TUBERCULOSIS (TB) UNIT
LESSON 1: GOOD NEWS! TB KILLER ON THE LOOSE!

TEXAS BIOMEDICAL RESEARCH INSTITUTE
HEALTH STARTS WITH SCIENCE

Objectives:

The Student Will Be Able To:

1. Evaluate tabular data generated from in vivo TB research. (HS)
2. Evaluate graphical data generated from in vivo TB research. (HS & MS)
3. Explain the body's immune response to infections, such as TB. (HS & MS)
4. Extrapolate the benefits and challenges associated with in vitro and in vivo studies. (HS)
5. Discuss the connection between TB infection and population density. (HS)
6. Compare TB disease to latent TB. (HS & MS)
7. Describe how TB is spread. (HS & MS)

Lesson Support Information

The global impact of infectious diseases is on the rise. To help students better understand how infectious diseases are spread and the body's response to infectious diseases, these activities examine tuberculosis (TB). Students will evaluate graphs from the transformed article to analyze the effect of TB on the body and the body's immune response.

General Information

On a global scale, TB persists as the ninth leading cause of death from an infectious pathogen. The scientific name for TB is ***Mycobacterium tuberculosis***. This bacterium can be spread by an infected person through a simple cough. Our bodies have an immune system which works to protect us from infectious invaders, like TB. But sometimes, pathogens, like TB, mutate or evolve in ways which makes our immune system less effective. Scientists conduct experiments to better understand the complex interactions between our immune system and infectious diseases. Information or data from these experiments can help scientists develop effective treatments and cures for TB infections.

Tuberculosis (TB) is caused by bacteria called ***Mycobacterium tuberculosis***. Although ***M. tuberculosis*** is commonly known as a "lung disease", once inside the body, the TB bacterium can attack any part of the body. The TB bacteria can migrate to the kidneys, spine, or brain and, if left untreated, TB can be fatal.

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Activity A: *Infect Me…If You Can!*

Activity C: *Design a TB Visual Abstract*

Tuberculosis – An Ancient Adversary

According to Dr. Larry Schlesinger, President and CEO of Texas Biomedical Research Institute and a leading TB researcher, it takes 1,000,000 TB bacteria to cause a mild skin infection but only 5 TB bacteria to cause [a tuberculosis] infection in the lung. With over 30-years-experience researching the TB bacteria, Dr. Schlesinger says TB has likely been around as long as humans have existed, making it a very ancient adversary.

TB is spread through aerosols with lungs usually being the first organ to be affected by TB. When the TB bacteria is in the lungs, exhaled air can carry the bacteria. When someone is infected with TB, every cough or sneeze can spread the TB bacteria where it stays suspended in the air as an aerosol. Once expelled from the body, the TB bacteria can stay suspended in the air for several hours! The TB bacteria can even be spread when an infected person speaks or sings! Should the TB bacteria land on a surface and that surface is not disinfected or exposed to sunlight, the TB bacteria can survive for up to six months!

Types of TB

There are two types of TB infection: latent TB and TB disease. When TB bacteria enter the lungs, most people's immune system stops the progression. However, sometimes the TB bacteria which enters the body is not active. This is called latent TB. People with latent TB are not contagious, but they may develop TB years later. The risk of latent TB becoming active increases if the immune system is compromised. Conditions or diseases, such as heart disease or diabetes, can compromise the immune system, creating conditions which are optimal for latent TB to become active. The key to TB's persistence is its ability to adapt and evolve, finding ways to hide within our own bodies where it can stay hidden for years. TB is not only found in the lungs. It can travel around the body, most often migrating to the brain, kidneys, and spine. Usually, the body's immune system is able to fight the infection on its own and some people never know they have it.

Immune System Responses

Our skin is the immune system's first line of defense. The skin has multiple layers with each layer creating a protective barrier against viruses and bacteria (collectively called pathogens). When skin layers are broken, like through a scrape or cut, it is easier for pathogens to enter our bodies. Fortunately, skin layers also contain immune cells which attack invasive pathogens.

Unlike the skin, lung tissue is relatively thin. To facilitate respiration (aka breathing), the inside passageways in the lungs can be only one or two cells thick. In addition, the lungs secrete mucus, keeping the lungs moist which helps with the exchange of oxygen and carbon dioxide (aka respiration). The combination of thin and moist tissue makes it a perfect habitat for pathogens, like TB, to stick to cell surfaces where they can then infect cells. But there is good news: the body's immune system sends out specialized cells to attack the bacteria.

