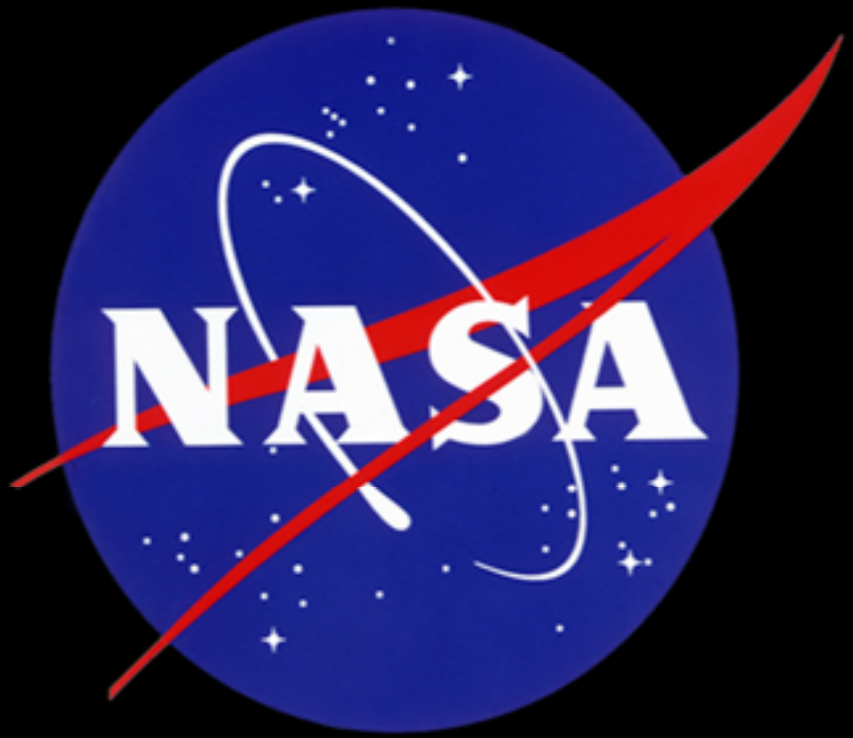


www.nasa.gov

Back to the Future

NASA Hits

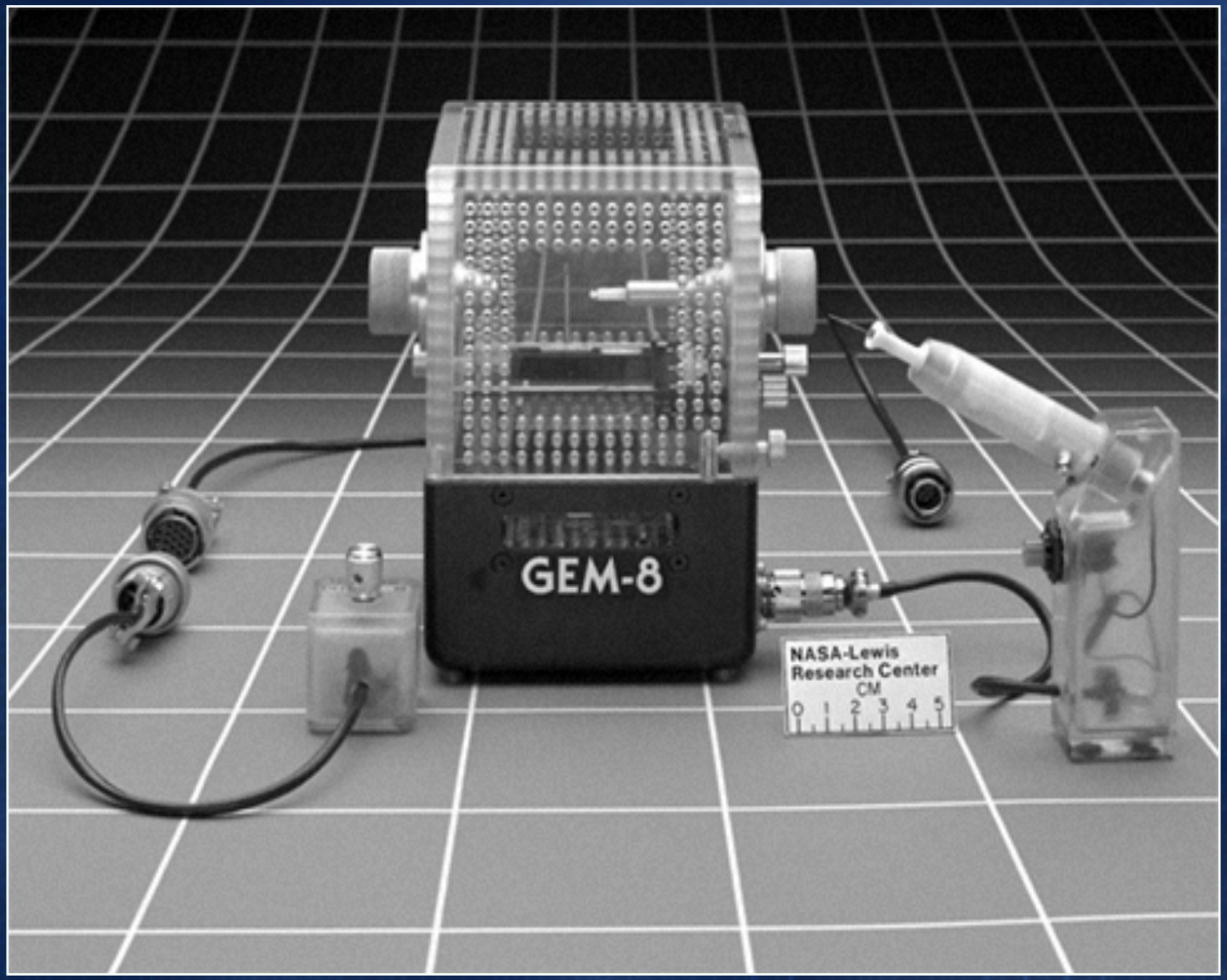
A Look at Some Shuttle Experiments

Extend Farraday's 19th Century Lectures

Would the candle burn in 0g?
And now the rest of the story…

NASA Hits

