Immunology: Behind the Scenes

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Summer 2021

Immunology: Behind the Scenes Unit Plan Table of Contents

Background Information: Immunology (the study of the immune system) is complex, fascinating, and rapidly changing. Scientists have been making great strides over the past several decades to understand the role of the immune system in preventing and sometimes causing disease. Importantly there have been great strides to harness the power of the immune system to treat or prevent disease. Technology has been advancing at an incredible rate which is allowing us to better understand how the immune system works. During this Covid-19 pandemic, technological advances have allowed scientists to rapidly respond to the many challenges during this global health crisis. Understanding immunology at the high school level is very valuable as much misinformation exists in our world right now around science. It is very challenging for people to understand behind the scenes how scientists detect disease with different types of assays or diagnostics. In my experience, many high school students are interested in medicine or biology and it is very difficult with resources, funding, and our training to be able to provide students with skills and knowledge that would give them a taste of what it would be like if they were to pursue the sciences. The goal of this unit is to help bridge the gap and not only teach fundamentals of our immune system functions, but also what is used to detect diseases and how the laboratory can detect the presence of pathogens. Many academically confident students will pursue some aspect of medicine, but I have seen many students without as much confidence that are interested but discouraged by the challenge. In this unit plan, I work to show a variety of different career paths with varying levels of education so students are more aware of the variety of options. Diversity is a topic that is very important and I've worked to include aspects and introductions of scientists that are of different racial backgrounds, as well as gender. Within many of the science fields, white males are still the most dominant type of individual to work in many biotechnology industries. Having role models or someone with a similar background can be motivating for students. At this point, I am an advocate for increasing the overall science knowledge of the general population as well as supporting and encouraging more students to be involved in the sciences.

Student Outcomes:

1. Basic understanding of mechanisms of the immune system
2. Understanding of how our immune system responds to different threats
3. Increased awareness of careers related to immunology
4. Basic understanding of different techniques used in laboratory diagnostics
    a. ELISA
    b. Gel Electrophoresis
    c. Blood Testing
    d. Flow Cytometry
5. An understanding of how vaccines are made and how they stimulate protective immunity
6. A better understanding of common challenges in immunology such as antibiotic resistance and HIV.
7. A basic understanding of cancer, autoimmunity, and allergies

Next Generation Standards:

1. HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
2. HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
    a. Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)
3. HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations
4. HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Recommended Course Placement:

Upper level human anatomy and physiology or AP/IB Biology

Student Activities:

a. Disease Spread
b. Underdog Scientist Assignment
c. Climate Change and Disease Spread
d. Blood Typing Lab
e. Gel Electrophoresis Lab
f. Antibiotics and antibiotic resistance
g. Viruses
h. Development of Vaccines
i. ELISA’s and Flow Cytometry Basics
j. Stages of Cancer
k. Animal Testing in Science
l. Autoimmunity Unit Project
m. Careers in biomedical sciences and immunology

Time Commitment:

Approximately 13 days of 60-80 minute lessons

Advanced Requirements:

Previous biology course and recommended chemistry

Advanced Preparations:

Copies of uploaded documents to online platform

Purchasing supplies prior to unit

Materials and Equipment:

Gel Electrophoresis Kit with dyes (pipettes, tips, chamber, centrifuge, voltage adapter, stains, agarose gels, combs) Amgen or Thermo Scientific are recommended

Blood Typing Lab Simulation Dyes

Glo-Germ

Phenolphthalein

Demo EPI Pen

Summative Assessments:

Act out the Immune System

Autoimmunity Project

Antibiotic Resistance

New Therapies in Cancer Treatment Project

Autoimmunity Project

Unit: Immunology: Behind the Scenes

Research Project: Using *Lactobacillus acidophilus* as a vector to create IgA and IgG as well as T cell immunity in lung tissue using E.Coli adjuvants, FliC and Ovalbumin peptide 323-339.

