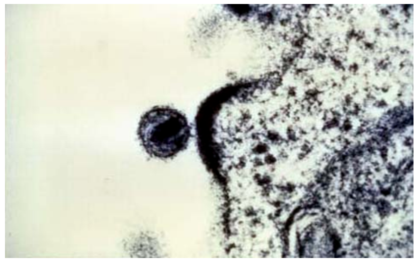
Lesson Plan for Infectious Diseases and Vaccination (5E Model)



Teacher: David Lagacé

Date: July 20, 2016

Subject/Level: Science and Technology/Secondary 3 (Grade 9)

Materials:
Computer
Projector and Smart Board
Internet access (for YouTube)
Cell sheets + questions, Appendix 1
Pathogen sheets + answers, Appendix 2
Activity 1 Questionnaire, Appendix 3
Activity 2 Questionnaire, Appendix 4
Activity 1 Answer Sheet, Appendix 5
Activity 2 Answer Sheet, Appendix 6
16 iPads

Learning Goals (ministère de l'éducation du Québec):

Diversity of Life, Living Systems, Respiratory and Circulatory Systems:

1) lymphatic system (circulation of antibodies)
2) Describe two ways in which to acquire active immunity (antibody production and vaccination)

Objective(s) of this lesson:

Students must have previously been introduced to antibody production by white blood cells. Essentially, when certain white blood cells ingest a foreign body (e.g. viruses) through phagocytosis, they will produce antibodies which recognize antigens found on the foreign body. These antibodies can then help neutralize the invader. The immune response by antibodies is called specific immunity (also adaptive or acquired immunity), as the antibodies produced are very specific to a particular antigen. In addition, students should have already addressed the concepts of inactivated and attenuated live vaccines (see Background Information, below).

Since the science program and technology in Secondary 3 does not mention anything about types of infectious diseases, viral entry into a cell, or the operating principle of a vaccine, the purpose of this lesson is to build upon prior knowledge (activity # 1) and deepen student understanding (activities # 1 and 2) of:

1) Infectious diseases (bacteria, viruses and parasites)
2) How a virus enters a cell
3) The function of vaccines

Background Information for the Instructor: The Immune System

This activity makes connections to the lymphatic system and the immune response (white blood cells). It aims to strengthen the concepts of antigen and antibody, by clarifying that antigens are components of bacteria and viruses recognized by the immune system. Also, this lesson makes a connection to antibodies and products of the immune system, deepening student understanding of how vaccines work (how an immune response is obtained) and what causes the immune response. Students should already have discussed the principles that lead to active immunity through the white blood cells.

Background Information for the Instructor: How Vaccines Are Made

The first step in producing a vaccine is cell culture of the pathogen (cells are used in order for the viruses to reproduce in large quantities). Next, the cells are chemically treated to render the pathogen harmless. There are two major types of vaccines: Live attenuated vaccines and inactivated vaccines.

Live attenuated vaccines *(Note: We say "living" here, but it is necessary to emphasize that viruses aren't technically living organisms because they require a cell to replicate. This is a frequent misconception in biology.)*: Cultures of the pathogen are treated with a chemical compound, which prevents them from causing disease. Next, these cultures are mixed with preservatives. The virus is still "living," but it has lost its ability to cause disease. There is also a second method of making this type of vaccine which makes use of genetic modification to render the pathogen harmless.

Inactivated vaccines: Inactivated vaccines are created by using only the parts of the pathogen (antigens) that are recognized by antibodies. The first step is to identify the antigens that are recognized by the antibodies and then treat them chemically. As for live attenuated vaccines, the antigens are mixed with chemical preservatives.

Vaccines are important for many reasons. They protect us against many serious diseases, help provide herd immunity to individuals who can't be immunized, reduce infant mortality and extend life expectancy, and have allowed certain diseases to be eliminated.

However, there are some issues associated with vaccine use. Some vaccines can cause side effects, and the potential exists for viruses to mutate and become resistant to a vaccine. In rare cases, a weakened virus may mutate to become virulent again.

Strategies for Differentiated Instruction:

- Group discussion with active questioning from the teacher
- Visual video support
- Dynamic pair activities
- Questionnaire

INTRODUCTION (*ENGAGEMENT*) (15 minutes)

- Students watch a TED Talk video describing how a virus infects a cell in order to multiply. (http://www.geek.com/science/animation-perfectly-explains-how-your-body-fights-a-virus-1591668/). For French-language students, French subtitles can be activated.

