Immunology Curriculum for Introductory High School Biology

I. **Here is a list of ways to integrate the immune system into a typical high school curriculum**:

- Cell Cycle: After lymphocytes are activated by antigen, they will divide rapidly. This is called clonal expansion.

- Cancer: The immune system is designed to recognize and eliminate cancer cells. Specifically, NK T cells can perform this task when MHC is not present on a tumor cell.

- Evolution: Invertebrates do not have adaptive immunity, they only have innate. In other words, invertebrates do not have T and B cells.

- Exons and Introns: There are 10 or more possible kinds of antibodies and T cells. This is due to different permutations of the same gene.

- Biochemical pathways/Cascading/Cell Signaling:
  For example, when antibodies encounter a pathogen with an antigen that it recognizes, they bind to the pathogen; a macrophage then engulfs the pathogen; the macrophage also presents antigen on its surface and secretes 5 different chemical messengers called cytokines. This will activate lymphocytes, initiate the inflammatory response, and possibly trigger fever, just to list a few of the events that would take place in this particular pathway.

- Inflammation: This is a physiological response that everyone has experienced so it is a good place to make a connection with your students.

- PUS: Now here's something we can all relate to. Did you know that pus is mostly dead and dying neutrophils which are very short lived phagocytic white blood cells.

- Catalase Lab: In our school, an enzyme lab that all of the teachers use, involves observing the decomposition of H O to H O and O . An interesting note is that H O (hydrogen peroxide) is produced by macrophages to degrade pathogens they have engulfed.

- Lock and Key Hypothesis: When teaching about enzyme –substrate interactions, is seems appropriate to also discuss antibody-antigen interactions because the basic method of recognition and binding is the same, that is, charge, H bonding and molecular shape are the main factors responsible for determining whether or not two molecules fit together or how well they fit together.

- Organelles and Endocytosis: When an antigen presenting cell, such as a macrophage, engulfs antigen via endocytosis, MHC molecules are then assembled and transported to the surface of the cell with the help of the endoplasmic reticulum and golgi appartus.

II. Vermont Standards, Grades 9-12, that will be addressed in this unit

Human Body

7.14, bbb:
Demonstrate an understanding that human beings have complex biochemical systems that enable them to function and reproduce (e.g., immunity).

7.14, ccc:
Analyze and describe how the health of human beings is affected by diseases passed through DNA, environmental factors, and activates that deliberately or inadvertently alter the equilibrium in ecosystems.

Problem Solving Process

2.2, Students use reasoning strategies, knowledge, and common sense to solve complex problems related to all fields of knowledge.

Relationships

3.10, Teamwork: Students perform effectively on teams that set and achieve goals, conduct investigations, solve problems, and create solutions.

Grade Expectations for Grade 9-12 that will be addressed in this unit

S9-12:42
Students demonstrate their understanding of the Patterns of Human Health/Disease by...

- Identifying a variety of nonspecific means of protection for the human body and explaining how these maintain human health (i.e., prevent disease).

AND

- Describing the general process of the human immune response to foreign substances and organisms (e.g., phagocyte action and antibody production and maintenance).

AND

- Showing through models/diagrams/graphic organizers how specific biological abnormalities alter the normal functioning of human systems (e.g., feedback diagram).

AND (EXTENSION)

- Explaining the effect of unique viral diseases on the cells of the human immune system (e.g., retroviruses).

Science concepts taught in this unit that correspond to the Grade Expectations

a. The Human Body protects itself against infectious diseases (caused by microorganisms, viruses, animal parasites) through physical protection and physiological (immune) responses.
b. The Immune System is designed to protect against microscopic organisms (bacteria, fungi) and foreign substances that enter from outside the body and against some cancer cells that arise within.
c. Some allergic responses are caused by the body's immune responses to usually harmless environmental substances.
d. Humans have a variety of mechanisms—sensory, motor, emotional, social and technological—that can reduce and modify health hazards (e.g. blinking, fight or flight, coping mechanisms, medicine).
e. The severity of human disease depends upon many factors, such as resistance to disease the virulence of the infecting organism.
f. Biological abnormalities, such as injuries or chemical imbalance, cause or increase susceptibility to disease (e.g. hormonal imbalance, epilepsy, depression). (Atlas 91)
g. (EXTENSION) Some viral diseases, such as AIDS, destroy critical cells of the immune system.

