Chapter 4

Vaccines and Prevention

Beadle believed that genetics were inseparable from chemistry—more precisely, biochemistry. They were, he said, “two doors leading to the same room.” ~ Warren Beaver¹

I was in my first week as a newly graduated doctor when I encountered a vaccine-skeptic – a patient who was convinced vaccines were dangerous and could weaken the human race. I remember thinking – as a doctor, I am supposed to take a detailed history, but I hope you forgive me if I switch off just for a little bit, because right now isn’t the time for this debate. You learn something at medical school and immediately try to tell people about it, but you can’t convince them – not easily anyway. Especially if you have been indoctrinated with factual information along the lines of this²: an estimated 1.5 million children die each year— one every 20 seconds—from vaccine-preventable diseases such as diarrhea and pneumonia.

When I was thirteen, I had my first experience of outcomes that such beliefs can lead to – one of my best friends, a would-be star track-athlete developed polio – when we were all lined up at school and given these bitter tasting drops (with a spoonful of sugar), Samuel had missed out as his parents had refused vaccinations for him. When you are thirteen, you

¹ Warren Weaver, ‘Science and Imagination’ (1967), xii. Quoted in Thomas Hager, ‘Force of Nature: The Life of Linus Pauling’ (1995), page 276.
² Gates Foundation. ‘The Challenge’ http://www.gatesfoundation.org/What-We-Do/Global-Development/Vaccine-Delivery accessed Dec 25, 2015.
couldn’t care less one way or the other – parents tell you what to do and you listen – most of the time, anyway. Then you get older and start making your own decisions.

But unbelief in the concept or power of vaccinations had its own dangers. Samuel always seemed to be faster and stronger than us, until polio took effect – then he could barely walk. Maybe this was something his parents were not expecting. They finally had proof, but they perhaps couldn’t tell it to anyone, because of the people they were – there was a need to make spiritual sense of their son’s disability – and resolve a conflict with their religious faith, that had led them to believe that God wouldn’t have given Samuel the talent at sport if he wasn’t going to use it.

Even where I live, in New Zealand, a few people I know are strongly against all forms of vaccinations. And, they are all not Internet wackos. In fact shoddiness at some historical points of vaccine research is partly to blame. Samuel’s parents refused to allow his being vaccinated, as they were staunch Jehovah’s witnesses. But the history of vaccination has had a few manufacturing missteps.

I remember my father telling me about polio and its dangers. 1952 was the year he entered medical school. In that year, the American polio epidemic was the worst outbreak in the nation’s history, he said. Of nearly 58,000 cases reported that year, over 3000 people died, and over 20,000 were left with mild to disabling paralysis. A few years earlier, Jonas Salk, an American doctor and virologist had accepted an appointment to the University of Pittsburgh School of Medicine. Salk felt that medicine owed a moral commitment to society to provide immunization from communicable diseases. He ended up making the world’s first polio vaccine.

In an interview with the New York Times, Salk merely viewed himself as a ‘highly evolved mutant’ – one that could tap into the prevailing current of evolution and speed it along. He felt this was his guiding force:

There is a dynamism, a dynamic force that propels us into the future, ... I have come to recognize evolution not only as an active process that I am experiencing all the time but as something I can guide by the choices I make, by the experiments I design,” he said. “I have always sensed this as the next evolutionary step. It’s not something of which a great many are capable, but some are... That is the source of my guidance”

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3 George Johnson, Once Again, A MAN WITH A MISSION. 25, Nov, 1990. New York Times magazine. http://www.nytimes.com/1990/11/25/magazine/once-again-a-man-with-a-mission.html?pagewanted=all accessed Dec 25, 2015.
On April 12, 1955, Jonas Salk’s polio vaccine — made by inactivating poliovirus with formaldehyde — was declared to be safe and effective. The three-pronged trial of Salk’s vaccine had included 1.8 million children who were inoculated with either vaccine (made by either Eli Lilly or Parke-Davis) or placebo or were not inoculated (but only observed). Given the scale of the epidemic, the Laboratory of Biologics Control rapidly granted licenses to produce the vaccine to five pharmaceutical companies: Eli Lilly, Parke-Davis, Wyeth, Pitman-Moore, and Cutter.

