INSTITUTE FOR DEFENSE ANALYSES

NSD-5335

The Age of Bioengineered Viral Pandemics and Collapse

Drew Miller

October 2014

Institute for Defense Analyses
4850 Mark Center Drive
Alexandria, Virginia 22311-1882

The Institute for Defense Analyses is a non-profit corporation that operates three federally funded research and development centers to provide objective analyses of national security issues, particularly those requiring scientific and technical expertise, and conduct related research on other national challenges.

About This Publication

The views, opinions, and findings should not be construed as representing the official position of either the Department of Defense or the sponsoring organization.

4850 Mark Center Drive, Alexandria, Virginia 22311-1882 • (703) 845-2000.

NSD-5335

The Age of Bioengineered Viral Pandemics and Collapse

Drew Miller

October 2014

The Age of Bioengineered Viral Pandemics and Collapse

Dr. Drew Miller

"Garden variety" flus now kill more than 40 thousand Americans each year. Ebola is now ravaging West Africans and arriving on our shores with ominous prospects. These bio threats should be of even greater concern to Americans than they are. But new technologies like bioengineering may soon actually enable a small terrorist group like ISIL, or even one dedicated individual, to modify and release a new virus that could cause both a pandemic and, as people react, a collapse in economic activity and possibly law and order. A host of experts say such bioengineered viral pandemics (BVP) are inevitable. Moreover, they say they are not a future threat but rather a present risk that is growing rapidly since it is increasingly easy to modify an existing pathogen to make it more lethal or transmissible. After a first pandemic of this kind plays out, there could be significant, possibly revolutionary changes in our economy, military, and foreign policy. This article explains why this bleak coming Age of BVP is almost upon us, and, more puzzling, why this impending disaster is so little addressed.

In December 2011 national media did cover news that scientists had created a deadly virus with 60% lethality.[1] The government then asked the scientists not to publish their results, citing risks of terrorists exploiting this information. While biotechnology promises great new treatments and advances in medicine, they could also be used to design deadly new viruses that could generate huge numbers of casualties. It appears to be too late to completely stop the spread of this technology and its misuse. Now it is really a question of how bad the bioengineered viral pandemics will be, and just when they will occur. The good news is that well prepared people and nations should be able to survive and adapt.

Genetic engineering or bioengineering is the manipulation of an organism's genetic material. Scientists have been creating genetically modified organisms (GMO) since the 1970s, and in 2010 the first synthetic (not made by combining existing organism's DNA) new life form was created. Genetic modifications are common in nature—that's why we get new strains of flu all the time and have had horrible viral pandemics (like the 1918 Spanish Flu, which killed upwards of 50 million people then). Now, however, geneticists can accelerate genetic change, creating viruses and bacteria that never existed. With newer techniques, a simple, cheap lab (perhaps in your neighbor's garage) can plausibly generate millions of recombinants in minutes.[2] Through bioengineering it may be possible to intentionally create a human-to-human transmissible version of avian flu, or to modify a lethal virus to have a longer latency period, which would facilitate its undetected spread.

A Brookings Institution report illustrates the bioengineered virus threat:

[1] Steve Connor, "Alarm as Dutch lab creates highly contagious killer flu," The Independent, 20 Dec 2011 http://www.independent.co.uk/news/science/alarm-as-dutch-lab-creates-highly-contagious-killer-flu-6279474.html

[2] "The SARS episode," Originally published by Institute of Science in Society April 16, 2003. Published on KurzweilAI.net April 17, 2003

> "Using gene-splicing equipment available online and other common laboratory equipment and materials, a molecular biology graduate student undertakes a secret project to recreate the Smallpox virus. Not content merely to bring back an extinct virus to which the general population is now largely naïve, he uses public source material to enhance the virus's lethality, enabling it to infect even those whom the government rushes to immunize. . . . While time-consuming, the task is not especially difficult. And when he finishes, he infects himself and, just as symptoms begin to emerge, he proceeds to have close contact with as many people from as many possible walks of life as he can in a short time."[3]

Dr. Tara O'Toole, former director of Johns Hopkins University Center for Civilian Biodefense Strategies, offers similar warnings: "…all you have to do is clink in the new gene, you get a new pathogen, you get a new weapon. There's no question in our mind that organized terrorists could mount at least a small bioterrorist attack now."[4] If it's a lone terrorist or lunatic launching the virus, it may not spread far before we detect it and limit the devastation. If it's an enemy nation, spreading a bioengineered virus with high lethality and transmissibility, with a long period where carriers are contagious but not suffering from the illness or symptoms, the virus might kill millions. This scenario could leave survivors in a radically disrupted social, economic, security and political environment for years.

