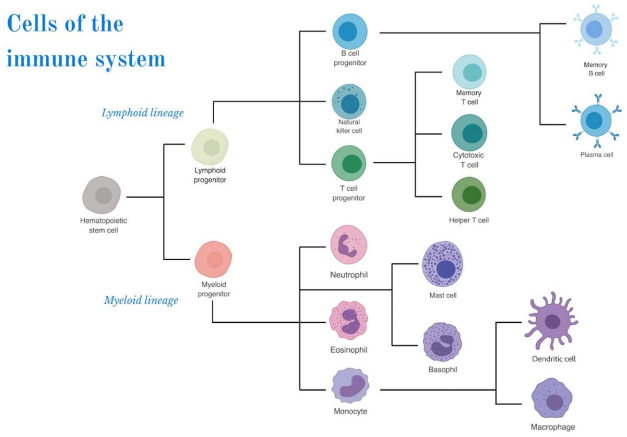
Session 1: Introduction: Which Cells Are the Players?

Overview:
The immune system helps us to fight pathogens, control cancer growth, and stay healthy. When not properly controlled, the immune system can also cause disease. Starting with a basic review of the immune cells, this session provides a general overview of the immune system and its activation. It includes a comparison between the innate and adaptive immune systems, and a characterization of T cell activation via MHC-I and MHC-II molecules.

First video:
Title: The Cells in the Immune System
Speaker: Brittany Anderton
Time: 5:54

Concepts: Review of the immune cells, innate and adaptive immune systems, antigen presentation, T cell activation via MHC-I and MHC-II molecules



Questions for First Video:

1. For the following cells in the immune system, provide a difference and a similarity:
    a. Red blood cells and T cells

    b. Helper-T cells and Cytotoxic T cells

    c. Macrophage and basophil

d. T cells and B cells

2. Which of the following cell types are specifically part of the adaptive immune system? (Select all that apply.)
    a. eosinophils
    b. plasma cells
    c. mast cells
    d. dendritic cells
    e. helper T cells

3. Cells of the immune system originate from precursors in the bone marrow.
    a. What are the two major progenitor subsets of white blood cells (leukocytes)?
    Lymphoid and myeloid progenitors.
    b. Which subset gives rise to most cells of the innate immune system?
    Myeloid lineage.
    c. Which subset gives rise to most cells of the adaptive immune system?
    Lymphoid lineage.

4. Compare and contrast activation of innate and adaptive immunity.

Second video:
Title: The Immune System
Speaker: Ira Mellman
Time: 35:31

Concepts: Recognition of self- versus non-self, dendritic cells, lymphoid tissues, innate versus adaptive immunity, inflammation, macrophages, Toll-Like Receptors, B cells, T cells and T cell receptors, CD8/CD4 T Cells, and T cell communication with dendritic cells

Questions for Second Video:

1. Which of the following are unique characteristics or components of the adaptive—but not innate—immune system? (Select all that apply.)
    a. immune “memory”
    b. natural killer cells
    c. phagocytosis
    d. specificity

2. Phagocytes kill harmful bacteria by
    a. endocytosis.
    b. producing antibodies.
    c. complement proteins.
    d. T cell stimulation.
    e. inflammation.

3. Indicate if the following statements are true or false. If false, briefly explain your answer.
    a. Toll-like receptors in macrophages get activated upon contact with yeast cells, which induces the macrophage to eat these cells.
    b. Dendritic cells travel through the blood system to the area of infection.
    c. Receptors on macrophages can recognize antibody-coated bacteria and “eat” them.
    d. Dendritic cells connect the adaptive and the innate immune system.
    e. Plants have immune systems.
    f. The immune system can both cause and prevent diseases.
    g. Immune cells are derived from cells in the spleen.
    h. Phagocytes are the main effector cells of the innate immune system.
    i. B cells make specific antibodies after first interacting with a pathogen.

4. (Choose all that apply) When pathogenic bacteria interact with the immune system,
    a. immune cells release cytokines that induce inflammation.
    b. recognition of antigens by B cells activates the innate immune system.
    c. Toll-like receptors recognize components of the cell wall, which induces the innate immune system.
    d. the adaptive immune system releases cytokines.
    e. None of the above.