The granting of the licenses took only 2 hours; however, 2 weeks later, the Director of the Laboratory of Biologics Control, William Workman, was informed that five children in California, all first- and second-graders, had become paralyzed after receiving polio vaccine. In each instance, Cutter Labs had manufactured the vaccine.

Paul Offit, who has chronicled this sad saga, views the Cutter Incident as a turning point in vaccine manufacturing. On one hand, we had a terrified nation, desperately seeking someone to kill a dangerous beast lurking within its midst. Then Big Pharma arrived, boots, white-coats and all, to reduce the critter to a clump of smoking red coals. Once the flames receded, people were crying, not able to understand how these medical industrial misadventures work – to keep the spirit of pharmaceutical progress alive, a few lives are often sacrificed.

The Cutter Incident led to a landmark court case in California, *Gottsdanker v. Cutter Laboratories*, that I remember studying when I studied Medical Law at the University of Glasgow. Because the Salk vaccine was rushed through, none of the laboratories manufacturing the vaccine had experience in mass production of such a vaccine — and all had difficulty completely inactivating the poliovirus. Therefore, while Cutter was technically not negligent, damages were nevertheless awarded for ‘implied warranty.’

However the Cutter case led to pharmaceutical companies’ reluctance to embark on ambitious vaccine projects — in 2004 only four big companies were producing vaccines globally, and two of them had severely reduced their vaccine research programs. Vaccine shortages are increasingly becoming common — the most recent and most widely known is the influenza vaccine shortage that created a public health crisis. Truth be told, shortages are not unknown for vaccines against tetanus, pneumococcal pneumonia, and other childhood diseases.

In actual fact, the vaccine for polio we had at school (that Samuel missed out on) was the oral Sabin vaccine, developed after the Salk vaccine, which was an injectable version.

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Francis Darwin once wrote⁴:

But in science the credit goes to the man who convinces the world, not to the man to whom the idea first occurs. Not the man who finds a grain of new and precious quality but to him who sows it, reaps it, grinds it and feeds the world on it.

So it was with smallpox vaccination. Edward Jenner is widely credited with discovering a vaccine for smallpox, even though the disease itself was known from ancient times – the mummified head of the Egyptian pharaoh Ramses V (died 1156 BC) bears evidence of smallpox.⁵ In fact, the word smallpox derives from the term small pockes (pocke meaning sac), and was first used in England at the end of the fifteenth century to distinguish the disease from syphilis, which was then known as the great pockes.⁶ In fact, smallpox had been reported in ancient Asian cultures – smallpox was described as early as 1122 BC in China and is mentioned in ancient Sanskrit texts of India. Even the practice of vaccination was actually introduced from Asia to Europe in the eighteenth century.

Before the formal process of vaccination was adopted, inoculation was the method to combat such infectious diseases – the inoculator usually used a lancet or needle and obtained pus or material from a ripe pustule of someone suffering from smallpox. This material was then introduced on the arms or legs of the non-immune person, thereby triggering an immune response. This was where Jenner made massive advances – with experiments using cowpox ‘pus’ on those infected with smallpox. In those days, in the eighteenth century, it was common knowledge amongst farm folk that those afflicted by cowpox never ended up with smallpox. It was reported that Jenner overheard a dairymaid say⁷: “I shall never have smallpox for I have had cowpox. I shall never have an ugly pock-marked face.” This lead to Jenner formally testing his theory – Jenner showed that cowpox not only protected against smallpox but also could be transmitted from one person to another as a deliberate mechanism of protection. In spite of being acknowledged worldwide for his work in the field of public vaccination, Jenner remained a humble, interesting and altruistic character. He built a one-room hut in his garden, which he called the ‘Temple of Vaccinia’ – where he vaccinated the poor for free.