- The teacher begins a discussion with the students and poses the following questions:
  1- What is a disease? What are some examples of diseases? Students will name diseases that they are familiar with (e.g. chicken pox, AIDS, the flu, etc.). The teacher writes the student responses on the board. Assist the students by reminding them of other diseases such as polio, malaria, measles, or diphtheria.

     Indicate to the students that these diseases are all infectious.

     Ask the students: What causes these diseases? Students should note that chicken pox, AIDS, the flu, polio, and measles are caused by viruses, malaria by a parasite, and diphtheria by bacteria. Answers will vary by student group.

  2- If students name other diseases which are not infectious, the teacher writes the name of the disease on the board but specifies that it is not infectious (e.g. atherosclerosis, Parkinson's, hemophilia)

  3- As a final question, the teacher asks: How does a vaccine protect against an infectious disease?

EXPLORATION

Activity 1 (15 minutes):

How is a virus able to enter a cell? Can all viruses enter into any cell?

- Create eight stations within the classroom, each with one of the Cell Sheets (the top image is a scientific diagram or an image of a cell, while the bottom image is a stylized drawing, Appendix 1). Give a Pathogen Sheet (the top image is of a disease-causing microorganism, while the bottom image is a stylized drawing, Appendix 2) to each team of two students. Each Cell Sheet contains two questions and each Pathogen Sheet contains two responses. Each cell represents a specific host for one virus in particular.

- The activity begins when the students, with their Pathogen Sheets, search the stations looking for a cell to infect. At each station, students will read their two questions and verify that the two responses on their Pathogen Sheets correspond to the two questions on the Cell Sheets. If so, the students have found the pathogen infecting that cell. If not, students should still try to answer the questions posed. These questions will review the lymphatic system (mainly white blood cells, phagocytosis, antibodies, antigens, and types of vaccines; this knowledge will have been acquired in previous lessons). Students will write their responses on their Response Sheet (Appendix 3). To validate their answers, students can check to see if the antigen on the pathogen surface (the shapes on the stylized drawing) matches the complementary cellular receptor on the surface of the cell. Students should visit each station.

- Students must keep in mind the concept of specificity.

Activity 2 (20 minutes):

The teacher then invites the students, still in groups of two, to watch a short video about vaccination on their iPads. The students must then fill in the video question sheet (Appendix 4) distributed by the teacher.

https://www.youtube.com/watch?v=Pt5ZMeGnp6I

EXPLANATION

Activity 1 (15 minutes) :

- When students have finished visiting all eight stations, they will return to their seats. The teacher projects the blank response sheet onto the Smart Board and asks students to fill in their answers. Students will confirm which pathogen infects which cell and also give the names of the diseases caused by these pathogens (see answer key, Appendix 5). It is necessary to check and correct student responses. The teacher should emphasize that each pathogen has a different structure and mode of action.

- The teacher can ask the students: Why does a virus need to enter a cell?
  Without too much hesitation, students may answer: A virus needs to enter a cell to reproduce. The teacher can then discuss with students the distinction in terminology between replication and reproduction.

  The teacher then asks students if they know of ways to protect themselves from viruses. Students should respond that vaccination is the best way.

Activity 2 (simultaneously with the Exploration Activity)

The teacher circulates throughout the classroom while students watch the video and answer the questions. He/She can help the students put the discussion into their own words or clarify certain explanations found in the video.

SUMMARY (10 minutes)

Activity 2 (This part is led by the teacher through direct instruction)

The best way of protecting oneself from a virus, along with general precaution, is through the use of vaccines. In both types of vaccines, live attenuated or inactivated, antibodies are produced by the body in response to the substances (antigens) found on the surface of the pathogen. Antigens are often made of proteins, but scientists have discovered that antigens made of sugars (carbohydrates) are also present on the surfaces of many pathogens.

These carbohydrate antigens are being studied in a relatively new and promising scientific field called glycomics. Researchers like Dr. Denis Giguère from Laval University use organic chemistry to build molecules that could be used to manufacture medicines to treat HIV or for vaccines for various infectious diseases. Glycomics research is a new field of research contributing towards the discovery of novel vaccines. We have learned that a vaccine contains all or some of the antigens from an infectious pathogen. The vast majority of antigens used in vaccines today are proteins. However, many pathogens contain carbohydrates (sugars) that also provoke an immune response. By attaching these carbohydrates to proteins, a stronger immune response can be obtained. Lastly, some molecules that resemble these carbohydrates can block certain key steps in the replication of a virus or the reproduction of bacteria.

The teacher should take this opportunity to remind students of the principal molecules of life: nucleic acids, proteins, fats, and sugars. Emphasis is placed on the fact that research in glycomics, the study of cell glycans, is a very promising branch of science that has yet to be fully explored.

