Draft NIEHS Strategic Plan

Mission, Vision, Strategic Pillars, Strategic Goals

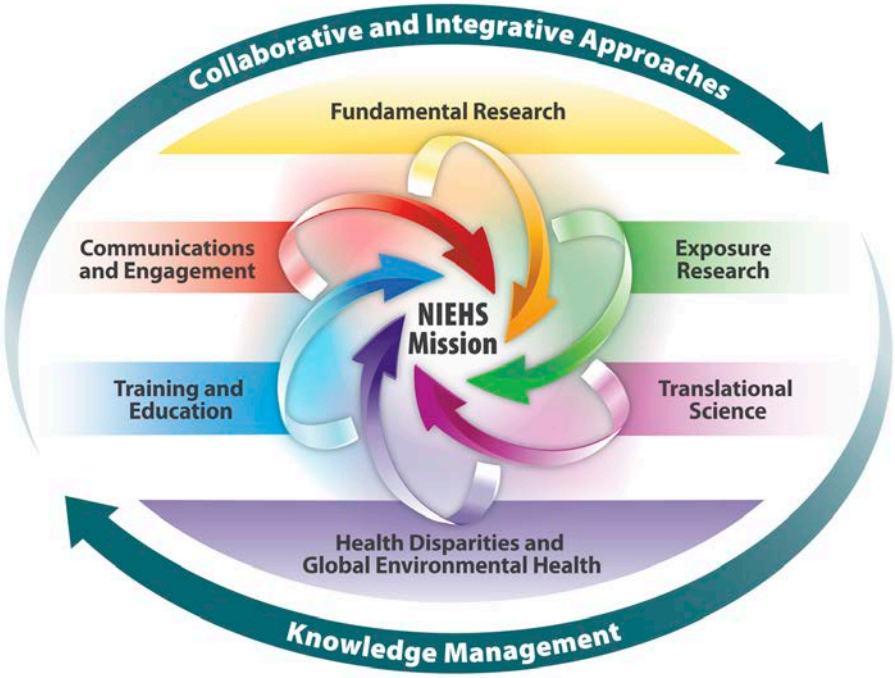
Draft Mission Statement

The mission of the National Institute of Environmental Health Sciences is to discover how the environment affects people in order to promote healthier lives.

Draft Vision Statement

The vision of the National Institute of Environmental Health Sciences is to provide global leadership for innovative research that improves public health by preventing disability and disease from our environment.

Draft Pillars Graphic



Draft NIEHS Strategic Planning Pillars and Crosscutting Themes

Pillar 1: Fundamental Research

Understanding the biology that defines basic mechanisms of response to environmental stressors and the implications for human health

"Fundamental research" investigates the basic biological processes of how our bodies function and of the pathways and systems that are susceptible to the effects of environmental stressors. This research addresses all levels of biological organization -- molecular, biochemical pathway, cellular, tissue, organ, model organism, human, and population -- and builds on the knowledge from new tools and techniques that allow us to ask more in-depth questions about the effects of our environment on biological systems.

These new research questions arise from our expanding knowledge of the genome, epigenome, and regulation of gene expression, and appreciation of direct effects of stressors on cells that do not involve genomic targets. They call for systems and computational approaches, and recognition of the importance of changes in sensitivity to environmental stressors at different life stages (e.g., prenatal, pregnancy, old age). Environmental agents can have both direct toxicities and can also influence biological processes that affect susceptibility to other agents. (The study of biological systems in response to specific environmental agents represents an area of overlap with Pillar 2, below.) The research under this Pillar (and Pillar 2) can be thought of as the fundamental knowledge base of "Prevention Science" for environmental health, because understanding the mechanisms of disease will help us reduce their incidence and mortality in susceptible populations. Through this research, we hope to create a foundation that will enable us to better understand the links between exposures and disease.

Contributions from epidemiology/population biology studies are a critical component of Pillar 1. Observational population-based research provides the real-world reflection of the questions being asked by laboratory science, and in turn, can provide observations that can generate the need for mechanistic understanding. Sometimes, relationships are only evident as a result of looking at exposures and health outcomes together in a population setting. At the same time, interdisciplinary, integrative, and collaborative approaches are necessary. For example, we need to develop better tools for data integration, systems, and computational biology. We must also leverage existing human cohort studies with well- characterized exposure and health information to address the role of environmental exposures in disease etiology.

