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Microbes Rule the School and the Entire Planet

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Content Objectives

The topic of microbes ruling the school is sure to be an exciting and relevant topic for middle school. After all, these particular students are smelly, goofy, and excitable. They are not focused on anything but themselves and each other. So, I need to get these students' attention. When I can make a connection to their everyday lives, they get engaged. After several years of teaching, it seems that the nastiest and most gross topics get middle school students' attention. Not that microbes are gross (after all, they're microscopic), but infectious diseases that are caused by microbes are mucho gross to adolescents. Sex, fecal matter, poison mushrooms, trash, sickness and diseases, and gross images are sure to engage middle school students. Violence, drama, raunchy hip-hop music, cell phones, sports figures, and celebrity drama are often discussed in class. The students' developing bodies are often an engaging topic in class. Prestigious athletic shoes are also prized in school. Students often take their shoes off and smell them, as well as each other's shoes, while they are checking them out! What's up with that? Video games are often played in class, whether teachers like it or not. I really could get students engaged if I could relate science to all these student conversations. How about a video game about viruses or the many different types of bacteria? How about a killer virus that preys upon unsuspecting bacteria? Some viruses called bacteriophages land on a bacteria cell like a lunar lander, implant DNA into the cell, and replicate viruses like a copy machine, until the cell explodes. These are very violent scenarios that are happening in the human body right now in real time. Or how about a cell phone app on infectious disease that could be applied as a group activity in the classroom? Perhaps an activity about why fungi and bacteria cause odors in sneakers? Well, guess what? Microbes are not all bad, in fact we must have them around to live. These topics and concepts are what I am going to present in this unit. I will demonstrate in this unit, how humans need most of these microbes to live and how they affect every biotic and abiotic thing on the planet.

Microbes are an effective topic for the engagement of middle school students, because in the microbial world, you have destruction, violence, sex, history, ecology, evolution, global warming scenarios, and video game action. I have created a curriculum unit to exploit all this drama that happens in the microbial world. The human microbiome is an emerging science with limitless possibilities for mankind. Microbes are related to almost every topic in my 8th grade integrated science class. In this Curriculum Unit (CU), I intend to show to middle school educators accessing this material, the importance of microbes in the world, and how they can be used to engage middle school students. As I stress throughout this unit, microbes can be related to most

any area of a science middle school curriculum. Along with the activities, I stress common core standards of reading and writing for science topics and describe the activities and concepts learned in and out of class. Also equally important, is the discussion of content knowledge. I will give some interesting facts and background stories you won't find in a textbook.

Background

The school in which I teach is a high needs, low performing middle school in a large inner city metro area. The students struggle with any learning outside of their cell phones and iPads. They have no relationship with the outdoors and the physical world around them. They don't know how much money their parents pay for utilities. They have no idea what it takes to be healthy, the kinds of microbes are on or in their bodies, and very little about infectious diseases. They think the ocean is a distant place that has no relationship with the places they live.

This CU addresses 8 th grade integrated science at a middle school in Charlotte, North Carolina. With 1200 or so students, the school is located in an affluent area of Charlotte, located near The University of North Carolina at Charlotte in the prestigious Research Park area of North Charlotte. The demographic makeup is approximately 90% African-American and the rest mostly Hispanic students. 80% of the student population receive free or reduced lunches. Charlotte and this school system see a large transient population, with some students living in hotels. Most students (60 %+) read below grade level and are seldom seen reading books. These students own tablets and smart phones, however, reading comprehension is weak in all subject areas. Reading and writing effectively about observations, science activities, and experiments are difficult for them.

This situation requires scaffolding and differentiation strategies while staying true to the Common Core Standards and New Science Essential Standards that are required for students to pass the North Carolina 8 th grade science End of Grade Test and transition into high school. North Carolina End of Grade Tests are packed with higher order questions, not just memorization questions, and for this reason it is imperative that students effectively analyze, write, and describe concepts and demonstrations performed and discussed in the classroom.

Microbes and Curricula

I want to let the teacher-reader know that this CU is not written as a textbook, but as an addition to previous knowledge that a teacher might have learned while attending college or professional development seminars while teaching. I attempt to keep the writing informal and discuss recent advances in microbiology, pedagogy, probiotics, and how microbes affect our everyday lives. After all, we teachers know how to get a student's attention by relating the content to their everyday lives. One topic to exploit is odor of the sneakers worn by students at school. Middle school students are fascinated with sneakers and who has which brand of sneakers. The cost is as important as the smell. How many times have you witnessed students passing their sneakers around to smell and adore them? Because their lives revolve around their shoes, we have a perfect opportunity to create a lesson on odor causing feet fungi and bacteria! Infectious disease can also be connected to middle school life, because many students have had an infectious disease or know someone who has. Infectious diseases are a fascinating subject for students to make a connection with, and thus helps engage them in class.

Microbes affect every part of our life and environment. The human microbiome is a complex microcosm that lives in and on the human body. Most of the microbes in our biome are necessary for our survival and have a beneficial relationship to us. They indeed rule our schools, bodies, global and local climate, and ecosystems.

