



Third Workshop NanoMed Berlin

February 17, 2003

The NASA-NCI Initiative

on

Biomolecular Sensor Development

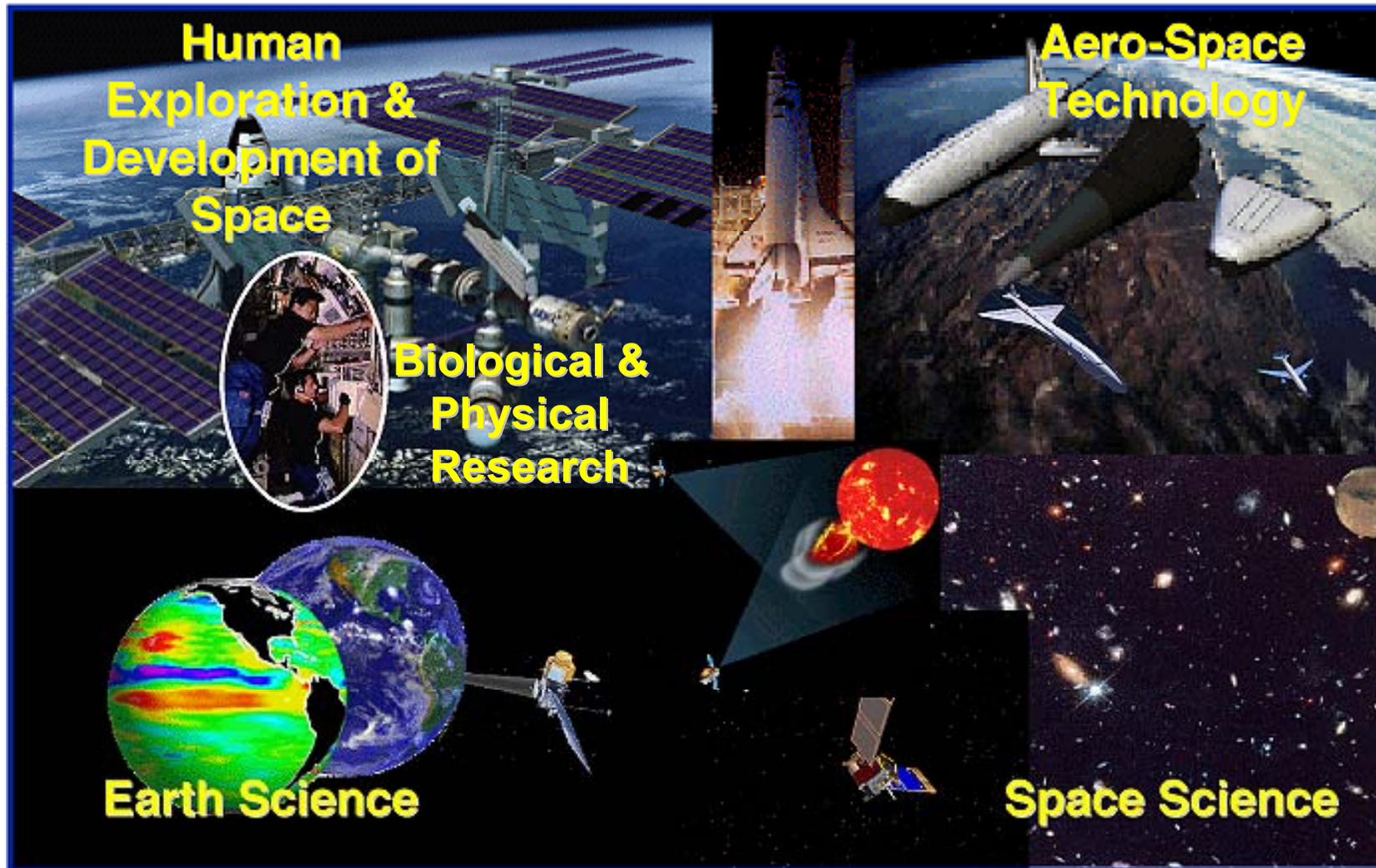


Minoo N. Dastoor
NASA