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Curriculum Outline

Lesson	Content Delivered	Current Event/History/Engagement	Lab- WIll provide instructions and supplies	Virtual Lab- Will provide video/or lesson details	Application/Relevant Exploration	Assessed
1	Video: Intro to Disease Spread and Innate Cells Big Overview of Immune System	History of 6' Social Distancing How environment impacts disease Retro Report: How Environment Impacts Disease Retroreport	Glo-Germ Demo (6+ feet spread) and Disease Spread with Phenylalanine	NA	Idea of Ro and comparison with different diseases (i.e. Measles vs influenza) OR Impact of Climate Change on Disease Spread (i.e. Mosquito-borne viruses)	Class Activity: Who started the outbreak with phenylalanine Assign Underdog Scientist Award Assignment I think this could be a good way for the kids to learn about diverse scientists and even find examples with a similar background Stagger Due Dates through the unit
2	Video: T Cell Immunity Helper T Cells	Ted Talk: HIV Treatments		Flow Cell Cytometry	Summarize how Flow Cytometry works in your own words and diagrams	Other factors that impact the immune system assignment
3	Video: B Cell Immunity with Antibody Focus B Cells	Passive Immunization with Antibodies	Blood Typing Lab			Blood Typing Simulation and Punnet Squares (apply agglutination)- Forensics Related
4	Big Group Activity: Act out the immune system					
5	Video: Mutations and Genetics of Disease/Cancer Cancer	Genetically modifying your body to cure diseases Fixing the Genetic Code for Diseases	Gel Electrophoresis Lab	Muscular Dystrophy Documentary (Exon Skipping Application) Gel Electrophoresis Online Option		Sequencing the Human Genome Retroreport
6	Video: Cancer Oncogenes Video Oncogene Video	Car T Therapy Penn State Video: Penn State Car T Therapy			Stages of Cancer	Assignment: New treatments in cancer therapy
7	Video: Viruses Video on Viruses: Viruses	First women to discover Covid Link: First Woman to Discover Covid Covid Retroreport and Lesson			ELISA Video	

	Covid Video: Biology of Covid					
8	Lecture: Intro and application to Worms and Large Bacteria immune responses Streptococcus Pnemoniae Video	Discovery of Penicillin Penicillin Discovery Ted Talk			Antibiotics and Antibiotic Resistance	
9	Lecture: Intro and application to Allergy Immune Responses Allergies Video	Sun Allergy/Allergy Treatments: Building Tolerance Read: Sun Allergy		How to use an EPI pen/support others in shock and other basic emergency treatments (Practice IUD/CPR)		Practical in Partners: Demo epi pen and act out scenarios in emergency situation
10	Intro to Vaccines/Expectations for Respect at all times	History of Vaccines Retroreport video: Retroreport Video		Research: Animal Testing and How to Study Viruses in lab	Frontline Outbreak: Ebola Documentary Maybe not during a pandemic	Interpretation of Covid Vaccines using NY Times Research
11	Read and Discuss as a class: Developmental Immunology- How and why it changes over time	Breast Feeding and Immunity Video				Vaccine Assignment
12	Video: Autoimmunity					**Autoimmune Disease Project**
13	Careers in Healthcare that fits your interests of career test	Biomedical Engineering John Hopkins Video: John Hopkins Biomedical Engineering				Career Test: What career fits you best Resources Biotech Roles without an advanced degree Learning about more specific biotechnology careers and educational requirements Added this resource as I think it can be helpful in learning more about a variety of biotech type careers Final discussion and reflection on unit

Lesson 1 Materials and Documents

Glow Germ and Outbreak Activity

Materials: Glow Germ Powder and or lotion and UV lights (4-6 small ones are ideal)

Manual:

Instructions:

1. WIth powder, have students cough or sneeze with a small amount of glow germ powder in hand
    a. Have UV lights on, and all others off and observe the distance of the spread
2. If using the lotion, wash hands completely, apply lotion, and then use UV lights to observe the amount of bacteria still present
    a. Discuss the idea of commensal bacteria as well
    b. Optional video: Ted Talk: Microbiome and Bacteria

Determine the Root of the Outbreak

Materials:
NaOH (any safe molarity)
Water
Cups
Phenylalanine

Instructions:

