Strategic Objective 1: 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 computational, experimental, observational, and clinical approaches to explore impacts of varying levels of exposure and varying levels of susceptibility to such exposure.

Research in EHS is aimed at discovering and explaining how factors in our environment, including chemical, physical, synthetic, and infectious agents; social stressors; diet and medications; and our own microbiomes, affect biological systems. The knowledge generated by EHS provides a critical component to the understanding of human health and disease.

Health effects of interest that are known or suspected to be environmentally related include, but are not limited to, developmental and behavioral outcomes (reproductive disorders, autism); chronic, non-communicable diseases (cancers, asthma, cardiovascular diseases, diabetes, obesity); neurodegenerative diseases (Parkinson's, Alzheimer's); and inflammation effects (autoimmune disorders, myositis). Focus areas of Advancing Environmental Health Sciences will include:

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 environmental exposures early on can impact the risk of disease much later in life, long after exposure has occurred, research on developmental processes will continue to be a priority.

Individual Susceptibility: Individual people can and do respond biologically in different ways to the same environmental exposure. EHS includes the study of differential individual susceptibility arising not only from the duration and degree of exposure, but also from genetic (alterations in the DNA sequence) and epigenetic (heritable changes in gene expression that do not involve changes to the DNA sequence) mechanisms. The combination of such knowledge with environmental exposure data, known as gene by environment, or GxE, provides a more complete picture of a person's risk of adverse effects.

The Microbiome: The collection of microbes (e.g., bacteria, virueses, fungi) living on and inside of our bodies, including 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 may impact health in myriad ways and even affect how we are exposed to some environmental chemicals. NIEHS will expand its focus on the role of the microbiome as both a target and a mediator of environmental exposures.

The Exposome: The exposome is the totality of environmental exposures experienced by an individual over the life course. Efforts will continue toward advancing exposure science and

integrating the exposome into EHS, including through technology development for exposure characterization.

Co-Exposures: People are exposed to a wide range of factors in the environment, both sequentially and simultaneously. Study of combined exposures, or "mixtures," will most closely replicate the human experience. It is also highly relevant to identifying the impacts on health of emerging environmental exposures such as those related to climate. Study of co-exposures will continue to require the development of novel technological and quantitative approaches.

Predictive Toxicology: This approach takes advantage of basic knowledge of biological pathways to build a set of targeted, computational, in silico, in vitro, and animal tests to predict toxic effects of a chemical exposure. Examples of predictive toxicology advances include new computational approaches and "organ-on-a chip" technologies. Predictive toxicology remains a priority component of EHS.

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 to capitalize on new discoveries and approaches.

Strategic Objective 2: Promoting the Translation of Data to Knowledge to Action

The Public Health Service Act of 1966 under which NIEHS was founded set forth the mission of the Institute to improve public health through research, training, and dissemination of health information. This language recognized that the value of environmental health knowledge created by NIEHS can only be fully realized through its use by the public, regulators, and policy makers to inform their decisions. NIEHS restates dissemination in the term "Data to Knowledge to Action," which reflects the translational cascade of research results into a collected body of knowledge that ultimately informs and supports public health action. Strategic Objective 2 reiterates our continued commitment to ensuring that NIEHS research priorities and outcomes remain directed at improving people's health. Focus areas of Promoting the Translation of Data to Knowledge to Action will include:

Data to Knowledge: Integrating research findings and data into a collective body of knowledge that can provide a holistic understanding greater than the sum of its parts is the goal of Data to Knowledge. The capacities outlined in the Data Science and Big Data element of Strategic Objective 1 are highly relevant to such integration. Other activities such as the use of Systematic Review techniques by NTP are related to NIEHS's commitment to developing evidence-based EHS assessments in a transparent manner.

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 of benefit to both them and EHS. NIEHS efforts in communication of environmental health information and promotion of environmental health science literacy are continued priorities.

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 evidence base 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.

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 vulnerabilities (age, gender, education, and others, in addition to race and income) to create health disparities and working to ensure environmental justice. These efforts will be supported by the EHS research priorities in Strategic Objective 1, as well as the other highly related priorities in Strategic Objective 2.

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, 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 such as Zika and Ebola, create a need for both immediate response and ongoing study to inform future similar threats. NIEHS is strongly committed to addressing emerging environmental health issues by integrating them into our research priorities, as well as by continuing to actively engage with our public health partners in research, training, and outreach to improve response and build resilience to such threats.

Partnerships for Action: All Strategic Objective 2 priorities are critically dependent on building and sustaining effective relationships between NIEHS and a wide variety of partner organizations, including other federal and state 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. NIEHS depends on these partnerships, which allow us to take advantage of the wide range of complementary missions and capabilities, to help turn EHS Data to Knowledge to Action for better environmental health.

Strategic Objective 3: Enhancing EHS through Stewardship and Support

To be successful in our first two Strategic Objectives, NIEHS must continue to provide strong stewardship of our resources (human, financial, infrastructure) and support for enhancing EHS. Focus areas of Enhancing EHS through Stewardship and Support will include:

The 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 include an emphasis on recruiting 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 dedicated to applying them to solve environmental health problems.

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 and ethnicity, sex and 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.

Promotion of Collaborative Science: The multifaceted and complex nature of modern EHS problems provides a compelling rationale for collaborative science approaches that work across traditional boundaries. Efforts to support effective collaborative science will include increased investment in data sharing infrastructure and data science approaches; exploration of existing knowledge and new ideas on how to facilitate team science; and solutions to address barriers that may act as disincentives.

Training and Capacity Building in Global Health: In our global society, people, products, pollutants, and pathogens constantly traverse geopolitical 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 all nations, for the health of the people of all nations.

Rigor and Reproducibility**:** NIEHS maintains our commitment to the highest standards of scientific rigor. Efforts include promotion of new approaches to improving experimental and observational design, analysis, and reporting, as well as active engagement in and supportive of NIH efforts to promote transparency and reproducibility of research results.

The Ethical Conduct of EHS Research: Research and education on the ethical, legal, and societal implications of EHS research continue to be important to NIEHS. Efforts to ensure responsible conduct of EHS research include protection of animals, human subjects, and communities under study; measures to ensure research integrity; appropriate and timely reporting of research results; data privacy and security; and related issues.

Scientific Research and Data Infrastructure: Cutting-edge, collaborative EHS research demands state-of-the-art facilities and resources. NIEHS will continue to provide funding to ensure development of and access to support and analysis cores, as well as mechanisms that encourage efficient and sustainable use of such resources. Of high priority will be investment in specialized infrastructure and resources to successfully implement the data science and data integration efforts described in Strategic Objective 1.

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 evaluation science and its integration into EHS. Indicators of interest include economic, social, and health impacts on policies, practices, and behaviors to promote health by preventing or reducing environmental. The knowledge generated by these efforts will provide a valuable resource to inform the decisions of individuals and policymakers.