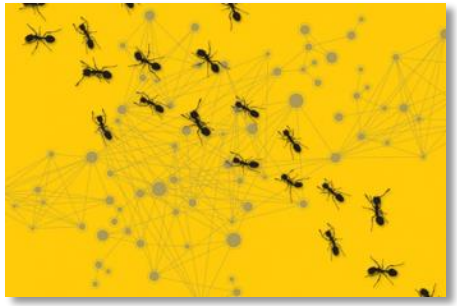


NASA Mission and Applications of Biomimicry

Biomimicry Summit and Education Forum (BSEF) for Aerospace

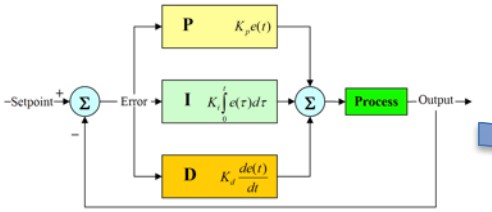
2 August 2016

Craig E. Kundrot, Ph.D.
Life Science Lead
Office of the Chief Scientist
NASA

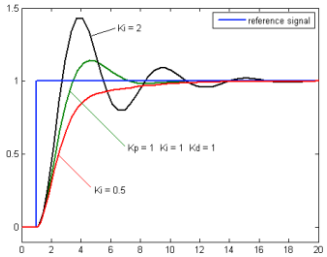
Foundational Differences

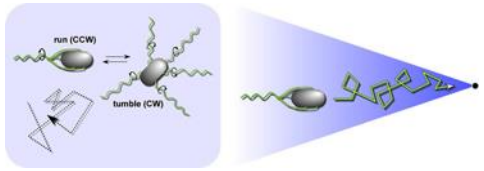
Engineers…	Life Scientists…
…design their systems	…reverse engineer Nature to understand the system
…use established frameworks to employ physical laws	…discover concepts and qualitative relationships before quantitating
…use quality controlled components	…study diverse individuals with diverse components
…design PID controllers	…discover biased walks in chemotaxis