1. Label the cups with numbers, one for each student.
2. Put water in all cups except 1 and make note of that student/cup number
3. Ask students to exchange fluid by pouring in and out of the cup into another three time with three different partners
4. After complete, come to the instructor to receive 2-3 drops of phenylalanine
5. If the liquid turns pink, that simulates that person is infected
6. Have the class figure out who was the root of the outbreak by collaborating and figuring out who was infected and who wasn't

Idea of Ro or Climate Change Application OR
Disease Spread Measurement Assignment

Chose one of the following two topics to research

A. Ro Values

Illnesses are often measured as how contagious they are by a value called R0, which is the average number that someone would infect. It varies based on illness and variant. Using the chart below, please find four different illnesses, the Ro, and how many would be infected after 5 passages of infection.

Infection	R0	1 person infected	1st passage (assume infect R0 value)	2nd passage (assume infect R0 value)	3rd passage (assume infect R0 value)	4th passage (assume infect R0 value)

Describe the differences in how many people are infected at the end, and research and cite in APA why that is the case (i.e. maybe the virus is able to enter the cells easier)

OR

B. Impact of Climate Change on Disease Spread

Diseases transmitted by mosquitoes are not new, but the cases are increasing in different areas of the world due to climate change. Write 2-3 paragraphs researching 1st paragraph: how the mosquito transmits the disease, 2nd paragraph- what happens physiological to the person infected, 3rd paragraph, how climate change is changing transmission rate or areas where it is transmitted.

Underdog Scientist Award

As in many aspects of life, prejudice has existed and occurred to many within the biological sciences. Some scientists made discoveries, but were credited to others, some women or people with different levels of income or different ethnicities were not given chances. The diversity has improved over the years, but in Biotech, the majority of those in those roles are white males.

Assignment
Choose a scientist that made a great contribution to science that was an underdog or someone who wasn't credited or believed for an accurate discovery that you think deserves more recognition. Present this contribution, including the history and challenges this person faced and what they had to overcome in order to get recognized, or discuss a scientist that was never properly recognized for the contributions in any science within immunology or biotechnology.

Sign up in advance so scientists are not repeated.

Example Scientist: Lise Meitner

Lesson 2 Materials and Documents

Factors that Influence the Immune System

Make a google document or presentation for this assignment, you must have at least four visuals, a reference page, and you will need to be able to address ONE of the topics below with all bullets included. If there is another topic of interest, feel free to ask if it would be an appropriate topic.

Genetics

- How and why do genetics influence our immune system?
- List five very common disorders that you are not born with that are likely to be carried and expressed within a family.
- Give two examples of genes that cause a disorder and how that occurs.
- Give two examples of genes that make a disorder/illness more likely and how it is often triggered.

Nutrition

- How does nutrition influence our immune system?
    - List at least 8 things that benefit our immune system and how
    - List three nutritional aspects that can be a detriment to our immune system
- Give a case study of how someone was exposed to an illness (can be anything) and what helped them nutritionally.
- Describe how staying hydrated supports the immune system

Exercise

- How does exercise positively impact the immune system?
    - Be detailed about what happens with the lymph fluid during exercise
- Discuss how three different types of exercise impact our immune system differently (there may be some similarities)
- Describe how too much exercise can be detrimental to the immune system
- What types of immune cells are more or less common

Stress- physical or emotional- pick one

- How does stress impact your immune system?
- Describe at least five hormones or neurotransmitters that are related to the immune response
- What immune cells are most effected by these changes in hormones, and why does that occur?

Sleep

- How does sleep impact your immune system?

- Describe at least five hormones or neurotransmitters that are related to the immune response
- How do they test this in a laboratory setting? What is measured and give an example of the controls.

Aging and the Immune System

- Discuss what impacts the immune system in development.
- If you were a doctor giving recommendations as to continuing to care for a healthy infant, what advise would you provide the parents?
- Over time, what changes about our immune system to make it less active?
- What are some conditions or struggles with the immune system that elderly individuals often struggle with later in life and why does it occur? Give at least three examples.