For example, schools have many microbes lurking in them ready to be sucked up someone's nose or drift into a student's ear. Most are beneficial to humans and we don't need to go around randomly killing microbes. That's where we get into trouble with antibiotics resistance, because bacteria tends to build up resistance to antibiotics over time. Some autoimmune diseases, such as peanut allergies may be caused by human attempts to manipulate our living environments and make us cleaner, which then alters the species in our microbiome and confuses the immune system into attacking the body by mistake. Most bacteria are beneficial, and humans tend to focus on the infectious disease microbes, without paying attention to all the so-called good microbes that we attempt to kill with anti-bacterial soap and dish detergent. Some scientific studies suggest that we shouldn't use anti-bacterial soap at all. We use anti-bacterial products thinking we will rid the world of microbes, however, we will never be able to rid the world of bacteria and viruses, and we really don't want to kill the beneficial microbes. Because they are so are so numerous and can live in extreme conditions for long periods of time, the effort to rid our bodies and environments from them is futile.

These bacteria, viruses, and fungi can survive and thrive in frozen conditions, and in extreme acidic and toxic locations, such as volcanos and under the ocean near hydrothermal vents, without light or photosynthesis. These bacteria and microbes that can withstand extreme conditions are called extremophiles. Deep in the ocean, where no light can penetrate, some types of bacteria use chemosynthesis instead of photosynthesis to create their own energy. These bacteria species called extremophiles are very interesting and very engaging to students and this subject can be exploited with some planning and creative activities.

Viruses: Friend and Foe

Viruses, the smallest of our microbial friends, live secretly in places we would never assume. They also perform activities and functions that science fiction writers use to make millions of dollars and impress their readers and movie-goers with their creativity, when in fact, they just get their ideas from the viruses themselves. Viruses are my favorite microbe because they are considered non-living and don't have cells. Just because they are non-cellular doesn't prevent them from doing amazing things for all life on the planet, as well as causing havoc in human beings at times. We cannot live without them. Albeit, some are strange looking, as they might have arrived here from another planet. Bacteriophages, the types of viruses that attack bacteria, sometimes look similar to the lunar lander created during NASA's Apollo era. All viruses do have genetic material and do some amazing things. They don't reproduce on their own, instead they replicate like a copy machine, using a host cell's energy to make more viruses. And viruses live everywhere; inside our bodies, in toxic environments, deep under the ocean, and even in unlikely places such as under thick layers of Antarctic ice. Cyanobacteria use their photosynthesis genes to make roughly 50% of the oxygen we breathe while their viruses, called cyanophages, also have these genes, and help create about 5% of the oxygen we breathe. Also, genes from viruses comprise about 8% of our human genome. Now, some scientists are saying that all life on earth could have evolved from viruses.

How can a living organism evolve from a so-called non-living virus? I prefer the term non-cellular myself, because the viruses do contain protein and genetic materials, similar to cellular life. Whether viruses are alive or not, is a very controversial issue because they lack cells and cell processes. The genetic material contained inside a virus depends upon the category and type of virus family to which it belongs. Virology is a growing field in science, as scientists are still discovering them faster than one can catalog them.

When Lita Proctor was a graduate student at the State University of New York at Stoney Brook, she decided to research how many viruses (if any) were in seawater. Proctor estimated there are at least 100 billion viruses in every liter of sea water. [1] So, the volume of a two liter soft drink bottle would contain a huge number of

viruses that help contribute to the survival of the human race and all life on the planet, through oxygen made by their photosynthesis genes. Of course, we know that viruses are so much smaller than bacteria and many viruses can live inside a one-celled bacterial host. Ocean dwelling viruses are so powerful that they infect a new microbe host ten trillion times a second and kill about half of all the bacteria in the ocean every day. [2]

So what role do viruses play in creating oxygen for us to breathe? As I stated earlier, viruses play a part in creating about 5% of all the oxygen in the world. The viruses that live in the ocean contribute to the manufacture of all this oxygen. An abundant species of ocean bacteria, called *Synechococcus*, carries out about a quarter of the world's photosynthesis. [3] Scientists examined theses bacteria and found virus genes carrying out their light harvesting. And researchers have found free-floating viruses carrying the photosynthesis gene searching for a new host bacterium to infect. A rough calculation showed 10% of all photosynthesis on earth is carried out with a virus gene. [4]

Viruses contribute to the success of all life on earth. However, they are also killers. Viruses such as the HIV virus can mutate very fast; that's the reason why HIV easily mutates to resist drugs and remains so deadly. Of course we know HIV causes AIDS. Doctors and scientists have developed a cocktail of different drugs and treatments to combat HIV. These drug cocktails confuse the viruses and this helps slow progression to AIDS (destruction of the immune system allowing any pathogen to enter the body and cause disease), because even HIV cannot mutate fast enough to overcome the complex mixture of drugs Although, only a very small percentage of viruses cause illness or death in humans, we are very aware of the ones that do. For example, the disease Smallpox, which is caused by variola virus, has been is said to have killed more people than any other disease in history. We don't have to worry about smallpox anymore because it has been eradicated through a global campaign to vaccinate people against the virus. Modern medicine has successfully eliminated this one killer virus of humans, but is it gone forever? Controversially, stocks of variola virus still exist in labs in Atlanta at the CDC and in a lab in Siberia. Smallpox caused epidemics and pandemics, killed people throughout the ages, and a lab accident or bioterrorism could cause the virus to kill again.

