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NASA: The New Biology Agenda

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NASA's mission to "boldly expand frontiers in air and space … and to benefit the quality of life on Earth" has a significant and increasing biological component. Across the full range of NASA's science programs - from learning about our solar system and the Universe we inhabit; observing Earth from space, innovative use of the space environment as a laboratory, and enabling access to and future human exploration of space - the biological sciences are increasingly prominent in our research programs and new technology development. The following are but a few of the ways biology figures prominently in NASA's major programs.

In Space Science, the Astrobiology program asks the questions: How did life in the Universe begin and evolve? What is the future of life on Earth and beyond? And, does life exist elsewhere in the Universe? The prospects for the study of life in the Universe have never been better. Recent discoveries of sugars and other organic compounds both in meteorites and in interstellar space provide significant clues about how life may have originated on Earth. Discoveries of multiple planetary systems, along with new techniques to analyze their atmospheres; evidence of liquid water on Mars and Europa; and the discovery of life in the most extreme and unlikely environments on Earth (In fact, everywhere we have looked!) make the discovery of life elsewhere in the universe seem tantalizingly possible. The coming decades may revolutionize our understanding of life, its origins and destiny. NASA will be at the forefront of this research. NASA's research also involves looking back at the Earth from space. Remote sensing satellites provide global data about weather; climate; land, oceans and ecosystems; and detect changes to the Earth system. This satellite-derived information is vital for analyzing ocean and land ecosystems and their interactions at regional and global scales. NASA's remote sensing data are combined with other investigations performed at ecosystem and smaller scales to help provide the complete picture necessary to develop an understanding of the Earth's complex and dynamic biological processes. With this understanding we can hope to find ways to ensure biodiversity and sustainability for our future generations. NASA also has a program to promote the use of remotely sensed satellite data to increase our understanding of the ecology of infectious disease and the effects of climate and climate change on health and the spread of disease. Partnerships with the National Institutes of Health, the National Science Foundation, universities, and others are providing disease researchers the capability to enhance their research methodology through incorporating NASA's wealth of regional and global meteorological and ecological data. Possibly the most exciting new development enabling research at NASA is the availability, since

March 2001, of the International Space Station (ISS), a space laboratory vastly more capable than anything that has flown before. The biology components of ISS and other space-enabled research are two-fold: understanding fundamental biological processes through investigations in microgravity, and developing the medical understandings, technologies and interventions that will enable humans to live and work safely in space (bioastronautics). In fundamental biology, researchers investigate processes from the molecular and cellular to complex organism development and evolution in space, including the multi-generational development of a variety of organisms. The fundamental biology program also provides necessary foundational understanding for the bioastronautics program. Numerous human systems are affected by the microgravity environment of space; particularly cardiovascular, bone, immune, muscle, neurovestibular, and human performance. Another factor is the potentially damaging radiation environment that must be characterized and from which the astronauts must be protected. Bioastronautics must also develop systems to detect, diagnose and treat disease and injury for astronauts in the relative isolation of Earth orbit, and ultimately in deep space or on other planetary bodies. The effects of microgravity on the astronauts have many parallels with aging. Thus, these investigations have the potential to provide important health care advances for use on Earth. Additionally, non-invasive sensing, remote procedures, and early detection and diagnosis techniques will improve telemedicine capabilities on Earth and will support earlier detection and treatment of disease. To capitalize on the potential benefits, NASA and the National Cancer Institute (NCI) signed a Memorandum of Understanding in April 2000. The NASA-NCI joint program will promote and support biomedical research and will expedite biomedical technology advances, such as minimally invasive sensing and signaling of early molecular signs of cancer. Finally, biological concepts are transforming NASA's technology development. The integration of biology and technology, enabled with advances in nanotechnology and information technology, are leading to the system concepts that are self-healing, self-assembling, intelligent, evolvable, adaptive, and self-replicating. Ultimately, we may be able to develop and operate biomechanical systems at the molecular level. The possibilities are so unlike anything we have previously dreamed that one one might be tempted to dismiss them as unrealistic. But as Dr. Ed Weiler, NASA Associate Administrator for Space Science, has often said, "The Universe is boundless and the discoveries unlimited."