design

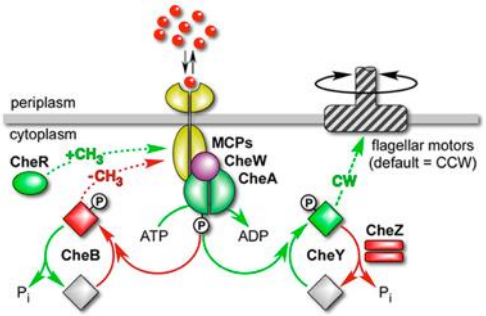


behavior



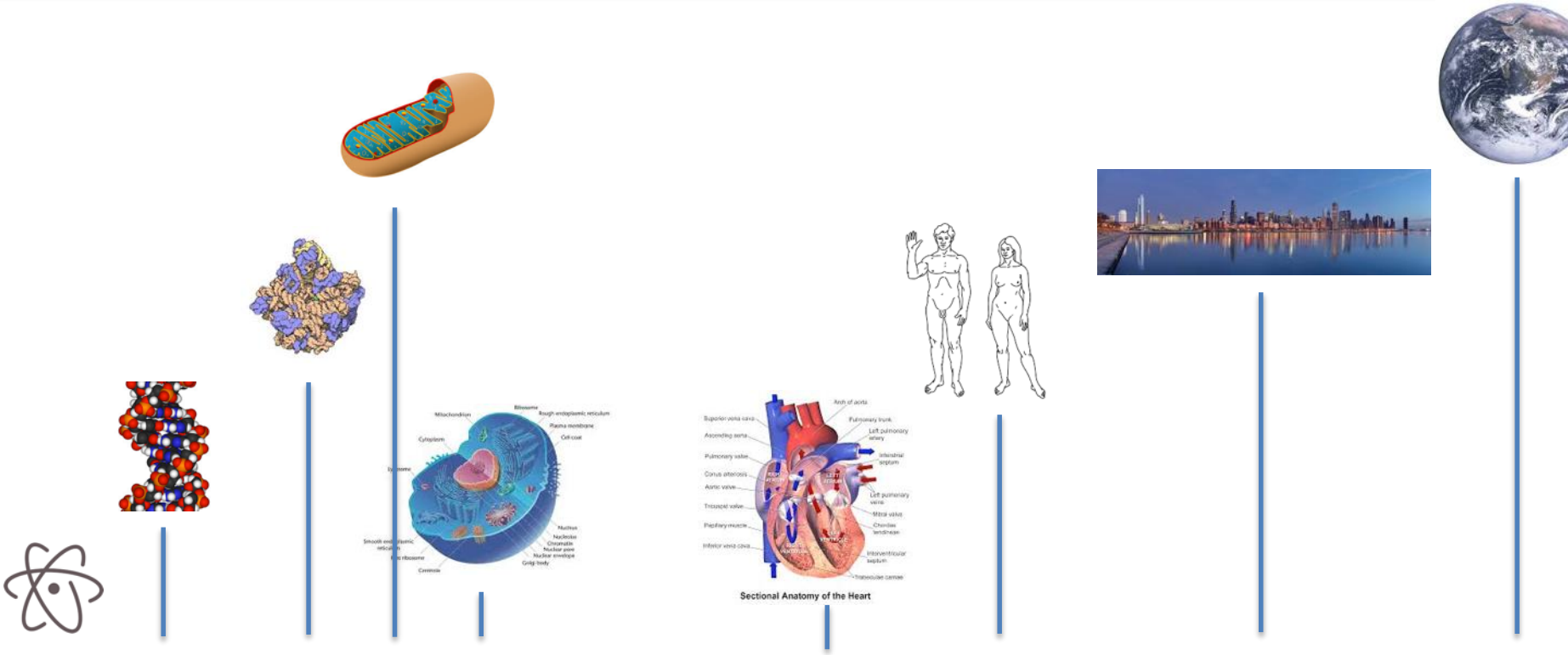


behavior



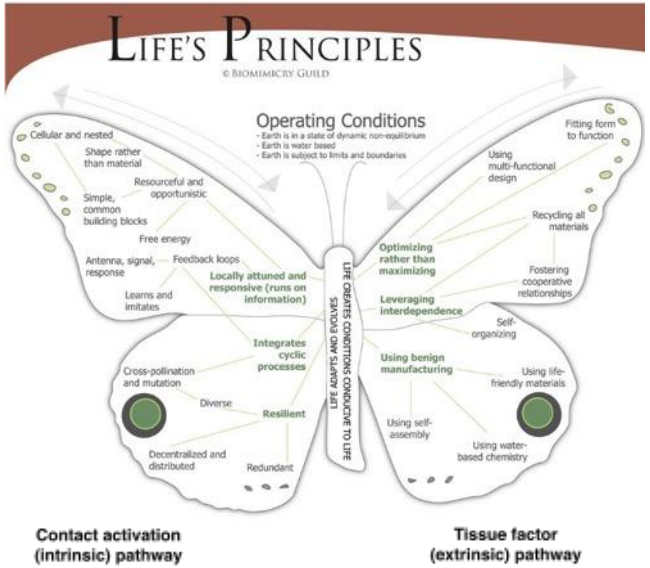
design

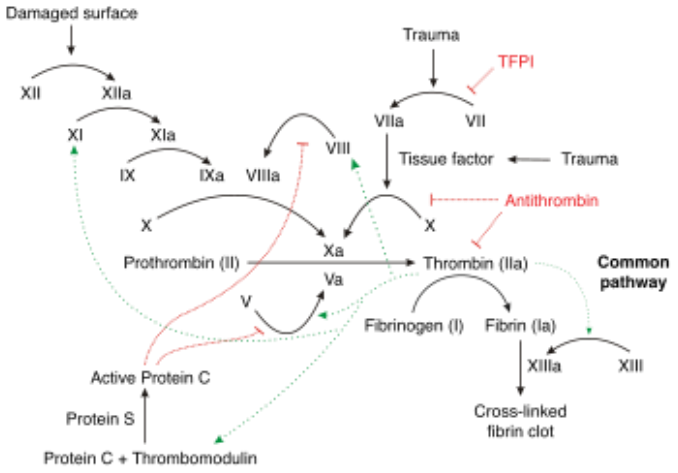
Levels of Biology

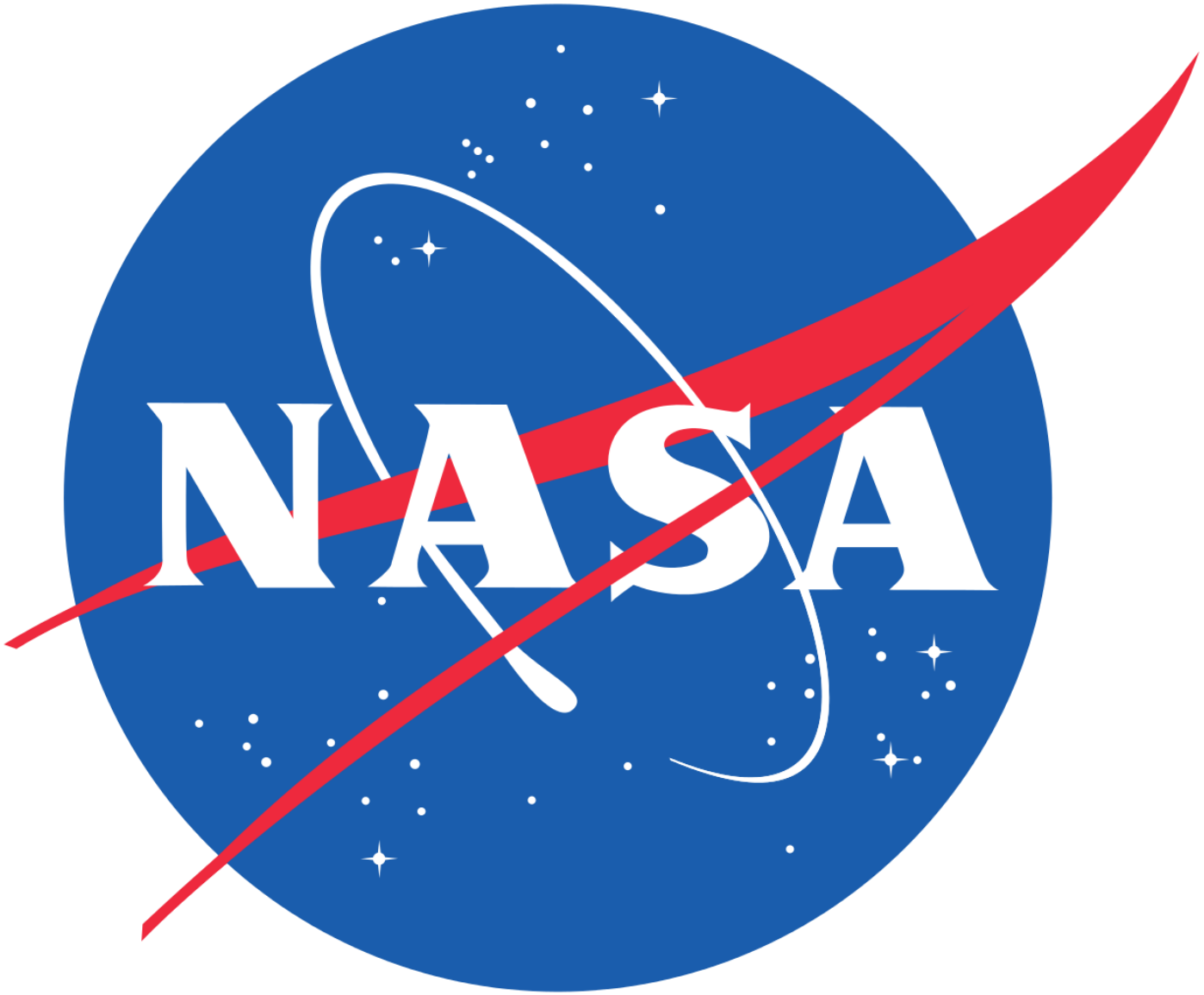


Some Types of Inspiration

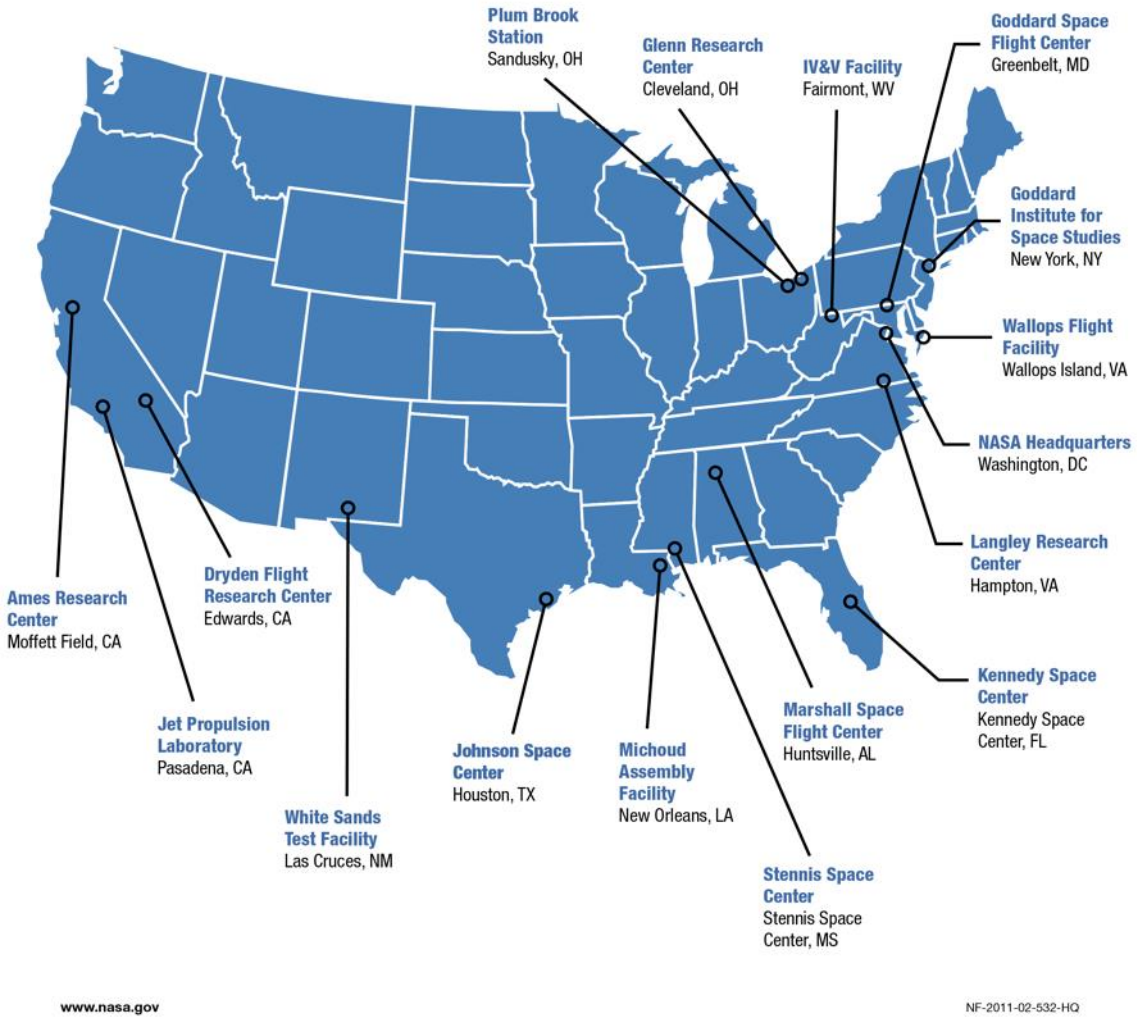
- Hardware solutions
  - Many examples
- Design Principles