Common cold viruses, although not deadly, cause annoying symptoms that make us dread them like the plague. Human cold viruses, especially rhinoviruses, is one of the most prevalent viral diseases in humans. Why can't we prevent or cure the common cold? One reason we can't cure the common cold is that our many antibiotics are ineffective on viruses and instead, only target bacteria. Also, rhinoviruses cannot be controlled by a vaccine because these viruses mutate so fast; constantly changing and evolving in just a short amount of time. By the time a vaccine is developed for a certain strain, it would have already mutated into a different type. All life on the planet must rely on viruses to survive and all life can be sickened or killed by viruses as well.

The Good and the Bad Bacteria

In my opinion, the lowly bacteria, single celled, and always microscopic, don't have the hip-hop star quality and fascination to science that viruses do. Bacteria are critters that can be defeated with antibiotics (or at least this used to be true before many of them evolved resistance). Scientists also debate which microbe evolved first, the virus or the bacteria. In my opinion, I would like to think viruses were here first, and came from outer space on a rogue asteroid from some strange world. I have no proof of this of course. There have been several books written on the subject, as well as TV shows. Bacteria can make us sick, or even kill us. When I think of bacteria, I think of strep throat. The bacterium streptococcus, which causes strep throat, is identified by doctors by simply swabbing the throat and peering through a microscope. At that point, an antibiotic is prescribed if it is a bacterial infection, but not prescribed if it is a viral infection.

Scientists at the Massachusetts Institute of Technology have discovered evidence concerning a mass extinction that occurred 252 million years ago. This mass extinction was one of the greatest in the earth's history. This event is commonly called *The Great Dying.* According to their article, large amounts of gene transfer (AKA microbe sex) occurred to create huge amounts of methane gas released into the atmosphere. [5] This release of methane gas changed the makeup of the atmosphere and caused climate change and global warming, thus resulting in the largest die-off of life in the earth's history. You won't find any fossil evidence of bacteria and viruses, however, they is plenty of evidence they have affected all life on the planet throughout history (that is another curriculum unit).

Bacteria are with us from day one, coating our tiny bodies in bacteria-laden vaginal secretions as soon we exit the womb. [6] At the first minutes of birth, the baby becomes a microbe-symbiosis mammal containing 100 trillion bacteria. The newborn is also exposed to fecal matter containing bacteria. All this bacteria is introduced into the body and gut by swallowing, and to the nose by breathing, and of course when a stranger holds the baby other foreign bacteria are transferred into and onto the previously sterile baby. After a few days things settle down and the bacteria start to help the baby be healthy by aiding in the digestion of the mother's milk. So, we are thrown into the world of microbes in the first few seconds of life. Eventually, the cells in the human body are outnumbered 10:1 by microbes performing various duties for us in the gut and on our skin—some good and some not so good. Hopefully, this balanced symbiotic relationship continues to be beneficial to both the host and the microbes, keeping the healthy human biome healthy.

The Relationship between Viruses and Bacteria

We can think of viruses that attack bacteria as having a predator-prey relationship. Viruses are so very different from bacteria because they are considered non-living or non-cellular. Viruses can only reproduce when they attach themselves to a cell and implant their genetic material into it. At that point, the virus replicates inside the cell and eventually the virus reaches the maximum amount of proteins for new viruses to be assembled inside the cell. When the cell cannot hold all the new viruses, the cell rips open and release an entire new batch of viruses ready to go out and infect other cells. The virus destroys its host cell, period. But in many cases, as is happening in seawater at this moment of time, the virus actually assists the photosynthesis process by providing a helping hand to the cell. Some viruses have the gene which contains the photosynthetic material which actually helps the bacteria be more productive in the production of oxygen during photosynthesis. Usually, the virus hunts down and eventually destroys the bacteria cell by replicating inside. In the case of viruses in the seawater, the virus implants DNA into the bacteria which assists the cell and then kills it through a rapid voracious copy machine like process, which results in the eventual explosion of the cell. Viruses kill about half of the bacteria in the earth's oceans every day. Proof of this is the white cliffs of Dover which contain millions of years of layers of dead microorganisms, where viruses were a major source of the mortality. Viruses are deadly, but can be used in medicine to kill harmful bacteria that make us sick, by providing an alternative therapy rather than traditional chemical antibiotics. Such therapies are examples of how humans can benefit from this type of symbolic relationship between bacteria and their viruses.