A bioengineered virus, launched in our crowded, interconnected world by an enemy working to spread it widely before it is detected, could yield a more devastating pandemic than anything experienced in the past. Smallpox killed as many as 90% of Aztec, Maya, and Inca citizens during the European takeover of the New World, and it killed 500 million people in the 20th century. Smallpox could do even worse now, since immunity is gone and our populations are far more vulnerable.[5] For example, Stanford Professor Dr. Nathan Wolfe warns that "if terrorists ever got their hands on one of the few remaining vials of smallpox, the results would be devastating. . . . Interestingly, in 2004 scabs from suspected smallpox were found in Santa Fe, New Mexico, in an envelope."[6] Many fear that laboratories beyond the U.S. and Russia still have smallpox virus, and that its genetic code has been posted on the Internet.[7]

---

[3] Benjamin Wittes, "Innovation's Darker Future: Biosecurity, Technologies of Mass Empowerment, and the Constitution," Brookings Institution study, Dec 2010

[4] Dr. Tara O'Toole, quoted in Secret Agents: The Menace of Emerging Infections, Madeline Drexler, Joseph Henry Press (National Academy of Sciences), Wash DC, 2002, p. 242

[5] Dr. Nathan Wolfe, "The Viral Storm: The Dawn of a New Pandemic Age," New York: St Martin's Griffin, 2011, pp.124-125; and Donald Henderson, MD, Et Al, "Smallpox as a Biological Weapon", Journal of the American Medical Association, June 9, 1999

[6] Dr. Wolfe, p. 156

[7] Laurie Garrett, "Biology's Brave New World: The Promise and Perils of the Synbio Revolution," Foreign Affairs, November/December 2013; Kathleen Sebelius, "Why We Still Need Smallpox," New York Times Op-Ed, April 25, 2011

Eckard Wimmer, who headed the team of researchers at SUNY Stony Brook that made live polio virus from scratch as part of a Defense Department project to prove the threat of synthetic bioweapons, said that any one of the 2,847 members of the American Society for Virology could figure out how to do the same.[8] Rob Carlson, a physicist-turned-biologist, like many others in the biotech field, warned that developing lethal viruses is increasingly cheap and easy. There is no need for a national program, a big lab, expensive equipment or specialized expertise.[9] With a human-to-human transmissible virus there is no need for difficult weaponization efforts—the malefactor would find a simple means of infecting people in crowded public transportation centers and let them spread the virus. Again citing Dr. Henderson, "between the time of an aerosol release of smallpox virus and diagnosis of first cases, an interval as long as 2 weeks or more is apt to occur because of the average incubation period of 12 to 14 days and the lapse of several additional days before a rash was sufficiently distinct to suggest the diagnosis of smallpox."[10] In short, only a few days are needed for a virus released in multiple airports to reach every city and probably most small towns in the U.S. Moreover, if the smallpox virus has been genetically modified, the limited supply of vaccines we have for smallpox may not even work on the new strain.

If smallpox is too difficult to obtain or to synthetically create, someone can grab another deadly virus like Ebola or Avian Flu that is still making its rounds, as Ebola is today. Dr. Henderson and other scientists, writing in an article on biosecurity, warned that H5N1 avian influenza kills about 60% of its victims, compared to just 2% for the 1918 Great Spanish Flu Pandemic (that killed about 50 million). "Like all influenza strains, H5N1 is constantly evolving in nature. But thankfully, this deadly virus does not now spread readily through the air from person to person. If it evolved to become as transmissible as normal flu and results in a pandemic, it could cause **billions** of illnesses and deaths around the world."[11] In 2011, Ron Fouchier of the Erasmus Medical Center, in Rotterdam, turned H5N1 virus into a possible human-to-human flu by infecting ferrets (mammals used to test human effects) repeatedly until a form of H5N1 that could spread through the air from one mammal to another resulted. This was not high-tech bioengineering, but instead simply swabbing the noses of the infected ferrets and using the gathered viruses to infect another round. A team of scientists at China's National Avian Influenza Reference Laboratory combined H5N1 with genetic attributes found in dozens of other types of flu. Some of their "man-made super flu strains" could spread through the air between guinea pigs, killing them.[12] This was condemned by scientists around the world as "appalling

[8] Dr. Ray Kurzweil, cited by Paul Boutin, "Biowar for Dummies: How hard is it to build your own weapon of mass destruction? We take a crash course in supervirus engineering to find out," July 11, 2006, originally published on Paul Boutin blog February 22, 2006. Reprinted with permission on KurzweilAI.net July 11, 2006
[9] Dr. Kurzweil, cited by Boutin "
[10] Donald Henderson, MD, Et Al, "Smallpox as a Biological Weapon", Journal of the American Medical Association, June 9, 1999
[11] Thomas Inglesby, Anita Cicero and D.A. Henderson, "The Risk of Engineering a Highly Transmissible H5N1 Virus," Biosecurity and Bioterrorism: Biodefense Strategy, Practice and Science, Vol 10, No. 1, 2012
[12] Laurie Garrett

irresponsibility" since the new viral strains created by mixing bird-flu virus with human influenza could escape from the laboratory and cause a global pandemic--killing millions of people.[13] If researchers we know of are tampering with H5N1 to make it human to human transmissible, we should not be surprised if terrorists and nation-states are doing this as well.

Scientists justify this kind of research and its publication by noting that bioterrorists already know how to do this and argue that we must research lethal agents as well to try and find countermeasures. This may be true, but unfortunately, it is easier to create a deadly virus than counter one.

Dr. Kathleen Eggleson wrote:

> "although publication of data about virulence factors does not necessarily equate to protocol distribution or instruction in bioweapon design, the current scope and trajectory of synthetic biology research are consistent with the concern exhibited by the NSABB [the Board that first blocked, then allowed publication] in the H5N1 case. Also distressing is the potential for potent virulence factors expressed by different organisms in nature to be recombined into a 'super bug' by human design, a phenomenon that may lead to a flourish of bioweaponization activity."[14]

The Soviet Union's biological warfare program, with far less capable equipment and knowledge than exists today, produced a host of biowarfare agents. This effort included 65,000 researchers in a vast network of secret laboratories, each focused on a different deadly agent. They produced traditional biological weapons and some believe they may have successfully combined smallpox, Marburg, Ebola and other viruses. If you could combine the 90% lethal Ebola virus with highly contagious smallpox, you might indeed create an existential BVP. A former leader of the Soviet biowarfare program believes his colleagues still work in Russia and many other nations, and predicts that bioweapons "in the coming years, will become very much a part of our lives." [15]

BVP will also come from accidents in professional labs and do-it-yourself (DIY) biologists in their garages. In 2001 Australian researchers attempting to make a contraceptive vaccine for pest control inserted a "good" gene into mousepox virus and accidentally created a lethal new virus that resisted vaccination. Other legitimate lab accidents have likely occurred but were not publicized. We don't want to imagine what do-it-yourself biologists and biohackers are doing.

