Cholera and the Scientific Method

Overview: Students act as epidemiologists and use the scientific method to track the contamination source.

Objective: To engage students in the scientific method

Skills: Collecting data, sorting and grouping, making inferences, predicting, comparing and contrasting, observing

Materials Needed: Five copies of Cholera Victims handout
Individual copies of Investigators for remaining students
Five beakers
Weak solution of ammonia used as "cholera testing solution"
One — two drops of phenolphthalein solution (See recipe below)

Preparation: Before class: Mix your own phenolphthalein solution or use prepared solution from a chemical supply house.

To make your own phenolphthalein solution: Crush 1 tablet of the laxative Feenamint with a spoon and mix with 1-2 spoonfuls of rubbing alcohol. Stir until the tablet dissolves, making a pale yellow solution.

Secretly place 1-2 drops of phenolphthalein solution in the beaker that will be used to collect the water from the "contaminated source."

To use phenolphthalein as an indicator: Phenolphthalein is normally colorless, but in this case is pale yellow due to the ingredients in Feenamint. Phenolphthalein remains colorless when it contacts an acid.

Phenolphthalein turns a vivid scarlet or bright pink when exposed to a base, such as the weak ammonia solution used as a "cholera testing solution" in this activity.

Lesson Suggestions: 1. IDENTIFY THE PROBLEM – As students enter the classroom, give the first five students a Cholera Victims handout, which explains that they are victims of a cholera outbreak and gives background of the disease. Allow about 10 minutes for them to develop their role and ask them to remain outside the classroom until you call for them.
Cholera and the Scientific Method (continued)

2. **PROBLEM** – Give the rest of the class a copy of the *Investigators* handout, which explains that they are a part of an investigative team made up of hospital epidemiologists, doctors, lab technicians and others. Their task is to discover the source of the contamination that caused the cholera outbreak and decide on a course of action. Together the class will use the scientific method to accomplish this.

3. **RESEARCH THE PROBLEM** – With the cholera victims out of the room, allow about 10 minutes for the class to read the handout and ask questions about the disease. You may want an encyclopedia on hand for an additional reference.

4. **FORM A HYPOTHESIS** – Call the cholera victims back into the room, but have them sit in the back as silent observers. The "investigators" begin by brainstorming ideas for the most logical sources of contamination within the school. Suggestions should be based on what students have learned about the disease and how it is transmitted. Since cholera is most frequently transmitted by food or water, the most likely places would be the cafeteria, bathroom sinks, and drinking fountains. Students usually take only 5-10 minutes to come up with likely contamination sources.

5. **TEST THE HYPOTHESIS** – The class must now decide on the best method of gathering information to test their hypothesis. Tell students that five cholera victims are at the back of the room awaiting questioning, but the class must first decide on how to conduct the investigation. Students usually agree that the best course of action is to call the victims to the front of the room one at a time and take turns questioning them.

   During questioning, students should take notes on anything they consider important. Some classes are able to focus quickly and direct their questioning. Other classes have difficulty organizing their thoughts and coordinating their efforts. With some help, though, students should be able to eventually direct their questions to the idea of transmission by water and therefore by the drinking fountains around the school. If students have difficulties, a post-activity discussion can help them sort out and analyze their problems. Once questioned, the cholera victims may remain in the classroom to observe the investigation, but they may not participate (since they already know the answer).
6. **COLLECT AND ANALYZE THE DATA** – When their questioning is completed, students look at their notes for patterns that could lead to the answer. Information such as where the victims had been and what they had done is often most useful. From the information given, the class concludes that the probable source of contamination is a drinking fountain in the media center (or whichever drinking fountain you select in advance).

Students then collect several samples from drinking fountains around the school, including the one they suspect is contaminated. Secretly place a drop or two of phenolphthalein solution in the bottom of the beakers that will be used to collect samples from the contaminated fountain. Leave the other beakers clean. Caution students not to rinse their beakers before collecting samples.

