Pretty Pathogens
Created by Anna-Maria Boechler, Education Coordinator, Canadian Light Source Inc. (2016)

Summary
Length: 5 Hours or 10 Hours

The Canadian Light Source provides up-to-date real world educational opportunities and resources for teachers and students across Canada. Students will investigate different types of pathogens, explore the Protein Data Bank and discover the Canadian Light Source by working through the five problems in this case study. Each problem has a set of closed and open-ended questions to provide guidance for students, if required. Students will emerge themselves in the causes, preventions, responses, and historical perspectives related to four different pathogens (involving Sleeping Sickness, Meningitis, Malaria and Whooping Cough) that they can choose from. This case study is designed to follow the Saskatchewan Health Science 20 Curriculum outcome HS20—HBS: Investigate various pathologies and ailments and their effects on cells, tissues, organs and systems of a healthy human outcome—but can be modified to fit with any curriculum dealing with health, disease, drugs, or pathogens.

Pan-Canadian Objectives

<table>
<thead>
<tr>
<th>Science Grade</th>
<th>Knowledge</th>
<th>Science, Technology, Society and the Environment</th>
<th>Skills</th>
<th>Attitudes</th>
</tr>
</thead>
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Teacher Information

This case study is designed to complement the Health Science 20 Human Body outcome—while introducing new technology and innovation within the field of X-Ray Crystallography. The Canadian Macromolecular Crystallography Facility at the Canadian Light Source can determine 3-D structures. The Canadian Light Source has help discover 500 and more protein structures within the body, some that are involved in diseases and illnesses. The discovered protein structure models are deposited into the Protein Data Bank – a worldwide archive describing and showcasing proteins and other biological molecules. Students have the opportunity to investigate pathogens, explore the Protein Data Bank and discover the Canadian Light Source while working through this case study!

Students can look at different pathogens involved with:

- Sleeping Sickness
- Meningitis
- Malaria
- Whooping Cough
In this Case Study you will find that there is a lot of flexibility with how you can present the case to your students. It will depend on your group of students, your resources, and time. There is a total of five problems, each problem goes over different concepts for students to figure out. You can omit certain problems to better fit with your resources and time schedule. A problem is designed to take one hour to two hours to complete – depending on the students and the mode of delivery.

This case study was designed to have the students figure out the curricular indicators on their own. However, additional questions are available with each problem. There are two sets of questions, closed and open end. Both or either set can be used to help guide students with their investigations.

There is a list of websites that the students could look at to find answers to the problems. You can choose to share those websites when students get stuck.

There are also worksheets in the appendix that are designed to help students approach the problem. You will find group and individual worksheets. For each problem each member of the group should begin with a Meet the Problem group worksheet, where they discover what they know, don’t know, and need to find out. This worksheet helps the group identify the problem and delegate tasks to the individuals to solve the problem. When students go out to do their own individual research then they use the Research individual worksheet. Students could also use technology to record their findings as a group – such as using google docs. When students get back together to discuss what they found, the Research Discussion group worksheet is used to help students put their ideas together and find out if they have answered their problem. These worksheets could be used for evaluation.

Finally you will also find a sample presentation rubric and sample reflective evaluations in the appendix. These can be used and be modified to suit your class.

Roles

This case study can be delivered like a problem based learning activity, an assignment or somewhere in-between.

The role of the teacher is dependent on how the problems are presented to the class. The goal is to have the teacher be a facilitator, making sure that the student groups are progressing with their problems and to provide students with guidance, if necessary.

Students are expected to take the lead in their own learning by completing the case study. They are not expected to have any preparation before the case study. This will allow for better discussions within the student groups.