Pillar 2: Exposure Research

Understanding how the complex nature of exposures, at the individual and population levels, contributes to health outcomes

This Pillar focuses on the study of environmental exposures themselves, internal and external: not just chemical environmental pollutants, but also exposures arising from a variety of sources such as the microbiome, infectious agents, nutritional sources, and stress. Key research needs include technology development for exposure measurement: better biological markers, new sensor/detector tools, remote detection of exposures, more sensitive analytical methods, high-throughput predictive pharmacokinetic models, and informatics tools to improve quantitation of information on exposure from large datasets. This Pillar also intersects with Pillar 1, since new metrics of exposures include biological effects on key pathways involved in disease pathogenesis.

New systems-based approaches to exposure science are now emerging that utilize "omics" technologies. This approach recognizes that environmentally related health and disease are the result of the totality of a person's environmental exposures, from all sources, across the life span. This totality of exposure is what we are describing in this document as the "exposome", a concept that has become increasingly salient in the field of environmental health sciences. Part of our strategic direction will be to engage the scientific community in the effort to clearly define the "exposome" and to create research opportunities to explore it.

Pillar 3: Translational Science

Transdisciplinary science to inform individual, clinical, and public health decision making to improve health

Research that moves a basic science observation into a public health or medical application is sometimes termed "Translational Science". Translational Science is Pillar 3, in recognition of the fact that our research priorities must include this kind of applied, outcome-oriented research for us to ensure that the full benefit of all of our research investments can be realized as part of public health, medical, regulatory, and individual practice. The Translational Science Pillar embraces broad, interdisciplinary approaches: molecule to cell to model organism to human to society and back again, as informed by public health imperatives.

While translational approaches in medical research are sometimes referred to as Bench-to-Bedside, NIEHS research results in much broader applications which have in common an emphasis on preventing adverse health consequences from environmental exposure. NIEHS research moves

through multiple translational pathways, not just to the bedside, but to the community, to individual behaviors and choices, and to wider public policy changes and public health practice.

Predictive Toxicology is one key component of this Pillar. The overall goal for the current Tox21 program is to take observations obtained from the study of biological pathways and deploy them in a new framework to provide specific information for making decisions about risk.

Environmental health translational science has been underutilized in the context of state-of-the-art medical practice. In the paradigm known as "personalized medicine", biomedical researchers are giving providers the tools to use genomic information to make better-supported individual decisions about diagnosis and treatment that are tailored to the biology of the specific patient. Knowledge of environmental exposures needs to be incorporated into this decision-making framework. Environmental health translational research can introduce into medical decision-making a new level of information about gene-environment interactions affecting drugs, biologics, infections, and other environmental factors in health and disease.

One important component of this Pillar is to enhance NIEHS use of metrics of comparative effectiveness in environmental health to inform health economics. A key need in this area is to develop tools and methods to evaluate the impact of environmental health research – including contributions to prevention of disease – that is systematic and transparent.

Pillar 4: Health Disparities and Global Environmental Health

Research to understand environmental contributors to global health and health disparities

It has long been recognized that individuals and communities that are socioeconomically disadvantaged also tend to suffer inequalities in both health and environmental burdens, and that these characteristics are interrelated. NIEHS has been a leader in studying health risks associated with the environmental toxicants and other stressors of vulnerable populations and has invested heavily in building capacity of affected communities to partner with environmental health scientists in order to study environmental concerns. This concept is embodied as Pillar 4, Environmental Health Disparities.

Pillar 4 incorporates aspects of all the other Pillars: Fundamental Research, Exposure Research, Translational Science, Training, and Communication.

Under this Pillar, NIEHS endeavors to support environmental justice research by defining the environmental factors and their complex interactions that contribute to environmental health disparities and by studying chemical and non-chemical stressors at the community level. This

research includes developing new approaches to community based research, fostering collaborations between community groups and research groups, establishing training programs for environmental health disparities research and capacity building within institutions well placed to undertake health disparities research. For environmental health disparities research, it is necessary to incorporate social and behavioral aspects as well as implications of environmental exposures into the research.