The NASA-NCI Initiative

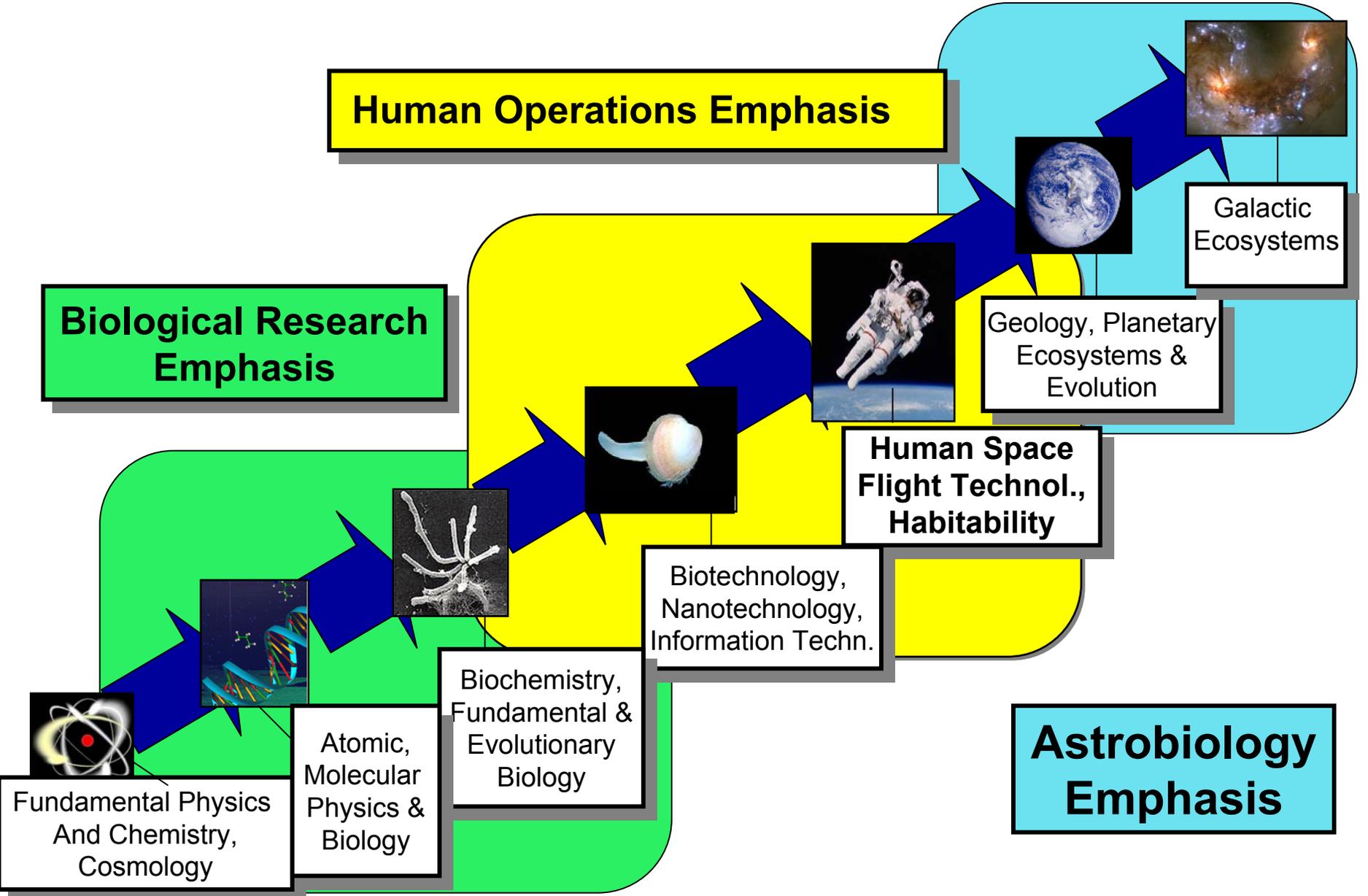
NASA's Strategic Enterprises





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Scope of NASA Biological Sciences Research





