Microorganisms and Their Effect on Human Life 1

An introduction into pathogenic bacteria and how it has impacted the world in which we live.

Microorganisms Are Always Around Us

Microorganisms can be found almost everywhere in the world. Some can be found in extremely hot environments such as hot springs, and others can be found in environments that are permanently frozen. These are just a couple examples of environments microorganisms, or microbes as they are often called, like to live in. However, there are many other environments microbes can be found in. What is special about all of these organisms is they cannot be seen with the naked eye, and can only be detected and examined when using a microscope. They come in many shapes and sizes, and over time techniques have been developed in order to help scientists properly place these tiny organisms into distinct classifications.

Classifying Microbes

The techniques used allow for various tests to be performed on microbial samples that are collected. These tests help researchers attempt to learn more about microbes, the environments they were gathered in, and which domain of life these organisms can be classified within. There are three different domains microbes can be placed under, they are known as Archaea, Bacteria, and Eukarya. Upon the classification within these domains, they can then be placed into different microbial families and have distinctions among the species of the microorganisms. There are differences among the domains that help researchers determine where microorganisms should be placed. The cell structure of Eukarya have a nucleus within them as well as different membrane-bound organelles which include mitochondria, and chloroplasts (Organismal Biology, 2023). Bacteria and Archaea however, have a simpler structure in comparison to Eukarya. Unlike Eukarya, the other two domains do not include any nuclei, nor does it have any membrane-bound organelles. They do have similar metabolic processes that many different microorganisms use during their lives (Organismal Biology, 2023). An example is the fermentation process some microorganisms are able to complete in their life cycle.

The Importance of Gram Staining Microorganisms

A common testing procedure is known as Gram staining. This test is performed in many introductory microbiology laboratories as they allow for scientists to determine if a microbe is gram-positive or gram-negative. What this means is if the microbe under a microscope is purple in color after the staining process it is categorized as Gram-Positive. If the microbe has a pink color to it, it is classified as gram-negative. The Gram staining procedure is important in laboratories as it helps to identify bacteria, and allows researchers to possibly omit some testing procedures that may not pertain to some microorganisms. The differentiation of gram-positive and gram-negative has to do with the cellular makeup of each microbe.

Gram-Positive microbes have a thick layer surrounding the outside of the cell consisting of a substance known as peptidoglycan. Peptidoglycan is made up of sugars and different amino acids all linked together. Gram-Negative bacterium also contains a layer of peptidoglycan on the outside of the cells, but it is a much thinner layer. These gram-negative bacteria also have an additional outer membrane surrounding their surface made up of an endotoxin known as Lipopolysaccharide, or LPS. The difference between these two categorizations seem small, but they can make a huge difference in various medical diagnostic testing, and in the course of antibiotic treatment which will be discussed later in the chapter.

Microbes as a Cause of Disease

As stated earlier microbes are found all around us, we just cannot see them without the use of laboratory equipment. Lots of research has been done in the past and is still being done today regarding all of the different microorganisms that we know to exist in order to determine what microbes can be helpful and which ones are harmful to our health. Today we know that some bacteria have the ability to cause disease when we as humans are exposed to them. However, in the past this was not known until experiments were conducted by scientists. Prior to the experiments being performed, a theory was proposed by a Greek physician by the name of Hippocrates in the fourth century.

This theory was known as the Miasma Theory, as it was believed a person's bad environment was the reason for the common illnesses at the time such as cholera and malaria (Kannadan, 2018). People during this time believed there were other reasons for sickness, most of them included the use of magic, or were punishment from a higher power for someone's wrongdoing (Kannadan, 2018). Hippocrates did not believe this was the reason, and felt the more logical reason for what was happening had to do with miasma, or "bad air" people inhaled. Fast forward to the 17th century when a man named Antonie van Leeuwenhoek designed a microscope that was able to help him be one of the first people to observe living microorganisms (Libretexts, 2022). Leeuwenhoek's invention of the first useful microscope helped other scientists during that time period to begin conducting experiments that involved microbes.

The Miasma Theory continued to be the accepted theory for disease, until the 19th century. A man by the name of Louis Pasteur was able to expand upon prior research of other scientists, and determined through his own experiments microorganisms could come from outside sources such as spores rather than spontaneous generation as his precursors before him had previously thought (Libretexts, 2022). A new theory was then proposed, and is known as the Germ Theory of Disease. At first this theory was rejected by society as they could not believe the reason for various illnesses were caused by organisms we could not see with the naked eye. However, over time this theory began to be more accepted, and is the current theory we still use today. While the previous theories discussed possible negative effects microorganisms can cause, they can also be very helpful to us as humans.

Microbes: Friends or Foes?

Microbes can be very helpful, as without them we would not get to enjoy some of our favorite food and drink products. Wine, beer, and even some dairy products are a result of microbes being used during fermentation processes (Openstax, 2022). We have trillions of microorganisms that live both within us and on our skin that cause us no harm, as it is a beneficial relationship. Microorganisms that do have the ability to cause disease are known as pathogenic microbes. In the past there was little understanding of these pathogen-causing microorganisms. They have been the root cause of plagues in the past, as well as various disease outbreaks all around the world. By using the Germ Theory of Disease, and developing better

sanitation techniques over time to help improve human health it has allowed for a decrease in the amount of illness that used to be a top cause of death in the past. Better hygiene practices helped to decrease the number of people infected by disease, but it was not until the creation of vaccines and antibiotics that the treatments of diseases became more effective.

