LEAGUE OF IMMUNO LEGENDS

Activity Packet

Carnegie Mellon University - Department of Biomedical Engineering

Note: This educational resource was developed as a project by the Carnegie Mellon student, Claire Kenny, for the summer 2020 course, Experiential Learning through Projects [99-520]. Editing and additional project development was also completed by Claire Kenny.

Project Summary

This project aims to give students the ability to classify and explain the different types of immune cells and their corresponding roles, recognize the immune system pathways, better identify the different immune responses, and recall basic immunoengineering applications. It does this in a two-part approach comprising of a PowerPoint introduction to the immune system and immunoengineering applications, and a role-playing card game in which the students play as different immune cells.

The PowerPoint presentation contains information on the functions of the immune system and immune cells, how the immune system works, the specific pathways and connections within the immune system, and how biomedical engineering can be applied to different immune issues (ie. cancer therapies, antibiotics, and etc.) The role-playing game involves students playing as different immune cells, with different functions and strengths, working together to fight different diseases or disorders with corresponding strengths. Students have the chance to receive an immunotherapy that can increase their cell's strength, give them immunity or give the human body a boost against the pathogen. This game will help students better perceive the steps the immune system has to protect the human body and the effect immunotherapies can have.

Keywords

Anatomy, physiology, biology, immune system, immunology, immunoengineering, biomedical engineering, immune system, diseases, disorders, medicine, therapeutics

Background

Real World Relevance

The immune system is a complex system of cells and proteins involved in the defense of the human body. Each cell has specific functions, interactions and capabilities to help protect, and strengthen the immune system. There are clear and well-known consequences when the immune system fails. If the immune system is invaded by microorganisms such as viruses, and the immune system cannot fight them off, the invader may cause the body to become sick, and if left untreated, may be fatal to those afflicted. The immune system may also face the issue of autoimmunity, in which it has trouble differentiating self from non-self. This in turn leads to the immune system attacking the very cells and body it was made to protect. The immune system also has trouble detecting some cancerous cells, as it cannot discern them as cells to be attacked. All of these issues start with the immune system and ends with real-world problems, that in turn may require engineering approaches to solve.

Engineering Connection

Immunoengineering is an application of biomedical engineering aimed at the immune system, health and diseases, in order to modulate a specific and desired immune response. Biomedical engineers must apply the engineering design process to obtain research efficacy, use their skills in the lab to best investigate the problem, and their intricate knowledge of biological systems to best model and analyze diseases.

Immunoengineering can aid in immune responses through amplification, or support, and can be applied to viral, bacterial, fungal, parasitic, and cancerous disorders. Commonly known applications include vaccines, antibiotics, antivirals, CAR-T cell therapy, monoclonal antibodies and much more.

Objectives

At the end of the activity students should be able to:

- Classify and explain the different types of immune cells and their corresponding roles
- Describe the different immune system pathways and better identify the different immune responses
- Recall basic immunoengineering applications

Materials

The planned activity will require the following:

- A computer to display the PowerPoint presentation
- PowerPoint presentation (provided, required)
- Slide guide (provided, required)
- Teacher handout (provided, required)
- PDF files containing game cards, health bar, exposure indicators, score sheets, and game instructions (provided, required)
- Paper (preferably cardstock)
- Color Printer
- Scissors
- 12-sided die
- 6-sided number die (x5)
- Paper clips or some form of marker

Safety Considerations

There are no consequential safety concerns in relation to the activity.

Vocabulary

1. **Adaptive Immune System** – antigen-specific part of the immune system that retains memory of past encountered antigens, initiates in days to weeks and can last months to years, involves B and T cells, antibodies and cytokines
2. **Anaphylactic shock -** a life-threatening reaction to an allergen (result of a severe allergic reaction), can cause trouble breathing, shock, vomiting, and more
3. **Antibiotic** – Drug to treat bacterial infections, can kill or inhibit growth of bacteria
4. **Antibody** - (also known as immunoglobulins) Y-shaped proteins that have the ability to recognize and bind to antigens

5. **Antigen** - Molecules capable of stimulating an immune response, with each having distinct surface features (or epitopes) resulting in specific responses
6. **Antiviral** - Drug aimed at treating influenza (flu)
7. **Autoimmune Disease** - Conditions where the immune system mistakenly attacks the body, as it sees the body as foreign and begins to attack healthy cells
8. **CAR-T Cell Therapy** - adoptive cell therapy that stands for Chimeric Antigen Receptor-T cell therapy, involves genetically modifying patients T-cells to recognize cancer cells
9. **Cytokine** - Proteins involved in cell signaling, especially between immune cells
10. **Cytotoxic** - Substance or process that results in cell damage or cell death
11. **Heparin:** Anticoagulant that inhibits blood clotting and promotes the movement of white blood cells in an area
12. **Histamine:** Widens blood vessels and increases flow of blood to injured tissue
13. **Immunoengineering** - An emerging area that involves the application of engineering tools and principles to quantitatively study the immune system in health and diseases and to develop therapeutic interventions for precisely controlling and modulating a patient's immune response.
14. **Innate Immune System** – nonspecific category of the immune system, initiates in minutes to hours and lasts days to weeks, involves many different white blood cells, has no memory
15. **Monoclonal Antibodies (mAB)** - involves exposing a mouse to an antigen and harvesting the resulting B-cells to be fused with tumor cells to make *hybridoma cells,* cells that in turn have the ability to continue making antibodies against said antigen, the antibodies produced are then purified and used to tag cancerous cells
16. **Pathogen** - Organisms or infectious agents that invades the body and can cause health issues
17. **Vaccine** - Product that stimulates a person's immune system to produce immunity to a specific disease, protecting the person from that disease