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When the body detects the bacteria, the body actives an ***immune response***. The first line of defense is specialized immune cells released from the thymus gland. Known as T cells or T helper cells (T because these cells are formed in the thymus gland), these immune system cells rush to the lungs. Specialized receptors on the surface of the T cells attach to proteins on the surface of the TB bacteria.

Effect of TB Disease

About 10% of people who are exposed to TB will become ill. Only when a person shows symptoms of TB will they be diagnosed with TB disease. TB disease causes multiple symptoms, including weakness, weight loss, fever, and night sweats. When active within the lungs, TB disease causes chest pain and coughing. Coughing spasms frequently result in coughing up blood. People with weakened immune systems are at higher risk of contracting TB disease. Medical conditions such as substance abuse, cancer, diabetes, and HIV infection can all cause the immune system to be compromised, making the individual more susceptible to contracting TB disease.

TB Testing

To find out if someone is infected with TB, there are two different tests: a skin test and a blood test. The skin test injects a small amount of a serum call ***tuberculin (two-BUR-que-lyn)***. Tuberculin is a combination of different TB proteins which have been purified or inactivated. When tuberculin is injected under the skin, it forms a small bubble. If the TB test is negative, the bubble will disappear within a few days as the body's immune system attacks and destroys the proteins. But if the TB test is positive, the bubble will spread out and form a red ring around the area. Although the test is positive, a blood test is needed to confirm the skin test results. This is necessary as it is possible to have a false-positive result from the skin test. The blood test analyzes a blood sample for TB infection markers and is a definitive test for TB. Although the blood test results are reliable, the skin test is less invasive making it the first choice for TB testing.

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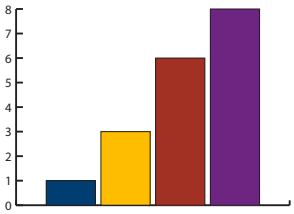
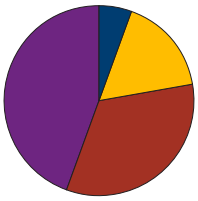
Transformed Article Research Highlights

One of these T cell receptors, (referred to as CD4 because it has 4 finger-like projections) has been shown to be effective at stopping the progression of TB. When attached to TB bacteria, the CD4 receptors trigger the T cell to release gamma interferon (GAM-ma inter-FEAR-on). This specialized molecule has been shown to be effective to stop the progression of TB infection. When T cells have lots of CD4 receptors (CD4+), the spread of TB within the lungs is minimized. However, the TB bacteria have evolved, causing other receptors on the specialized T cells to work against the CD4 receptors. These T cell receptors are called ***killer cell lectin-like receptor G1 (KLRG1)***. The KLRG1 receptors "override" the CD4 receptors which reduces the amount of gamma interferon released. In other words, when T cells have more KLRG1 receptors than CD4 receptors, the TB infection can spread.

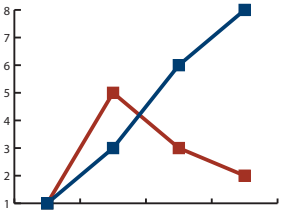
Reading a research article can be overwhelming. Transforming a research article into a shorter and more understandable form can make the information more accessible to the general public. The same is true for research data. The data collected from TB research is often represented by graphs, tables, and charts. Knowing how to interpret graphs, tables, and charts is an important skill. There are different types of graphs: bar graphs, pie charts, line graphs, and whisker plots.



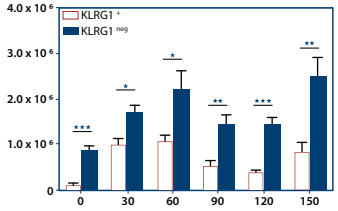
Bar Chart



Pie Chart



Line Graph



Whisker Plot

Bar charts are used to show distribution of data or comparisons between data. Pie charts are used to show a percentage of a whole, with each section representing a percent. Line charts are used to show trends or to show comparisons between different data sets. Whisker plots are also known as box plots. The "whisker" is the line which extends above or below the box of data ad shows the range of data. Most of the data falls within the range inside the box. However, a few data points fall outside of the box. These data points and are statistically important, but are considered "outliers".

Lesson Reference:

Centers for Disease Control (CDC). Retrieved August 9, 2022. https://www.cdc.gov/tb

Extensions:

Texas Biomedical Research Institute. Retrieved August 9, 2022. https://www.txbiomed.org/

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KLRN SciTech Now Tuberculosis. Retrieved August 9, 2022. https://www.youtube.com/watch?v=5eSESO7X9GI

To better understand the structure and function of the respiratory system, students can construct a 2-D model of the respiratory system https://www.txbiomed.org/education-outreach/educational-resources/curricular-units/#, located on the Texas Biomed Education page. The activity is downloadable and freely accessible.