Classroom divided into two sections for a debate or roundtable discussion

Procedure:

1. Teacher will prepare classroom for debate/ discussion.
2. Teacher will organize students into groups of students who agree with medical treatment and those who oppose medical treatment.
3. Teacher will read the rules of the debate that allows each group to have equal time to defend their position. The teacher must create rules ahead of time that is specific towards the management of his/her classroom. Example rules include allowing each team adequate time for talking, each member in the team must speak, and students must use data and/or other forms of evidence to support their arguments.
4. Teacher will list all of the essential questions on the board to help organize and facilitate the discussion.
   a. Is it possible to prevent becoming ill by a microbe?
   b. How often should prescription medicine be used to treat an illness?
   c. Should there be a universal healthcare to help those who are ill? And prevent others from becoming ill?

d. Should doctors be required to have a background in evolutionary biology in order to accurately treat patients?

Post activity:

1. Post assessment on unit content and debate
2. Essay: Personal response to the importance of Darwinian medicine when treating ill patients

Glossary

All terms are defined using the Modern Biology student textbook. [9]

Acquired immunity: specific immune response

Antibiotic: a substance that inhibits the growth of or kills microorganisms

Antibody: a protein that reacts to a specific antigen or that inactivates or destroys toxins

Arthropod: invertebrate having a segmented body, jointed limbs, and chitinous shell examples are insects and spiders

Asexual reproduction: reproduction that does not involve the union of gametes and in which a single parent produces offspring that are genetically identical to the parent

Bacteria: domain made up of prokaryotes that usually have a cell wall and that usually reproduce by cell division; this domain aligns with the traditional kingdom Eubacteria

Conjugation: an exchange of genetic material that occurs between two temporarily joined cells; in prokaryotes, the process by which two organisms bind together and one cell transfers DNA to the other cell through a structure called a sex pilus

DNA: the material that contains the information that determines inherited characteristics

Endocytosis: cellular ingestion of an invading substance in the body

Enzymes: a type of protein or RNA molecule that speeds up metabolic reactions in plant and animals without being permanently changed or destroyed

Eukaryote: an organism made up of cells that have a nucleus enclosed by a membrane, multiple chromosomes, and a mitotic cycle; eukaryotes include animals, plants, and fungi but not bacteria or archaea

Evolution: a heritable change in the characteristics within a population from one generation to the next; the development of new types of organisms from preexisting types of organisms over time

Fungi: a kingdom made up of nongreen, eukaryotic organisms that get food by breaking down organic matter and absorbing the nutrients, reproduce by means of spores, and have no means of movement

Helminthes: a worm that can be parasitic examples are roundworms or tapeworms

Host: a living organism that supplies nourishment to a parasite

Immunocompromised: immune system that is incapable of developing a normal immune response due to disease or immunosuppressive therapy

Immunosuppressed: the inhibition of the immune system response due to drug use, surgery, or disease

Innate immunity: nonspecific immune response

Pathogen: a virus, microorganism, or other organism that causes disease; an infectious agent

Prion: an infectious particle that consists only of a protein and that does not contain DNA or RNA

Prokaryote: a single celled organism that has no nucleus and has no membrane bound organelles; examples include bacteria and archaea

Prophage: the viral genome (DNA) of a bacteriophage that has entered a bacterial cell, has become attached to the bacterial chromosome, and is replicated with the host bacterium's DNA

Protozoa: unicellular, nonphotosynthetic organisms

Retrovirus: a virus that contains single stranded RNA and produces a reverse transcriptase, which converts RNA to DNA

RNA: a natural polymer that is present in all living cells and that pays a role in protein synthesis

Transformation: the transfer of genetic material in the form of DNA fragments from one cell to another or from one organism to another

Virulent: describes a microorganism that causes disease and that is highly infectious; strictly, refers only to viruses that reproduce by the lytic cycle

Virus: a nonliving, infectious particle composed of a nucleic acid and a protein coat; it can invade and destroy a cell

Zoonosis: a disease that can pass from animals to humans; an example is Lyme disease, which can be passed from deer to humans through infected ticks

Implementing District Standards

The Connecticut science standards are listed below in no particular order of presentation. However, the appropriate grade level for the content standards to be taught is solely reliant upon when Biology is taught within the particular high school.

