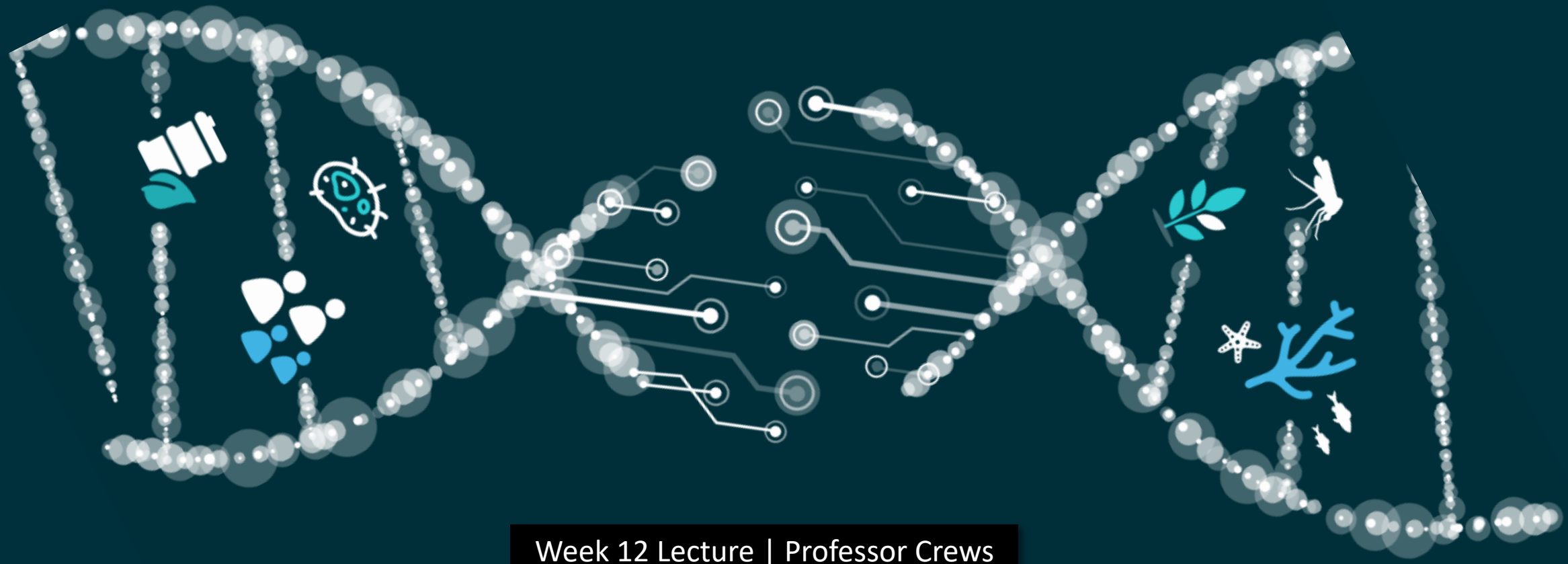
The End of the World

Biotechnology & Information Hazards

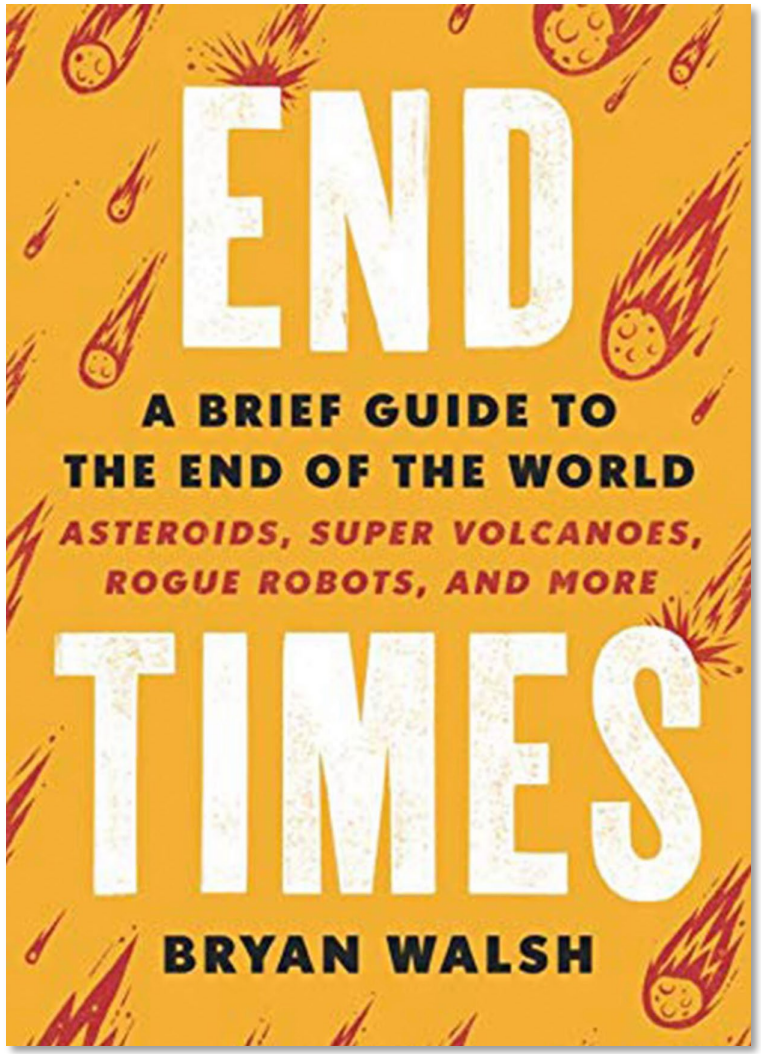


Week 12 Lecture | Professor Crews
Religious Studies 357 W

In *End Times: A Brief Guide to the End of the World*, author Bryan Walsh takes us through a wide range of possible end of the world scenarios, from asteroids and super volcanoes to killer robots and climate apocalypse.

