Designer Biology

The Ethics of Intensively Engineering Biological and Ecological Systems

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Remediation vs. Steering

An Act-Description Approach to Approving and Funding Geoengineering Research

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INTRODUCTION

On Tuesday, October 4, 2011, the Bipartisan Policy Council convened a panel of climate policy analysts in Washington, DC, to announce the release of a report on Geoengineering and Scientific Research. The panel included 14 representatives from the scientific, environmental, and policy communities. In the report, the Task Force on Climate Remediation Research (TFCRR) suggested that the White House Office of Science and Technology Policy begin funding and supporting research into technical fixes for our climate problem.[1] The TFCRR report offered several arguments in favor of geoengineering research, many of which also count as presumptive arguments in favor of geoengineering *simpliciter*.

The panel added one more voice to a growing chorus of researchers who have been calling for increased funding and support for geoengineering research. The National Academy of Sciences, the American Geophysical Union, and the British Royal Academy of Sciences have each convened workshops and special sessions, promulgated reports and statements, in which participants, almost all scientists, have called for research into geoengineering (Keith, 2000; Shepherd FRS, September 2009; Solomon, 2011).[2] What made the TFCRR report unique, however, was that it introduced an otherwise unfamiliar new frame into the geoengineering discussion. Rather than referring to geoengineering technologies as "climate engineering," as had theretofore been the convention, the authors instead referred to geoengineering as "climate remediation," thus implying that all sets of geoengineering projects aim at the same end: remediation of anthropogenic climate change.

In this essay I aim to cut the distinction more finely. I suggest that the emphasis on remediation goes well beyond a mere "semantic distinction" or "rebranding effort," as some critics of the TFCRR report have recently charged.[3] Instead, I acknowledge that some geoengineering technologies do aim fundamentally at climate remediation, where others aim more primarily at steering the climate toward a preferred outcome. I suggest that morally permissible geoengineering research ought to be limited to *climate remediation* projects, which make up only a small subset of geoengineering proposals, but that *climate steering* projects ought to be off the table. Without a clear conceptual delineation between the two types of geoengineering—GeoSteering vs. GeoRemediation—we are not in a position to move forward with research. Once we are careful to make this distinction, we must then ensure that proper institutions are in place to promote remediation projects but to constrain steering projects. In essence, I suggest that the so-called "dual use" criterion—distinguishing between technologies that are beneficial and pernicious—can and ought to be cut along non-harm lines in the case of geoengineering. Below I offer a basic framework that can help guide research.

Because of the extraordinary risk and wide scope of geoengineering, which if implemented will affect many billions of people and animals, geoengineering research ought not to move forward on scientific grounds alone. Rather, the ethical implications of the research must also be fully considered. Institutional Review Boards (IRBs) and monitoring organizations should be put in place that can deliberate the merits of a research program and determine not only the potential scientific or engineering hurdles for a given project, but also the extent of ethical and political restrictions on such research.

I begin my argument by suggesting that geoengineering cannot be assessed with a one-size-fits-all approach, but must be evaluated in terms of the most "appropriate act description." I then explore a recent proposal for limiting research, advanced by David Morrow, Robert Kopp, and Michael Oppenheimer, pointing out that their proposal is perhaps more appropriate for limiting research on individual human subjects. Following this, I explore briefly a few common restrictions on global-scale research, including nuclear technology and genetic engineering. Finally, I suggest that dual use considerations do not apply as neatly to geoengineering, thanks to the conceptual entanglement between remediation projects and steering projects I mention above. This entanglement can be avoided, I propose, by ensuring that IRBs and monitoring organizations employ an evaluation of the appropriate act description with regard to proposed geoengineering research.

CONCEPTUAL ENTANGLEMENT: GEOREMEDIATION VS. GEOSTEERING TECHNOLOGIES

Are we permitted to research geoengineering? On the face of it, this is a relatively simple question. If geoengineering is permissible, the answer is clearly "yes." How could it be otherwise? If geoengineering is impermissible, on the other hand, the answer is only "maybe." Thus, for the sake of argument, I will assume that geoengineering is not permissible.

Much of the time, this "maybe" is answered by appeal to risk or potential damages. Provided that the research will not actually geoengineer the climate, and thus create damages akin to those that are presumed to be the core concern of geoengineering detractors, then such research seems relatively unproblematic. What could be wrong with running a few tests into the reflectivity of aerosols or the proliferation of algae blooms? Maybe such research won't be worth the effort or the investment, but this is an actuarial, not an ethical, determination. If the research does threaten to create damages of the wide scope that worries geoengineering detractors, then we are not considering research, so much as geoengineering itself, so our answer will be established by the permissibility or impermissibility of geoengineering *simpliciter*.

Though the public discussion of geoengineering has recently grown more heated (Mercer, Keith, & Sharp, 2011), most commentators make few conceptual distinctions between geoengineering technologies. This, despite the fact that geoengineering proposals vary wildly both in scientific plausibility and in moral permissibility. Some proposals seem relatively innocuous, like those that encourage property owners to paint their roofs white (Humphreys, 2011; Jacobson & Ten Hoeve, 2011); whereas others seem extremely pernicious, like those that propose to fertilize the oceans with iron and stimulate algae blooms, thus removing carbon from the atmosphere and storing it in the oceans (Chisholm et al., 2001; Hale & Dilling, 2011; Powell, 2007; Scott, 2005). Politically speaking, it tends to be the case that geoengineering proponents point to the least problematic proposals—cloud brightening, say—as support for apparent *carte blanche* authorization of all geoengineering projects (Brand, 2009; Levitt & Dubner, 2009). Such proponents tend to emphasize the innocuous uses of geoengineering. On the flip side, detractors often point to the most outlandish proposals—giant space mirrors, say—to support stringent ethical proscriptions on such research (Fleming, 2010; Kintisch, 2010).[4] Such proponents tend instead to emphasize the pernicious uses of geoengineering.