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⁴ Francis Darwin. First Galton Lecture before the Eugenics Society’, Eugenics Review, 1914, volume 6, page 9.
⁵ A.S. Lyons, R.J. Petrucelli II. Medicine—An Illustrated History. New York: Abradale Press, Harry N Abrams Inc, 1987.
⁶ J.C. Moore. The History of the Smallpox. London: Longman, 1815.
⁷ H.J. Parish. ‘Victory with Vaccines: The Story of Immunization.’ Edinburgh: E & S Livingstone, 1968.
Smallpox eventually became the first disease for which mass vaccination was practiced, and appropriately it was the first disease to be eradicated globally in 1979.

At a basic level, vaccinations using ‘live’ agents induce immunity via one of the following methods – using a related virus from another animal, unnatural route, or unnatural cell type.

A related virus from another animal was the method used by Edward Jenner. The principles of ‘Jennerian’ vaccines was to make vaccines using infective agents that either do not cause disease or cause mild disease in humans, or for any animal being vaccinated. Jenner used cowpox against smallpox; in later years, using the same principle, BCG vaccine was made from *Mycobacterium bovis* – the agent that causes tuberculosis in cattle, to protect against human tuberculosis.

The principle of using an unnatural route hinges on the fact that viruses are known to be less potent if introduced via an unnatural bodily route – this was the technique used when military recruits in the 1970s were vaccinated against the adenovirus that causes Adult Respiratory Distress Syndrome (ARDS). This virus was potent and pathogenic in the respiratory system of humans, but when given via the gastrointestinal system (as enteric-coated tablets) they replicated without causing disease, thereby inducing immunity.

While Jenner showed that inoculating people with cowpox pus could prevent against smallpox, he did not understand or explain how the human immune system developed this protection. It was Louis Pasteur, the French microbiologist, who went a long way in explaining this. Unlike Jenner, Pasteur used inactivated vaccines. In the late 1800s, Pasteur experimented with the killed Rabies virus (that he derived from dried rabbit spinal cords) that he used to prevent disease in animals, and later humans. Remember Jonas Salk whom we discussed earlier? Salk essentially used the Pasteur technique – he grew poliovirus in a culture, then purified it and then inactivated it using formaldehyde – and then used it in an injectable form against polio.

The other method of creating live vaccines is to make the virus inactive by serial passage through unnatural or artificial cell types – for example one measles vaccine was made by passing it 24 times through human kidney lines, 28 times in human amniotic cells, 6 times in a chick embryo and 85 times in chicken fibroblasts. The idea in such cases is to create viral ‘mutants’ that are best suited to growing in such artificial media, but less dangerous when returned to the original host. Now that genomes have been sequenced and DNA technology is everywhere, it is possible to deliberately induce such mutations in human cells and this is where vaccine technology seems to be heading.
The problem with killed vaccines is that they don’t last long; the problem with live vaccines is that they can be unstable and also interfere with each other; the problem with human beings is that they are fickle, and immune systems can be variably deficient or unpredictable.

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We were not a hugging people. In terms of emotional comfort it was our belief that no amount of physical contact could match the healing powers of a well made cocktail. – David Sedaris

It is difficult to imagine the history or sociology of Western society without alcohol – Scotch Whiskey, Irish Guinness, Rum from the Caribbean and American attempts at prohibition are all part of our collective consciousness. Louis Pasteur’s name is irrevocably linked to both alcohol and vaccines. He was the first to conclude that fermentation is a vital (as in living) process, and he defined it as “respiration without air.” The story goes that in the 1850s, a brewer named Bigo contacted Pasteur because he was having problems producing alcohol from beetroot fermentation. His containers were producing sour milk-like liquids instead of alcohol, and he sought help from Pasteur, as he was considered an expert in fermentation. When Pasteur examined the containers, he could detect large amounts of yeast from the vats containing alcohol, but in containers containing the abnormal samples there were cells much smaller than yeast. Pasteur concluded that there are two types of fermentation: caused by alcohol or lactic acid. Alcoholic fermentation occurs by the action of yeast; lactic acid fermentation by the action of bacteria.

