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SPECIAL FOCUS: GOVERNANCE OF NANOBIOTECHNOLOGY

An international nanoscience advisory board to improve and harmonize nanotechnology oversight

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Abstract As governments around the world begin to implement regulations aimed at controlling nanotechnology, those regulations should be based upon the best available science, applied as consistently as possible within jurisdictions and, to the extent feasible, across jurisdictions. These goals would be easier to achieve with the creation of an international nanoscience advisory board. Such a body could be modeled on similar international scientific advisory bodies for other issues, such as the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Such a body should also take into account lessons learned from these similar organizations. An international nanoscience advisory board could assist regulatory bodies by providing a central source of accurate scientific information about the risks and benefits of nanotechnology, including relevant uncertainties, rather than having each regulatory body make these determinations independently. An international nanoscience advisory board could facilitate harmonization within and between jurisdictions by involving the top experts in the field to produce a centralized knowledge base for regulatory decisions. While an international nanoscience advisory board presents many potential benefits, it also faces significant difficulties, which are best illustrated by examining the history and challenges of existing international science advisory bodies.

Keywords Nanotechnology · Science advisory boards · Scientific advice · Ethical · Legal · Social issues · Governance

Introduction

Regulators from nations around the world are in the process of developing the first regulations for nanotechnology. At this dawn of the era of nanotechnology regulation, three principles should govern the design and implementation of nanotechnology regulation: (i) regulations should be based on the best available scientific information and knowledge; (ii) regulations should be consistent across regulatory programs and agencies within a jurisdiction; and (iii) regulations should be harmonized to the extent possible between jurisdictions. An international nanoscience advisory board has the potential to promote and advance all three of these goals.

An international nanoscience advisory board could be modeled on the Intergovernmental Panel on Climate Change (IPCC) or other similar international scientific advisory bodies created to provide authoritative assessments of the current scientific understanding, including uncertainties, for a specific technological problem. An assessment "is a process by which

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independent experts review and synthesize available scientific and technical knowledge relevant to [a particular problem or issue] that is needed by policy makers to help make decisions" (IAC 2010, p. 7). Such an assessment process "can establish the importance of an issue, provide an authoritative resolution of policy-relevant scientific questions, demonstrate the benefits of policy options, identify new research directions, and provide technical solutions" (NRC 2007, p. S-1). Any and all of these assessment functions could be performed by an international nanoscience advisory board, and would serve the dual purposes of establishing scientifically rigorous and harmonized regulatory programs for nanotechnology.

An international nanoscience advisory board would consist of leading scientists from around the world convened to issue periodic authoritative reports on what is known (and not known) about the risks of specific nanotechnology materials, applications, and processes. It could provide the best available answers to critical questions such as: (i) are nanomaterials inherently more dangerous than non-nanomaterials?; (ii) which nanomaterials are likely to present the greatest risks?; (iii) can nanoparticles in cosmetics and sunscreens penetrate the skin?; (iv) what are the likely risks of any particular nanomaterial?; (v) what toxicological tests can best evaluate the risks of specific nanomaterials?; (vi) what is the projected nature and timeline for the next generation of nanomaterials?; and (vii) what should be the research priorities for nanomaterial safety assessments?

Answers to these questions, even if preliminary and uncertain in the interim, are critical to effective regulation of nanotechnology. Rather than having every jurisdiction make these determinations independently, an international advisory board could promote efficiency and avoid duplicative efforts by providing a single body that makes decisions. It would also have the potential to make the best possible decisions, as it could involve the top scientists from around the world, who would be more likely to participate and volunteer their time to a single, authoritative, international assessment of nanotechnology science. Finally, having a single international body producing a consensus assessment of the state of nanotechnology science would promote consistency in regulatory decisions within and between jurisdictions.

Harmonization of nanotechnology at the national and international levels would provide many benefits (Abbott et al. 2010; Breggin et al. 2009; Bowman and Hodge 2007; Marchant and Sylvester 2006). Consistent regulatory standards would avoid the trade disputes and disruptions that have occurred for other technologies, such as genetically modified foods. Many companies have international operations and would benefit from a single regulatory standard that is harmonized across global marketplaces. Harmonized standards would avoid a "race to the bottom" or "risk havens" that could result from some nations sacrificing worker or public safety in order to attract nanotechnology industry, jobs, and tax revenues (Marchant et al. 2009; Abbott et al. 2010).

Despite the significant potential benefits of harmonized standards at the transnational level, there are many practical impediments to negotiating formal international agreements or other formal legal instruments to harmonize national regulations (Breggin et al. 2009; Marchant et al. 2009). In the absence of such formal agreements, more modest, informal measures may be most appropriate and feasible for encouraging harmonized national approaches to nanotechnology regulation in the short and medium term (Abbott et al. 2010). An international nanoscience advisory board is one such measure that may be feasible to implement and which could contribute to harmonized national standards (Abbott et al. 2010). If regulators across the globe start from the same scientific foundation and conclusions, they are much more likely to adopt consistent regulations than if each regulatory body adopts regulations based on its own, idiosyncratic scientific assessments (Breggin et al. 2009).

The advantages and disadvantages of such an international scientific advisory board, as well as the design and implementation choices, can best be evaluated by examining the history, achievements, and criticisms of previous international scientific assessment bodies. This article, therefore, reviews the record and lessons to be learned from the experience with the IPCC and other international scientific advisory bodies, and provides some conclusions about the feasibility, desirability, and design choices for an international nanoscience advisory board.

The intergovernmental panel on climate change

The IPCC is an intergovernmental scientific body created by the World Meteorological Organization and United Nations Environment Programme in 1998 to provide international assessments of climate change caused by human activities. The main focus of the IPCC is the scientific aspects of climate change, including projections of future climate change, the causes of climate change, and the impacts of climate change on both human and natural systems. However, the IPCC also publishes reports on more policy-oriented questions, such as methods for slowing or mitigating the human causes of climate change (Grant 2006). The IPCC assessments are intended to be policy-relevant, but not policy prescriptive (IAC 2010), in that they provide information critical for making policy decisions, but do not dictate the outcome of those decisions.

The IPCC structure

Unlike most international organizations, the IPCC is a relatively inexpensive, decentralized institution with a very small permanent staff that operates primarily through the volunteer efforts of government officials and participating scientists (Lawler 2002). The IPCC is composed of multiple components, including a controlling Plenary panel, a Bureau consisting of the IPCC leadership, and three Working Groups. The Plenary panel is composed of representatives from 194 participating governments, who meet once per year to make major decisions regarding the IPCC's structure and the focus of the individual Working Group reports. The Bureau is currently composed of thirty-one individuals and consists of the IPCC Chair, three vice-chairs, and the various chairs and vice-chairs of the three Working Groups. The Bureau provides guidance and overall supervision for the preparation of the assessment reports by the Working Groups.

The three Working Groups share the same structure and differ only with respect to the specific topic area each is tasked with addressing in its reports. Working Group I (WGI) is tasked with assessing the physical science aspects of climate and climate change. Working Group II (WGII) is tasked with assessing the vulnerability of socio-economic and physical systems to climate change, as well as the positive and negative aspects of climate change, along with options for adapting those systems to climate change. Working Group III (WGIII) is tasked with assessing options for mitigating and limiting climate change, primarily through lowering emissions and increasing activities that remove emissions from the atmosphere.

WGI reports historically have created the most controversy, received the most publicity, and would likely be the closest analog to the proposed nanoscience advisory board. WGI reports compile data assessing the risks of planet warming and the specific geographic effects of climate change. In addition, WGI reports have traditionally contained information indicating that climate change is at least partially caused by human effects.

Governments and other participating organizations submit names for consideration as Lead Authors for the respective Work Groups, at the request of the Work Group chairs (IPCC 1999). The IPCC Bureau selects those nominees who it concludes are best qualified to participate as Lead Authors, Contributing Authors, Expert Reviewers, and Review Editors. The selections are based on the general reputation of the nominees, including their scientific and academic credentials, research, and publications.

The Lead Authors prepare the first draft of a report by soliciting materials from experts in the relevant fields. Additional experts who want to contribute to the report can submit materials directly to the Lead Authors. Submitted materials are expected to be supported with extensive peer-review and supporting research. Lead Authors are given explicit guidelines to deal with issues of uncertainty (IPCC 2005). Where the uncertainty is due to differing points of view, and not structural defects in the research, Lead Authors are expected to identify this source of uncertainty and to note how the opinions of experts differ (IPCC 2005). Lead Authors are also expected to "clearly identify disparate views for which there is significant scientific…support, together with the relevant arguments" (IPCC 1999, p. 5).

When the IPCC Bureau selects the Lead Authors, it also selects two Review Editors from the same list of experts. One of these Review Editors is generally a member of the Working Group and often a member of the Bureau itself, while the other is usually an independent expert. These Review Editors are the first reviewers to review and to make extensive comments on the report.

Experts identified by the Working Group and the Bureau, as well as experts identified by the member governments and participating organizations, review the draft report after the two Review Editors have submitted their comments. The recommendations from this second wave of reviews are taken into account, and a second draft report is produced. Governments are then invited to send an "integrated set of comments" on this second draft, and non-governmental reviewers are also encouraged to submit their comments. The Lead Authors and Review Editors then work together to produce a final draft that takes all these collected comments into account. The final draft is subsequently sent on to the Working Group for approval. The Working Group leaders produce a summary section of the report for policymakers. These summary sections are "subject to simultaneous review by both experts and governments" (IPCC 1999, p. 7) before being subject to a line-by-line approval at the full IPCC plenary meeting.

Accomplishments of the IPCC

The IPCC has issued four sets of assessment reports on climate change to date, each of which has had a major impact on government policy and public opinion. The first IPCC assessment report, completed in 1990, spurred the negotiation and subsequent ratification of the 1992 United Nations Framework Convention on Climate Change (UNFCCC). The IPCC's Second Assessment Report in 1995 was "instrumental" in persuading the UNFCCC parties to adopt emission limits for industrialized nations though negotiations that culminated in the 1996 Kyoto Protocol (Lohan 2006a). The third and fourth assessment reports, approved in 2001 and 2007, respectively, have likewise provided authoritative statements on the risks and impacts of climate change, as well as its uncertainties. These statements have played a central role in national and international policy deliberations and actions on climate change.

In 2007, the IPCC was jointly awarded, along with Al Gore Jr., the Nobel Peace Prize "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change." (Norwegian Nobel Committee 2007). The Nobel Committee stated that the IPCC has produced "an ever-broader informed consensus" about the impact that human activity has had on global climate (Norwegian Nobel Committee 2007).

One of the most impressive accomplishments of the IPCC is the apparent "consensus" its reports have engendered in the scientific community, the press, and the public at-large (Schrope 2001; Hulme and Mahoney 2010; Solomon and Manning 2008). While few, if any, scientific theories or findings receive unanimous support, the IPCC reports have been influential in establishing what has generally been regarded as the most influential and broadly accepted international benchmark of what science can (and cannot) tell us about the trends, causes, and likely consequences of global climate change. For example, a 2004 survey of 928 published articles on climate change published between 1993 and 2003 found that over 75 % of articles on climate change agreed with or endorsed the views expressed in the most recent IPCC Assessment Report (Oreskes 2004). In 2001, the US National Academy of Sciences published a report assessing "the current understanding of global climate change," which concluded that the IPCC's findings "accurately reflect the current thinking of the scientific community." (NAS 2001, p. 5). Much of the scientific credibility of the IPCC is attributable to its ability to involve the leading climate change scientists from around the world in its process, and its methodology that seeks to incorporate a range of views and opinions into assessments (IAC 2010).

Critiques of the IPCC

Notwithstanding the impressive accomplishments of the IPCC, the organization has come under increasing criticism in recent years (Schiermeier 2010). The IPCC has been criticized for the slow pace at which it issues reports (Revkin 2009). The Fifth Assessment report is not scheduled to be issued until 2014, more than 7 years after publication of the Fourth Assessment. An enormous amount of new data and findings will become available over this 7 year period, making the Fourth Assessment increasingly outdated. Moreover, the process for producing a new assessment report is so laborious that the report is often outdated by the time that it is published. The production schedule generally requires that the scientific material for the reports be completed more than 2 years prior to the public release of the report (NRC 2007). Suggestions to address this problem include drafting more focused, expeditious reports on specific issues, rather than issuing massive, comprehensive assessments of all evidence and issues, or moving to a Wikipedia-style online system that allows for regular updates and opportunities for comment (Revkin 2009). Conversely, two key participants in past IPCC assessments warn that "[a]ny move toward more rapid products risks incomplete identification of the range of justifiable views and a consequent reduction of the rigor, clarity, and robustness of the consensus" (Solomon and Manning 2008, p. 1457).

The IPCC has also been criticized for the selection of its participating scientists and the literature on which it relies. For example, although each Working Group is led by two co-chairs, one from a developed country and the other from a developing country, the IPCC has been criticized for its authors and reviewers demonstrating a bias in favor of experts from OECD countries, while under-utilizing scientists from non-OECD nations (Miller 2007; Demeritt 2001). In addition, although the IPCC claims to rely primarily on peer-reviewed studies, it has been criticized for using non-peer-reviewed data (so-called "grey literature") (Nature 2010; IAC 2010). Current discussions within the IPCC are seeking to address and clarify these issues.

A third criticism of the IPCC is that it has improperly, or at least imprudently, transgressed into policy matters, rather than adhering to the scientific mission for which it was created (IAC 2010; Broder 2010; Lawler 2002). For example, when announcing the Fourth Assessment Report, IPCC Chairman R.K. Pachauri reportedly stated, "I hope this will shock people and governments into taking more serious action" (Crook 2007, p. 7). These types of policy advocacy statements give rise to concerns and open the door to criticisms that the IPCC is a political or policy body, thereby significantly under-cutting the organization's scientific credibility and appearance of objectivity (Broder 2010). Because it seeks to be "policy relevant" by producing information that will feed into the policy-making process, the IPCC must straddle a delicate line between science and policy, a long-standing tension for such "boundary organizations" (Guston 2001).

A fourth, but related, criticism is that, despite professing to incorporate all legitimate scientific views and data into its assessments, the IPCC structure and process encourages "group think" that favors a more pessimistic view about climate change, while downplaying or ignoring contrary opinions and evidence (Kerr 1997; Schrope 2001). Thus, some critics believe the IPCC has slipped into becoming an "issue advocate," rather than its intended role as an honest broker (Pielke 2007; Sarewitz 2010). According to one IPCC participant, John R. Christy, "It just feels like the IPCC has gone from being a broker of science to a gatekeeper" (Revkin 2009). The recent release of confidential emails from the University of East Anglia disclosing the attempts of prominent IPCC participants to shut out some opposing perspectives lends credence to such criticisms. Moreover, the IPCC has come under fire for alleged errors and biases in its substantive findings, such as an apparent error relating to the longevity of the Himalayan glaciers, which may have been caused or overlooked by this "group think" mentality (Economist 2010; IPCC 2010; IAC 2010; Schiermeier 2010).

These criticisms must be tempered by the realization that the climate change issue is highly polarized, contentious, and politicized, and, thus, any entity offering scientific recommendations or findings in this field is almost certain to come under attack by some stakeholders who disagree with whatever conclusions are reached (IAC 2010). Indeed, some environmentalists criticize the IPCC for being too cautious, claiming the IPCC's findings are being watered down to appease the various governments that must provide line-by-line approval of the report summaries (Kerr 2007; Revkin 2009). Nevertheless, several reviews of the IPCC have concluded that its transgressions or errors are relatively minor or isolated, and that the overall findings of the IPCC remain valid (Netherlands Environmental Assessment Agency 2010; NAS 2001; NRC 2010). Notwithstanding this overall vote of confidence in the IPCC, the credibility of the IPCC has certainly come under attack and has raised questions about whether the IPCC assessment process can be strengthened and improved.

To that end, and in response to the growing concerns about the IPCC, the United Nations and the IPCC itself commissioned a review of the process and procedures of the IPCC by the InterAcademy Council (IAC), an organization of national academies of science from fifteen jurisdictions, including the US, UK, Japan, and China (IAC 2010). In its report issued in August 2010, the IAC concluded that "the IPCC assessment process has been successful overall," but that the IPCC process needed some revisions to adapt to the problems and tensions that have arisen over the years (IAC 2010). Some of the recommended changes were the creation of an Executive Committee that could make interim decisions between full IPCC meetings; a more targeted and effective process for responding to the more than 90,000 review comments received for the most recent reports; greater transparency in how Working Group chairs, authors, and reviewers are selected; strengthening the independence and rigor of the report review process; and implementing a more effective communication strategy. With respect to communications policy, the IAC cautioned, “IPCC leaders have been criticized for making public statements that were perceived as advocating specific climate policies. Straying into advocacy can only hurt IPCC’s credibility” (IAC 2010, p. 5).

Other international assessment examples

International scientific advisory bodies have also been established for assessment of other issues and may provide additional experience and lessons for an international nanoscience advisory board. Two such bodies address the issues of biodiversity and stratospheric ozone depletion.

Biodiversity

There have been attempts for many years to create an international scientific advisory body to address biodiversity, which appear to be coming to fruition in 2010. The Convention on Biological Diversity (CBD), negotiated in 1992 and entered into force in 1993, did not include a formal scientific assessment body. The United Nations Environment Programme (UNEP) repeatedly sought to include an independent scientific assessment of the Earth’s biodiversity into the CBD beginning in 1993 (Larigauderie and Mooney 2010). After initial efforts to create such a body within the CBD failed, UNEP created a stand-alone scientific assessment entity called the Global Biodiversity Assessment (GBA) in 1995. Although hundreds of scientists from around the world participated in the GBA, and it provided the first comprehensive scientific assessment of global biodiversity, it suffered from a number of shortcomings, including the lack of a clear mandate, insufficient funding and political support, and a weak relationship with policymakers in national governments (NRC 2007). Although considered a useful first step, the GBA sparked interest in a more effective international assessment body for biodiversity structured along the lines of the IPCC (NRC 2007).

This effort received a major boost in 2005 when then-President Chirac of France called for the creation of an “intergovernmental panel on biodiversity” (Larigauderie and Mooney 2010). The resulting momentum and activity culminated in the approval for the creation of an Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) by almost 90 countries in June 2010 at a meeting in Busan, South Korea (Marris 2010). The proposed IPBES shares many similarities with the IPCC. Like the IPCC, it will meet regularly, probably for the first time in 2011. It will include delegates from national governments and scientists and will issue regular reports on the global and regional status of biodiversity (Marris 2010). Unlike the IPCC, the IPBES reports will be organized around geographical region. The focus of the reports issued by the IPBES will be “new topics,” rather than established areas of contention or uncertainty in biodiversity, based on the determination by members of the Busan meeting that emerging issues require the most immediate attention. The IPBES will focus on providing stakeholders, primarily governments and policymakers, with useful and independent information that can be acted on for such emerging issues (Jowit 2010).

Like the IPCC, the IPBES is not intended to make policy recommendations. Many of those involved in the creation of the IPBES were worried that it will become the target of political attacks and have vowed it “will not be policy prescriptive” (Marris 2010). While the IPBES will strive to remain policy neutral, it will identify research and useful tools for policy decisions that require the attention of policymakers and other stakeholders. In addition to producing regular reports, the IPBES will accept requests for information from its voting national government members. In addition, unlike the IPCC, the IPBES will help to train environmental scientists in the developing world.

Stratospheric ozone depletion

International scientific assessments also played a key role in the negotiation and successful implementation of the 1987 Montreal Protocol to protect the stratospheric ozone layer by phasing out chlorofluorocarbons and taking other actions. A series of national scientific assessments had created an inconsistent picture of the stratospheric ozone depletion problem prior to the Montreal Protocol, but a series of international assessments before and after negotiation of the Protocol helped to clarify and harmonize the scientific understanding of the problem and cleared the way toward an international agreement for action (Kerr 1997). In particular, a 1985 international assessment by hundreds of scientists from many countries coordinated by a network of international agencies provided the scientific basis for negotiating the Montreal Protocol, which implemented an aggressive program for phasing out ozone-depleting substances (NRC 2007). As a subsequent review by the National Research Council summarized, the contribution of the 1985 assessment was “its scale and prominence, as well as its technical authority, comprehensiveness, and detail, which brought coherence to the public debates over stratospheric ozone science that had never been attained before” (NRC 2007, p. 4–4). In recognition of the important role that the 1985 assessment played, the Protocol maintained an assessment function by establishing a system of expert advisory panels that periodically evaluated the scientific nature and condition of the ozone layer, the rate and impacts of ozone loss, and the technological and economic aspects of potential alternatives to ozone-depleting chemicals (NRC 2007). These assessments have been continued every 4 years and are made available to the Protocol’s signatories in advance of periodic meetings to review and update the Protocol (NRC 2007).

A number of factors are responsible for the success of the ozone assessment process. One factor that has been identified is its well-defined mandate and consistent support from the requesters (NRC 2007). In addition, the relatively narrow subject matter of the Protocol and the accompanying scientific assessment limited involvement to a relatively small number of stakeholders, greatly simplifying the process of stakeholder participation and supporting credibility and legitimacy among affected interests (NRC 2007). The ozone scientific assessment panels also had “extreme autonomy,” which helped to demarcate the scientific assessment from the policy process, building credibility as to the independence and objectivity of the scientific review (NRC 2007). One criticism of the ozone assessment process is that the panels still provide comprehensive reviews of the entire body of relevant scientific evidence, rather than more limited and expeditious updates of this relatively mature subject matter (NRC 2007).

Implementing a nanoscience advisory body

The experiences the IPCC and other international scientific advisory bodies have generally been positive, albeit with some concerns and lessons for other attempts to create a similar body for technologies such as nanotechnology. On a positive note, the IPCC has done much to achieve a scientific consensus on the very controversial issue of climate change, or at least to define a range of credible positions. Indeed, the success of the IPCC has directly contributed to calls for establishing similar bodies for other problems (Schrope 2001; Tonn 2007). As the National Research Council concluded, “If policy debate on an issue is characterized by conflict or deadlock because conflicting claims are being made about … key scientific questions, an assessment can inform and advance the policy debate by authoritatively resolving these questions” (NRC 2007, p. 2–2). Thus, the record of such international assessments to date supports considering the establishment of an international assessment process or institution for nanotechnology, especially given the international relevance of nanotechnology, the need for harmonized nanotechnology policy, and the uncertainties and divergent scientific views that exist today about nanotechnology risks.

The success of the IPCC is due in large part to its ability to attract the participation of a critical mass of the world’s top scientists in the relevant fields to participate in the assessment process (NRC 2007, p. 3–2). One of the concerns that have been expressed about the IPCC and similar international assessments is the heavy workload it imposes upon scientists and the significant opportunity costs for individual scientists and the field as a whole resulting from scientists spending large amounts of their time on international assessments rather than on their own research (NRC 2007). Nevertheless, it is likely that an international nanoscience advisory board, if created under appropriate auspices and procedures, would attract the participation of leading experts on nanoscience to provide an international authoritative scientific review. Many such experts are called upon to participate in scientific advisory roles for national government agencies, professional societies, industry groups, and other bodies, and would likely welcome centralizing and consolidating scientific assessments into one primary international body.

While the success of the IPCC and other international assessments lends credence to the concept of establishing an international nanoscience advisory board, these prior experiences also provide important lessons on pitfalls that should be avoided and structural and process-related improvements that should be considered. A key lesson from the IPCC experience is that the international nanoscience advisory body must be separate and insulated from policy and politics as much as possible. Scientific assessments often lead to strong indications of appropriate policy responses, so it is an understandable temptation for experts involved in a scientific assessment to extrapolate their findings to policy prescriptions. Delving into policy, whether done by the body itself or by key individuals holding leadership positions in the body, risks exposing the scientific assessment to criticisms of political bias that can undermine the credibility of the body and its assessments. The policy recommendations should thus be left to those outside the scientific assessment entity, who can utilize and apply the scientific findings in the assessment to guide their decisions. Past attempts at separating technical advice from policy and political opinion have proven successful in other contexts, such as the US Commission on Base Closure and Realignment (Kowen 1992) and the European Food Safety Authority (MacBeth and Marchant 2008). An international nanoscience advisory board should, therefore, be strictly limited to providing the scientific information.

Another lesson from the IPCC is that full assessments of an entire field may be too burdensome and time-consuming to issue on a regular basis. Rather, focused, expeditious reports on narrower issues may be more timely and useful (Revkin 2009). Another important lesson is that transparency is a critical factor for the institutional success of such an international science advisory body (Lohan 2006b). A related lesson is the importance of protecting against "group think" that favors one view of the problem and excludes or downplays contrary evidence or views. Promoting participation and openness in the process, including in the selection of leaders, lead authors, and reviewers, can help mitigate the risk of group think. Some other valuable lessons from the IPCC and other previous assessments include the importance of including scientists from developing countries and developing clear criteria for whether non-peer-reviewed literature may be considered and, if so, under what circumstances and for what purposes.

The National Research Council (2007) recently completed an analysis of lessons learned from global scientific assessments, which identified other key factors for the success of international assessments. The Council's findings are consistent with the lessons identified above. Three key aspects of a scientific assessment identified by the NRC are the credibility of the assessment (i.e., perception by experts), the legitimacy of the assessment (i.e., perception by stakeholders), and the salience of the assessment (i.e., relevance and timeliness for policy decisions) (NRC 2007, pp. 1-9–1-11). Additional features of a successful assessment also relevant for an international nanoscience advisory body include: (i) clear strategic framing of the assessment process, including well-articulated mandate; (ii) adequate funding; (iii) engagement and commitment of interested and affected parties, with a transparent science-policy interface; (iv) realistic and credible treatment of uncertainties; and (v) an independent review process (NRC 2007, p. S-4). These recommendations should be considered in the design of an international nanoscience advisory body.

Conclusion

The experience of other international scientific advisory bodies suggests that an international nanoscience advisory board could serve a useful and important role for providing consensus scientific opinions on scientific issues relating to nanotechnology. These opinions could include much-needed authoritative assessments of hazard and risk information on specific nanomaterials or nanoapplications, opinions on toxicological methods and assay development, timelines and benefit assessments of future nanotechnology applications, and research funding priorities (Service 2006). International, uniform, and respected scientific opinions on such matters could not only support regulatory and policy development, but could also help to harmonize oversight at the international level by providing a consistent scientific foundation to support regulation.

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References

Abbott KW, Sylvester DJ, Marchant GE (2010) Transnational regulation: reality or romanticism? In: Hodge G, Bowman D, Maynard A (eds) International handbook on regulating nanotechnologies. Edward Elgar, Cheltenham

Bowman DM, Hodge GA (2007) A small matter of regulation: an international review of nanotechnology regulation. Columbia Sci Tech Law Rev 8:1–32

Breggin L, Falkner R, Jaspers N, Penderrass J, Porter R (2009) Securing the promise of nanotechnologies: towards transatlantic regulatory cooperation. Environmental Law Institute, Washington. http://www.chathamhouse.org.uk/files/14692_r0909_nanotechnologies.pdf. Accessed 21 Nov 2010

Broder JM (2010) Scientists take steps to defend climate work. NY Times, 3 March, pp. A1, 11

Crook C (2007) The steamrollers of climate science. Financial Times, 2 Aug, p. 7

Demeritt D (2001) The construction of global warming and the politics of science. Ann Assoc Am Geo 91:307–337

Economist (2010) Science behind closed doors. Economist 10 July:76–77

Grant J (2006) A guide to the intergovernmental panel on climate change, 4th edn. International Petroleum Industry Environmental Conservation Association, London. http://www.ipieca.org/?q=system/files/event-materials/cc.pdf. Accessed 21 Nov 2010

Guston D (2001) Boundary organizations in environmental policy and science: an introduction. Sci Technol Human Values 26:399–408

Hulme M, Mahoney M (2010) Climate change: what do we know about the IPCC? Prog Phys Geog 34:705–718

Inter Academy Council (IAC) (2010) Climate change assessments: review of the processes and procedures of the IPCC. IAC, Amsterdam. http://reviewipcc.interacademycouncil.net/. Accessed 21 Nov 2010

Intergovernmental Panel on Climate Change (IPCC) (1999) Procedure for the preparation, review, acceptance, adoption, approval, and publication of IPCC reports. IPCC, Geneva

Intergovernmental Panel on Climate Change (IPCC) (2005) Guidance notes for lead authors of the fourth assessment report on addressing uncertainties. IPCC, Geneva

Intergovernmental Panel on Climate Change (IPCC) (2010) IPCC statement on the melting of Himalayan glaciers. IPCC, Geneva

Jowit J (2010) UN's 'IPCC for nature' to fight back against destruction of natural world. The Guardian. http://www.guardian.co.uk/environment/2010/jun/11/un-ipcc-for-nature-biodiversity. Accessed 21 Nov 2010

Kerr RA (1997) The right climate for assessment. Science 277:1916–1918

Kerr RA (2007) Pushing the scary side of global warming. Science 316:1412–1414

Kowen SG (1992) Base closings and the politics-administration dichotomy revisited. Pub Admin Rev 52:526–531

Larigauderie A, Mooney HA (2010) The Intergovernmental science-policy platform on biodiversity and ecosystem services: moving a step closer to an IPCC-like mechanism for biodiversity. Environ Sustain 2:9–14

Lawler A (2002) Battle over IPCC chair renews debate on US climate policy. Science 296:232–233

Lohan D (2006a) Assessing the mechanisms for the input of scientific information into the UNFCCC. Colorado J Int Environ Law Policy 17:249–308

Lohan D (2006b) A framework for assessing the input of scientific information into global decisionmaking. Colorado J of Int Environ Law Policy 17:1–44

MacBeth A, Marchant GE (2008) Improving the government's environmental science. New York University Environ Law J 17:134–169

Marchant GE, Sylvester DJ (2006) Transnational models for regulation of nanotechnology. J Law Med Ethics 34:714–725

Marchant GE, Sylvester DJ, Abbott KW, Danforth TL (2009) International harmonization of regulation of nanomedicine. Stud Ethics Law Technol 3: Article 6

Marris E (2010) UN body will assess ecosystems and biodiversity. Nature 465:859

Miller CA (2007) Democratization, international knowledge institutions, and global governance. Governance 20: 325–357

National Academy of Science (NAS) (2001) Climate change science: an analysis of some key questions. National Academy Press, Washington

National Research Council (NRC) (2007) Analysis of global change assessments: lessons learned. National Academy Press, Washington

National Research Council (NRC) (2010) Advancing the science of climate change. National Academy Press, Washington

Nature (2010) Editorial: validation required. Nature 463:849

Netherlands Environmental Assessment Agency (2010) (2010) Assessing an IPCC assessment: an analysis of statements on projected regional impacts in the 2007 report. Netherlands Environmental Assessment Agency, The Hague

Norwegian Nobel Committee (2007) The nobel peace prize for 2007. Nobelprize.org. http://nobelprize.org/nobel_prizes/peace/laureates/2007/press.html. Accessed 21 Nov 2010

Oreskes N (2004) The scientific consensus on climate change. Science 306:1686

Pielke R Jr (2007) The honest broker: making sense of science in policy and practice. Cambridge University Press, Cambridge

Revkin AC (2009) Nobel halo fades fast for climate change panel. New York Times, 4 Aug, p. D1

Sarewitz D (2010) Curing climate backlash. Nature 464:28
Schiermeier Q (2010) IPCC flooded by criticism. Nature 463:596–597
Schrope M (2001) Consensus science, or consensus politics? Nature 412:112–114
Service RF (2006) Priorities needed for nano-risk research and development. Science 314:45
Solomon S, Manning M (2008) The IPCC must maintain its rigor. Science 319:1457
Tonn B (2007) The Intergovernmental panel on climate change: a global scale transformative initiative. Futures 39:614–618