  - Resiliency balanced against efficiency
    - Change in environment
    - Mutation
  - Multi-function components
  - Interconnected networks
  - Extensive control networks
  - Exponential amplification of
    - Signals
    - Components
    - Organisms
  - Demand driven synthesis, degradation and replication
  - Autonomy






NASA

Ten Centers
Several Installations

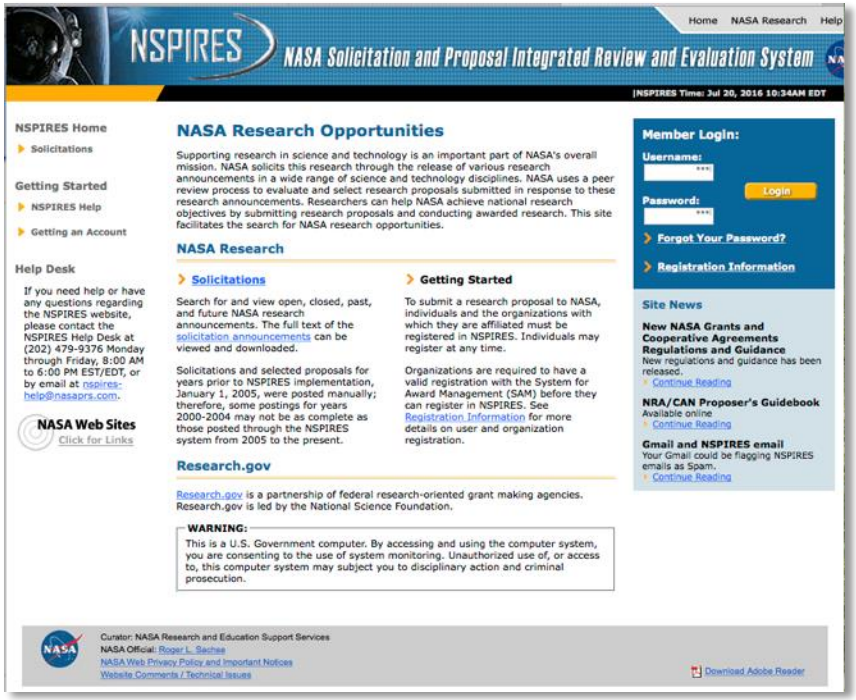


Four Mission Directorates

1. Aeronautics
2. Human Exploration and Operations
3. Science
4. Space Technology

Cheat Sheet

- NASA research opportunities are announced on NSPIRES
  - nspires.nasaprs.com



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Aeronautics

- Meet global demand for air mobility
  - environmentally friendly
  - sustainable
- Embrace revolutionary technology from outside aviation