Walsh explores many common end times scientific worries and asks how realistic these threats are and what we can do to address them. As he noted in the introduction:

"If we don't appreciate the present, it's in part because we don't fully understand the past— even as we make the mistake of assuming the future will be like the present... Risks that are most available to the mind are the ones that we care about, which is why so much of our regulation is driven by crisis, rather than by reason."



Bryan Walsh argues that since "viruses and bacteria can be self-replicating, even an accident could be just as catastrophic as a deliberate attack…This is why biotechnology ultimately poses the single greatest existential risk humans will face in the years to come..."

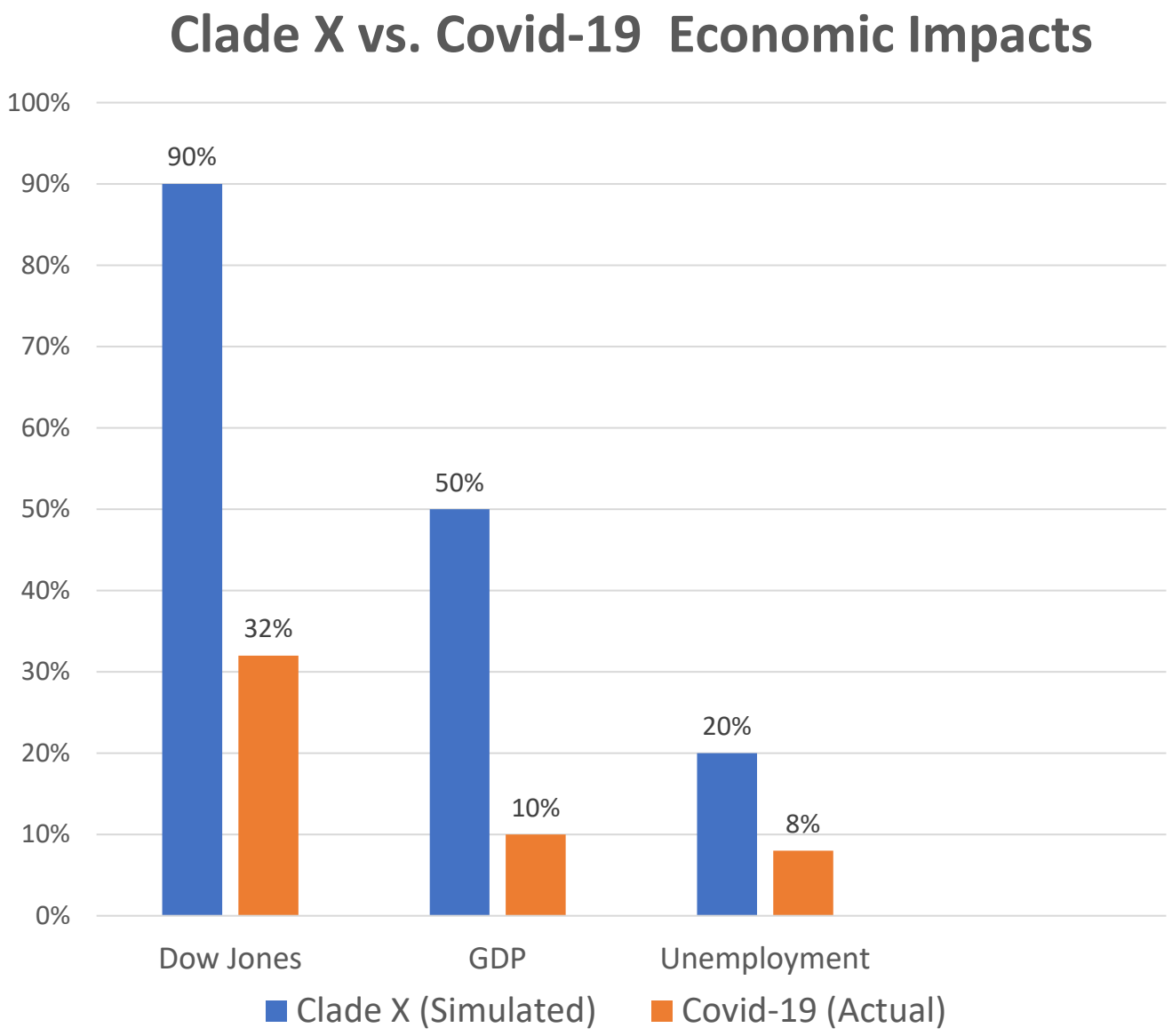
As we discussed last week, and as we're experience right now with the coronavirus pandemic, bacteria and viruses post a serious threat to the world. These natural risks are magnified each year as new scientific innovations allow humans even greater powers to manipulate life, from synthetic biology and gene manipulation to bioengineering and cloning.

In 2018, Johns Hopkins led a pandemic response exercise to simulate US preparedness for a global influenza outbreak (Parainfluenza Clade X), a virus which is unlikely to occur in nature.

