Ohio Department of Education

The History of Germ Theory – Grade 12

Ohio Standards Connection:

Life Sciences

Benchmark G
Summarize the historical development of scientific theories and ideas within the study of life sciences.

Indicator 11
Trace the historical development of a biological theory or idea (e.g. genetics, cytology, and germ theory).

Related Standard

Scientific Inquiry

Benchmark A
Make appropriate choices when designing and participating in scientific investigations by using cognitive and manipulative skills when collecting data and formulating conclusions from the data.

Indicator 1
Formulate testable hypothesis. Develop and explain the appropriate procedures, controls, and variables (dependent and independent) in scientific experimentation.

Indicator 3
Research and apply appropriate safety precautions when designing and/or conducting scientific investigations (e.g., OSHA, MSDS, eyewash, goggles and ventilation).

Lesson Summary:
In this lesson students will learn the history of germ theory, from the 1600s to the present day. They will examine how germ theory developed and test antibacterial wipes for their "germ killing" properties. This lesson helps students learn the content of the indicators and benchmarks by weaving the history of germ theory with scientific inquiry as they "do" science and look at it through the eyes of scientists instrumental in the development of germ theory.

Estimated Duration: *Four hours*

Commentary:
This lesson helps students to understand the historical discoveries of how disease is caused by microorganisms that are passed on from one individual to another. As people understood how germs caused disease, methodologies were developed to prevent the spread of disease. Students will examine the full spectrum of germ theory and evaluate future implications.

Pre-Assessment:
On a sheet of paper, have students answer the following questions:

- What causes infectious disease?
- What is the best way to avoid becoming ill?
- How do we know this?

Scoring Guideline:
Do not formally score this activity. Instead, have students share their responses with the other members of their lab group. Have lab groups share their responses as a whole class. Use these responses to help design instruction for the development of germ theory.

- What causes infectious disease?
  Many agents are responsible for disease, including viruses, bacteria and fungi. For this lesson diseases that are caused by heredity will not be discussed.

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- What is the best way to avoid becoming ill?
  Limiting exposure to disease-causing agents may reduce transmission of disease.

- How do we know this?
  Through research and experimentation many scientists have developed the germ theory, which states that infectious diseases are transmitted by microorganisms or germs.

Post-Assessment:
Have students complete Attachment A, *Post-Assessment*.

Scoring Guidelines:
Use Attachment B, *Post-Assessment Scoring Guidelines* to evaluate students' understanding of germ theory.

Instructional Procedures:
Part One – The History of Antibiotics and Germ Theory
1. Build the framework for the history of germ theory by sharing with students the Miasma Theory of Disease, which associated disease with "bad air" or poor sanitation. It was believed that if sanitation was improved, the spread of disease was reduced.
2. Have students work in groups of three to research a scientist that contributed to the development of the germ theory.
3. Instruct the group to identify the year of study for each scientist, as well as that scientist's major contribution to germ theory.
4. Have students record their findings on a sheet of chart paper.
5. Once students have completed their research on the scientist, have them as a class organize the timeline of discovery for germ theory.
6. Provide the overall framework of the germ theory, and have students fill in the scientists with presentations of their findings.

Instructional Tip:
Sample of scientists to be included in the timeline.
  a. 1676-Van Leeuwenhoek – First primitive microscope in which microorganisms were observed
  b. 1798-Edward Jenner – Reported the use of cowpox inoculation for the prevention of smallpox in humans
  c. 1847-Ignaz Semmelweis – Reduced the number of deaths from puerperal fever by instructing health workers to wash their hands between patients
  d. 1849-John Snow – Traced cholera to a germ that was water borne
  e. 1859-Louis Pasteur – Fostered belief that human diseases were caused by microorganisms. Disproved spontaneous generation
  f. 1865-Joseph Lister – Used antiseptic to prevent wound infection in surgery
  g. 1873-Robert Koch – Traced a disease back to a particular bacteria, anthrax

7. Instruct the class to use their charts to trace and record the history of germ theory.

Part Two – Lab Experience

8. Have students discuss how to control the presence of germs.
9. Ask students to design a methodology for testing the presence of germs on their lab tables.
10. If necessary, teach students proper technique for pouring agar plates, bacterial sampling techniques and disposal methods (See Attachment C, *Preparing Bacterial Cultures.*)
11. Have students read the lab exercise found on Attachment D, *Do Cleaning Wipes Really Kill Germs?* Please review appropriate safety instructions at this time. This will take a couple of days, and during the interim, instruct students on how to count bacterial cultures.
12. Discuss antibiotics and antiseptics. Provide examples and clarification, if necessary. Provide students with information on how antibiotics work in the body to kill bacteria.