---

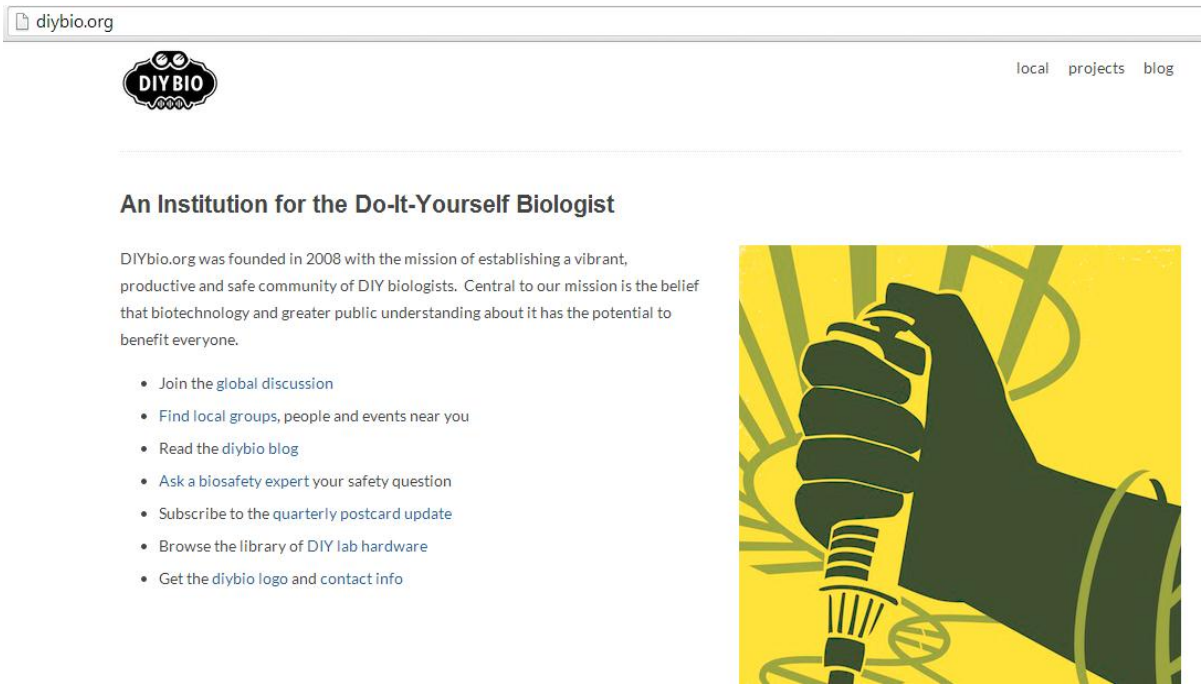
[13] Steve Connor, "'Appalling irresponsibility': Senior scientists attack Chinese researchers for creating new strains of influence virus in veterinary laboratory," The Independent, 2 May 2013

[14] Dr. Kathleen Eggleson, "Dual-use nanoresearch of concern: Recognizing threat and safeguarding the power of nanobiomedical research advances in the wake of the H5N1 controversy," Nanomedicine: Nanotechnology, Biology, and Medicine, 9, 2013 pp. 316-231

[15] Ken Alibek, "Biohazard: the chilling true story of the largest covert biological weapons program in the world—told from inside by the man who ran it", Random House, 1999, pp. xi, 258-9, 262-3, 271-2, 275

There are over 2,000 DIY Bio members (website below). Some work alone at home, others in small rent-a-lab spaces around the world.[16]

Figure 1: Do-It-Yourself Bio organization, web site



Advances in DNA manipulation technology, cheap lab equipment, and information posted on the Internet enable a single person with the right resources to make artificial smallpox or worse.[17] With "professional" scientists in controlled labs irresponsibly making human transmissible forms of highly lethal Avian flu and publishing the instructions, there should be no question that DIY bio folks in their garage, biohackers, lunatics, terrorists, or countries like Iran and North Korea will either intentionally or accidentally unleash a BVP.

If the first bioengineered virus comes from an accident or is unleashed by one madman it may fail to spread to pandemic status. A worse threat is Iran or Al Qaeda bioengineering a virus they release against us in multiple locations, perhaps after they've developed a vaccine to protect themselves. For new, bioengineered viruses, however, there will very likely be no immunity or treatment. So if a nation-state were to put even a small lab to work to develop a GMO with the "cubed" power of high lethality, high transmissibility, and long latency period, and if they created a vaccine that only they have, this state could have the capability to destroy many

[16] Ritchie King, "When Breakthroughs Begin at Home," New York Times, Jan 16, 2012

[17] Roger Brent, a geneticist who runs a California biotech firm cited by Paul Boutin, "Biowar for Dummies: How hard is it to build your own weapon of mass destruction? We take a crash course in supervirus engineering to find out," reprinted with permission on KurzweilAI.net, July 11, 2006

enemies. Delivered “correctly,” the devastated population would not even know who to blame for the attack.

