

BIOCOMPLEXITY

Studying various science and social science disciplines is necessary to understand the world we live in. But how can we integrate these concepts and use them to our benefit? Biocomplexity is an approach to these studies that brings our knowledge into a broader view.



The Ecological Society of America

WHAT IS BIOCOMPLEXITY?

Biocomplexity arises from the behavioral, biological, environmental, social, chemical, and physical interactions that affect, sustain, or are modified by living organisms, including humans. The science of biocomplexity seeks a quantitative and integrative approach towards a better understanding of these complex interactions. The theory behind biocomplexity is that the interplay between living things and their environment is intricate. The goal of ecologists studying biocomplexity is to understand how components of the global ecosystem interact with each other in order to gain knowledge of the complexity of a system and to develop fundamental principles from it.

These are some characteristics of biocomplexity:

- nonlinear (including chaotic) behavior
- interactions that span multiple levels or space and time scales
- must be studied as a whole, as well as piece by piece
- relevant for all kinds of organisms -- from microbes to human beings
- relevant for environments that range from frozen polar regions and volcanic vents to temperate forests and agricultural lands

Why Study Biocomplexity?

Biocomplexity is a field of study that is useful to a wide range of scientists and researchers. It helps scientists pinpoint ecological, chemical, physical, and human dynamics which occur in both time and space. Since biocomplexity encompasses many different disciplines, the knowledge gained through its study is utilized in many arenas.



Photo Courtesy of the U.S. Long Term Ecological Research Network

As the stability of ecosystems becomes uncertain, predictive measures are often used to assess the current global situation. The study of biocomplexity is helpful in its predictive capabilities to determine the future health of ecological systems. In particular, how these may or may not survive and how they might be disrupted. These results can have implications for scientists and policy makers.



Research questions that scientists are trying to answer with biocomplexity include:

- How do systems with living components (including people) respond and adapt to stress?
- Are adaptation and change predictable?
- How will climate change affect species' ranges?
- Can we forecast the combined effects of changing climate and socioeconomic change?
- How does diversity (species, genetic, cultural) affect system stability?

How is biocomplexity studied and what are some basic principles?

Biocomplexity is driven by theory and modeling which leads to experiments. It is interdisciplinary, utilizing bioinformatics (using computers to solve information problems in the life sciences), mathematics, physics, geography, and computer science.

Although biocomplexity is a relatively new field, some universal principles have been established: (1) there is a hierarchical structure in biological systems. For example, enzymes-cells-organisms-societies-ecosystems; (2) these hierarchies are interrelated through control processes and feedback mechanisms that operate in both directions of the structures; and (3) biological systems are able to learn, adapt, and change over time.

How is biocomplexity research different from classic research techniques?

Classic research techniques follow a reductionist approach. Mainly because of time and money constraints, scientists have sought to *reduce* complexity in field and laboratory studies. Although this approach has yielded much knowledge, it has forced us to isolate underlying mechanisms for a more 'manageable' piece of the puzzle. The results of such studies may not be robust in real-world situations. Environmental phenomena are easier to understand through the synthesis and integration of information across relevant temporal, spatial, and thematic scales. Biocomplexity research aims to combine the efforts of scientists from different disciplines to work at these scales and produce more elaborate answers to complex questions.

What types of biocomplexity studies are possible?

Currently available 'super computing' tools allow scientists to study how biological, human, and physical interactions in a given ecosystem affect biodiversity. For example, researchers examine the association between natural systems and the reappearance of vector-borne illnesses, or the outbreak of pandemics related to ocean temperature and other climatic events. The predictive models created from biocomplexity studies may help determine the long-term effects of ecosystem change brought about by burning rainforests, bleaching coral reefs, and global warming.