When students return with the samples, simply add a small amount of "cholera testing solution" (a weak solution of ammonia, sodium hydroxide, or other base) to each sample. To the astonishment and joy of the class, the samples from the contaminated drinking fountain will turn vivid scarlet or bright pink, while the others show no change, indicating that students have indeed found the contaminated drinking fountain.

7. **STATE A CONCLUSION** – Now that students know the source of the outbreak, they need to arrive at a possible solution to the problem. Suggestions range from simply shutting off or removing the contaminated fountain to closing the school until the government can assure a safe drinking water supply. Together students analyze all of the suggestions and normally decide that the best course of action is to remove the contaminated drinking fountain.

To avoid misconceptions, at this point explain that in the case of a real cholera outbreak, it is unlikely that only one fountain would be contaminated. The presence of cholera bacteria in the drinking water would indicate that the water supply to the school was contaminated, so removing the drinking fountain would not solve the problem. Cities and towns constantly monitor and test water supplies to ensure that a situation like this does not occur.
8. **ASSESSMENT** – Students must now prepare written reports of the group's findings, which are used to assess how well students understand the scientific method. Have each student write a report containing the following:

- A description of how cholera is transmitted
- A step-by-step account of how the class determined the source of the contamination, including a description and name for each step of the scientific method
- The source of contamination
- The class recommendation to solve the problem

Before students begin writing, briefly review the steps of the scientific method. It helps solidify what students have learned and condense it into a more practical format. It is helpful to make notes on the chalkboard for students to copy.

9. **DEBRIEFING** – Explain the phenolphthalein trick.

**Topics for Discussion:**

Research your water supply. From where does it come?

Who monitors the quality of the water, and how often is this done?

Are any chemicals added to the water supply? If so, what are they, and why is each one added?

For a follow-up lesson, visit the water treatment plant, or have a speaker from there come to the class.

**Writing Extension Grades 5-8:**

Instruct students to compose a writing piece describing each step of the scientific method as experienced in this activity. The writing needs to be logical, chronological, and stated clearly enough that someone outside the class could follow the activity easily on their own.

**Writing Extension Grades 9-12:**

Have students compose a writing piece stating their recommendation to solve the problem based on their own thoughts and knowledge gained from the experience.
"Cholera Victims"
Cholera and the Scientific Method

You will be playing the role of a victim of the dreaded *Vibrio cholerae* bacteria. This means that you have contracted the disease known as cholera. The rest of the class will be a group of investigators trying to discover the source of the disease.

Cholera is a disease caused by food or water that has the *Vibrio cholerae* bacteria growing in it, usually as a result of improper sewage treatment or impure water supplies. The symptoms of this disease are severe muscular cramps in your extremities (arms, legs, hands and feet). Cholera is extremely contagious!

Develop a character with the following information in mind. At some time two days ago, you went to the media center and got a drink of water from the drinking fountain there. Later, within 8 to 24 hours, you started feeling many of the symptoms listed previously and went to the hospital.

Don't forget that you are an active student. Remember the classes you attended prior to your library visit and the number of times you went to the bathroom. Did you eat a meal before the visit? If so, what did you eat? Did you hug or kiss anyone during the time in question? Make a good case for not knowing where you "got cholera." It makes the lesson more real.

When the investigators question you, answer as truthfully as possible but do not volunteer any information if they do not ask relevant questions. Try not to make the circumstances of the outbreak too obvious.

Thank you for your cooperation in this role play. Do not tell anyone how you contracted the disease until the entire lesson is over. If other students find out the answer, it will ruin the lesson for everyone. They will all discover the answer soon enough, so please keep it a secret.
"Investigators"
Cholera and the Scientific Method

You have been selected to be on a blue-ribbon committee of investigators, including epidemiologists, doctors, and lab technicians, to help solve an urgent public health problem. There seems to be an outbreak of the disease cholera. Five individuals who have been infected have been brought in for you to interview. These people, and several others, seem to have been infected about two days ago and have been receiving regular treatments of antibiotics to kill the infection.