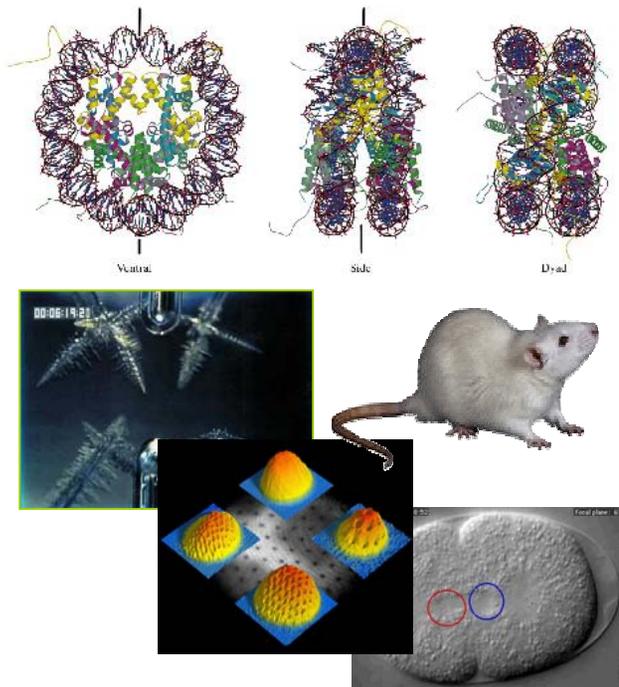
The NASA-NCI Initiative OBPR Fundamental Questions



Understanding Nature's forces in space

Goal: Use the space environment as a laboratory to test the fundamental principles of physics, chemistry and biology

Goal: Conduct research to enable safe and productive human habitation of space



Understanding and enabling the human experience in space

Goal: Conduct research to enable safe and productive human habitation of space

Goal: Enable and promote commercial research in space





The NASA-NCI Initiative Biomolecular Physics & Chemistry Program



The Biomolecular Systems Research Program is an integrated research program focused on developing molecular level technologies to monitor cellular signals and processes with applications to crew health and safety, basic biology research, life detection, planetary protection, and nanotechnology



The NASA-NCI Initiative

Biomolecular Systems Research



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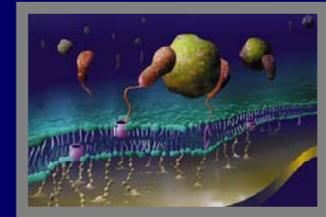
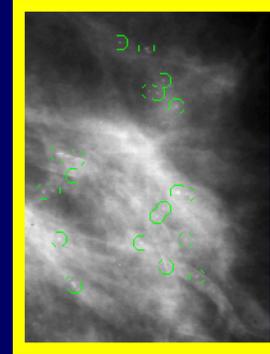
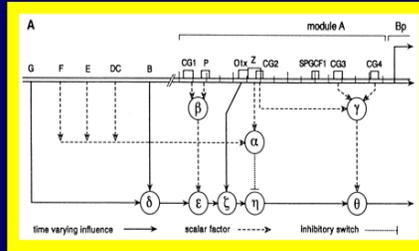
- Monitor cellular signatures and processes at the molecular level
 - Conduct long-term scientific research
 - Develop enabling technologies
 - Deliver prototype micro- and nano- systems for the detection, imaging, recognition and monitoring of biological signatures and processes at the molecular level
- Conducted in partnership with the National Cancer Institute (NCI)
- Cross-cutting Research: NASA Applications Include
 - Astronaut health and safety (Bioastronautics)
 - Detection of molecular signatures of life (Astrobiology)
 - Processing of biology related information (Bioinformatics)
 - Molecular scale systems engineering (Nanotechnology)
 - Planetary protection (Space Science)
- NCI applications are primarily in the area of in-vivo and minimally invasive methods for the early detection and treatment of cancers.



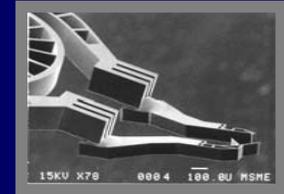
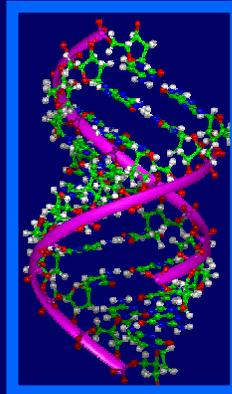
The NASA-NCI Initiative BioMolecular Systems Research Program