Case Study

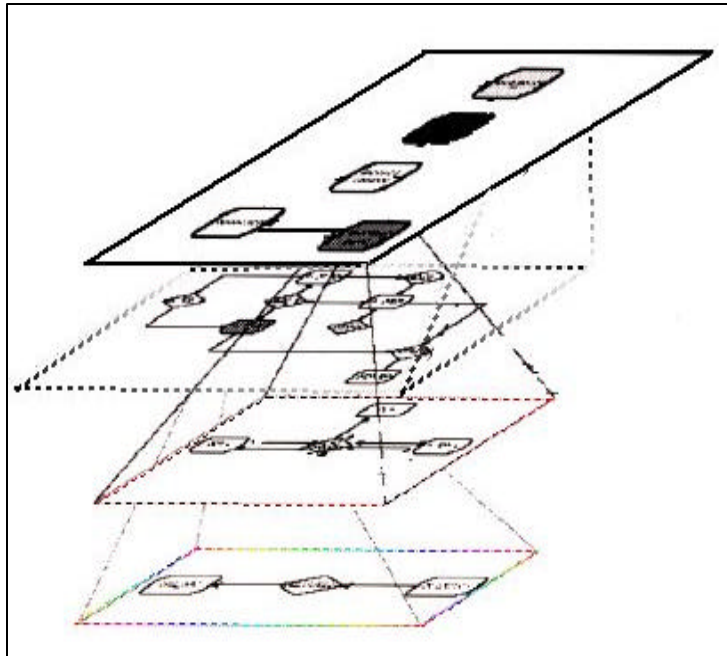
ATLSS Project: Across Tropic Level System Simulation for the Freshwater Wetlands of the Everglades and Big Cypress Swamp



Florida Coastal Everglades
Photo Courtesy of the U.S. Long
Term Ecological Research Network

The goal of this project is to create models of community-level ecological interactions. Specifically, it seeks to model the effects of water flow systems on plant and animal life in the Everglades and Big Cypress Swamp of South Florida. Water flow is a major factor controlling trophic dynamics of this system and the main objective of ATLSS is to compare the alternative hydrological scenarios' future impacts on the biotic components of the systems.

Modeling studies are necessary; but a single modeling approach would not be sufficient because of varying scales. Thus, a set of models were developed to integrate four approaches for different trophic levels of the system. This system is then coupled to a hydrology model. As a result, the effects of alternative proposed restoration scenarios can be assessed. This project is driven by the policy makers' need for information to make recommendations about scope, type and nature of restoration efforts for the region. Biocomplexity research supports this intricate study which will help make a more sound policy decision.



National Science Foundation's Biocomplexity Competitions

The NSF is the leading organization in biocomplexity research support. In 1999, its Phase I program focused on the functional interrelationships between microorganisms and biological, chemical, geological, physical, and social systems. Phase II of the competition widened research goals, searching for integrated research to better understand and model complexity among biological, physical, and social systems. In 2001, NSF announced Phase III of the competition, "Biocomplexity in the Environment." This competition focused on four areas: (1) coupled biogeochemical cycles; (2) genome-enabled environmental science and engineering; (3) dynamics of coupled natural and human systems; (4) instrumentation development for environmental activities. In 2002, another focus, 'materials use: science, engineering, and society', was added.

What is the future of biocomplexity research?

Biocomplexity projects will help us learn more about human influences on natural processes and will add to our knowledge about the environment. They will help us develop methods and computational strategies which will allow us to model and manage complex systems. This research may lead to a paradigm shift where scientists routinely will be able to address complex problems at the proper spatial scales in an integrative fashion. Biocomplexity research is expected to ultimately benefit from collaboration among multiple disciplines and from the development of truly interdisciplinary teams of scientists.

Biocomplexity in Education

Studies in biocomplexity complement related research on campus, bridging the disciplines of ecology, evolution, and environmental science programs and connecting these other natural and social science fields.

Students enjoy studying biocomplexity because it is an interesting and interactive field which involves contemporary issues and may include participation in contemporary scientific research. This subject challenges students to integrate their knowledge because it requires an interdisciplinary approach. Additionally, biocomplexity activities involve students in a range of hands-on inquiry and research techniques.

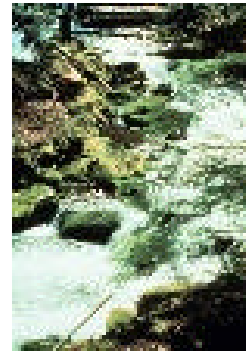


Photo Courtesy of the
U.S. Long Term Ecological
Research Network

FOR MORE INFORMATION...

NSF ERE Biocomplexity in the Environment Competitions

http://geo.nsf.gov/ere/ere_be-competitions.html

Biocomplexity in the Environment

<http://dlesecommunity.carleton.edu/biocomplexity>

National Biological Information Infrastructure (Search NBII)

<http://search.nbii.gov:9999/nbii/search.html>

Integrating Research and Education: Biocomplexity Investigators Explore the Possibilities:
Summary of a Workshop

<Http://www.nap.edu/books/0309088712/html/>

ATLSS

<http://atlss.org>