5. Tetanus infection could occur when a patient suffers an injury with a rusty nail. Note, symptoms for tetanus can occur as early as three days after exposure.
    a. Could you help the patient from developing tetanus if you treat them with the tetanus vaccine right after the injury occurs? Briefly explain.

    b. What alternative treatment could you use to prevent tetanus development in this patient? Briefly explain.

6. Compare and contrast innate and adaptive immunity.

7. Antibody recognition can lead to microbe killing. List two mechanisms of antibody-mediated microbial death and state the cells and/or compounds involved.

8. Explain why the lymph nodes are described as “communication hubs” for immune cells.

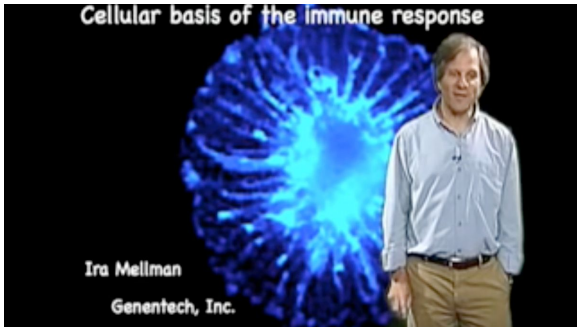
9. The immune system is comprised of several interrelated parts.
    a. What signal must a T cell receive before it can help a B cell be activated?

    b. Predict why the adaptive immune system has evolved to have B cell activation be informed by T cells.

    c. Explain why dendritic cells are considered to be the missing link between innate and adaptive immunity.

Third video:
Title: Cellular Basis of the Immune Response
Speaker: Ira Mellman

Time: 6:33
Concepts: MHC Class I molecules and activation of CD8+ cytotoxic T cells



Questions for Third Video:

1. Indicate if the following statements are true or false. If false, briefly explain your answer.
    a. MHC class I molecules present antigens produced by viruses.
    b. Cytotoxic T cells are CD8 positive cells.
    c. Helper T cells are activated by antigen presenting cells.
    d. CD8+ T cells specialize in killing cells infected with intracellular pathogens.
    e. The cytoskeleton is a critical component of cytotoxic T cell activity.

2. You are studying a new type of virus that seems to have a high rate of infectivity. You discover that this virus is able to block the effect of perforin (released by cytotoxic T cells). Briefly explain what would be the effect of this inhibition.

3. You are a doctor examining a patient's blood test reports. You are looking at the ratio of helper T cells and cytotoxic T cells. Helper T cells _____; cytotoxic T cells _____. You can tell them apart by the type of protein they _____.
    a. activate other immune system cells; kill altered host cells; secrete
    b. activate other immune system cells; kill altered host cells; express on their plasma membrane
    c. kill altered host cells; activate other immune system cells; secrete
    d. kill altered host cells; activate other immune system cells; express on their plasma membrane
    e. activate antigens; destroy antigens; digest

4. You are a doctor examining a patient's blood test results. The patient's cytotoxic T cell count is low, and T cells that are present are not well-developed. You are concerned that the patient will _____.
    a. be susceptible to infection by all types of bacteria
    b. have low antibody levels from decreased B cell activity
    c. have strong allergies
    d. have a reduced ability to kill host cells if they become infected
    e. develop cancer

5. CD8+ T cells are known as cytotoxic T cells.
    a. How does a CD8+ T cell "know" that a given cell is infected with a pathogen?

    b. Predict why activation of costimulatory receptors is necessary for T cell activation.

6. (Connection to previous video) How is cell killing mediated by CD8+ T cells similar to and different from killing mediated by phagocytes?

Answers for Session 1:

Questions for First video:

1. For the following cells in the immune system, provide a difference and a similarity:
    a. Red blood cells and T cells
    Differences: Red blood cell carries oxygen in the body while T cells are involved in the immune system. Alternative answers not covered by this video: the DNA of red blood cells does not change upon differentiation; differentiation of T cells requires VDJ recombination (changes in the DNA).

    Similarities: Both are derived from the same stem cell.

    b. Helper-T cells and Cytotoxic T cells
    Differences: Helper-T cells get activated upon binding of MHC II proteins while cytotoxic-T cells bind to MHC I proteins; activation of helper-T cells generates cytokines that activates other helper-T cells, B cells and cytotoxic-T cells; cytotoxic-T cells activation creates a response that allows to kill a pathogen-infected cell.

    Similarities: Both are cells of the acquired immune system; they derived from the same cell. Alternative answers not covered by this video: both need to go through positive and negative selection; both have T-cell receptors.

    c. Macrophage and basophil
    Differences: Macrophages are phagocytes (engulfs and digests pathogens); A Basophil is a granulocyte. Alternative answer not coverd in this video: Basophil releases histamine.

    Similarities: They belong to the innate immune system; they activate the inflammation process. Alternative answer not coverd in this video: both can promote T cell development

    d. T cells and B cells
    Differences: T cells get activated upon binding of antigen and MHC proteins (B cells can be activated by cytokines and/or binding of pathogen particles); B cells have the capacity to produce antibodies that are released into the blood.

    Similarities: **These are cells of the acquired immune system. Alternative answers not covered in this video: receptors go through VDJ recombination; they go through the process of clonal selection, positive selection and negative selection.**

2. Which of the following cell types are specifically part of the adaptive immune system? (Select all that apply.)
    a. eosinophils
    b. plasma cells
    c. mast cells
    d. dendritic cells
    e. helper T cells

3. Cells of the immune system originate from precursors in the bone marrow.
    a. What are the two major progenitor subsets of white blood cells (leukocytes)?
    Lymphoid and myeloid progenitors.

    b. Which subset gives rise to most cells of the innate immune system?
    Myeloid lineage.

    c. Which subset gives rise to most cells of the adaptive immune system?
    Lymphoid lineage.

4. Compare and contrast activation of innate and adaptive immunity.
    Innate immunity is activated through receptors known as pattern recognition receptors, which bind common motifs on pathogens. Adaptive immunity is activated through presentation of antigen by MHC molecules to T cells, which leads to their activation. Both types of immunity help to defend the body against pathogens, and both types rely on communication via surface proteins.

Questions for Second Video:

1. Which of the following are unique characteristics or components of the adaptive—but not innate—immune system? (Select all that apply.)
    a. immune "memory"
    b. natural killer cells
    c. phagocytosis
    d. specificity

2. Phagocytes kill harmful bacteria by
    a. endocytosis.
    b. producing antibodies.
    c. complement proteins.
    d. T cell stimulation.
    e. inflammation.

3. Indicate if the following statements are true or false. If false, briefly explain your answer.
    a. Toll-like receptors in macrophages get activated upon contact with yeast cells, which induces the macrophage to eat these cells. **(True)**
    b. Dendritic cells travel through the blood system to the area of infection. **(False, the immune cells, like dendritic cells, travel through the lymphoid system)**
    c. Receptors on macrophages can recognize antibody-coated bacteria and "eat" them. **(True)**

d. Dendritic cells connect the adaptive and the innate immune system. **(True)**
e. Plants have immune systems. (**True**)
f. The immune system can both cause and prevent diseases. (**True**)
g. Immune cells are derived from cells in the spleen. (**False - they are derived from cells in the bone marrow**)
h. Phagocytes are the main effector cells of the innate immune system. (**True**)
i. B cells make specific antibodies after first interacting with a pathogen. (**False - mature B cells have pre-existing antigen specificity**)

4. (Choose all that apply) When pathogenic bacteria interact with the immune system,
   a. immune cells release cytokines that induce inflammation.
   b. recognition of antigens by B cells activates the innate immune system.
   c. Toll-like receptors recognize components of the cell wall, which induces the innate immune system.
   d. the adaptive immune system releases cytokines.
   e. None of the above.

5. Tetanus infection could occur when a patient suffers an injury with a rusty nail. Note, symptoms for tetanus can occur as early as three days after exposure.
   a. Could you help the patient from developing tetanus if you treat them with the tetanus vaccine right after the injury occurs? Briefly explain.
      No. A vaccine induces the adaptive immune system, which takes a couple of weeks to produce protective cells. By that time, the patient will already be infected with tetanus.

   b. What alternative treatment could you use to prevent tetanus development in this patient? Briefly explain.
      You could treat the patients with a serum harvested from a donor that has immunity against the tetanus. This serum will contain antibodies that will help the patient induce an immune response that will be protective against the tetanus.