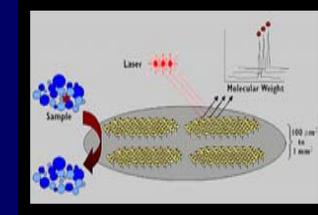
Biosignatures



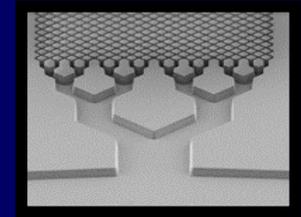
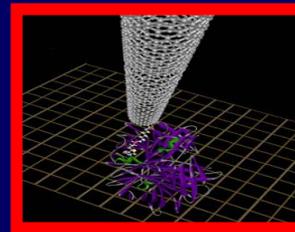
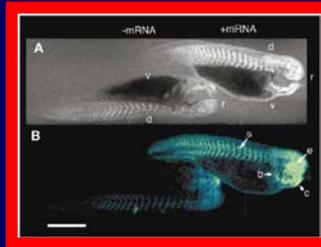
Signal Amplification



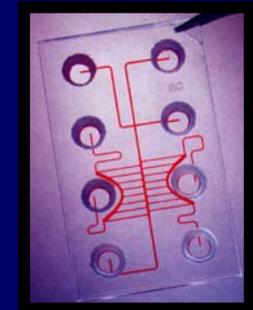
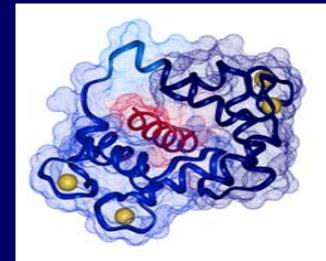
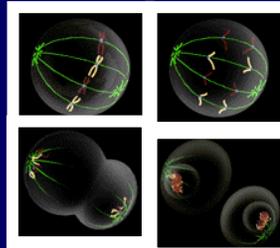
Biomolecular Sensors & Effectors:



Biomolecular Imaging



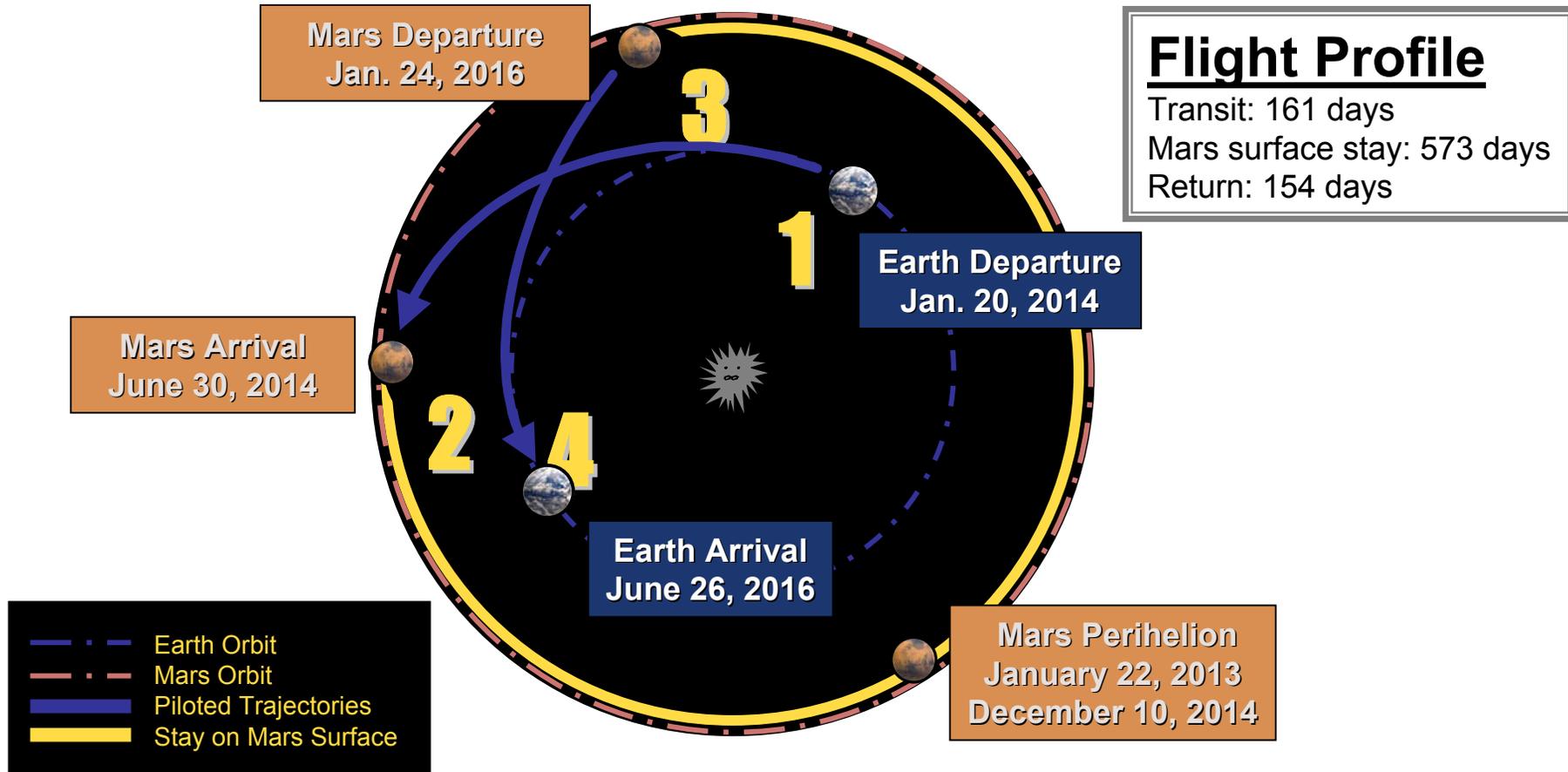
**Bioinformatics/
Info. Proc.**





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Typical Mars Design Reference Mission Scenario

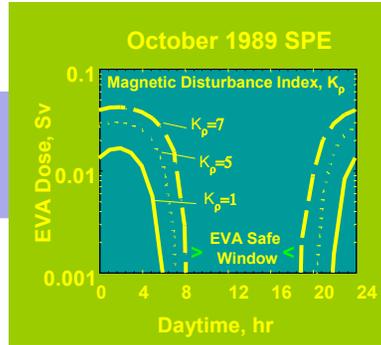


Nanoparticles with molecular biosensors are being developed to detect and treat radiation-damaged cells in astronauts. The nanoparticles containing DNA repair enzymes are targeted to cells which show increased expression of specific proteins in response to radiation dose.



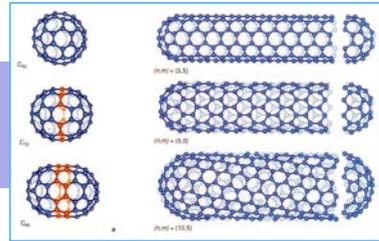
The NASA-NCI Initiative

Crew Health & Safety: Radiation Protection



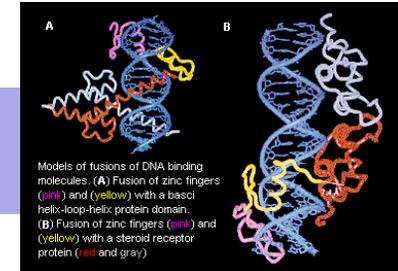
Flight rules

Now



Optimal shielding materials

10 years



Biomolecular Intervention

20 years

Application Missions

Uncertainty in cancer risk
Radiobiological database
Solar flare strategies
Model Validation

Short duration missions in low Earth orbit

600%
10% complete
40% complete
High altitude balloons

Extended missions in Earth's Neighborhood

120%
50% complete
75% complete
Int'l Space Station

Long-duration missions to more distant destinations

50%
100% complete
100% complete
Beyond Van Allen Belts

Leading Candidates Technologies:

- Biomolecular risk prediction; molecular surveillance
- New structural materials with optimal shielding properties with significant improvement over aluminum
- Electromagnetic shields, including electrostatic, magnetic, and plasma shields from innovative propulsive techniques
- Pharmacology: antioxidants, antisense drug discovery, ribozymes
- Biomolecular intervention, such as stem cell replacement

National Benefits:

- Contribution to the diagnosis, prevention and treatment of cancer.
- Potential application to infectious, chronic diseases.

