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Vaccines and the Outbreak of Nonsense

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Introduction

Vaccines are the only intervention that has eradicated an infectious disease from planet Earth. Perhaps there has been no bigger leap in terms of public health than the widespread introduction of vaccines. Despite this, there are controversies and disbelief surrounding the effective and safe use of vaccines. Building a deeper understanding of the science behind vaccination will allow students to understand important biological functions, and by examining the benefits, costs, and controversies surrounding vaccines, students will gain insight while building critical thinking skills**.**

In today's world, "fake news" has run amok. Whether in the realm of politics or wild rumors about celebrities or fad diets, no area of modern life seems to be free from the plague of bad information shouting down good information. We find ourselves in an increasingly scientific and technologically driven society, but unfortunately, science is not exempt from the plague of bad information and nonsense. The need for scientific literacy is critical.

We often discuss literacy as educators, and often we even speak of the need for scientific literacy in particular. What I propose for this unit is to teach information literacy that will apply to specific scientific instances, but more importantly, students engaging with this unit will come away with information literacy they can apply in any classroom – and in life.

Who the Unit Serves

As a middle school science teacher at Central Junior High School in Tulsa, Oklahoma, I have taught both 7th and 8th grade science. Moving full time to 7th grade science has opened up a great opportunity to dive deeper into the biology component of the 7th grade science course.

7th Graders at Central Junior High School in Tulsa, Oklahoma are vibrant, hilarious and insatiably curious learners who crave meaningful, engaging content. Providing that content will hopefully lead to a lifelong love of learning. The diverse student population at Central Junior High come to us at all levels, with a significant portion arriving with gaps in knowledge and different learning strengths and challenges. To reach them, I work to create a variety of learning tasks and endeavor to make learning fun and interesting.

As a teacher in Oklahoma, I have seen the devastating consequences of budget cuts on classrooms and on students. A large part of the challenge is the loss of high quality experienced teachers to other states where pay and working conditions are better. Thus, I am motivated to create this unit to help all teachers get quality content to students, but especially teachers who work in challenging circumstances.

The History of Vaccines

Introduction

Vaccination has been a technology breakthrough for humanity since its implementation at scale in fighting infectious diseases. At its core, vaccination is a form of preventative care. But in wealthy nations, parents of recent generations have not witnessed the ravages of infectious diseases within their lifetimes. As a result, some parents have come to question the wisdom of subjecting healthy children to a series of injections when there is seemingly no obvious or apparent danger to their children's health.

Still, the fact remains that vaccination is a critical part of the care of children. Vaccination has dramatically reduced infant mortality over the last century and has even defeated diseases like smallpox globally, and greatly reduced the incidence of other diseases like polio.[1]

Smallpox is a deadly contagious disease caused by the variola virus. The virus is transmitted directly from person to person or through infested clothing and bedding, and the disease has a case fatality rate as high as 30%.[2] It was a leading cause of death in 18th century Europe and had a mortality rate of 80% in infants.[3] Because of the virulence of the smallpox virus, doctors were keenly interested in finding a way to prevent or reduce its impact. Perhaps this is why the first progress towards vaccines was centered on preventing smallpox.

So where did the idea of vaccines come from?

China

Claims have been made that the practice of inoculation against smallpox in China date back as far as the tenth century, but reliable records would indicate that the practice dates back to the 16th or 17th century, still predating the European breakthroughs in vaccination.[4] The Chinese method of inoculation is called variolation and involves using the 'live' or disease-causing form of smallpox virus.

Variolation practices sometimes include the use of a needle or similar tool to place dried and powdered smallpox scabs or fluid into the skin of a non-afflicted individual, with the aim of creating a milder infection with a lower mortality rate, of between 2% to 3%.[5] The hope is that after treatment the inoculated person will be less susceptible to the more intense, deadly form of the smallpox virus.

The Manchu Imperial family, which ruled China from the 17th through early 20th centuries, desperately avoided contracting smallpox. Measures included not allowing the first Manchu ruler, Shunzhi, to enter the capital city. He contracted smallpox and died anyway – as did large numbers of his troops following the conquest of China.[6] His successor would implement variolation in 1681. In 1742 the practice of variolation was officially

adopted and legitimized by the Imperial court, making it a mainstay of Chinese medical practice,[7] and by 1807, charities in China began offering the variolation inoculation for free.[8]

It took time for the practice of variolation against smallpox to spread across China. Political necessity on the part of the ruling family saw them adopt the practice, and in so doing, added legitimacy to it. The practical benefits of variolation outweighed the risks, with 2% to 3% dying from variolation as compared to a 30% mortality rate for a full blown virus infection.

While China saw success with its practices, it would rapidly adopt the later developed findings from Europe, often attributed to Edward Jenner.

Europe

Edward Jenner (1749 – 1823) was a doctor and variolator in England, who with the help of his nephew, Henry Jenner, collected epidemiological evidence on 28 individuals between 1792 and 1797, which he used to create a hypothesis.

In particular, Jenner was interested in local beliefs that milkmaids seemed to be immune to smallpox. After seeing a supportive correlation in the data, Jenner took a sample of cow pock from a diary maid named Sarah Nelmes, and inserted it into the arm of a boy named James Phipps. The vaccination produced a lesion only at the inoculation site unlike variolation and did not cause serious illness.[9]

Jenner then subjected Phipps to a variolation treatment using live smallpox virus. Phipps did not become ill, which convinced Jenner that he had found a safe inoculation.[10] This seemed to confirm Jenner's theory: Perhaps cowpox could confer a protection against smallpox infection, and those routinely exposed to cattle that had contracted cowpox were thus immune.[11]

Jenner's work prompted the spread of his vaccination technique, and laid the foundation for other scientists to build deeper understandings of disease spread and prevention. Jenner's legacy continued well beyond his death. The last recorded natural case of smallpox on the planet occurred in 1977. Shortly afterwards in 1980, the World Health Organization declared the disease was eradicated, following a global effort to vaccinate as many humans as possible against the virus.[12]

Despite the massive impact of vaccines, Jenner did not fully understand why his method worked because he did not understand the germ theory of disease. Understanding the germ theory allowed science and medicine to take Jenner's discovery to the next level.

The Germ Theory of Disease

While today we take for granted the idea that microscopic organisms can cause illness and disease, this idea was revolutionary and was not widely accepted until much later than the concept of vaccination. Jenner was able to empirically demonstrate that smallpox vaccination worked but did not offer a comprehensive view about the underlying cause of the disease. That is because germ theory was not yet widely accepted. The predominant theory was spontaneous generation.

Even as far back as 1658, scientists were able to view microorganisms under a microscope, but did not make the link that some microbes are disease agents. The common belief was that living organisms could arise from nonliving things. Decomposition, fermentation and the like were considered to spontaneously arise. This would later be disproven by Louis Pasteur.

Louis Pasteur (1822 – 1895)

Louis Pasteur was a French scientist who conducted research on microbiology in the 19th century, and the process of pasteurization was named for him. The experimental evidence debunking the theory of spontaneous generation came from Louis Pasteur. In order to prove that life could not originate from nonliving matter and to prove his germ theory once and for all, Pasteur set out to devise an experiment to test germ theory.

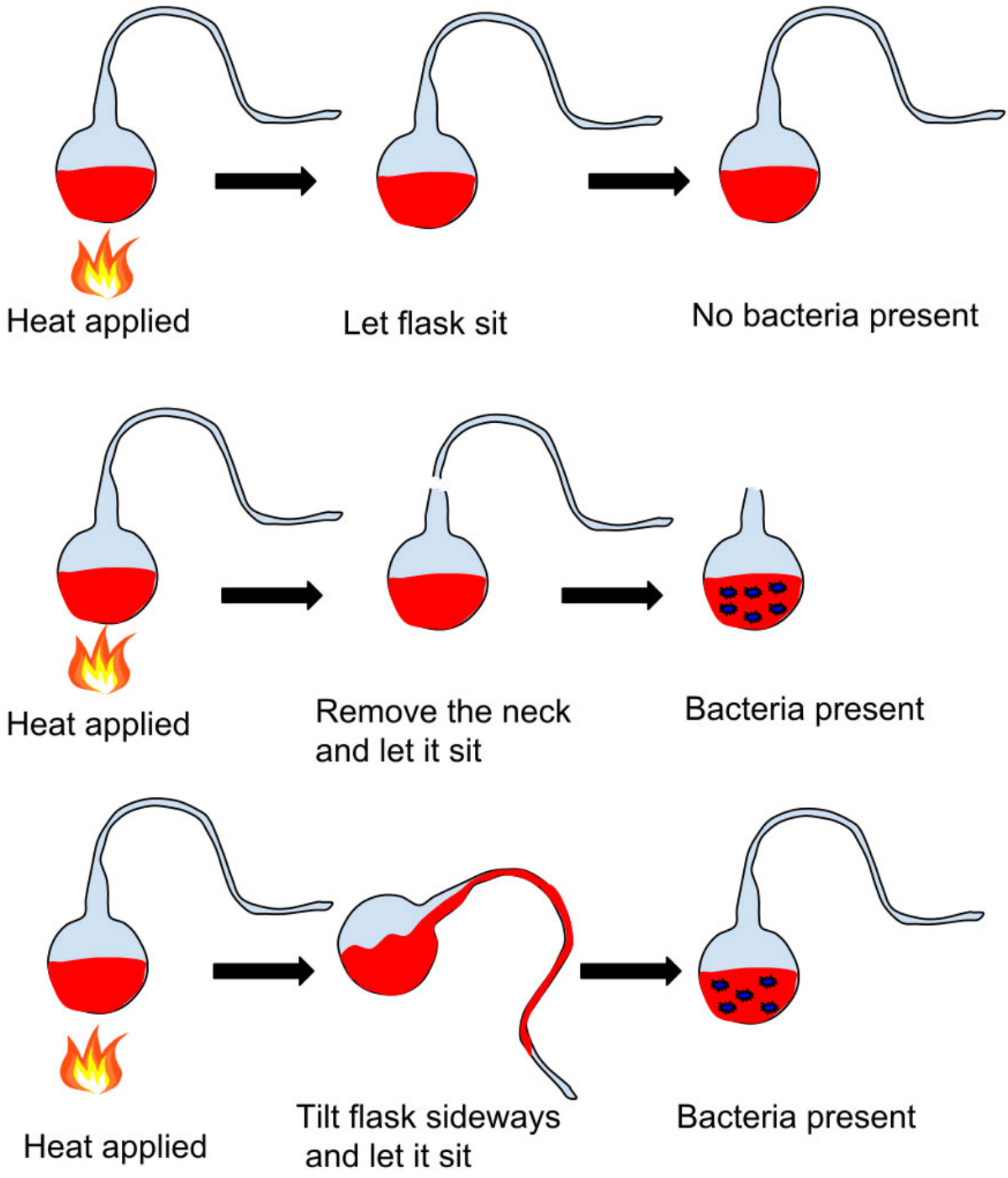

Figure 1: Louis Pasteur's experiment illustrates that spoilage does not spontaneously generate.

Creative Commons 4.0. Author: Kgerow16.

Pasteur's experiment started with a preparation of a nutrient broth similar to a soup. He placed equal amounts into long necked flasks, one with a straight neck and one curved. Both of the flasks were boiled to sterilize any living matter in the broth. They were allowed to sit for several weeks afterward at room temperature. He noted that the broth exposed directly to the air was cloudy and had microorganisms living in it, but the broth where germs could not land in the flask was still clear.[13]

The idea that microorganisms are responsible for decomposition and contamination is taken for granted today. The discovery that life does not spontaneously generate but comes from other life has been added to the pantheon of scientific knowledge alongside evolution. [14]

But the full medical implications for germ theory would not come close to its full potential and use until the advent of Joseph Lister's surgical techniques.

Joseph Lister (1827 – 1912)

Lister is well known for his practices regarding antiseptic surgical techniques in a time when even simple practices like handwashing were unheard of in a medical context. He used carbolic acid spray on surgical sites and insisted on clean instruments, whereas other surgeons wore clothing with blood splatters from one patient while working on other patients.

Convincing fellow doctors of the threat from microorganisms got easier after Lister operated on Queen Victoria to drain an abscess, using his techniques to help save her life. He would later be knighted for his efforts in improving surgical outcomes.[15]

What inspired Lister's breakthrough and belief in microorganisms causing disease? Simply put, he had been encouraged to read over Louis Pasteur's papers, *Researches sur la putrefaction* (Research on Putrifaction) and made the intellectual leap that the same thing that causes food spoilage could be affecting injured people, especially those with compound fractures of bones that broke the skin and were exposed to the air.[16]

His ideas that invisible microorganisms were responsible for disease was generally supported by the research of Robert Koch, who worked to show which germs caused which diseases.

Robert Koch (1843 – 1910) and his Postulates

Robert Koch's first major breakthrough came from working with anthrax (a bacterial disease) and farm animals. Koch started by confirming the work of prior scientists. He inoculated mice with material from the spleens of cattle who had died of anthrax as well as another set of mice that were inoculated with material from the spleens of healthy animals. The mice that received the spleen material with the anthrax bacilli died.[17] This was Koch's first step in confirming that there was a link between a specific disease and a specific microorganism.

Koch continued his work by growing pure bacilli samples in the laboratory on newly invented petri dishes and he developed new ways of staining bacteria to make them easier to observe under the microscope.[18] Koch's additional work went on to isolate the disease-causing agent for Tuberculosis.[19]

To understand how to isolate and prove that certain diseases were caused by a specific microorganism, Koch established four basic postulates:

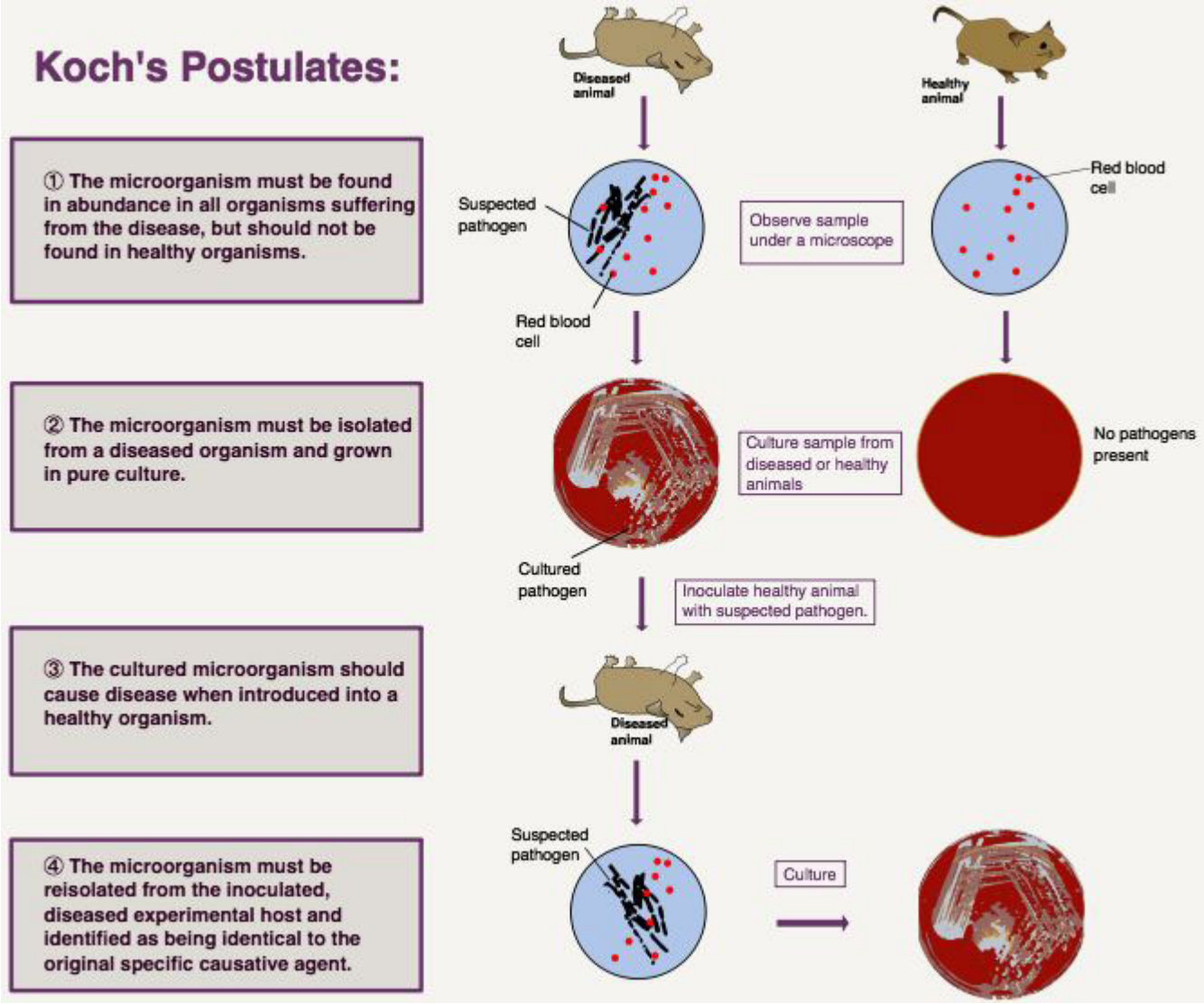

Figure 2: Koch's postulates which are designed to establish causal relationships between disease and microorganisms. Creative Commons 3.0. Author: Mike Jones.

1. A specific microorganism is always associated with a given disease.
2. The microorganism can be isolated from the diseased animal and grown in pure culture in the laboratory.
3. The cultured microbe will cause disease when transferred to a healthy animal.
4. The same type of microorganism can be isolated from the newly infected animal.[20]

The application of Koch's postulates is not universal. Sometimes organisms cannot actually be grown in a culture separately from a living host, so some disease causing microbes would fail to meet all of Koch's postulates. What they do demonstrate is the importance of establishing casual relationships rather than simple correlative relationships that can often be mistaken for causal, as we will later see with the relationship between vaccination and autism.

Why is it important to understand the history of germ theory to understand and teach vaccination? While Jenner relied on science to the extent that he performed epidemiological research, formulated a hypothesis, and tested it, he did so without fully understanding the science of disease or the causes of smallpox and

cowpox (different infectious agents).

By modern standards, Jenner was putting people at risk in his experiments. Today we know that in order for vaccines to be effective, they rely on the proven relationship between disease causing viruses and bacteria and the actual disease they cause. Perhaps this is why it took almost 100 years and additional work before other vaccines were created. So, how do vaccines work?

Benefits of Vaccines

How Vaccines Work

While a lot of medical practice is focused on treating the sick, vaccination is a rare opportunity to prevent infection and the course of a disease from ever happening. In fact, an entire disease agent can be driven into eradication through vaccination, as was the case for variola virus that causes smallpox disease. In the 20th century alone, smallpox killed some 300 million people before it was halted by vaccination.[21]

There are increasing concerns of bacterial agents rapidly evolving under selective pressures from antibiotics. It is a well-known fact that antibiotics are becoming less and less effective. Vaccination is an obvious answer. Vaccination primes the body's immune system to fight off disease causing agents without the use of antibiotics and can entirely prevent the course of illness. Developing vaccines is no easy task. Because creating vaccines is difficult, antibiotics are still very important for treating disease.

There are two basic categories that vaccines fall into: active and passive. Active vaccines can include live and non-live vaccines, because it produces a strong immune response, making it a better vaccine.[22] Essentially, the adaptive immune system develops a "memory" of foreign invaders and will be primed to protect the body once exposed.

The human immune system has the ability to respond to foreign invaders in specific ways and non-specific ways. It can take days for the immune system to craft a specific response to an invading microorganism, and those days can be critical in terms of surviving the infection. During that intervening period the virus or bacterium could be exponentially reproducing. This can lead to the onset of severe diseases, and the victim also can be contagious and spread the infection to others. Vaccination closes the window to create a specialized response, priming the body to immediately fight off the invader, helping to prevent or shorten an illness and stop the spread of the disease causing agent.

Herd Immunity

Herd immunity, sometimes also called community immunity, occurs when the number of people vaccinated and fully immunized is high enough as a proportion of the population to prevent the spread of a disease causing pathogen even to those who are unvaccinated and vulnerable.[23]

Japan offers a case study that demonstrates the importance of keeping vaccination rates high enough to confer herd immunity. Between the years 1962 and 1987, school-aged children were required to be vaccinated against influenza virus that causes the flu, not just to protect the children being vaccinated, but also to protect the elderly, nonvaccinated citizens of Japan. There is a significant portion of the elderly

population in Japan that lives with extended family, including school aged children. Incidence of flu, including death rates, fell during this period. The program of mandatory vaccination was discontinued in 1994. The authors of the study believe that 37,000 to 40,000 deaths were prevented annually by the program. Additionally, they found while the program was in effect, one death was prevented for every 420 children vaccinated.[24]

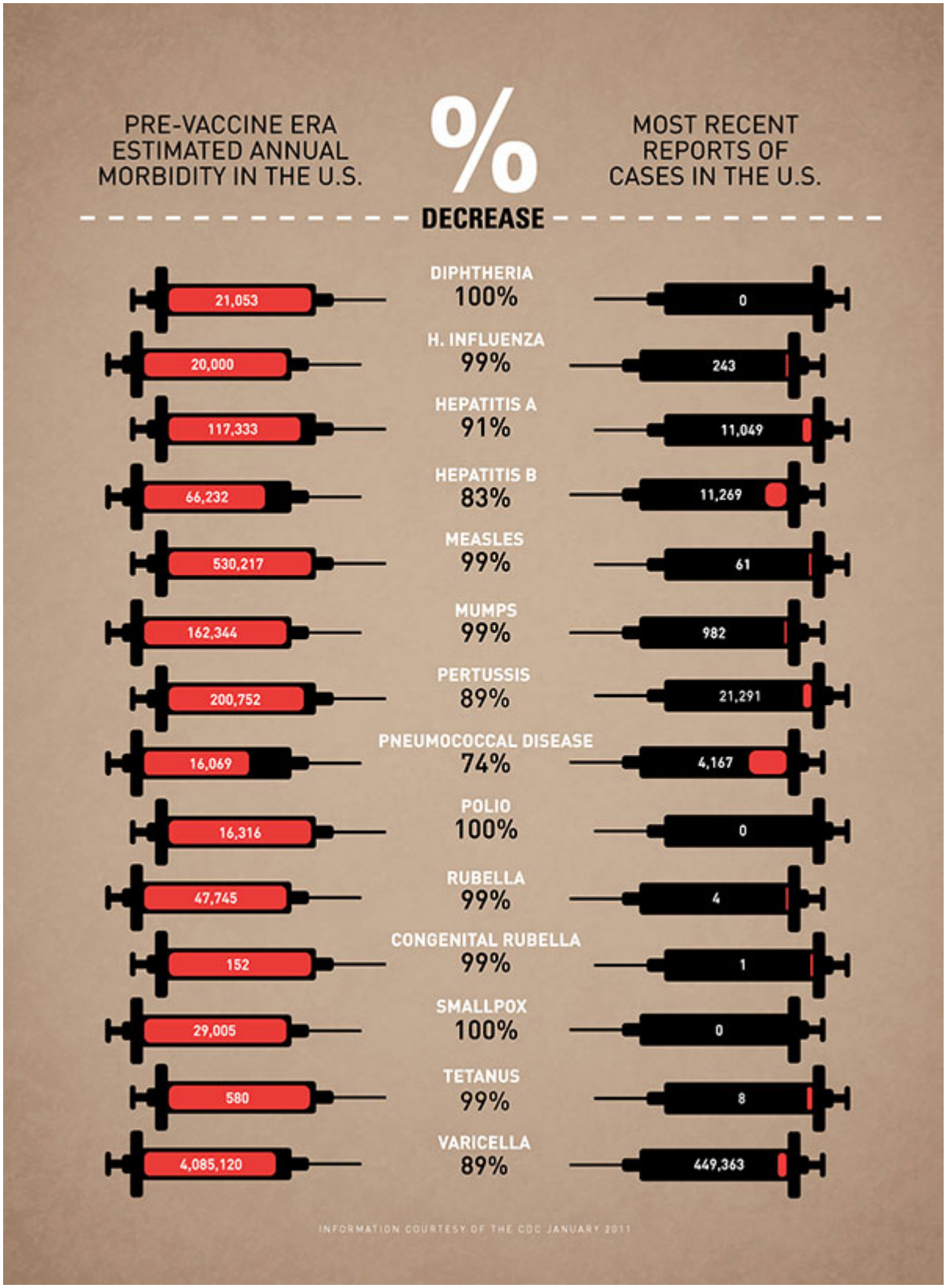

Figure 3: Pre-Vaccine era estimated annual morbidity (death) in the U.S. as compared to the most recent reports as of 2011. Creative Commons 4.0. Author: Leon Farrant.

According to the World Health Organization, 3 million lives are saved annually thanks to vaccination, and 750,000 children are saved from disability.[25] Other organizations, like UNICEF credit immunization for saving 9

million lives each year.[26]

Vaccination is key in saving lives. Vaccines make once fatal infections less of a threat by preparing our immune systems to fight them. This has drastically cut down on the disease mortality of many infectious agents, including those causing the diseases diphtheria, hepatitis, polio, smallpox and many others. In doing a simple cost benefit analysis to decide if vaccinations are worth the trouble, how should we value a human life? Or 3 million human lives? Any rational thinker or voter with real research and data before them would have to say that vaccines have done an amazing job at making the world safer for human existence. UNICEF projects that if vaccines were used against all vaccine preventable diseases, an additional 16 million lives could be saved each year.

Disease Eradication

Famously, smallpox was declared eradicated in 1980. Smallpox was the first vaccine available and the breakthrough of smallpox eradication came after decades of constant work to diligently vaccinate people around the entire planet. So far, smallpox is the only human disease that has been completely eradicated, but that does not mean that it will be the last. Additionally, Rinderpest, a bacterial disease that affected cattle, has also been globally eradicated.

According the Centers for Disease Control, the numbers are straightforward, and progress is being made. In the United States, measles was a common if not universal childhood disease. Most doctors in the modern era have not seen a case of the measles. In 1921, 15,000 Americans died because of the measles. Only two cases were reported between 2004 and 2014. Between 1964-65, 12.5 million Americans were killed by the viral disease rubella during an epidemic. 2,000 babies were killed, and 11,000 miscarriages took place. Since 2012 there have been 15 cases reported to the CDC.[27]

By aiming to attain high enough levels of vaccination coupled with the effects of herd immunity, diseases like polio could easily be next on the list for complete global eradication. Already polio has gone from a worldwide-threat that was potentially fatal or could cause lifelong disability, to being reduced by 99%; In fact, there are just three countries where polio has not been completely eradicated.[28]

This does not mean that vaccination is perfect, nor does it mean that vaccination comes without costs.

Costs

Equitable Distribution

Unfortunately, vaccines are not distributed to all children and people in the world equally. Vaccines have accounted for a 74% reduction globally in deaths from measles in the last decade alone. Despite this, 1.5 million children are dying each year from vaccine preventable diseases. For some countries in the world, the price for vaccines places them out of reach. Additionally, there are challenges in some countries in terms of providing the basic infrastructure to even distribute them.

More than 70% of unvaccinated children live in 10 countries with large populations. Private, public, non-governmental organization cooperation has worked to invest billions of dollars to spread vaccines to these

countries, but problems persist in basic infrastructure, like roads and refrigeration, to deliver these lifesaving vaccines.[29]

Additionally, vaccine development is expensive. It is difficult to nail down the cost of vaccine creation in particular, but a single drug can cost over a billion dollars to bring to market.[30] In an instance where vaccination has been its own worst enemy, many companies view vaccine preventable illnesses as already largely solved, and profit margins too slim to continue research on new vaccines. Many companies have stopped work on vaccines altogether. For companies that have continued to work on vaccines, the high costs of research and development are passed on to the patients. In some cases, companies have drastically lowered prices for developing countries while keeping prices high in developed nations to offset the cost of development. [31]

Influenza, more commonly known as the flu, is an instance where the lack of development of new vaccines can harm even wealthy nations. In the United States since 2010 the flu has caused between 9.2 million and 35.6 million illnesses, 140,000 to 710,000 hospitalizations and between 12,000 and 56,000 deaths.[32]

Centers for Disease Control estimate that vaccinations have prevented 13.59 million cases of the flu since 2005. However, the flu virus mutates frequently and flu vaccines need to be reformulated each year; scientists have to make predictions about which strain will be more common and how to match the vaccine to the virus – the effectiveness for flu vaccines has ranged between 10% and 60%. Additionally, supplies of the vaccine also often fall short of what is actually needed[33]

There has been discussion and attempts concerning creation of a universal vaccine for the flu, targeting parts of the virus that do not frequently change or mutate. However, federal appropriations for this research have only reached $40 million, far short of the billion dollar threshold often needed for new medicines to be fully researched and developed.[34] This is not to imply that developing a universal vaccine is simply a matter of allocating dollars to the problem, as developing it would be a large scientific undertaking with no guarantee of success.

Controversies

Historic Anti-Vaccine Movements

One of the main cruxes of the anti-vaccination movement dating back to the early 1800s is that vaccination is an encroachment onto personal liberty, an argument that inflamed tensions as governments began legally mandating vaccinations. Additional anti-vaccination sentiment stemmed from sanitary and religious grounds. At various points early in vaccine history, clergy were against the practice because the smallpox vaccine required the introduction of animal tissue into people.[35] Because public education around vaccination was brand new and because the germ theory was not yet proven, some of this pushback is understandable.

But, progress continued and England passed the 1853 Vaccination Act making the inoculations mandatory for infants up to 3, and later expanded to age 14. Citizens responded by protesting and demanding the rights to control what would happen to their children. By 1885, demonstrations of up to 100,000 people took place in Leicester. Legal penalties were removed from the laws as a result, and conscientious objection was allowed as

a way to avoid vaccination.[36]

Anti-vaccination campaigns also spread in the United States. However, Cambridge Massachusetts issued a mandate in 1902 after a smallpox outbreak. Henning Jacobson refused to be vaccinated claiming a violation of his personal rights. The case went all the way to the U.S. Supreme court, where the court found in favor of the compulsory law.[37]

Figure 4: 1804 cartoon caricature of Smallpox and Inoculation Hospital in Pancras London. Caption reads "Cow-Pock—or—The Wonderful Effects of the New Inoculation!" Library of Congress.

Modern Anti-Vaccine Movements

Historic opposition to vaccines is at least to some degree understandable. The adoption of a new technology with the possible downside of illness or death, or even transmission of additional disease in the case of arm-to-arm transfer of immunity, were real issues. However, in the modern context, vaccines have a track record for safety, disease eradication and reduction in mortality from disease.

Despite all this, some parents have concerns that are not necessarily based on rational evidence. For example, one survey reports that a quarter of parents felt that their children receive too many vaccines and the result is a weakened immune system, with worries of a "pincushion effect" due to the number of vaccines a child is recommended to get in the first two years of life. [38]

It is common wisdom that vaccination has fallen victim to its own success as a medical treatment. Because it works so well, many of the most harrowing childhood diseases have all but disappeared in some parts of the world. Because of this, people no longer see the need to subject their children to the practice.

We expect sound logic from those who serve at the highest level of our Justice system, and in this case an analogy used by Supreme Court Justice Ruth Bader Ginsberg applies to vaccines. Regarding the voting rights act, Justice Ginsberg stated: "Throwing out preclearance when it has worked and is continuing to work to stop discriminatory changes is like throwing away your umbrella in a rainstorm because you are not getting wet."

Similarly, throwing out vaccinations because you are not getting sick is tantamount to the same thing: Throwing away the umbrella you are standing under in a rainstorm because you are not getting wet.

Despite this logic, a number of controversies around vaccination have cropped up over the years. Perhaps the most pressing of the 21st century deals with the MMR (measles, mumps and rubella) vaccine.

Measles Mumps and Rubella Vaccine Controversy

Much of the modern anti-vaccination movement hinges on a study published by medical journal, *TheLancet,* claiming a link between autism and the MMR vaccine. Andrew Wakefield and fellow authors had a small sample size (12), and uncontrolled design, in a study that spurred a drop in parents vaccinating for MMR.

The shoddy research conducted by Wakefield spurred research debunking the claims, which pointed out that there is a correlation in time between vaccination and when autism symptoms first appear which is not causal.[39]

The *Lancet* retracted the paper in 2010; Wakefield had undisclosed financial interests in his findings, and was finally held accountable for ethical violations, and for scientific misrepresentation.[40]

Wakefield lost his medical license, and *Time* magazine reports that it took almost 20 years for the vaccination rate to recover in the United Kingdom following 12,000 cases of the measles and at least three deaths. Wakefield has continued in recent years on his anti-vaccination crusade, including a documentary film called *Vaxxed.* His activities have been linked to 25 measles related deaths in 2017.[41]

In the United States, measles had been declared a disease of the past by the year 2000. But since the *Lancet* published Wakefield's work, there have been more than 2,216 cases reported including an outbreak at Disneyland amusement park in California that lead to 130 infections. Additionally, there have been a number of outbreaks in 2017 in Minnesota where Wakefield's message was directly responsible for parents choosing not to vaccinate.[42]

Science is a process that requires trust, and when scientists break that trust, the outcomes can be negative and even fatal. The media unfortunately also played a role in publicizing the initial 1998 claims, and the *Lancet* ran a tiny retraction more than ten years later. The follow up to the story has not been as splashy or sensationalized as the initial false claims were, which hurts public trust. The proliferation of antivax propaganda not only through the traditional media, but also through social media has also added to the problem.

This of course leads me to the question: How do I teach my students how to be critical thinkers and readers able to sort good information from bad information? Time magazine quotes Mark Twain to great effect: "A lie

can travel halfway around the world while the truth is putting on its shoes."[43]

The problem with misinformation about vaccines is that it is literally putting lives in danger. Because the spread of misinformation is an outbreak of its own, it is more important than ever to promote good science and information literacy. It is my hope that I have written information that will enable teachers to impart the background knowledge and skills students need to navigate the vaccine issue.

Content Objectives

It is my expectation that this unit will take 3 weeks to cover in my class. When I teach this unit, it is my intention that students will be able to cite evidence by gathering, reading, comparing, summarizing and synthesizing information from multiple sources while thinking critically about the quality of those sources. Students should also be able to identify the influence humans have exerted on the spread of vaccine preventable diseases and the microorganisms that cause them. Finally, students should be able to identify the social impacts vaccination technology is exerting on society.

Strategies

Strategies I will employ to teach this unit will include close readings that are structured and employ annotation of texts, vocabulary, read alouds, and pairing and sharing of selected texts as well as whole group reading activities. Students will engage in research of their own, and create a presentation explaining what they have learned throughout this unit in small groups.

Activities

Introduction Activity

I would like to prime my students to understand how bad information can seem compelling. I would like to start with an outrageous statement that students will obviously know is wrong: Basketballs are not spheres – they are flat. I will then proceed to offer "compelling evidence" for my claim: photographic evidence. The photograph will be taken from an extremely up-close angle that obscures the curvature of the basketball as proof. I will then allow for class small group discussion where students will have to discuss why this claim is false, and actually provide proof to the contrary. I will also inform students that there are people who believe the Earth is flat using the same evidence. I will then prompt the class to explain why one form of proof is better than the other. The close of this activity will be for students to brainstorm any other "fake news" or urban myths that some people believe. At closing, I will introduce the concept of vaccines as something that has been controversial.

Readings

For this unit it will be important for students to do reading on the topic. A great resource that offers texts containing the same content for students at different levels is NewsELA. NewsELA is a website that has a searchable database of articles on wide range of topics, including many on the vaccine controversy. Students will read the issue overview and complete notes on the topic, before taking a short check for understanding consisting of 3-5 questions, depending on the reading. I may also prepare readings on each of the scientists in this unit which will help students understand the scientific method.

Seminar

As a class, I also intend to conduct a Socratic seminar following the readings over the political cartoon published in 1804 which can be found in figure 4. The cartoon is imaginative and depicts people sprouting cattle from their noses, ears, and rear-ends as a result of inoculation. As a class we will first conduct a pre-reading activity where we will note the features of the image as well as note the caption. Leading the seminar, I will craft questions that will elicit the controversies on display and explore them through the image. When conducting a seminar in my classroom and teaching students how to conduct group conversations as learners I furnish or post sentence starters such as "I respectfully disagree with _____'s point because…" and "I want to build on _____'s comment about…." The goal of seminars in my classrooms is not to make each student feel as though they must answer each question, but instead to be active listeners contributing where they see fit. Typically, I do start out with a single question that goes around the room as a warm up that each student will answer. The key in crafting good seminar questions is to create space for open ended questions.

Questions for this seminar could include: What do the cows represent in this image? Why did the cartoonist create this picture? Does the creator of this image want people to get vaccinated or not? Is this a balanced idea of what vaccination is about? Do you agree with the cartoonist's representations?

It is my belief that all of the images presented in this unit would make good catalysts for Socratic seminars depending on the needs or emphasis of teachers utilizing this unit.

It is also important for students to map the seminar either by visually representing the flow of the conversation of a labeled map of the room with student's names, or even to jot down which comments they think are the best. This will allow students who are not engaging verbally to show that they were actively listening and learning.

Final Product

The final activity for this unit will be for students to research and develop an opinion on mandatory vaccination. Students should present quality research to illustrate both the pros and cons before then being allowed to weigh their research and come to a conclusion. Students will prepare a presentation to share with the class that must include an original piece of artwork or cartoon that demonstrates their stance on mandatory vaccination.

My expectation is that students will complete a checklist/scaffold prior to making their presentation that will ensure they are prepared to meet the expectations for the assignment.