Probiotics and Food and Energy

Research also has shown that there is a symbiotic relationship between the human body and the microbiome. Research shows this relationship can become unbalanced and cause problems for the human body associated with various diseases such as obesity, Crohn's disease, autoimmunity diseases and others. This community of dietary microbes in our gut is called enterotypes. Adding food from a low-fat diet, high fiber diet in the long term can change the types of microbes in the gut, especially the proportion of bacteroidetes present. [7] Recent

research has shown the importance of a healthy and balanced microbiome. The practice of introducing probiotic bacteria to reach a balance and assist in the regulation and digestion of food energy has shown some promise in balancing the microbiome. Probiotics are living organisms that are used to change or add to our gut microbiome to improve the balance of beneficial microbes in our bodies to improve our health and possibly help ease the symptoms of some chronic diseases. Many companies promote their products as helpful in maintaining the correct balance of bacteria in the gut.

There is even a website for a company that will analyze your microbiome sample and give suggestions on how to balance the bacteria in your gut. But this is controversial, because scientists are still discovering which bacteria should and should not be present in the gut. According to recent studies, the types of bacteria in your stomach will correlate with your weight. The ratio of two genera of bacteria, Prevotella and Bacteroides, parallels the amount of plant carbs in your diet. In western countries, diets high in animal protein and saturated fats reflect more Bacteroides bacteria, and different diets for people living in certain areas of Africa show more Prevotella bacteria. [8] If you want to lose weight, apparently you should adopt a diet which encourages a Prevotella enterotype. According to recent studies, the proper types of bacteria and the right balance of bacteria in the gut can result in weight loss, and better health in general.

Seawater: Interactions of Bacteria and Viruses that affect the Climate

Ocean water contains many different substances. Among them are dissolved oxygen, minerals, salt, microscopic life, such as algae, and surprisingly, bacteria and viruses. There are an estimated 100 billion viruses for every liter of seawater. Through processes and reactions that occur in the oceans, microbes control the makeup of our climate. There is a surprising interaction involving oxygen, bacteria, viruses, and ocean water that affects every living thing on the planet and the climate. With that being said, why and how do viruses and bacteria interact to affect the climate? Not only do viruses control the amount of oxygen created in the ocean and on the earth, but directly affect the ecology of the oceans and earth's global climate. [9] Emerging research may or may not show that human activity through the accelerated release of greenhouse gases has perhaps affected the delicate microbial balance in the ocean. If you have ever researched global warming, you know that the amount of carbon dioxide, methane, oxygen, moisture and dust in the atmosphere dictates the amount of sunlight that reach plants and animals on earth. As I mentioned before, viruses kill about half of all bacteria in the ocean every day and algae and photosynthetic bacteria create about 50% of all the oxygen we breathe. Some microbes absorb and release large amounts of carbon dioxide into the atmosphere. Releasing too much carbon dioxide into the atmosphere would allow more global warming through the greenhouse effect. Algae and photosynthetic bacteria absorb carbon dioxide and make the planet cooler (think about the reaction that occurs during photosynthesis but on a global scale). When microbes in the ocean die, they absorb carbon, which cools the planet. These marine microbes occur in huge numbers and make up most of the biomass on earth. Marine snow (the fall of dead organisms to the bottom of the ocean) absorbs huge amounts of carbon. This is one reason scientists think of the ocean as a huge carbon sink or sponge, and again, too much carbon dioxide equals more global warming. So as I have said though out this CU, viruses rule and a delicate balance is present in the oceans.

Chemical and physical reactions occur amid habitats in photic and aphotic zones. Microbes are fundamental in ocean floor sediment formation and there is life under the seabed. Biofilms are dense sheets of bacteria created on surfaces of objects and living organisms. Modern scientific methods and advances in technology have led to new ideas and discoveries about the evolution of microbial life. Ocean research is suggesting that human activity through the accelerated release of greenhouse gases has affected the delicate microbial balance in the ocean thus far. The increased acidity of the ocean affects microbes as well as all life in the

oceans. Also, remember that photosynthetic microbes can only live in the photic zone of the ocean where sunlight can penetrate to complete photosynthesis. Microbes rule the oceans as well as land areas.

Fungi, Sneakers, and Feet

In order to connect the sometimes bad smell of sneakers in school to bacteria and fungus, we need to know why this smell occurs. Sometimes it might be the feet, socks, or actual sneaker itself. Let's discuss which fungi or bacteria are the masterminds of all this odor. At any given time, millions of bacteria live on our feet, along with fungi, molds, ammonia, and denatured proteins. Like all living things, these organisms on our feet have survival activities which consist of food intake and the production of waste. Bacteria will consume dead skin cells and naturally, produce waste. It is the waste material that is often the cause of shoe odor. As physical activity increases, bacterial growth, waste and odor intensify. The primary culprit is sweat. The human foot has around 250,000 sweat glands that produce around 1 cup of perspiration per day. Interestingly enough, sweat itself has no odor. It is sweat in conjunction with other factors that can lead to having stinky feet.