Instructional Tip:

- Antiseptics are substances which prevent the growth and development of microorganisms. These are usually topical agents.
- Antibiotics are agents that are derived from bacterial sources to prevent and treat infections.

13. As students complete this lab exercise, have them discuss their results from the viewpoints of the scientists studied in the "History of Germ Theory" section.

Instructional Tip:

Results of the lab will vary, depending on types of cleaning agents used. Agents that kill bacteria, such as bleach or alcohol, should have no growth present if proper lab technique is employed. Antibacterial agents may have some growth present, if not all of the bacteria died upon application of the agent. Those bacteria that have genetic resistance to the agent will survive and reproduce.

Differentiated Instructional Support:

Instruction is differentiated according to learner needs, to help all learners either meet the intent of the specified indicator(s) or, if the indicator is already met, to advance beyond the specified indicator(s).

- Provide students with pre-poured agar plates for their lab experience and their post-assessment. This may help students who have difficulty with sequencing when they are writing their lab procedures.
- Complete graphic organizers before the lecture/discussion on the history of antibiotics. If this is the case, share the completed graphic organizer, and have them follow along by lightly coloring in each square/circle as they are discussed in class, so that they stay focused and on task.

Extension:

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- Have students conduct research using a spectrophotometer to collect data about bacterial growth. If you have access to one, present this as an alternate method to using agar plates.
- Research the Center for Disease Control and Prevention for current data on the effectiveness of antiseptics, such as alcohol gels, soaps, alcohol wipes and the like. An additional lab could be developed in which the effectiveness of the antiseptic properties of these products is tested.

Homework Options and Home Connections:
Have students collect data around their home, such as kitchen, bathroom, baby changing station or basement. If their parents won't allow them to collect samples from around the house, encourage them to ask at their place of employment or a local grocery store. Provide them with agar plates that are pre-poured and taped shut to maintain sterility. Explain how they should collect samples and apply them to the plate. Make sure that they know to re-tape the plate and return it to school for data collection.

Materials and Resources:
The inclusion of a specific resource in any lesson formulated by the Ohio Department of Education should not be interpreted as an endorsement of that particular resource, or any of its contents, by the Ohio Department of Education. The Ohio Department of Education does not endorse any particular resource. The Web addresses listed are for a given site's main page, therefore, it may be necessary to search within that site to find the specific information required for a given lesson. Please note that information published on the Internet changes over time, therefore the links provided may no longer contain the specific information related to a given lesson. Teachers are advised to preview all sites before using them with students.

For the teacher: Nutrient agar, agar plates, autoclave, variety of different cleaning wipes (e.g., antibacterial, bleach, ammonia, vinegar, alcohol), swabs, beakers, stirring rods, goggles.

For the students: Nutrient agar, agar plates, swabs, beakers stirring rods, goggles, cleaning wipes (for lab).

Vocabulary:
- antibiotics
- germ theory
- agar
- spontaneous generation
- pasteurization
- microbe
- penicillin
- antiseptic
- disinfectant

Technology Connections:

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Have students research the various types of lab equipment used to examine the microscopic world (e.g., the history of the microscope and the various types of microscopes that allow us much greater detail, such as the electron-scanning microscope).

Research Connections:

Marzano, R., Pickering, D., Pollock, J. *Classroom Instruction that Works: Research-Based Strategies for Increasing Student Achievement*, Alexandria. VA: Association for Supervision and Curriculum Development. 2001.

> Generating and testing hypotheses engages students in one of the most powerful and analytic of cognitive operations. It deepens students' knowledge and understanding. Any of the following structured tasks can guide students through this process:
> - systems analysis,
> - problem solving,
> - historical investigation,
> - invention,
> - experimental inquiry,
> - decision making.

General Tips:

- Check with local colleges or hospitals to see if they have any petri dishes and other microbiology supplies that they no longer need and are willing to donate to your school.
- If possible, use pre-poured agar plates. The risk of student contamination is greatly reduced with the use of pre-poured plates.

Attachments:

Attachment A, *Post-Assessment*
Attachment B, *Post-Assessment Scoring Guidelines*
Attachment C, *Preparing Bacterial Cultures*
Attachment D, *Do Cleaning Wipes Really Kill Germs?*

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Attachment A
Post-Assessment

Name ___________________________

Read the passage, and answer the following questions:

Puerperal fever was widespread in women who delivered children in public hospitals during the early to mid-1800s. Puerperal infections result from exposure to contaminated instruments or hands following childbirth. The infection begins in the female reproductive organs and spreads into the blood in the lymph, resulting in blood poisoning, which may lead to widespread infection throughout the body. Death may result in as many as 25% of those infected.

Ignaz Semmelweis, an Austrian physician, observed fluctuating puerperal rates between two delivery wards in the Vienna, Austria hospital in 1847. One delivery ward had young physicians performing autopsies of patients who died of puerperal fever. The physicians would then return to the ward and examine patients, using their unwashed hands. In the second ward he observed the young physicians performing autopsies of patients who had also died of puerperal fever, but upon returning to the wards, they would just monitor the patients' progress without physically touching them. The number of infections in the first ward was high; whereas, the number of infections is the second ward was low. The accepted explanation at this time was that miasma, poor ventilation, overcrowding of the wards, weather and the onset of lactation caused the discrepancy. Unfortunately, many accepted the infection as inevitable and that death was unpreventable.

1. What evidence is there that would lead one to conclude that there was something different between the two wards and the infection rates, other than the explanations generally accepted?

2. What instrument would have helped Semmelweis identify what was causing the infection?

3. What are some reasons that he may not have used such an instrument?

4. Name two other scientists that contributed to the discovery of germ theory from our class activities, and explain their contributions.

5. What procedures would you observe doctors using today prior to an examination if you were in an emergency room or having an operation?

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Attachment B
Post-Assessment Scoring Guidelines

1. What evidence is there that would lead one to conclude that there was something different between the two wards and the infection rates, other than the explanations generally accepted?

    - *The first ward had physicians performing autopsies without gloves and then going to the ward to examine patients who had recently delivered a baby. These physicians were observed not to have washed their hands between the autopsies and the examination of patients. They passed on the infection.*
    - *The second ward had physicians who also performed autopsies, but when they went to the wards to examine their patients, they did not touch the patients during their examinations. No germs were introduced to the patients.*

2. What instrument would have helped Semmelweis identify what was causing the infection?

    - *The availability of the microscope would have helped Semmelweis to identify a microbe from tissue samples of infected patients.*
    - *The technique of Gram staining would have helped to identify the type of microbe causing the infection. (This would have required the microscope, as well.)*

3. What are some reasons that he may not have used such an instrument?

    - *The availability of microscopes during the 1800s may have been limited.*
    - *The delivery of ordered items would have been slower and would have taken longer in the 1800s than now.*
    - *The hospital facilities may not have the funds for a microscope or the facilities to conduct an evaluation of the infected tissue samples of patients.*

4. Name two other scientists that contributed to the discovery of germ theory, and explain their contributions.
    a. *1676-Van Leeuwenhoek – First primitive microscope in which microorganisms were observed*
    b. *1798-Edward Jenner – Reported the use of cowpox inoculation for the prevention of smallpox in humans*
    c. *1847-Ignaz Semmelweis – Reduced the number of deaths from puerperal fever by instructing health workers to wash their hands between patients*
    d. *1849-John Snow – Traced cholera to a germ that was water borne*
    e. *1859-Louis Pasteur – Fostered belief that human diseases were caused by microorganisms, disproved spontaneous generation*
    f. *1865-Joseph Lister – Used antiseptic to prevent wound infection in surgery*
    g. *1873-Robert Koch – Traced a disease back to a particular bacterium, anthrax*

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Attachment B (continued)
Post-Assessment Scoring Guidelines

5. What procedures would you observe using today prior to an examination if you were in an emergency room or having an operation?

- *Physicians would have worn surgical gloves, masks, surgical aprons, surgical clothes, face shields and surgical booties.*
- *Medical personnel would change the above listed items between patients.*
- *Surgical instruments would have been disposed of between patients or would be autoclaved.*
- *Disinfectant would have been used to cleanse the utensils and surfaces used between patients.*

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Attachment C
Preparing Bacterial Cultures

To prepare sterile petri dishes:
1. Use sterile, unopened petri dishes if possible.
2. If you have petri dishes that are used, autoclave them according to autoclave directions. (Caution: Do not put plastic petri dishes in the autoclave.)
3. If you don't have an autoclave, boil them in hot water.
4. If you don't have an autoclave, you can also microwave them.

To prepare nutrient agar – follow package directions, OR use directions below:
1. 11.5 g nutrient agar powder per 500 mL cold water. Stir.
2. Microwave to boiling (or boil on hot plate).
3. Pour into sterile petri dishes.
4. Allow to cool for 24 hours, and then store upside down in a refrigerator.

To dispose of used agar plates:
1. Autoclaving is the best method for disposal of microbiological materials. All materials should be autoclaved at 121°C, 15 psi, for 60 minutes. Biohazard bags can help simplify the disposal procedure.
2. If you don't have an autoclave (or a pressure cooker to autoclave), household bleach or 70% ethanol can be used as an effective disinfectant. Dilute full-strength bleach to 10% strength, and then submerge cultures and other potentially contaminated materials in the bleach or alcohol solution. Let them sit overnight. When drained, the materials can be safely incinerated.
3. After sterilization, materials can be thrown in the trash.

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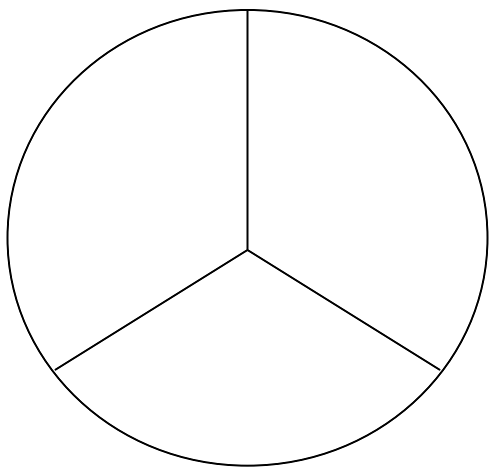
Attachment D
Do Cleaning Wipes Really Kill Germs?

Many popular cleaning products supposedly kill germs. In this lab activity, we will investigate the germ-killing effectiveness of cleaning wipes, which are a very popular, relatively new product on the market.

Materials: Agar plates, cotton swabs, cleaning wipes, marker,

Directions:
1. Using the marker, divide the bottom of your agar plate into three parts, like the example below:



2. Label the three parts as follows: Sample 1 – lab bench; Sample 2 – Cleaning wipe #1; Sample 3 – Cleaning wipe #2.
3. Collect a sample of your lab bench surface by rubbing the cotton swab across the bench and gently rubbing it onto the agar in the correct section of the plate.
4. Clean a small part of your lab bench with cleaning wipe #1. After this has dried, collect a sample from this cleaned area with a new swab, and place this in the "Sample 2" section of your Petri dish. Be sure to gently rub the swab across the agar.
5. Clean a different part of your lab bench with cleaning wipe #2. After this has dried, collect a sample from this cleaned area with a new swab, and place this in the "Sample 3" section of your Petri dish. Be sure to gently rub the swab across the agar.
6. **<u>Tape your agar plates shut and keep them closed for the remainder of the experiment.</u>** Store them upside down in an incubator set at 30°C. If your teacher doesn't have an incubator, put the plates on the counter for about two days at room temperature.
7. Make predictions in the space below about what will happen in each sample.
8. Put your agar plates in the area designated by your teacher.

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Attachment D (continued)
Do Cleaning Wipes Really Kill Germs?

Predictions: Write your predictions for each sample in the space below. Which sample will provide the most bacteria? Which sample will provide the least bacteria?

Sample #1 Prediction:

Sample #2 Prediction:

Sample #3 Prediction:

Data collection: Look at your data every other day, and record information in the data table below:

Sample	Number of colonies/color Day 1	Number of colonies/color Day 3	Number of colonies/color Day 5
Dirty lab bench			
Cleaning wipe #1			
Cleaning wipe #2			

Data analysis questions:
1. Which sample had the most bacterial growth? Why?

2. Which sample had the least bacterial growth? Why?

3. Do you think the use of the cleaning wipes had anything to do with bacterial growth? Why or why not?

4. What ingredient in the cleaning wipes do you think played a critical role in inhibiting the bacterial growth on that sample?

Attachment D (continued)
Do Cleaning Wipes Really Kill Germs?

5. Conclusion: Explain the results of your experiment, including the following elements: your predictions; a brief statement describing the procedure and results; and analysis of results viewed by one of the scientists studied.

6. The Center for Disease Control and Prevention has recently recommended that physicians use alcohol wipes and hand washing solutions rather than antibacterial soap. How does this current problem relate to the history of germ theory?