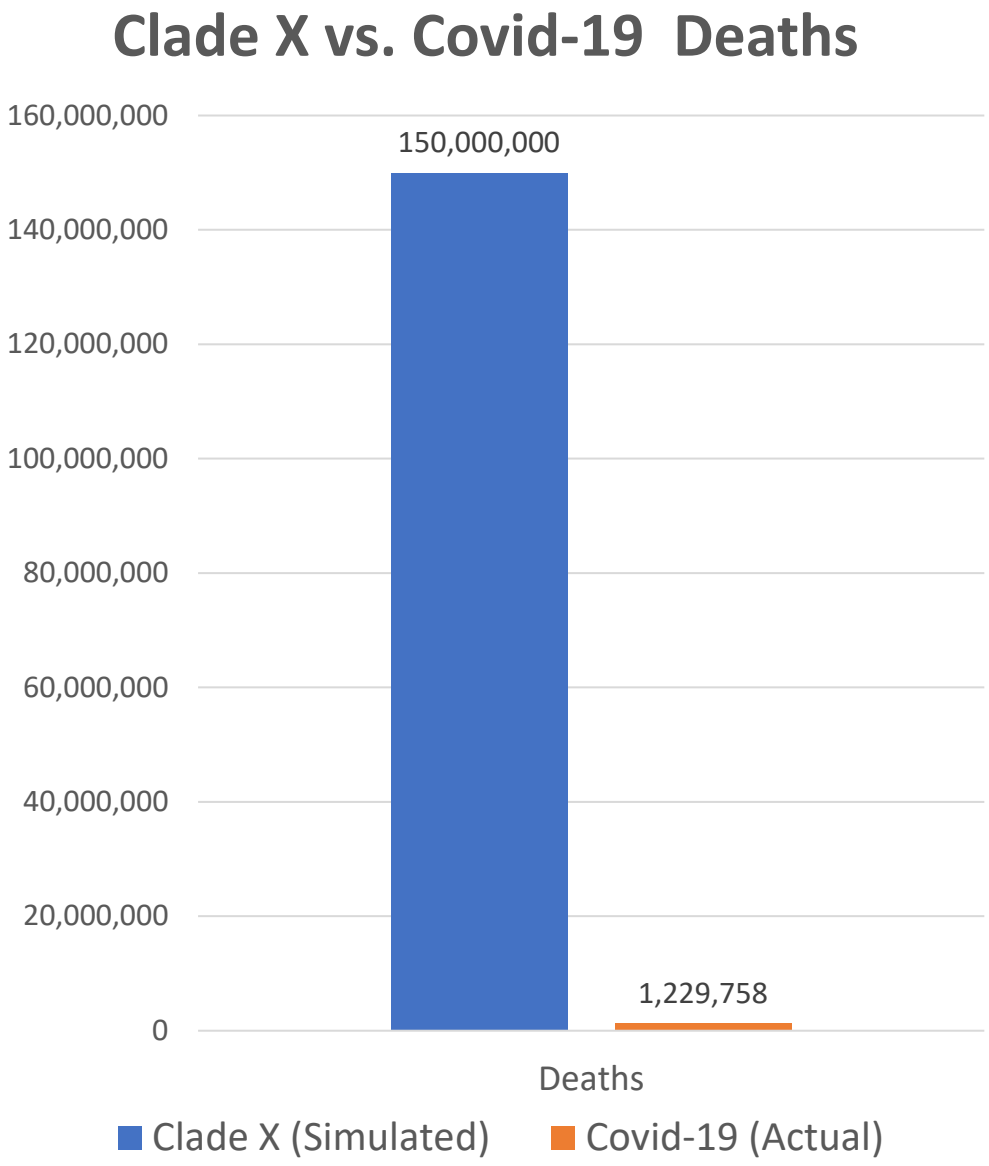
"The makers of Clade X have used biotechnology to override evolution, ensuring that their creation can retain both transmissibility of a parainfluenza virus and the deadliness of Nipah [virus]. It is the perfect bioweapon: a virus that spreads like the common cold and kills like Ebola. The world is defenseless."

In the 2018 simulation, Clade X killed an estimated 150 million people (2% of global population) over a 20-month period and led to the collapse of the US and global economy.

United States



Global



An earlier Johns Hopkins simulation took place in June of 2001 called “Operation Dark Winter,” based on a smallpox bioweapon attacks that began in Oklahoma City then also in Georgia and Pennsylvania. It then spread to large parts of the US and led to a catastrophic failure of the US health and disaster response networks and over 1 million US deaths.

The University of Pittsburgh Medical Center’s Center for Health Security noted 5 key findings in a summary report after the completion of the Dark Winter exercise, many of which apply to covid-19:

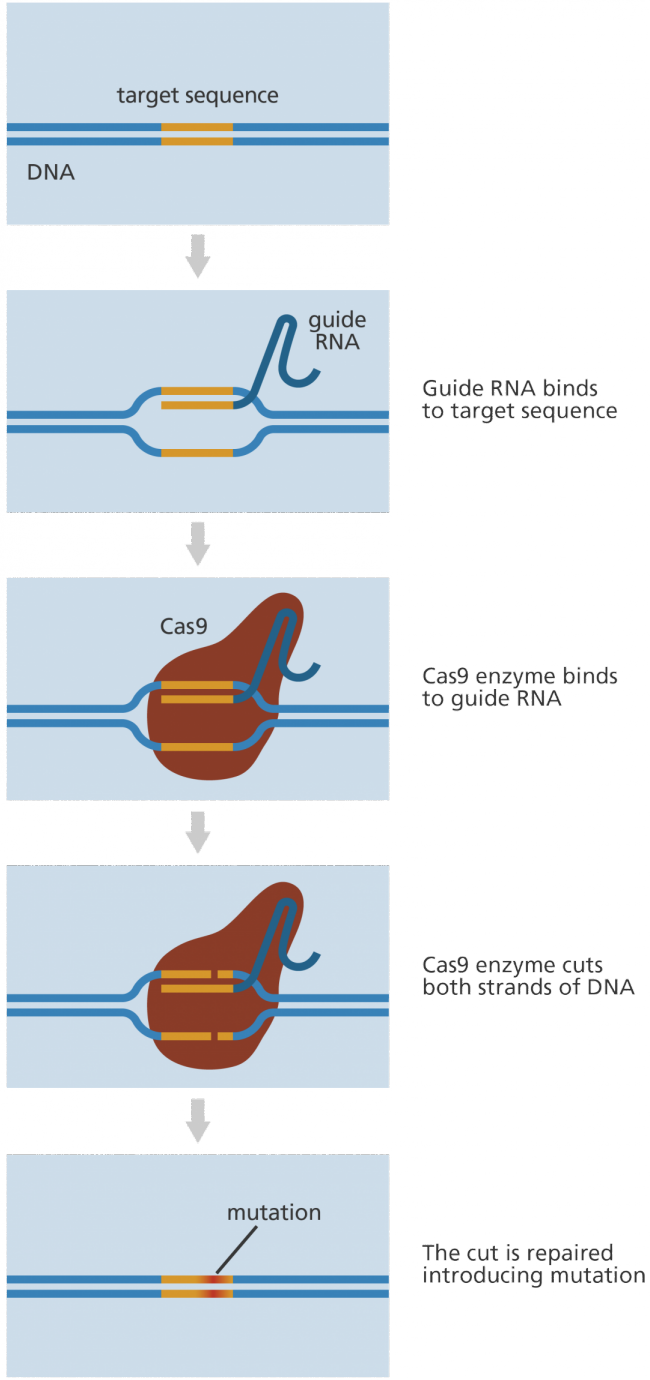
- An attack on the United States with biological weapons could threaten vital national security interests.
- Current organizational structures and capabilities are not well suited for the management of a biowarfare attack.
- There is no surge capability in the U.S. healthcare and public health systems, or in the pharmaceutical and vaccine industries.
- Dealing with the media will be a major immediate challenge for all levels of government.
- Should a contagious bioweapon pathogen be used, containing the spread of disease will present significant ethical, political, cultural, operational, and legal challenges.

Synthetic biology is the leading edge of biotechnology research, and the one with the most promise and peril for the future of science. It involves the practice of using technological interventions to rewrite genetic information in living organisms through the addition, subtraction, or manipulation of DNA.

The most well known of these new technology is CRISPR Cas-9 (Clustered Regularly Interspaced Short Palindromic Repeats – CRISPR Associated Protein 9), a genome editing tool that allows for the rapid editing of DNA by removing, adding, or altering a DNA sequence in order to produce a targeted genetic change.

CRISPR-Cas9 uses a two-part process to do its gene editing work:

- Cas9 protein enzyme which "cuts" the DNA double-helix at a precise point.
- gRNA or a "guide RNA" that identifies DNA sequences for manipulation.

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As Bryan Walsh argues, "That's what makes biotechnology so scary and so exhilarating. It is a dual-use technology, capable of being wielded for both benign and malevolent ends." One example of the worst-case use of these technologies was on display during World War II as every major power had some form of official government biological weapons program in operation.

Some examples of biowarfare throughout history:

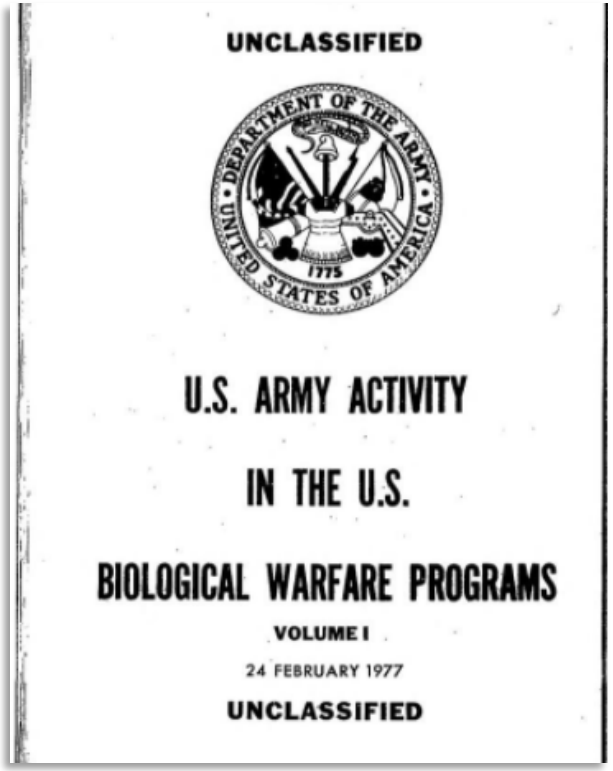
- Athenian politician Solon uses plants to poison water supply in city of Kirrha, Greece (~600 BCE)
- Alexander the Great of Macedonia throws diseased bodies into cities under siege (~332 BCE)
- Mongol armies throws plague-infested bodies into city of Caffa in Ukraine (~1344 CE)
- British army uses smallpox infected blankets against the Ottawa forces under Chief Pontiac during French and Indian War (~1763 CE)
- US, Japanese, Russian experiments during WWII

"I will try to inoculate the Indians by means of blankets that may fall in their hands, taking care however not to get the disease myself." - Colonel Henry Bouquet, July 13, 1763

Bioweapons research was carried out on a large scale in Japan by Unit 731 of the army's Epidemic Prevention and Water Purification Department, which experimented with ways to conduct large scale viral attacks using insects. The Russians were also involved in bioweapon work, the biggest of which was on the island of Vozrozhdeniya, and included tests with anthrax, smallpox, plague, and other diseases.

The US also conducted secret bioweapons tests (Ft. Detrick, Maryland; Dugway Proving Grounds, Utah). Scientists used fleas, mosquitoes, and other germs in experiments to develop offensive and defensive strategies for entomological warfare. At least 239 covert germ warfare tests were finally revealed in a 1977 Army report to Congress, including more than 20 secret public tests.

