Special Section: Synthetic Biology: Ethical and Philosophical Challenges

The Bioethicist Who Cried "Synthetic Biology"

An Analysis of the Function of Bioterrorism Predictions in Bioethics

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Abstract: This article analyzes a specter that has haunted bioethics almost since its inception, namely the specter of the misuse of biotechnology by maleficent agents bent on mass destruction, or the complete eradication of human kind and life as we know it. The article provides a general account of why bioethicists cry "catastrophic bioterrorism potential" when new biotechnologies emerge, and an analysis of the arguments that flow from the prediction, especially in relation to synthetic biology.

Keywords: bioethics; bioterrorism; bioterrorism argument; catastrophic risk; existential risk; recycling of arguments; slippery slope; synthetic biology

Introduction

Many, perhaps most, biotechnologies have potential for "dual use." They can be used to great benefit but they can also be used deliberately to cause harm. Some biotechnologies do not only have dual use possibilities in the hands of state actors, but also have the theoretical potential to be deliberately used by non-state actors to develop novel infectious organisms, or to "resurrect" old ones such as smallpox or the 1918 Spanish flu. Let us call the persons who attempt to develop such organisms "bioterrorists," and their final goal "bioterrorism." Bioterrorists may target living organisms other than humans; however here I will focus on humans as targets. Depending on the characteristics of the pathogen produced, and the method of dissemination, the potential/predicted effects of releasing it can range from very limited to the complete extinction of humankind. In the literature on catastrophic risk, an existential risk is defined as the risk of extinction of humankind, and a catastrophic risk is defined as the risk of an event leading to the death of 10 percent or more of the global population.[1]

The prediction of significant bioterroristic use of a particular biotechnology has been a recurrent theme in bioethics over the years, and it has been raised again in relation to synthetic biology.[2,3,4,5,6] The general structure of the argument and the content of the premises supporting the predictions of imminent bioterrorism and the need for bioethicists to take this risk seriously (I will call them the "bioterrorist argument" and the "bioterrorism problem" respectively) have been remarkably stable over the years and can be reconstructed in outline as follows:

P1 There are evil people in the world bent on mass destruction
P2 One of the ways in which to achieve mass destruction is through bioterrorism

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P3 Technology X will make it easier/easy for bioterrorists to make a dangerous pathogen
P4 Technology X will make it cheaper for bioterrorists to make a dangerous pathogen
P5 Technology X will make it easier for bioterrorists to hide from the authorities while developing a dangerous pathogen

Therefore

C1 It is likely that Technology X will be used by bioterrorists to achieve their nefarious aims
P6 A significant bioterrorist attack is a very bad thing

Therefore by C1 and P6

C2 Bioethicists ought to take this risk very seriously

I believe that P1, P2, and P6 are uncontroversial and true, and that the soundness of the argument therefore hinges on the truth of P3–P5 and the validity of the inference from P3–P5 to the likelihood of bioterrorism actually occurring.

The argument from P1–P5 to C1 is generic to debates about bioterrorism, and the only bioethical contribution is the introduction of P6 as the justification for C2. The bioterrorist argument is closely related to an argument with premises predicting a possible accidental release of novel pathogenic microorganisms created during scientific experiments, and to similar arguments focusing not on biotechnology, but on nanotechnology. The predictions of a likely major catastrophe through the use of biotechnology and the similar nanotechnology- based arguments have already formed the basis for science fiction novels in the biopunk and nanopunk subgenres (most famously perhaps in Michael Crichton's novel *Prey*).[7]

The generic bioterrorism argument is quite old, and has been applied to technologies as simple as bacterial culture of unmodified pathogenic bacteria.[8] Simple bacterial culture was also the technique used in the only verified bioterrorist attacks aimed at causing mass casualties. These completely unsuccessful attacks were carried out using aerosolized anthrax by the Aum Shinrikyo cult in Japan in 1993.[9] They were so unsuccessful that they were only identified later when the cult was investigated by the police after its successful sarin gas attack in the Tokyo Metro in 1995.

In relation to synthetic biology, the focus of the argument has been the putative malevolent biohacker doing DIY synthetic biology in his or her garage. We are asked to imagine "… a world where practically anybody with an average IQ would have the ability to create novel organisms in their home garage."[10] The biohacker has been endowed with very considerable powers in the literature. Not only is the hacker able to design and synthesize (or edit) the DNA or RNA of the novel pathogen, she or he is also able to culture it in the necessary quantities, weaponize it as an aerosol or a powder, and package it in a suitable delivery vehicle and spread it, all within the enclosure of the suburban garage and without becoming infected and without anyone becoming suspicious. All of these powers of the biohacker are to some extent mythical in that they are not based on the current reality of laboratory work needed to perform any meaningful synthetic biology.[11]

