Lesson 2

Graphing Scientific Data

Hilleman & Vaccines

Student Pages

VACCINES & INFECTIOUS DISEASE

Infectious diseases have been around for thousands of years and have plagued humanity across the globe. As early as 1000 CE, people in China, India, Africa and Turkey used variolation to immunize people against smallpox. This method involved inoculating people with material taken from an infected patient in the hope that a mild infection would result and cause immunity. The practice spread to Europe where it caught the attention of Edward Jenner, who used cowpox pustules to inoculate patients successfully against smallpox in 1796, laying the foundation for the modern concept of vaccines.

In the late 1800s, Louis Pasteur proposed the Germ Theory of Disease and created the first live attenuated bacterial vaccine in 1879 against chicken cholera, followed by rabies in 1884, which he used in humans in 1885. Vaccine research and development saw exponential expansion in the mid-20th century through the efforts of Dr. Maurice Hilleman, Dr. Jonas Salk (polio), Dr. Charles Mérieux (vaccine mass production), and others.

Vaccine Safety

Today, vaccines are credited with saving millions of lives. Their regulation, development and use are organized around mandates, research and testing, informed consent and disparities in access.

Vaccine mandates, particularly in schools, seek to protect the greatest number of people. Research and testing ensure that vaccines must pass rigorous safety and efficacy standards. The inclusion of diverse experts of scientific and social disciplines invites ethical discussions that prioritize safety and communication. Informed consent is part of the transparency process. Access issues remain a challenge as access can depend on socioeconomic and ethnic status. There is a need for continued efforts to ensure equal opportunity for people to benefit from vaccination.

Throughout his life, Dr. Hilleman was obsessed about vaccine safety. He rigorously tested all of his vaccines and led by example. In developing his hepatitis B vaccine in the late 1970s, Dr. Hilleman used human blood and developed a chemical process to kill any possible contamination. Convinced of its safety, Dr. Hilleman first tested the vaccine on himself, then conducted a successful trial among Merck employees and executives. In the case of the mumps vaccine, he vaccinated his second daughter, Kirsten, with the vaccine he had named for his first child, Jeryl Lynn.

When a vaccine works, the disease does not manifest. People often forget the devastating effects of past pandemics when millions died. When asked about the growing levels of vaccine skepticism in the documentary HILLEMAN: A Perilous Quest to Save the World's Children, Dr. Hilleman lamented, "I think the only way we're actually going to get people to understand the importance of these vaccines is to watch children suffer again."

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Vaccines undergo a rigorous safety process, including review of every study, phase and trial by an independent safety board of experts and the Federal Drug Administration, before a vaccine is authorized for use in the United States public. People concerned about the safety of vaccines are invited to visit cdc.gov/vaccine safety/index.html for more information.

Vaccine Development in Montana

Founded in response to the outbreak of spotted fever in the Bitterroot Valley in 1900, Rocky Mountain Labs is now a National Institute of Health biomedical research facility located in Hamilton, Montana. For the first two decades of its existence, scientists traveled to the valley to investigate the cause, treatment and prevention of spotted fever. Initially, they lived in tents and worked out of cabins and farmhouses. In fact, Dr. Ralph Parker even performed research on ticks in an old woodshed before renting an abandoned schoolhouse in 1921. Dubbed the Schoolhouse Lab, this building would become the site of the creation of the first effective vaccine against spotted fever.