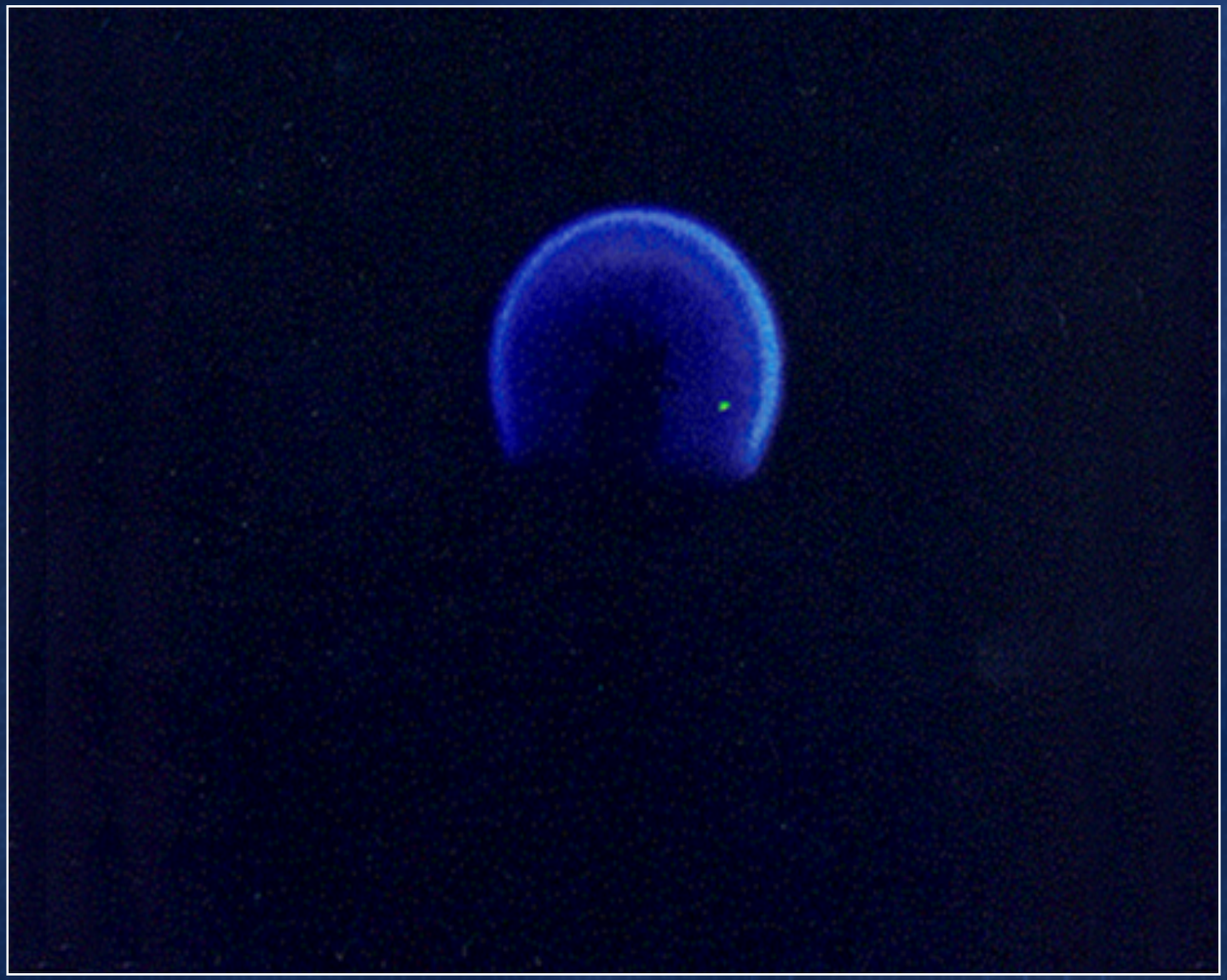
STS-50: Candle Flames in Microgravity



Better safe than sorry…

NASA Hits

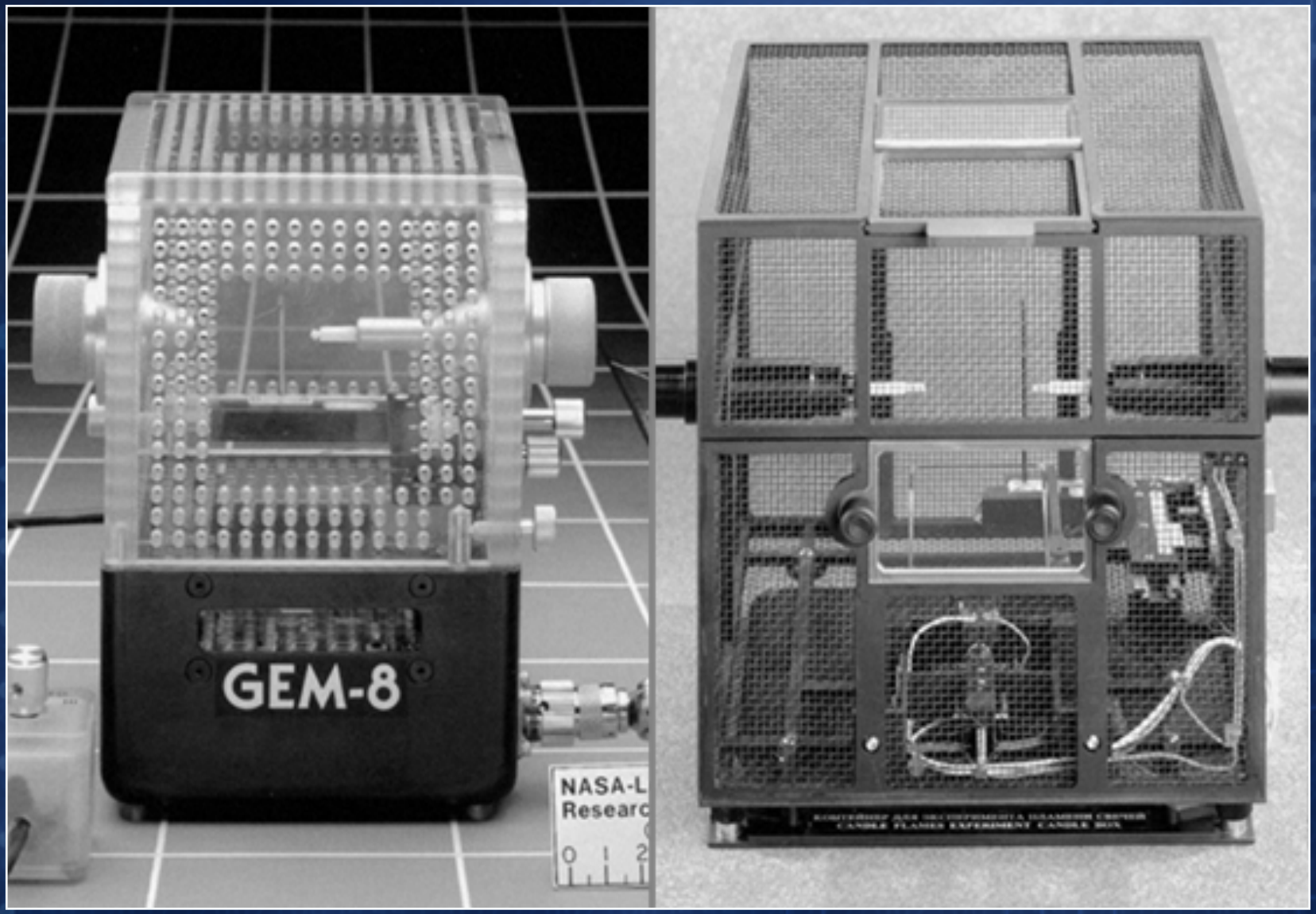
STS-50: Candle Flames in Microgravity



Round, as expected – it burned for 45 sec, but was it because of the box?