There are several types of bacteria associated with causing foot odor. The most common is *Brevibacterium.* Found primarily on feet, it eats and survives on dead skin. As it eats, a gas known as methanethiol is produced. It has a sulfur like aroma that has been compared to that of cheese or rotting cabbage. Amazingly enough, *Brevibacterium* is used in the fermentation processes of certain cheeses. *Propionibacterium* is a rod shaped bacterium found mostly in the sweat glands. It has the ability to metabolize amino acids contained in sweat into propionic acid. Propionic acid is commonly found in sweat and is recognized by a strong, vinegar smell. *Staphylococcus epidermis* is a bacteria not only found on feet, but all over the human body, as well. As it interacts with sweat, it produces isomeric acid which is known to have a cheese or musty odor. It is amazing how many chemical reactions and processes that go into the smell of dirty feet.

Fungi are other major players that live around the toenails and on feet. Actually, there are about 100 different species of fungi on our feet. [10] A team of scientists studied the locations of microbes on the human body and found the greatest concentration of microbes were on our heels. [11] Our feet are attractive to certain colder-loving fungi because the extremities are a little cooler than our core body. Julie Segre, senior investigator at the National Human Genome Institute, states that fungi also offer important benefits to our skin as they help keep disease causing bacteria from sticking to our skin. She also says that attempting to rid our skin of these beneficial microbes is not the best decision. [12] It is amazing that there are huge numbers of species of bacteria and fungi, just on our feet. This reinforces the notion that microbes rule our schools, our bodies, and the entire planet. One could write a book or teach an entire year on the reactions chemicals, and microbes that are involved in the smell of dirty feet and sneakers. Science teachers realize that everything is very complicated in the world of science, and microbes are no exception.

Teaching Strategies

One must understand that my particular middle school curriculum does not go very deep into the subject of microbes. We are primarily attempting to introduce the differences and some minor characteristics, such as cellular vs non-cellular, sizes, shapes, and what diseases the microbes cause in the human body. The other units that are included in the curriculum I teach relates to microbes in a different context. One example is the composition of seawater as in the water unit I teach and another example is how oceans affect global warming

through the carbon cycle. In my local school system's Food and Energy unit, we cover how food is converted into energy from plants, directly and indirectly. Each section of the previous background is related to the activities listed in that section.

This particular CU attempts to teach microbes as related to other topics in the curricula throughout the year and in reviewing and preparing students for the End of Grade Standardized Testing at the end of the school year. The content above was background information and interesting facts in order to attempt to broaden the horizon of the typical middle school teacher. There are an infinite number of methods with respect to teaching 8 th grade integrated science and integrating the importance of microbes in the various curricula. When implementing this unit, I believe it would be helpful to use a Socratic seminar type day for instructing how microbes relate to just about any area of a typical middle school curriculum.

As I mentioned earlier, I believe I can engage the students more effectively with a CU that relates to the adolescent students' lives. I intend to make this unit project-based with a great deal of literacy involved such as writing and analyzing texts for comprehension and knowledge. Any activities or experiments designed will demand writing at least a paragraph or more about the student's observation and interpretation of what they witnessed. Students must be encouraged and allowed to construct their own learning, using prior knowledge and creativity to learn the standards and eventually pass standardized tests which are stressed heavily in public schools today.

Again, my intended audience for this curriculum unit is 7 th and 8 th grade inner city middle school students in a large metropolitan area. These particular students today face a myriad of learning challenges including attention deficit problems due to excessive exposure to video games, excessive TV viewing, and internet usage. Books, newspapers or e-readers are looked upon with disdain. Low reading levels and transient living conditions are the norm at this school. These children face many challenges to become prepared to contribute to the world of science, technology, engineering, and mathematics. As a teacher, I find it very difficult to explain the abstract concepts such as microbial interaction in seawater to an audience who is fixated on smartphones and hip hop music. Teachers need a connection that will motivate students to prepare for high-tech jobs that have not been created yet.

Another focus and intention of this curriculum unit is to enhance reading comprehension and increase implementation of higher order reasoning while providing a more effective written analysis of science demonstrations and activities. Text in the science reading can include more than just textbooks and articles. I have listed some examples of "text" in the science classroom below.

- Charts, tables, graphs
- Video files, audio files
- Works of art
- Pictures & diagrams
- Models
- Maps
- Smells, odors, textures
- Patterns that require knowledge to interpret; i.e. patterns seen in waves, spectra (light & sound), test results (gels, karyotypes, microscopic slides, x-rays, Punnett squares, etc.), land and rock formations, seismic charts
- Articles from science journals or textbook readings

Thus, resources and methods have been included to assist science content teachers in the preparation and motivation for struggling middle grades readers and writers. The focus of this unit was developed to target the specific needs of this middle school; targeting below level readers in transient living conditions. This unit encompasses higher order thinking, rigorous activities, and teaching methods to utilize Gardner's Multiple Intelligences as well as some common reading and writing strategies.