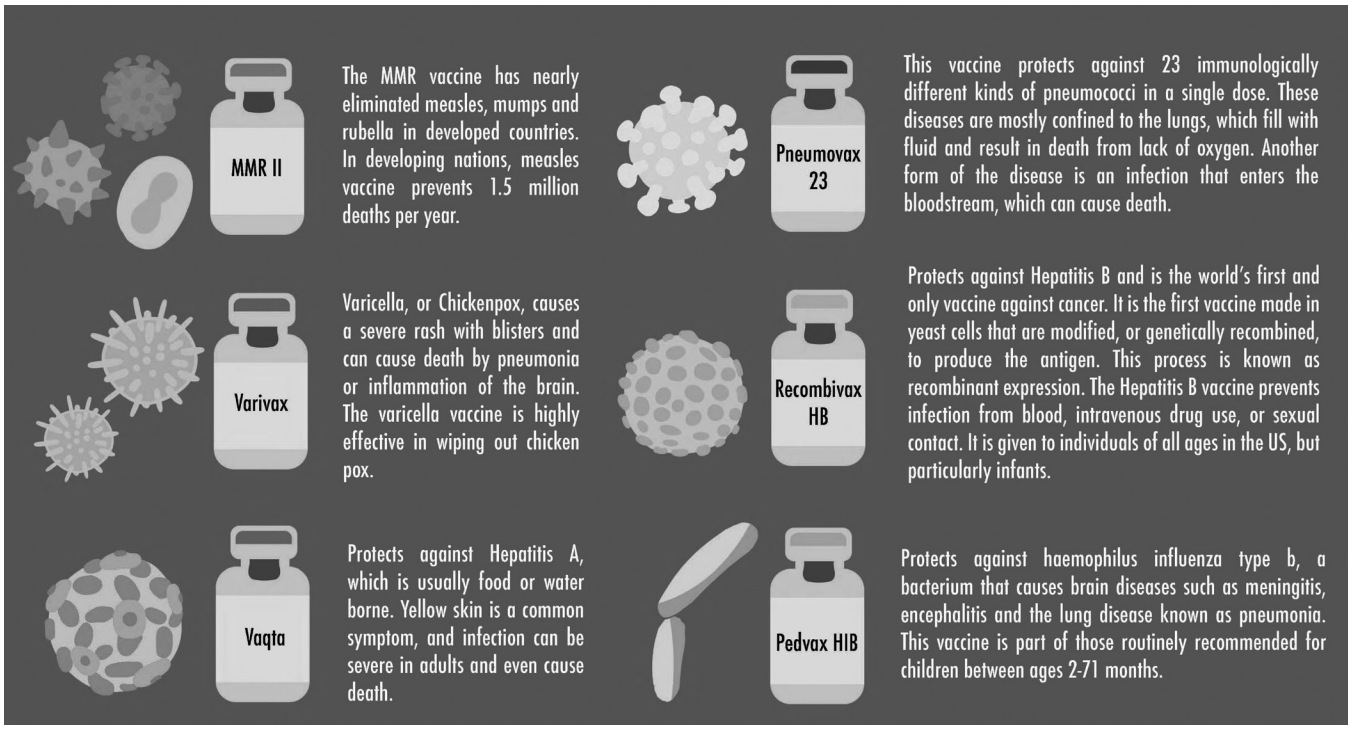
In 1927, the Montana state legislature appropriated $60,000 for the construction of an entomological laboratory, and Hamilton was chosen as the site. This inspired protests, as residents were worried that ticks might escape and widespread infection would occur. Construction was completed in 1928, and the Public Health Service rented space within the building for continued research on vaccine production. In February 1932, the federal government purchased the facility for $68,757 from the state of Montana. Rocky Mountain Labs became part of the National Institute of Health in 1937, manufactured the United States' supply of yellow fever vaccines during World War II, and helped develop the Ebola vaccine in 2014 for use in West Africa.

Today, the facility is one of nine federal facilities in the country with a biosafety Level 4 capacity, the highest such rating, and scientists there are responsible for Investigating a wide variety of infectious diseases.

