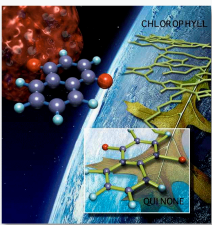


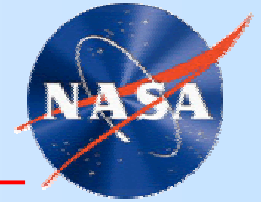
NASA's Grand Vision

Exploration of Life in the Universe

**... and sharing the adventure of
discovery with all humanity**



Exploration Grand Challenges: **Process and Personnel**



The Decade Planning Team's *Exploration Grand Challenges* are intended to be Agency-wide and incorporate the priorities of NASA's science and exploration enterprises.

The goal is to articulate the motivation for space exploration in a manner that is both credible to professionals and understandable to the general American public.

These exploration challenges were developed from the current and near-future Agency and Enterprise strategic plans, while incorporating the philosophy of the Decade Planning Team.

Participants

Harley Thronson (Code S; DPT Senior Science Manager)

Mary Cleave (Code Y)

Roger Crouch (Code U)

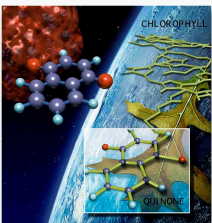
Jim Garvin (GSFC/Code S; DPT Lead)

Lika Guhathkurta (Code S)

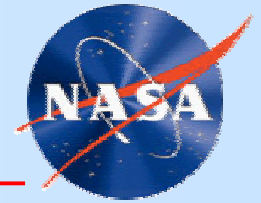
Lynn Harper (NASA ARC)

Jack Kaye (Code Y)

Julie Swain (Code U)

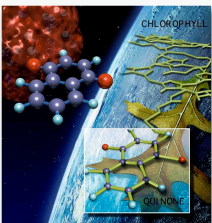


NASA's Exploration Grand Challenges

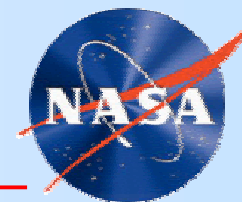


Scope and Content

- **These Agency-wide goals are the core justification for space exploration**
- **The Exploration Grand Challenges consist of fundamental questions of discovery, science, and the human development of space**
 - **The EGCs are derived directly from Enterprise and Agency strategic plans**
 - **The EGCs do *not* include challenges related directly to aeronautics, technology, economics, or public outreach, which are handled by the DPT as *enablers* to space exploration**
- **Exploration destinations are derived from the EGCs as vantage points to carry out exploration and scientific discovery**



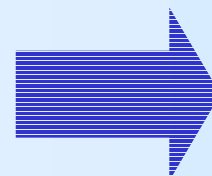
The NASA Strategic Plan and Products of the DPT



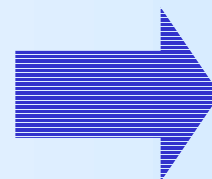
Agency Fundamental Questions

- [1] Formation of the Universe, galaxies, stars, and planets, and understanding of physics, chemistry, and biology.
- [2] Earth-like planets and life outside the Solar System.
- [3] Utilization of knowledge about the Sun, Earth, and other planets, and development of capabilities for environmental and climatological protection.
- [4] The fundamental role of gravity and cosmic radiation in biomedical systems in space, and application of knowledge to establish human presence in space.
- [5] Enable revolutionary technological advances to enable air and space travel for anyone, anywhere, anytime.
- [6] Technologies to enable the Agency research agenda, and transfer of scientific and technological information to the commercial sector.