Pasteur’s findings had huge implications for the alcohol industry and Pasteur even patented his own beer-making equipment. Today alcohol is a huge industry. In America, where booze was once banned, Bourbon and Tennessee whiskey production resulted in $2.2 billion worth of revenue in 2012, according to a recent report from the Distilled Spirits Council of the United States. Most yeast strains can tolerate an alcohol concentration of 10–15 % before being killed. This is why the percentage of alcohol in wines is typically in this concentration range. For beverages with higher concentrations of alcohol the fermented products must be distilled, as is done with whiskey and other spirits (Scotch is whisky made in Scotland, while bourbon is whiskey made in the U.S.A, generally Kentucky; there is even a Bourbon law – ‘Federal Standards of Identity’ for Bourbon the law stipulates that for a whiskey to call itself bourbon, its mash, the mixture of grains from which the product is distilled, must contain at least 51 % corn, and there are specifications about how this must be distilled).

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8 David Sedaris, ‘Naked.’ Hachette, UK, 2010.
However, like human beings, yeasts also have different tolerance levels for alcohol. Therefore, brewers and wine makers have to select different strains of yeast to produce different alcohol contents in their fermented beverages.

Yeast has uses in the vaccine industry other than the well-known uses in bread-making and brewing. If the previous generation of vaccines were using intermediate organisms or unnatural cell types to weaken the disease-causing pathogen, newer vaccine technology using recombinant DNA has found yeast as useful as brewers did. A small piece of DNA is taken from the virus or bacterium that we want to protect against. This is then inserted into the DNA of yeast cells. These yeast cells are then able to produce proteins from the virus, and this is purified and used as the active ingredient – this was method used to produce the vaccine against Human Papillomavirus that is implicated in certain types of genital warts and cervical cancer. Therefore, if the previous ideology behind vaccines was to prevent infectious diseases, we are now looking at ‘vaccines’ against cancers and non-communicable conditions. The paradigm has shifted from population health to more personalized medicine in the future where high-risk individuals may receive individualized vaccines. Of course, with such measures comes an invariable increase in cost and less democratization.

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Jones and Bartlett, writing about the AIDS Epidemic, loves to quote TIME magazine in 1981: “(Genetic engineering) ... the most powerful and awesome skill acquired by man since the splitting of the atom.” But microbiology in particular has always been the forefront of evolution, as the Earth is littered with many different creatures. Unencumbered by size, viruses and bacteria, these little microscopic meddlers keep morphing into new forms and view us merely as companions and co-inhabitators, and not as superiors. Scientists by nature do not make people immediately suspicious that something is out of control, as they wait to study the evidence. The AIDS Epidemic is worth studying to see the response of modern science to ancient evolution. Everyone now generally agrees that SIV (Simian Immunodeficiency Virus) crossed over to man from monkey in the 1940s or 1950s, and this led to new strains of viruses that became HIV. It was evolution at its finest, these viruses had acquired a new fullness, a savagery – and what really mattered was if humans, in response would do the same, even with the advantage of scientific shortcuts.

In June 1981, 2 years before I was a freshman at medical school, the CDC wrote in its MMWR (Morbidity and Mortality Weekly Report) about five

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9 The AIDS Epidemic. Jones & Bartlett Learning; 7 edition (February 22, 2013).
Californian gay men suffering from *Pneumocystis* pneumonia. These men had deficient T-cell immunity. In July 1981, there was another MMWR report describing Kaposi’s sarcoma in gay men. These were relatively rare diseases surfacing due to immunodeficiency. Because the disease was only (at this stage) reported in gay men, doctors postulated possible causes based on known gay behavior (could amyl nitrate, a drug used by gay men cause this?) rather than recognizing this for what it was – a new transmissible virus. By early 1983, when I entered medical school, the disease had been reported in 16 countries, more than 1000 Americans were afflicted, and mother-to-child transmission and heterosexual infection had also been reported.