6. Compare and contrast innate and adaptive immunity.
   The innate immune system responds to shared molecular patterns on microbes. It provides an immediate response that is limited in scope. The adaptive immune response can generate B and T cells that are specific to individual pathogens. It provides a delayed response that is stronger and has memory.

7. Antibody recognition can lead to microbe killing. List two mechanisms of antibody-mediated microbial death and state the cells and/or compounds involved.
   Complement fixation: antibody binds to microbe and recruits complement proteins.

   Induction of phagocytosis: antibody binds to microbe and recruits phagocytes, such as macrophages.

8. Explain why the lymph nodes are described as “communication hubs” for immune cells.
   When immune cells in the periphery detect pathogens, they travel to the lymph nodes where they interact with lymphocytes (B and T cells) to activate them. Activated lymphocytes then travel to the site of infection to clear it.

9. The immune system is comprised of several interrelated parts.
    a. What signal must a T cell receive before it can help a B cell be activated?
    A T cell must be activated by a dendritic cell presenting antigen via MHC.

    b. Predict why the adaptive immune system has evolved to have B cell activation be informed by T cells.
    This helps to maintain a high level of regulation of the immune response. Furthermore, it helps to generate an immune response that is highly pathogen-specific.

    c. Explain why dendritic cells are considered to be the missing link between innate and adaptive immunity.
    Dendritic cells use innate immune components (Toll-like receptors) to identify pathogens in the periphery (innate immunity). Once they recognize pathogen, they then interact with T cells to activate an adaptive immune response (adaptive immunity).

Questions for Third Video:

1. Indicate if the following statements are true or false. If false, briefly explain your answer.
    a. MHC class I molecules present antigens produced by viruses. **(True)**
    b. Cytotoxic T cells are CD8 positive cells. **(True)**
    c. Helper T cells are activated by antigen presenting cells **(True)**
    d. CD8+ T cells specialize in killing cells infected with intracellular pathogens. (**True**)
    e. The cytoskeleton is a critical component of cytotoxic T cell activity. (**True**)

2. You are studying a new type of virus that seems to have a high rate of infectivity. You discover that this virus is able to block the effect of perforin (released by cytotoxic T cells). Briefly explain what would be the effect of this inhibition.
    Activated cytotoxic-T cells (effector cells) will normally bind to pathogen-infected cells to destroy them by releasing perforin. If this virus is able to block this effect, it means that it would be able to bypass the acquired immune system and your body will not be able to easily get rid of them.

3. You are a doctor examining a patient's blood test reports. You are looking at the ratio of helper T cells and cytotoxic T cells. Helper T cells _____; cytotoxic T cells _____. You can tell them apart by the type of protein they _____.
    a. activate other immune system cells; kill altered host cells; secrete
    b. activate other immune system cells; kill altered host cells; express on their plasma membrane
    c. kill altered host cells; activate other immune system cells; secrete
    d. kill altered host cells; activate other immune system cells; express on their plasma membrane
    e. activate antigens; destroy antigens; digest

4. You are a doctor examining a patient's blood test results. The patient's cytotoxic T cell count is low, and T cells that are present are not well-developed. You are concerned that the patient will _____.
    a. be susceptible to infection by all types of bacteria
    b. have low antibody levels from decreased B cell activity
    c. have strong allergies
    d. have a reduced ability to kill host cells if they become infected
    e. develop cancer

5. CD8+ T cells are known as cytotoxic T cells.
    a. How does a CD8+ T cell "know" that a given cell is infected with a pathogen?
    The cell presents antigen derived from the pathogen at its surface, on an MHC molecule.

    b. Predict why activation of costimulatory receptors is necessary for T cell activation.
    To help amplify the signals for T cell activation and to provide multiple levels of control so that T cells are activated only in the appropriate context.

6. (Connection to previous video) How is cell killing mediated by CD8+ T cells similar to and different from killing mediated by phagocytes?
    Cell killing by CD8+ T cells occurs in an antigen-specific manner, and CD8+ T cells kill only self cells because they require activation via MHC presentation (only on self cells). Cell killing by phagocytes occurs in a less specific manner (i.e., through TLR activation). Phagocytes can kill both self and pathogen cells.