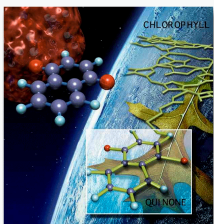
DPT Product



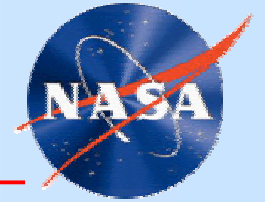
Exploration
Grand Challenges



Exploration
Technology Strategy



NASA's Exploration Grand Challenges

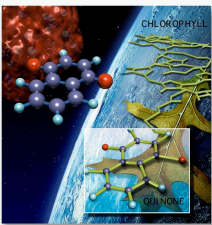


NASA's mission is to ***explore*** the cosmos, to ***enable*** humanity to travel safely into space, and to ***reveal*** our discoveries for the benefit of life on Earth.

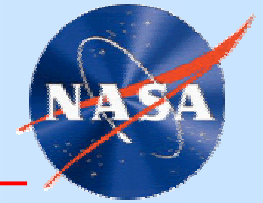
NASA's motivation for exploration is that space provides a unique perspective on our planet, other worlds, the Universe . . . and ourselves.

The imperative for space exploration can be articulated by three questions:

- **How did we get here?**
- **Where are we going?**
- **Are we alone?**



The Exploration Grand Challenges: **The Pursuits**



NASA's Grand Vision: *Exploration of Life in the Universe*

How Did We Get Here?

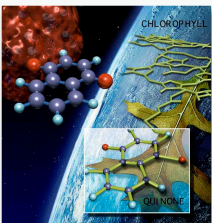
- Look backward in time to the early Universe [S]
- Reveal and understand the laws of nature [U,S]
- Determine the role of gravity and other fundamental processes in the origin and evolution of life [U]
- Explore the history of the Solar System [S, HEDS]
- Understand the origin of solar variability and its effect on Earth [Y,S]
- Explore the paths of life on the Earth [Y, S]

Where Are We Going?

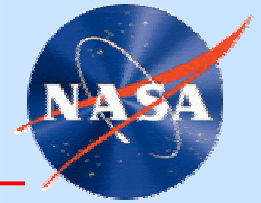
- Understand the future habitability and sustainability of the Earth [Y]
- Expand the human presence beyond the vicinity of the Earth [HEDS]

Are We Alone?

- Reveal the cycles of life in the Universe [Y, U, S]
- Search for life in the Solar System [HEDS, S]
- Search for life in the Universe [S]



Exploration Grand Challenges and the NASA Enterprises



HEDS

- Expand the human presence beyond the vicinity of the Earth
- Explore the history of the Solar System
- Search for life in the Solar System

*... and which makes possible our most indispensable capability for exploration:
human participation*

Code Y

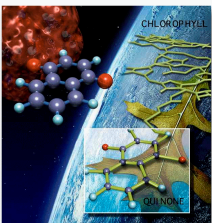
- Understand the origin of solar variability and its effect on Earth
- Explore the paths of life on the Earth
- Understand the future habitability and sustainability of the Earth
- Understand the cycles of life in the Universe

Code U

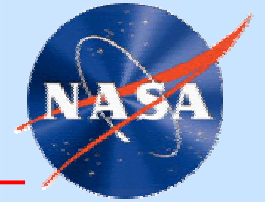
- Reveal and understand the laws of nature
- Determine the role of gravity and other fundamental processes in the origin and evolution of life
- Reveal the cycles of life in the Universe

Code S

- Look backward in time to the early Universe
- Reveal and understand the laws of nature
- Explore the history of the Solar System
- Understand the origin of solar variability and its effect on Earth
- Understand the future habitability and sustainability of the Earth
- Explore the paths of life on Earth
- Reveal the cycles of life in the Universe
- Search for life in the Solar System
- Search for life in the Universe



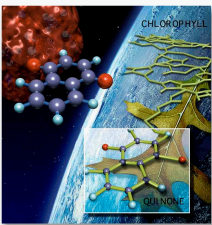
How did we get here?



