

**EVOLUTION AND DEVELOPMENT GRANTS PROGRAM
PLANNING WORKSHOP**

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NASA Ames Research Center, Moffett Field, CA

*A Workshop Sponsored by
The National Aeronautics and Space Administration's Gravitational Biology
and Ecology Program*

Organizers: Mel Averner
Eric Davidson
Executive Secretary: Catherine Golden

The Evolution and Development Grants Program Planning Workshop was a resounding success. The purpose of the workshop centered around the formation of a new external research grant program to be funded by the National Aeronautics and Space Administration, beginning in 1998. This program will focus on research which employs developmental molecular biology to elucidate the fundamental mechanisms and pathways by which the evolution of multicellular forms has occurred on Earth. This novel program will represent an expansion of the Gravitational Biology and Ecology Program in new directions. The specific goals to be accomplished at the workshop were to determine and define clearly the scientific framework of the new program and to provide guidance to NASA with regard to the appropriate objectives and emphases in this area of research. This workshop assembled a group of premier scientists in the field of evolution and developmental biology, with specific interest in molecular mechanisms which have led to novel forms in evolution. In addition, various NASA representatives with responsibilities for formulating and implementing the new grant program were in attendance.

The workshop began with an introduction by NASA's Gravitational Biology and Ecology (GB&E) Program Manager, Dr. Mel Averner. Dr. Averner discussed the fact that the life sciences are leading scientific investigation into the 21st century and NASA's goals include providing major contributions to life sciences discovery. With this in mind it is clear that the study of evolutionary biology is encompassed by, and an important component of, these goals, and NASA has great interest in expanding the GB&E extramural grants program to include metazoan evolution. The scientists participating in this Program Planning Workshop were asked to provide guidance and expertise regarding appropriate themes, objectives and emphases that should be the focus for such a program. Toward this aim, the meeting was designed to generate specific directives which could be included in the 98-HEDS-02 NASA Research Announcement (NRA).

Opening remarks given by the Chair of the workshop, Dr. Eric Davidson, centered around the excitement that "evolution provides a fundamental lens by which to view gravitational biology". It was remarked that this is an extremely exciting time in this field and for the first time scientists have the capability to begin to answer mechanistic questions regarding evolutionary history. Until now this area has not been approachable. Such mechanistic studies will be essential for enlightening our understanding of evolutionary processes. This is something altogether different from adaptational biology, which should not be a subject of this program. Dr. Davidson asked that this group of experts help provide clear and concise guidelines for what this program should and should not address. It was also highlighted that there are currently no major funding sources for this area of research.

Although there is support for evolutionary biology, the fraction of funded studies investigating the area of mechanistic developmental biology and its relation to evolution is a very small.

The following topics provided a foundation for discussion at the workshop:

- (1) Mechanistic explanations of organismic evolution in terms of developmental processes that are directly encoded in the genome; evolution of developmental processes identified by comparative analysis.
- (2) Experimental analysis of the evolution of the mechanisms by which gravity is sensed, and of the developmental mechanisms by which the body plans and structures of multicellular organisms are oriented with respect to gravity; exploration of the basic question whether gravity has played any role in the evolution of multicellular organisms.
- (3) Efforts to approach the most basic and general aspects of metazoan development in order to conceive principles with which to recognize complex living systems if they exist elsewhere in the cosmos; e.g., the role and extent of information processing necessary for metazoan life.

These introductory discussions set the stage for the workshop. The focus was then turned to the individual participants to present their scientific interests and discuss the evolution problems they are working on, and to discuss their ideas regarding the scope, boundaries, and form of the prospective grants program in regard to molecular mechanisms of metazoan evolution (topic 1). In addition, participants were asked to discuss practical aspects of the grants program and share ideas concerning the type, size and focus of the grants that should be considered in this grants program, keeping in mind that this program should change the shape of the life sciences world.

A summary of salient points brought out in these presentations and the associated discussions follows:

There is a lot of activity and interest in the area of questions of life, and evolutionary biology has made an important impact in life sciences. There is a growing awareness that this field is poised for major discoveries. The major area of interest is in the area of origins and diversification of animal body plans. It is essential that this grants program have a major focus on the molecular mechanisms responsible for the major changes in animal body plans. This is the level at which the greatest answers lie. For example, with regard to the chordate basic body plan scientists don't know how it evolved. Major transitions took place in evolution in chordate body plan organization and it would be of significant importance to discover how this occurred. Clearly key regulatory genes have been players in these transitions. It was discussed that this program should also attract investigation of the evolutionary diversification of gene regulatory systems. How do genes playing evolutionarily ancient roles acquire new functions, or new target genes? Why do genes become duplicated in terms of function? There are numerous opportunities to explore these kinds of mechanistic issues, other examples include; identification of key regulatory events that control all basic functions of metazoans; unraveling the gene networks that control various functional differences in organisms, such as muscle function; discovering the spatial and temporal pattern of expression regulated by cis-regulatory elements, which has undoubtedly played a major role in evolutionary transitions; and, tracing enhancer sequences to determine how these regions account for morphological change. Each of these areas are ripe for exciting discovery.