Problem Summary and Questions

Problem One

The Pathogen

This problem sets up the case study and has the students investigating one of the four pathogens. It begins with the students getting a new job in the pharmaceutical industry with a drug company and are asked to investigate one of the four pathogens. This problems provides career connections, exploring a new pathogen and has students discovering different vocabulary related to pathogens.
Questions
(C=Closed; OE = Open Ended)

C – What does pathogen mean?
C – What does a microbiologist do?
C – Give an example of disease, illness, ailment, disorder, infection, medical condition, syndrome, and abnormal condition on it. What do each of these terms mean?
C – What are the signs and symptoms for your group’s assigned disease?
C – How does someone get sick with your group’s assigned disease?
C – What does pharmaceutical mean?
OE – Tell me about your group’s assigned disease.
OE – What is the reason in having different terms like pathogen, disease, illness, ailment, disorder, infection, medical condition, syndrome and abnormal condition to describe someone who is unwell?
OE – How can you become a microbiologist? What kind of careers could you have?
OE – Describe what a pharmaceutical drug company.
OE – When you see the word pathogen, what does that mean to you?

Problem Two

Bacterial VS. Viral Connection
The problem introduces students the concept of bacterial and viral infections and the differences between them. It begins with the student being sick but a teammate is questioning if the sickness is bacterial or viral. Students have the opportunity to investigate Streptococcus and Influenza by looking at the differences between them.

Questions
(C=Closed; OE = Open Ended)

C – What is Streptococcus? What are the signs and symptoms of Streptococcus?
C – What is Influenza? What are the signs and symptoms of Influenza?
C – Can a bacterial infection be transmitted the same way as a viral infection? Why or why not?
C – Can the body deal with a bacterial infection the same way as a viral infection? Why or why not?
C – What are the differences between the ways that a bacterial and a viral infection can be treated?
OE – What are the differences between a bacterial and a viral infection?
OE – Would you rather have a bacterial or viral infection? Why?

Problem Three

Lifestyle and Immune System Response
Students are introduced to the idea that pathogens can have an impact on the lifestyle of an individual. Students look at different methods and are asked to conduct a study on how people affected by the pathogen respond and the progression of the response for different lifestyles. The problems goes over the importance of taking research surveys and interacting with individuals during studies.

Questions
(C=Closed; OE = Open Ended)

C – What does ‘lifestyle’ mean?
C – What does the immune system do?
C – What is a research survey? What type of data would you expect?
C – What is an in-depth interview? What type of data would you expect?
C – How would your group’s assigned disease impact someone’s life?
C – What is the immune response for your group’s assigned disease?
OE – There are many different ways to collect data scientifically. Which way would be best way to get the information that you need? Why?
OE – In what way would your group’s assigned disease impact the following people’s lives: women with three children, a college student, a 5 year old that lives with their grandparents, an owner of a large food chain, and typical grade 11 student?
OE – Why do peoples immune systems respond differently to your group’s assigned disease?

Problem Four

Historical and Cultural Perspectives
The problem starts with a protest against the large drug company. Students look at how cultural and societal perspectives are important for organizations and should be brought forward when dealing with information that impacts the community. Students will investigate the historical, societal, and cultural impacts of their pathogen.

Questions
(C=Closed; OE = Open Ended)
C – What does protest mean?
C – Why do people protest?
C – What are some examples of alternative medical remedies for disease and illnesses that you know of?
C – Are there other remedies for your group’s assigned disease used by Asians? First Nations? Ukrainians? Your culture?
C – Has your group’s assigned disease been cared for differently in the past then it is today? In what way?
OE – Do you feel people should protest? Why or why not?
OE – There are many different cultures in the world that have their own way of caring for diseases and illnesses. Has your group’s assigned disease been seen in different cultures? How have cultures cared for people with your group’s assigned disease?
OE – How has society changed in the way that people with your group’s assigned disease are taken cared of compared to how society treated these patients in the past?

Problem Five

Protein Data Base and Synchrotron
Students are able to look at real world science and technology that is used to help design drugs. Students are exposed to the Protein Data Bank and the Canadian Light Source. This helps students connect what they learn in class to the real world by bringing in real life examples. The pathogens students are looking at involve many different proteins, however students will focus on a targeted structure to understand the concept of drug design and decide if a drug can be made for their pathogen.

Questions
(C=Closed; OE = Open Ended)
C – What kind of synchrotron is located at the Canadian Light Source? How does the synchrotron work?
C – What are the CMCF beamlines? What kind of information can you get when using the CMCF beamlines?
C – What is a protein structure?
C – What is crystallography?
C – What is the Protein Data Bank? What information can you get from the Protein Data Bank?
C – What is a peer reviewed journal article? Why would there be links to peer reviewed journal articles on the Protein Data Bank?
C – What information is there about your group’s assigned disease when researching it on the Protein Data Bank?
C – How do proteins interact with drugs?
C – What information do you get when looking at the 3D structure involved with your group’s assigned disease to help you determine if the drug company can develop a drug for it? Can a drug be made for your group’s assigned disease? Why or why not?
OE – What can be researched at the Canadian Light Source? How?
OE – Describe what a synchrotron is.
OE – Why would the CMCF beamlines be useful for a drug company?
OE – Describe what crystallography is.
OE – Why is there a Protein Data Bank? How can the Protein Data Bank be useful?
OE – When looking at the 3D structure involved with your group’s assigned disease on the Protein Data Bank and reading the peer reviewed article about the 3D structure of your group’s assigned disease, do you think there is a possibility of developing a drug for your disease? Why or why not?

**How To Use the Protein Data Bank**

The Protein Data Bank is a resource that contains information about the 3D shapes of proteins, nucleic acids, and complex assemblies that helps students and researchers understand all aspects of biomedicine and agriculture. The Protein Data Bank builds upon the data by creating tools and resources for research and education. If you click on the link you will find yourself on the homepage of the Protein Data Bank. [http://www.rcsb.org/pdb/home/home.do](http://www.rcsb.org/pdb/home/home.do)
Students can take an interactive tour of the Protein Data Bank by clicking here:

This tour will let students click on a molecule of their choice. They can then learn more about that molecule, manipulate a 3D structure or protein related to the molecule and change aspects of the structure using different choices found on the right hand side of the screen.

The molecule above has 2 PDB ID codes: 2UVB and 2UVC. There are two codes for one protein to indicate that different research groups have submitted the same structure into the protein data bank. The structure is the same for each code, but the research process was different. When you click on either one of the codes, it will take you to a page with the peer-review publication related to it and information about the protein. Each protein has a unique code in the Protein Data Bank – for the structure above (fatty acid synthase) it is 4V59.
This is all the students will need to know about the Protein Data Bank to be able to use it. It is recommended they do the tutorial before they get started on their own (http://mm.rcsb.org/). The Protein Data Bank has an education website which provides various animations, posters, videos, and activities related to the Protein Data Bank under the “Learn” tab (http://pdb101.rcsb.org/). The Protein Data Bank is a great place for students to explore, look at different 3D structures of proteins and find out more about the disease they are looking at. The four pathogens in this case study have had a 3D structure involved with the disease submitted into the Protein Data Bank from research done at the Canadian Light Source. Below you can find the unique codes to use in the Protein Data Bank:

- **Sleeping Sickness: 4NEV**
  - Sleeping sickness is caused by a parasite. This parasite belongs to the family of trypanosomatids. It has a unique metabolism that is based on flavoenzyme trypanothione reductase (TR). TR is identified as a potential drug target, and it is what the students will be looking at. When searching the structure in the Protein Data Bank students will find the structure of TR with an inhibitor.
    DOI: 10.1002/cmdc.201402032

- **Meningitis: 4QQ1**
  - Meningitis is caused by *Neisseria meningitidis* which inhabits the human upper respiratory tract. A surface receptor made of transferrin-binding proteins A and B are responsible for getting iron from host transferrin. Scientists looked at the interaction between the two surface receptor proteins and the process of iron acquisition. Students will be looking at the surface receptor transferrin-binding protein B on the Protein Data Bank.
    DOI: 10.1002/mbo3.254

- **Malaria: 4FGJ, 4FGK, 4FGL**
  - Malaria is a mosquito-borne infectious disease of humans and other animals caused by parasitic protozoans belonging to the genus *Plasmodium*. There has been antimalarial drugs designed for treatment of malaria. Quinone reductase enzyme is the only known human target of two antimalarial drugs, primaquine and chloroquine. Differences between oxidized and reduced forms of this enzyme and the structural basis for inhibition by the antimalarial drugs were investigated. Students will see the enzyme structure interacting with the antimalarial drugs when they search for it on the Protein Data Bank.
    DOI: 10.1074/jbc.M113.457002