(vocabulary sources found at the end of document)

Vocabulary Continued: Immune Cells

Innate Immune System

1. **Basophils** - Important for allergic and antigen response, excrete histamine and heparin, can also release chemical signals to attract eosinophils and neutrophils to an infection site

2. **Dendritic Cells** - Bind and retain antigens to be presented to T-Cells, induce the differentiation of germinal B-cells into memory B-cells

3. **Eosinophils -** Respond to allergies, parasitic infections, collagen diseases, and diseases of the spleen and central nervous system, secretes chemicals to destroy large parasites

4. **Macrophages** - Detect, consume by phagocytosis and destroy bacteria and other harmful organisms, can also present antigens to T-Cells and release cytokines to initiate an inflammation response

5. **Mast Cells** - Carry granules containing histamine and heparin, play a role in the inflammatory process

6. **Natural Killer Cells** - Defend the host from tumors and virally infected cells, do not require prior activation, release cytotoxic granules that destroy altered cells

7. **Neutrophils -** Usually first responder to a microbial infection, active in the phagocytosis of bacteria and can be found in pus, effective against bacterial or fungal infections

Adaptive Immune System

1. **Cytotoxic T-Cells -** Also known as Killer T-Cells or CD8+ cells, produce toxic granules containing enzymes that induce the death of pathogen-infected cells

2. **Helper T-Cells -** Also known as CD4+ cells, produce cytokines to direct an immune response against a pathogen, necessary to activate B-cells and Cytotoxic T-Cells

3. **Memory B-Cells -** Important for maintaining immunity, makes any secondary exposures to an antigen quicker (and possibly stronger), can lessen symptoms to the point of not even feeling sick

4. **Plasma B-Cells -** Activated B-cells that produce antibodies specialized for one pathogen

5. **Regulatory T-Cells** - Act to suppress immune response, help maintain homeostasis and self-tolerance, able to inhibit T-cell proliferation, cytokine production and autoimmunity

(vocabulary sources found at the end of document)

Procedure

1. Read through teacher handout
2. Ask students for any previous insights on the ideas of immunoengineering or the immune system in general
3. Share the PowerPoint slides provided
4. Introduce the idea behind the card game and explain the instructions of how to play
5. Break students into groups to play the game
6. Once students finish the game, have each student explain a concept on immunoengineering they have learned

Additional Resources

1. InformedHealth.org [Internet]. *Cologne, Germany: Institute for Quality and Efficiency in Health Care (IQWiG)*; 2006-. The innate and adaptive immune systems. 2010 Dec 7 [Updated 2016 Aug 4]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK279396/

   This resource gives more in-depth information on the immune system, including further analysis of the innate and adaptive immune system, the cells, proteins and more involved with each, and much more.

2. BAM! Body and Mind. *Centers for Disease Control and Prevention*. Last Reviewed, April 8, 2020. https://www.cdc.gov/healthyschools/bam/teachers.htm

   This is a resource made by the CDC for teachers of grades 4-8. It includes units on maintaining a healthy life, different diseases, conditions and disabilities, as well as other outreach projects such as science comics.

3. Immunoengineering. *Nature*. June 3, 2019. https://www.nature.com/collections/bgebjchdah

   This resource contains information on the field of engineering and how materials science comes into play. It includes content on using material immunoengineering for cancer therapy, autoimmune disease and tissue regeneration.

4. Monoclonal Antibodies and Their Side Effects. *American Cancer Society*. Last Reviewed: December 27, 2019. Last Revised: December 27, 2019. https://www.cancer.org/treatment/treatments-and-side-effects/treatment-types/immunotherapy/monoclonal-antibodies.html

   This resource goes into the actual background of monoclonal antibodies (cancer therapy). It includes what mAbs are made of, the types used, and side effects of mAb therapy.

5. CAR T Cells: Engineering Patients' Immune Cells to Treat Their Cancers. *NIH: National Cancer Institute.* Last Updated: July 30, 2019. https://www.cancer.gov/about-cancer/treatment/research/car-t-cells

   This resource delves much deeper into CAR T cell therapy. It includes more details on the background behind this cancer therapy, the avenues it offers, and the evolution of current research.

Next Generation Science Standards

MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Authors

Lesson idea by Aditi Ramesh, final product designed and developed by Claire Kenny as a project for 99-520 O *Development of Biomedical Engineering Educational Outreach Activities for Middle and High School Audiences*

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