Environmental exposures of widespread public health significance occur throughout the world; many disproportionately affect not only the disadvantaged in our country but also the developing world. Populations around the world will continue to be a focus of NIEHS research. Taking a global environmental health focus includes opportunities to perform research to learn about risks from widespread exposures. For example, increasing changes in global climate are expected to result in changes to weather, ecosystems, water supplies, and other aspects of our physical environment. These changes, and the mitigation and adaptation efforts that accompany them, will have implications for emerging environmental exposures, especially affecting vulnerable populations.

An additional component of this Pillar that intersects with Pillar 3, Prevention and Translational Science, is the development of new tools and approaches that will help us understand the economic impacts of environmental health risks, decisions, and policies. The field of health disparities research can benefit greatly from the contributions of cost-benefit analysis and comparative effectiveness research. Developing quantitative approaches that can be linked to economic impact is an important capability that can be used to inform decision making in ways that will disproportionally benefit exposed communities.

As with all the Pillars, implementation of the goals under this Pillar will depend on wide-ranging and effective partnerships and collaborations. This requirement points to the need for good relationships between community groups, their leaders and representatives, and the invested researchers. Internationally, the collaborations extend also to foreign scientists and governments.

Pillar 5 – Training and Education

Developing and retaining a sustainable pipeline of environmental health professionals across a range of related disciplines including fundamental science, exposure science, translation, policy, and outreach through efforts in education, training, and career development; raising the level of environmental health literacy of the general population and all other NIEHS stakeholders

NIEHS will facilitate development of a cadre of top-notch, innovative, and dedicated environmental health scientists and professionals. Within the scientific enterprise, researchers who are open to transdisciplinary approaches need to be developed, recruited, and trained from across a wide

range of disciplines in order to meet the NIEHS mission of solving the increasingly complex problems in environmental health. Examples include not only traditional basic biological, medical, and population sciences such as toxicology and epidemiology, but also translational sciences, data and information sciences, chemistry, engineering, biostatistics health economics, bioethics, risk communication, behavioral sciences, and others. In tandem with the development of the scientific cadre, NIEHS must also seek to develop a base of professionals who can translate the scientific knowledge into policy, education, communications, and outreach to meet the needs of NIEHS stakeholders. Efforts in both of these areas should include specific focus on increasing the involvement of underrepresented groups in environmental health research, on the use of integrative and collaborative approaches, and on effectively relating environmental health science to actual public health problems that need solutions. NIEHS needs to emphasize the real-world relevance of its scientific efforts to make environmental health sciences an exciting and enticing field of study and career.

A necessary requirement for development of continuing generations of environmental health science is providing children an introduction to the field at a very early age and on a continuing basis throughout their education. Efforts in this area not only provide a sustainable pipeline of new researchers into the field, but also provide a framework for education that improves overall environmental health literacy with the capacity to affect understanding, behavior, and health outcomes across the age spectrum. Thus, K-12 and environmental health literacy embedded in education are necessary conditions both for the environmental health scientist pipeline and for wider health promotion/disease prevention efforts.

Pillar 6: Communications and Engagement

Advancing translation and dissemination of scientific knowledge on the role of the environment and human health; pursuing appropriate and effective means of engagement of the broad range of institute stakeholders in environmental health research and public health promotion.

A part of the Congressionally mandated purpose of the NIEHS is the dissemination of research findings, knowledge, and information on environmental health science. Because the Mission and Vision of the NIEHS comprise the prevention of illness and improvement of public health, this mandate is interpreted broadly to encompass a range of communication activities.

In order to be successful in these activities, NIEHS must continue to develop, refine, and implement an innovative and comprehensive communication and engagement strategy that draws on the latest in best practices, standards, and technologies established by professional communications practitioners and researchers.

Communication and engagement activities provide information that can be understood and applied by the range of NIEHS stakeholders, including decision makers at all levels, from individuals to global organizations. A good communication strategy for NIEHS is multi-directional for two-way engagement with our stakeholders, and deployed both internally and with external partners to develop a broad constituency for environmental health sciences.