Lesson 3 Materials and Documents

Blood Typing Lab - A Lesson in Mendelian Genetics **Name:**

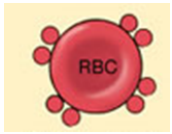
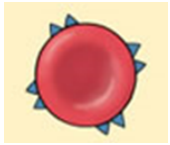
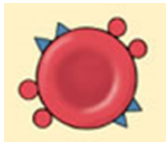
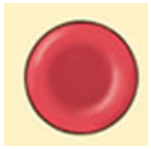
Background Notes:

- **ANTIGENS –**
- **ANTIBODIES –**
- **1900 – Karl Landsteiner**
- **1901 –**

There are 3 alleles, or genes, for blood type:

Since we inherit 2 genes for blood type, one from each parent, there are 6 possible combinations.

- **A and B are dominant**
- **O is recessive**
- **Type A can be AA, AO**
- **Type B can be BB, BO**
- **Type AB has a genotype of AB**
- **Type O has a genotype of OO**

Blood Type	Cell Diagram	Antigens (Surface Proteins) present on the RBC	Antibodies a person with this type would produce	Can Receive from:	Can Donate to:
A					
B					
AB					
O					

•While studying Rhesus monkeys, a certain blood protein was discovered. This protein is also present in the blood of some people.

•The presence of the protein, or lack of it, is referred to as the Rh (for **Rhesus**) factor.

•If your blood does contain the protein, your blood is said to be Rh **positive** (Rh+). If your blood does not contain the protein, your blood is said to be Rh **negative** (Rh-).

•Rh + can receive + or -

•Rh - can only receive -

Whose Blood is it Anyway? A Blood Typing Lab

Part A - Answer the following questions based on the results from the lab:

Blood Type	Anti-A Antibodies Results	Anti-B Antibodies Results	Anti-Rh Antibody Results
A+			
A-			
B+			
B-			
AB+			
AB-			
O+			
O-			

Sample	Anti-A Result	Anti-B Result	Anti-Rh Result	Blood Type	% of population (SYW!
Suspect 1: Lyle Mondelo					
Suspect 2: JW Gretsky					
Suspect 3: Larry Gretsky					
Suspect 4: Mitch Wilson					
Crime Scene					

Victim					

1. What blood type was found at the crime scene? Explain how you came to this conclusion.

2. Does the blood type from the crime scene match any of the suspects or the victim? Explain how you came to this conclusion.

3. Using the percentages below, calculate the percentages of individuals that could be considered suspects for each suspect evaluated above. *Show your work in the space provided!*

Type	% of Population	Type	% of Population
A	**42**	**Rh+**	**85**
B	**12**	**Rh-**	**15**
AB	**3**		
O	**43**		

A+: 0.42 x 0.85=

Part B - Define the following important terms:

1. **Antigen –**
2. **Antibody –**
3. **Agglutination –**

Part C - Answer the following using a different font color:

Question:	Response

1. A person with AB blood will... **a. have the possible genotype: AB**	
b. have these surface proteins on their RBC:	
c. produce these antibodies against blood surface proteins:	
d. be able to donate blood to all of the following blood groups:	
e. be able to receive blood from all of the following blood groups:	
2. A person with type O blood will… **a. have the following possible gene combination(s):**	
b. have these surface proteins on their RBC:	
c. produce these antibodies against blood surface proteins:	
d. will be able to donate blood to all of the following blood groups:	
e. is able to receive blood from all of the following blood groups:	
3. A person with type A blood could have the following gene combinations for blood type:	
4. A person with type B blood could have the following gene combinations for blood type:	

5. Identify which antigens (surface proteins) are present in:

Type O-	Type AB+	Type B-	Type A+

6. Identify which antibodies each of the following would produce:

Type O-	Type AB+	Type B-	Type A+

Part D

A woman has contacted an attorney claiming that a certain man is the father of her child. The mother of the child has type A blood and this woman's own father is type O. The baby is type AB. The man provides a sample of his blood, which agglutinates with Antiserum B but not Antiserum A. On the Punnett Square provided, show and explain whether it is possible for him to be the father of this child. Include a statement to support your square.

