

Implementing the **MIT Global Environment Initiative**

Executive Summary
to the Report of the
**MIT Environmental
Research Council**
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Massachusetts Institute
of Technology



The MIT Global Environment Initiative

Humans play an increasingly prominent role in shaping Earth's environment, with profound implications for our welfare and that of future generations. Acting to sustain the environmental systems on which we depend requires understanding how the biosphere works, just as knowledge of human physiology and genetics enables the practice of modern medicine.

This is the challenge to which the MIT Global Environment Initiative rises—integrating the Institute's core strengths in scientific, engineering and social research to better understand the global environment and manage our role in it through technological and social innovation.

Cover Design:

The co-evolution of life and Earth

A figurative sunrise brings another day of light and life to our world. The corona around the sun is the genome map of the marine bacterium *Prochlorococcus*—the most abundant photosynthetic cell on Earth. Meanwhile, pre-dawn Europe lies sharply defined by its dense web of urban illumination—a striking manifestation of the extent of human influence on the planet.

[Earth images courtesy of NASA; genome image courtesy of the Professor S. W. Chisholm Lab at MIT; Artist rendition by Tim Blackburn Design, Inc.]

Report of the Environmental Research Council: Executive Summary

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MIT Environmental Research Council

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This Executive Summary is a synopsis of the *Report of the Environmental Research Council: Implementing the Global Environment Initiative at MIT*. Refer to the full report for more detail.

MIT Global Environment Initiative

More than a century of economic expansion since the start of the Industrial Revolution has produced unprecedented improvements in human welfare, along with unprecedented stress on the global environment. As advanced nations consume evermore resources, while developing countries struggle to meet the needs of growing populations, the natural systems that sustain us are increasingly strained. It is clear that human societies must transform themselves if we are to flourish in the centuries to come.

Grounded in the conviction that scientific knowledge must inform how we choose to live on Earth, the MIT Global Environment Initiative (GEI) will invigorate the Institute's vital role as a source of that knowledge, and of the engineering innovations and social strategies for implementing it. The overarching question driving GEI is: ***How can we enable sustainable human development?*** Finding answers and putting them to work is the mission of GEI, which will pursue a broadly integrated agenda of basic and applied research to inform real solutions for the real world.

To begin, the Environmental Research Council (ERC) has focused on six of humanity's most pressing environmental challenges.

- *Global Climate Change*—Greenhouse gas emissions affect Earth's chemistry, climate, weather patterns and ocean circulation in ways we are only beginning to understand. Global climate change threatens major disruptions to terrestrial and aquatic ecosystems, as well as human societies. What are the plausible trajectories of the global climate system, and what are the risks and uncertainties associated with each path? How can we better communicate those risks? And how can human societies both mitigate and adapt to the impacts of climate change?
- *Health of the Oceans*—Overfishing, coastal runoff, habitat disruption, and acidification due to increasing concentrations of atmospheric carbon dioxide have markedly changed the world's oceans. Although oceans play a significant role in the climate system and provide vital ecological services, they are poorly understood and ineffectively governed. How have human activities affected the coastal zones and open ocean? How can we reduce our impact on the oceans through better management of coastal development, fishing, and other human activities?
- *Fresh Water Supply*—We are rapidly depleting and degrading our vital fresh water supplies due to unsustainable practices—inefficient irrigation, water-intensive lifestyles and landscaping, groundwater use exceeding replenishment, contamination—and the simple reality of population growth. Already, some one billion people lack reliable access to water, while two billion have inadequate sanitation. How does water circulate through the Earth system, and how are these cycles impacted by climate change? How can we better design households, landscapes, patterns of development and use, agricultural practices and industrial processes to conserve water? What clean water technologies can be developed and implemented effectively?
- *Resilience of Ecosystems*—Ecosystems around the world are under pressure from harvesting, fragmentation, and changes in the water and biogeochemical cycles that sustain them. Many have already experienced major changes, and their future is uncertain. What attributes of ecosystems are most critical to their stability? How does

biological diversity enhance ecological resilience in the face of natural and human-caused disturbances? How can we properly value ecosystem services so that they remain available to future generations?

- *Environmental Contamination*—Synthetic chemical compounds are becoming ubiquitous in the environment and are accumulating rapidly. Contamination threatens to have both acute and chronic effects on human health and the environment, but those impacts remain poorly understood. What are the chronic and acute effects of exposure to different kinds of contaminants? How can we design chemicals, pharmaceuticals, materials, genetically-modified organisms, and production processes that are benign-by-design? And how can we mitigate the damage from harmful products already in circulation?
- *Sustainability of Societies*—With global population and per capita consumption rising, the strain on Earth's natural systems can only increase. Meanwhile the world is urbanizing, presenting both challenges and opportunities for societies to become more sustainable. How can developing countries urbanize without exacerbating local and global environmental problems? Can restructuring of industries and markets, adjustments to supply chains, and the adoption of new production practices lead to improved corporate financial and environmental performance? Can we use the design features and assembly rules of natural ecosystems to guide us toward sustainable designs for human societies?

Although these environmental challenges are enormous, so are our growing scientific, technological and social capacities to confront them. These new capabilities promise to transform environmental science and management in much the same way that the science and practice of medicine have been revolutionized by molecular biology and advanced imaging technologies. We now have an unprecedented opportunity to radically improve our understanding of how Earth's biosphere works, how human activities alter natural systems, how social, economic and political forces govern these impacts, and how we prepare our students to pursue a sustainable future for humanity.

Initial Research Agenda

We recognize that the challenges of global climate change, health of the oceans, fresh water supply, resilience of ecosystems, sustainability of societies and environmental contamination are both complex and interrelated. For example: climate change influences and is influenced by oceanic processes; climate change also affects ecosystems and the global water cycle; and as cities strive to reduce their carbon footprint, improve their air quality and prepare for sea-level rise, a radical rethinking of urban design is underway. Similarly, contamination reduces available clean water supplies, damages ecosystems, and affects the habitability of vast swaths of urban land.

Addressing these urgent and fundamentally related challenges will require deep scientific understanding of the interactions that comprise the global environment, creativity in devising behavioral and technological solutions, and a clear-eyed sense of the economic and political obstacles to adopting and implementing those solutions. With its interdisciplinary, problem-solving culture, MIT is well-positioned to undertake an initiative that demands such an integrated approach.

The Global Environment Initiative will adopt an inclusive approach that welcomes the participation of all interested faculty, research staff and students. Already, through an extensive process of Institute-wide inquiry and engagement, the ERC has begun to organize six areas of research momentum with which to launch the Initiative—*Climate, Oceans, Water, Ecological Resilience, Sustainable Societies and Contamination Mitigation*. These interrelated research themes define an action agenda for GEI representing the convergence of MIT's strengths and potential with the suite of pressing global environmental challenges identified above.

- *Climate*—Scientists, engineers, and social scientists from across MIT are currently engaged in four climate-related programs: the Center for Global Change Science, the Joint Program on the Science and Policy of Climate Change, the Climate Modeling Initiative and the Lorenz Center. Taken together, they constitute a comprehensive foundation for understanding the climate system, its responses to human activity, and the policies for mitigation and adaptation. An emerging priority within this theme is to reduce the uncertainties of predicting climate variability and change in response to both natural cycles and human activity.
- *Oceans*—In partnership with the Woods Hole Oceanographic Institute (WHOI), MIT has unparalleled capabilities in ocean observation and modeling, microbial oceanography, and the analysis of marine ecosystem dynamics. Researchers from MIT and WHOI are also investigating the impacts on coastal and marine ecosystems of urban development, fishery management and other human activities. Priorities within this theme include understanding the role of oceans in climate and in global biogeochemical cycles, and detecting the impacts of global climate change, particularly sea-level rise and ocean acidification.
- *Water*—Researchers at MIT aim to comprehend the impact of climate on regional water supplies, assess the consequences of chemical accumulation in fresh water systems, and lead in the development of clean water technologies. Designers at MIT are working to create landscapes that conserve water and restore regional aquatic ecosystems. Policy scholars are analyzing human impacts on regional water systems, and devising governance processes and policy mechanisms to mitigate and avert water shortages around the globe. Priorities within this theme include observing and understanding the role of water in the global environment, developing technologies and policies to ensure safe water supplies, and innovating in water-conserving landscape and urban design.
- *Ecological Resilience*—Through an alliance between the physical and life sciences and engineering, MIT researchers are forging the new discipline of Modern Ecology, which focuses on the fundamental building blocks of ecological systems. One aim of modern ecology is to model the dynamics of ecosystems and understand the sources of their resilience. Another is to draw on advanced technologies and theoretical developments in order to decode “ecosystem genomes.” Other research priorities include proper valuation of ecosystem services, and investigating the effectiveness of different strategies to conserve biodiversity in both developed and natural landscapes.
- *Contamination Mitigation*—Research on contamination mitigation is embedded in diverse research labs scattered across the schools of Science and Engineering. Social scientists at MIT are also investigating the true costs of environmental contamination, as well as the effectiveness of policies aimed to discourage the use of harmful substances

and processes. Significant potential for innovation in the science, engineering and practice of contamination remediation remains to be tapped, while an emerging area of priority research within this theme lies in developing ‘benign-by-design’ chemical, material, process and biological engineering practices to reduce the need for future remediation.

- *Sustainable Societies*—Scholars from across MIT are working to enhance our understanding of how societies can become more sustainable. The School of Architecture and Planning boasts an international reputation for the design and governance of resilient cities. Researchers at the Sloan School of Management pursue pioneering work on environmentally sustainable business practices. Integrating these resources with those of the schools of Engineering, Science, and Humanities, Arts and Social Sciences, priorities within this theme include addressing the technical, managerial, economic, business, policy and cultural challenges of simultaneously optimizing human welfare and environmental sustainability.

Despite differing levels of existing faculty participation and organization at present, these six synergistic research themes represent a strong and coherent starting point for GEI. How they and the Initiative evolve will depend largely on the interests, commitment and energy of faculty. As the enterprise matures, some themes and research priorities may be consolidated, while new ones are added in response to emerging environmental challenges, opportunities for engagement and faculty support. In any case, a primary function of GEI will be to facilitate communication, coordination, collaboration and innovation within and among its major environmental research themes.

Research for Solutions

The ambitious research agenda presented above is motivated by and seeks to inform a wide array of pressing global environmental issues. Following the example of modern medicine, we advocate a revolution in environmental practice that is fueled by knowledge born of fundamental research, aimed at areas of critical need, and realized through engineering and social innovation. In other words, with environment as with human health, basic and applied research must merge to create the knowledge and capabilities that solve problems.

This “research for solutions” orientation is already well established at MIT across a broad range of scientific, engineering and social research relevant to the environment. Important new areas of integrated, impact-oriented research embraced by GEI include:

- Developing carbon mitigation technologies and assessing the potential of geoengineering schemes to produce desired results versus unintended consequences.
- Creating and deploying new sensing technologies to drive our understanding of Earth’s oceans and how best to manage our use of and impact on them.
- Solving the riddle of affordable, equitable and sustainable global access to clean water through technological, economic and social innovation.
- Revealing the genetic and biogeochemical foundations of ecosystem function and resilience, and enabling strategies to restore and maintain the services they provide.

- Developing the technologies, practices and commitment to realize the environmental lifecycle benefits of benign-by-design materials and manufacturing.
- Exploring the sources, metrics and the very meaning of human welfare. How can it be optimized for societies and individuals across the world in a sustainable way?

Educational and Campus Engagement

The research agenda of GEI encompasses an inherent and substantial educational footprint, both in terms of curricular and experiential training for students. Simply put, incorporating an understanding of the linkages between environmental quality and human welfare must become an essential part of MIT's basic educational message delivered in the classroom, the lab and the field. Therefore GEI will develop new educational programs to parallel and complement its research agenda, building on the solid foundation provided by many existing programs at MIT. In addition, GEI will support the ongoing effort to develop a new undergraduate Minor in Environment and Sustainability. A GEI Education Task Force will be created to help guide these efforts to ensure the direct impact of its research agenda on the training of future leaders in environmental science, engineering and planning.

But full campus involvement for GEI will entail much more than its footprint in formal educational programs. A truly transformative community at MIT focused on environment and sustainability must embrace and exploit all the enthusiasm, initiative and creative energy on campus—particularly from students, our greatest resource. Embracing and partnering with existing campus organizations (e.g. the student group Sustainability@MIT and the Office of Environment, Health and Safety) and programs (e.g. the Green Ambassadors Initiative and the Campus Energy “Walk the Talk” Task Force) will be a major emphasis for GEI as it evolves.

Organization and Administration

GEI will coordinate MIT's environmental research and education activities in much the same way the MIT Energy Initiative (MITEI) serves as the focal point for the Institute's energy activities. Indeed as many human-caused environmental impacts result from energy production and use, GEI will make close collaboration with MITEI a cornerstone of its operation.

Thus GEI will develop MIT's portfolio of environmental research, cooperate with other MIT programs, cultivate new research efforts, and work to recruit new sponsors and donors in collaboration with the MIT Office of Resource Development. The Initiative will allocate ignition grants, sponsor environmental fellows (graduate students, post-docs and visiting faculty) and manage internal and external communications. Hosting workshops and symposia that engage faculty and research staff from across disciplines will be another priority for GEI. With these GEI will foster the development of new research themes, explore synergies between themes and build a truly multidisciplinary community of environmental research at MIT.

Although distinct in their mix of research priorities and participating faculty, as described in the full report, GEI's research themes are inherently complementary and their activities will be fully coordinated through the Initiative. While the level of activity within the themes does vary with their degree of current development—some involving well established programs and others being relatively nascent—any healthy research enterprise needs a mixture both to thrive over the long term. As is always the case at MIT, the vitality of any given research theme will depend

ultimately on the energy, interest and participation of faculty, sponsors and donors. The Global Environment Initiative will be no exception.

The senior administration of GEI will consist of a director and deputy director appointed from the faculty by the Provost, and an executive director hired by them. As GEI grows, additional staff will be added as needed, including: a financial/administrative officer to manage daily operations and accounting, a communications specialist to provide writing and web support, and one or more administrative assistants as warranted. An Environmental Council, consisting of faculty representatives from all five schools at MIT, will advise GEI's senior administration and participate as appropriate on education, outreach and development projects. Additional strategic guidance will be provided by an External Environmental Board to be recruited by the President and Provost in coordination with the Environmental Council.

Implementation and Resourcing

Implementation of GEI will be gradual, with financial resources increasing as the initiative demonstrates its value over time. The six inaugural research themes will develop at different rates according to the interests and efforts of the affiliated faculty. Since the themes are designed around ongoing research, no new funding is required to launch GEI's research agenda—the work is already ongoing.

The central office of GEI will require modest startup support—salaries, space, services, equipment, and materials—some of which will be inherited from the Earth System Initiative. To achieve its full potential, GEI must attract new resources. Therefore the executive and senior faculty directors will focus on securing external funding to support targeted graduate and post-doctoral research fellowship programs, an ignition grant program to jump-start new research, a communications and outreach program to deliver that research, and visiting, professor-of-practice and tenure-track faculty development programs.

Securing support for the research fellowships and ignition-grant programs will be the top priority, as these are essential to GEI's development. Additional programs will be phased in as funding becomes available. The addition of new research themes and activities will be driven by faculty commitment and encouraged through fellowship and ignition-grant support.