It may seem irrational for a nation state to unleash a contagious agent. But it’s more understandable given the ability to launch the attack secretly, without any identification of what country is responsible. There are thousands of cases one could foresee, none as irrational as the world going to war after a terrorist assassinated the Arch Duke of a declining state at the start of WW I.

While we cannot forecast the odds of a BVP, a host of experts believes it is inevitable, as Figure 2 shows, and could certainly happen very soon.

Figure 2: Experts warning of an inevitable, potentially existential, pandemic threat

"[t]he world has never been at more risk to [Weapons of Mass Destruction] use by regional powers hostile to American interests, or to the widespread effects of disease-causing pathogens." - 2010 DoD Chemical Biological Defense Program Annual Report to Congress

"It is clear that the offensive nature of the threat is proceeding at a pace that requires us to be prepared to defend our warfighter and out Nation from the inevitable emergency of a new threat from biological and chemical agents and that we move rapidly in response. . . . the likelihood of surprise from biological and chemical threats is inevitable**"** - Defense Threat Reduction Agency, Chemical & Biological Technologies Directorate, "DTRA R&D Enterprise Chemical-Biological Directorate Strategic Vision, 2012"

Bio agents listed as an "existential threat." "Given the enormous universe of microbial threats, the power of modern biology to enhance the microbial virulence and the high likelihood that biological weapons will continue to threaten humanity one must face the question of how best to protect society. The sheer number of threats and the availability of technologies to modify microbes to defeat available countermeasures suggest that any attempt to achieve defense in depth using microbe-by-microbe approaches to biodefense is impractical and ineffective." - Dr. Arturo Casadevall, Dept of Microbiology and Immunology and Division of Infectious Diseases, Albert Einstein College of Medicine, NY, 2012

"There's no question in our mind that organized terrorists could mount at least a small bioterrorist attack now." - Dr. Tara O'Toole, former director of Johns Hopkins Center for Civilian Biodefense Strategies, 2002

"We conclude that, broadly stated, peaceful scientific advances, global statistics and demographics of GMOs suggest that the potential for corruption of biotechnology to catastrophic malevolent use is considerable. At a more detailed level, we find that there are tangible opportunities for many potential adversaries to acquire, modify, and then manufacture to scale a potential GMO pathogen." - Center for Technology and National Security Policy, National Defense University, "Analysis of the Threat of Genetically Modified Organisms for Biological Warfare," May 2011

"We have an existential threat now in the form of the possibility of a bioengineered malevolent biological virus. With all the talk of bioterrorism, the possibility of a bioengineer bioterrorism agent gets little and inadequate attention. The tools and knowledge to create a bioengineered pathogen are more widespread than the tools and knowledge to create an atomic weapon, yet it could be far more destructive. I'm on the Army Science Advisory Group . . . Without revealing anything confidential, I can say that there is acute awareness of these dangers, but there is neither the funding nor national priority to address them in an adequate way."- Dr. Ray Kurzweil, a leading scientist and futurist, member of the Army Science Advisory Group, quoted in instapundit.com, Sep 2, 2005

"Using disease, terrorists can substantially multiply the devastation and societal disruption that they cause, and they can do it without sophisticated infrastructure or state support. For this very reason, we would be mistaken to treat a worst-case scenario as a remote possibility. Instead, we must deal with this as an eventuality for which we need to be prepared." - Ronald K. Noble, Secretary General of INTERPOL, Bioterrorism International Tabletop Exercise, 2007

"It is 'more likely than not that a weapon of mass destruction will be used in a terrorist attack sometime by the end of 2013.' . . . Nuclear proliferation and advances in biotechnology have given terrorists new means to carry out their avowed intention to commit mass murder." –Commission On The Prevention Of Weapons Of Mass Destruction Proliferation And Terrorism, Dec 11, 2008

"by the year 2020 an instance of bioterror or bioerror will have killed a million people." - Lord Martin Rees, President of the Royal Society, Master of Trinity College, Cambridge University, Visiting Professor at Harvard/Caltech/Berkeley/Institute of Advanced Studies at Princeton, foreign associate of the Nat'l Academy of Science

"It would be a mistake to underestimate the risk for bioterror, and most who study it contend that it is just a matter of time before it's unleashed on a human population." - Stanford Professor, Dr. Nathan Wolfe, "The Viral Storm: The Dawn of a New Pandemic Age," New York: St Martin's Griffin, 2011

"Within the last century we have had four major flu epidemics, along with HIV and SARS. Major pandemics sweep the world every century, and it is inevitable that at least one will occur in the future." - Professor Maria Zambon, head of UK Health Protection Agency's Influenza Laboratory

"So convinced are public health officials of the inevitability of a flu pandemic that they call the past 30 year's respite the 'inter-pandemic' period." - Madeline Drexler, Editor of Harvard Public Health Review, Harvard University Public School of Health, "Secret Agents: The Menace of Emerging Infections," Joseph Henry Press (Nat'l Academy of Sciences), 2002

"if it [H5N1 avian influenza]evolved to become as transmissible as normal flu and results in a pandemic, it could cause billions of illnesses and deaths around the world." - Thomas Inglesby, Anita Cicero and D.A. Henderson, "The Risk of Engineering a Highly Transmissible H5N1 Virus," Biosecurity and Bioterrorism: Biodefense Strategy, Practice and Science, Vol 10, No. 1, 2012