The checklist/scaffold students will need to complete may include a list of evidence and how they know that the evidence comes from a quality source. This will go back to the class discussion from the introductory

activity. Students will cite evidence and explain why it comes from a credible source as a checkpoint before constructing their presentations. Students will need a minimum of 8 slides with 3-5 sentences on each slide. Slides should be visually engaging and use multimedia. Slides can be creating utilizing Google Slides and Google Classroom, or other mediums like Prezi or Adobe Spark.

Appendix

Standards

Next Generation Science Standards/Oklahoma Academic Standards for Biological Unity and Diversity (MS-LS4-5)

Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

This standard is deceptively simple but allows for a wide discussion of how humans influence the living world around them. By discussing how we understand and manipulate the world around us with vaccines, students will develop a deeper understanding of the natural world.

Bibliography

"10 Facts on Polio Eradication." World Health Organization. March 14, 2018. Accessed July 16, 2018. http://www.who.int/features/factfiles/polio/en/.

Author, Contributing. "Louis Pasteur, Spontaneous Generation, and Germ Theory." ZME Science. May 12, 2016. Accessed July 15, 2018. https://www.zmescience.com/other/feature-post/louis-pasteur-spontaneous-generation-germ-theory/.

Bronfin, Daniel R., MD. "Childhood Immunization Controversies: What Are Parents Asking?" *The Ochsner Journal* 8, no. 3 (2008): 151-56. Accessed July 13, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3096324/.

Answers a number of common questions parents might have regarding vaccination. Covers the basics of vaccine effectiveness in introduction.

Dayton, Kels. "More Federal Funding Approved for Universal Flu Vaccine." WTNH. March 23, 2018. Accessed July 16, 2018. https://www.wtnh.com/news/health/more-federal-funding-approved-for-universal-flu-vaccine_20180403104021491097764975.

"Edward Jenner and the Development of the Smallpox Vaccine." Books, Health and History. May 13, 2016. Accessed July 14, 2018. https://nyamcenterforhistory.org/2016/05/13/edward-jenner-and-the-development-of-the-smallpox-vaccine/.

Narrative of Jenner's vaccination breakthrough with images.

"Germ Theory." Open Collections Program: Contagion, The Yellow Fever Epidemic in Philadelphia, 1793. Accessed July 14, 2018. http://ocp.hul.harvard.edu/contagion/germtheory.html.

Overview of the discovery and adoption of germ theory and its link to disease.

"Global Alliance for Vaccines and Immunization (GAVI)." World Health Organization. November 22, 2010. Accessed July 16, 2018. http://www.who.int/mediacentre/factsheets/fs169/en/.

Up to date statistics about lives saved from vaccination, as well as information about the impacts of vaccines not being universally available in poorer regions of the world.

Harris, William. "How the Scientific Method Works." HowStuffWorks Science. March 08, 2018. Accessed July 15, 2018. https://science.howstuffworks.com/innovation/scientific-experiments/scientific-method5.htm.

Explanation of the scientific method using Pasteur's experiment on spontaneous generation as an example. Includes images.

"History of Anti-vaccination Movements." History of Vaccines. Accessed July 16, 2018. https://www.historyofvaccines.org/content/articles/history-anti-vaccination-movements.

Great, in depth information about the early history of the anti-vaccine movements in the United States & United Kingdom.

"Investment in Research Saves Lives and Money." Research America. 2016. https://www.researchamerica.org/sites/default/files/Vaccine Fact Sheet_2016.pdf.

Light, Donald W., and Rebecca Warburton. "Demythologizing the High Costs of Pharmaceutical Research." *BioSocieties* 6, no. 1 (2011): 34-50. doi:10.1057/biosoc.2010.40.

Louten, Jennifer, Ph.D. *Essential Human Virology*. Elsevier Science Publishing, 2016.

Miller, Henry I. "We're Underfunding Research on Vaccines That May Be Able to Prevent Another Terrible Flu Season." Los Angeles Times. January 19, 2018. Accessed July 16, 2018. http://www.latimes.com/opinion/op-ed/la-oe-miller-flu-vaccines-could-be-more-effective-20180119-story.html.

MPH, Jonathan D. Quick MD, and Heidi Larson. "The Vaccine-Autism Myth Started 20 Years Ago. Here's Why It Endures Today." Time. February 28, 2018. Accessed July 16, 2018. http://time.com/5175704/andrew-wakefield-vaccine-autism/.

Pitt, Dennis, and Jean-Michel Aubin. "Joseph Lister: Father of Modern Surgery." Advances in Pediatrics. October 2012. Accessed July 15, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3468637/.

Leung, Angela Ki Che. *History of Vaccine Development*. Edited by Stanley A. Plotkin. New York: Springer, 2011.

This book is a compendium of chapters written by different authors covering a number of topics in the history of vaccination.

Baxby, Derrick. *History of Vaccine Development*. Edited by Stanley A. Plotkin. New York: Springer, 2011.

Covers Edward Jenner’s Role in the Introduction of Smallpox Vaccine

Rao, T. S. Sathyanarayana, and Chittaranjan Andrade. "The MMR Vaccine and Autism: Sensation, Refutation, Retraction, and Fraud." Advances in Pediatrics. 2011. Accessed July 16, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3136032/.

"Robert Koch - Biographical." Nobelprize.org. Accessed July 15, 2018. https://www.nobelprize.org/nobel_prizes/medicine/laureates/1905/koch-bio.html.

"Smallpox." World Health Organization. January 13, 2014. Accessed July 14, 2018. http://www.who.int/biologicals/vaccines/smallpox/en/.

Statistics on smallpox, background about vaccine development by Jenner.

"Smallpox." Emergencies Preparedness, Response. May 02, 2018. Accessed July 14, 2018. http://www.who.int/csr/disease/smallpox/en/.

Smith, David R., M.D.. *The Promise of Vaccines: The Science and the Controversy*. New York, NY: American Council on Science and Health, 2001.

Useful history, statistics, and explanation of different types of vaccines.

Stevenson, Lloyd Grenfell. "Robert Koch." Encyclopædia Britannica. May 25, 2018. Accessed July

15, 2018. https://www.britannica.com/biography/Robert-Koch#ref700442.

Overview of Koch's career, including his famous postulates.

"Vaccine Delivery." Bill & Melinda Gates Foundation. Accessed July 16, 2018.

https://www.gatesfoundation.org/What-We-Do/Global-Development/Vaccine-Delivery.