Show students the following video; French sub-titles can be used for francophone students:

https://www.youtube.com/watch?v=CQGEGloqTpQ

ASSESSMENT

- Students must hand in their answer sheets for activities 1 and 2
- The teacher will ask the students, at the end of the period, to hand in an exit slip. In a few lines, students should explain what they have learned about vaccines.

References

Progression des apprentissages, ministère de l'éducation du Québec

Programme de Formation de l'École Québécoise.

Astronomo, R.D., Burton, D.R. Carbohydrate vaccines : developing sweet solutions to sticky situations? *Nat Rev Drug Discov*, v. 9, n. 4, p. 308-24, Apr 2010.

CMASTE
Centre for Mathematics, Science, and Technology Education

GlycoNet

UNIVERSITY OF ALBERTA
FACULTY OF EDUCATION

Vaccination Video Question Sheet

What parts of a microbe need to be identified in order to develop a vaccine?

Antigens that are specific to a particular microbe need to be identified in order to develop a targeted vaccine.

What is the most common method of introducing a vaccine into the body?

By injection

What other component of a vaccine is often administered along with the antigen, and what is its role?

An adjuvant is often added to a vaccine along with an antigen. An adjuvant helps to stimulate the immune system and generates a stronger immune response.

To which site(s) in the body will the vaccine antigen travel, and which immune system cells will it encounter?

The vaccine antigen will travel to the lymph nodes, and the first immune system cells it will encounter are the macrophages.

What is the scientific term for the ingestion of the vaccine antigen by a macrophage?

Phagocytosis

After having "eaten" the vaccine antigen, with which other immune system cells will the macrophage communicate?

The lymphocytes

What is the role of the lymphocyte clones?

To produce specific antibodies

What is the name given to the ability of "sleeping" lymphocyte cells to reactive whenever an antigen they recognize appears in the body?

Immune memory

What do antibodies look like? In a few lines, explain their mode of action.

Antibodies are Y-shaped. They are made to specifically recognize an antigen. Each antigen corresponds to a particular antibody like a lock corresponds to a particular key. When an antibody attaches to its antigen, it forms an antigen-antibody complex that is rapidly eliminated by the body.

How much time is necessary to produce the first immune response to an antigen? Is the response time the same for the second encounter between the antigen and the immune system?

It takes from 10 to 20 days to develop the first immune response. When the body encounters the same antigen a second time, the immune response (reactivation of lymphocyte clones and the production of antibodies) is much more rapid and the level of residual antibodies is also much higher.

In the example of a person with a bacterial infection, what is the advantage of being vaccinated?

For an unvaccinated individual, the bacteria have more time to divide and cause disease, along with associated complications, before an immune response is mounted. In the case of vaccinated individuals, the reactivation of lymphocyte clones and the production of antibodies are very rapid, and the bacteria are eliminated quickly without causing disease.

Is vaccination equally effective at all stages of life?

No. It is less efficient in very young children and the elderly, as they have lower-functioning immune systems.

CMASTE Centre for Mathematics, Science, and Technology Education

GlycoNet

UNIVERSITY OF ALBERTA FACULTY OF EDUCATION

Answers – Pathogen Quest

Sheet	Answer	Pathogen – indicate if a virus or bacterium	Infected cells
#1	Q1: Antigens Q2: Phagocytosis	Bacterium *Corynebacterium diphtheriae*	Respiratory tract epithelium
#2	Q3: A virus Q4: Specificity and immunity	Virus Ebola	Capillary epithelial cells
#3	Q5: An antibody Q6: Water, components of blood plasma, and white blood cells	Virus Herpes simplex 1	Skin cells near the mouth
#4	Q7: Diapedesis (or leukocyte extravasation) Q8: Live attenuated vaccines and inactivated vaccines	Virus HIV/AIDS	Cells of the immune system
#5	Q9: A vaccine is a solution capable of immunizing an organism against one or several diseases Q10: Phagocytosis and antibody secretion	Virus Influenza	Intestinal epithelial cells
#6	Q11: Lymph nodes Q12: Muscle contractions	Protozoan Malaria	Liver cells
#7	Q13: Valves Q14: 1) Protect against many serious diseases; 2) Herd immunity; 3) Reduction in infant mortality; 4) Extend life expectancy	Virus Rotavirus	Digestive tract cells
#8	Q15: Interstitial fluid Q16: 1) Certain vaccines can cause side effects; 2) Rarely, vaccines can mutate to regain their virulence	Bacterium *Clostridium tetani*	Skin cells