Mom: Type A:
Grandpa: Type O:
Baby:
Man: Type B:

Lesson 4 Materials and Documents

Act out the Immune System

In groups that you find appropriate, have students make a 3-5 minute skit as to how the immune system responds making sure you have the following addressed:

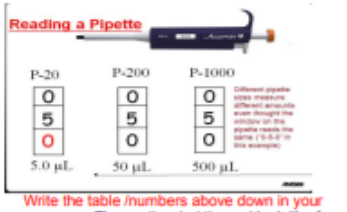
- Pathogen
- Natural Killer Cells
- Macrophages
- B Cells
- T Cells
- Antibodies
- Suppressor T Cells

Lesson 5 Materials and Documents

This is linked in a google presentation, but each image below is a new slide

Purpose/Goals:

- Be able to safely use DNA Tech equipment such as:
  - Micro-centrifuge
  - Micro-pippeter
  - Gel Electrophoresis box
- Explain how DNA gets separate during Electrophoresis.



Write the table /numbers above down in your warm up. Then write what it wood look like for:
1) 6.5 on a P-20 2) 165.5 on a P-200
3) For a P- 1000, 350.

Micropipette Volume Ranges

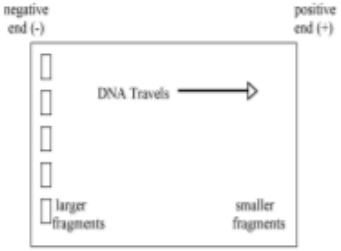
Micropipette	Minimum Volume (µl)	Maximum Volume (µl)
P2	0.2	2
P20	2	20
P200	20	200
P1000	100	1000

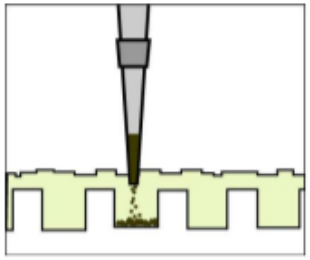
Using a Pipette

- How to make the gel plates:
- Measure 0.5 g of agarose powder
- Mix with 50 ml of buffer solution in a beaker
- Heat in microwave until the powder is dissolved swirling every 30 seconds using the liquid reaches a temperature of 65 degrees.
- Wait until the gel cools enough so it is not too hot to touch
- Place masking tape around the sides of the gel plate to ensure that the gel doesn't overflow.
- Place the comb in the middle slot in the gel plate
- Carefully pour the gel in the gel bed and let it sit until it solidifies into a gel

Agarose

Running A Gel





Video Link:

Muscular Dystrophy

Watch this documentary:

Muscular Dystrophy Video: This video shows a rare and fairly unknown disorder that is very devastating that is driven from a genetic disorder.

Duchenne with a Future: The Power to Live

59 minutes

Write a 2-3 paragraph summary about what the video showed on muscular dystrophy, the consequences on health, and any other vital information.

Are You Innocent? Name_____
Date_____Per_____

Go to http://learn.genetics.utah.edu/content/labs/gel/

Follow the simulation and answer the following questions as you go…

1. **The small tube contains _____.**
2. **How can the strands be sorted and measured?_____ _____**
3. **Besides DNA, what other molecules can be sorted by this method?_____**
4. **What common things do they compare the gel to?_____**
5. **DNA is placed in _____ at one end of the _____.**
6. **DNA is pushed through the gel filter by adding an _____ _____**
7. **Shorter strands will move more _____ and will end up _____ _____ from the starting point.**
8. **Strands of the same length will move at the _____ _____ and will end up _____.**
9. **_____ the strands makes them visible.**
10. **The groups of stained strands show up as _____.**

RUN THE GEL!

11. **You first make the _____.**
12. **The agarose used for the gel is made from _____.**
13. **Buffer is a _____ _____ solution that allows _____ _____ to flow.**
14. **The salt water/agarose mixture must be heated until the agarose _____.**
15. **A special _____ is placed in the liquefied gel; when the gel solidifies, there will be _____ _____.**

16. These holes are for the _____ _____.

17. The gel is then placed in an electrophoresis _____ and the gel is submerged in more _____.

18. So they DNA samples can be seen, the loading buffer contains a _____. The DNA sample is _____ so it drops in the well instead of floating away.