Unlike other technologies that admit of "dual uses," such as nuclear or genetic modification technologies to take just two, the traditional distinction between innocuous versus pernicious applications is considerably hazier for geoengineering technologies. This is because all geoengineering proposals aim at least at the end of alleviating damages stemming from climate change, which is mostly a peaceful and beneficent objective. The justifications for geoengineering are thus entangled not necessarily with the intent or objectives of those who deploy such technologies, as many presume (Jamieson, 1996; Reynolds, 2011), but with the more amorphous "nature" of each specific technology and the extent to which there are unanticipated consequences and/or unconsidered dimensions of the deployment of that technology.[5] What is needed is a mechanism to distinguish between the innocuous uses versus the pernicious uses. Researchers must cut through this conceptual entanglement to determine not just which projects are scientifically worth pursuing, but whether such projects are the kinds of things that we can justify. That is, one aspect of distinguishing problematic technologies from innocuous ones involves describing what the technology will be used to do.

Hale and Dilling (2011) have argued elsewhere that geoengineering cannot be understood properly in the absence of consideration of the antecedent conditions that have given rise to its deployment, as well as the variety of factors that coalesce to justify the practice. Like any other action in need of ethical evaluation, geoengineering must be evaluated by the appropriate act description (Korsgaard, 2009): the circumstances that have brought about its consideration, what justifies it, and what its deployment will entail. In other words, one does not simply take some action (Φ), one Φ's for the sake of something else (E). It is Φ-ing for the sake of E that we must assess, not simply Φ-ing. Just as we cannot understand whether an instance of killing is justified without also taking into account the conditions that have given rise to that killing—whether the killing was in self-defense, retribution, passion, aggression, pathology, and so on—so too must we understand each individual geoengineering technology as a response to anthropogenic climatic change that seeks to address some unique aspect of the climate change problem, and to do so in such a way that is more or less sensitive to an enormous range of principles of global ethics and justice.

We must distinguish, in particular, between technologies that aim to remediate damages and technologies that aim to steer the climate toward perceived beneficial ends. Let's call these two categories of "geoengineering" technologies "GeoRemediation" and "GeoSteering." I have argued elsewhere that GeoRemediation technologies—air capture, say—are permissible and perhaps even required (Hale, 2012), whereas GeoSteering technologies are not permissible (Hale & Dilling, 2011).[6]

It may help to be more specific about the distinction. Some geoengineering technologies fall under the appropriate act description of "GeoRemediation technologies," which aim primarily to remediate or clean up damages, as one might remediate an oil spill from the sands of a beach. Such cleanup technologies may include those used for filtering the water, scrubbing the sand and soil, introducing a containable colony of microorganisms to digest the oil, or simply removing the dirty sand and replacing it with clean sand. Such remediation projects are justified in part by an obligation to repair damages, where such obligations of reparation are reflected throughout the moral and legal literature. Locke, for instance, understands reparation as a right that the injured party holds against the perpetrator, and therefore a duty of the perpetrator to respect this right (Locke, 1963). W.D. Ross distinguishes between duties resting on previous wrongful acts of my own, which he calls duties of reparation, versus duties of justice, which relate to the distribution of pleasure or happiness (Ross, 1930). For the most part, duties of reparation require victims, but more recent work in environmental and legal theory has sought to demonstrate how these obligations can be extended to cases of environmental wrongdoing (Cairns, 2003; Caney, 2006; Gosseries, 2004; Hale, 2012; Hale & Grundy, 2009; Neumayer, 1999; Schüssler, 2011; Shue, 1999). In the case of Geoengineering, such clean-up technologies include any and all that seek specifically to remove carbon or methane from the atmosphere, or that seek to remediate land use changes that may be driving climate change.

Other geoengineering technologies are more aptly described as "GeoSteering technologies," and aim not directly at remediating damages, but rather at steering around or repairing *anticipated* damages resulting from some known incident or emission, as one might build a retaining berm in order to prevent anticipated damages from oil spills.[7] Such environmental modification projects aim primarily to address damages caused by the oil spill, not to clean up the spill *per se*. In this respect, they are more like typical forward-looking engineering projects: the construction of levees to avoid flooding, the development of roads and superhighways to lubricate the channels of commerce, and so on. Generally speaking, environmental modification projects of the steering sort must be justified without appeal to damages already done, but must instead appeal to better and worse states of affair. In other words, such technologies do not seek to repair damages so much as to steer around or avoid damages. In the case of Geoengineering, such technologies include any and all that seek to mitigate or lessen the anticipated global-scale climatic damages.

At this point, it would be natural to object that all geoengineering technologies, whether GeoRemediation or GeoSteering, are in some respect a response to anticipated damages from anthropogenic climate change. Therefore, one might reason, the distinction between the two sorts of technologies collapses. But this is not so. If we subscribe to such a line of reasoning, then any geoengineering project whatever, no matter how outlandish or invasive, no matter how dramatically it will alter the climate of the earth and thereby impact the lives and livelihoods of people, gets a free pass on the question of what it is ultimately designed to do. Essentially, the mere threat of climate change, given its severity, would grant *carte blanche* to take any and all action to avoid the impacts of climate change, possibly disregarding individual rights and essentially begging the question on a costs-benefit-risk calculus. If we were to apply the same reasoning to any other smaller scale engineering project today, for instance, the outcry would be tremendous. Suppose, say, that because we have already irrevocably altered inland waterways, we reason that we do not need to seek public support for further levee construction projects. Such a conclusion would be unthinkable. We thus need to think more carefully about the finer justificatory distinctions between the varieties of projects we are considering.