- **Operation Sea Spray (1950)**
  - Germs sprayed on San Francisco to test germ dispersal dynamics
- **Operation Big Itch (1954)**
  - Experiments using fleas dropped via munitions at the Dugway Proving Grounds in Utah
- **Operation Big Buzz (1955)**
  - Experiments using mosquitoes dropped in munitions on civilian populations in Savannah, Georgia and later in Florida
- **Operation Drop Kick (1956)**
  - Experiments using mosquitoes - details uncertain (still classified)


UNCLASSIFIED

U.S. ARMY ACTIVITY

IN THE U.S.

BIOLOGICAL WARFARE PROGRAMS

VOLUME I

24 FEBRUARY 1977

UNCLASSIFIED

The US bioweapons program starting in 1943 in response to worries about Nazi scientists developing bioweapons and continued until 1969 when President Nixon stopped all offensive bioweapons research and ordered the destruction of existing US bioweapons. As Nixon said about this decision: "Mankind already carries in its own hands too many of the seeds of its own destruction."

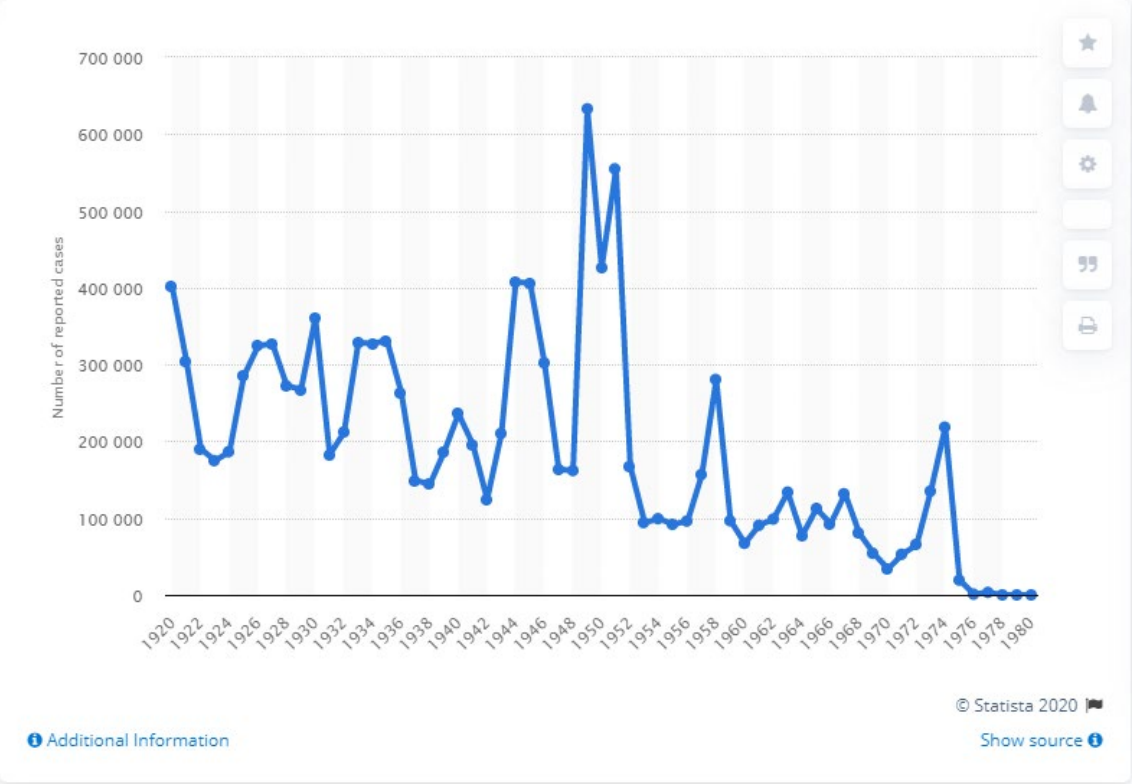
Soon after the Biological Weapons Convention (BWC) was signed (1972) and became ratified (1975). "To this day, the BWC represents the only time that the world has agreed to ban an entire class of weapons." Decades later Russia admitted to continuing a secret biowarfare research program during the Cold War because they feared the US was doing the same (as far as we know the US was not).

As Bryan Walsh argues, "This is the dilemma of dual-use technologies, and it is key to understanding the existential risk of biotechnology, and almost every other man-made existential risk as well, including artificial intelligence. In both fields it has become increasingly difficult to draw a distinction between research that benefits mankind and work that could led to our extinction."

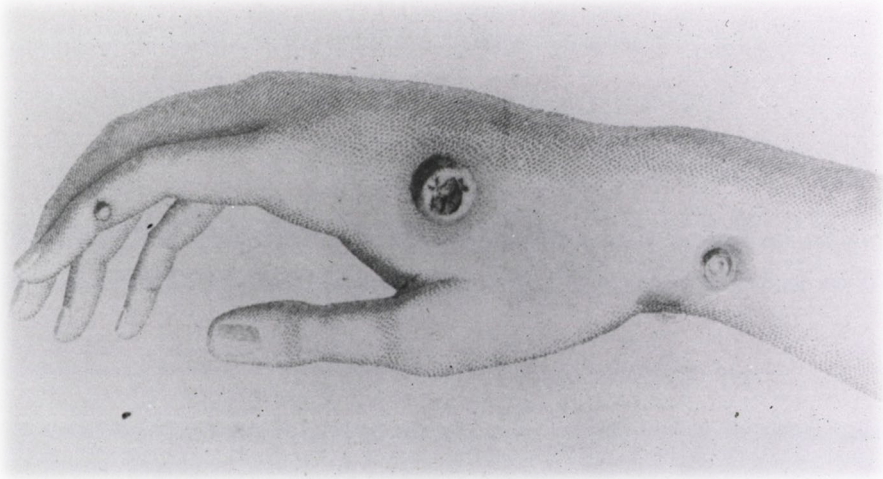
For those familiar with Marvel's Agents of S.H.I.E.L.D. this dual-use dilemma is at the heart of what we might call the "AIDA/Framework Paradox", where well-intentioned scientific creations go terribly, catastrophically wrong!