Scope and Sequence

Day 1:

Brief overview of different kinds of diseases.

-Genetic
-Pathogenic
-Environmental
-Cancer

We will discuss the basic structure and function of viruses and bacteria, and the difference between the four categories of disease.

Assigned readings in Exploring Life, Prentice Hall:
-16.1, Prokaryotic Life Began on a Young Earth
-16.2, Diverse Prokaryotes Populate the Biosphere
-16.4, Some Prokaryotes Cause Disease
-16.5, Viruses infect cells by Inserting Genes

Read article and answer questions about Typhoid Mary

CASE STUDY

This will be the third year I have given my students a case study to solve. There is nothing I do that engages the entire class more. At the end of the year the students will tell you that it is the case study the enjoyed the most.

The case study involves giving the students a set of symptoms and having them come up with a diagnosis. The more personalized the case study, the better. I have used a scenario with J.F.K. and Addison's disease. I have also used Edgar Allen Poe with a set of symptoms that suggest he actually died from rabies. I followed this one up by having the students watch Fall of The House of Usher to determine what disease the Rodericks had.

The students will be given a couple of weeks to complete their case study. In the mean time I will be covering different material, probably something in the realm of genetics or an overview of organ systems and homeostasis. I will be collecting some where around 60 case studies to grade, typically 2-3 pages long, so it will likely be a couple of weeks before I hand them back.

During the two weeks that the students are working on their case study, we will have discussions about questions they have and problems they have encountered such as vocabulary they don't understand.

Day 2:

When I hand back the work students will find out that the person had Lyme disease. We will then have a discussion about the particulars of Lyme disease.

<u>PowerPoint/Lecture:</u> The parts of the immune system, non specific defenses, and an overview of innate and adaptive immunity
<u>Assigned Readings</u>:

-30.1, The Circulatory System transports materials throughout the body
-31.1, Infectious Diseases are caused by pathogens
-31.2, The Human Body has three lines of defense against infections
-31.3, The Immune system recognizes specific invaders

Give students vocabulary

Day 3:

ELISA lab: The students will perform a standard test for the presence of antibodies. I will revisit our Lyme scenario here and have the test be for the presence of antibodies to Borrelia burgdorferi (the bacterium that causes Lyme disease) in the serum of Allen.

This lab can be done with material from Bio Rad, or by simply using water, NaOH, and phenolphthalein. See the lab in the appendix for details.

Day 4:

PowerPoint/Lecture: Here I will discuss Vaccines, auto immunity, and use Borrelia burgdorferi and HIV as a specific example of an infection.

Assigned Readings:
-31.4, Vaccines stimulate the immune response
-31.5, Disorders of the immune system are major health problems.

Day 5 - 9

Interactive Models: Groups of 4 students will design and build a functional model that simulates either Humoral or Cell Mediated Immunity. Each group will explain their pathway to the class and demonstrate how their model works for the entire class.

The basic premise of the model is the old Mouse Trap game or a Rube Goldberg design whereby one action triggers a second action which triggers a third action, etc., until--in this case--a final outcome has been achieved. Each trigger will represent an actual chemical or cell and each action will represent an actual physiological response.

Day 10

Tie up loose ends and give vocabulary quiz

Day 11

Review for test

Day 12

Unit test

Case Study

Allen is a lawyer who lives in Southern New Hampshire. He has three children, the youngest being 25 years old. He typically works 50 hours a week. In his spare time he likes to go sailing. His house is located in the country on a 100 acre estate. His daily routine includes going for a walk with his dog before and after work. Allen is also an avid birder and usually brings his binoculars with him. They typically walk through the woods and fields of his property.

As a child Allen grew up in the suburbs of Boston in an area where there were a lot of factories and textile mills. Allen had always been healthy but one of his two siblings had developed cancer. The other was chronically ill and the doctors had never been able to come up with a specific diagnosis.

In late August of 2004 Allen began to feel run down. It occurred to him that he had been having more headaches than usual. He didn't go to work for two days due to a fever and general malaise. He felt better for a few days and then missed another two days of work with a low grade fever and occasional sweats or chills.