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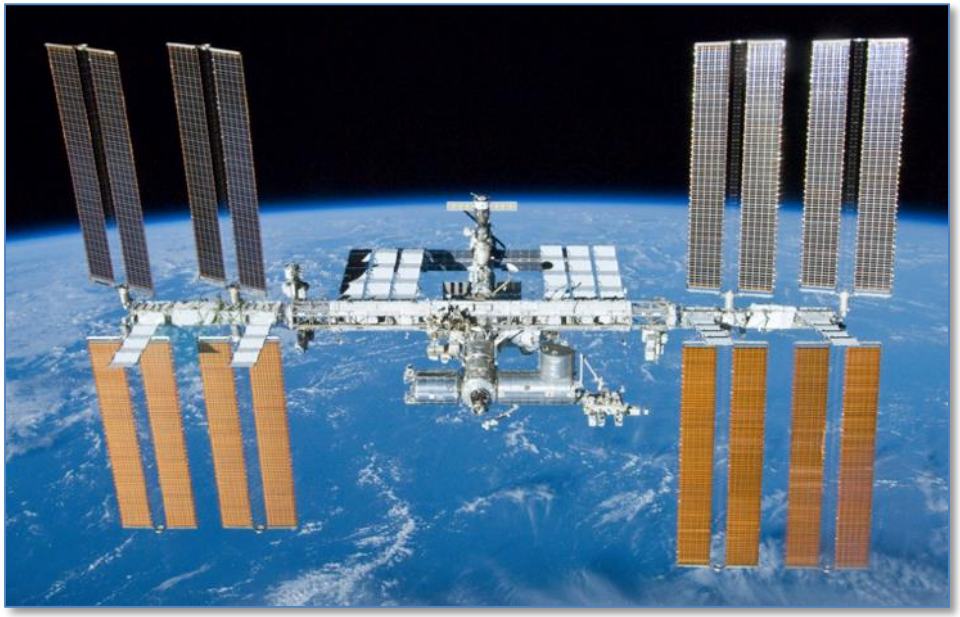
Human Exploration and Operations

Focuses on

- International Space Station operations
- Development of commercial spaceflight capabilities
- Human exploration beyond low-Earth orbit



HEO Programs

- Operations
  - International Space Station
  - Launch Services
  - Space Communications and Navigation (SCaN)
- Commercial Space Transportation
- Exploration Systems Development
  - Space Launch System
  - Orion Spacecraft
  - Ground Systems Development
- Research and Technology
  - Advanced Exploration Systems
  - Space Life and Physical Sciences Research and Applications
  - Human Research Program

www.nasa.gov/directorates/heo/programs.html

HEO: AES

- Crew Mobility Systems (Space Suits)
- Habitation Systems
- Vehicle Systems
- Foundational Systems
  - Automated Propellant Loading
  - Autonomous Systems and Operations
  - Avionics and Software
  - Delay/Disruption Tolerant Networking
  - In-Space Manufacturing (ISM)
  - Ka-Band Objects Observation & Monitoring
  - Synthetic Biology Applications
- Robotic Precursor Activities

www.nasa.gov/content/aes-domains

HEO: HRP

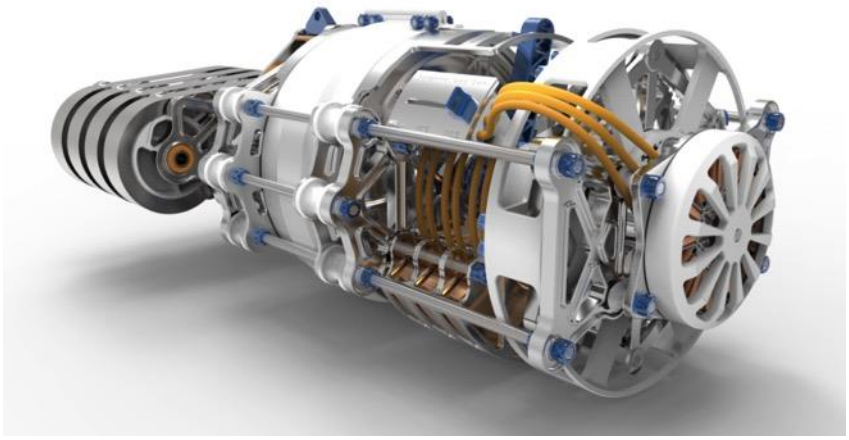
- Human Health Countermeasures
- Behavioral Health & Performance
- Exploration Medical Capability
- Space Human Factors and Habitability
- Space Radiation

www.nasa.gov/hrp/research

BioInspired Microgravity Exercise Concept

Orion capsule egress

Shuttle era rower



"BioInspired Microgravity Exercise Concept"

Key Question: Can we look to nature to provide insights to how to generate up to 400 lb force in a compact exercise device without using vehicle power?