Technology is so important in our daily lives. I, along with my students, must learn to incorporate smartphones, iPads, *gaggle*, *wiki spaces*, tablets, and *remind 101* into our daily lessons to engage our imaginations. In order for today's educator to effectively reach most students, we must effectively integrate technology into our students' daily classroom time through *YouTube* video creation, writing eBooks, creating video lessons and through Power Point lessons created by the students themselves.

I have included some of the Essential Questions students are required to know and be able to answer during the school year related to diseases. Some of these questions include: Why are viruses considered nonliving? Why are antibiotics used to treat bacterial infections and vaccines used to prevent viruses? How do parasites affect a living organism? How are fungal infections treated? What is a pathogen? What is the difference between an epidemic and pandemic? Students need to be able to answer these questions eloquently with strong writing skills and be able to analyze text and observations. And the best way to learn to write is to write and write often, perhaps every day, and receive feedback from a teacher. Just writing a sentence or two is important. It is important to note that writing about science is a little different from language arts writing. I have included the Common Core Writing Standards for 8 th grade science in the appendix and will be referring to them in the activities. My warm up usually contains writing one or two sentences to be read back to the class and teacher. Just write!

Graphic organizers, KWL charts, and *read write think*, are all commonly used techniques to enhance student learning. In today's technology driven world students must know how to research a topic and make sure the data is factual and authentic. This can be challenging for the student, and they must be trained in making judgments about the validity of texts and images.

Socratic Seminar

Because I have chosen five days spread throughout the year to cover this unit and complete the activities, I have included instructions for a Socratic seminar in the appendix. I want to make these 5 days special and different from the rest of the school days. The Socratic seminar can be utilized throughout the school year to relate microbes to the different standards that will be taught. Also, the combination of the Microbes Rule CU and the Socratic seminar for re-teaching is appropriate to re-loop and re-teach microbes just before the 8 th grade End of Grade Standardized Test. A Socratic Seminar is a lively discussion of an essential question in which student opinions are shared, proven, refuted, and refined through discussion with other students. In larger classes, the fishbowl setup for Socratic seminars should be used. In this format, the teacher facilitates the discussion. Only half the class, seated in an inner circle, participates in the discussion at one time. The other half of the class, seated in an outer circle, consists of the students who act as observers and coaches. Every student's participation receives a grade.

The seminar provides an opportunity for reading texts critically, teaches respect for diversity, enhances students' knowledge, creates a community of questioning, develops critical thinking, problem solving and listening skills, and encourages student participation. Before he seminar, the teacher will select a text. The text must be complex ideas that promote thinking and discussion. All students will read the text before the

discussion. The teacher needs to have an essential question ready for the discussion. An effective opening question has no single "right" answer, and is to create a discussion leading to greater understanding of the ideas in the text.The teacher might share all discussion questions with students before the seminar or the teacher may share only one question before the seminar starts, depending on the length of the text, and difficulty of the discussion question(s) and ideas presented in the text, and the time allowed for the discussion. Before the discussion, the teacher must provide time for all students to record the essential question, develop their answer, and give supporting data for the answer. To prepare for the seminar students should sit in one of two circles (inner circle for participants, outer circle for coaches).

At that point teacher asks the essential question. Also, the teacher may need to ask follow up questions to lead the students to a greater understanding of the text. Students then respond to the question orally or in writing. The teacher then facilitates the discussion by guiding students to a deeper meaning of the ideas of the text, a respect for different points of view, and to follow the rules of the seminar process. Students can then give evidence from the text, ask questions, speak, listen, make connections, and add meaning or new knowledge to discuss their point of view in regards to the opening question. The teacher always takes notes for evaluation, but provides feedback that challenges what the students say. The teacher might ask follow-up questions and when satisfied that the essential question has been fully discussed, the teacher asks one or more additional questions to examine main points of the text. Students may ask new questions when the discussion is finished. New questions asked must relate to students' ideas and ideas in response to the essential question. Once the text has been discussed fully the teacher may ask a closing question, which is comes from the text but which has students apply the topic to their own lives or the world. The roles should state that students may only participate in the discussion if they have read the selection. They must support their opinions with evidence from the text. They can speak at any time during the seminar with respect for the other participants. They may whisper with their coaches if the teacher allows it and may refer to other works the class has read if the teacher allows. The students can also write notes to themselves ask relevant questions of other participants during the discussion if allowed. The teacher/leader should provide thinking time for students to respond appropriately and can only ask questions; cannot give his or her opinions or interpretations. Also, they should ask participants to support their opinions with evidence from the text and encourage participants to agree and disagree for good reasons. They might record the number and quality of student responses and decide when to stop the seminar. Allow no more than 30 minutes for the first seminar; after students have become familiar with the seminar format, 45-50 minutes may be allotted for discussion, particularly when examining more complex texts. You should select students for inner and outer circles carefully. Students should share rules, expectations, and grading practices with other students prior to the seminar.

Student participation and understanding may be assessed and evaluated using rubrics to assess student conduct, speaking, reasoning, listening, and/or preparation. Provide a checklist of positive and negative behaviors, student self-evaluation, and peer evaluation.