People at work were concerned about his health. They noticed that he didn't have the same energy levels they were used to seeing. They also noticed that he was more forgetful and had a hard time concentrating on important issues.
Allen stopped walking because his knees were bothering him and he often felt weak. He became depressed and stayed in bed more and more. Finally his wife convinced him to go to a doctor.

You are the doctor. What do you think is wrong with Allen?

Case Study
Instructions and Grading

Step 1

Read the case study a few times. Circle the symptoms and any relevant information. List this information on a separate piece of paper.

Step 2

Use books from the library and on-line resources to find a disease that fits some of these symptoms. You won't necessarily get a perfect match. You will most likely have to research quite a few diseases before you come up with one that fits.

It is very important that you keep track of all your resources and every disease you consider.

Step 3

Discuss the process you went through. Tell me how you decided what disease this person has. Be thorough. For every disease that you considered but ruled out, tell me why you ruled it out.

Step 4

Tell me what disease you think this person has and defend your hypothesis. Discuss all of the symptoms in the case study and most, if not all, of the symptoms you found in your research. Discuss the common symptoms and the ones that don't fit. In other words, don't try to make your hypothesis sound better than it is. If there are a few symptoms this person has that are not mentioned in the disease description, or a couple of symptoms people with this disease should have that he doesn't have, be sure to tell me about them.

<u>Examples of the way you will make defending statements:</u>

This man died of a broken heart because (name your resource) indicates that fluctuating pulse is a symptom of heartbreak and this man had a fluctuating pulse.

According to (name of your resource) people suffering from Delusions of Grandeur usually have a Persian cat. This person does not have a Persian cat; therefore I don't think he is suffering from delusions of grandeur.

REMEMBER

I have purposely included some information that is NOT relevant. It is your job to sift through all of the information and decide which you need and which you should discard.

This will simulate a real situation, because as a doctor, you always have more information than you need.

*A wrong diagnosis with a good defense is worth a lot more than a correct diagnosis with a poor defense. I am most interested in good documentation of your thought process.

*I will answer one question for each person so use your question carefully.

*Your work must be typed, double spaced, with a 12 font or it will not be accepted.

GRADING

Minimum of 4 resources, at least one that is not on-line = **4 points.**

You MUST include a copy of all of your resources.

Discuss all symptoms/relevant information from the case study and the *important* symptoms/relevant information from your resources = **4 points**

Discussion of the process of elimination = **10 points**
Correct hypothesis = **2 points**

Defense of your hypothesis = **10 points**

TOTAL POINTS = 30

Interactive Models of the Adaptive Immune System

Your job is to create an interactive model of the immune system that simulates one of the following two immune system pathways. You will use any material you want to represent parts of the immune system. If you need something you do not have, ask me, I may be able to help. You will work in groups of 4.

Your model will represent a schematic of either Humoral Immunity or Cell Mediated immunity. The items in boxes are cells or cell products and will be represented by objects. The items on the arrows are processes and will be represented by actions or interactions. For example, in the Cell Mediated scenario, a structure representing an Antigen Presenting Cell (APC) will come in contact with a structure representing a T-Helper Cell which will release something representing cytokines. The cytokines will travel to a structure representing a Cytotoxic T-Cell. The Cytotoxic T-Cell will then come in contact with an Infected Host Cell. This contact will simulate the killing of the host cell as much as possible. A structure representing a Macrophage will then make contact with the Infected Host Cell, representing phagocytosis. The Cytotoxic T-Cell also releases something that represents interferon which can block viral replication.

The structures and interactions should be as realistic as possible. The entire process should be as autonomous as possible. In other words, the less students interact with the model, the better.

This project is purposely open ended to encourage and inspire creativity. Your grade will reflect how creatively you solve the problem.

Expectations and Grading:

- Everyone in the group will receive the same grade unless there are extenuating circumstances.

Each group will:

1.) Create an interactive model of Humoral or Cell Mediated Immunity. Each person in the group will be able to name each structure and process in the real scenario, and explain the significance of this process for maintaining homeostasis.(**5points**)

2.) Draw a sketch of your model that labels every structure and process by the name of the real structure or process. **(5 points**)

3.) Write a summary of how your model works and the biological significance of your model. **(5 points**)

Grading the performance of the model:

*Each group will demonstrate how their model works to the class. You will be given adequate time to build your model and make sure everything works.