Crosscutting Theme: Knowledge Management

Environmental effects on health and disease are complex, and understanding these effects requires an integrated and comprehensive approach to data management. The pace of data generation in environmental health sciences has outstripped the existing infrastructure for information acquisition, management, analysis, visualization and dissemination. The various issues around information/data/knowledge management comprise an overarching issue with implications applicable to all the Strategic Planning Pillars.

There is a broad consensus in the scientific community that more informatics expertise and resources are required to support environmental health sciences research. Emerging technologies allow for transformative analysis of genome structure and sequence, gene expression (transcriptome), DNA methylation (epigenome), the metabolome, proteome, envirome, exposome, phenome, etc., but currently the field of environmental health sciences has relied on other disciplines to define the bioinformatic parameters necessary for data integration. While environmental health sciences has made some progress within these constraints, it has become apparent that dedicated strategic investments of resources are necessary to support the information/knowledge needs of the multiple disciplines within the environmental health sciences. Strategies that facilitate integration of such data in the context of environmental exposures would permit greater synergy among environmental health science researchers and improve our basic understanding of environmentally associated diseases. Across the environmental health sciences community there is a need for centralizing, accessing and analyzing diverse environmental health data through public resources. A path forward could include leveraging multiple sources of existing data which are now unconnected and create better ways to federate and access these data to address pressing environmental health questions into the future.

Crosscutting Theme: Collaborative and Integrative Approaches

An overarching theme identified during the NIEHS strategic planning process is the importance of collaborative and integrative approaches to environmental health sciences. Adverse effects leading to disease occur at multiple points throughout complex systems, often from multiple exposures,

and across various life stages. The research enterprise for environmental health sciences needs to be positioned to exploit all relevant disciplines in a coordinated, integrated fashion to solve these complex problems. Environmental health scientists need to be enabled to work across a wide array of fields: cell and molecular biology, structural biology, biochemistry, genetics, pharmacology, toxicology, epidemiology, biostatistics, behavioral sciences, engineering, and many others. Systems biology, computational biology, and other promising new approaches are dependent on interdisciplinary collaborations. In addition to interdisciplinary approaches to fulfilling its science mission, NIEHS must also work to develop innovative collaborations with sister agencies, communities, and other partners to effectively translate this knowledge to inform prevention and interventions, as well as to guide stakeholder decision making at all levels.

Draft NIEHS Strategic Goals

1. Identify and understand fundamental shared mechanisms or common biological pathways (e.g., inflammation, epigenetic changes, oxidative stress, mutagenesis) underlying a broad range of complex diseases, in order to enable the development of broadly applicable prevention and intervention strategies.
    a. Investigate the effects of the environment on genome structure and function.
    b. Investigate the effects of the environment on the epigenetic regulation of biological and pathological processes.
    c. Understand the role of key protective mechanisms and their regulation in determining resistance and susceptibility to environmental stressors.
    d. Understand the normal processes of human development and identify environmental factors that contribute to altered function.
    e. Develop a pipeline to integrate high throughput screening, cell systems and model organisms to identify fundamental mechanisms underlying responses to existing and emerging environmental toxicants and to better predict their relationship to disease.

2. Understand individual susceptibility across the life span to chronic, complex diseases resulting from environmental factors, in basic and population-based studies, to facilitate prevention and decrease public health burden.
    a. Using a life span approach, identify critical windows of susceptibility to the effects of environmental exposures.
    b. Deepen our understanding of dose response relationships to environmental factors across the lifespan.
    c. Study the factors that determine individual susceptibility to environmental stressors across the lifespan.

3. Transform exposure science by enabling consideration of the totality of human exposures and links to biological pathways and create a blueprint for incorporating exposure science into human health studies.
    a. Advance characterization of environmental exposures through improved exposure assessment at both the individual and population levels.
    b. Define and disseminate the concept of the exposome.
    c. Create tools and technologies, and the research capacity, needed to characterize the exposome.

4. Understand how combined environmental exposures affect disease pathogenesis.
    a. Assess the joint action of multiple environmental insults (including chemicals, non-chemical stressors, and nutritional components) on toxicity/disease and identify interactions resulting from combined exposures.
    b. Study the role of the human microbiome and its influence on environmental health; explore the role of the microbiome in responses to environmental exposures.
    c. Study the interactions of infectious agents with environmental exposures.
    d. Understand how non-chemical stressors (including socioeconomic, behavioral factors, etc.) interact with other environmental exposures to impact human health outcomes, and identify preventive measures that could be taken.