More recently, a version of the argument has appeared in which the malevolent agent is no longer a human being, but a superintelligent artificial intelligence (the "AI takeover scenario").[12]

In the bioethics literature it is not only the structure of the bioterrorist argument that is recycled, it is also often the specific examples given to provide credence to the premises. The following quote from an article by Tom Douglas and Julian Savulescu is typical in this regard (original references removed):

> A third concern about synthetic biology has been that the knowledge it produces might be intentionally misused. Two ground breaking studies last decade reported the de novo synthesis of human pathogens—the poliovirus, and the 1918 Spanish influenza virus. These studies raise the prospect that states or terrorist cells without access to wild-type viruses might acquire the ability to create human pathogens for use in biological weapons. Further into the future, synthetic biology may enable the creation of novel pathogens more deadly than any known before. Scientists have already accidentally created a vaccine resistant strain of the mousepox virus through more traditional genetic engineering techniques.This killed 100% of mice infected. The mousepox virus is not a human pathogen, but the same technique might also render viruses that do affect humans, such as smallpox, vaccine resistant. Prior to eradication by vaccination, smallpox was the scourge of humanity killing about a third of all affected people in a horrible manner. If the results of the mousepox experiment applied to smallpox, it would be possible to significantly increase its lethality and render it vaccine resistant. If the incubation period, almost ideal already for terminal pandemic, could be further increased, it may become possible to produce a bioweapon capable of devastating humanity. The virus could be released at airport terminals, stadiums, train stations and public events. Thousands could potentially be infected at such loci and the virus might be spread during the incubation period all around the world, before any pandemic could be detected.[13]

The polio virus, Spanish flu, and mousepox examples can also be found in many other articles, as can the expansion of the actual mousepox research to create a full human smallpox bioterrorism scenario.[14,15,16] Both the argument and the examples used to lend credence to it have therefore become a stock, routinely applied item in the bioethics literature. Why has this happened? Are there functions of the bioterrorist argument that can help to explain its attractiveness?

The Functions of the Argument

What role does the bioterrorist argument play in bioethics? A pragmatic role played by the argument is that the continuing development of new technologies to which the argument can be applied allows the middle-aged or older bioethicist to recycle arguments in an eternal recurrence.[17,18] The arguments used in discussing the bioterrorist potential of recombinant DNA in the 1970s can, with very limited modification, be recycled to write a new article on synthetic biology or gene editing,[19,20] and every new emerging terrorist group can become the occasion for reconsidering whether that specific group will engage in bioterrorism.[21]

However, the bioterrorist argument can be used for three more substantial purposes as well. It can be used:

1) As the basis for a precautionary argument in relation to the development of a particular technology
2) As a marker for how important the argument that follows is (almost irrespective of what that argument is)
3) As a bogeyman frightening people into agreeing with one's arguments and solutions (almost irrespective of what these arguments and solutions are)

The first of these uses is the most straightforward and legitimate. If it is really true that synthetic biology makes catastrophic (or for that matter non-catastrophic bioterrorism) likely, then there is a good reason to proceed with caution in the development of synthetic biology. However, as "synthetic biology" is an umbrella term covering a wide range of different activities, one needs to be careful when targeting (pre)caution. There are activities and developments within the field of synthetic biology that are very unlikely to make bioterrorism easier/cheaper/more likely, and regulatory efforts have to be precisely targeted to avoid hampering developments in the "safe" areas. I have previously written on the problems inherent in the precautionary principle; therefore, I will not expand on that here.[22,23,24]

The second use of the bioterrorism argument is a version of the much more general rhetorical figure of "my X is bigger than your X," in this case completed as: "I am thinking about the really big problem of bioterrorism—we could all become extinct!—whereas you are just thinking about small problems such as justice between the First and the Third Worlds or the euthanasia of people with dementia. Therefore, I am (or perhaps slightly more modestly my arguments are) much more important than you(rs)"

This claim of comparative importance is then often linked to the claim "that apart from my work very little work is being done on the bioterrorism problem" and/or "more resources should be allocated to the bioterrorism problem;" that is, "someone should make grants available to me." There is a significant amount of work being done on the general dual-use problem raised by biotechnologies;[25] therefore, both claims about too little work being done are empirically dubious.

The philosophical problems with this use of the bioterrorism argument are that (1) it can be very difficult to correctly assess the comparative importance of the analysis of different philosophical questions, and (2) that even if comparative importance could be established, there is a fallacy involved in eliding the importance of a particular question and the importance of a particular person's thinking and writing about that question (the question could be genuinely important, but what that person writes about it could be garbage!).

What is the best analysis of the comparative importance of philosophical questions, and what does the best analysis say about the importance of the bioterrorist argument?