Also of particularly critical importance is to gain an understanding of the developmental mechanisms from diverse groups of organisms through directly comparative research. This area of investigation should consider both conserved roles among organisms as well as the differences between organisms. Such comparative research would further our understanding of developmental mechanisms and the events leading to evolutionary diversification. Such projects would be best accomplished by multi-laboratory collaborations.

Another exciting area, that has been particularly sparse in evolution research, is the events responsible for the transition from single cell to multiple cell metazoa. There are very few investigations in this area of metazoan origins. It is understood that multi-cellular forms appeared on various occasions, not as a result of sudden expansion, however it is unknown what events led to the formation of multicellular creatures.

Currently the progress in these areas of research is driven by developmental biologists and geneticists, since this is where the funding lies, however, it is important that evolutionary biologists have more formal and supported involvement in this field. This new NASA program will undoubtedly make this possible. To accomplish these goals it is imperative that this program focus on the molecular mechanisms underlying evolutionary history whereby grants are based on hypothesis driven research, not descriptive research.

It is also notable that there is enormous inertia in the world in terms of interest and support for these areas of research. A discussion revealed that Japan, Germany and England have created significant funding opportunities for this type of research, much more so than the United States. Thus, it seems the opportune time is upon us for the United States and NASA to also become involved. Currently, there is a major disparity between the publication level of support for this type of work and the level of funding available, thus the field is not reaching its potential due to the relative paucity of funding. Scientists have been forced to find creative ways to get this type of work accomplished, and much of the work that is done is by accretion onto other related areas. With funding support this area of research will expand markedly. This is a unique opportunity for NASA to play a vital role toward advancing this exciting area of research and toward advancing NASAs mission to seek knowledge.

Participants then addressed the scope of the program and considered whether plant evolutionary biology should be included with this program. The knowledge base for plant evolutionary biology and the mechanistic underpinnings of gene regulation is not as advanced as that of animals. Plant proposals would then necessarily be of a different nature than animal proposals. There was also concern that forming an effective peer review panel, containing both plant and animal experts, would be very difficult. This has occurred on National Science Foundation panels and has created deficiencies in the review of proposals. It was brought out, however, that consideration of the impact of plants should not be eliminated. For example, it is possible that the molecular mechanistic insights gained in investigation of the animal kingdom may prove true in plants as well. It was agreed however, that the current excitement in this area of research rests squarely on the animal kingdom.

Following these discussions the ideas presented were consolidated into five major areas of focus for this grants program. The grants program should focus on hypothesis driven research of evolutionary import that targets these major areas:

- 1) Developmental mechanisms in the evolution of metazoan body plans. (this may or may not include higher plants)

- 2) Evolutionary diversification of gene regulatory systems
- 3) New phylogenetically important experimental organisms for mechanistic comparative studies
- 4) Origins of metazoa
- 5) Comparative developmental studies of evolutionary importance

In order to have the intended impact three different types of grants should be funded:

- 1) Standard 3 year grants (R01 type)
- approximately 12-15 awarded annually and funded at ~ \$150,000 per year,
- 2) Young investigator awards (R29 type)
- 3) Investigator sponsored consortia (program project/NSCORT type grants)

The new program must have intellectual clout, thus, “blue ribbon” peer review panels composed of recognized leaders in the field are essential. These panels should have a core group with rotating membership and ad hoc representatives.

Following these discussions Mike Meyer, Program Manager for Space Sciences, presented the emphases and areas of funding supported by the Space Sciences Division including; astrobiology, exobiology and evolutionary biology. It was apparent that the emphasis of the Space Sciences Division and the prospective funding areas of the proposed GB&E grants program do not have appreciable overlap.

With regard to Topic 2 - the consideration of gravitational biology and the role gravity has played, if any, in evolutionary biology and developmental mechanisms - the discussion was limited. Participants felt that it is imperative that the program **not** be limited to investigating the role of gravity in evolution. However, it was indicated that this may be an interesting area to consider, especially, for example, with regard to organisms that are known to have gravity sensing organs.

The workshop concluded with a short discussion of the definitive features and fundamental characteristics of living systems (Topic 3), such as how information is stored and processed in living systems that allows for the plasticity of life. At the conclusion of the workshop it was indisputable that this workshop had fostered very exciting and provocative discussion, and that NASA clearly could make an enormous contribution to the problem of metazoan evolution, a subject that holds the imagination of the world. The participants were very encouraged and excited about this impending grants program and the impact that it will undoubtedly have on life sciences and our understanding of evolutionary history.