Classroom Activities

Sickweather Activity (Infectious Diseases)

While reading the *Mashable* Blog I discovered an app that students can download to their smartphones or

iPads called S*ickweather* (it is located in the *iTunes* store, or the website version, sickweather.com). *Sickweather* identifies any areas in the United Sates that have outbreaks of infectious diseases and alerts you any time you enter the area. Once downloaded, this app produces reports and allows for a long term project or group classroom activity about pandemics, epidemics, and the different types of activities. Users can see up to 23 different symptoms and illnesses on a map, which are grouped into four categories: respiratory, gastrointestinal, environment and childhood. When passing through a sick zone, the app user can touch the notification bubble to view the illness report and see how close they are to the area. The data could be used in various ways and with several different teaching strategies. This would be an excellent small group activity (I would use small groups because all students do not carry an *Apple* brand cellphone). This unit can be integrated into an infectious disease unit using prior knowledge and requiring the students to know the definitions and differences between viral and bacterial infections. Make sure students know which category (viruses, bacteria, or, fungi, or pathogen) that each illness falls into. A long term homework project could be created; perhaps an analysis of data, location, time of year, and creation of a poster project, eBook, or power-point. Students should also comment on the possible fallacies in the app and discuss the applications of future updates and apps in disease outbreak control health benefits. Additional questioning should include validity of data, accuracy of locations, and overall effectiveness of application. The desktop address is s*ickweather.org.*

uBiome Activity (Microbiology, Biotechnology Careers)

This activity integrates *uBiome.com* with talking points for a group activity and class discussion about an online website. This biotech startup called *uBiome* uses online crowdsourcing to map the human microbiome which of course is the complex ecosystems of bacteria living intimately with us. The website is very well constructed with many keywords used in this unit. The text on the website states that scientists can analyze your microbiome to check and determine if it is balanced or needs some medical attention. This will be a good opportunity for students to investigate the website and its offerings and determine if the services are worth the almost $90.00 fee. The students should discuss the services offered in groups, give background information from prior knowledge, and how the offerings relate to the digestion and processing of food into energy. The rubric would cover use of the Food and Energy unit vocabulary words, other terms, and validity of the results, and of course, writing abilities. The web address is u*Biome.com*

Geologic Time Scale and Mass Extinctions Activity (Geology, Evolution, Microbiology)

As I mentioned and cited above, scientists at MIT have discovered evidence for a mass extinction that occurred 252 million years ago. This mass extinction was one of the greatest in the earth's history. This event is commonly called *The Great Dying.* I realized this would be perfect for creating a lesson about theories of how and why extinctions occur. According to MIT scientists, this mass extinction occurred because of a huge increase in carbon dioxide in the oceans at the time. Evidence suggests that a change in *Methanosarcina* allowed methane production to increase and sediment samples show an increased amount of nickel deposits. The researchers believe that *Methanosarcina* acquired this ability to produce extreme levels of methane through gene transfer (sex) with a different microbe. The *Methanosarcina* needed the right nutrient to proliferate so quickly with the nickel as a nutrient. This activity, in conjunction with the article, can be used in a larger unit on chemistry, oceans, microbes, and genetic variation and evolution. An effective writing prompt or essential question for this unit would be: How can changes in environmental conditions affect the survival of individual organisms and species of life on Earth? Geology also relates to this activity. The address is:

Science Fiction Story about Giant Microbes Activity (Infectious Diseases, Evolution)

I intend writing (literacy from the core curriculum) to be a large part of this CU. Creating a science fiction story

or project about giant viruses recently found in the permafrost (from a *Mashable* online article) would be a creative way for students to learn about potential outbreaks of infectious diseases for which humans have no defense. The outbreaks could arise from global warming scenarios, as well as astronauts bringing back some strange diseases from other planets and asteroids. Students will need to know the differences in viruses, bacteria and infectious diseases from prior lessons. The link below is to a reading from a Mashable blog entry:

Oceans Review Activity: What kinds of microbes are in the Ocean and what's going with them? (Oceans, Global Warming, Ecosystems, Carbon Cycle, Renewable Resources)

Seawater contains viruses, bacteria, and other microscopic organisms. I believe an engaging and relevant activity would be to create a demonstration and observation using tap water to simulate seawater that would allow student groups to discuss and guess the number and types of microbes in a 2 liter bottle of simulated seawater. Students can learn based on readings the relationships between bacteria and viruses and how they create oxygen and control carbon in the atmosphere. A Socratic seminar could be used to recover prior knowledge and discussions in class. Students could create an eBook using information from prior knowledge, previous videos, Power Point presentations, readings, and peer discussions in groups relating to the seawater activity. Listed here is an excellent link to a pertinent Power Point covering the substances in seawater:

Smelling each other's shoes activity… (Microbiology, Infectious Diseases)

You know how sneakers become during those hot summer months when you wear them all the time, sometimes without socks? They get kind of ….stinky. This is especially true if you get them wet in the creek one day and then forget to place in out the sun to dry properly. Wet, dirty sneakers can really smell funny. Does that smell, though, mean that your sneakers have microbes in them and are unsafe to wear?