I will first consider what is meant by saying that a philosophical question is important *simpliciter* before tackling the issue of comparative importance. One initial relevant distinction is whether:

1) A question is important because simply trying to analyze and answer it is likely to lead to major philosophical advances (philosophical importance),

2) A question is important because the answer to the question is important (practical importance)
3) A question is important because an answer is urgently needed (urgency)

A question may fall into the first category either because analyzing is likely to lead to a major advance within this particular field of philosophical inquiry, or because analyzing it is likely to lead to advances in a number of fields because it is a very fertile question. And a question may fall within the second category either because an answer will have significant practical implications, or because it will require all of us, including non-philosophers, to reconsider commonly held assumptions about ourselves or our place in the world. Many philosophical questions will be important in all three senses, but others will only be important in one of them.

The claim that a philosophical question can be important because of its fertility is very similar to Gilbert Ryle's claim that questions of principle are important:

> A philosophical question is a question of principle when it is philosophically much more important than most other questions. And the relative importance of philosophical questions could be explained on these lines that when, given the answer to one question, it is at once clear what are the answers, or of what sort are the answers, to an expanding range of other questions, while the answers to any of the latter do not in the same way throw light on the former, then the former is a question of principle relative to the latter.[26]

How should the philosophical questions that arise if the bioterrorism argument is accepted be categorized? The putative bioterrorism problem created by synthetic biology does not seem to be important in the first sense: analyzing it or even solving it is unlikely to lead to any major philosophical advance that could not be achieved simply by considering the undramatic, general "dual use" problem, and the question does not seem particularly fertile either.

If the bioterrorism argument is valid and sound, the bioterrorism problem does, however, seem to be a prima facie important problem in the two other ways identified. The answer is practically important. We want to prevent catastrophe or extinction; and, given that bioterrorism is claimed to be imminent, the answer also seems to be urgent. But how important it is comparatively in relation to other problems crucially depends on the real probability of bioterrorism and the likely magnitude of bioterrorist events. If Aum Shinrikyo had been successful in 1993, they would have infected hundreds, perhaps even thousands, of people with anthrax and would have killed a large proportion of them; however, even though that would have been very successful bioterrorism, it would have been far from being considered a catastrophic or existentially threatening event. Even if a future scenario in which bioterrorism killed an average of 100,000 people every year was postulated as likely, the bioterrorism problem would be fairly low on the list of important problems that bioethicists could spend their time analysing, as 842,000 people, of whom 361,000 are children, die from lack of access to clean drinking water every year, and 303,000 women die from preventable complications in childbirth.[27,28] It is, therefore, only if bioterrorism is a catastrophic or existential risk that it is obviously a more important question than many other questions in bioethics.

The third use of the bioterrorism argument is perhaps the most problematic, because it can have real life consequences. The specter of the bioterrorist ready to unleash microbial havoc on the unsuspecting world can be, and is, used to argue for the necessity of wide-ranging and privacy-infringing surveillance and draconian legal powers,[29] or for the necessity of (compulsory?) moral enhancement.[30] The claimed likelihood of an imminent attack, and the predicted enormous magnitude of the harm caused, combine to make what looks like an unassailable pragmatist or consequentialist case for strong and effective intervention. Almost any loss of welfare/utility caused by the intervention can be outweighed by the continued benefit of human existence.

But is all what it seems? For a bioterrorist attack to be catastrophic in the sense defined, it has to be at least as successful as the most "successful" historical, natural epidemics,[31] and about twice as deadly as the 1918 Spanish flu.[32] Therefore, the bar is being set quite high for true catastrophic success, and this of course entails that the likelihood of achieving success becomes correspondingly lower. Even a single attack causing 1,000,000 deaths, thus making it the most successful single terrorist attack ever by some considerable margin, is three orders of magnitude away from being catastrophic, and if there were such an attack, it would immediately lead to very significant regulation, surveillance, and enforcement that would make the "War on Terror" pale into insignificance, thereby significantly decreasing the likelihood of any further bioterrorism. What has to be postulated, therefore, is not only the possibility of bioterrorism developing toward being a catastrophic or existential risk, but that that development happens before any major, albeit non-catastrophic, bioterrorism attack has taken place. This is possible, but not very likely.

These considerations also point to an inherent issue with the bioterrorism argument; that is, that it does not account for the government actions that would follow from a significant, but not catastrophic bioterrorism attack. If there were such an attack, governments would immediately act to ensure that P3–5 were no longer true. The bioterrorism argument is, therefore, only sound as long as no successful, significant bioterrorism has occurred.

Of course a bioterrorist attack leading to 1,000,000 deaths is still "catastrophic" in the normal sense of this term, and is something that governments should try to prevent, but given that it would likely be an isolated event, a serious cost–benefit analysis would have to be made to estimate whether the ongoing costs imposed on citizens by a particular regulatory and surveillance regime would be outweighed by the benefits.