Key Challenges Faced: Orion crew exercise is highly resource-constrained - low mass, low volume and completely unpowered solutions were sought using a "biomimetic" approach

Task Summary: Innocentive Challenge was run in 2015 with Human Research Program's (HRP) Advanced Exercise Concepts (AEC) Project and Center of Excellence for Collaborative Innovation (CoECI). 50 proposals received, 1 winner selected.

Results: The Bio-Inspired Micro-Gravity Exercise Concept (BIMGEC) was selected winner in Innocentive competition (2016). Consists of 3 major systems; Force Generation, Force Variation and Load Profile Variation. Uses notion of 'chameleon's tongue' collagen helical spiral, storing energy in a constant force spring.

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Science

- Explores
  - the Earth
  - solar system
  - universe beyond
- Charts the best route of discovery
- Reaps the benefits of Earth and space exploration for society

Science Divisions

- Earth
- Heliophysics
- Planetary
- Astrophysics

Research Opportunities in Space and Earth Sciences (ROSES) – 2015
Closes May 31, 2017

Science: Earth

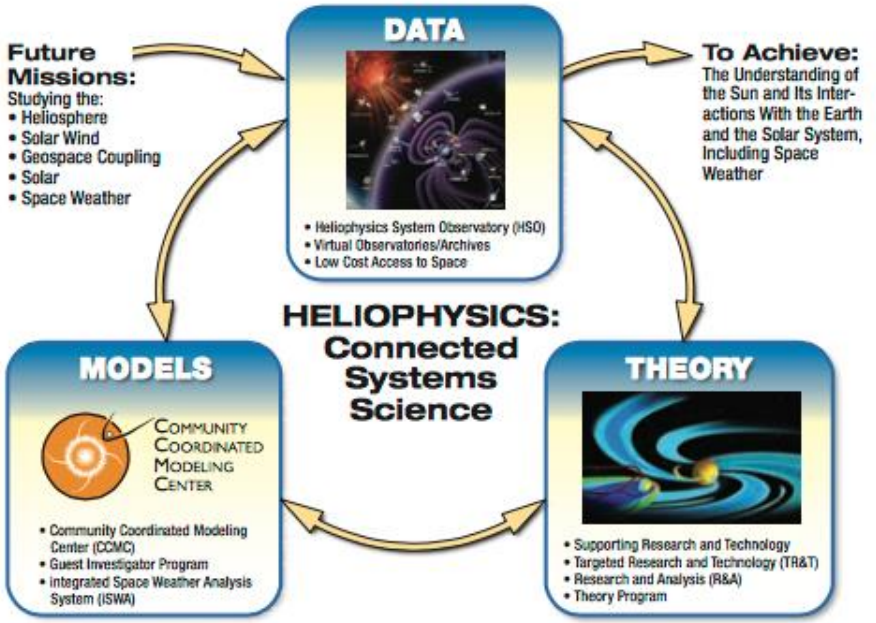
- Applied Sciences Program
  - appliedsciences.nasa.gov