- **Whooping Cough: 5BU6**
  - Whooping Cough is a respiratory tract infection caused by the bacterium *Bordetella pertussis*. Bordetella species create an exopolysaccharide known as Bordetella polysaccharide (Bps) which is required for biofilm formation. Biofilm prevents treatment and causes resistance from host immune response. BpsB is a protein involved in Bps production. BpsB is responsible for deacetylation of PNAG oligomers (an exopolysaccharide) produced by a wide variety of medically important bacteria. Students will be investigating BpsB on the Protein Data Bank.
    DOI: 10.1074/jbc.M115.672469

Each of these 3D structures were discovered at the Canadian Light Source. Students will explore each code and look more into how the structure is connected to their disease and decide if a drug can be made with what they find.
Lesson Plan

1. Introduction
   - Students should be placed into groups – the method can be decided by the teacher. If the groups are random, play an icebreaker game to get the students in each group to get to know one another and to build confidence as a team. Three small group ice breaks can be found in the appendix.

2. Expectations
   - Let students know what is expected of them and of you throughout the process. This will depend on how you plan to evaluate the case study. There are worksheets in the appendix that can be used to gain information from the student’s and group’s progression throughout the case study as individuals and as a group.

3. Activities for Each Problem
   For each of the five problems:
   - Give the problem to the students (take note of the different pathogens)
   - Decided if you want the students to have any of the questions, closed or open ended, to guide them with their research.
   - Students can delegate the tasks (or you can if groups are having difficulties)
   - Let students research (computer lab may need to be booked)
     - Remind students they could use a google doc to have all the information in one location. (This could also be used for evaluation)
   - Get students to come back together to discuss their individual findings within the group. Student may need research more to answer the problem. If students found enough information, have students decide what their group answer is to the problem.
   Throughout the process students should be keeping record of their findings and what they are doing within the group. Individual and group worksheets are provided in the Appendix.

4. Final Project
   - Having a final project is ideal as student might be working on different pathogens and they could share what they learned with their classmates. The presentation can be done using different media such as a PowerPoint presentation, Prezi, video, interpreted dance, poster, etc. A sample rubric for evaluating the presentation can be found in the Appendix.

5. Evaluation
   - Evaluations can be done for individual students, the group, and presentation. A reflection of the students experience could also be used as an evaluation.
APPENDIX
**Small Group Icebreaker Games**

1. Desert Island
   Announce, ‘You’ve been exiled to a deserted island for a year. In addition to the essentials, you make take one piece of music, one book and one luxury item you can carry with you i.e. not a boat to leave the island! What would you take and why?’
   Allow a few minutes for the group to draw up their list of three items, before sharing their choices with the rest of the group.

2. Name Grid
   Each group needs paper and pens. Ask them to draw a grid on which they write their first names. For example:

<table>
<thead>
<tr>
<th>S</th>
<th>I</th>
<th>M</th>
<th>O</th>
<th>N</th>
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<tbody>
<tr>
<td>W</td>
<td>E</td>
<td>N</td>
<td>D</td>
<td>Y</td>
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<tr>
<td>R</td>
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<td>B</td>
<td>E</td>
<td>R</td>
</tr>
<tr>
<td>A</td>
<td>N</td>
<td>N</td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

   Give each team three minutes to write down as many words (three letters or more) that they can make only using the letters in their names. Letters must adjoin each other in the grid, but do not have to be in a straight line i.e. BOAR, or NODE. When the time is up each team adds up their score:
   - 3 or 4 letter word = 1 point
   - 5 letter word = 2 points
   - 6 letter word = 3 points

3. Vocabulary
   You begin by thinking of a word and then give the first letter. The next player thinks of a word beginning with this letter and gives the second letter. The third player thinks of a word that begins with the first two letters and adds a third. The object of the game is to avoid completing a word. When a player has completed three words or failed to add a letter they can rest their brain from the remainder of the game.