Vaccines and Antibiotics to Fight Disease

Vaccines and antibiotics are both very useful when used in the prevention of bacterial infections as well as in the course of treatment (Normark, 2014). Vaccination is an important preventative measure people can take in order to protect themself from being infected by a very deadly disease. Vaccines contain dead or in some cases live microorganisms that are known to be pathogenic. They are given typically in the form of a shot, and are then injected into the host's body.When our bodies are exposed to these microbes that are known to cause disease, it allows our bodies to create an antibody response as the microbes act as an antigen, which overall allow us to build up an immunity to these diseases (Idsociety, 2022).

The use of vaccines in the past has allowed for the eradication of some illnesses that were more common during that time. However, the topic of vaccination can be quite controversial due to some of the listed side effects, as some of them are given to children during infancy. It is important to note that while vaccines do have some negative side effects, there are still very many good outcomes that can result if people who live within populations are vaccinated. As mentioned above, vaccinations are a very good prevention method for a person to not become infected with various illnesses.

However, vaccines are not available for every disease that is caused by pathogenic microorganisms. If someone were to become infected with group A strep pharyngitis, or strep throat, they would more than likely be prescribed antibiotics by a doctor in order to treat their infection (CDC, 2022). Antibiotics work by targeting specific structures located on or within bacteria. Yet an antibiotics ability to enter the target cell in order to kill the bacterium depends on whether it can penetrate or break through the cell wall of the organism.

Today we have more knowledge about both vaccines and antibiotics, but upon the discovery of antibiotics it was a very big breakthrough in the world of science. After the discovery and production of antibiotics, there became a big market for them as they were needed as a form of treatment for sick people all around the world. This was great at the time, but today we are becoming more aware of microbes that are becoming resistant to these antibiotic treatments.

Antibiotic Resistance: A Cause for Concern?

Microbiological organisms have evolved over time, which is why antibiotic resistance from these organisms is on the rise in today's society. While evolution has played a role in the course of antibiotic resistance, the type of bacteria is also very important as well. We discussed earlier the importance in knowing the difference in gram-positive versus gram-negative bacteria.

Because of their thicker peptidoglycan layer, gram-positive bacteria are often more susceptible to antibiotics and medications that attack the cell wall. One common antibiotic often prescribed that can attack and stop the growth of these gram-positive bacteria is penicillin (Manoa, 2023). Gram-negative bacteria have the additional outer membrane layer on the outside of their surface. Because of this they can be more difficult to treat in comparison to gram-positive bacteria. Bacteria that are gram-negative typically have to be treated with antibiotics that can permeate across the outer membrane like fluoroquinolones and cephalosporins as they are two of the classes of antibiotics that exist (NEJM, 2003).

Narrow-spectrum antibiotics are a type of antibiotic that work against a small range of bacteria. This type of antibiotic is most useful against infections that are known to be caused by specific bacteria (Demeke et al, 2021).

Broad-spectrum antibiotics are used against a larger scale of bacterial infections, and are most often chosen to be a treatment method for gram-negative bacterial infections.

Antibiotics that can target more than one bacteria are effective in most treatments, but a consequence is that it can kill off the healthy bacteria that live within our bodies along with the harmful bacteria it should be targeting (Demeke et al, 2021). When the broad-spectrum antibiotics are used against the gram-negative bacteria multiple are often prescribed at one time. By prescribing more than one, it is done as a precaution in order to help prevent antibiotic resistance. If an antibiotic is always prescribed for a certain bacterial infection then it can lead to the antibiotic no longer being effective in killing off the bacterium responsible for the infection.

Antibiotic resistance is a growing concern in today's society. It can be a detrimental thing if people were to become sick with common illnesses and treatment options available are no longer effective. It is important to take preventative measures during times when the rate of infection is high in an attempt to limit taking antibiotics so an individual does not run the risk of building up a resistance to the medication they are prescribed by a doctor.

Too Much of a Good Thing Can Have Negative Effects

Humans have a symbiotic relationship with various microorganisms. The human digestive tract is home to a bacteria known as *Escherichia coli*,or E.coli. It makes up part of the natural flora we have in our bodies, but there is only a small amount. By only having the optimal amount of E.coli present in our bodies it allows for the symbiotic relationship to remain balanced. If an overgrowth of this bacteria were to occur it can lead to a plethora of health problems that can negatively affect human health.

Urinary tract infections (UTI's), and different gastrointestinal infections can occur when there is an influx of E.coli (Cleveland Clinic, 2023). E.coli infections can be treated with various antimicrobials as they are most useful in certain cases. If antibiotic resistance is on the rise, then it is possible that E.coli may also become resistant to some current treatment options. This could possibly be concerning as E.coli is part of our natural microbiome and if it were to become resistant to treatment it could leave the person with various health consequences.

Tiny Organisms Make a Big Impact

Described above have been all of the various ways these microscopic creatures have an impact on our everyday lives. From the food we eat to the air that we breathe, microbes are always around. Some families are known to cause disease, while humans have a symbiotic relationship that is beneficial to one another for quite a few bacterial species that are known to us. While many families of microbes have been published after being researched, there are still many possible microorganisms that have yet to be discovered. There are some microorganisms that have been published about, but the environments they are collected from are difficult to recreate in a laboratory. Because of this, characteristics of some publicized microbes are still not known.

The study of microbiology is important since it is known that these very small organisms are responsible for many illness-related deaths all throughout history. By continuing to research microbes in the world around us, we will be able to further understand the impact they have not only on the environment they are from, but the impact they have on our health as well.

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