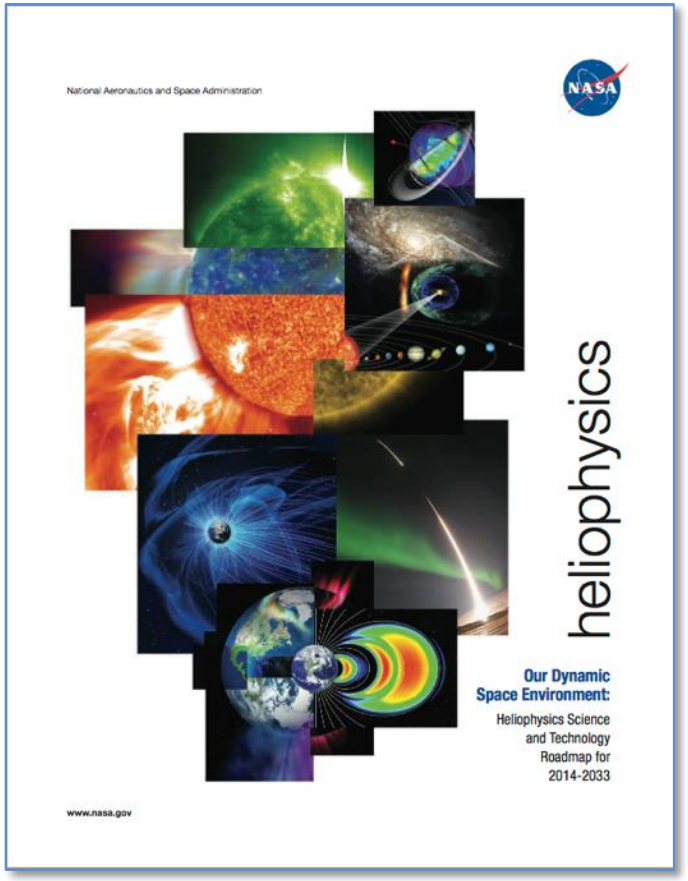
Next Generation AVIRIS Instrument Completes Successful First Flight

- Earth Science Technology
  - esto.nasa.gov

NASA satellite data on harmful algal blooms such as this recent bloom in Lake Erie help local authorities assess public health risks and target responses.
Credits: NASA

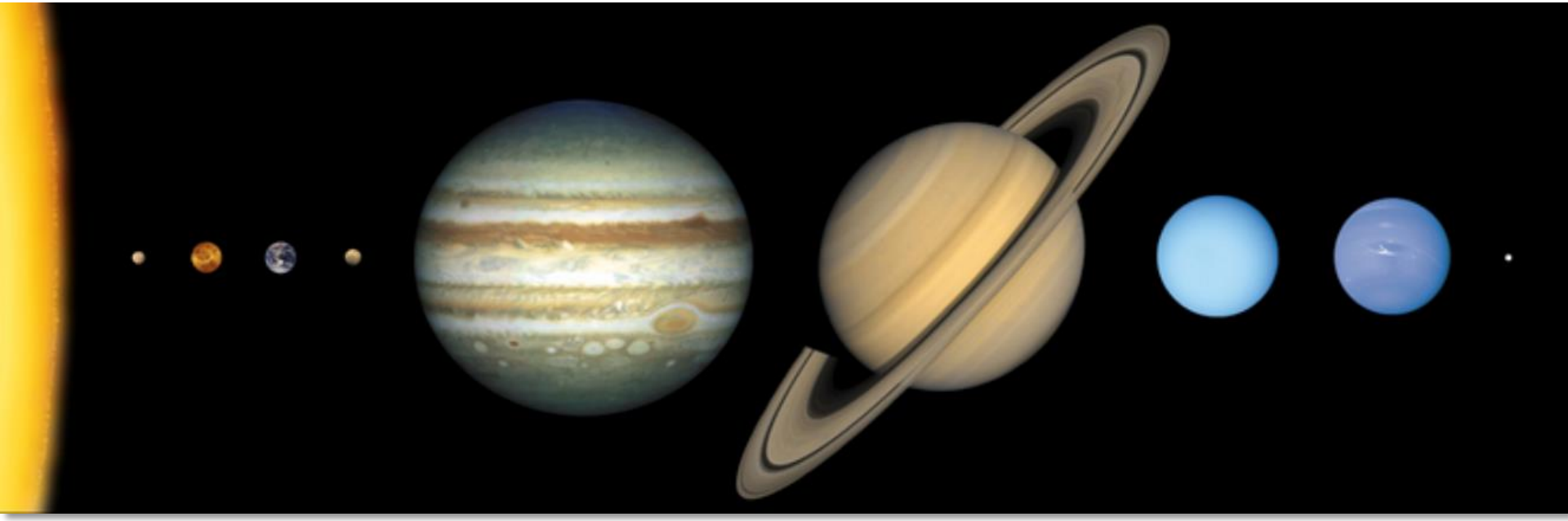
Science: Heliophysics





science.nasa.gov/media/medialibrary/2015/04/07/2014_HelioRoadmap_Final_Reduced.pdf

Science: Planetary



solarsystem.nasa.gov

An Entomopter on Mars

An Entomopter is a vehicle that flies through the generation of lift in a fashion similar to that of an insect. It is based on very low Reynolds number aerodynamics and can be applied to flight on Mars.