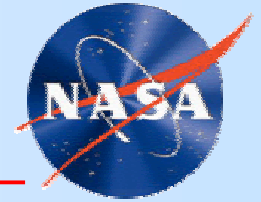
- Look backward in time toward the early Universe

Explore the Universe, from the formation of the first atoms, stars, and galaxies to the local neighborhood of the Milky Way

- **How did the first stars and galaxies form, and what were they like?**
- **What is 'dark matter' and 'dark energy', and how are both related to the structure and fate of the Universe?**
- **What produced the structure that we find in the Universe today, from the largest to the smallest scales?**



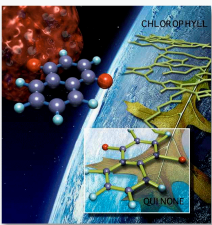
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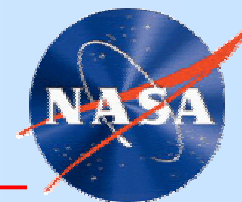
- **Reveal and understand the laws of nature**

Use the Universe as a laboratory to discover the fundamental principles of physics, chemistry, and biology in the widest range of environments found in nature

- **What are the most extreme events in the Universe?**
- **Are there new insights into nature, which might be revealed by exploring extreme environments throughout the Universe?**
- **What are the biologically and chemically important events in the Universe?**
- **What are the fundamental principles of biology?**



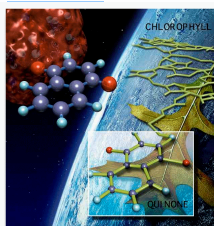
How did we get here?



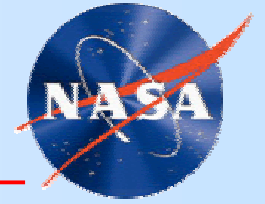
- **Determine the role of gravity and other fundamental processes in the origin and evolution of life**

Understand the importance of gravity on biological systems of all sizes and complexity

- **What are the effects of gravity and other fundamental processes at the cellular level?**
- **What are the effects of gravity and other fundamental processes on complex living organisms?**
- **What terrestrial processes are enhanced in a low-gravity environment?**



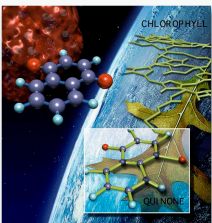
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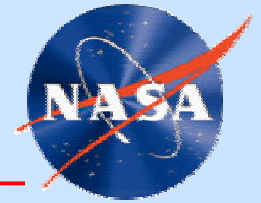
- **Explore the history of the Solar System**

Determine how our Solar System formed and evolved

- **What were the early conditions of our Solar System?**
- **What are the evolutionary differences among the planets?**
- **What is the evolutionary history of the “habitable zone,” where liquid water exists in the Solar System?**
- **What are the key markers in paleo-planetology that can be used to derive the history of the members of the Solar System?**



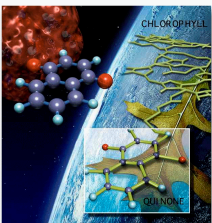
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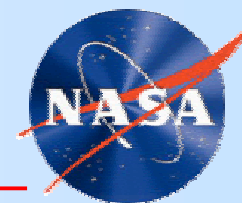
- Understand the origin of solar variability and its effect on Earth

The Sun's variability, on all timescales, is a complex process that significantly affects its immediate vicinity.

- How and where do solar 'active regions' form and how do they evolve?
- What is the nature of the Sun's polar regions?
- What are the global magnetic field properties of the Sun?
- How do the Sun and Earth interact as a system?
- What have been the effects of the Sun throughout Earth's history?



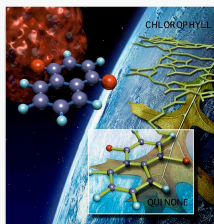
How did we get here?