   [Link to Icebreakers](https://insight.typepad.co.uk/40_icebreakers_for_small_groups.pdf)
Resources

Google Scholar – Articles can be found on the pathogen -  https://scholar.google.ca/
World Health Organization – Look up the different pathogens (Sleeping Sickness, Meningitidis, Malaria, Whooping Cough)-  http://www.who.int/en/
Microbiologist - http://www.aboutbioscience.org/careers/microbiologist
- http://medicine.usask.ca/department/schools-divisions/biomed/microbiology-immunology.php
Bacteria Vs. Viruses - http://www.diffen.com/difference/Bacteria_vs_Virus
Different Research Methods - https://explorable.com/different-research-methods
Immune System Response - http://www.uic.edu/classes/bios/bios100/lecturesf04am/lect23.htm
Protein Data Bank - http://www.rcsb.org/pdb/home/home.do
Canadian Light Source - http://www.lightsource.ca/
CMCF Website - http://cmcf.lightsource.ca/beamlines/about-cmcf/
References

*A collection of readings I did to help develop this case study


MEETING THE PROBLEM – Group Worksheet

Complete all four questions before starting your research.
Do questions 1-3 on your own.

1. What is the problem?

2. What do YOU KNOW about the problem? Brainstorm and list all your ideas.
3. What do YOU NEED TO KNOW about the problem? Brainstorm and list all your ideas.

Share your answers to questions 1-3 with your group.
Do questions 4-5 as a group.

4. What is the PROBLEM?


When is the next meeting? _______________
Name:_______________________  Date:_______________________

RESEARCH – Individual Worksheet

1. What are YOU RESEARCHING?

2. Research Notes:
   *** DO NOT FORGET TO INCLUDE CREDIABLE CITATIONS***
DISCUSSING RESEARCH – Group Worksheet

Each team member will share his or her findings to the group.

1. What does your group KNOW? Brainstorm and list your ideas.

2. What does your group NEED TO KNOW? Brainstorm and list all ideas.

3. Revisit your group’s problem and consider what your group KNOWS and what you still NEED TO KNOW. Do you need to change your problem?

# Final Project Rubric

<table>
<thead>
<tr>
<th>Group Members:</th>
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<tbody>
<tr>
<td>Pathogen:</td>
<td>Exceeds Expectations 3</td>
<td>Meets Expectations 2</td>
<td>Minimum Expectations 1</td>
</tr>
<tr>
<td>Date:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group Collaboration</th>
<th>Evidence of strong group collaboration</th>
<th></th>
<th>All group members contributed to presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriateness to Audience</td>
<td>Targeted to a professional audience</td>
<td>Appropriate for audience</td>
<td>Style, form, and vocabulary are too casual.</td>
</tr>
<tr>
<td>Visual Aid</td>
<td>Use of multiple and varied visual aids that enhance presentation</td>
<td>Handful of visual aids supporting presentation</td>
<td>A couple of visual aids supporting presentation</td>
</tr>
<tr>
<td>Science Content</td>
<td>Extra effort to gain an exceptional understanding of the knowledge content</td>
<td>Understanding knowledge content is greater than expected</td>
<td>Shows an adequate understanding of knowledge content</td>
</tr>
<tr>
<td>Fit of Solution to the Problem</td>
<td>Solution demonstrations forward thinking</td>
<td></td>
<td>All criteria of the problem were met</td>
</tr>
</tbody>
</table>

Notes:
Name:_______________________ Date:_____________________

Individual Reflection Evaluation

1. Describe your contribution to solving the problems and with the final project for this case study:

2. If you were doing this case study again, what would you do differently to improve your work?

3. How could your team work together more effectively next time?
Group Name:_______________________  Date:____________________

Group Reflection Evaluation

1. Describe how your group worked together to solve the problems and complete the final project for this case study:

2. Did everyone have the chance to voice their opinions and contribute to the case study?

3. How could your team work together more effectively next time?