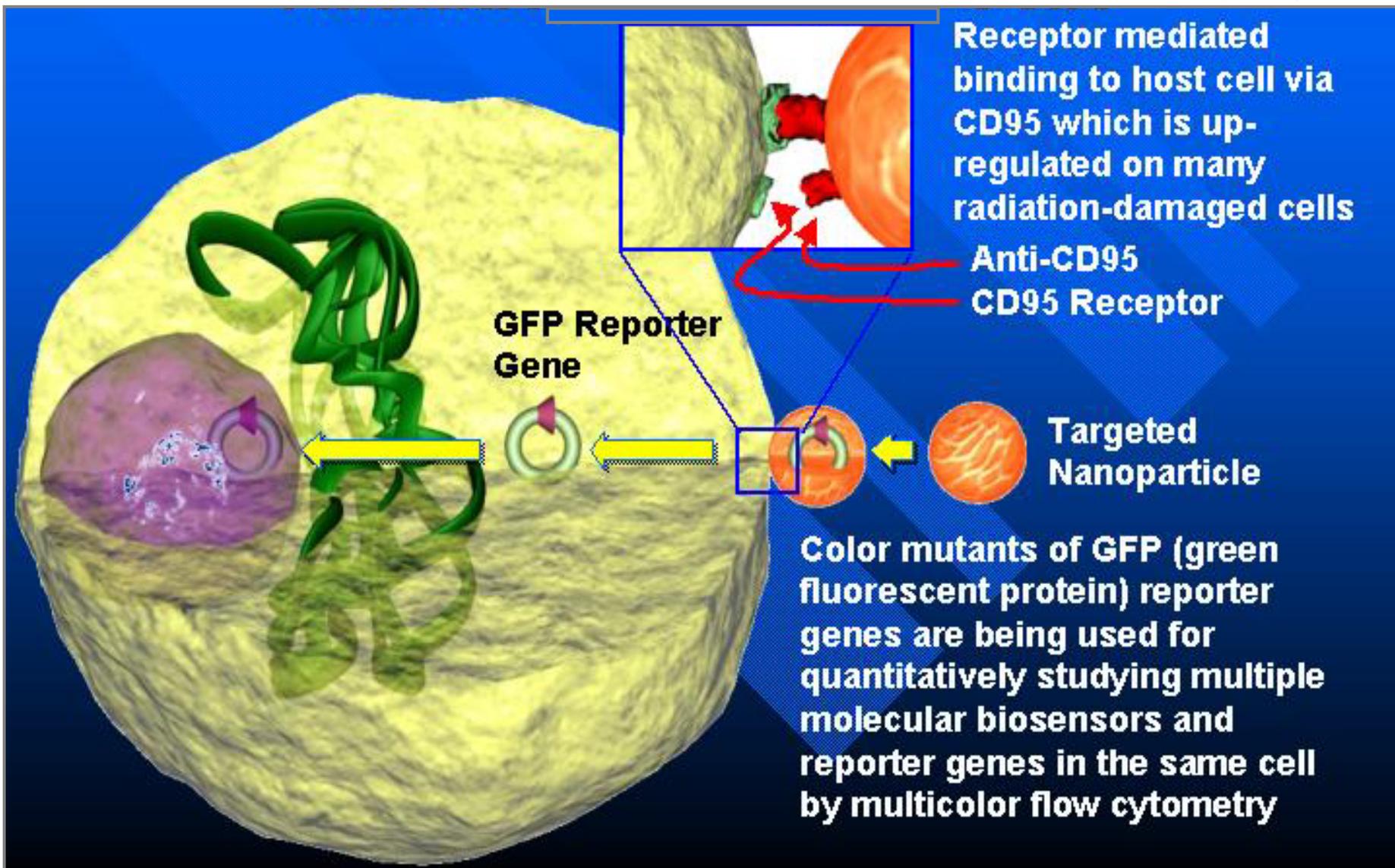


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Nanoparticle/Biosensor Targeting and
Delivery of DNA Repair Enzymes to Radiation-Damaged Cells