Plainly, there is considerable conceptual entanglement remaining, as it will rarely be entirely clear whether and when any given program should count as a steering or a remediation program. What I contend, however, is that the justificatory process for steering projects is different than the justificatory process for remediation projects. Justifications for remediative actions must appeal to backward-looking assignments of responsibility and related obligations to rectify damages, whereas justifications for steering projects must appeal to forward-looking aversion of damages and/or whether a particular environmental modification is desirable. In turn, what justifies a remediative action is partly the extent to which it can be established that some prior action was unwarranted or wrong or unjust or damaging, and then establishing the degree to which the rectification of that damage is desired or demanded by affected parties. What justifies a steering action, by contrast, is the extent to which uptake and assent from affected parties can be secured.

REMEDIATION VS. STEERING: AN ILLUSTRATION

Given the above distinction, it should be clear that even once an action is determined to be either remediative or steering, this distinction alone is itself not enough to establish whether an action or an intervention is permissible. In many small scale interventions, for instance, steering options may be preferred, as perhaps with the case of containment berms used to avert damage from an oil spill. In such cases, steering is likely preferable to remediation, since it may be relatively easy to secure assent from local stakeholders to build the berms. In the case of larger-scale GeoSteering technologies, I believe, it is a fair bit harder to secure uptake and assent. Steering involves radically shifting the climate of the earth in one direction or the other, after all, and so everyone affected must be taken into consideration or, more stringently, consulted. It is much easier, however, to secure uptake and assent to remediate polluting emissions and/or to return degraded land to its original state. Such a view, far from being conceptually abstruse, is at least intuitively compelling. There is, in other words, an intuitive difference between removing carbon from the atmosphere in order to clean up or remediate prior carbon emissions, and shifting the climate of the earth through an outside and unrelated steering mechanism aimed to avert disaster before it occurs. Thus, we find geoengineering advocates like David Keith promoting technologies like air capture but cautiously warning against technologies such as sulfate aerosols (Keith, 2009; Keith, Ha-Duong, & Stolaroff, 2006).

There may be good historical explanation for this intuition, of course. Steering technologies have a checkered history. In their purist form, steering technologies aim to steer the world toward a perceived better outcome, as when Australia introduced a foreign species, the cane toad, into an ecosystem in order to address a known hazard or problem, sugar cane pests. This again was a steering, not a remediation, scheme; and it is not unlike some of the geoengineering proposals currently on the table. Engineers sought to address the perceived negative aspects of an environmental nuisance, all the while neglecting the implications of the technology they were unleashing. Other steering technologies include, for instance, recent attempts to genetically engineer mosquitoes so that they self-destruct, thus preventing adults from acting as vectors for malaria or dengue fever (Pollack, 2011).

It would be easy to construe the problem here as merely one of unanticipated outcomes and unintentional damages, but the wider point is that steering technologies, like the introduction of the cane toad, offer an added justificatory challenge to those who hope to deploy them. To authorize a steering technology, all affected parties must be consulted and/or their interests taken into consideration. This differs somewhat from a remediation technology, since damages have already been done and responsible parties bear a *prima facie* obligation to undo those damages or clean up their pollutants (Ross, 1930).

Climate modifications rightly worry ethicists, not simply because the risks from steering projects are great, but also because the potential for encroachment and trespass on the rights of others is tremendous. Some have argued recently that the wrong of geoengineering isn't adequately captured by the harms or risks engendered by geoengineering, but must instead also be understood in terms of trespass. Without getting into detail, the idea is that climate alteration, whether intentional or unintentional, creates circumstances that violate the rights or the interests of everyone on the planet (Gardiner, 2010). Without uptake from all affected parties, which in the case of GeoSteering technologies is near impossible to secure, steering interventions amount to a kind of trespass.[8]

To illustrate using several Carbon Dioxide Removal (CDR) technologies, there is a difference between planting trees to restore a damaged forest, thereby removing carbon from the atmosphere (GeoRemediation), and removing carbon out of the atmosphere by way of creating whole new phytoplankton environments (GeoSteering). Or, put differently, there is a difference between creating an artificial carbon sink—an artificial tree, say—in order to remove carbon that was collectively emitted into the atmosphere (GeoRemediation) and devising engineering fixes to address expected temperature fluctuations in climate (GeoSteering). It is of course true that in both cases the action might be described roughly as "remediating the sky," but this is why it is important to honestly and earnestly seek the most appropriate act-description: what description *really* best captures the technology and how is that technology justified? GeoRemediation technologies and GeoSteering technologies have a morally different valence. One is justified by appeal to principles of restoration, whereas the other constitutes an attempt fundamentally to avoid the implications of and/or repair the damages created by a mess. We ought to be encouraging GeoRemediation technologies, I propose, but discouraging GeoSteering technologies.

It is important here to observe that these types are not hard and fast metaphysical categories, but rather rough conceptual categories in place primarily to offer some guidance with regard to the more and less ethically problematic technologies. The question for researchers and for ethicists is not simply, therefore, whether the project aims at intentionally engineering the climate, but how the project or action is best described.