19. What does the micropipetter do?_____

20. What is the function of the DNA standard?_____

_____

21. DNA has a _____ charge.

22. The black end generates a _____, the red generates a _____ charge.

23. _____ are proof an electrical current is produced.

24. DNA is _____ by the negative charge in the box. The strands move based on _____.

25. Ethidium bromide is used as a _____ so the DNA can be seen under _____ _____.

26. Individual strands cannot be seen but _____ can be seen as _____.

27. Record the lengths of the DNA base pairs:

    Top _____ bp

    Middle _____ bp

    Bottom _____bp

28. These values are not exact, they are _____.

Look below the Gel Electrophoresis animation and click on "Can DNA Demand a Verdict". Find "Forensic DNA Analysis" on the right and briefly describe the steps used at a crime scene.

1.

2.

3.

4.

5.

6.

7.

8.

9. **Looking at the gel provided,**

Who is implicated by the DNA results?_____

Why is the victim's DNA included?_____

Why is the officer's DNA included?_____

Cancer Article Research

Individually, please read 1 article that is reliable on a topic of your choice of an issue that involves treatment of an issue within cancer that is being used or evaluated as a potential use within the last three years. After reading, write two to three paragraph summary (at least four sentences each) on the article. Make sure to cite your source in APA.

Recommended sources (if you need ideas):

Science Daily

New York Times (has some good, applied science)

Lesson 8 Materials and Documents

Antibiotic Resistance Assignment

Antibiotic resistance is increasing due to many factors. Describe the following:

- The two different categories of antibiotics and how they work. Feel free to use images to support your explanation.
- Find a statistic showing the use of one type of antibiotic in a year
- What are antibiotics used to treat?
- Describe how microbes are being resistant to antibiotics.
- What should scientists do to help limit this problem from getting worse?

Lesson 10 Materials and Documents

Research: Animal Testing to Study Viruses in the Lab

Animals are used to advance studies in medicine. Regardless of your views on this topic, please find an example of how animals (rats, mice, cats, dogs, or hamsters) have been used to advance the knowledge of a treatment.

Include the following:

1. What was the treatment?
2. How was the study performed and what were the subjects?
3. What were the results?
4. How did this progress to human trials?
5. What is one surprising thing you learned from your research?

Cite your references in APA format.

Week 11 Materials and Documents

Vaccine Assignment

Research three different types of vaccines and how they work.

- Include the disease it targets
- How it works
- The efficacy
- The percent of the population that receives it
- When it is administered
- If boosters are needed

Covid Vaccine Assignment

Read one of the articles from the New York Times and describe how the vaccine works to provide immunity in 1-2 paragraphs. In your answer, you should discuss antigen, antibody, virus, spike protein, mRNA, replication. Be prepared to discuss in small groups and to the class.

Pfizer: https://www.nytimes.com/interactive/2020/health/pfizer-biontech-covid-19-vaccine.html

Johnson and Johnson: https://www.nytimes.com/interactive/2020/health/johnson-johnson-covid-19-vaccine.html

Moderna: https://www.nytimes.com/interactive/2020/health/moderna-covid-19-vaccine.html

Day 12 Materials and Documents

Autoimmune Disorder Project

Select an issue/disorder/ or disease of the immune system.

Please include the following:

- Name of the disease/condition with a brief description - 4
- How does an individual get it?- 4
- What are the demographics of this disorder? (Give percentages as well as significant breakdown of ages/gender, etc. if applicable)- 2
- List the symptoms- 4
- How is it diagnosed? Be specific- and include images of what could be seen (such as the visuals I've used or Sherlyn showed with endoscopy, colonoscopy pictures, or any other imaging necessary.- 4
- Treatments- 6
    - Current options
    - Describe any new research for treatments if applicable
    - Include recommended diet recommendations
- Describe all the systems and how they are affected.
- Give a story of someone's case with this disorder- 4
- Cite sources in APA format (at least 2)- 2
- Must have at least 4 visuals- 4
- Presentation is thorough and organized- 4
  Total /42/2= /21 each
- Presentation is thorough and organized- 4
  Total /42/2= /21 each

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