Front exterior view of the Canyon Creek Schoolhouse Laboratory in Hamilton, Mont. Image Courtesy Rocky Mountain Labs Historical Collection, Montana Memory Project

VACCINE SPOTLIGHTS

During his lifetime, Dr. Hilleman developed over 40 vaccines, including eight of the 14 vaccines commonly recommended for children. The pediatric vaccines prevent more than four million deaths per year worldwide. Other vaccines prevent respiratory illness, hepatitis A and B, and even cancer. Thanks to these vaccines, the principal diseases of children are no longer significant in the USA and in much of the developed world. Some of these vaccines and their associated diseases are described in the infographic below.



Graphic by Jenn Hall,
Words by Sabre Moore
"Shots Felt 'Round The World" Exhibition
by Carter County Museum and Museum of the Rockies (2021).

Graphing Guidelines

1. Graphs should have a **title** that is clear and concise about the content so that the graph can stand alone. The title should include the information on both axes and describe the visual you are trying to portray. The reader should not have to study the axes closely to figure out what you were trying to represent.

2. In APA formatting, the **title** is to be italicized, in title case, and left aligned (The Writing Lab, The OWL at Purdue, & Purdue University, 1995-2020). This is up to your teacher.

3. **Axes** should have significant words capitalized and include units of measurement with proper abbreviations. For example, you might use days, or months, or milliliters. One axis might read, "Branch Length (cm) or Volume (mL)". The abbreviations will appear in parentheses. You could also write out, "Branch Length in Centimeters". The first way is more brief and still includes the units of measurement.

4. The s**cale** you choose should include all data points and allow for interpolation or making predictions.

5. **Fonts and colors** should be very easy to read and not distract the reader from the visual representation of data.

6. A **legend** should be used, and well-labeled, anytime it makes the graph clearer.

Bibliography

The Writing Lab, The OWL at Purdue, & Purdue University. *Tables and figures.* Retrieved from https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_and_style_guide/apa_tables_and_figures.html.

Circle, Line and Bar Graph Practice

Instructions:
1. Use the data below to make a graph in Google Sheets. The graph must include a title, labels in each section of the graph, and a color key. (Communicable Disease in Montana Annual Report 2018. Montana Department of Public Health)

Category	Percentage of Reported Communicable Diseases
Enteric Diseases	9.8
General Communicable Diseases	0.5
Hepatitis	17.2
Sexually Transmitted Diseases	67.6
Vaccine Preventable Diseases	3.8
Zoonotic Disease	1.0

Instructions:
2. Create a graph of the data below. Make sure you include a title, label both axes, and a color key with the series labeled. (Vaccination coverage percent by grade and antigen among public and private school students, Montana 2018-19 academic year. Montana Department of Public Health)

Grade Level	2+ Dose MMR (%)	3+ Doses IPV (%)	4+ Doses DTaP (%)	1+ Dose Tdap (%)
9	97	96.9	96.7	95.8
10	96.8	96.2	96	96.2
11	97.3	96.8	96.5	96.4
12	97.9	97.3	97.1	97.2

3. What is the independent variable?

4. What is the dependent variable?

5. What could you use as a control?

6. What would you have for constants (at least 3)?

Instructions:

7. Make a bar graph of the following data. Make sure you include a title, labels for both axes, labels for the categories, and a color key. (COVID-19 Vaccination Data from Montana Department of Public Health, April 9, 2021.)

Montana County	Number of Eligible Population Fully Immunized	Total Eligible Population
Blaine	1654	4910
Carter	201	1003
Dawson	1795	6944
Gallatin	18017	94211
Garfield	218	1001
Hill	3686	12328
Liberty	462	1917
Musselshell	649	3895
Phillips	831	3113
Teton	1000	4810
Valley	1411	5917
Wheatland	340	1722

8. What is the dependent variable?

9. What is the independent variable?

Bibliography

Montana Department of Public Health and Human Services. 2018-2019 School Immunization Assessment Results. dphhs.mt.gov. https://dphhs.mt.gov/Portals/85/publichealth/documents/Immunization/2018-2019SchoolImmunizationReport.pdf. Published May 2019. Accessed March 2021.