One of these major scientific concerns is a bioweapon involving smallpox, a deadly virus that was finally brought under control thanks to the smallpox vaccine. An estimated 300-500 million people died in the 20th century alone, but the last recorded case in the US was in 1949, and globally in 1979. Smallpox was brought under control thanks to a successful eradication program led by the WHO in the 1970s.

Global smallpox cases reported between 1920 and 1980

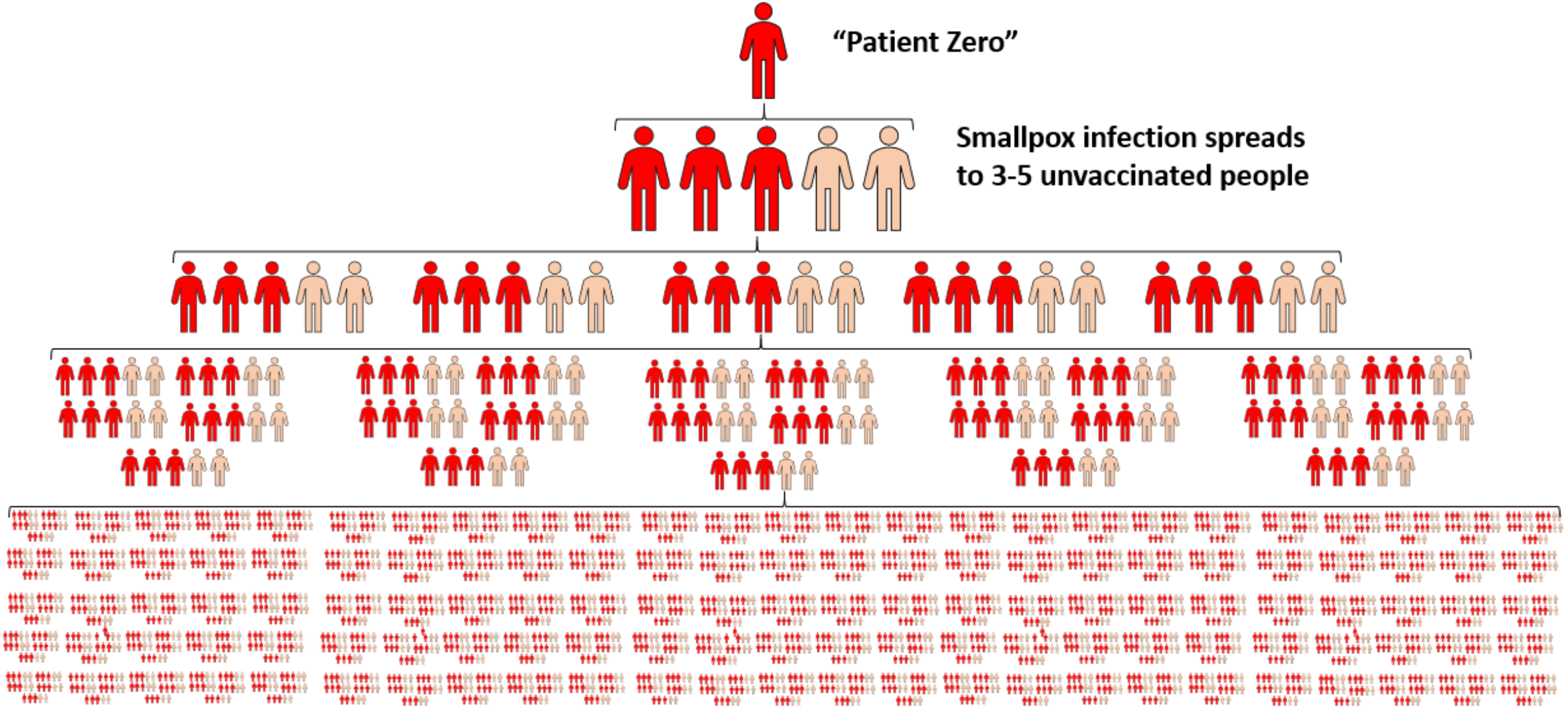


The smallpox vaccine was the first successfully developed vaccine in the world. The word vaccine comes from "*vacca*" (Latin for cow) because the cowpox virus was used by Edward Jenner to develop his smallpox vaccine.



Milkmaid Sarah Nelmes' hand, which Edward Jenner used for his smallpox vaccine in 1796.

The worry about weaponized smallpox today is that very few people have immunity to it (no one born after 1949 in the United States or 1979 globally), so its effects would be greatly amplified. It has a mortality rate of close to 30%, can be spread by droplets in the air, and is highly contagious (R0 of 5-7).



The smallpox virus is kept under strict medical protocols in 2 facilities in the US and Russia. But thanks to the advances in synthetic biology, from the Human Genome Project to CRISPR-Cas9, the ability to digitally replicate genetic data, including viruses, is becoming easier and faster. "Before the synthetic biology revolution, a virus was a thing. Not quite living, not quite dead, but it existed only in the real world, whether in the wild in its human hosts or as archived samples in a lab."