Cholera is caused by the *Vibrio cholerae* bacteria, commonly transmitted by untreated waste or impure drinking water. It can also be contracted by eating improperly cooked shellfish or fruits and vegetables that have been washed in contaminated water. It can also be transmitted through the bite of certain insects. Today, cholera is not very common in our country, but it has been and continues to be a major health problem in many parts of the world.

The symptoms of cholera are severe dehydration, diarrhea, vomiting and severe muscle cramps in the extremities (arms, legs, hands and feet). Patients frequently go into shock and can die.

Treatment of cholera involves giving intravenous fluids and oral antibiotics. To prevent further spread of the disease, sewage and drinking water treatment systems are installed to eliminate breeding grounds for the *Vibrio cholerae* bacteria.

Your task is to use the scientific method to discover the source of this disease and a way to prevent more infections. Good luck, we are all depending on you.
Common Core Standards Addressed

**RST.11-12.7** - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1), (HS-ETS1-3)

**RST.11-12.8** - Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1), (HS-ETS1-3)

**RST.11-12.9** - Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1), (HS-ETS1-3)
Cholera and the Scientific Method

OVERVIEW: Students act as epidemiologists and use the scientific method to track the contamination source.

OBJECTIVE: Students will demonstrate their knowledge of the scientific method, by collecting data, sorting and grouping, making inferences, predicting, comparing and contrasting, and making observations.

INTRODUCTION: Five students in the classroom are Cholera Victims - they will leave now to develop their role. The rest of you are investigators. With the cholera victims out of the room, your team has about 10 minutes to read the handout and ask questions about the disease. You may use the chrome books at your lab stations as an additional reference. Use the following CDC website:

http://www.cdc.gov/cholera/index.html

FORM A HYPOTHESIS - The "investigators" begin by brainstorming ideas for the most logical sources of contamination within the school. Students usually take only 5-10 minutes to come up with likely contamination sources.

TEST THE HYPOTHESIS - The class must now decide on the best method of gathering information to test their hypothesis. The five cholera victims are at the back of the room awaiting questioning, but the class must first decide on how to conduct the investigation. During questioning, students should take notes on anything they consider important.

COLLECT AND ANALYZE THE DATA – When their questioning is completed, students look at their notes for patterns that could lead to possible source of the contamination.

One member form each group will then collect several samples from possible sources around the school.

When students return with the samples, simply add a small amount of "cholera testing solution" to each sample. If the samples turn vivid scarlet or bright pink this is a positive result, while the others which show no change, indicate a negative result.

STATE A CONCLUSION – Now that you know the source of the outbreak, your team needs to arrive at a possible solution to the problem.

REPORT WRITE-UP – Students must now prepare 1 written report per team of the group's findings, which are used to assess how well students understand the scientific method. Have each student write a report containing the following:

- **Background**: A paragraph description of what cholera is and how cholera is transmitted
- **Purpose**: A simple sentence stating why you are performing this investigation
- **Question**: What is the question you are intending to answer in this experiment
- **Hypothesis**: Your proposed answer to the question
- **Procedure**: A step-by-step account of how the class determined the source of the contamination.
- **Data Analysis**: a short paragraph explaining the source of contamination?
- **Conclusion**: Have students compose a writing piece stating their recommendation to solve the problem based on their own thoughts and knowledge gained from the experience.
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Don't forget that you are an active student. Remember the classes you attended prior to this class and the number of times you went to the bathroom. Did you eat a meal before the visit? If so, what did you eat? Did you hug or kiss anyone during the time in question? Make a good case for not knowing where you "got cholera." It makes the lesson more real.

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Title: 10th Grades Biology Article Reviews and Summary
By: Michelle Poquette and Chris Ladwig, Cabrillo High School
Grades: 9-10
NGSS: These will vary as there are articles for multiple concepts.
Common Core Standards:

- **CCSS.ELA-LITERACY.RST.9-10.1**
  Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

- **CCSS.ELA-LITERACY.RST.9-10.2**
  Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

Time: 1 – 45 min class period for each article (the first one may take two days as you model format for the first time)

Summary: We use these articles as introductions to each unit taught in our 10th grade biology course. Students are introduced to a real life application of a concept that will be later taught in the unit. The students are introduced to performance tasks of reading, analyzing and evaluating scientific articles which are similar to the process on the SBAC. The students get exposure to published scientific writing as well as up to date studies in the field of science. The strategy presented is flexible to use with any article, the only recommendation is using short one page articles for one 45 minute time period.