NASA Hits

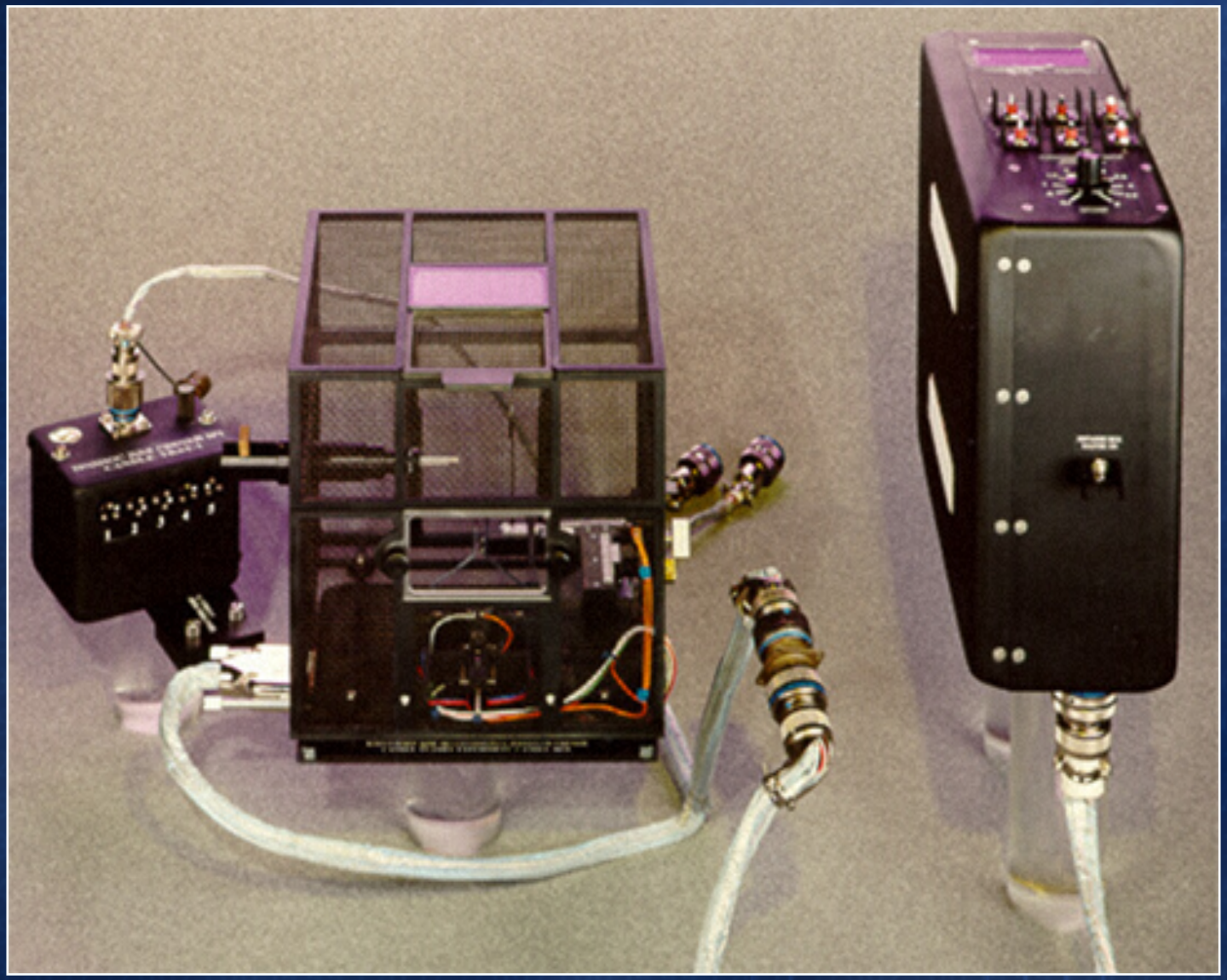
Re-Fly on Mir



More open, wire-mesh box

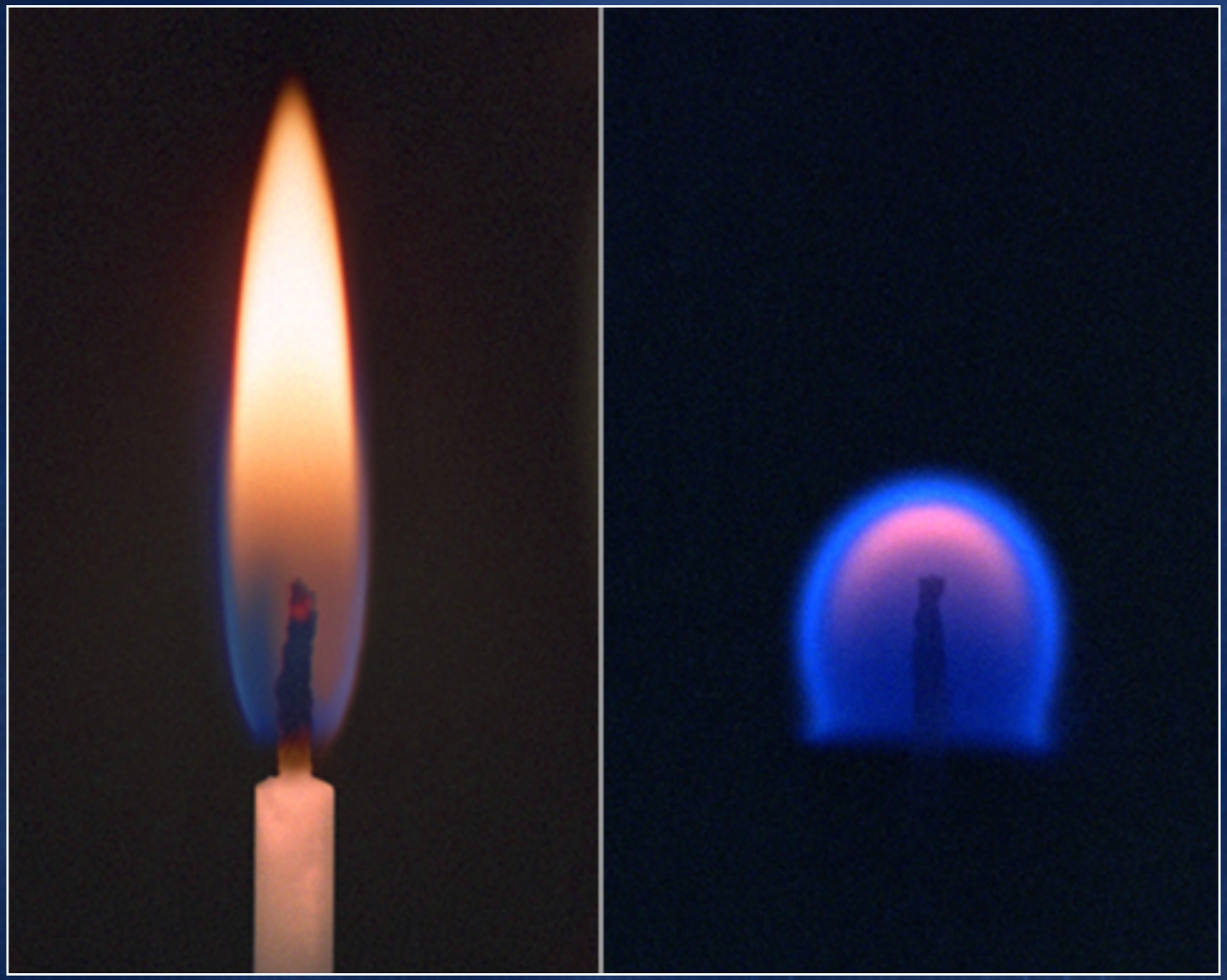
NASA Hits

Re-Fly on Mir