In this experiment, you'll be checking out your students' sneakers to see if they smell and then using swabs to collect samples of any microbes that are present. You'll need to obtain petri dishes that contain nutrient agar before you begin your experiment. You can get these at a biological supply company, or another science teacher might be able to give you a few. Round up some objects that you want to test, and the nastiest pair of sneakers you can find. Be sure to choose a variety of objects, such as the pencil you use to do your homework, the doorknob of your front door, the inside of your bathroom sink, and so on. Cellphones have been reported to contain more bacteria than the bathroom toilet. Test as many places as you like, as long as you have a petri dish in which to transfer any bacteria you collect.

Bacteria are everywhere, from mountaintops to the bottom of the oceans. Bacteria have even been found in rocks in Antarctica. When you start the activity, make sure to record detailed observations about the objects you're testing, including the following such as; is the shoe clean or dirty? Does the shoe smell bad? Where was the object located?

Using a clean cotton swab, wipe the surface of the object you're testing, and then wipe the swab across the surface of the petri dish. Be sure to label each dish, so you know which object the sample was taken from. Cover the dishes and put them in a warm, dark place where they won't be bothered. Check them twice a day—once in the morning and once at night—for a week, and record your observations about what's happening. After a week, you'll be able to see which items you tested contained the most bacteria. Were they the dirtiest-looking items? The smelliest ones? Make a chart on which to record your findings, then be sure to dispose of the petri dishes according to your local school system rules. Reading is from

Resources

Annotated Bibliography for Teachers

Mashable. "Ancient whodunit may be solved: The microbes did it!" MIT News Office. (accessed July 12, 2014).

Mashable is a technology blog that has articles relative microbiology, genetic engineering, and other science topics.

Gunning, Thomas G., *Developing higher-level literacy in all students: building reading, reasoning, and responding*. Boston: Pearson/Allyn and Bacon, 2008.

This book assist teachers with reading comprehension.

Karlen, Arno. *Biography of a germ*. New York: Pantheon Books, 2000.

This book discusses how microbes affect the human body through infectious diseases.

Legendre, Matthieu. "30,000 Year Old Distant Relative." National Academy of Sciences. (accessed July 4, 2014).

This blog article reveals the discovery of a new giant virus frozen in Siberia.

Money, Nicholas P. *The amoeba in the room: lives of the microbes*. New York NY: Oxford University Press, 2014.

A fascinating book with some interesting facts about common microbes found in ponds and discusses the importance of the human microbiome.

Zimmer, Carl. *A planet of viruses*. Paperback ed. Chicago: University of Chicago Press, 20122011.

An easy to read book that lay teacher-scientists and students can understand. Discusses how viruses affect global warming, the production of oxygen, and infectious diseases.

Common Core State Standards Initiative. "" Common Core Standards. (accessed July 11, 2014).

Core writing and reading standards related to science and science writing and projects.

Munn, C. B. *Marine microbiology: ecology and applications*. Second ed. New York NY: Taylor and Francis Group, 2011.

Explains research concerning microbes in the ocean.

HealthDay. "Today's Health News." Current Health News. (accessed July 13, 2014).

This blog article highlights fungus and other microbes on our bodies.

Dell'Amore, Christine. "Some 100 Species of Fungus Live on Our Feet." National Geographic. (accessed July 14, 2014).

This National Geographic article discusses research that has cataloged the types and locations of fungus and bacteria that live on human feet.

Zimmer, Carl. *Microcosm: E. coli and the new science of life*. New York: Pantheon Books, 2008.

Another easy to read book by Carl Zimmer which focuses on the many types of E. coli.

Notes

1. Zimmer, Carl. *A planet of viruses*. Paperback ed. Chicago: University of Chicago Press, 2011, 41.

2. Zimmer, Carl. *A planet of viruses*, 43.

3. Zimmer, Carl. *A planet of viruses*, 45.

4. Zimmer, Carl. *A planet of viruses, 45.*

5. Mashable. "Ancient whodunit may be solved: The microbes did it!." MIT News Office. (accessed July 12, 2014).

6. Money, Nicholas P. *The amoeba in the room: lives of the microbes*. New York NY: Oxford University Press, 2014.

7. Money, Nicholas P. *The amoeba in the room: lives of the microbes*. 137

8. Money, Nicholas P. *The amoeba in the room: lives of the microbes*. 134

9. Zimmer, Carl. *A planet of viruses*. 43.

10. Dell'Amore, Christine. "Some 100 Species of Fungus Live on Our Feet." National Geographic. (accessed July 14, 2014).

11. Dell'Amore, Christine. "Some 100 Species of Fungus Live on Our Feet." National Geographic.

12. Dell'Amore, Christine. "Some 100 Species of Fungus Live on Our Feet." National Geographic.