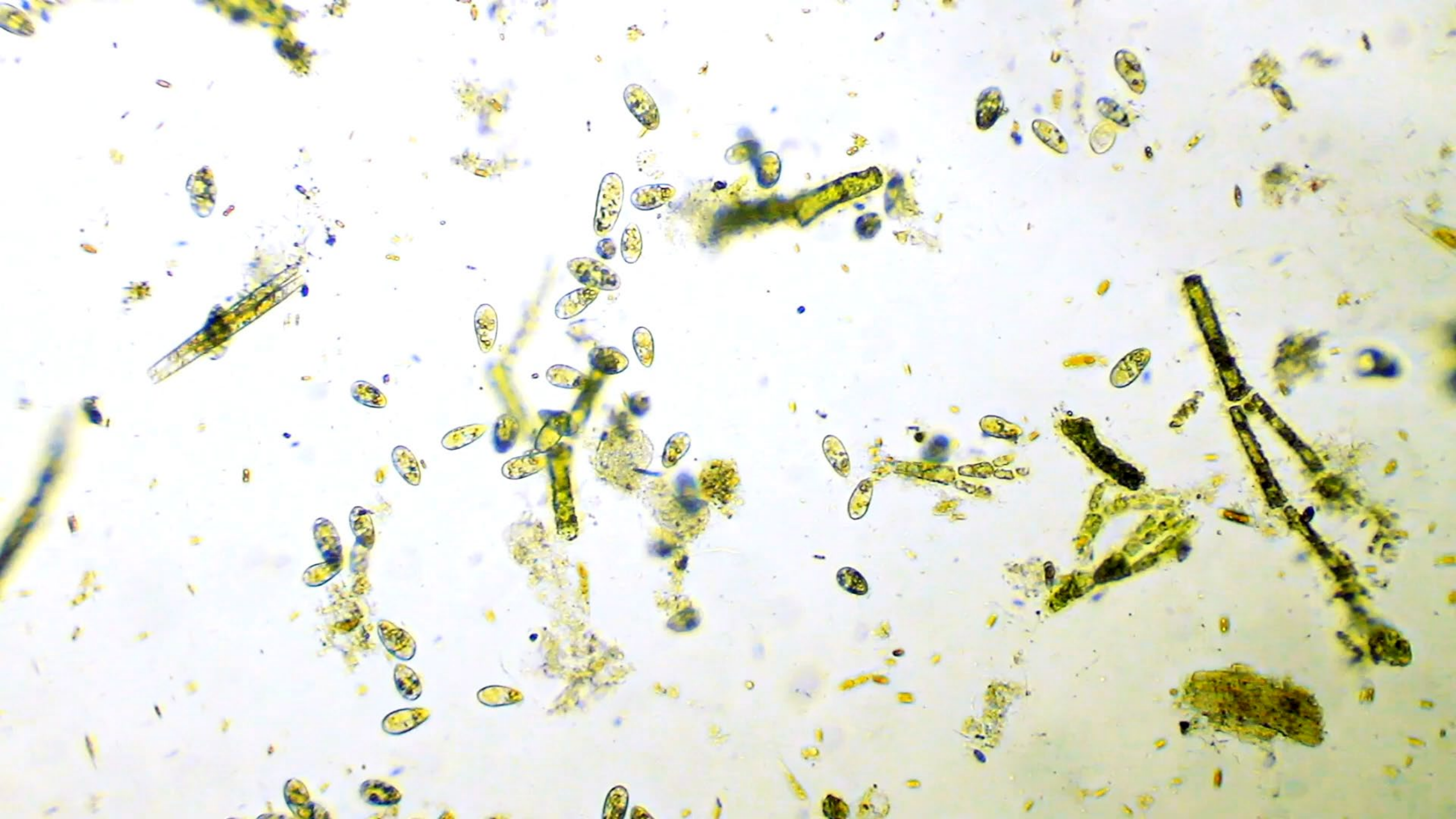
In 2017 Canadian researcher David Evans announced he had successfully created horsepox, an extinct cousin of smallpox, by using bits and pieces of DNA that had been stitched together in his lab. He did this in six months and for only $100,000, showing how easy it could be to create a new viruses. As Bryan Walsh argues, this case highlights two key aspects of existential risks posed by synthetic biology:

Information Hazards

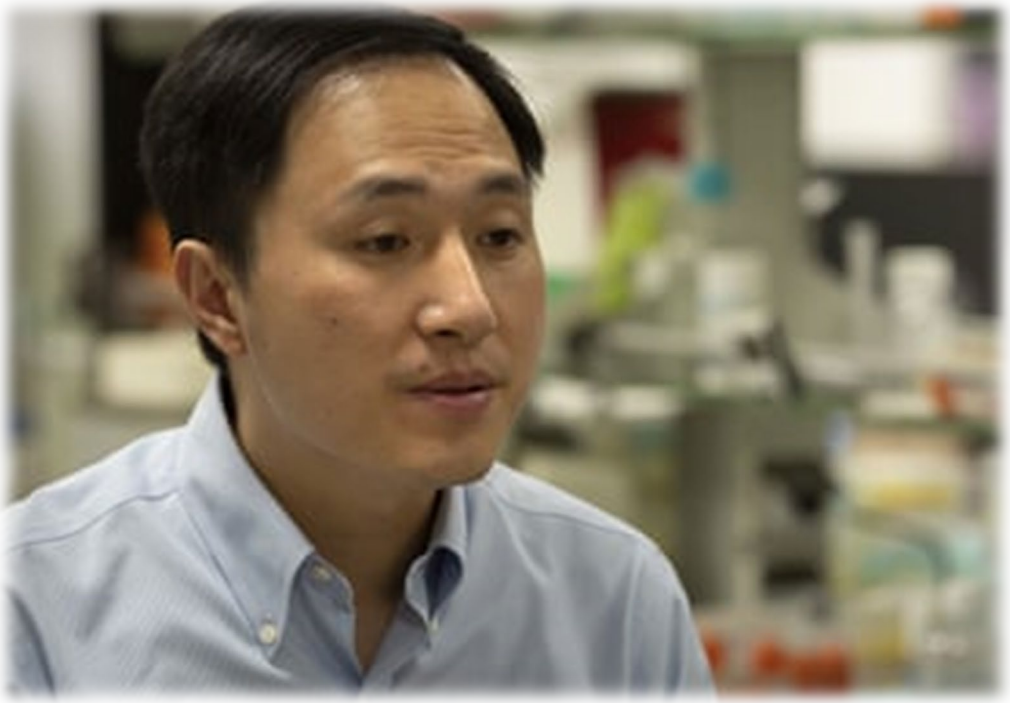
With genetic information being available as digital code, anyone with access to a computer and a lab can tinker with DNA and viruses without strict regulations. "Information wants to be free."