For the first three years of the AIDS Epidemic, the number of cases ‘only’ doubled every 6 months, almost as quickly as a new theory of its origins was hypothesized – all increasingly religious, conspiratorial, moral or microbiologic. It was in 1986 that the HIV virus finally got its name.

In the 1980s, Max Essex of the Harvard Public Health School recovered a virus in African Green Monkeys that was biochemically very similar to HIV. This virus was SIV. Essex’s team theorized that perhaps the SIV had crossed over into humans via a monkey-bite. About a decade later, Vanessa Hirsh of the National Institute of Allergy and Infectious Diseases found a strain of SIV almost identical to that of HIV from Sooty Mangabey monkeys in West Africa. What both these researchers discovered was that like humans, viruses are extremely adept at evolutionary experimentation. More recently, in 2010, Preston Marx reported that SIV was prevalent in as many as 40 species of African monkeys for 32,000 years. Evolution is an ancient discipline; human memory and attention is short-lived – this reality is what makes the world perilous for us. In some ways as Laurie Garrett points out in ‘The Coming Plague’\(^\text{10}\) – we were fortunate with AIDS in that it gave us easy clues that a new organism had emerged: AIDS caused atypical infections (*Pneumocystis*) or cancers (Kaposi’s) rather than the infections found in regular folk; it was first noted in gay men; it was first noted in the USA, a first world country with a highly developed disease control system, and further, scientists had just developed the ability to study retroviruses.

Yet, 30 years later, the Ebola Epidemic was allowed to get out of control for precisely the same reasons – but Ebola is different, vastly more aggressive – AIDS has a long latency period of nearly a decade while Ebola’s latency is under a month – yet there was lack of funding as this was seen as an African virus. By mid-March 2015, the current Ebola outbreak in Guinea,\(^\text{10}\) Laurie Garrett. *The Coming Plague: Newly Emerging Diseases in a World Out of Balance*. Penguin Books; Reprint edition (October 1, 1995).
Liberia, and Sierra Leone had reported over 24,000 cases, and close to 10,000 deaths including around 500 healthcare workers – causing Dr. Jim Yong Kim, President of the World Bank, to warn participants at the 2015 World Economic Forum\textsuperscript{11}: “The world is dangerously unprepared for future deadly pandemics like the Ebola outbreak in West Africa.”

The Médecins Sans Frontières (MSF) organization, whose doctors and nurses do selfless and amazing work in many troubled countries could not hide its frustration, calling the international response “slow, derisory and irresponsible”\textsuperscript{12} adding, “Dead bodies in the street, families wiped out, dozens of health care workers infected, hospitals shut down and panic and mistrust in the eyes of the people in the streets.” Hardly an encouraging picture, as this is unlikely to be the last epidemic the world or us humans shall face. The poor initial response to Ebola will have repercussions for all, not least of all the loss of medical experts in a continent where they are needed. As George Dvorsky noted in an article regarding the Ebola Epidemic\textsuperscript{13}:

The effects (of Ebola) will be felt for years to come. The loss of so many medical personnel is expected to have downstream effects on the health system of affected West African countries, including a sharp rise in maternal mortality to the tune of an additional 4,022 deaths each year for the foreseeable future. Moreover, the ability of healthcare workers to deal with other major diseases, like Malaria and Lassa (another hemorrhagic fever), was severely curtailed during the epidemic.