Naturally this quickly gets very complicated, since at least one factor in the determination that a mess must be cleaned up will depend on the characterization of the mess—whether in terms of damages or harms, for instance, or in terms of vice and/or trespass. In most instances there is little wrong with introducing an artificial reef into an ocean environment in order to stimulate the proliferation of marine species. In fact, it may be that the introduction of the artificial reef is exactly what is required, since remediation of a dead or dying reef is not possible. The issue of steering, however, relates to the scope and reach of the problem to be addressed, as well as the extent to which we can justify steering that environment in a new direction. As I point out elsewhere, many geoengineering schemes move the universe not back to an initial starting point as is sometimes claimed, but rather to a new state altogether (Hale & Dilling, 2011). Depending on the scope and reach of this new state, which in the case of GeoSteering technologies is wide and expansive, the deployment of such technologies will be more or less difficult to justify.

All geoengineering technologies aim intentionally to avert damage from climate change, of course; but only some geoengineering technologies aim specifically to clean up the environmental pollutants and modifications that are the drivers of climate change, thus returning the world to its baseline state. It is the remediative function of geoengineering technologies, I propose, that we can get behind, not the steering function. By characterizing geoengineering along the axis of the appropriate act description, as opposed to the axis of intention, we are in a better position to make assessments and claims about the scale and scope of engineering projects for instance. I argue, in other words, that it is important at this historical juncture to *exclude* GeoSteering technologies from the research portfolio, precisely because these are the problematic geoengineering technologies. Where some kinds of geoengineering research are permissible, research into GeoSteering technologies is not as easy to justify. Without making careful distinctions between the variety of geoengineering technologies under discussion, all geoengineering technologies appear to fall into the same category, which is clearly too broad to offer guidance with regard to permissible and impermissible research. Others have sought to make careful distinctions as well, of course, but they have generally done so by looking to research protections and constraints in other areas of research. In the case of geoengineering technologies, I think the research situations are not clearly analogous and will argue as much below.

RESEARCH ETHICS: HUMAN SUBJECTS PROTECTIONS

There are essentially two core sources on the topic of ethics and geoengineering research: an essay by David Morrow, Michael Kopp, and Robert Oppenheimer (Morrow, Kopp, & Oppenheimer, 2009) and an essay by Martin Bunzl (Bunzl, 2009). Morrow, Kopp, and Oppenheimer (hereafter MKO) seek primarily to outline restrictions and regulations that must be taken to prevent abuse or damaging research, whereas Martin Bunzl argues against geoengineering research on methodological grounds. There are many other explorations of the research question, of course, but they tend to be focused less on ethical matters and more on clarifying uncertainties and risks (Macmynowski, Keith, Caldeira, & Shin, 2011), emphasizing matters of governance (Kintisch, 2007), and/or exposing the scientific implausibility of successfully undertaking gargantuan research projects (Robock, Bunzl, Kravitz, & Stenchikov, 2010).[9] To gain a grip on the issue, consider the MKO standards.

According to Morrow, Kopp, and Oppenheimer, we should be careful to distinguish between three core sorts of geoengineering research: modeling research, engineering research, and climatic research. For the most part, the distinction between these sorts of research is a matter of scale. Let's call this the "Scale Distinction." Modeling research, they propose, poses no environmental risk, since most models are confined to paper or computer systems. Engineering research, by contrast, occurs on a much smaller scale, and thus differs little from many other sorts of engineering projects. Functioning on such a small scale, they propose, means that it is too small to pose a major risk. Climatic research, finally, occurs on a much larger scale. I shall attend to the Scale Distinction in greater length near the end of this chapter.

From there, MKO begin laying out guidelines and restrictions for geoengineering research by leaning heavily on the extant body of work in research ethics. MKO appear to presume that the core objection to geoengineering is that there are risks to human populations. If this is true, if there is reason to be concerned that the subjects of said research will be harmed or violated in some important way, then a natural stepping off point is the work on "human subjects" protections. For obvious reasons, let's call this the "human subjects" model.

Generally speaking, the most important document in the establishment of Human Subjects protections has been the Belmont Report, which was later elaborated as the "four principle approach" advocated by Tom Beauchamp and James Childress (Beauchamp & Childress, 1983). Beauchamp and Childress's four principles are:

BC1: Respect for autonomy
BC2: Beneficence
BC3: Justice
BC4: Non-maleficence

These four principles are directed for the most part at clinical biomedical research. For this, they are wholly appropriate. BC1, respect for autonomy, insists that subjects be treated as persons. BC2, beneficence, proposes that the benefits of treatment be weighed against the risks of treatment and that the health and well-being of the patient always be taken into consideration. BC3, justice, demands that benefits, risks, and costs be distributed fairly amongst all patients. And BC4, non-maleficence, requires that medical researchers avoid causing harm that is disproportionate with the benefits of treatment.

MKO, however, seek to adapt the human subjects model to apply to geoengineering: a move that is beset with difficulties (Morrow et al., 2009). Borrowing directly from the Belmont Report and the Beauchamp and Childress criteria, they propose four principles that should be applied to geoengineering research. To keep things straight I shall distinguish between BC (Beauchamp and Childress) criteria and MKO (Morrow, Kopp, and Oppenheimer) criteria. Here are the MKO criteria:

MKO1: Respect
MKO2: Beneficence
MKO3: Fairness/Justice
MKO4: Minimization

These principles are essentially lifted directly from the Human Subjects model, though they are aimed to pertain to the population of the earth more broadly, where the BC criteria apply to specific individuals. The ethical consequences of this distinction bear some discussion.

MKO1 "requires that the scientific community secure the global public's consent, voiced through their governmental representatives, before beginning any empirical research" (Morrow et al., 2009). BC1 is clearly limited to respect for individual persons, where MKO1 expands the respect that one is to accord others in a global, representative, democratic fashion. It is perhaps clear intuitively how this sort of democratic representation is supposed to respect autonomy, though as with all democratic regimes, it is also clear that the mechanism of representation is subject to any manner of corruption, thereby undercutting apparent respect.[10]

MKO2, beneficence, proposes again that there be a favorable risk-benefit ratio, but as before, when taken at the global level, this differs from BC1. Risks and benefits associated with climate engineering will be distributed unevenly across portions of the population. Just as there are political concerns about respect for persons in a representative democracy, so too are there concerns about aggregating risks and benefits across large numbers of people. Benefits may clearly be bestowed upon the many, say, where the risks are borne by the few. Shifting from the individual level to the global level is fraught with difficulties.

MKO3 faces yet slightly different difficulties. Whether a geoengineering experiment is fair will depend not on whether the distribution of benefits and burdens is fair for any given individual, but whether and how the benefits and burdens are distributed across a population. The BC criteria advance an individualized relational notion of justice, where practitioners are to consider the individual subject's position within a wider community of benefit and burden sharers. The MKO criteria, on the other hand, seek to apply this individualized notion of justice to the world, when what they really must do is look at the *shape* of the distribution.

Finally, MKO4 requires that researchers minimize the extent and intensity of geoengineering experiments such that the risks in proportion to the benefits are appropriately minimal. Again, this principle suffers from distributional considerations that the BC criteria do not.

I hope to have demonstrated above that the analog to biomedical research on human subjects as reflected in the BC criteria is not as neat as it might first appear. In what follows, I will be arguing against all three categories of research that MKO introduce with their scale distinction—modeling, engineering, and climatic. To do that, however, I will have to consider constraints on other kinds of research. I look specifically at global-scale engineering technologies and assess the objections to those technologies. I also explore the practical implications of restricting research of grand-scale, rather than the narrower human subject restrictions. To do so, I first investigate prohibitions on nuclear research and then prohibitions on biological modification, as the concerns in these cases are more akin to concerns expressed in the geoengineering debate.

RESEARCH ETHICS: WIDER-SCOPE, GLOBAL PROHIBITIONS

"Dual use" is a principle of research ethics that acknowledges that some technologies admit of both military and peaceful aims. Nuclear research offers one poignant case. Most people agree that nuclear wars ought to be prevented. Some further argue that because of this, nuclear research ought also to be prevented. Such was the position, for instance, of the Catholic Church.[11] But there is an obvious complication with placing outright restrictions on nuclear research. Such research is not only good for waging nuclear wars, but it is also potentially good for creating new and efficient sources of energy. Since many people agree that we ought to have new and efficient sources of energy, there's a conflicting imperative to develop better nuclear technologies. From this reasoning, the notion of "dual use" was born.

In the practical realm, dual use considerations are generally addressed by imposing monitoring requirements on researchers, either in the form of Institutional Review Boards (or IRBs) or international watchdog organizations. The International Atomic Energy Agency (IAEA), for instance, is coordinated through the UN. Through the guidance of the member states of the UN, it monitors Iran, North Korea, Pakistan, India, as well as several other "nuclear" nations. IAEA's core responsibilities include inspecting, providing information, and developing standards to which all signatories are to subscribe. These monitoring responsibilities help assure the world that governments and scientists are engaging in the right kind of nuclear research and not the wrong kind of nuclear research.

Of course, one reason that inspection and monitoring are possible in the nuclear case is that the research and technology used to develop nuclear weaponry are not the same as the research and technology used in energy production. Weapons grade enriched uranium, for instance, is more refined than reactor grade enriched uranium, so even though the physical ingredients and the physics may be quite similar, the IAEA can identify non-beneficent uses and distinguish them from beneficent uses relatively handily. Though such monitoring tasks are not without their difficulties, determining whether uranium is low-enriched or high-enriched, and/or identifying the equipment necessary for enriching the weapons grade uranium, helps clue the IAEA into the various uses.

Matters get quite a bit more complicated, however, when identical technologies can be used for beneficial or injurious purposes. Genetic engineering offers a paradigm case. On one hand, genetic engineering holds great promise to provide the world with new and abundant food sources, important medical advancements, and a greater measure of agricultural security. On the other hand, there are concerns that GMOs could possibly be released into the environment, that there are many uncertain effects of GMO introduction, and/or that genetic engineering can be used in a military context, perhaps in the production of biological weapons. Given that hostile and beneficial uses rely essentially upon identical research and technology, it is a much trickier matter to restrict research. IRBs, funding agencies, and monitoring organizations must be in place not just to ensure that the right technologies are developed but also to evaluate the merit of the justifications for the research. These organizations can help ensure that research is conducted for beneficent and not maleficent reasons.

Geoengineering presents yet a slightly different complication, since dual uses don't cut neatly along the military/peaceful or maleficent/beneficent divide. It is my hope in this chapter to suggest that dual use arguments can also be made along non-harm lines. Technologies can and I believe ought to be evaluated according to likelihood of trespass and encroachment. One reason we ought to be very cautious about genetic research, for instance, is not only because the risks are great, but because genetically modified organisms threaten to spill over into areas that impact innocents. The concern in this case isn't clearly that damage will be done, but rather that whatever damage will be done will be *unacceptable* damage. There is a problem of containment. Invasive genetically modified entities may pose no severe risk of harm to health or well-being, but the alterations to the environment that they engender are perhaps not of the sort that people would countenance.

These issues of containment were some of the main concerns that brought scientists together at the first Asilomar conference in 1975, when fifty-five scientists, biologists, engineers, politicians, ethicists, lawyers, and policy makers convened on Asilomar, California, to discuss the future of biotechnology (Krimsky, 2005). Participants then expressed concerns over gene splicing and recombinant DNA, but also enthusiasm about its potential (Berg, 2008). The outcome of the conference was informed by similar such dual considerations. Among other things, participants recommended placing prohibitions on the cloning of highly pathogenic organisms.

It is no accident that thirty-five years later, in 2010, a similar contingent of climate scientists, engineers, politicians, and policy makers convened on Asilomar once again, this time to discuss Geoengineering.[12] Throughout the event, scholars and scientists debated the merits and pitfalls of a variety of geoengineering proposals. Asilomar II was widely viewed to be far less successful than Asilomar I, though the participants did release a statement . . . essentially calling for more research.[13] They write:

> We do not yet have sufficient knowledge of the risks associated with using climate intervention methods, their intended and unintended impacts, or their efficacy in reducing the rate of climatic change to assess whether they should or should not be implemented. Thus, further research is indispensable.

This is where the distinction between GeoRemediation and GeoSteering reenters. Much of the discussion of perils and pitfalls at Asilomar II focused on risk and uncertainty, distinguishing between the varieties of geoengineering proposals by employing what is essentially a scientific and technical category: Solar Radiation Management (SRM) or Carbon

Dioxide Removal (CDR). The same distinction has been echoed throughout the literature, including in the Bipartisan Council Report.[14] But this distinction is not one that carries any moral weight. It is only technical—a scientific description of the two broad methods of geoengineering: those that aim to control the earth's temperature by managing solar radiation, and those that aim to do so by removing excess carbon dioxide from the atmosphere.

It should be clear from the outset that the former is most appropriately described as a steering proposal, where the latter has shades of a remediation proposal. Though all is not as it seems. Some CDR proposals aim not merely to capture and return extracted carbon into bedrock, but rather to dump excess carbon into the ocean, thereby shifting one mess to a new dumping ground. Thus even some CDR technologies—those without a clear plan to sequester captured carbon—can be categorized as GeoSteering technologies.

Unlike GeoRemediation technologies, which aim primarily to clean up pollutants emitted by individuals or collectives, GeoSteering technologies aim fundamentally to halt further or anticipated damage by steering the climate away from catastrophe, and in so doing, threaten to trespass upon innocents. Determining whether a technology is one or the other will require the deliberation and judgment of a range of experts, scientists and ethicists alike. The question therefore is not whether a geoengineering technology is prophylactic, protective, or peaceful; rather, the question is whether it could possibly avoid concerns of trespass (Hale, 2012). In other words, whether all affected parties could or would accept the consequences and side effects that might result from the particular geoengineering technology, and whether that technology could be anticipated to satisfy everyone's interests.

Fortunately, there are already international treaties in place that make empowering IRBs and international monitoring organizations relatively easy. Alan Robock argued as early as 2008 (Robock, 2008), and Andrew Light argued in 2010 at the University of Montana Workshop on Geoengineering, that the Environmental Modification treaty of 1977 (or ENMOD) addresses just this wide scope modification.[15] ENMOD is intended to restrict or constrain the actions of nations primarily with regard to scorched earth military warfare, though given its wide scope, it restricts large-scale environmental modification for nonmilitary purposes as well.[16] Activities that ENMOD restricts include: triggering earthquakes, manipulating ozone levels, altering the ionosphere, deforestation, provoking flood or drought, using potent herbicides, setting fires, seeding clouds, introducing invasive species, eradicating a species, creating storms, manipulating El Niño/La Niña systems, and destroying crops. Only seventy countries ratified the agreement, though almost all of the countries that did so are those with the scientific wherewithal and financial means to support a geoengineering project.

When the treaty was written, global-scale climate engineering was likely not on the minds of the authors. Nevertheless, there are provisions in the treaty that are in fact quite appropriate to climate engineering. For instance, the opening lines read thus:

> Each State Party to this Convention undertakes not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party.

This is the so-called Troika provision of ENMOD, since it spells out three criteria by which environmental modifications are to be judged. While the full statement limits the scope of ENMOD to military or hostile use, it also proscribes techniques that have widespread, long-lasting, or severe effects, as almost any geoengineering technology would. This provision was added by the United States government specifically.

Digging a little deeper, the ENMOD treaty distinguishes between "high" and "low" technologies. So, for instance, technologies used primarily for agricultural purposes are excluded from the purview of ENMOD, where technologies used for destroying foliage are not. Almost any geoengineering technology one can imagine, if deployed at a large enough scale to impact the earth's climate, would fall into the "high" technology category. This seems to me as true for stratospheric particle injection as it is for a globally coordinated effort to paint white millions of roofs, parking lots, and roads.

More recently, Light has argued that due to pressures within the international environmental community, geoengineering research is inevitable (Light, 2011). Inasmuch as this is the case, we ought to work with structures that are already in place to limit incidences it might be used for military, hostile, or nefarious purposes.

DISENTANGLING CONCEPTUAL ENTANGLEMENT

Exploring the complicated terrain of dual use problems, Seumas Miller and Michael Selgelid offer a taxonomy of different types of "experiments of concern" (Miller & Selgelid, 2007). They explore cases including the development of the mousepox virus and research into Ebola, essentially unpacking the very idea of dual use by demonstrating that it is far more complicated than a mere matter of hostile versus peaceful use. Miller and Selgelid claim that it functions along a good/harmful axis, as well as a military/nonmilitary axis. They further point out that nonmilitary purposes are not all necessarily good. For instance, a drug manufacturer could release a drug to make people sicker in order that they use more of the drug.

While not directly related to the considerations I have spelled out above, there are I think reasons to re-evaluate the simplistic picture of dual use that frequently dominates decision-making about research, and perhaps that even underwrites the first line of the Troika Provision in ENMOD. There is a reason to support the appropriate act description view that I have described in the first section. Namely, establishing the nature of the geoengineering technology—whether GeoRemediation or GeoSteering—will be necessary for the successful enforcement of ENMOD. If there are real concerns that geoengineering technologies could be used for hostile purposes, then establishing the purpose of environmental modification technologies will be exceptionally important.

What is needed instead is a system of deliberative bodies—IRBs and international monitoring organizations seem the most natural—that can commence an earnest deliberation into the variety of geoengineering proposals currently on the table. These deliberative bodies must determine whether any specific proposal is aimed primarily at remediation or at steering. If it is aimed at steering, I suspect that it is not of the sort that can be justified, and thus research into it ought not to proceed. If it is aimed primarily at remediation, it may well be justifiable, if not also ethically required, and thus such that it can proceed.

To better understand the reach of my proposal, return to the Scale Distinction sketched out above. This is the distinction, again, that seeks to draw a line between global research, engineering research, and modeling research.

Consider first global research. Is there anything wrong with conducting scaled-up experiments? One argument is that to recognize any climatic effects, one would have to conduct geoengineering experiments at the global level. So the answer to this question is that research at the global scale essentially involves geoengineering the earth. If it is impermissible to geoengineer the earth, then such research is also impermissible. But we have seen above that not all geoengineering is alike. Removing carbon dioxide from the atmosphere by way of remediation, which as a consequence also shifts the climate back down to normal, is not morally problematic in the same way that removing carbon dioxide from the atmosphere in order to steer the thermostat of the earth is problematic. A scaled up remediation plan, so long as it does not also involve steering, ought not to be restricted.

What about scaled-down engineering experiments? On a risk/harms view, scaled down engineering projects seem, perhaps, less problematic. On the other hand, the remediation/steering distinction can play a role here as well. Injecting aerosols into the stratosphere to determine the extent and degree of radiation that they will deflect essentially lays the groundwork for larger scale stratospheric aerosol injection, which is a steering technology. This sort of research ought to be restricted, even though smaller scale versions of it are likely to do little damage. As Lisa Dilling and I argue, these sorts of experiments are only permitted to proceed when they do not threaten to trespass on others, or when the consent of all affected parties (and/or their legitimate proxies) can be secured (Hale & Dilling, 2011). The problem is that in conducting these experiments, one essentially begins the process of building the bomb. For instance, a recent proposal by researchers at the Universities of Bristol, Cambridge, Edinburgh, and Oxford in the UK aimed to test the plausibility of jettisoning particles into the stratosphere.[17] The Stratospheric Particle Injection for Climate Engineering project (or SPICE) was eventually tabled due to concerns from critics.[18]

Finally, is there anything wrong with running mathematical models? If one accepts the risk/harms position, it would appear that there could be little wrong with running mathematical models, since the impacts on the planet are non-existent. But as I have tried to show, risk/harms are not the only ethical considerations. One must also take account of trespass and rights violations.

Consider more mundane cases in which it might be problematic to run mathematical models. If I run a population model to evaluate fight-or-flight responses of five-year-olds, essentially to learn how children flee when assaulted by armed gunmen, there are good and bad reasons to run such models. Perhaps I aim to run these models in order to design safer schools. In the event of an armed gunman, I need to understand the crowd dynamics of kindergarteners so that I can best know which schools are in greatest need of renovation and redesign. If, on the other hand, I aim to run these models in order that I can enter a school and *be* an armed gunman, and I aim to understand which school I should target so as to maximize my kill, I am indeed running these models for the wrong reasons. This sort of research ought to be severely restricted.[19]

The important observation is that these arguments against GeoSteering are arguments writ large, against the practice of GeoSteering and all that it entails, which includes the setting up of a geoengineering project. If some ambitious scientists aim to begin the project of understanding aerosols in the atmosphere and can offer an equally ambitious and compelling argument as to why those aerosols can be studied—an argument, namely, that *does not* introduce the possibility that research is conducted for the purpose of GeoSteering—then it is reasonable to go forward with the project. But the argument for GeoRemediation and not GeoSteering must be compelling, and it must pass justificatory muster with a suitably qualified and empowered review board.

One important implication of this view is that we ought to begin the process now of establishing guidelines by which Institutional Review Boards (IRBs), funding organizations, and international monitoring organizations can begin to limit research into geoengineering. I thus propose, in concert with Morrow, Kopp, and Oppenheimer, an International

Climate Engineering Review Board, though the framework for restrictions on research that I propose is far more restrictive than theirs.

CONCLUSION

I have argued that the Human Subjects model for restrictions on research is unsuccessful at addressing ethical concerns at the global scale of proposed research into geoengineering technologies. Instead, I have pushed for a global model involving institutional review boards and monitoring organizations. Specifically, I have suggested that dual use considerations associated with prior engineering projects are not as easily understood in the case of geoengineering as in the cases of nuclear or genetic research, since there is considerable conceptual entanglement between GeoRemediation technologies and GeoSteering technologies. The clearest method of distinguishing between remediation and steering technologies is to describe correctly the technology according to the most accurate act description: whether it is in fact an act of cleanup or instead an act of manipulating the climate in order to avert a projected disaster. Unfortunately in a chapter of this length it is difficult to include everything one would like to include, but I believe that the view I've defended reinforces the need for careful judgment and deliberation by a panel of experts. Thus, the need for International IRBs and Monitoring Organizations is strong.

Even though it is true that, if well engineered, GeoSteering technologies may cause nowhere near the devastation that climate change may cause, it is nearly impossible to secure the acceptance of all affected parties. Because of their global impact, GeoSteering technologies hold extraordinary potential to deny humanity and all other residents of this earth the respect that they are owed. Such concerns are less pronounced with GeoRemediation technologies, since remediation aims primarily not to steer the climate, nor to control the temperature of the earth, but essentially to clean up a mess of our own making. Admittedly, the distinction between GeoSteering and GeoRemediation technologies is a thin one. It will be a conceptual challenge to determine which technologies fall into which categories. Nevertheless, it is critical to interpret and regulate the spectrum of geoengineering proposals more acutely.

NOTES

1. http://www.bipartisanpolicy.org/sites/default/files/BPC%20Climate%20Remediation%20Final%20Report.pdf.
2. http://www.agu.org/sci_pol/positions/geoengineering.shtml
3. http://www.guardian.co.uk/environment/blog/2011/oct/06/us-push-geoengineering/print; Stuart Strand at the University of Washington also characterized the BPC report of engaging in semantics in his posting to the geoengineering listserv (geoengineering@googlegroups.com) on October 9, 2011, at 7:55 p.m. He writes: "None of this argument over semantics should distract from recognition of the need for research in the lab and for monitored field scale experiments with SRM technologies."
4. See also the ETC Group's "GeoPiracy: The Case Against Geoengineering," available online at: http://www.cbd.int/doc/emerging-issues/etcgroup-geopiracy-2011-013-en.pdf.
5. In many cases, of course, intentions or objectives are critical—as the intentions or objectives of the user of a gun, for instance, will aid in establishing the innocuous versus pernicious uses of that gun—but they alone do not do the work. Sometimes technologies reshape the landscape of possibility.
6. I avoid this neologistic terminology in those earlier works, but the distinction can nevertheless be helpful.
7. Note that such practices were used in the cleanup of the 2010 BP Deepwater Horizon Oil Spill. Such practices were justified primarily on risk/cost/benefit lines. What is at issue in these instances, however, is not so much the risk as the containment, the possibility of trespass. BP received considerable criticism for this practice, though almost all responses were framed in terms of risks, which I think was too limiting. See, for instance, the Environmental Protection Agency's explanation: http://www.epa.gov/bpspill/dispersants-qanda.html.
8. This position stems from work by Benjamin Hale (Hale, 2012; Hale & Dilling, 2011; Hale & Grundy, 2009), Stephen Gardiner (Gardiner, 2010, 2011), and Mark Sagoff (Sagoff, 2004), but is also reflected more tangentially in foundational work by Joel Feinberg (Feinberg, 1990) and Judith Jarvis Thomson (Thomson, 1992).
9. See also: http://thinkprogress.org/romm/2010/09/27/205526/martin-bunzl-geoengineering-fix-solar-radiation-management-aerosols-volcanoes/
10. MKO do raise the concern that representative consent may not be sufficient for respecting autonomy. But the concern over respect for persons goes well beyond a simple question of whether affected parties can have their interests reflected in a representative democracy. They take as evidence in favor of their position on informed consent a variant of the "lesser of two evils" argument, suggesting that "existing processes are already altering the global climate regardless of anyone's consent." But this cannot possibly serve as a mitigating consideration. That existing processes may be altering someone's health, for instance, does not in itself authorize a physician to intervene on behalf of the ill.
11. Stop Funding for New Nuclear Weapons Research (statement from the United States Conference of Catholic Bishops), http://www.nccbuscc.org/sdwp/international/rnep705aa.shtml
12. Eli Kintisch, "Treating Climate Change as a Curable Disease," http://www.wired.com/wiredscience/2010/04/climate-desk-geoengineering/.
13. http://news.sciencemag.org/scienceinsider/2010/03/full-text-of-asilomar-2-statemen.html
14. The report says: "Researchers are interested in pursuing two major categories of climate remediation technologies today: (a) those that are designed to remove carbon dioxide or other greenhouse gases from the atmosphere (carbon dioxide removal, or CDR) and (b) those that are designed to reduce the Earth's absorption of the energy from sunlight (solar radiation management, or SRM)." Task Force on Climate Remediation Research, 2011, pp 7.
15. Geoengineering Workshop, "The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management," University of Montana. October 18-20, 2010.
16. http://www.sunshine-project.org/enmod/primer.html; http://en.wikipedia.org/wiki/Environmental_Modification_Convention
17. http://www.nerc.ac.uk/press/releases/2011/22-spice.asp
18. http://esciencenews.com/sources/physorg/2011/10/05/spice.geoengineering.project.delayed.due.critics.issues

19. Author's note: This example was written and typeset before the massacre in Newtown, CT. Any resemble to actual events is completely coincidental.

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