Russians require oxygen sensors, which we flew…
COTS didn't work…

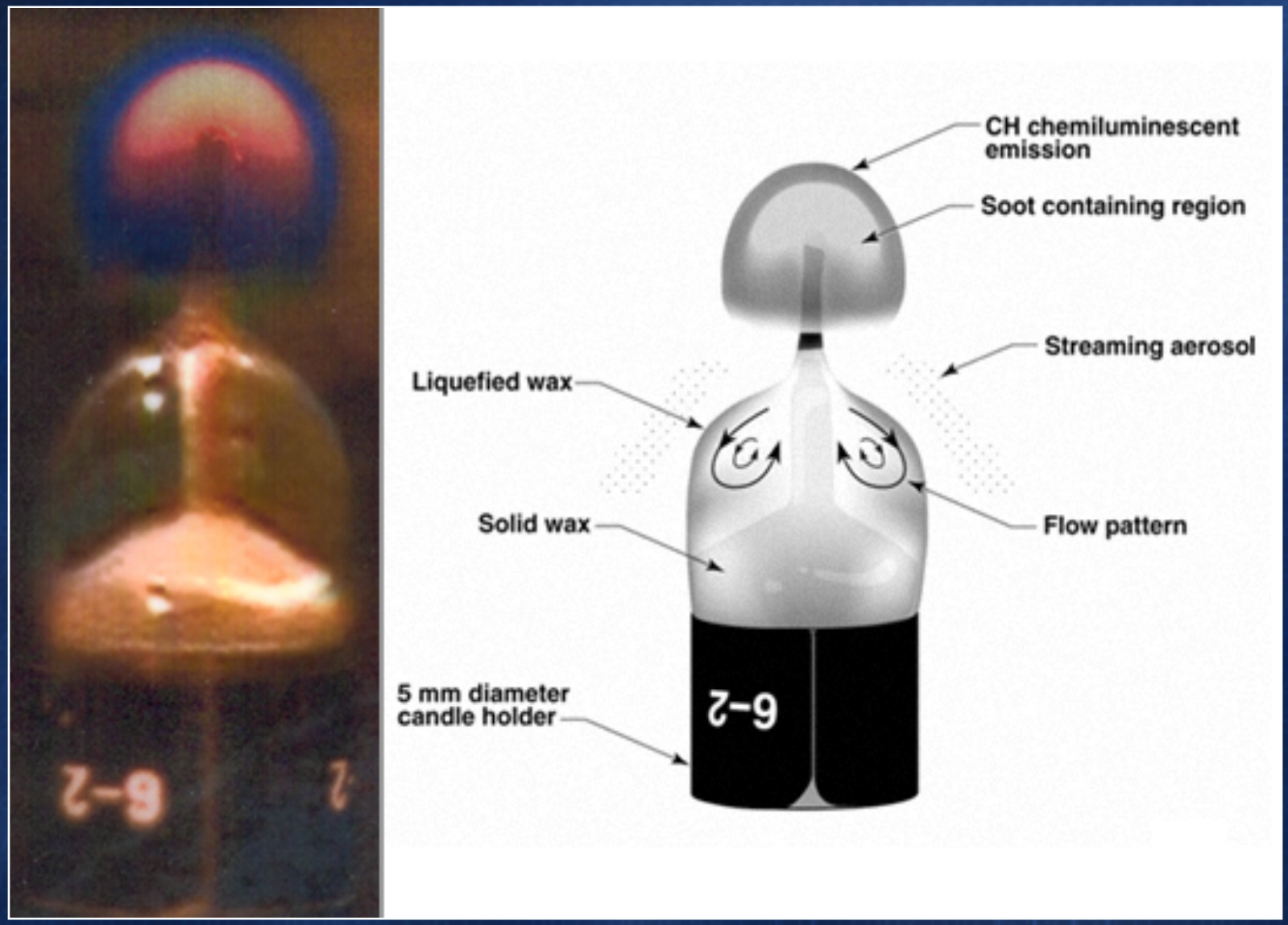
Re-Fly on Mir



Burned 10 minutes in 1g – 45 minutes in Og!