1.) All of the structures and processes are represented **(4 points)**

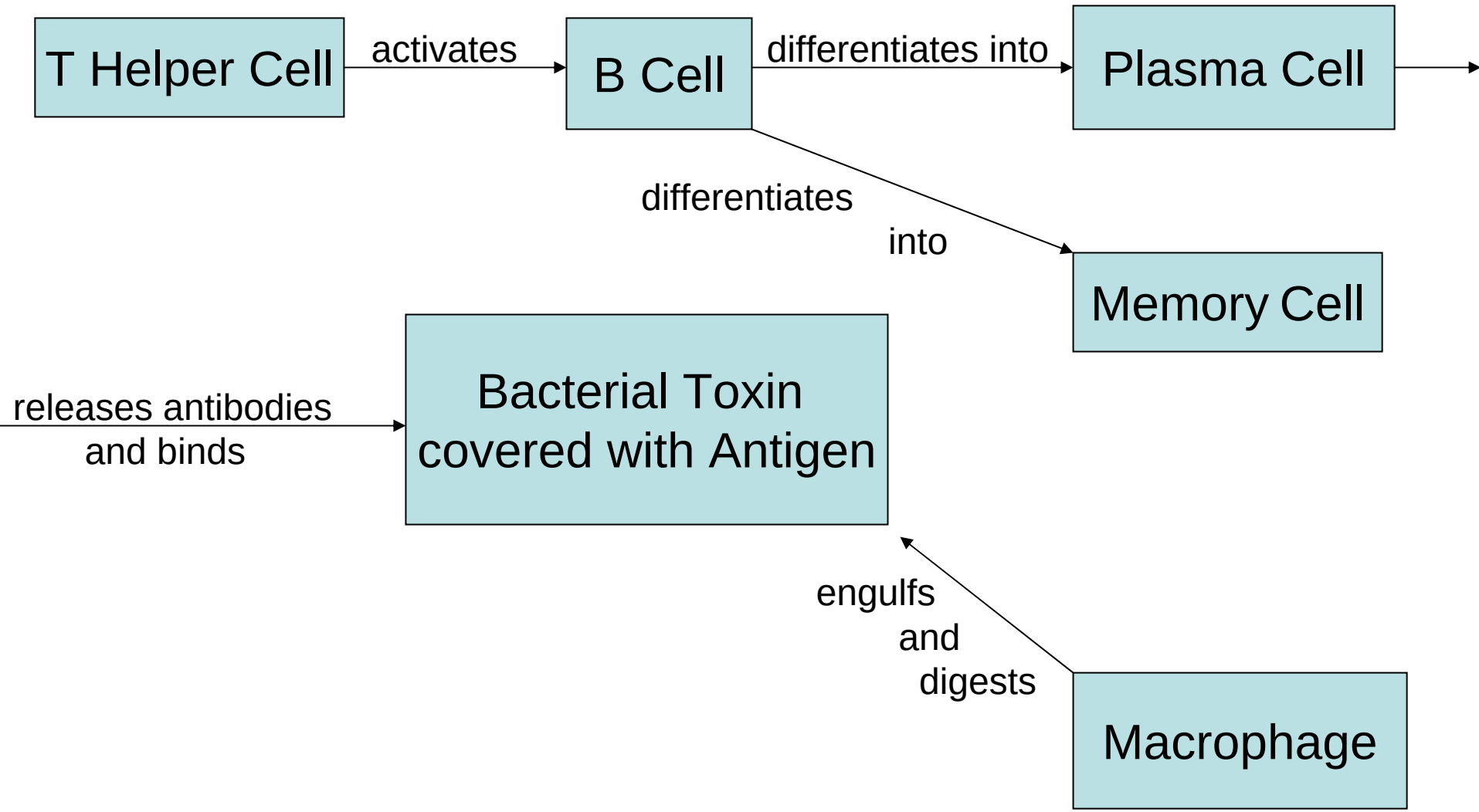
2.) Everything works **(4 points)**

3.) Creativity in design and process **(4points)**

4.) Students only interacted with the model to creatively trigger the start (**3 points)**

Total points = 30

Humoral Immunity



Cell Mediated Immunity