Communicable Disease Epidemiology Section, Public Health and Safety Division, & Montana Department of Public Health and Human Services. Communicable Disease in Montana Annual Report 2018. dphhs.mt.gov. https://dphhs.mt.gov/Portals/85/publichealth/documents/CDEpi/StatisticsandReports/CDEpiAnnualSummaryReports/2018CDEpiannualreport_final.pdf. Accessed March 2021.

Table 2. Vaccination coverage percent by grade and antigen among public and private school students, Montana, 2018–2019 academic year.

Grade	No. students	Conditional Exemptions (%)	Medical Exemptions (%)	Religious Exemptions (%)	1 Dose Hib (%) *	1 or 2 doses Varicella (%)‡	2+ doses MMR (%)	3+ doses IPV (%)	4+ doses DTaP (%)	1+ dose Tdap (%)
Pre-K under 59 months	4,039*	62 (1.9)	9 (0.2)	138 (4.2)	3736 (92.5)	4,754 (92.9)	4,785 (93.3)	4,924 (93.7)	4,866 (93.0)	
Pre-K 59 months+	5,380									
K	12,480	238 (.5)	27 (0.4)	529 (3.4)		11,588 (95.4)	11,683 (96.1)	11,698 (96.0)	11,607 (95.6)	
1	12,088	60 (0.5)	27 (0.2)	482 (4.0)		11,481 (95.0)	11,515 (95.3)	11,531 (95.4)	11,459 (94.8)	
2	12,007	31 (0.3)	35 (0.3)	409 (3.4)		11,506 (95.8)	11,534 (96.1)	11,526 (96.0)	11,455 (95.4)	
3	11,878	37 (0.3)	35 (0.3)	429 (3.6)		11,353 (95.6)	11,391 (95.9)	11,378 (96.0)	11,305 (95.2)	
4	12,257	45 (0.4)	39 (0.3)	426 (3.5)		11,752 (95.9)	11,823 (96.5)	11,792 (96.2)	11,716 (95.6)	
5	12,714	55 (0.4)	47 (0.4)	423 (3.3)		12,143 (95.5)	12,242 (96.3)	12,213 (96.1)	12,129 (95.4)	
6	12,386	43 (0.3)	51 (0.4)	355 (2.9)		11,936 (96.4)	12,008 (96.9)	11,996 (96.9)	11,982 (96.7)	
7	12,470	77 (0.6)	54 (0.4)	450 (3.6)		12,008 (96.3)	12,081 (96.9)	12,070 (96.8)	12,067 (96.8)	11,679 (93.7)
8	11,727	37 (0.3)	65 (0.6)	380 (3.2)		11,304 (96.4)	11,385 (97.1)	11,382 (97.1)	11,368 (96.9)	11,211 (95.6)
9	11,839	20 (0.2)	47 (0.4)	388 (3.3)		11,359 (95.9)	11,485 (97.0)	11,470 (96.9)	11,444 (96.7)	11,343 (95.8)
10	11,314	18 (0.2)	57 (0.5)	341 (3.0)		10,857 (96.0)	10,957 (96.8)	10,885 (96.2)	10,861 (96.0)	10,881 (96.2)
11	10,595	22 (0.2)	61 (0.6)	309 (2.9)		10,154 (95.8)	10,312 (97.3)	10,257 (96.8)	10,229 (96.5)	10,218 (96.4)
12	9,912	13 (0.1)	73 (0.7)	293 (3.0)		9,481 (95.7)	9,707 (97.9)	9,640 (97.3)	9,622 (97.1)	9,630 (97.2)

*Students in Pre-K are required to have at least on dose of Hib vaccine administered on or after their first birthday, unless the student is older than 59 months.

**Tdap = tetanus toxoid, diphtheria, and acellular pertussis for 7-12th grades.

‡Varicella was added to school vaccination requirements beginning in the 2015-2016 academic year. The rate includes those reported as having a verified history of disease