This STEAM Project will explore how four major types of white blood cells function in the body's defense against the bubonic plague, with a particular emphasis on lymph nodes during Yersinia pestis infection. The bubonic plague was one of the worst outbreaks in the case of disease. It was caused by the bacteria Yersinia pestis. This bacteria was acquired mostly through flea bites. A major symptom of the disease is largely swollen painful lymph nodes that are called buboes accompanied by flu-like symptoms. In order to contain and defend against the bacteria, our immune system requires white blood cells to defend this disease. Neutrophils, macrophages, monocytes, and lymphocytes all serve a specific function in order to eliminate Yersinia pestis from the body.

Lymph nodes are small oval shaped organs that function as a filtering system throughout the body in our immune system. They filter lymph fluid, trap bacteria, viruses, and other potentially harmful pathogens. This is the gathering point for white blood cells. When bacteria enters the body it will then quickly travel to the nearest lymph nodes where it is filtered and potentially transported throughout the body. In the presence of Yersinia pestis, the bacteria is able to spread through the lymphatic system and reach the lymph nodes. This is where the disease can rapidly multiply and cause tissue damage accompanied by painful swelling.

Upon infection of the Yersinia pestis bacteria, white blood cells function as the body's initial defense against infection. The first acting white blood cell to reach and aid in defense against the bacteria are neutrophils. Neutrophils engage in phagocytosis, meaning this particular white blood cell ingests the pathogen due to enzyme production within the cell, allowing the neutrophil to essentially digest the invasive bacteria. According to Guinet et al. (2015), even though large areas of destructed tissue occur during the presence of Yersinia pestis, the bacteria can still spread throughout the body, making Yersinia pestis more difficult to contain.

Macrophages also perform phagocytosis. Yersinia pestis unfortunately can survive inside macrophages, specifically by stopping phagocytosis. Research by Li and Yang (2008) explains that Yersinia pestis can block signaling and phagocytosis, which makes it more likely to survive attacks by other immune cells. The bacteria is able to produce a protein that prevents the phagosome from digesting itself, this allows it to survive and spread more effectively, especially within the lymph nodes.

Monocytes play a similar role to both neutrophils and macrophages. Monocytes can also act as the first line of defense in fighting bacteria, but they also share the similarity of potentially facing the inability to perform phagocytosis in the presence of Yersinia pestis. When monocytes are needed, they are able to travel through the bloodstream to particular areas developing into mature macrophages.

Lymphocytes are white blood cells that produce two main types: B cells, which make antibodies to target specific pathogens once infected by bacteria like Yersinia pestis, and T cells, which help destroy infected cells or help other immune cells carry out their functions (Feodorova et al., 2018). Once the bacteria has been recognized by these cells the body acquires active immunity, resulting in the production of antibodies and memory cells that provide longer defense. Shorter defense is recognized as passive immunity which involves receiving antibodies for immediate defense without directly engaging B and T cells.

The immune system uses different white blood cells to defend against Yersinia pestis. Neutrophils, macrophages, and monocytes try to destroy the bacteria through phagocytosis, while lymphocytes (B and T cells) create a targeted response. This leads to active immunity and long-term protection. Lymph nodes play a key role by filtering bacteria and activating these immune cells to defend the body.

Sources

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STEAM Project Link:

https://docs.google.com/presentation/d/1M36u2Tbt9Wy0FTlWJji8LGMRdTkP5f_q4icn8zWCn0U/edit?usp=sharing