BIO Five Grand Challenges

Summary

The Directorate for Biological Sciences envisions the comprehensive grand challenges described in the 2010 NRC Report: *Research at the Intersection of the Physical and Life Sciences* as the way to create opportunities for the innovative research that is needed to transform our understanding of life on earth and our place in a changing world.

Background

GC1: Synthesizing Life-Like Systems

Synthetic biology seeks to fabricate both living and non-living "systems" based the features of natural living systems. It has the potential to revolutionize the application of biological knowledge to areas that contribute to US worldwide competitiveness in bio- and nanotechnology, and biomaterials and to address critical societal needs in energy, agriculture, medicine and industry.

GC2: The Brain

Unraveling the mystery of how the brain works is one of the greatest challenges of science. Neuroscience is challenging *scientists and engineers* to develop new research tools to investigate multi-scale non-linear dynamical systems *as problems* of fundamental interest essential for constructing a comprehensive brain activity map. Fundamental neuroscience research including species-comparative approaches will provide the necessary foundation for understanding how the genomic architecture, nuclear organization, synaptic activity, and neural circuitry underlie the emergent properties of the brain.

GC3: Predicting Individual Organisms' Characteristics from Their DNA Sequence

An organism's DNA sequence contains the basic blueprint for its form and function. Deciphering the interrelationship between an individual's characteristics (phenotype) and its DNA sequence (genotype) will profoundly impact our understanding of how living organisms develop, interact with and adapt to their physical and biological environment.

GC4: Interactions of the Earth, its Climate and its Biosphere

Natural processes operate over widely different scales of time, size and scope, and involve intricate, continual interactions between Earth's biological and physical systems. The recent discovery that evolutionary adaptation can take place within a few generations suggests that ecology and evolution can dynamically interact to restructure the populations, communities and physical environment of the planet. The principal challenge is to understand how some species adapt to environmental change while others do not, and especially how endemic populations respond to geographic invasion by opportunistic species in response to environmental change.

GC5: Understanding Biological Diversity

Life continuously remodels Earth's atmosphere, oceans, and land while adapting to a wide range of diverse physical habitats and changing environments. Biodiversity governs the flow of materials and energy through ecosystems, affects the physical environment on local and global scales, and provides many practical benefits from agriculture to medicine. The immediate challenge is to fill persistent gaps in our understanding of the processes that produce biodiversity and contribute to its loss, and to gain a fundamental understanding of how diversity affects the systemic properties of resilience, productivity, and invasive ability in the face of environmental and other anthropogenic changes.