5. Identify and respond to emerging environmental threats to human health on both a local and global scale.
    a. Enlist the capacity of the EHS research enterprise to elucidate information necessary for timely and effective public health action.
    b. Act proactively with other public health partners to provide appropriate responses to emerging environmental threats.
    c. Focus on research needs to help inform policy responses in public health situations in which lack of knowledge hampers policymaking (e.g., health effects of exposures related to hydrofracking or climate change, or exposures to engineered nanomaterials).

6. Establish an environmental health disparities research agenda to understand the disproportionate risks of disease and to define and support public health and prevention solutions in affected populations.
    a. Conduct community-based participatory research.
    b. Include research and education on the ethical, legal, and social implications of EHS research, including human participation issues, research integrity, reporting of results, and other issues.
    c. Develop and recommend or implement interventions to reduce or eliminate environmental exposures that cause the greatest burden of disease to affected populations.

7. Use knowledge management techniques to create a collaborative environment for the EHS community to encourage an interdisciplinary approach to investigate, analyze, and disseminate findings.

a. Develop bioinformatics, biostatistics, and data integration tools to conduct interdisciplinary research for application to environmental health science.
b. Develop and invest in publicly available resources and computational tools for integrating and analyzing environmental health data

8. Enhance the teaching of EHS at all levels of education and training (K-professional) to increase scientific literacy and generate awareness of the health consequences of environmental exposures.
    a. Empower individuals at all levels of education with knowledge to make better health decisions.
    b. Use leadership and partnerships to strengthen EHS education and literacy, using research on effective EHS education strategies and creating mechanisms for educators to promote EHS education.
    c. Develop critical training programs in EHS research tailored for multiple groups (students, postdocs, foreign scientists, and science teachers).
    d. Incorporate EHS into Medical Education/Practice (nursing, MD, etc.) to increase awareness of environmental medicine in healthcare practice

9. Inspire a diverse and well-trained cadre of scientists to move our transformative environmental health science forward; train the next generation of EHS leaders from a wider range of scientific disciplines and diverse backgrounds.
    a. Foster cross-disciplinary training in areas that are necessary but underrepresented in EHS (informatics, engineering, biobehavioral, etc.)
    b. Recruit trainees from other disciplines to diversify our science base.
    c. Ensure effective opportunities across the entire career trajectory, for young investigators' transition to independence and also for retraining of mid-career scientists and other EHS professionals.
    d. Promote the integration of EHS into Medical Education to increase the number of physician or nurse researchers that are trained in EHS.
    e. Build environmental health research capacity in those countries around the world experiencing the greatest burden of death, disease, and disability related to the environment.
    f. Increase diversity within training programs for environmental health scientists.

10. Evaluate the economic impact of policies, practices, and behaviors that reduce exposure to environmental toxicants through prevention of disease and disabilities; invest in research programs to test how prevention improves public health and minimizes economic burden.

a. Develop an interdisciplinary research and training program in environmental health economics, to better understand the economic costs and benefits of environmental exposures, related diseases, and interventions to prevent exposures and diseases.
b. Measure economic benefits and comparative effectiveness of NIEHS investments, employing health economics as a part of the NIEHS research agenda – developing the tools and databases to advance this research.
c. Assist policymakers with systematic review and state of the science assessments to help them make clinical/policy recommendations.

11. Promote bidirectional communication and collaboration between researchers and stakeholders (policy makers, clinicians, intervention/prevention practitioners, and the public) in order to advance research translation in the environmental health sciences.
    a. Promote NIEHS as a trusted and accessible source of EHS-based information. Increase NIEHS's reach and effectiveness in communication and outreach.
    b. Identify and expand our relevant stakeholder communities; enhance engagement to understand their priorities, concerns and needs related to EHS.
    c. Build and lead long-term federal and non-federal partnerships with health education agencies and mission-related stakeholder groups to create a pipeline for the coordination of disseminating scientific results to the public and also to hear back from their constituents.
    d. Conduct research as needed on effective EHS communication strategies (including risk communication).
    e. Develop an integrated, searchable knowledge base on the impact of environment on health.