Unilateralist's Curse

Once scientists have developed the techniques to manipulate DNA and life itself, it only takes one mad scientist with no ethics to open Pandora's Box. "The genie is out of the bottle"



These twin dangers were made abundantly clear in 2018 when Chinese scientist He Jiankui announced he had successfully created the first genetically engineered twins (Lulu & Nana) using CRISP-Cas9. Dr. He claimed he engineered the children to be immune to HIV, but these research claims were disputed by scientists. Dr. He was sentenced to 3 years in jail and a ¥ 3 million yen fine ($.5 million) by the Chinese government for violating medical regulations and forging research documents. He fired by university.



Dr. He Jiankui, Southern University of Science and Technology

"The field of gene editing will carry the hashtag #CRISPRbabies in the mind of the public for a period longer than He's sentence…I hope that this stain will soon diminish relative to the positive impact that gene editing is likely to have in ethically treating existing disease. Moving forward, the real threat of severe legal action is the right deterrent for future Herostratus-like individuals whose hubris could drive them to follow in He's footsteps."

Fyodor Urnov, CRISPR researcher, UC Berkeley

While news of Dr. He's efforts to use gene-editing on human embryos raised many alarms in the medical community, it is a different area of synthetic biology research that poses a real risk for humans and may be the closest to an existential, end of the world scenario—virus enhancement research.

These new viral dangers emerged in 2010 and 2011 as part of what is known as "gain of function" (GOF) research, where doctors intentionally try and create modified or new viral strains in the hopes of predicting how viruses might mutate in the future in order to develop vaccines in advance.

Dr. Yoshihiro Kawaoka (UW-Madison, US) and Dr. Ron Fouchier (Erasmus Medical Center, Netherlands) both announced they had successfully made the H5N1 avian influenza virus more transmissible. As with Dr. He, the news shook up the scientific community, with many calling for an immediate halt to all gain of function research with deadly viruses to avoid an accidental global pandemic.

In 2014 the US Dept. of Health and Human Services placed a moratorium on all gain of function research and launched an investigation into the work of Kawaoka, Fouchier and others. As Walsh notes, "let's assume that the modified H5N1, like its wild cousin, would kill three out of every five people is sickened. If about a third of the global population were infected by the new, far more transmissible virus—not unreasonable, since no one would have immunity—the result could be a death toll as high as 1.4 billion people, even more than in the fictional Clade X scenario."

nature video

Under the Trump administration, the NIH lifted the moratorium on gain of function research in 2017 following a secretive review process that was not made public. While more stringent controls were put in place for future research, many scientists believe the lack of public transparency in the review process, combined with the risk of a deadly lab-created pandemic, are strong enough reasons to stop gain of function research on what are referred to as potential pandemic pathogens (PPP) like H5N1.

The possibility of a new engineered supervirus being released (intentionally or accidentally) is precisely why many scientists opposed this line of research and question its social and ethical value. As gain of function science critics Dr. Marc Lipsitch and Dr. Alison Galvani argued, "recent experiments that create novel, highly virulent and transmissible pathogens against which there is no human immunity are unethical. We note that they impose a risk of accidental and deliberate release that, if it led to extensive spread of the new agent, could cost many lives…even a low likelihood should be taken seriously."

In 2018, the first two scientists to have their GOF projects approved for US funding were the same doctors from the original controversy, Dr. Yoshihiro Kawaoka and Dr. Ron Fouchier. Both are continuing the exact same research without major changes today. This is a good example of how the Information Hazards and Unilateralist's Curse that Walsh talked about can work in tandem to make the existential risks posed by synthetic biology both more likely and more widespread.

But these sorts of technological risks are not limited to the field of biology. As technology continues to advance and "deskilling" makes the work more accessible thanks to high-speed computing costs decreasing (Moore's Law), the risk of a technological end of the world scenario becomes greater.

We've already seen this with geoengineering schemes to address climate chance. The possibility of an engineered viral pandemic is another technology-driven risk. Next week we'll delve into the risks associated with Artificial Intelligence (AI) and the digital information revolution. What all these existential risks share in common is a reliance on technology that allows humans to manipulate nature.

For some, these are changes to be celebrated, and are proof of the creative force of the human mind and the power of science and innovation to change the world for the better. For others, these changes mark a dangerous boundary-crossing by one species arrogant enough to think it can play God with the universe, manipulating and changing nature however it desires. This is the "dark twin" science dilemma.

As Walsh concludes, "That is why biotechnology ultimately poses the single greatest existential risk humans will face in the years to come, as the science continues to mature. Biotechnology takes our ingenuity, our thirst for discovery—and turns it against us. It leaves us only as strong as our weakest, maddest link. It gives us promise and it gives us power, the most dangerous gifts of all."

Weekly Assignment Reminder

- Remember to check our class Blackboard regularly for updates, announcements, and other related class information…

- Have you done the weekly readings and watched any associated videos? Weekly readings are listed on the Class Schedule page.

- Complete the weekly discussion post response. Initial post due **Wed, Nov 11** by end of day, and peer response post due **Fri Nov 13** by end of the day.