D.40 - Explain how the process of genetic mutation and natural selection are related to the evolution of species. This standard is addressed through the discussion of why genetic variability is important. Students must be able to connect genetics to evolution to show how both microbes and humans have evolved over time to display the most favorable traits necessary for survival.

D.42 - Describe how structural and behavioral adaptations increase the changes for organisms to survive in their environments. This standard is addressed when students research their infectious disease pathogen. Also, it is necessary to know when discussing treatment options for patients and comparing bacteria to viruses.

D.43 - Describe the factors that affect the carrying capacity of the environment. This is particularly important in helping students recognize the impact of infectious diseases on the human population. Example graphs of human populations impacted by diseases would help students visualize the harmfulness of infectious diseases.

D.45 - Explain how technological advances have affected the size and growth rate of human populations throughout history. This standard connects with CT Standard D.43 because it shows students that through science research and experimentation, technology has grown for its importance in helping the human species to survive.

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. This standard is the foundation of the debate between the students and synthesizes all of the content learned in the unit so that students may be able to demonstrate how to use information to create well informed decisions on their lives.

Bibliography for Teachers

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Zimmer, C. 2007. Tuesday Science Times: Scientists Explore Ways to Lure Viruses to their Death. New York Times, March 27, 2007. Discusses the current work of scientists to eliminate viruses that attack the human body.

Websites:

Darwinian Medicine Website: http://www-personal.umich.edu/~nesse/Articles/OnDarMed-LifeScience-1999.PDF. Provides valuable background information on Darwinian medicine.

Data and Statistics on infectious diseases: www.cdc.gov/DataStatistics. Resource for obtaining current and past statistics on a specific infectious disease.

H1N1 Flu Website: www.cdc.gov/h1n1flu. A valuable resource in understanding the most current pandemic influenza virus.

Healthy People Initiative 2010 Website: www.healthypeople.gov. A resource for students to use for their debate and developing new debate topics regarding the advancement in healthcare and medicine.

Emerging Infectious Diseases website: www.cdc.gov/ncidod/eid. Provides valuable background information on emerging infectious diseases and discusses its trends.

Healthy People Initiative 2020 Website: www.healthypeople.gov/hp2020. A resource for students to use for their debate and developing new debate topics regarding the advancement in healthcare and medicine.

Mini clip Website: Sneeze: http://www.miniclip.com/games/sneeze/en/. A game that demonstrates the transmission of germs.

Minority Scientists in Biology Website: http://www.ascb.org/index.php?option=com_content&view=article&id=227&Itemid=6. A website for celebrating minorities in science, which may be a resource for the in class timeline.

Reading List for Students

Bakalar, N. 2008. Helpful bacteria may hide in appendix. New York Times, June 17, 2008. Article discusses the function of the appendix by discussing the evolution of a symbiotic relationship between bacteria and human as a possible reason behind the appendix.

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Endnotes

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3 Durham, J. and Lashley, F. Emerging Infectious Diseases: Trends and Issues, 43-44.

4 Durham, J. and Lashley, F. Emerging Infectious Diseases: Trends and Issues, 43-44.

5 Hopson, J. and Postlethwait, J. Modern Biology, 486-487.

6 Hopson, J. and Postlethwait, J. Modern Biology, 486-487.

7 Abeche, AM and Berlim, MT. "Evolutionary Approach to Medicine," 26-32

8 Durham, J. and Lashley, F. Emerging Infectious Diseases: Trends and Issues, 43-44.

9 Hopson, J. and Postlethwait, J. Modern Biology, 486-487.