At very low Reynolds numbers lift generation mechanisms are unique to insects and applying this to the Mars environment would enable:

- An Entomopter to have the ability to take off, fly, land and possibly hover.
- An Entomopter to be capable of slow flight and precision flight control.
- The Mars environment may be ideal for Entomopter flight:
  - Low atmospheric density means a larger vehicle (≈ 1 m wingspan) is in the same very low reynolds number environment as insects on earth, which reduces the need for miniaturization, increases lifting capacity
  - Low gravitational force (1/3 that of Earth) increases the potential flapping frequency and reduces the required wing loading

Courtesy: Anthony Colozza

Science: Astrophysics

- Balloon program
  - www.nsbf.nasa.gov/index.html
- Sounding rocket program
  - rscience.gsfc.nasa.gov/index.html
- Astrophysics Division Technology
  - science.nasa.gov/technology/astrophysics-division-technology/

science.nasa.gov/astrophysics/

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Space Technology

- Rapidly
  - develops
  - innovates
  - demonstrates
  - infuses
- Technologies
  - revolutionary
  - high-payoff
- Enable NASA's future missions
- Provide economic benefit to the nation

STMD Programs

- CENTENNIAL CHALLENGES
- CENTER INNOVATION FUND
- FLIGHT OPPORTUNITIES
- GAME CHANGING DEVELOPMENT (GCD)
- NASA INNOVATIVE ADVANCED CONCEPTS (NIAC)
- REGIONAL ECONOMIC DEVELOPMENT
- THE SMALL BUSINESS INNOVATION RESEARCH (SBIR) AND SMALL BUSINESS TECHNOLOGY TRANSFER (STTR)
- SMALL SPACECRAFT TECHNOLOGY PROGRAM
- SPACE TECHNOLOGY RESEARCH GRANTS
- TECHNOLOGY DEMONSTRATION MISSIONS (TDM)

www.nasa.gov/directorates/spacetech/programs

STMD Solicitations

- Space Technology Research, Development, Demonstration, and Infusion (REDDI)
  - October 1 release
- Utilizing Public-Private Partnerships to Advance Tipping Point Technologies Draft Appendix
  - Responses due July 25, 2016
- Early Stage Innovations NASA Research Announcement
  - Proposals due July 1, 2016
- Game Changing Development High Performance Spaceflight Computing (HPSC) Processor (NNG161574410R) Presolicitation
  - Comments on the draft solicitation due May 23, 2016
- Space Technology Research Institutes Appendix
  - Final appendix released on or about July 1, 2016

www.nasa.gov/directorates/spacetech/solicitations

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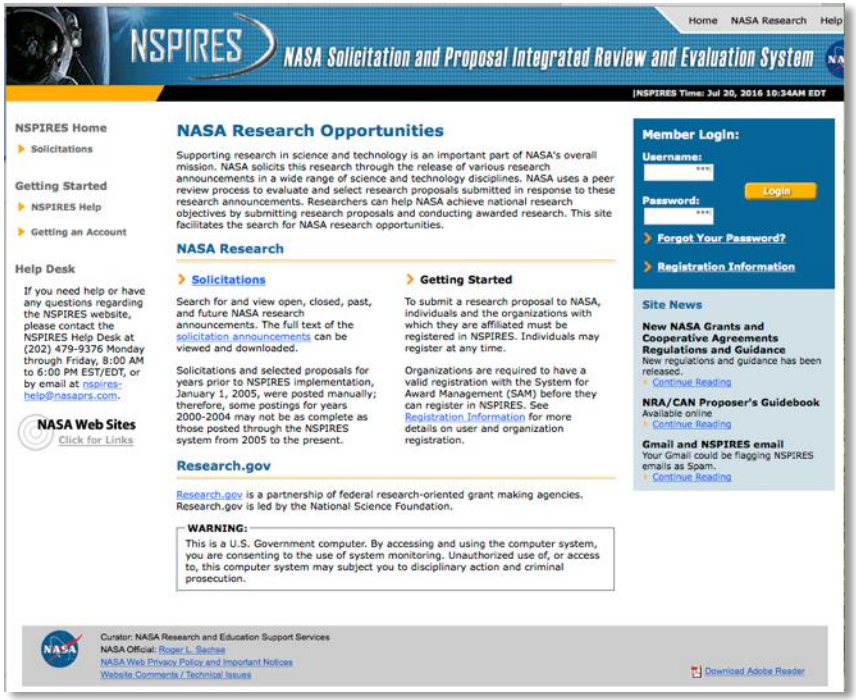

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Conclusion

- The deep differences in design principles between traditional human-engineered systems and biological systems at various scales are a motivation for biomimicry

- Biomimicry can be applied to problems in all four of NASA's Mission Directorates

- NASA research solicitations are posted in NSPIRES: nspires.nasaprs.com