NASA Hits

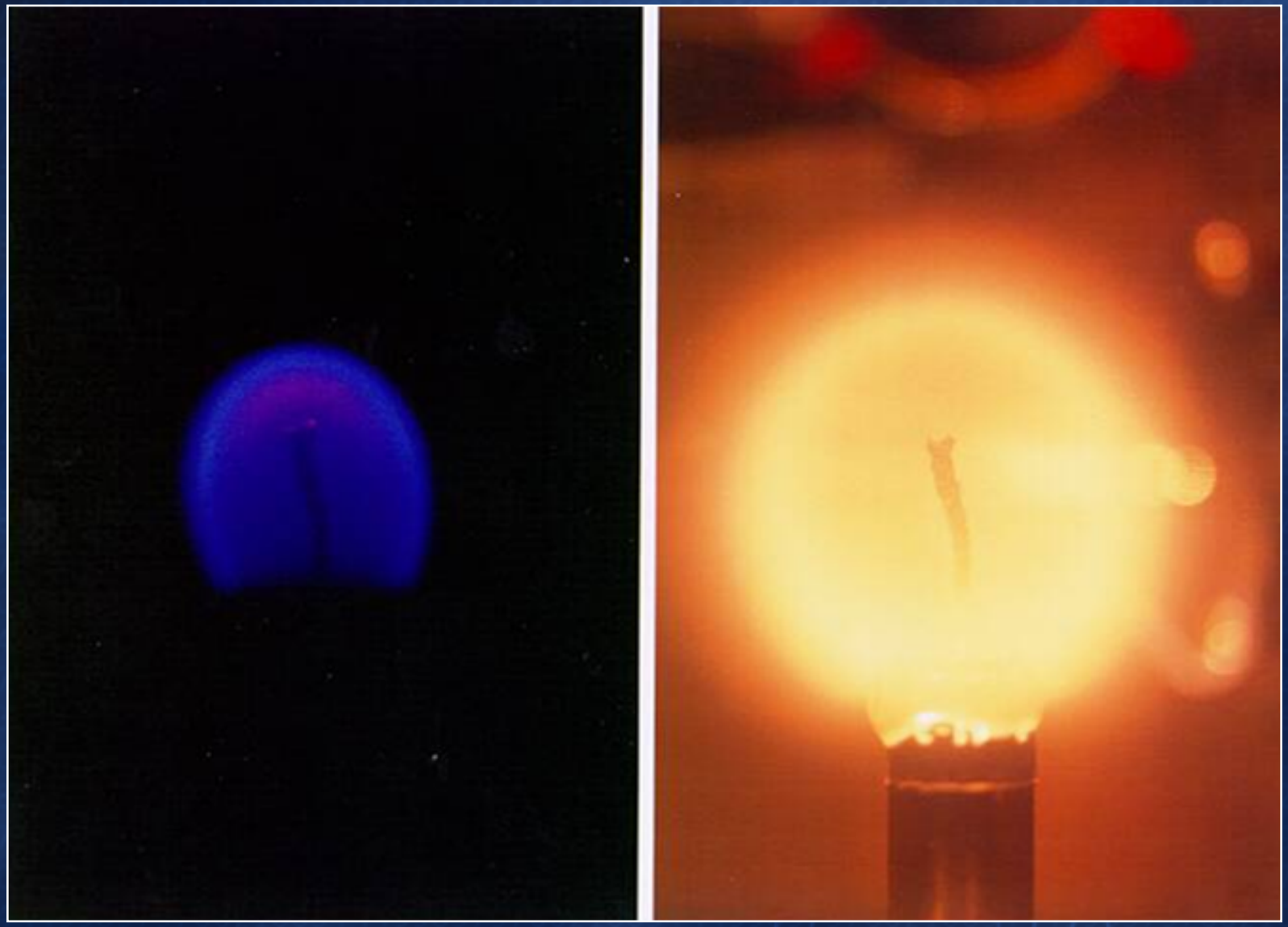
Lights on, lights off… who knew?



Spontaneous flame oscillations, rapidly liquefied wax with fast internal flow, aerosol streaming…

NASA Hits

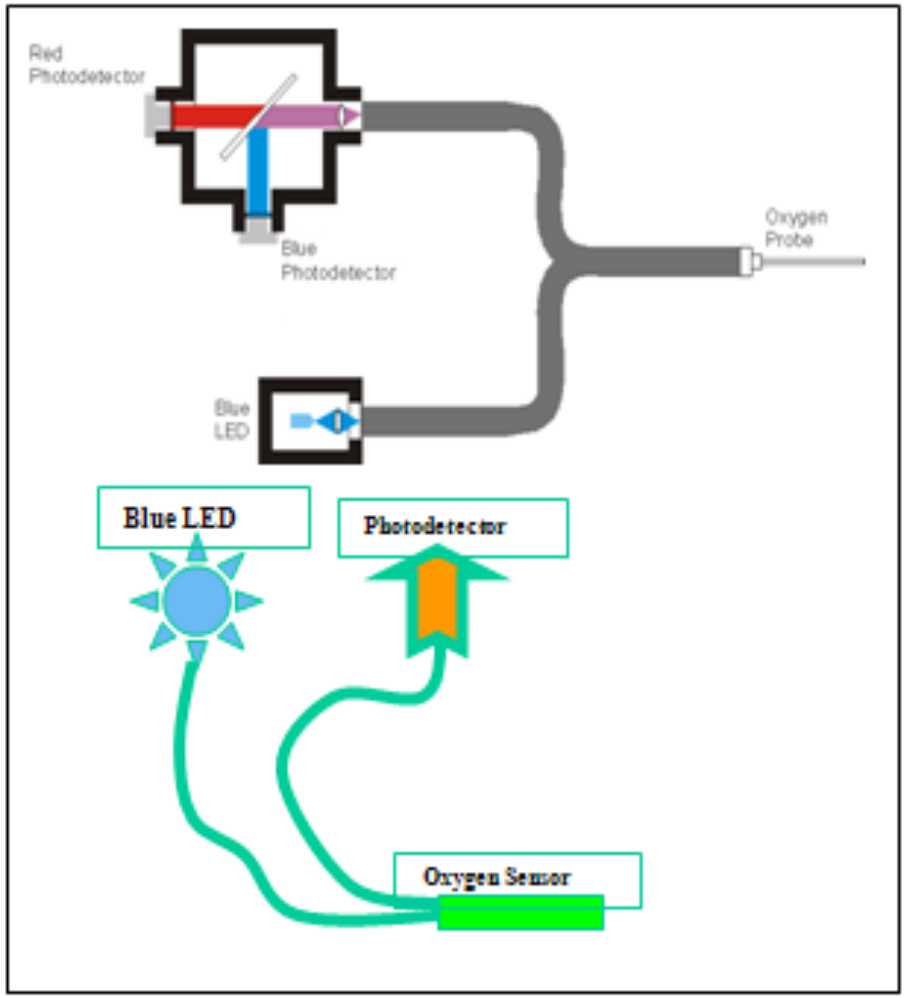
Lights on – post burn… who knew?

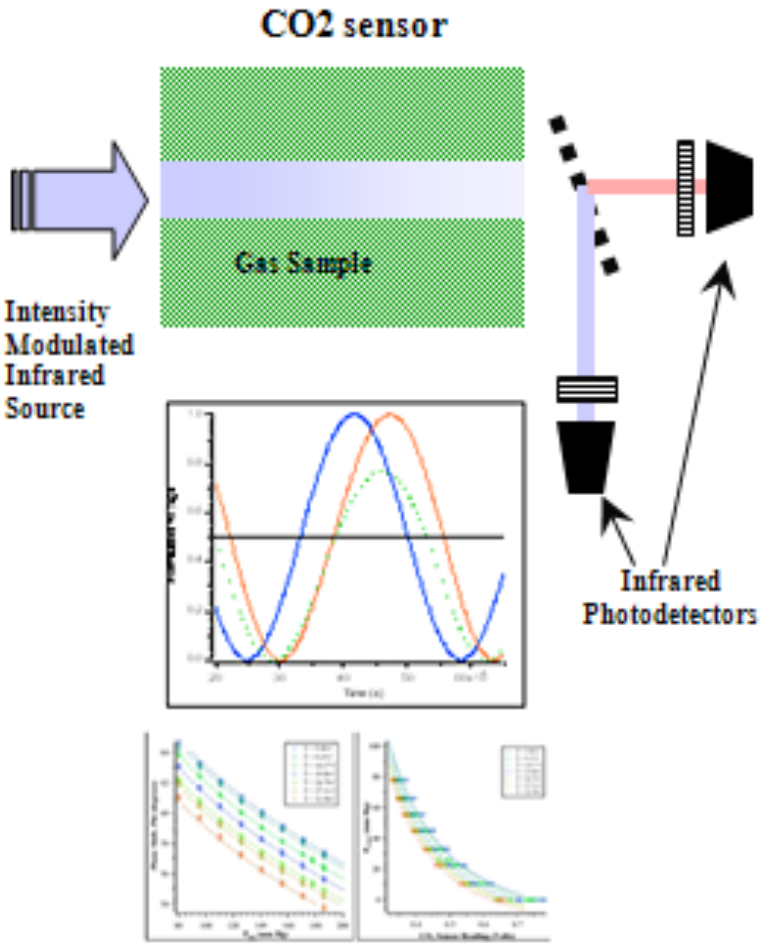


Be careful on post-fire startup operations!

NASA Hits

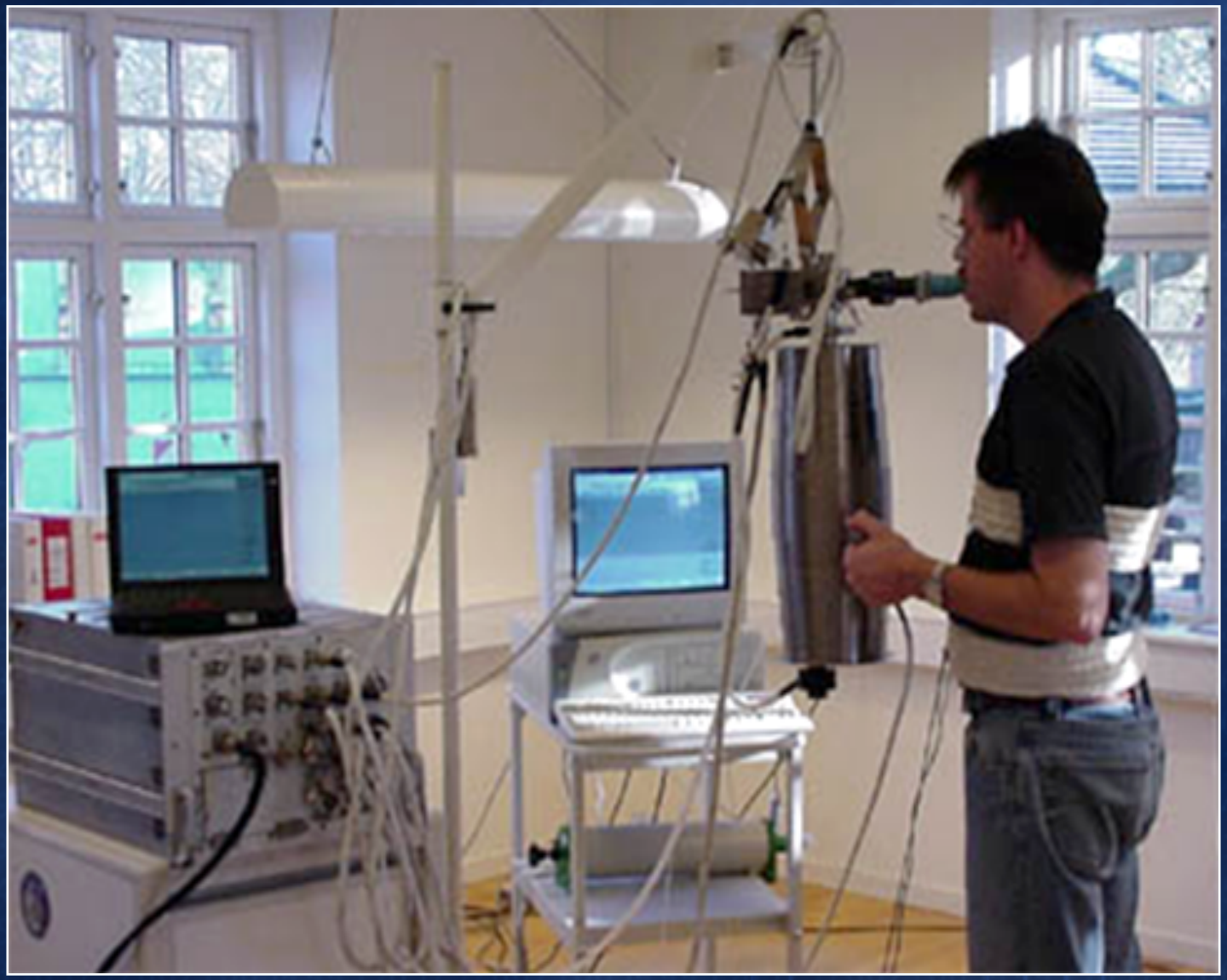
Need better O2 and CO2 sensing!





Minimally invasive sensors with improved reliability, faster sampling rate, and less drift

From STS-50 to…



Use for metabolic analysis?

NASA Hits

From STS-50 to…

Portable Unit for Metabolic Analysis (PUMA)

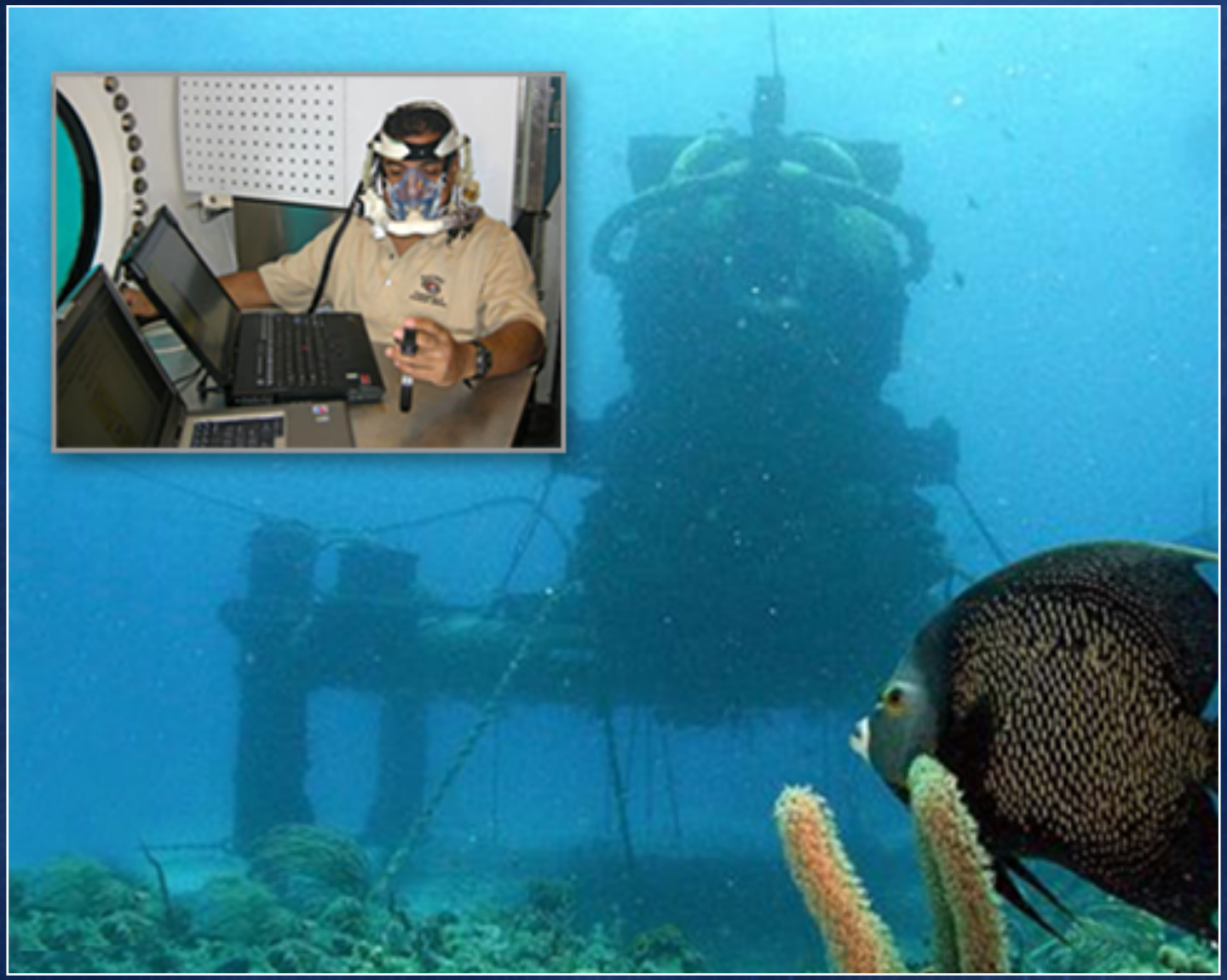
NASA Hits

From STS-50 to… PUMA

Work with the Exercise Physiology and Pediatric Cardiology Research Lab (CWRU/UHRI)

NASA Hits

From STS-50 to… Testing in NEEMO



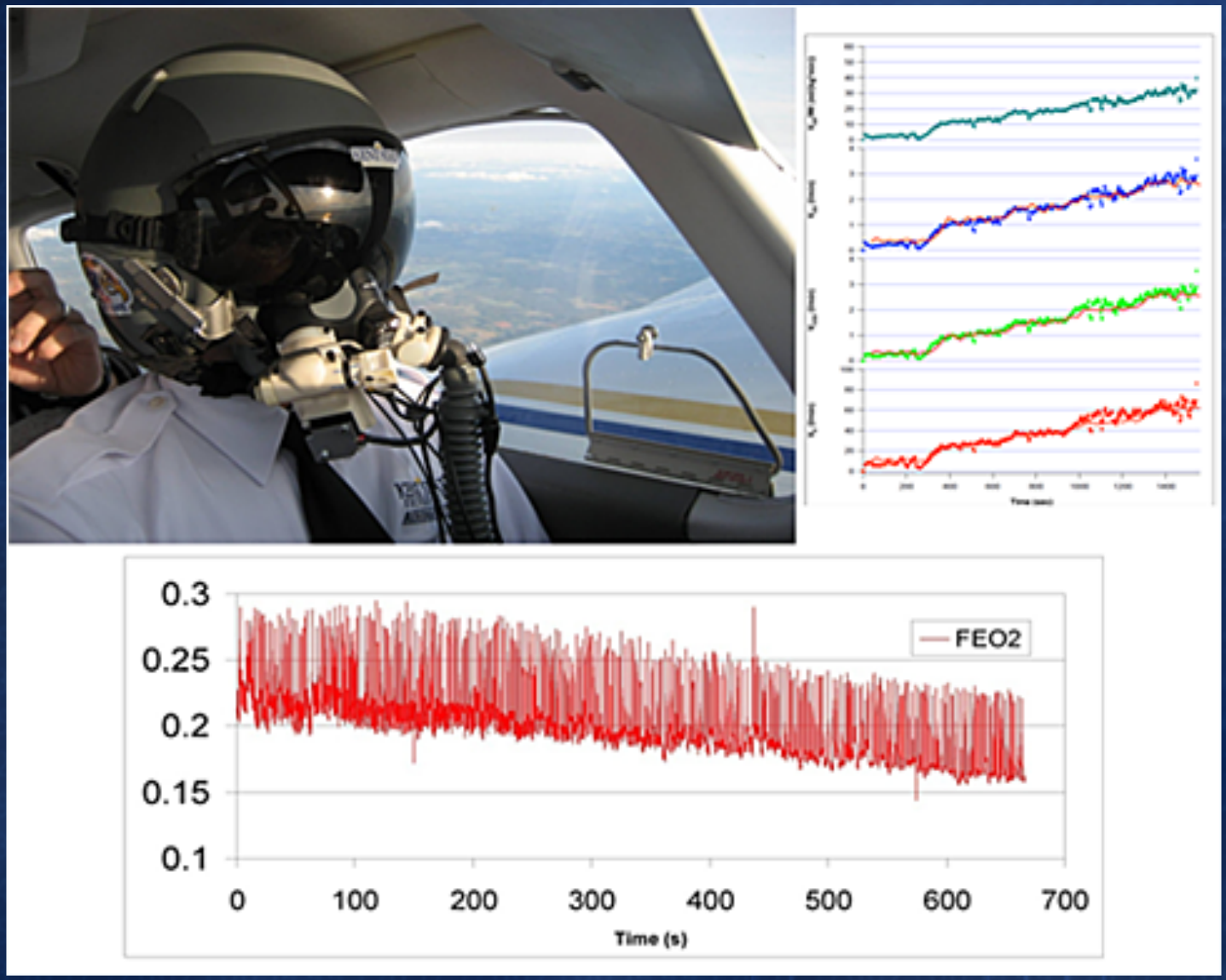
It works, even at 2 ½ atmospheres…

NASA Hits

From STS-50 to… Use in ISS?