- James Leary, U. of Texas





The NASA-NCI Initiative



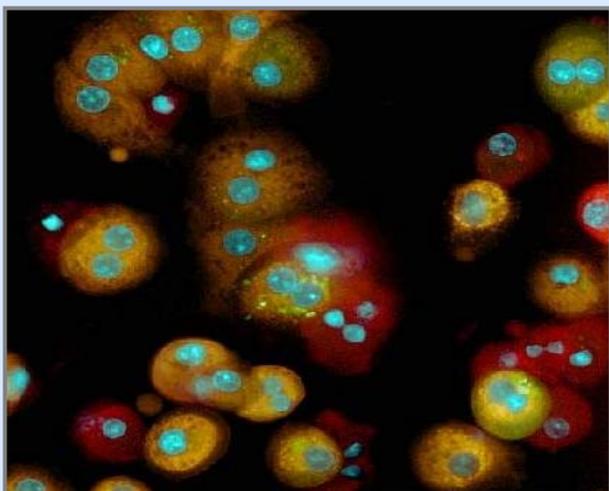
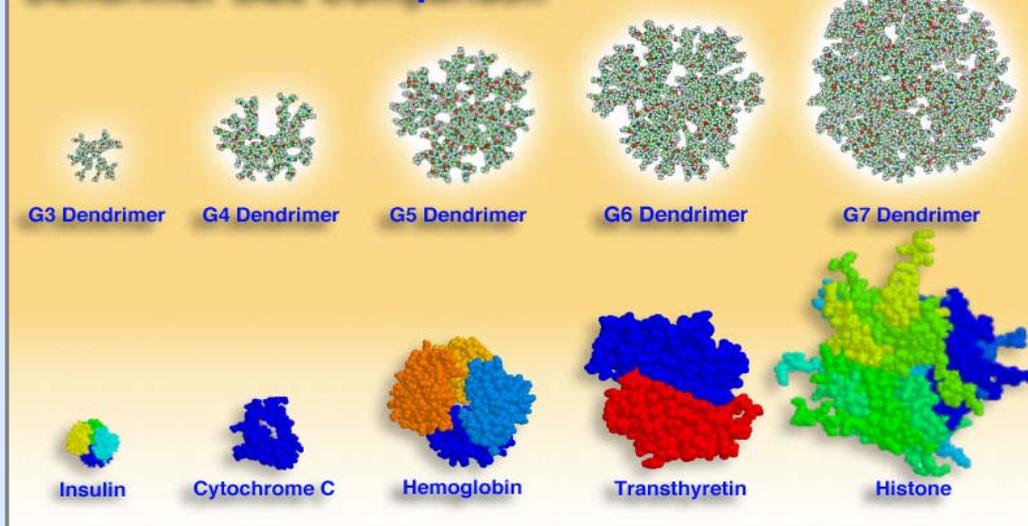
Fundamental Technologies for the Development of Biomolecular Sensors

- James R. Baker, Jr., U. of Michigan

Biomolecular Systems Research Program

Nanoscale dendritic polymers are the same size as Proteins and can be used to deliver materials to cells.

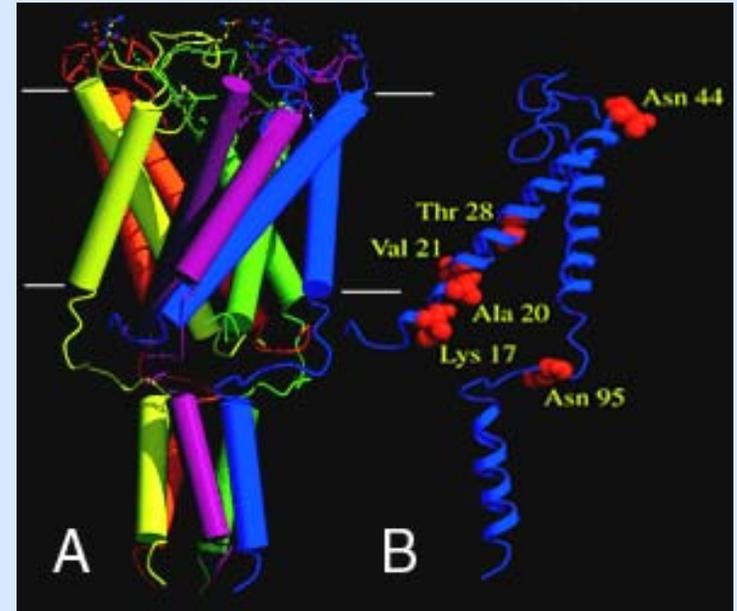
Dendrimer Size Comparison



Multiprobe fluorescence of isolated hepatocytes. The photograph is an example of the composite fluorescence of 4 probe with pseudocolor assigned to the corresponding peak emission characteristics of each dye. Nuclei are in blue (Hoechst 33342), lysosomes in green (lysotracker), mitochondria in orange (TMRM) and plasma membrane permeability

- Jay Nadeau, Victor White, NASA JPL

- Miniature Electronic Dynamic Ion Channel Sensor (MEDICS)
 - Interesting approach to using transmembrane ion channels as biosensors by stabilizing them in a physically supported lipid bilayer.
 - Research will provide a bridge linking the messy, water world of biology to the electronic technology of engineering.
 - Developing a useful biosensor based on ion channel proteins found the cell membranes is likely to eventually lead to a nearly perfect device: single channel molecules responds to single agonist molecules with a signal of 10-100 picoamps, with background noise of <0.5 pA.





