2. Grand challenges of planetary governance in the 21st century

1 INTRODUCING THE 21ST CENTURY'S GRAND CHALLENGES

Four grand challenges top the list of 21st-century needs for governance requiring urgent and sustained responses on a planetary scale. For shorthand purposes, I will refer to these challenges as: (i) protecting the Earth's climate system, (ii) controlling the eruption of pandemics, (iii) suppressing disruptive misuses of cyberspace, and (iv) guiding the biotechnology revolution. Each of these challenges is anthropogenic in nature. Human actions are among the principal driving forces generating needs for governance in each case; human well-being, from the level of the individual person up to the level of our species as a whole, is at stake in all four cases. All these challenges are embedded in highly complex systems featuring rising levels of systemic connectivity, non-linear and often exponential patterns of change, and recurrent surprises (Young 2017). This makes them difficult – if not impossible – to address effectively using familiar steering systems centered on the efforts of sovereign states to negotiate and administer international legally binding instruments. The four grand challenges differ with regard to the nature of the problem involved and the character of the responses required to solve or manage them. But in each case, there is an urgent need to create and implement a governance system to avoid socially undesirable and potentially disastrous consequences. We can learn a lot about governance in the 21st century by comparing and contrasting the efforts of leading actors to create effective governance systems dealing with one or another of these four challenges.

We should be under no illusion about the prospects for coming up with some new approach to Earth system governance that will prove effective in addressing these grand challenges. Many efforts to address ordinary transnational needs for governance produce disappointing results; some end in outright failure (Speth 2004; Hale et al. 2013; Conca 2015). The problems embedded in the grand challenges are even more imposing. Nevertheless, a careful assessment of the character of each of these challenges and the nature of the governance system needed to address it can tell us a great deal not only about

the repertoire of strategies that will be required to meet an array of 21st-century needs for governance, but also about the ways in which the strategies required to deal with these needs must differ from the approaches to governance familiar to us from mainstream thinking about international institutions.

This chapter addresses this subject in several steps. I begin with a series of thumbnail sketches, introducing each of the grand challenges with an eye toward revealing the core of the relevant problem. This leads to a discussion of problem types, an enquiry designed to explore the extent to which common analytical distinctions among basic types of problems giving rise to needs for governance can help us to grasp the issues embedded in the grand challenges. The discussion then turns to a consideration of agency, asking questions about those actors whose behavior is critical in each case and about the principal sources of their behavior. This sets the stage for an analysis of alternative behavioral mechanisms that may prove effective in steering or guiding the actions of the key actors. A final substantive section addresses policy instruments in the sense of specific procedures used to operationalize behavioral mechanisms that may provide leverage in coming to terms with each of the grand challenges. The concluding section offers some projections about the probable trajectory of efforts to create governance systems to address these grand challenges and highlights key differences among them we need to bear in mind going forward. Running through the entire analysis is a consideration of the role of technological innovations both as sources of 21st-century needs for governance and as elements in the institutions we put in place to address each of the grand challenges.

2 CONSTRUCTING THUMBNAIL SKETCHES

The 21st-century grand challenges are all planetary in scope in the sense that our responses to them will affect the well-being of all human beings and the fate of the Earth system more generally. But as the following thumbnail sketches make clear, they differ in ways that have major consequences for the character of the governance systems needed to address them.

Protecting the Earth's Climate System

In contrast to weather, the climate system is planetary in scope (Archer and Rahmstorf 2010). Emissions of greenhouse gases occurring everywhere raise the concentration of such gases in the Earth's atmosphere; reductions in emissions anywhere will slow the rate of increase in the overall concentration of these gases in the atmosphere. Human actions, largely in the form of the combustion of fossil fuels used to drive industrialization, have increased atmospheric concentrations of carbon dioxide from about 280ppm at the start

of the Industrial Revolution to ~415ppm today. The level is higher when other greenhouse gases are included and is expected to continue to rise during the coming years. While the consequences of climate change in such forms as increases in ambient air temperatures, sea-level rise, severe weather anomalies, shifts in the composition of ecosystems, the spread of wildfires, and so forth will vary from place to place, no place on Earth will escape the impacts of climate change. This means we are leaving the Holocene, an era of remarkable stability in the Earth's climate system lasting roughly 10,000 years and coinciding with the rise of human civilizations, and entering a new era commonly called the Anthropocene. With regard to the Earth's climate system, we have reached a planetary boundary (Rockström et al. 2009). Efforts to protect the climate system, focused on the 1992 UN Framework Convention on Climate Change (UNFCCC) and several additional measures elaborated within this framework (e.g., the 2015 Paris Climate Agreement) have failed to put a stop to rising concentrations of greenhouse gases, much less reversing this trend. The disruptive impacts of climate change are already becoming apparent, most dramatically but by no means exclusively in the high latitudes of the northern hemisphere. It is clear that more decisive steps must be taken if we are to avoid what the UNFCCC calls "dangerous anthropogenic interference with the climate system" (UNFCCC 1992).

Controlling the Eruption of Pandemics

There is nothing new about the spread of devastating infectious diseases responsible for the death of large numbers of human beings (Snowden 2019). The bubonic plague pandemic of the 14th century killed an estimated 30–60% of Europe's population. In the period following European contact at the end of the 15th century, smallpox (sometimes combined with measles) killed an estimated 80–90% of the Indigenous population of the Americas, a population that may have numbered 20–25 million people prior to European contact. The great influenza epidemic of 1918–1919 infected a third of the Earth's human population and killed an estimated 50 million people. The later decades of the 20th century brought a wave of enthusiasm regarding the prospects of eradicating infectious diseases. A focused effort produced notable success in the case of smallpox. Nevertheless, as the cases of SARS, avian bird flu, Ebola, and most recently Covid-19 make clear, we now face the prospect of global pandemics that have the potential to kill huge numbers of people, wreaking havoc with the economic and social systems of industrialized societies in the process. In the absence of vigorous and coordinated efforts to address this problem, pandemics that make Covid-19 seem mild by comparison will occur in the future. Effective mechanisms to address this challenge must encompass a combination of concerted efforts to prevent outbreaks from occurring, rigor-

ous measures to control the spread of disease once an outbreak does occur, and ample support for the development and distribution of vaccines to combat the worst cases. The mechanisms presently in place to address this problem (e.g., the World Health Organization) are entirely inadequate to respond to this need for governance successfully (Cueto et al. 2019). As experience with Covid-19 has made clear, there is an unfortunate tendency for both governments and members of the general public to react to the outbreak of a pandemic in a narrowly self-interested manner, turning inward, suppressing information, blaming others, and failing to take the steps needed to mount a coordinated global response to the problem.

Suppressing Severe Misuses of Cyberspace

The emergence of digital technologies giving rise to virtual reality, the growth of cyberspace, and the subsequent increase in interactions between digital systems and physical or material systems has transformed the human experience (Isaacson 2014). The development of the internet, the establishment of the world wide web, and the introduction of a host of technologies that allow for the transmission of audio, visual, and graphic data widely and inexpensively has allowed humans to engage in a range of activities that were literally inconceivable prior to the onset of the cyber age. While many of the results are undoubtedly positive, the cyber age has brought with it an array of needs for governance that did not exist and had no counterparts in earlier times (DeNardis 2014). These range from dealing with smallscale misuses of cyberspace in such forms as identity theft and virtual bullying or harassment to largescale misuses including clandestine financial transactions, foreign interventions in electoral systems, cyberterrorism, and cyberattacks on national security systems. Those who engage in such misuses run the gamut from individual hackers motivated by idiosyncratic desires to promote social disruption to criminal organizations exploiting digital technology to engage in illegal commercial activities and on to government agencies seeking to control the behavior of people through various forms of electronic surveillance. There is every reason to expect opportunities to misuse cyberspace to grow in both variety and significance in the coming years (Perlroth 2020). There is no basis for assuming that states making use of conventional measures like international legally binding instruments will be able and willing to address such misuses effectively (Young, Yang, and Guttman 2020). In some cases, governments endeavoring to control their own citizens or to disrupt social order in other states will be part of the problem rather than part of the solution. The grand challenge in this case is to find ways to avoid or mitigate the worst consequences of this problem, without limiting the positive results afforded by the rise of cyberspace.

Guiding the Biotechnology Revolution

Just as breakthroughs in physics gave rise to several of the great issues of the 20th century (e.g., the control of nuclear weapons), breakthroughs in biology today are being put to use to produce an array of forms of biotechnology giving rise to some of the great issues in the 21st century (e.g., the management of genetic editing). The last several decades have brought a cascade of advances in biotechnology, including but not limited to, biofuels, genetically modified crops (GMO), gene drives, synthetic biology, and gene therapy in humans. Perhaps the most dramatic development from the perspective of global governance is the emerging prospect of germline editing, a procedure making it possible not only to take steps to reduce or even eliminate diseases caused by monogenetic mutations like cystic fibrosis, Huntington's disease, and sickle cell anemia, but also (at least in principle) to "design" human beings by selecting for heritable traits relating to matters like intelligence, looks, and strength (Renneberg and Loroch 2017; Davies 2020; Isaacson 2021). Biotechnology presents exciting opportunities in areas like enhancing food security and repairing or avoiding genetic defects. But it opens up profound issues relating to governance, both because specific applications of biotechnology trigger major value conflicts (e.g., the fight over GMO crops) and because biotechnology may lead to deep-seated concerns in the realm of human rights and social justice as well as social distortions that would undermine key features of major streams of thought regarding what it means to be a good society (Greeley 2021; Isaacson 2021). While governments may endeavor to regulate the development and application of various uses of biotechnology, it is far from clear whether these institutions have either the authority or the capacity to address such issues effectively. At a minimum, meeting this grand challenge will require initiatives that are coordinated on a planetary scale where the challenge is to develop systems of governance in the absence of a government in the conventional sense (Rhodes 2010).

3 CONCEPTUALIZING THE PROBLEMS

Analysts who think about governance broadly as a social function centered on societal steering have devised a number of analytical models to help in differentiating among types of problems giving rise to needs for governance and calling for different responses. These models point to key differences among what are commonly known as collective-action problems, externalities or problems of social cost, and problems involving incommensurable values. Collective-action problems are situations in which groups of two or more actors make choices that seem perfectly reasonable from an individual perspective but generate outcomes that are harmful to all members of the group.

Familiar examples include the tragedy of the commons in which the seemingly rational actions of the commoners lead to the depletion of a common pool resource (e.g., a pasture or a fishery) and the free-rider problem in which the seemingly rational unwillingness of individuals to contribute leads to the failure of a group to produce a public good beneficial to all (e.g., an intact climate system) (Olson 1965; Hardin 1968). In Thomas Schelling's well-known phrase, understandable micromotives produce macrobehavior that is disadvantageous to all (Schelling 1978).

Contrast such problems with another class of problems centered on externalities or unintended (and often unforeseen) byproducts of self-interested actions of individuals that affect the welfare of others. Though analysts have noted that some externalities are positive, problems of governance come into sharp focus in the case of negative externalities or what are often called social costs, ranging from smallscale interactions in which the self-interested actions of one person detract from the well-being of a neighbor to largescale cases, such as the disruption of the stratospheric ozone layer resulting from the production and consumption of ozone-depleting substances (Mishan 2011). Yet a third class of problems features incommensurable values in which proposed actions that are compatible with or even demanded by values motivating some members of a group are incompatible with the values of others (Hsieh 2016). Some conflicts of this sort are mild enough to allow for what is often called "logrolling" in which the members of two or more groups make tradeoffs to promote their highest values. But others (e.g., many conflicts over animal rights or the rights of future generations) cut deep and lead to irreconcilable differences between advocates of conflicting positions regarding specific issues (e.g., the killing of whales). When problems are framed in this way, it is difficult to avoid outcomes that produce distinct winners and losers.

What can a consideration of analytic distinctions among problem types tell us about the core problems associated with the grand challenges of global governance? The first thing to note is that it is seldom straightforward to map real-world needs for governance onto these simple analytic distinctions. Consider the example of long-range air pollution. From one perspective, long-range air pollution is an externality arising from the construction of tall smokestacks associated with industrial facilities, which are themselves typically a response to complaints from those living nearby about the effects of local pollution. On the other hand, we can think of clean air as a common pool resource in the sense that it is depletable or degradable but non-excludable. From this perspective, air pollution emerges as a collective-action problem. Micromotives drive individual members of a society to take actions that result in the degradation of the resource to the detriment of all. As this example suggests, moreover, efforts to conceptualize problems giving rise to needs for governance often devolve into political exercises. If air pollution is simply an

externality caused by the emission of particulates from tall smokestacks, it stands to reason that the proper response is to impose regulations requiring the owners of the relevant facilities to internalize these social costs. If we approach the problem as a matter of avoiding the degradation of clean air treated as a common pool resource, on the other hand, it seems appropriate to ask all members of the relevant community to make contributions to ensure that the tragedy of the commons does not occur. As a result, there is every reason to expect that efforts to address needs for governance associated with the grand challenges will be political from the outset.

Turning now to the specific challenges, we can begin with the observation that no one intends to take actions that disrupt the Earth's climate system. Increases in the concentration of greenhouse gases in the atmosphere are byproducts or side effects of a variety of human activities involving the burning of fossil fuels, the clearing of land, the consumption of ozone-depleting substances, and so forth. This suggests that we should think of this grand challenge as a matter of internalizing social costs. But who should assume responsibility for the harm caused by emissions of greenhouse gases? To take the case of fossil fuels, is it the producers of hydrocarbons, those who burn coal, oil, and natural gas to generate electricity or power industrial plants, or the consumers of all the goods and services they produce? On the other hand, we can approach the problem of climate change from an entirely different perspective. The Earth's climate system is a kind of common pool resource; it is both non-excludable in the sense that everyone experiences it and depletable or degradable in the sense that climate change is eroding the stable and generally benign climate system of the Holocene. Despite the fact that some harbor the illusion that they may benefit from climate change, all stand to suffer from largescale climate change over time. If this is the case, we may find it helpful to think about climate change as a collective-action problem, one that requires us to think about ways to encourage everyone to assume responsibility for contributing to the public good of an intact climate system rather than about devising means to compel specific emitters to internalize the costs arising from emissions of greenhouse gases. While neither of these conceptualizations is objectively correct, there are good reasons to expect adherents to advocate actions that differ sharply in political terms in efforts to tackle this grand challenge.

The grand challenge of controlling the eruption of pandemics presents a different set of issues. Everyone wants to avoid being blamed for causing the eruption of a pandemic. Many hope that they can take steps to isolate or insulate themselves, so that the disease becomes someone else's problem that they can safely ignore. The Covid-19 pandemic offers striking examples. It is tempting for political reasons to "blame" China for failing to control the outbreak and the World Health Organization for failing to respond quickly enough. Similarly, there is a temptation among some – especially younger

people who may feel less vulnerable – to refuse to take proper precautions including social distancing, wearing masks, and avoiding unnecessary interactions with others. It is true, of course, that the incidence of the disease is highly unequal. The statistics regarding the prevalence of infection and the likelihood of death among certain vulnerable groups (e.g., prison inmates, nursing home residents, people of color) are shocking. Nevertheless, there are compelling reasons to think about controlling pandemics in collective-action terms. The avoidance of pandemics is a type of public good. Everyone benefits from avoiding an eruption; the benefits accruing to individual members of the community do not detract from the benefits accruing to others. If this is the case, the challenge is to avoid free-riding on the part of individuals who hope that they can benefit from the efforts of others to maintain a disease-free environment, while making little or no contribution themselves.

The onset of the cyber age featuring the development of the internet and the world wide web has triggered remarkable innovations in the realm of governance on a global scale. For example, the governance system for the internet, arising to a large extent spontaneously, has evolved to encompass a cascade of technical developments and has proven surprisingly effective as a steering mechanism (DeNardis 2014). But the increasing power and sophistication of digital technologies has opened up opportunities for actors, ranging from single individuals to government agencies, to use cyberspace for purposes that lack social legitimacy or are likely to produce socially disruptive outcomes (Klimburg 2017). In some cases (e.g., identity theft, illegal financial transactions), the activities in question are criminal in nature, and the problem becomes a matter of law enforcement. In other cases (e.g., invading and disrupting the computer systems of large corporations), the activities can cause major economic damage, and the problem is to find ways to avoid serious harm not only to the initial targets but also to the well-being of those who are employees or customers of the victims. In still other cases (e.g., foreign interference in electoral systems, the use of digital technology to disable military systems), the perpetrators are either sponsored by governments or are government agencies, and the problem is to avoid the escalation of hostile interactions on an international scale (Kaplan 2016; Perlroth 2020). The need for governance in all these cases centers on the challenge of preventing or preempting illegitimate uses of cyberspace without restricting ordinary users' enjoyment of the benefits made possible through applications of digital technologies. This is a concrete example of a need for governance that all societies face: how to establish societal norms regarding the bounds of legitimate behavior. On a global scale, this involves determining who should make decisions about such matters, where exactly to draw the line between legitimate and illegitimate behavior, and how to elicit compliance with the relevant norms from a diverse range of actors.

Rapid advances in biotechnology are generating novel needs for governance. Some of these needs, involving matters like intellectual property rights and the procedures governing the licensing of new drugs, are subject to treatment through the operation of existing governance systems. The grand challenge of guiding the biotechnology revolution centers on two major concerns. One arises from the extremely destructive potential of biowarfare and bioterrorism; the other centers on the potential of germline editing not only to give rise to far-reaching issues of social justice but also eventually to pose profound normative questions about the nature of human life (Doudna and Sternberg 2017; Greeley 2021). It seems reasonable to approach the problem of biowarfare and bioterrorism, like the problem of chemical warfare, as a collective-action problem. While there may well be temptations to cheat in this realm, it is hard to argue with the proposition that the imposition of tight limits or even a total ban on uses of bioweapons is desirable from a collective or societal point of view. The case of germline editing, on the other hand, may give rise to conflicts between or among incommensurable values that are difficult to resolve. Most are likely to agree that it makes sense to use new knowledge regarding genetics to address problems resulting from genetic defects, such as Down syndrome. But how can we deal with conflicts between those who want to be allowed to make designer choices regarding individual human lives and those who believe that it is morally unacceptable to permit such interventions in the human reproductive process (Evans 2020)?

4 IDENTIFYING THE PRINCIPAL AGENTS

Responding to needs for governance invariably requires identifying key actors and finding ways to induce these actors to alter or adjust their behavior in ways that allow for the establishment and operation of institutions designed to solve the relevant problems. But we ordinarily confront choices regarding whom to identify as the key actors and need to think about issues regarding the sources of their behavior. Consider the problem of avoiding the depletion of fish stocks due to overfishing as an example. Are the key actors harvesters, processors, distributors, retailers, or consumers of fish products? There is no correct answer to this question. But as we will see, choices regarding the identification of key actors can make a big difference in terms of the nature of the governance system put in place and the prospects that the system will prove effective in solving the problem that led to its creation. Once the key actors have been identified, it becomes important to think carefully about the sources of their behavior. This is a complex subject. But to provide an introduction to the issues involved, we can ask whether the behavior of the key actors conforms to the logic of consequences, the logic of appropriateness, or some mix of the two (March and Olsen 1998). Whereas incentive mechanisms may prove

effective in steering the behavior of actors whose decisions reflect the logic of consequences, normatively grounded principles may produce better results in steering the behavior of actors who respond to the logic of appropriateness.

A number of practical questions come into focus right away in thinking about the principal actors associated with a need for governance. Thus, we want to know: how many key actors are there, will they have incentives to cheat, how hard is it to monitor their behavior, and does the situation lend itself to the creation and operation of effective compliance mechanisms? Once again, the case of ozone-depleting substances (ODSs) is helpful in thinking about the significance of these issues. When negotiators reached agreement in 1987 on the terms of the Montreal Protocol on Substances that Deplete the Ozone Layer, one company (DuPont) produced ~25% of the known substances that deplete the ozone layer; these products accounted for only ~3% of the company's annual income stream, and the company's leaders had confidence in their ability to lead the way in the research and development needed to come up with (seemingly) benign alternatives for most uses of ODSs (Parson 2003). What is more, a small number of other companies accounted for the rest of the production of ODSs. Under the circumstances, it made sense to highlight the role of producers rather than consumers in developing the core provisions of the ozone regime. This did not eliminate concerns about the development of a black market in existing ODSs or the argument for creating a multilateral fund to assist developing countries to avoid becoming dependent on ODSs. But the structure of the industry provided clear guidance regarding whom to treat as key actors and how to think about influencing their behavior in the effort to protect and restore the stratospheric ozone layer.

What are the implications of these observations for efforts to come to terms with the four grand challenges of the 21st century? One difficulty facing those seeking to deal with climate change is that it is not easy to reach clearcut conclusions regarding the identity of the key actors. In the case of fossil fuels, for example, should we concentrate on altering the behavior of the producers of coal, oil, and gas, the refiners of these energy sources, intermediate users (e.g., power plant operators, producers of motor vehicles), or the ultimate consumers of energy (e.g., homeowners, owners of motor vehicles)? There is no consensus regarding answers to questions of this sort. As a result, the provisions of international agreements aimed at solving the problem of climate change are either silent regarding the identity of the key actors (e.g., the UNFCCC) or leave it to member states to make their own choices regarding this matter (e.g., in crafting the Nationally Determined Contributions called for in the 2015 Paris Climate Agreement). There are legitimate arguments in favor of different responses to questions about the key actors in the case of climate change. But a scattershot approach featuring desultory efforts to guide the actions of a wide range of actors is unlikely to prove successful in solving the problem.

Reducing emissions of greenhouse gases both drastically and rapidly to avoid breaching the planetary boundary regarding climate with highly disruptive consequences for human societies will require a concentrated effort to bear down hard on the behavior of a set of actors located at well-defined links in the behavioral chain involved in the emission of greenhouse gas.

Controlling the eruption and spread of diseases is a critical concern of public health authorities in all societies. But the grand challenge of avoiding the eruption of pandemics is a matter of preventing diseases that originate in one place from spreading across national boundaries killing large numbers of people on a planetary scale (Snowden 2019). In today's globalized system, there are numerous vectors along which a disease can spread from one country or part of the world to another; there is no way to eliminate the possibility of pandemics occurring. What this suggests regarding the control of pandemics is that the key actors will be agencies (e.g., the World Health Organization) able to monitor outbreaks of disease closely and provide early warning regarding the onset of pandemics coupled with public health authorities within countries (backed by political leaders) who are able and willing to cooperate effectively in taking steps to respond quickly and effectively to any signs of the spread of diseases across national boundaries. Two critical issues arise from this observation. One involves the challenge of maintaining effective early warning systems to respond to events that occur infrequently. This is a matter of combatting a natural tendency toward complacency and the degradation of systems that are used infrequently, though their role is critical when they are needed. The other issue arises from the tendency of political leaders to blame outbreaks of diseases on others rather than cooperating to minimize the spread of diseases across international boundaries. The challenge here is to combat calculations based on narrow and short sighted conceptions of political self-interest that can lead to behavior that is counterproductive from an Earth system perspective.

What makes it hard to avoid or respond effectively to misuses of cyberspace is that perpetrators may range all the way from isolated individuals exhibiting various forms of antisocial behavior to governments seeking to exploit cyberspace as a weapon in efforts to advance their own interests. This means there is no way to come to terms with this grand challenge without developing a range of strategies tailored to the actions of a variety of key actors. While the capacity of individuals to wreak havoc may be limited, dealing with their actions is difficult both because they are often hard to track down and because they may be unresponsive to efforts to impose more or less severe sanctions on their actions. Misuses of cyberspace involving illegal business activities or impermissible financial transactions, on the other hand, are often the work of actors responsive to the logic of consequences. While it may be difficult to track them down, the availability of effective enforcement measures is likely to make a difference regarding the choices they make. Misuses of cyberspace

on the part of governments or government agents present a different challenge. Such actions may well give rise to collective-action problems in the sense of situations in which everyone would be better off, at least in the long run, if it were possible to prohibit such activities on the part of each individual member of international society. They are, in other words, a subset of the broader category of arms control problems (Schelling 1966). But it is not easy to see a way to shift from the status quo to an alternative state featuring an effective ban on misuses of cyberspace to achieve national objectives. Overall, the onset of the cyber age, which features the development of numerous beneficial technologies, has brought with it a diverse and highly complex set of needs for governance (DeNardis 2020).

Although they are far from simple, many applications of biotechnology are subject to governance through familiar procedures. Existing regulations governing the award of licenses or patents, for example, can be extended to cover a variety of applications of biotechnology. While the tradeoff between food security and the production of biofuels may pose a hard choice, it does not present an unprecedented problem. But guiding the biotechnology revolution comes into focus as a grand challenge when serious value conflicts arise and especially when applications may generate irreversible changes in *homo sapiens* as a distinct species (Harari 2018; Isaacson 2021). This is what makes it hard to resolve conflicts over the production and use of GMO crops. And it is what leads many observers to see the issue of germline editing as one of the most difficult challenges regarding governance we have confronted as a species. A critical question in these cases concerns the identity of key actors and the recognition of who can speak for them. It is not sufficient to leave issues regarding GMO crops to commercial patenting processes when major groups object to their use on moral or ethical grounds. It is not acceptable to leave matters regarding germline editing to public health agencies or scientific establishments when these matters raise profound issues of concern to all members of society. We know that these issues are planetary in scope; there is no way to address them effectively on a national or even regional basis. But progress in meeting this grand challenge will depend, in the first instance, on determining who should be authorized to make the critical choices within what venues.

5 ASSESSING BEHAVIORAL MECHANISMS

Mainstream thinking, at least in the Western world, generally reflects a regulatory perspective on governance (Chayes and Chayes 1995). Analysts assume that the way to respond to needs for governance is to introduce and implement rules treated as prescriptions telling more or less well-defined categories of subjects what they are required to do or prohibited from doing under speci-

fied conditions. For example, fishers must adhere to gear restrictions and not exceed quotas; emitters of sulfur dioxide or nitrogen oxides must have permits covering their emissions; coastal states must allow transit passage through recognized international straits; members of the ozone regime must ban the production and consumption of designated chlorofluorocarbons beyond agreed upon dates. The regulatory approach to societal steering directs attention to matters of compliance with the relevant rules, including monitoring and reporting to document whether subjects are adhering to requirements and prohibitions, the imposition of sanctions as a means of enforcing compliance, and the development of procedures to arrive at authoritative interpretations in cases where there are disagreements regarding the application of rules to specific cases (Mitchell 1996; Raustiala and Slaughter 2002). Where needs for governance extend beyond the jurisdiction of individual nation states, this way of thinking presupposes that the rules should be articulated in the provisions of international agreements and that legally binding or hard-law agreements are to be preferred to informal or soft-law agreements.

In thinking about the 21st century's grand challenges of global governance, however, it is important to recognize that there are alternatives to the regulatory approach. All governance systems must make use of behavioral mechanisms structured in such a way as to influence the behavior of those actors whose activities are (or may become) the source of the problem. But relying on rules is only one way to meet this challenge. Some governance systems emphasize the role of principles construed as normative guidelines or codes of conduct rooted in the application of the logic of appropriateness rather than the logic of consequences. Others highlight the use of standards that actors must meet before they are certified or licensed to engage in specified activities. Still others make use of goals (e.g., the goals set forth in five-year plans) to focus attention on key issues, guide the allocation of resources, and galvanize the efforts of groups to solve specific problems within a limited period of time. The point is not that one behavioral mechanism is better than others or more well suited to address needs for governance in some general sense. Rather, we need to include a range of options regarding behavioral mechanisms in our governance toolkit, and develop expertise in determining which of the options or combination of options is likely to produce the best results in addressing particular needs for governance.

With all due respect to the attractions of geoengineering, including both solar radiation management and carbon dioxide removal, any lasting solution to the problem of climate change will require transformative change in economic systems dependent on the combustion of fossil fuels. There is no shortage of emerging technologies that can play a role in this transformation, including solar, wind, and hydrogen energy, electric vehicles, increased reliance on virtual meetings, and so forth. The problem is to restructure existing

incentives in such a way as to alter the behavior of producers and consumers of fossil fuels and products derived from the combustion of fossil fuels. It is unlikely that market forces alone can bring about these changes. Vested interests are powerful, and collective-action problems (e.g., the tendency to engage in free-riding) constitute a form of market failure in this realm that seems insurmountable in the absence of public intervention. When societies are ready to take this challenge seriously, it may make sense to opt for a mix of governing through goals and regulatory measures. There may well be a role for carbon taxes or cap-and-trade procedures. But real progress is likely to require the setting of ambitious goals combined with measures designed to prioritize these goals and to exert effective pressure on actors to pursue them vigorously (Kanie and Biermann 2017). The introduction of the idea of Nationally Determined Contributions (NDCs) in the 2015 Paris Climate Agreement represents a step in this direction. But the initial NDCs are not ambitious enough to do the job. Coming to terms with the grand challenge of climate change will require mobilizing the political will needed to ratchet up the level of ambition reflected in the NDCs substantially and rapidly through what the 2015 agreement describes as a “global stocktake” process.

Two distinct issues relating to the choice of behavioral mechanisms arise in the case of controlling the eruption of pandemics. Addressing needs for preparedness, early warning, testing, and contact tracing is relatively straightforward. Public health specialists are trained to tackle needs of this sort. So long as resources are available and political posturing does not interfere with their efforts, these specialists can be expected to tackle such tasks in a professional manner. The more difficult issue concerns the politics of controlling pandemics. The problem here is an instance of the situation that arises when actors guided by micromotives generate macrobehavior that is undesirable for all. Thus, it is tempting for political leaders to suppress news regarding the outbreak of a disease in order to avoid criticism from outsiders and to blame others for outbreaks within their own jurisdictions rather than cooperating to minimize the spread of the disease. But this sort of self-interested and shortsighted behavior will lead to outcomes that are undesirable for all under a variety of conditions. It is worth noting in this regard that many actors faced with situations of this sort behave in ways that do not conform to the expectations of those who assume all behavior is rooted in rational choice calculations (Kahneman 2011). It may be that what is needed in coming to terms with the grand challenge of pandemics is a concerted effort to promote behavior that is more responsive to the logic of appropriateness than to the logic of consequences.

In the case of misuses of cyberspace, there are at least three separate problems: suppressing antisocial behavior on the part of immoral individuals, controlling illicit activities motivated by a desire for financial gain, and combatting

the actions of governments or their agents designed to promote national interests or the interests of authoritarian leaders. It seems clear that addressing these problems will require distinct behavioral mechanisms. Immoral individuals care little about rules and may develop great ingenuity in avoiding detection or the imposition of ordinary sanctions. Ostracism or expulsion from society may be the only remedy in such cases. Controlling the use of digital technologies to pursue illicit activities, on the other hand, is a matter of adjusting rules to cover new situations and enhancing enforcement procedures. This may call for strengthening the capacity of organizations like the International Criminal Police Organization (Interpol). Perhaps the toughest challenge arises in cases where governments or their agents employ digital measures to interfere in the electoral processes of other countries or to destroy or disable weapons systems of others (Kello 2017). This sort of mischief is rooted in interactions among states motivated by a desire to maximize relative gains and the dynamics of power politics. As cases like the prohibition on the use of poison gas and the campaign against the use of landmines suggest, regulatory measures are not altogether ineffectual in situations of this sort. But achieving success in the development of regulatory measures designed to control digital interference in the domestic affairs of others will not be easy.

The cases of bioterrorism and biowarfare bear some resemblance to the cases of misuses of cyberspace discussed in the preceding paragraph. Dealing with bioterrorism is a matter of developing suitable rules and establishing effective enforcement mechanisms. Prohibiting or at least limiting biowarfare requires the development of regulatory arrangements in a setting that lacks a government in the ordinary sense of the term or, in other words, what is often called governance without government. What is novel in this realm is the challenge of responding to applications of germline editing that could produce profound problems of social justice and raise serious ethical conflicts relating to the legitimacy of some types of intervention in human reproductive processes. It seems doubtful whether public authorities employing conventional regulatory approaches to governance will be able to address this challenge effectively. For one thing, it is difficult to legislate solutions to ethical or moral problems. For another, there is no way to avoid the need for a coordinated international response to a set of developments that are planetary in scope. Research and development in this field is a global enterprise; there is little prospect of controlling the development of technological applications on a state-by-state basis. The best prospect for meeting this grand challenge may lie in the creation of principles or codes of conduct regarding activities like germline editing that are planetary in scope and that are linked to some system of licensing or certification designed to ensure that those who have the skills and access to the resources needed to engage in such activities understand the ethical or moral significance of their actions and are held accountable for the consequences.

6 CRAFTING POLICY INSTRUMENTS

The analysis of behavioral mechanisms is a matter of distinguishing among different sources of behavior that are relevant to societal steering and thinking about which source(s) to focus on in efforts to respond to any given need for governance. But issues of institutional design do not come to an end once a behavioral mechanism has been selected. Policy instruments are techniques or procedures developed to operationalize behavioral mechanisms with regard to specific needs for governance. Consider efforts to control emissions of sulfur dioxide or nitrogen oxides through regulatory measures as a case in point. There are vigorous debates in this context regarding the relative merits of command-and-control regulations, cap-and-trade systems, and taxes as instruments for moving from a general preference for regulation to operational procedures to be used in applying a regulatory approach to the specific circumstances associated with the problem of reducing emissions of the relevant chemicals. Similar questions regarding policy instruments arise with regard to other behavioral mechanisms used in the creation and implementation of institutions to perform the function of societal steering.

An important observation in this context is that it is essential to avoid panaceas in the selection of policy instruments needed to operationalize behavioral mechanisms (Young, Webster et al. 2018). Individual transferable quotas (ITQs), for example, are currently in fashion regarding efforts to manage marine fisheries. While this instrument makes sense in some cases, ITQs run into serious market failures under some conditions and may produce results that are unacceptable from the point of view of compelling concerns regarding equity or social justice. Similar remarks are in order regarding the use of incentive mechanisms to internalize social costs like the dangers of air pollution to human health. In cases where too many permits are issued or it is difficult to monitor whether actual emissions are covered by valid permits, what looks like an efficient way to operationalize regulations on paper may yield little progress toward solving the problem in practice. The point is not to embrace or reject particular policy instruments in general terms. Rather, what is called for is a well-stocked toolkit containing a range of instruments, the development of sophisticated procedures for matching instruments to specific situations, and the flexibility to choose preferred instruments on a case-by-case basis rather than seeking to establish preferences among instruments in general terms.

Most thinking about policy instruments in the case of climate change has focused on crafting procedures designed to provide emitters of greenhouse gases with incentives to reduce their emissions. This has led to elaborate assessments of the relative merits of different types of carbon taxes and cap-and-trade systems (Nordhaus 2008; Stern 2009). Underlying this approach

is the presumption that the problem is to find ways to internalize social costs without altering the basic character of the prevailing system of decentralized markets. But there are legitimate reasons to question whether this approach is capable of making real headway in addressing the challenge of climate change. If what is required is a wholesale restructuring of industrial societies, regulatory measures that aim to shift behavior at the margin may be doomed to failure. This suggests the desirability of considering the merits of alternative behavioral mechanisms, such as the approach known as governing through goals. Interestingly, the 2015 Paris Climate Agreement takes some tentative steps in this direction, coupling a quantified formulation of the overall goal with a procedure for fulfilling the goal often characterized as pledge-and-review. As many observers have noted, the initial Nationally Determined Contributions are woefully inadequate to fulfill the goal of holding temperature increases at the Earth's surface to a maximum of 2°C, let alone 1.5°C, and there are serious doubts about the effectiveness of the agreement's instrument for ratcheting up the pledges incorporated in the NDCs over time vigorously enough to make progress toward meeting the goal. Still, this initiative has the virtue of drawing attention to a distinct perspective on policy instruments and recognizing that individual member countries differ in ways that make it sensible to allow them to devise instruments for fulfilling their pledges in ways that are compatible with their own circumstances. The result is a way of thinking about policy instruments that differs sharply from the approach embedded in conventional regulatory perspectives.

With regard to policy instruments, a prime concern in the case of controlling pandemics is to reduce the temptation to engage in behavior that seems appealing from a shortsighted, self-interested perspective but that makes things worse for all parties concerned over time. Blaming others while refusing to contribute to coordinated efforts to control the spread of a disease constitutes a prominent example. The critical issue here, as those familiar with the analytic model known as prisoner's dilemma will understand right away, is to provide assurance to all members of the group that they will not be exploited by others if they opt for a cooperative strategy. Fortunately, there is some evidence to suggest that many actors are inclined to behave cooperatively, even when they run a risk of being exploited. But it is possible to devise policy instruments that can provide assurance to others regarding an actor's willingness to behave cooperatively. The key point is to demonstrate that commitments to cooperation are credible. Specific procedures for enhancing credibility include staking one's honor on a pledge to cooperate, posting a bond to be forfeited in the event of a failure to cooperate, agreeing to accept public sanctions for uncooperative behavior, and so forth. As usual, the trick is to design procedures for maximizing assurance that take into account the specific features of the case at hand.

Suppressing misuses of cyberspace is complicated by the fact that the relevant behavior is driven by different forces. Whereas antisocial behavior on the part of individuals may arise from a variety of psychological problems, the actions of criminals seeking to maximize financial gains often reflect careful benefit–cost calculations, even though they center on activities that break the law or violate established norms. Misuses of cyberspace on the part of states or government agents, on the other hand, generally involve efforts to achieve influence or exercise power in pursuit of the national interest or the interests of a ruling elite. It seems clear that there are no policy instruments that will prove effective in dealing with the full range of misuses of cyberspace. One thing that is likely to be useful in all these cases, however, is the development of procedures for monitoring, reporting, and verifying that can provide accurate and timely warning regarding the occurrence of various misuses. As the case of determining exactly who is meddling in various ways in electoral processes makes clear, it can be extremely difficult to devise effective procedures of this sort, especially in settings where actors are considered innocent until proven guilty and there is sensitivity about intrusive measures that constitute violations of rights to privacy. It follows that devising procedures for information-gathering that are both effective and normatively acceptable will constitute a cutting-edge concern in this realm during the foreseeable future.

Because private companies and even individuals will be able to engage in applications of biotechnology in such forms as germline editing, governance in this realm is a matter of finding effective ways to guide the actions of those who have access to the relevant technologies. While regulatory measures may be helpful in this regard, it may make more sense in a variety of cases to rely on principled governance, an approach that features the development of ethically based codes of conduct, the use of various forms of licensing or certification, and the creation of accountability mechanisms to verify proper conduct and to impose sanctions on misconduct. The basic idea here is to socialize individuals to ensure that they have a clear sense of right and wrong regarding the relevant activities, to update their understanding in situations featuring rapid change, and to provide sanctions in cases of wrongdoing. As the examples of medical ethics and legal ethics make clear, there is no way to make such arrangements foolproof in the sense that they rule out all forms of corruption. But policy instruments involving systems of professional ethics that are grounded in normative or moral principles, well maintained, and regularly updated may offer the best way forward in dealing with applications of biotechnology. The choice of this approach opens up numerous detailed questions concerning the policy instruments needed to operationalize it in specific settings.

7 PROJECTING FUTURE PATHWAYS

The 21st century's grand challenges have a number of things in common. They are all embedded in complex systems; they are all difficult to cope with using familiar approaches to governance; they all require responses that are planetary in scope; and they all call for urgent and sustained attention. But this does not mean that all four present challenges that are broadly similar in nature. And it most assuredly does not mean that one size will fit all when it comes to devising governance systems to solve or manage the relevant problems. In closing this chapter, I draw on the preceding analysis to highlight what I see as the likely pathway to the future in each case.

The problem of climate change is, at least in principle, solvable. That is, we can envision a world that is not dependent on technologies generating emissions of greenhouse gases as a byproduct of their operation. But making the shift from the existing socioeconomic system to an alternative climate-friendly system will require transformative change rather than a more limited reformation of the existing system (Scheffer 2009). Whether or not the trigger that precipitates transformative change is a matter of conscious choice or involves biophysical forces set in motion by the onset of a climate catastrophe remains to be seen. From the point of view of governance, however, the central question is whether it is possible to achieve a managed transformation in contrast to more chaotic transformation occurring in the absence of effective guidance. It is unlikely that familiar regulatory approaches to governance will prove effective in either case. The entrenched interests resisting fundamental changes in the existing system will not yield to regulatory measures. Changes resulting from the biophysical impacts of climate change are not subject to conventional regulatory guidance. Under the circumstances, alternative approaches to governance, such as governing through goals, may offer more scope for effective governance than a more conventional regulatory approach when policymakers are ready to take climate change seriously.

The problem of infectious diseases that spread broadly and rapidly, by contrast, is not solvable even in principle. There will be eruptions of novel diseases from time to time; some of them are likely to pose severe threats to the lives of large numbers of people. The best we can hope for is the development of a governance system that prioritizes the development and maintenance of effective early warning systems and that emphasizes coordinated responses in contrast to shortsighted and self-interested responses on the part of major players. Providing competent early warning systems is a technical challenge that should not prove excessively difficult to handle. The coordination problem will be more difficult to address, since there will always be incentives to cheat driven by narrow individualistic motives. The governance challenge in this

connection is a matter of emphasizing the benefits of coordination and taking steps to assure individual members of the global community that they do not need to fear being exploited as a consequence of defections on the part of others.

The governance system for various uses of cyberspace (e.g., the internet, the world wide web, social media) emerged and has evolved over time in a largely spontaneous or self-generating manner, giving rise to a remarkable example of the efficacy of governance without government. But it has become increasingly clear that the same technologies that allow for constructive interactions are subject to misuse on the part of a diverse collection of actors. And the destructive potential of these misuses is on the rise. This problem, too, is not solvable in any definitive way. The best we can hope for is the development of a governance system that makes it possible to manage the problem, tracking the activities of those engaged in various misuses as promptly and accurately as possible and providing a measure of protection against the destructive consequences of specific misuses. A variety of regulatory arrangements and licensing procedures may prove useful in differentiating between legitimate and illegitimate uses of cyberspace. Nevertheless, it is clear that this problem will not go away during the foreseeable future. There is no alternative to settling for a set of procedures designed to deter illegitimate uses and to minimize the harmful impacts of such uses when they do occur.

For its part, the case of the biotechnology revolution presents a classic challenge of developing community standards regarding acceptable and unacceptable applications of novel technologies like germline editing and ensuring that those in possession of the relevant knowledge and resources are socialized to behave in ways that are compatible with these standards. This is not a new challenge; it resembles the familiar problem of developing effective codes of conduct applicable to members of the medical and legal professions. What makes the case of biotechnology a grand challenge for the 21st century is that the stakes are extremely high and the relevant code of conduct must be accepted and applied on a planetary basis. We have no relevant models to draw on in developing and applying such a code of conduct on a global scale. The steps we take and the results we achieve will not only be critical for this case; they will also have profound consequences for the future of planetary governance.