"Vaccines & Immunizations." Centers for Disease Control and Prevention. March 10, 2017.

Accessed July 16, 2018. https://www.cdc.gov/vaccines/vac-gen/whatifstop.htm.

"Vaccines Bring 7 Diseases under Control." UNICEF. Accessed July 16, 2018.

https://www.unicef.org/pon96/hevaccin.htm.

Endnotes

1. Bronfin, Daniel R., MD. "Childhood Immunization Controversies: What Are Parents Asking?" *The Ochsner Journal*8, no. 3 (2008): 151. Accessed July 13, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3096324/.
2. "Smallpox." World Health Organization. January 13, 2014. Accessed July 14, 2018. http://www.who.int/biologicals/vaccines/smallpox/en/.
3. "Edward Jenner and the Development of the Smallpox Vaccine." Books, Health and History. May 13, 2016. Accessed July 14, 2018. https://nyamcenterforhistory.org/2016/05/13/edward-jenner-and-the-development-of-the-smallpox-vaccine/.
4. Leung, Angela Ki Che. *History of Vaccine Development*. Edited by Stanley A. Plotkin. New York: Springer, 2011.
5. Louten, Jennifer, Ph.D. *Essential Human Virology*. Elsevier Science Publishing, 2016.
6. Leung, Angela Ki Che. *History of Vaccine Development*. Edited by Stanley A. Plotkin. New York: Springer, 2011.
7. Ibid
8. Ibid
9. Baxby, Derrick. *History of Vaccine Development*. Edited by Stanley A. Plotkin. New York: Springer, 2011.
10. "Edward Jenner and the Development of the Smallpox Vaccine." Books, Health and History. May 13, 2016. Accessed July 14,

2018. https://nyamcenterforhistory.org/2016/05/13/edward-jenner-and-the-development-of-the-smallpox-vaccine/.
11. Baxby, Derrick. *History of Vaccine Development*. Edited by Stanley A. Plotkin. New York: Springer, 2011.
12. "Smallpox." Emergencies Preparedness, Response. May 02, 2018. Accessed July 14, 2018. http://www.who.int/csr/disease/smallpox/en/.
13. Harris, William. "How the Scientific Method Works." HowStuffWorks Science. March 08, 2018. Accessed July 15, 2018. https://science.howstuffworks.com/innovation/scientific-experiments/scientific-method5.htm.
14. Author, Contributing. "Louis Pasteur, Spontaneous Generation, and Germ Theory." ZME Science. May 12, 2016. Accessed July 15, 2018. https://www.zmescience.com/other/feature-post/louis-pasteur-spontaneous-generation-germ-theory/.
15. Fulton, April. "'The Butchering Art': How A 19th Century Physician Made Surgery Safer." NPR. October 13, 2017. Accessed July 15, 2018. https://www.npr.org/sections/health-shots/2017/10/13/557367840/the-butchering-art-how-a-19th-century-physician-made-surgery-safer.
16. Pitt, Dennis, and Jean-Michel Aubin. "Joseph Lister: Father of Modern Surgery." Advances in Pediatrics. October 2012. Accessed July 15, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3468637/.
17. "Robert Koch - Biographical." Nobelprize.org. Accessed July 15, 2018. https://www.nobelprize.org/nobel_prizes/medicine/laureates/1905/koch-bio.html.
18. Ibid
19. Stevenson, Lloyd Grenfell. "Robert Koch." Encyclopædia Britannica. May 25, 2018. Accessed July 15, 2018. https://www.britannica.com/biography/Robert-Koch#ref700442.
20. Ibid
21. "Investment in Research Saves Lives and Money." Research America. 2016. https://www.researchamerica.org/sites/default/files/Vaccine Fact Sheet_2016.pdf.
22. Smith, David R., M.D.. *The Promise of Vaccines: The Science and the Controversy*. New York, NY: American Council on Science and Health, 2001.
23. Ibid
24. Ibid
25. "Global Alliance for Vaccines and Immunization (GAVI)." World Health Organization. November 22, 2010. Accessed July 16, 2018. http://www.who.int/mediacentre/factsheets/fs169/en/.
26. "Vaccines Bring 7 Diseases under Control." UNICEF. Accessed July 16, 2018. https://www.unicef.org/pon96/hevaccin.htm.
27. "Ibid
28. "10 Facts on Polio Eradication." World Health Organization. March 14, 2018. Accessed July 16, 2018. http://www.who.int/features/factfiles/polio/en/.
29. "Vaccine Delivery." Bill & Melinda Gates Foundation. Accessed July 16, 2018. https://www.gatesfoundation.org/What-We-Do/Global-Development/Vaccine-Delivery.
30. Light, Donald W., and Rebecca Warburton. "Demythologizing the High Costs of Pharmaceutical Research." *BioSocieties*6, no. 1 (2011): 34-50. doi:10.1057/biosoc.2010.40.
31. Ibid
32. Miller, Henry I. "We're Underfunding Research on Vaccines That May Be Able to Prevent Another Terrible Flu Season." Los Angeles Times. January 19, 2018. Accessed July 16, 2018. http://www.latimes.com/opinion/op-ed/la-oe-miller-flu-vaccines-could-be-more-effective-20180119-story.html.
33. Ibid
34. Dayton, Kels. "More Federal Funding Approved for Universal Flu Vaccine." WTNH. March 23, 2018. Accessed July 16, 2018. https://www.wtnh.com/news/health/more-federal-funding-approved-for-universal-flu-vaccine_20180403104021491097764975.
35. "History of Anti-vaccination Movements." History of Vaccines. Accessed July 16, 2018. https://www.historyofvaccines.org/content/articles/history-anti-vaccination-movements.

36. Ibid
37. Ibid
38. Bronfin, Daniel R., MD. "Childhood Immunization Controversies: What Are Parents Asking?" *The Ochsner Journal*8, no. 3 (2008): 151. Accessed July 13, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3096324/.
39. Rao, T. S. Sathyanarayana, and Chittaranjan Andrade. "The MMR Vaccine and Autism: Sensation, Refutation, Retraction, and Fraud." Advances in Pediatrics. 2011. Accessed July 16, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3136032/.
40. Ibid
41. MPH, Jonathan D. Quick MD, and Heidi Larson. "The Vaccine-Autism Myth Started 20 Years Ago. Here's Why It Endures Today." Time. February 28, 2018. Accessed July 16, 2018. http://time.com/5175704/andrew-wakefield-vaccine-autism/.
42. Ibid
43. Ibid

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