But what about the non-zero risk of a truly catastrophic or existentially threatening bioterrorist attack? Should that not be taken into account?

Here it is important to distinguish between the catastrophic and the existential risk scenarios. If it can be assumed that a bioterrorist group could manage to mount a catastrophic attack killing 10 percent of world population, this would be a very bad outcome involving a large immediate loss of welfare; however, the underlying causation would be time limited and would not leave any longer-term environmental problems, unlike some other postulated catastrophic risk scenarios (e.g., asteroid strikes, supervolcano eruptions, and global warming).[33] This means that the longer-term loss of welfare/utility caused by a catastrophic bioterrorist attack would be limited. There is good evidence that near-catastrophic epidemics such as the Spanish Flu have limited long-term economic effects.[34,35] A catastrophic

bioterrorist attack will, therefore, lead to a very large, but finite loss of welfare/utility. Because the loss is finite, this in turn entails that it does not generate a blank cheque in so far as prevention is concerned. The long-term costs of prevention have to be assessed and balanced against the benefits of preventing a catastrophic bioterrorist attack, taking into account also that prevention might not be 100 percent effective.

This leaves bioterrorism leading to existential risk as the final issue for discussion. The extinction of humankind might initially seem to lead to an infinite loss of welfare/utility, because the production and experience of welfare would stop. However, this is not actually the case. As philosophers of animal rights have shown, humans are not the only beings producing and experiencing welfare; therefore, a world without humans would still be a world full of welfare/utility. Exactly how much would be lost, and how much would be regained when animals gradually filled the void left by humans is difficult to say, because there is no known way to compare welfare among species in general, or more specifically between humans and animals. As an illustration of this point, consider the interspecies comparison of welfare between lions and wildebeest. It is possible to make intraspecies comparisons; that is, to estimate with some degree of accuracy whether a particular lion or wildebeest is doing better or worse than some other lion or wildebeest, but there seems to be no obvious way of making interspecies comparisons between lions and wildebeest when both have normal levels of welfare for their species. Even if plausible comparative welfare claims can be made when comparing a happy and well-fed lion with a miserable and starving wildebeest, this does not entail that it is possible to make comparative claims between happy lions and happy wildebeest. It might be objected that it is possible to make other interspecies comparisons of welfare; that is, between lions and mosquitos, where one could be fairly certain that a non-suffering lion had a higher level of welfare than even the best-fed mosquito. This is true; however, the reason it is true is that most of us do not tend to think that mosquitos and other insects have a welfare in a subjective sense, because their nervous systems are not sufficiently developed to sustain an inner life. Therefore, would a world where humans had been extinct for 1000 years be better or worse and by how much? The loss in human welfare can be estimated, but could the countervailing gains be estimated, and would non-welfare gains, such as the value of the global reestablishment of wilderness have to be taken into account?[36]

In relation to existential risks, it also must be remembered that they are in an important sense mutually exclusive. Humankind can only become completely extinct once. Any particular extinction is subject to causal preemption; therefore, the probability that has to be estimated to assess the size of the bioterrorism problem is not the probability of an existentially threatening bioterrorist attack, but the probability of an existentially threatening bioterrorist attack being the first extinction event out of all the possible extinction events.

It may finally be interesting to note that the bioterrorism argument is very similar in structure and function to empirical slippery slope arguments.[37,38] In both cases there is an innocuous initial development predicted to lead to catastrophic consequences through a development that will automatically proceed if the first fateful step is taken. Because of this similarity, it is quite surprising to see the bioterrorism argument used by bioethicists who reject the validity of slippery slope arguments and decry anyone who uses them.

Conclusion

What is to be made of the use of the bioterrorism argument in bioethical analysis of synthetic biology?

As shown, the argument fulfils a range of functions that do not depend on it being valid and sound, but simply on it being (superficially?) rhetorically convincing. The use in bioethics is, therefore, very similar to the more general use of the argument; that is, to establish synthetic biology as an important locus of activity. Proponents of synthetic biology paradoxically use it to illustrate the power and usability of this new technology in which they are invested, and politicians use it to argue for non-liberal security and surveillance policies. We should, therefore, expect the bioterrorism argument to recur again and again as new biotechnologies are developed.

As argued, the possibility of bioterrorism is an important problem that needs attention, as does the prevention of ordinary terrorism that kills hundreds every month (although mostly in countries outside of the media gaze of the Western world). However, the bioterrorism problem is probably not as important as it is often made out to be in the more excitable parts of the literature. Bioethicists should not cry 'Bioterrorism!' any louder than they cry 'Systemic injustice!' or 'Abuse of power!'

Notes

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