And, finally after plenty of handwringing and political maneuvering, an effective Ebola vaccine was made. The vesicular stomatitis virus (one that causes mouth ulcers and is relatively harmless) was genetically altered – a gene for its native envelope glycoprotein was replaced with that from an Ebola virus strain (Zaire, Kikwit 1995). This vaccine had been developed by the Public Health Agency of Canada and it had been patented as early as 2003, even though adequate human trials were not available until recently. Phase III (final stages of efficacy and safety) trials were undertaken in Guinea using ‘ring vaccination’ – an almost biblical process that involves identifying an infected person, their contacts, and their contacts’ contacts and vaccinating them. The vaccine proved 100% effective – and scientists

\textsuperscript{11} BBC News. ‘Ebola crisis: World’ dangerously unprepared’ for future pandemics.’ 28 January, 2015 http://www.bbc.com/news/world-31013636 accessed Dec 25, 2015.

\textsuperscript{12} MSF. ‘Ebola: the failures of the international outbreak response.’ 29 August, 2014 http://www.msf.org/article/ebola-failures-international-outbreak-response accessed Dec 25, 2015.

\textsuperscript{13} George Dvorsky. Approaching Zero: How West Africa is Crushing the Ebola Epidemic. Gizmodo, 26 October, 2015. http://gizmodo.com/approaching-zero-how-west-africa-is-crushing-the-ebola-1738267946 accessed Dec 25, 2015.
hailed this as a potential game-changer. The early results, published in *The Lancet*, showed the vaccine had 100% effectiveness when given immediately. However, there were 16 cases of Ebola in those that were (in the study) a part of the delayed vaccination group (0.5%).

The panic when a new virus emerges out of Africa is surprising. After all, the same chemistry and DNA lies within the cellular frames of most creatures. The density or color of our blood, the patterns of our vertebral systems, the unreliability of our nerves may vary – but there is a certain commonality. When primitive humans left Africa about 100,000 years ago, our ancestral diets and behaviors did not matter, as they were but a speck on the surface of the Earth. Now we have, within a short space of time over-populated, polluted and destroyed our environment to the degree that of all organisms to emerge out of Africa, *Homo sapiens* may indeed be the most dangerous of all. The Earth may be our hermitage – and nature’s world may be wonderfully brilliant to behold – but nature is essentially non-discriminatory to color, friends, angels, parents, books or stories – ultimately, only the fingerprints of evolutionary processes matter. Therein lies the problem with industrializing immunity.

You see, there is fundamentally a problem with trying to create artificial immunity, as if we can gratify evolution or satisfy its needs. The problem with evolution and Natural Selection was that the process remained aloof from individual needs, solitary cries or quick satisfaction – all things that the vaccination industry seeks to now commercialize. Can intimacy between human and viral DNA end up being dangerous? This was the problem Penn State University Professor, Andrew Read pondered over. In 2001, Read proposed that “leaky” vaccines – ones that allow transmission of disease to organisms – might prompt the evolution of more dangerous strains of organisms. Read, an evolutionary biologist stumbled upon experimental evidence that vaccines can alter evolution – organisms we are trying to protect against ending up creating more virulent forms.

In 2001, Read published a paper in *Nature*, using mathematical modeling to predict that vaccination could alter evolution of viruses. But he lacked experimental evidence; until more recently. Read is cautious about the risks in the future from scientists engineering Ebola vaccines. Could vaccines make viruses evolve to more virulent forms? After all, it would be typically human and arrogantly presumptuous of us to assume we are the only ones evolving. We may be trying to create artificial men, but other creatures are happy enough to let their destiny be determined by nature’s own devices.