Materials: Each student needs the following: one copy of the article, Binder paper, and a computer/tablet/laptop with internet access. Be sure to review appropriate internet use and how to determine credible websites.

Procedures:
1. See attached student instructions

Attachments:
- Instruction's for summarizing, reviewing and comparing scientific article
- Sample biology unit articles
- Teacher grading rubric
# 10th Grade Biology Article Review Rubric

<table>
<thead>
<tr>
<th>5 key points present</th>
<th>1</th>
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<tbody>
<tr>
<td><strong>Summary</strong> – one paragraph answering each question (summarized below)</td>
<td>4</td>
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<tr>
<td>• Article topic explained</td>
<td></td>
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<tr>
<td>• Article claim stated</td>
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<tr>
<td>• Evidence stated</td>
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<tr>
<td>• Conclusion drawn</td>
<td></td>
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<tr>
<td><strong>Review</strong> – one paragraph answering each question (summarized below)</td>
<td>4</td>
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<tr>
<td>• Personal opinion stated</td>
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<tr>
<td>• Something learned stated</td>
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<td>• New questions proposed</td>
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<tr>
<td>• Recommendation</td>
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<tr>
<td><strong>Article Comparison</strong> - one paragraph answering each question (summarized below)</td>
<td>6</td>
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<tr>
<td>• Name, author and date of article present</td>
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<tr>
<td>• Website cited</td>
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<td>• 2-3 sentences comparing the two articles</td>
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<td>o How are they the same</td>
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<td>o How are they different</td>
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<td>o Do they have the same evidence?</td>
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<td>o Did they draw the same conclusion?</td>
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<td>• Article recommendation stated</td>
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**Consensus Score** ________________
Brain naturally follows scientific method?

It turns out that there is a striking similarity between how the human brain determines what is going on in the outside world and the job of scientists. Good science involves formulating a hypothesis and testing whether this hypothesis is compatible with the scientist's observations. Researchers have now shown that this is what the brain does as well. A study shows that it takes less effort for the brain to register predictable as compared to unpredictable images.

Alink and colleagues based this conclusion on the characteristics of responses in the primary visual cortex. It is known that the primary visual cortex is critical for vision and that responses in this brain area create a map of what we are currently looking at. Alink and colleagues, however, for the first time show that images induce smaller responses in this area when they are predictable. The implication of this finding is that the brain does not just sit and wait for visual signals to arrive. Instead, it actively tries to predict these signals and when it is right it is rewarded by being able to respond more efficiently. If it is wrong, massive responses are required to find out why it is wrong and to come up with better predictions.

One implication of this study is that when you enter the office the image of your colleague at his desk, who has the annoying trait of always being there before you, will require very little effort for your brain to register. The image of your mother in law sitting on the same chair, however, would make your brain go haywire. Not necessarily because you are not fond of this person but because this image makes it clear to your brain that it is doing a lousy job at predicting what is going to happen next and that it will have to make an effort to improve its predictions. This suggests that the brain’s main job, alike that of a scientist, is to generate hypotheses about what is going on in the outside world.

The study, published in the Journal of Neuroscience, represents a significant advance in understanding how the brain supports visual perception. An important implication of this study is that visual perception depends on an active generation of predictions. This stands in contrast to the classical view that visual perception mainly results from a more passive cascade of responses to visual signals spreading through the brain.

Further research is still required to determine whether indeed we are all carrying along a little scientist in our head. At present the idea of the scientific brain is rapidly spreading through the neuroscience community and provides a novel approach to resolving how the most complex organ of the human body works.
Report Title:
Team members names:
Date: __________ Per __________

Background:

Purpose:

Question:

Hypothesis:

Procedure:

Data Analysis:

Conclusion: