NIEHS Strategic Plan 2018–2023: Advancing Environmental Health Science, Improving Health

Director's Message

During the past five years, our work at the National Institute of Environmental Health Sciences (NIEHS) has been guided by our 2012–2017 Strategic Plan, "Advancing Science, Improving Health: A Plan for Environmental Health Research." In constructing that plan, we engaged in a process that was broadly inclusive in order to gain the input and expertise of the environmental health science (EHS) community and NIEHS's many other stakeholders. The result was a plan that has led not only NIEHS, but the entire field of EHS, to new achievements in knowledge, technologies, approaches, and interventions to address environmental health challenges. But as some challenges continue—and new ones arise—so must our work.

As we began to map our strategies for the next five years, we again turned to our stakeholder communities and asked for their input through a *Trends & Insights Survey,* conducted online in the summer of 2017. The responses to this survey were both wide-ranging and specific. A particular theme that was broadly expressed was the continuing need for many of the priorities articulated in the 2012-2017 Strategic Plan. For example, study of the exposome, which was still in its infancy as a concept in 2012, is now a thriving area of research that is helping to elucidate the impact of the totality of our exposures from the individual to the population level. Similarly, our understanding of the role of epigenetic processes as mediators of environmental effects has advanced greatly, as has predictive toxicology. The evolution and integration of data science remains crucial to the study of environmental health. So, in considering where we want to lead NIEHS and the field of EHS in the future, we took these goals as our starting point. Our challenge was this: to set NIEHS research priorities within a rapidly evolving scientific landscape while ensuring that our science continues to be responsive to meeting the environmental public health needs of people in the United States and around the world.

This new Strategic Plan, therefore, might be considered a "2.0 version" of the previous plan; one that incorporates many of its priorities and commitments with the objective of building on progress made, but that allows for and enables innovation and growth in our ability to explore new and ever-more complex problems. Like its predecessor, this plan supports the NIEHS Mission to discover how the environment affects people in order to promote healthier lives, as well as our continuing Vision to provide global leadership for innovative research that improves public health by preventing disease and disability. It should also be noted that this Strategic Plan continues to align with the broader goals of the NIH Strategic Plan, and provides support to trans-NIH and federal interagency priorities and initiatives such as the All of Us precision medicine initiative,

The Public Health Service Act of 1966 set forth the foundational statutory responsibility of the Institute to improve public health through research, training, and dissemination of health information. Per its mission statement, NIEHS strives to conduct and support the very best environmental health science in alignment with real-world public health needs, and to translate science findings into knowledge that can inform real-life individual and public health outcomes. Success in our mission requires the highest standards of stewardship and a solid foundation of supportive strategies, resources, and training. The 2018–2022 NIEHS Strategic Plan comprises these three highly interdependent, interactive, and inclusive Themes:

- **Advancing Environmental Health Sciences**
- **Promoting Translation -- Data to Knowledge to Action**
- **Enhancing Scientific Stewardship and Support**

Each of these Themes is achieved through focused efforts toward a number of Goals. The sections that follow describe in more detail our Themes and the supporting goals identified for each of them.

Theme I: Advancing Environmental Health Sciences

Environmental Health Sciences (EHS) encompasses the study of all levels of biological organization: molecular, biochemical pathway, cellular, tissue, organ, system, model organism, individual, and population; at all stages across the lifespan from preconception through old age. EHS uses a rich, diverse, and constantly evolving set of observational, experimental, computational, and clinical approaches to explore the impacts of varying levels of exposure and varying levels of susceptibility to such exposure. The support of novel, cutting-edge research approaches—"high risk for high reward"—is an important element of the Advancing EHS Theme.

Research in EHS is aimed at discovering and explaining how factors including chemical, physical, synthetic, and infectious agents, social stressors, diet and medications, and our own microbiomes, among others, affect biological systems. The knowledge generated by EHS, inclusive of interactions between humans, animals, and our natural and built environments, provides a critical component of our understanding of human health and disease.

Major health effect areas of interest and outcomes that are known or suspected to be environmentally related include—but are not limited to—developmental and behavioral impacts (*e.g.*, reproductive disorders, autism); non-communicable diseases (*e.g.*, cancers, asthma, cardiovascular diseases, diabetes, metabolic disorders); neurodegenerative diseases (*e.g.*, Parkinson's, Alzheimer's); and inflammation effects (*e.g.*, autoimmune disorders, myositis).

Advancing Environmental Health Sciences goals include:

1) ***Basic Biological Research:*** Research on the effects of the environment on biological systems and processes is central to EHS. It is important to understand the pathways

within our cells and bodies that are the targets of environmental action. Because evidence is increasing that early environmental exposures can impact the risk of disease later in life long after such exposures have occurred, research on developmental processes will continue to be a priority.

2) ***Individual Susceptibility:*** Individual people can and do respond in different biological ways to the same environmental exposure. EHS includes the study of differential individual susceptibility arising not only from the lifestage, duration, and degree of exposure, but also from genetic (alterations in the DNA sequence) and epigenetic (potentially heritable changes in gene expression that do not involve changes to the DNA sequence) mechanisms. Underlying health status and sex differences in response to exposures are also important factors in susceptibility. The combination of susceptibility knowledge with environmental exposure data, known as gene by environment studies, provides a more complete picture of a person's risk of effects on health.
3) ***The Microbiome:*** The collection of microbes (bacteria, viruses, fungi) living on and inside of our bodies, including in the gut, skin, and other organs, is known as the microbiome. Because the microbiome is a key intersection between the body and the environment, these microbes impact health in myriad ways and even affect how we are exposed and respond to certain environmental chemicals. NIEHS will expand its focus on the role of the microbiome as both a target and a mediator of environmental exposures.
4) ***The Exposome:*** The exposome is the totality of environmental exposures experienced over an individual's lifespan. Efforts will continue to advance exposure science and integrate study of the exposome into EHS, including through development of new technologies to characterize exposures. Exposome assessment approaches will require integrating data across various "omics" (proteomics, metabolomics, and others), and are supported by the Data Science and Big Data goal.
5) ***Co-Exposures:*** People are exposed to a wide range of factors in the environment, both sequentially and simultaneously. Study of combined exposures, or "mixtures," most closely replicate the human experience, and thus may provide unique insights to EHS. Such study is especially relevant for understanding health impacts of environmental exposures such as those related to climate or experienced as a result of disasters. Study of co-exposures will continue to require the development of novel technological and quantitative approaches.
6) ***Predictive Toxicology:*** Predictive toxicology remains a priority component of EHS. This approach takes advantage of basic knowledge of biological pathways to build a set of targeted, human-relevant computational, *in silico*, *in vitro*, and animal tests to predict adverse effects of a chemical exposure. Predictive toxicology advances

include such examples as “organ-on-a chip” technologies and systems biology platforms.

7) ***Data Science and Big Data:*** Development of innovative data science and data-driven approaches, including data sharing platforms, integration, and analytics, is integral to the EHS enterprise specifically, and to health initiatives generally. The broad use of “Big Data” frameworks and FAIR (Findable, Accessible, Interoperable, and Reusable) principles facilitate this development. Continued emphasis on partnerships within and outside NIH will help EHS capitalize on new discoveries and approaches.

Theme II: Promoting Translation -- Data to Knowledge to Action

The NIEHS mission directive on information dissemination recognized that the value of EHS knowledge can only be fully realized through its use by the public, health providers, regulators, and policy makers to help inform their decisions. NIEHS restates dissemination in the phrase “Data to Knowledge to Action,” which reflects the translational cascade from research results into a collected body of knowledge that ultimately informs and supports public health action. This Theme reiterates our commitment to ensuring that NIEHS research is directed toward improving people’s health.

Promoting Translation-- Data to Knowledge to Action goals include:

1) ***Creating Knowledge from Data:*** The overall emphasis of this goal involves integrating and synthesizing data and research findings in a way that will ultimately make a meaningful impact on public health. One example of creating knowledge from data is the use of Systematic Review techniques to develop evidence-based assessments in a transparent manner. This goal demonstrates the NIEHS commitment to integrating high-quality research findings into collective knowledge to inform solutions to EHS problems. The capacities outlined in the Data Science and Big Data goal are highly relevant to this goal.
2) ***Outreach, Communications, and Engagement:*** The strong lines of communication and relationships that NIEHS maintains with its stakeholder communities are an essential asset. Maintaining and expanding our outreach and engagement with these communities is critically important to ensuring the Institute’s awareness and understanding of stakeholder priorities, concerns, and needs related to EHS and to ensuring that community members and researchers work together on science that is important to both. These efforts also enhance our ability to share new findings with affected groups, as well as to gain their unique knowledge and perspectives through collaborations that benefit both them and EHS. NIEHS efforts in communication of environmental health information and promotion of EHS literacy are continued priorities.

3) ***Evidence-based Prevention and Intervention:*** NIEHS research findings that identify and demonstrate the causes of environmentally related diseases and outcomes provide a critical part of the basis for actions to avoid or mediate such impacts. Efforts will continue in promoting research findings to networks of scientists, community advocates, educators, healthcare providers, and public health officials, who can translate such evidence into credible and understandable information and actions that individuals and communities can use to decrease their risk, prevent harm, and improve their health. This effort will be supported by research to develop, test, and validate evidence-based prevention and intervention strategies to reduce or avoid exposures and their resulting health impacts.
4) ***Environmental Health Disparities/Environmental Justice:*** EHS has long been at the forefront of efforts that recognize and seek to address the disparate health impacts of environmental hazards on disadvantaged and diverse communities. NIEHS remains committed to uncovering the exposure burdens that combine with other social determinants of health, such as age, gender, education, race, and income, to create health disparities, as well as working to ensure environmental justice. These efforts will be supported by all of the NIEHS Themes.
5) ***Emerging Environmental Health Issues:*** We live in an increasingly complex environment in which new exposures and related health threats continually arise, both locally and globally. Some, such as industrial accidents and weather-related disasters, pose acute public health emergencies that require the capacity for immediate action to understand and respond to them. Others, such as long-term climate impacts on health and pandemic diseases, create a need for both immediate response and ongoing study to inform preparedness for future similar threats. NIEHS is strongly committed to addressing emerging environmental health issues through our research and translation goals, as well as by continuing to engage with our public health partners in efforts to improve response, recovery, remediation, and resilience to EHS threats.
6) ***Partnerships for Action:*** Promoting the Translation of Data to Knowledge to Action is critically dependent on building and sustaining effective relationships between NIEHS and a wide variety of partner organizations, including other federal, state, and tribal public health and environmental agencies; patient groups and advocates for environmentally related disease research; community advocates and leaders from affected communities; and EHS research scientists around the world. Such partnerships allow NIEHS to take advantage of the wide range of complementary missions, capabilities, expertise, and perspectives needed to implement actions that will improve environmental health.

Theme III: Enhancing EHS through Stewardship and Support

Success in our mission requires that NIEHS continue to provide strong stewardship of our resources—whether human, financial, or infrastructure—as well as support for approaches that will enhance EHS and research translation. NIEHS, as an institute of the NIH, confirms its commitment to the highest standards of scientific rigor, including promotion of new approaches to improving experimental and observational design, analysis, and reporting, as well as active engagement in and support of NIH efforts to promote transparency and reproducibility of research results. Efforts to ensure responsible conduct of EHS research include protection of human subjects and communities under study, responsible use of animals, measures to ensure research integrity, appropriate and timely reporting of research results, data privacy and security safeguards, and related issues.

Enhancing EHS through Stewardship and Support goals include:

1) ***EHS Professional Pipeline:*** NIEHS will continue recruiting and training the next generation EHS workforce and its leaders in research, science management, and research translation. These efforts will tap a wide range of disciplines and emphasize recruitment of trainees and mid-career researchers from related fields to build a workforce that is both highly qualified in the use of cutting-edge knowledge, technologies, and approaches, and that is dedicated to applying them to solve environmental health problems.
2) ***Greater Workforce Diversity:*** Diversity of thought, perspectives, and approaches is critical to maximizing the public health impact of EHS research and translation efforts. This diversity is achieved, in part, by a commitment to developing an EHS workforce that comprises a wide range of characteristics, including race, ethnicity, gender, socioeconomic status, geographic location, and disability status. NIEHS is committed to promoting a diverse EHS workforce by ensuring widespread opportunity and inclusion in our recruitment and training programs.
3) ***Promotion of Collaborative Science:*** The multifaceted and complex nature of modern EHS problems provides a compelling rationale for collaborative science approaches that work across disciplines and global boundaries. Efforts to support effective collaborative science will include increased investment in data sharing infrastructure and data science approaches, emphasis on creating opportunities and efficiencies through biological repositories and shared infrastructure, exploration of innovative approaches for promoting team science, and solutions to address barriers that may act as disincentives.
4) ***Training and Capacity Building in Global Health:*** In today's world, people, products, pollutants, and pathogens constantly traverse global boundaries. Building EHS capacity around the world promotes improvement in global environmental health, while helping to ensuring safety and health here at home. NIEHS will continue to provide U.S. training opportunities for students and researchers from other

countries, collaborate with foreign research and health institutions to share expertise and maximize resources, and partner with international organizations to ensure access to the best EHS information by and for all nations.

5) ***Scientific Research and Data Infrastructure:*** Cutting-edge, collaborative EHS research demands state-of-the-art facilities and resources. NIEHS will continue to provide funding for development of, and access to, shared support and analysis cores. We will also work to implement mechanisms that encourage efficient, sustainable use of resources and to protect research investments through infrastructure resilience. Of high priority will be investment in specialized infrastructure, resources, and training to successfully implement our Data Science and Big Data goal.
6) ***Impact Evaluation:*** To demonstrate our stewardship and iteratively inform EHS efforts, NIEHS will expand evaluation of the impacts of our research, training, and translation activities, as well as encourage the conduct and use of evaluation science in EHS. Indicators of interest include economic, social, and health impacts on policies, practices, and behaviors aimed at promoting health by preventing environmental exposures. The knowledge generated by these evaluations will provide a useful resource to inform the decisions of individuals and policymakers.

A Solid Foundation–A Springboard to Discovery

The process of periodically updating the NIEHS Strategic Plan requires NIEHS to reflect on our strengths, recognize our weaknesses, and project the future needs of both EHS, and most importantly, the public we serve. It is a process we undertake not lightly, but with the full knowledge of our mission and our responsibility as global leaders for the field. In this process, we seek the perspectives, experience, and insight of all interested people, and consider their input deliberately and thoughtfully. The final result of this process reflects a recognition that NIEHS, over more than five decades, has built a solid scientific foundation for EHS, and that this foundation must act as a springboard to discovery if we are to meet the challenges we now face. The Themes of this plan and the goals within them have been crafted to use this springboard to launch NIEHS and the field of EHS into the future, with the knowledge that we must be open in our thinking, nimble in our adapting, and visionary in our imagining of the possibilities if we are to make even greater strides toward a healthier environment and healthier lives for all people.

The **National Institute of Environmental Health Sciences (NIEHS)** is one of 27 Institutes and Centers of the NIH, an operating division of the U.S. Department of Health and Human Services. The mission of the NIEHS is to discover how the environment affects people, in order to promote healthier lives. The Vision of the NIEHS is to provide global leadership for innovative research that improves public health by preventing disease and disability. NIEHS works to accomplish its mission by conducting and funding research on human health effects of environmental exposures; developing the next generation of environmental health scientists; and providing critical research, knowledge, and information to citizens and policymakers to help in their efforts to prevent hazardous exposures and reduce the risk of preventable disease and disorders connected to the environment.

The **National Toxicology Program (NTP)** is an interagency program established in 1978 to coordinate toxicology research and testing across the Department of Health and Human Services (HHS). FDA and CDC also participate in NTP, which is headquartered at NIEHS. The program works to strengthen the science base in toxicology, develop and validate improved testing methods, and provide information about potentially toxic chemicals to health regulatory and research agencies, scientific and medical communities, and the public. The NTP is responsible to its own leadership, Board, and Executive Committee, but the priorities of the NIEHS Strategic Plan extend to the Institute's portion of the NTP.