In a National Defense University study, scientists, biologists and defense experts released an "Analysis of the Threat of Genetically Modified Organisms for Biological Warfare." Their report notes that "the tools and information required for genetic modification of microorganisms are readily available worldwide." They are also very cheap, and "the work can be successfully accomplished by a small cadre [of three people]." This study estimated that the materials and facilities to weaponize a bioagent would cost about $250,000. "Compared to other projects that might be undertaken by governments or private organizations, the cost of equipping and staffing a laboratory scale bioprocessing facility is trivial." As noted in the Figure above, they concluded that "the potential for corruption of biotechnology to catastrophic malevolent use is considerable" with "tangible opportunities for many potential adversaries to acquire, modify, and then manufacture to scale a potential GMO pathogen."[18]

Bioengineering is not the only new technology that some scientists believe could pose an existential threat. The Cambridge Centre for the Study of Existential Risk includes many scientists concerned that developments in technology such as artificial intelligence, biotechnology, and nanotechnology, pose new, extinction-level risks to our species.[19] Lord Rees is part of this Cambridge University group, and he warned in 2013 that "we're entering an era when a few individuals could, via error or terror, trigger societal breakdown. . . . [T]hese human-induced threats are different—they are newly emergent, so we have a limited time base for exposure to them and can't be so sanguine that we would survive them for long, or that governments could cope if disaster strikes."[20] Experts at a Global Catastrophic Risk Conference in 2008 estimated a 19% chance of human extinction over the next century.[21] Oxford Professor Nick Bostrom wrote that "the balance of evidence is such that it would appear unreasonable not to assign a substantial probability to the hypothesis that an existential disaster will do us in. My subjective opinion is that setting this probability lower than 25% would be misguided, and the best estimate may be considerably higher."[22]

A BVP or other triggering disaster need not be that effective in killing infected victims to generate a collapse which kills millions and destroys the nation's strength.

"Collapse" is defined here as a cessation of most economic activity and widespread lack of law and order, for a prolonged period of time, with very high fatalities (millions, over 10% of the population). Indeed, GMOs pose an "existential threat," meaning a risk not just of killing

---

[18] Jerry Warner, James Ramsbotham, Ewelina Tunia and James J. Valdes; Center for Technology and National Security Policy, National Defense University, "Analysis of the Threat of Genetically Modified Organisms for Biological Warfare," May 2011

[19] Ross Andersen, "When we peer into the fog of the deep future what do we see – human extinction or a future among the stars?" Aeon Magazine, 25 Feb 2013

[20] Martin Rees, "Denial of Catastrophic Risks," Science, 8 March 2013, Vol. 339 no. 6124, p. 1123

[21] Cited in Sandberg, A. & Bostrom, N. (2008): "Global Catastrophic Risks Survey", Technical Report #2008-1, Future of Humanity Institute, Oxford University

[22] Dr Bostrom, "Existential Risks"

millions of people, but potentially billions, wiping out civilization as we know it. An existential threat is defined here as one that could kill most of the population (over 90%), causing a collapse that lasts beyond a few years, with the level of pre-collapse civilization and normal life not returning for generations. Oxford Professor Bostrom, part of the unheard chorus now warning us of the bioengineering threat, defines an existential risk as "one where humankind as a whole is imperiled. . . [with] major adverse consequences for the course of human civilization for all time to come."[23] Compared to nuclear weapons which require the vast resources of a nation-state to produce, DNA manipulation and bio engineering technology puts tremendous, potentially existential, killing power in the hands of a few zealots.

With a largely rural population and relatively little, slow international travel, the plague wiped out about one third of Europe's population in the Middle Ages. Today, over half of the world's 7 billion people live in cities, visited daily by international travelers. Unlike the Middle Ages, people today have better sanitation and health care, but are much more urbanized and densely packed together, sustained by food and water that arrives from distant locations, relying on delivery systems and economic operations that could very well shut down if there is a lethal contagious virus spreading and people understandably not reporting to work. Even people with the courage to face the risk may change their mind when they realize they could bring a fatal virus home to infect their families. Those that do keep working, medics and police in particular, are likely to catch the virus. We should expect that most economic activity, public services, production of essential goods, and transportation may cease. To minimize inventory costs, businesses, even hospitals, have "just in time" delivery of supplies, sourcing from lowest cost providers on the other side of the world. Even if your local trucker decides to continue working, with multiple long-distance suppliers and shippers involved in moving foodstuffs, a contagious pandemic would certainly disrupt the flow of goods. Would panic buying and hoarding add to the problem of getting food to the population? How long will our public water supplies continue functioning when maintenance personnel fail to report for work? Our highly interdependent, just in time delivery economy is very vulnerable to disruptions. Nassim Taleb, an expert in risk and thinking about rare events, points this out: "Our connected world appears to be more efficient. But when there is a disturbance, the setback is much harder to handle. Not only are we building riskier systems, but also the risks involved in failure are a lot larger."[24]

More critical than the probability of a disastrous event occurring is whether the effects spread, how people react, and whether or not it leads to collapse. In a pandemic with lack of food and water, widespread marauding may occur. Katrina was an eye opener for many: a very predictable, relatively small disaster quickly led to violence and breakdown in law and order. Looting rapidly spread throughout the city, often in broad daylight and in the presence of police

[23] Professor Nick Bostrom, Oxford University, "Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards," Journal of Evolution and Technology, 2002

[24] Nassim Taleb, quoted in Fortune Magazine, April 11, 2011

officers. One third of New Orleans police officers deserted the city in the days before the storm, many of them escaping in their department-owned patrol cars. In 1977 New York City suffered a lightning strike, which led to a power failure for one night. Over 3,000 arrests were made for looting, 400 policemen were injured, 500 fires were started. Given this, what should we expect in the far more threatening scenario of a spreading, deadly viral pandemic? Pandemonium.

Some of the major changes in our society's vulnerability to disruptions and resilience to recover are summarized in the chart. In addition to these factors, there are many additional reasons why we are far more likely to suffer when a widespread disaster hits. For example, despite rising population, we have fewer hospital beds and emergency rooms in the U.S. Between 1990 and 2009, emergency rooms in non-rural U.S. hospitals declined 27%, from 2,446 to 1,779.[25]

Figure 3: Relative vulnerability of our population to disruptions

	1800s	2010s
% population farming	>80%	<2%
Food travel distance	few miles	1,000s
Food on hand	months	days
Water supply	well	municipal
Electronic dependence	none	heavy
Production sourcing	local	int'l
Inventory levels	large	tiny (JIT)
resiliance of people	Pioneers	Katrina
Overall vulnerability	**low**	**high**

Some may not wait to exploit a disaster, they may loot and maraud immediately. UK riots in 2011 showed that law enforcement can break down and violence spread without an underlying trigger disaster. The British Prime Minister called it "pure criminality"; others said it was inevitable violence from youth fed up with unemployment or family breakdown. Attacks on police and looting started in London, but spread quickly to cities across the UK. Looting and violence grew as more people took advantage of the opportunity and "marauding gangs" formed. Police "lost control" of many areas. Innocent people were shot dead in cars and robbed on streets. Thugs in Birmingham killed three men trying to protect their businesses. And the riots and marauding continued the following night—and the next. Violence repeated in London for four nights until an extra 16,000 police officers were moved in to restore order.

Will gangs accelerate the breakdown in law and order and magnify marauder threats? The number of gang members in the world is estimated at several million. In the U.S. an estimated 30,000 gangs and 800,000 gang members were active in 2007. The MS-13 Latino gang, known for brutal murders, has tens of thousands of members dispersed among most U.S. states.[26] Some people may use the disaster and distraction to police as an opportunity to pillage.

[25] RAND Fact Sheet, "Why are Many Emergency Departments in the United States Closing?" 2011
[26] The List: The World's Most Dangerous Gangs, Foreign Policy, May 2008

A major disaster could lead to economic and societal shutdown that escalates out of control in ways we cannot forecast, but can foresee as potentially worse than the losses from the trigger event. A recent Defense Science Board study warned that even a relatively benign cyber-attack could trigger collapse: "food and medicine distribution systems would be ineffective, transportation would fail or become so chaotic as to be useless. Law enforcement, medical staff, and emergency personnel capabilities could be expected to be barely functional in the short term and dysfunctional over sustained periods."[27]

Figure 4: The Risk of collapse is rising rapidly, driven by six bad trends

1. New technologies: DNA manipulation and bioengineering, new means to manufacture nuclear materials, nanotechnology
2. Rising overpopulation, high population densities, international travel
3. Increased economic interdependence, just in time inventories, long-distance sourcing
4. Very high dependence on daily food shipments, inadequate local water supplies
5. Less personal resilience
6. More bad people, gangs, with means to create chaos

Combined Effect: More lethal threats against an increasingly unstable economy and vulnerable population

The nation's leading agency for protecting against WMD, the Defense Threat Reduction Agency, warns that we face the "inevitable emergency of a new threat from biological and chemical agents." The Commission On The Prevention Of Weapons Of Mass Destruction Proliferation And Terrorism, the international police agency INTERPOL, the former president of the Royal Society of London all warn of bio terror attacks that could kill millions. When Dr. Henderson, who led the World Health Organization global smallpox eradication campaign, predicts that a human transmissible form of Avian flu could injure and kill billions, that's a credible warning of an existential threat. But none of this generates as much publicity, attention, or action as a football game.

To understand why we are blind to this pending disaster, Nassim Taleb's *The Black Swan: the Impact of the Highly Improbable* offers insights.[28] A "Black Swan" is an extreme impact event that is outside the realm of regular expectations; nothing in the past can convincingly point to its possibility. Concerning such events, Taleb warns that: "things have a bias to appear more stable and less risky in the past, leading us to surprises. . . . The history of epidemics, narrowly studied, does not suggest the risks of the great plague to come that will dominate the planet."[29]

[27] Defense Science Board, "Resilient Military Systems and the Advanced Cyber Threat," Jan 2013, p. 5.
[28] Nassim Taleb, *The Black Swan: the Impact of the Highly Improbable*, 2nd edition, Random House, 2010.
[29] Taleb, p. 354

Taleb cites 27 widespread errors in human thinking processes and misapplications of statistics to explain why we neglect Black Swan disasters like a coming BVP. The world is more complicated and random than many people realize. Many people cling to current truths and past experiences that new technologies and changing conditions may soon render wrong. We often fool ourselves with stories and anecdotes, invent memories. What we don't see regularly, we tend to ignore. We learn by repetition, react and decide by gut feel, thinking that we've thought it through and made a rational choice when in fact we often have not. "We are made to be superficial, to heed what we see and not heed what does not vividly come to mind. . . . Out of sight, out of mind: we harbor a natural, even physical, scorn of the abstract."[30] In sum, "we are naturally shallow and superficial—and we do not know it."[31] We overestimate what we know and underestimate uncertainty. "Our human race is affected by a chronic underestimation of the possibility of the future straying from the course initially envisioned, . . . an ingrained tendency in humans to underestimate outliers—or Black Swans."[32] Taleb cites as examples the diaries of people prior to WWII—they had no inkling that something momentous was taking place, that large scale war was coming. And indeed, while we hear much about Churchill's warnings, his was a rare voice and ignored.[33]

This BVP "disaster blindness" may be stronger in the U.S. because we have the mightiest military and feel immune from attack. Yet this may be precisely why a BVP is a likely weapon of choice for attacking the U.S. It could kill more people than even a large nuclear attack, cause more lasting devastation and economic collapse, and best of all for the attacker—they may get away with no retaliation since we may never be able to determine or prove who released the virus.

A National Research Council committee on chemical and biological defense scolded in 2012 that "The US probably has not yet adequately embraced the opacity of the threat. It will be much, much more difficult to prepare for and defend against than prior threats."[34]

When I interview biologists, researchers and businessmen who should be troubled by the coming BVP their more immediate worry is that their research will be curtailed or over regulated. They believe biotechnology promises great advances in medicine and is a huge economic opportunity. "Distributed biological manufacturing is the future of the global economy."[35] Critics of GMO,

---

[30] Taleb, p. 121
[31] Taleb, p. 132
[32] Taleb, p. 141
[33] Taleb, p. 14
[34] Committee on Determining Core Capabilities in Chemical and Biological Defense Research and Development; Board on Chemical Sciences and Technology; Division on Earth and Life Studies; National Research Council; "Determining Core Capabilities in Chemical and Biological Defense Science and Technology," Pre-Publication — Uncorrected Proofs, 2012
[35] Rob Carlson, "Open-Source Biology And Its Impact on Industry," March 3, 2004, Copyright © 2001 Institute of Electrical and Electronics Engineers. Reprinted from IEEE Spectrum. Published on KurzweilAI.net March 3, 2004

particularly food, often overstate risks of health threats from genetically modified food and call for bans. Scientists I've interviewed often link GMO food criticism to bioweapon misuse concerns, fearing that warnings about BVP will lead to banning genetic research and their work. The American Society for Microbiology President said that requiring scientists, institutions, or experiments to be licensed "would have a devastating chilling impact on biomedical research."[36] I agree that it would certainly drive the research to other parts of the world where it's not regulated, and that it's too late to stop. The Beijing Genomics Institute is the largest sequencer of the human genome, and owner of a California company manufacturing genome-sequencing machines.[37]

Once assured that my goal is not to ban their work, most bioresearchers interviewed acknowledge but still discount the risk, insisting that it's extremely difficult to do bioengineering. It is common for professionals to regard their work as so difficult that non-professionals can't do it. Maybe biohackers cannot, but certainly countries like Iran have professionals, possibly with assistance from former Soviet bioweapons experts. The continuing advances in biotechnology make it easier, faster and cheaper to do. The accidental creation of deadly viruses in labs indicate it's not that difficult. It is difficult to do beneficial, planned, targeted bioengineering. But to experiment with combinations of existing deadly viruses, stuff viruses up ferrets' noses, and do thousands of genetic mutations in a small lab until you find something that kills off lab animals (and these "animals" might be human prisoners in some parts of the world), would not be terribly difficult. A targeted goal of designing a specific formulation of EbolaPox would be hard to achieve, but experimenting with Avian flu or Polio until one concocts something that's lethal, human-to-human transmissible, and has a several day latency period ought not be beyond the capacity of professional researchers.

Bioresearchers often cite past natural viruses that were controlled as well as inept groups like the Aum Shinrikyo cult that failed to release Ebola virus. But this is what Taleb warned we naturally tend to do in evaluating threats—we focus on past experiences, not on the new Black Swan threats. The important question is what would happen if a professional terrorist group or national program, rather than an inept religious cult (that ultimately used Sarin nerve gas), undertakes the effort? Is a pandemic beyond their reach? Oxford Professor Bostrom, cited earlier, counsels us to "be careful not to use the fact that life on Earth has survived up to this day and that our humanoid ancestors didn't go extinct in some sudden disaster to infer that that Earth-bound life and humanoid ancestors are highly resilient."[38]

---

[36] Ronald M. Atlas, quoted in "The SARS episode," Originally published by Institute of Science in Society April 16, 2003. Published on KurzweilAI.net April 17, 2003

[37] "Beijing Genomics Institute: For Making DNA Sequencing Mass-Market," Fast Company, March 2014, p. 120

[38] Professor Nick Bostrom, Oxford University, "Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards," Journal of Evolution and Technology, 2002

In the usual course of our discussions, after citing examples listed in this article, the biologist will sometimes take consolation in guessing that the pandemic would be small, detected early, and then handled. A pandemic would be detected quickly once victims start dying, but if the virus has a natural or bioengineered long latency period and is spread by a smart but simple dissemination plan, a very small effort could lead to infected people in every corner of the U.S., if not most of the world. Biologists also assume that once detected, quarantine will stop the spread. For such an important question, ought we to test this hypothesis? Will the procedures employed by security and health officials work if a BVP has been engineered (say with long latency) to defeat them? Will they work if significant elements of the population abandon civil behavior (as in the UK in 2011)?