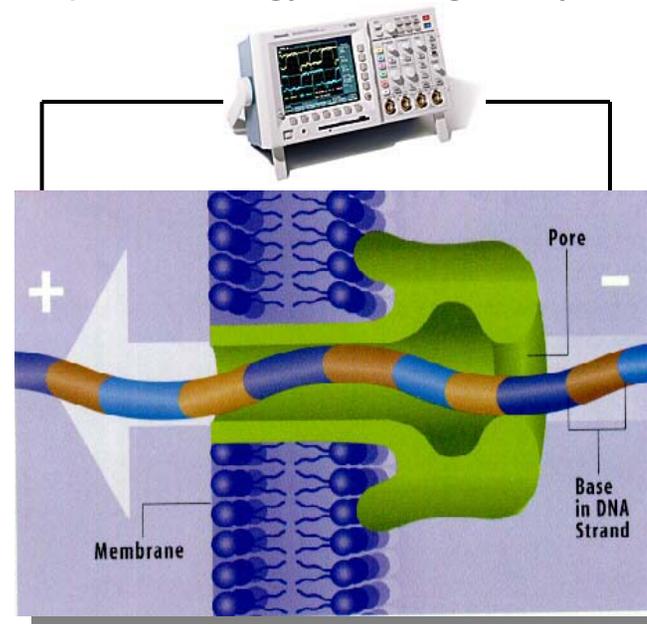
The NASA-NCI Initiative DNA Sequencing With Nanopores

- Viktor Stolc, NASA ARC

- Develop a device that can sequence single molecules of nucleic acid (DNA or RNA) at rate of million bases per second. Based on electrophoresis of charged DNA molecules through a solid state nanopore structure (~ 5 nm pore) made by nanofabrication techniques. Solid state nanopore structure believed to eliminate problems to previous methods using membrane/protein channels.
- Important research given the ever-increasing need in the biological community to perform higher throughput and less costly DNA sequencing, resequencing, and SNP identification and detection.
- Improvements to existing methods are required in order to have dramatic impact on the scale and number of DNA sequence projects in the future.
- The realization of this project will have enormous impact in biology, touching nearly every major discipline in the field.

- Nanopore in membrane (~2nm diameter)
- DNA in buffer
- Voltage clamp
- Measure current

G. Church, D. Branton, J. Golovchenko, Harvard
D. Deamer, UC Santa Cruz





The NASA-NCI Initiative BioMolecular Systems Research Program



JPL: Microdevices & Sensors, Advanced Environmental Monitoring & Control, Revolutionary Computing, Chemical AFM, CSMT

ARC: Fundamental Biology, Biomedical Advanced Technology Development, Information technology, Nanotechnology, Exobiology, Space life sciences ...

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Biomolecular Sensors and Effectors:

Bioinformatics/ Info. Proc.

Biosignatures

Biomolecular Imaging

Signal Amplification

Extramural emphasis

Integrated Micro-Nano Biomolecular Systems And Testbeds:
Resident programs & facilities:
nanotechnology, microdevices, information technology
Specific Technology Areas (systems technologies)
- sample mgmt
-sensing/detection
-information systems

External Agencies:

Biowarfare detection, Unconventional Innovations, Intelligent materials

Intramural emphasis

- Advanced Technology Development
- Advanced Environmental Monitoring & Control
 - Chemical & Macromolecular Biotechnology
 - Astrobiology
 - Multigen Biology
- ISS Fundamental Biology
- Planetary Protection
- Biomedical Research & Countermeasures
 - Advanced Life Support
 - Space Human Factors
 - Space Medicine
 - New Biology Initiatives
 - Patient Care
 - Novel therapies & research tools

Other Apps And Orgs