

the science of
MICROBES

Milestones in Microbiology

Activity 7 from *The Science of Microbes: Teacher's Guide*

by

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RESOURCES

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INTRODUCTION

Microbial Challenges

Infectious diseases have plagued humans throughout history.

Sometimes, they even have shaped history. Ancient plagues, the Black Death of the Middle Ages, and the “Spanish flu” pandemic of 1918 are but a few examples.

Epidemics and pandemics always have had major social and economic impacts on affected populations, but in our current interconnected world, the outcomes can be truly global. Consider the SARS outbreak of early 2003.

This epidemic demonstrated that new infectious diseases are just a plane trip away, as the disease was spread rapidly to Canada, the U.S. and Europe by air travelers. Even though the SARS outbreak was relatively short-lived and geographically contained, fear inspired by the epidemic led to travel restrictions and the closing of schools, stores, factories and airports. The economic loss to Asian countries was estimated at \$18 billion.

The HIV/AIDS viral epidemic, particularly in Africa, illustrates the economic

For an emerging disease to become established, at least two events must occur: 1) the infectious agent has to be introduced into a vulnerable population, and 2) the agent has to have the ability to spread readily from person to person and cause disease. The infection also must be able to sustain itself within the population and continue to infect more people.

and social effects of a prolonged and widespread infection. The disproportionate loss of the most economically productive individuals within the population has reduced workforces and economic growth in many countries, especially those with high infection rates. This affects the health care, education, and political stability of these nations. In the southern regions of Africa, where the infection rate is highest, life

expectancy has plummeted in a single decade, from 62 years in 1990–95 to 48 years in 2000–05. By 2003, 12 million children under the age of 18 were orphaned by HIV/AIDS in this region.

Despite significant advances in infectious disease research and treatment, control and eradication of diseases are slowed by the following challenges.

- The emergence of new infectious diseases
- An increase in the incidence or geographical distribution of old infectious diseases
- The re-emergence of old infectious diseases
- The potential for intentional introduction of infectious agents by bioterrorists
- The increasing resistance of pathogens to current antimicrobial drugs
- Breakdowns in public health systems.



Baylor College of Medicine, Department of Molecular Virology and Microbiology, www.bcm.edu/molvir/.

USING COOPERATIVE GROUPS IN THE CLASSROOM

Cooperative learning is a systematic way for students to work together in groups of two to four. It provides organized group interaction and enables students to share ideas and to learn from one another. Students in such an environment are more likely to take responsibility for their own learning. Cooperative groups enable the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. Materials must be managed, investigations conducted, results recorded, and clean-up directed and carried out. Each student must have a specific role, or chaos may result.

The Teaming Up! model* provides an efficient system for cooperative learning. Four “jobs” entail specific duties. Students wear job badges that describe their

duties. Tasks are rotated within each group for different activities so that each student has a chance to experience all roles. For groups with fewer than four students, job assignments can be combined.

Once a model for learning is established in the classroom, students are able to conduct science activities in an organized and effective manner. Suggested job titles and duties follow.

Principal Investigator

- Reads the directions
- Asks the questions
- Checks the work

Maintenance Director

- Follows the safety rules
- Directs the cleanup
- Asks others to help

Reporter

- Records observations and results
- Explains the results
- Tells the teacher when the group is finished

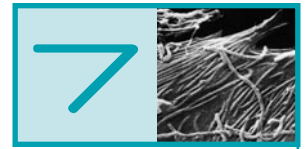
Materials Manager

- Picks up the materials
- Uses the equipment
- Returns the materials

* Jones, R.M. 1990. *Teaming Up!* LaPorte, Texas: ITGROUP.

Overview

Students will read about six important events in the history of microbiology and decide on these events' most probable chronology, based on evidence provided. Students will learn that most scientific discoveries are related to other work, and that scientific advances often depend on the development of appropriate tools and techniques (see Answer Key, sidebar, p. 30).



Ebola virus. CDC \1836 C. Goldsmith.

TIME

Setup: 10 minutes

Activity: 45 minutes
for one or two class periods

M I L E S T O N E S I N

Microbiology

Very little attention was paid to the world of microbes until the 1600s, when Robert Hooke developed a primitive compound microscope (one which uses two lenses in sequence) and described tiny organisms that he observed with it. Even more detailed observations of microscopic organisms were made by Anton van Leeuwenhoek, who developed precise techniques for grinding magnifying lenses. Van Leeuwenhoek observed numerous small, swimming organisms in pond water and named them “animalcules.”

It was not until the mid-1800s that scientists had enough tools to begin serious studies of microbes. In the 1850s, Louis Pasteur studied the fermentation of wine, which he found to be caused by yeast cells. He proposed that microorganisms also could cause disease, and later developed the process of pasteurization to remove harmful bacteria from food.

Pasteur's work stimulated that of Robert Koch, a physician who studied anthrax (a disease of cattle and sheep). Koch is credited with developing many culture techniques, including the use of nutrient agar for growing bacteria. He also established a set of rules to guide decisions about whether a given microbe actually caused a disease. These rules are known as “Koch's Postulates” (see sidebar, right).

Much later, in the 1930s, Walter Fleming accidentally discovered that substances produced by a common

fungus, *Penicillium*, could kill *Staphylococcus* bacteria in cultures. His work led to the development of penicillin, the first antibiotic.

Since viruses are so much smaller than bacteria, most research on viruses and viral diseases began later than work on other microbes. In the 1890s, two investigators working separately, Martinus Beijerinck and Dmitrii Ivanowski, studied juices extracted from the leaves of plants infected with what is now known to be tobacco mosaic virus. They filtered the juices to remove bacteria and found that even when highly diluted, the liquid still could cause infection in plants. Ivanowski concluded that an infectious agent other than a bacterium—a filterable “virus”—led to the disease. Beijerinck called the substance “contagious living fluid.”

Neither investigator was able to observe or grow the hypothesized disease-causing agents. Later, in the 1930s, Wendell Stanley isolated crystals of tobacco mosaic virus. The invention of the transmission electron microscope by Ernst Ruska in 1933 made it possible to observe viruses for the first time at magnifications of 10,000 times or more. For this, Ruska received the Nobel prize in physics.

The process by which microbiology knowledge has accumulated is typical of how science proceeds. Often a critical tool, such as the microscope, is needed before questions even can be

Continued

SCIENCE EDUCATION CONTENT STANDARDS

Grades 5–8

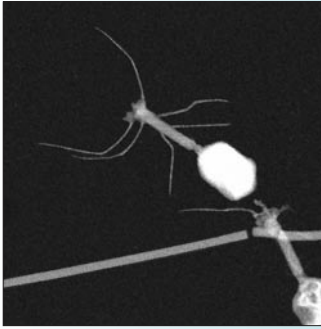
History and Nature of Science

- Women and men of various social and ethnic backgrounds—and with diverse interests, talents, qualities, and motivations—engage in the activities of science, engineering, and related fields, such as the health professions.
- Science requires different abilities, depending on such factors as the field of study and type of inquiry.
- Many individuals have contributed to the traditions of science.
- Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted.

KOCH'S POSTULATES

One can conclude a microbe causes a disease if:

- the same microbe is present in every case;
- it is possible to take a sample from a sick animal and grow the microbe in the laboratory;
- a healthy animal exposed to a sample from the microbes grown in the lab develops the same disease; and
- it is possible to isolate and grow the same microbes from the newly infected animal.



Rod-shaped tobacco mosaic virus and alien-like T4 bacteriophages (viruses that infects bacteria). NIAMS, NIH\A.Steven, M. Cerritelli, and Brookhaven National Laboratory\ M. Simon, J. Wall, J. Hainfeld.*

ANSWER KEY

1600s - A New World:

Early microscopes make tiny life forms visible.

1881 - A Culture Medium:

Culture techniques make it possible to “grow” bacteria.

1884 - Mechanisms of Disease:

Scientists learn how to connect a specific bacterium to a disease.

1890s - Contagious Living

Fluid: Scientists learn that something smaller than a bacterium can cause disease.

1929 - The Discovery of

Penicillin: Scientists find that penicillin acts to kill bacteria in culture.

1930s - Seeing Viruses:

Science advances sufficiently to allow viruses to be observed.

* Fibers enhanced by M. Young, Baylor College of Medicine. Image courtesy of the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), NIH. Image taken with the Brookhaven National Laboratory Scanning Transmission Electron Microscope.

asked. Progress occurs unevenly, with one critical discovery suddenly opening entire new areas of investigation.

MATERIALS

Teacher (see Setup)

- 24 sheets of cardstock

Per Group of Students

- Set of prepared *Discovery Readings* cards (pp. 31–33)
- 4 highlighters (4 different colors)
- Pair of scissors
- Paper clips
- Transparent tape
- Copy of the *Timeline* student sheet (p. 34, see Answer Key, left sidebar)
- Group concept map (ongoing)

SETUP

Make six copies of the student sheets on cardstock. Cut out the *Discovery Readings* to make sets of cards (one set of all readings per group). Place materials in a central location. Have students work in groups of four.

PROCEDURE

1. Ask students a question about how one discovery or invention can lead to another, such as, *Which came first, the wheel or the cart? Or Would a light bulb be of any value if ways to utilize electricity had not been invented?* Discuss students’ responses.
 2. Distribute the *Discovery Readings* sets to each group. Tell students that they will use clues from each reading to figure out the historical order in which events described in the articles occurred. Have each student select a highlighter and one article from the group’s set. Instruct students to highlight words that provide clues related to the order of events.
 3. When a student finishes an article, he or she should pass it to another group member until all members have read and marked all of the articles. If a word or phrase already has been
- highlighted and the next reader agrees with the marking, that reader should draw a line with his or her highlighter above the mark.
4. Next, have each group discuss and determine the most likely order of events and discoveries.
 5. At the bottom of each reading, have each group list major clues that might help others recreate the order of events.
 6. Distribute the *Timeline* sheets. Have groups cut out the sections and tape the timeline together.
 7. Tell students to paper clip (not tape) the articles in order along the top of the timeline. Have each group share its results with the class. Discuss any differences among the groups’ timelines. If there is a disagreement, let students present their cases. Lead the class toward consensus. Ask, *Why do all of the groups have the same article first on the timeline?* (microscope) *What is the most logical second event?* (agar plates) Ask, *Why is the development of this technique important?* (It provided a reliable way to grow bacteria for study.)
 8. Based on the readings, it will be difficult for students to decide whether “The Discovery of Penicillin” or “Contagious Living Fluid” came first. Ask, *What additional information might help us to make a decision?* You may want to ask students to research these topics on their own.
 9. Finally, have groups calculate the number of years between events and discuss the possible reasons for the varying time intervals between discoveries. You may wish to discuss why related discoveries sometimes occur close together in history.
 10. Allow students time to add this information to their concept maps.





Timeline

Cut out the sections and tape together to form a long strip, starting with the 1600s on the left and ending with the 1930s on the right.

1600s 1881

1884 1890s

1929 1930s