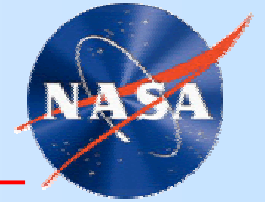
- **Explore the paths of life on the Earth**

Determine the history of the Sun, the Solar System, and the Earth, which led to the Earth's habitability and the origin(s) of life

- **What was the origin and early evolution of life on Earth?**
- **How does the Earth's 'life support system' work?**
- **What was the effect of changing environments on life on Earth, and the effect of life on the environment?**
- **What were the fundamental characteristics of major biological events in Earth's evolution (e.g., origin(s), the appearance of multi-cellularity, Pre-Cambrian explosion, intelligence, etc)?**



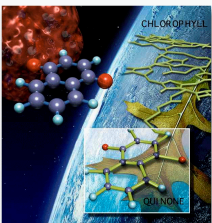
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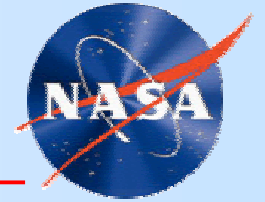
- **Understand the future habitability and sustainability of Earth**

Determine the major natural and human-generated processes that affect the ability of the Earth to sustain life

- **What are the major natural forces that affect the global ecosystems and the climate of the Earth?**
- **What is the effect of human activity on the environment and ecosystems of the Earth?**
- **How does the Earth system change over time, and what are the potential impacts of these changes on human civilization?**
- **How can we best predict ecological trends from a local to a global scale?**
- **How does solar variability affect life and society?**
- **How can we best insure survival of life on the Earth?**



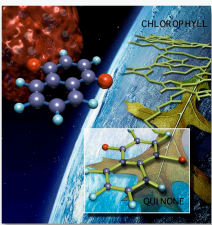
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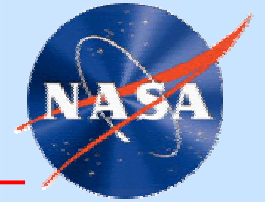
- **Expand the human presence beyond the vicinity of the Earth**

Make it possible for safe human exploration of the Solar System, including the development of essential capabilities for habitation beyond the immediate vicinity of the Earth

- **How can robotic explorers create a "virtual presence" throughout the Solar System as a precursor, enabler, and complement to human space travel?**
- **What are the key steps that must be taken for permanently safe and productive human habitation beyond Earth?**
- **What resources are available for human use in space?**
- **How will planetary exploration affect humanity's future?**



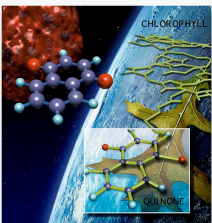
Are we alone?



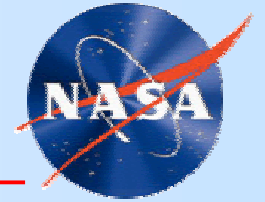
- **Reveal the cycles of life in the Universe**

Understand the universal principles and processes that are necessary for life

- **How is organic material produced in the cosmos and what forms does it take?**
- **What are the fundamental characteristics of life (e.g., origin(s) and early evolution, frequency, use of energy and nutrients, impact on environment, etc)?**
- **What is the range of terrestrial, planetary, and cosmic environments that provide the necessary conditions for life, and under what conditions can life flourish?**
- **What is the distribution of organic and biogenic material and how is it incorporated into planets?**



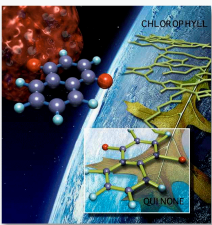
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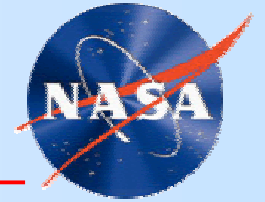
- **Search for life in the Solar System**

Search for life on Mars and in promising worlds in the outer Solar System

- **Did life ever arise on Mars or elsewhere in the Solar System?**
- **Do other locations in the Solar System harbor the potential for life?**



Are we alone?



- Search for life in the Universe

Determine the frequency and location of life in the Universe, and the relationships between stars and planets under which life can originate

- **What are the fundamental processes of planetary and stellar formation and evolution?**
- **How common are planets like the Earth?**
- **What are the fundamental characteristics of stars and planetary systems that affect the habitability of their environment?**
- **Is there life elsewhere in the Universe?**
- **Is there intelligent life elsewhere in the Universe?**