Read began examining a virus that causes something called Marek’s disease in chickens. In a series of experiments, Read looked at different strains of the Marek’s virus. The older, milder strains kill about half of the
unvaccinated birds in a couple of months, but the newer “hot” strains kill 100% of infected chickens in 10 days – in other words all unvaccinated birds had no chance of survival. What caused this increase in virulence? Vaccines? To test this theory, he began looking at the population ‘fitness’ of these organisms – essentially evolutionary ‘fitness’ is determined by how good a virus is in replicating in different environments. What Read’s experiments showed was this – the newer, more deadly or “hot” strains were ‘not very fit’ in unvaccinated birds – in other words if there were no vaccines against Marek’s disease, these increasingly virulent forms would die away – the hot strains would burn themselves out by killing their hosts before they had transmitted the infection to other birds. But now, given the hot strain has been rendered fitter by the vaccine, vaccinated birds survive longer and thereby shed more virus – and thereby continue to transmit disease.

Read’s ideas may be controversial, if only for the fact that his science is sometimes quoted by the anti-vaccine movement. But his experimental methods are sound and stack up scientifically. This year, his team’s research and findings were published in the influential journal, *PLOS Biology*.14

Humans are increasingly full of manufactured parts, working valves and artificially enhanced intelligence, but at our core we are biological and biochemical beings. After all, as the American Society of Human Genetics noted, humans share over 90% of their DNA with their primate cousins.15 As we sleep, evolution is busy at work tinkering with little enzymes, proteins and genetic code; every time we wake, tiny invisible creatures have become wholer, fitter and more improved. And, as far as nature or our planet are concerned, there is no need to specifically guard or protect the human race – from their point of view such wasted energy is corny and has but the symbolism of a statue. And all statues shall eventually crumble.

**Bibliography**

1. Offit PA. The cutter incident, 50 years later. N Engl J Med. 2005;352:1411–1412. DOI 10.1056/NEJMp048180
2. Reidl S. Edward Jenner and the history of smallpox and vaccination. Baylor Univ Med Centre Proc. 2005;18:21–25.
3. Mullin D. Prometheus in Gloucestershire: Edward Jenner, 1749–1823. J Aller Clin Immunol. 2003;112:810–4.

14 Read AF, Baigent SJ, Powers C, Kgosana LB, Blackwell L, Smith LP, and others. (2015) ‘Imperfect Vaccination Can Enhance the Transmission of Highly Virulent Pathogens.’ *PLoS Biology* Volume 13 (page 7).

15 American Society of Human Genetics. “Humans, chimpanzees and monkeys share DNA but not gene regulatory mechanisms.” ScienceDaily, 6 November 2012 [http://www.sciencedaily.com/releases/2012/11/121106201124.htm](http://www.sciencedaily.com/releases/2012/11/121106201124.htm) accessed Dec 25, 2015.
4. Marshall GS. The vaccine handbook: a practical guide for clinicians: the purple book. New York: Professional Communications, PCI Books; 2010.
5. Parry E. Principles of medicine in Africa. Cambridge: Cambridge University Press; 2004.
6. Alba-Lois L, Segal-Kischinevzky C. Beer & wine makers. Nat Educ. 2010;3(9):17.
7. The Vaccine Knowledge project. University of Oxford. http://www.ovg.ox.ac.uk/vaccine-ingredients#yeast%20proteins. Accessed 25 Dec 2015.
8. Flam F. Vaccines that alter evolution. Forbes. Pharma and Healthcare section, July 28, 2015.
9. The AIDS Epidemic. 7 ed. Burlington, Massachusetts, United States: Jones & Bartlett Learning; 2013.
10. Chan J. Scaling up the Ebola response: what we learned from AIDS activism. J AIDS HIV Infect. 2015;1(1):1–5.
11. Regules JA and Others. A recombinant vesicular stomatitis virus Ebola vaccine — preliminary report. N Engl J Med. 2017 Jan 26;376(4):330–341. doi: 10.1056/NEJMoal414216. epub Apr 1, 2015.
12. Henao-Restrepo AM and Others. Efficacy and effectiveness of an rVSV-vectored vaccine expressing Ebola surface glycoprotein: interim results from the Guinea ring vaccination cluster-randomised trial. Lancet. 2015.