Scientists and businessmen engaged in this research clearly want it to continue because of the benefits it promises and their personal interest in it. Regardless, it is far too late to get back the equipment and information that is spread all over the world, enabling any country, if not a dedicated individual, to generate a BVP.

The federal government is aware of the bioterrorism risk, but it is not a top priority. The lead agencies dealing with biotechnology fund and promote the research. Until the first instance of disaster, it is doubtful there will be strong action to prepare for the very viable threat of a BVP collapse. Nothing major happens in DC without laws directing action, budgeting, and top elected official commitment. All are lacking now. There are no special interests and lobbyists pushing for bioterrorism preparedness. Biotechnology firms and university researchers will fight limits on research. Public research universities in particular wield tremendous political power in many states. Attempts to limit or control access to biotechnology will have negative economic impact with the research and businesses shifting elsewhere. Enemies will have little trouble getting the technology overseas.

DHS has the lead on homeland defense against a BVP, not the DoD. DoD has far greater resources, but even when defense agencies like DTRA do get involved, the bureaucratic "swim lane" they must stay in is protecting our troops, not American citizens. Less than 1% of DoD spending could be construed as dedicated for homeland defense recovery operations.

The bottom line for biotechnology is that it holds tremendous promise for good, has huge industrial and academic support, and, at this point, can't be significantly restricted.

The initial or "triggering" Black Swan disaster may not be the biggest thing to worry about. The "cascading effects" of an economic shut down, loss of law and order, some people looting and marauding, disruption of health, sanitation, water and transportation systems triggered by the initial disaster may deliver much worse, longer lasting damage. For example, can nuclear reactors safely shut down when no one reports to work because they don't want to risk viral

exposure? What cascading problems will result when the electric grid goes down? Will the public water system fail because everyone has started filling bathtubs and every container they can find and municipal water plants are no longer manned or running? There are thousands of such follow-on disasters that could happen.

The real Black Swan uncertainty is not if a BVP or other Black Swan disaster will occur, but how bad it will be, what depth of collapse results, and the deaths and damage caused in the aftermath of the collapse. Even after the first pandemic and collapse, it will likely be impossible to prevent repeat bio attacks. It may be the next era of warfare and terrorism that may define the next era of "civilization." In an era when individuals can wield the power to kill millions and cause a collapse, the outlook for mankind may be more bleak than rosy. From the Stone Age through the Bronze, Iron and Industrial Ages, into today's Information Age, humans have enjoyed longer lifespans and improving quality of life and civilization. Every major technological advance has also been applied to new weapons and means of killing. Mass produced weapons and chemical agents in World Wars. Cyber war now. Nuclear weapons were very difficult to make or hide, and largely held in check by nation-states. But biotechnology puts larger destructive power in the hands of individuals to wield against societies that are far more vulnerable. The Biotech Age could deliver great advances in medicine and means of production, but with the destructive power of GMOs and the uncontrollable ability of individuals to unleash a BVP, this Age may yield a reversal in our fortunes, with shorter lifespans, crueler lifestyle, and perhaps a collapse in civilization.

Whether the first bioengineered virus comes from an accidental release or is spread by Iran's Revolutionary Guards, the key point is "Black Swans being unpredictable, we need to adjust to their existence (rather than naively try to predict them)."[39] Estimating, assuming, hoping that accidents, lunatics, terrorists, or enemy states won't release a GMO, or that we can always detect and stop them, is a mistake we should not make. As a nation, we must adapt to the existence of the BVP threat now and make big changes in our strategy, military forces, economy, and preparedness to ensure the consequences do not cascade into a societal collapse. We need to be prepared to deal with the consequences of a viral pandemic that produces horrific numbers of casualties and cannot be stopped with a simple quarantine. This problem deserves far more attention and resources. While we likely can't stop the release of lethal new GMOs, we can survive if we are ready.

[39] Taleb, p. xxiv

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YY)	2. REPORT TYPE	3. DATES COVERED (From – To)
October 2014	Final	

4. TITLE AND SUBTITLE	5a. CONTRACT NO.
The Age of Bioengineered Viral Pandemics and Collapse	HQ0034-14-D-0001
	5b. GRANT NO.
	5c. PROGRAM ELEMENT NO(S).

6. AUTHOR(S)	5d. PROJECT NO.
Drew Miller	5e. TASK NO.
	5f. WORK UNIT NO.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NO.
Institute for Defense Analyses 4850 Mark Center Drive Alexandria, VA 22311-1882	IDA NS Document D-5335

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR'S / MONITOR'S ACRONYM(S)
Institute for Defense Analyses 4850 Mark Center Drive Alexandria, VA 22311-1882	IDA
	11. SPONSOR'S / MONITOR'S REPORT NO(S).

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

New technologies such as bioengineering could enable a small terrorist group, or even one dedicated individual, to modify and release a new virus that could cause both a pandemic and, as people react, a collapse in economic activity and possibly law and order. A host of experts says such bioengineered viral pandemics (BVP) are inevitable since it is increasingly easy to modify an existing pathogen to make it more lethal or transmissible. This article explains why this bleak coming "Age of BVP" is almost upon us.

15. SUBJECT TERMS

biological agent, pandemic, virus, bioengineering, genetically modified organism, bioengineered viral pandemic, BVP, national defense, collapse, threats, terrorism

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NO. OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include Area Code)
U	U	U	UU	16	