No… well, not yet…

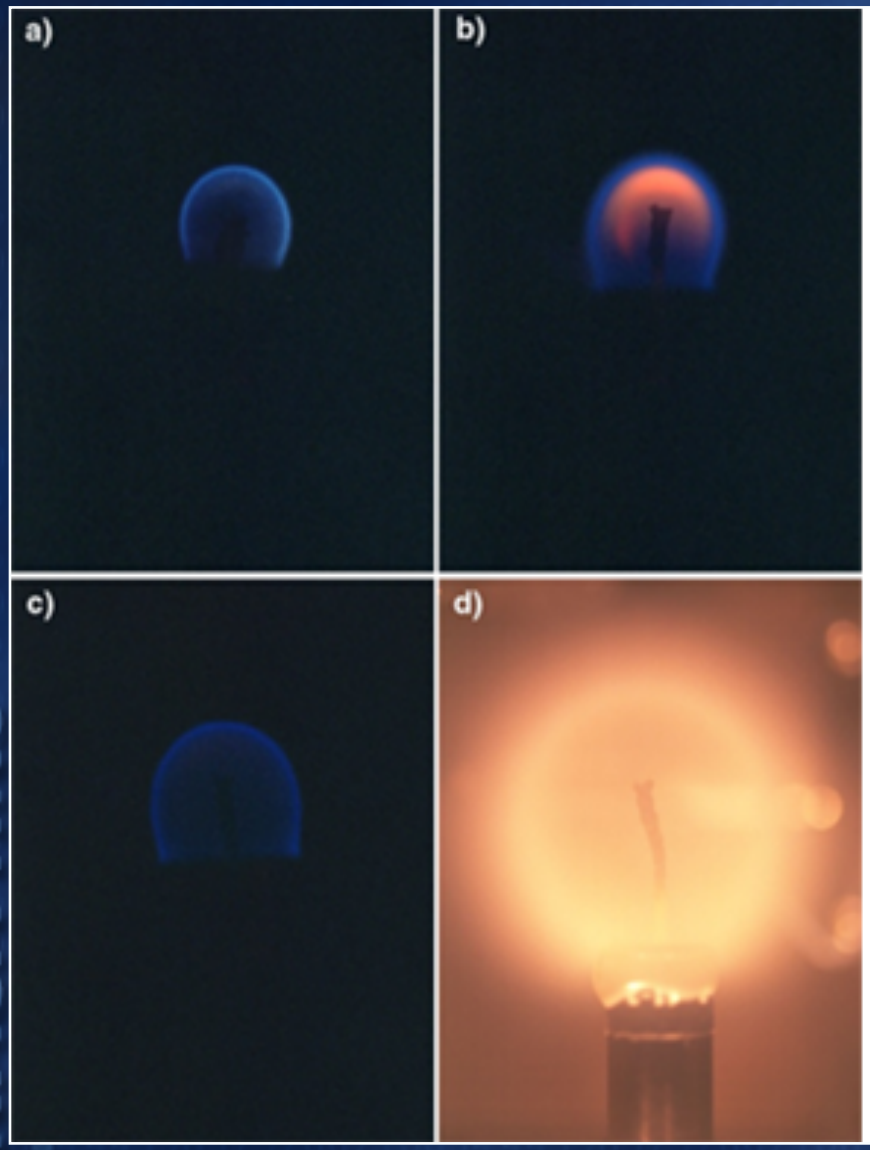
From STS-50 to… Testing for Hypoxia in Pilots!



Commercial company with SBIR from the Navy…

NASA Hits

From STS-50: Candle Flames in Microgravity



Not only curiosity-driven science:

Scientific American, Popular Science, Combustion Science and Technology (2X), ongoing student and teacher inquiries…

Who could have guessed the applications 18 years later?

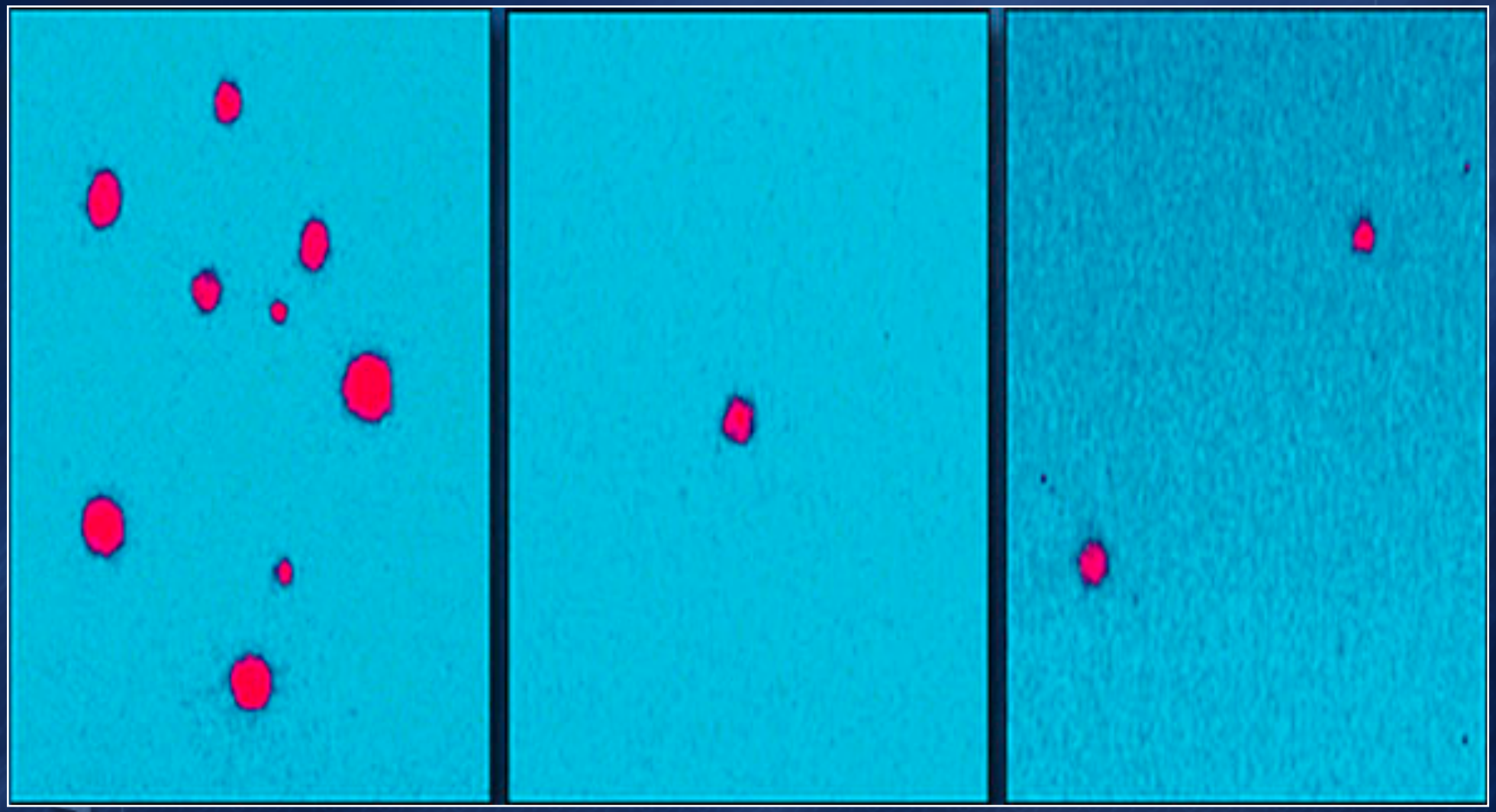
NASA Hits

Combustion Science

Rewriting the textbooks and impacting industry

NASA Hits

Combustion Science



Flame balls: Weakest flames ever observed in space or on Earth

Combustion Science

NASA Hits

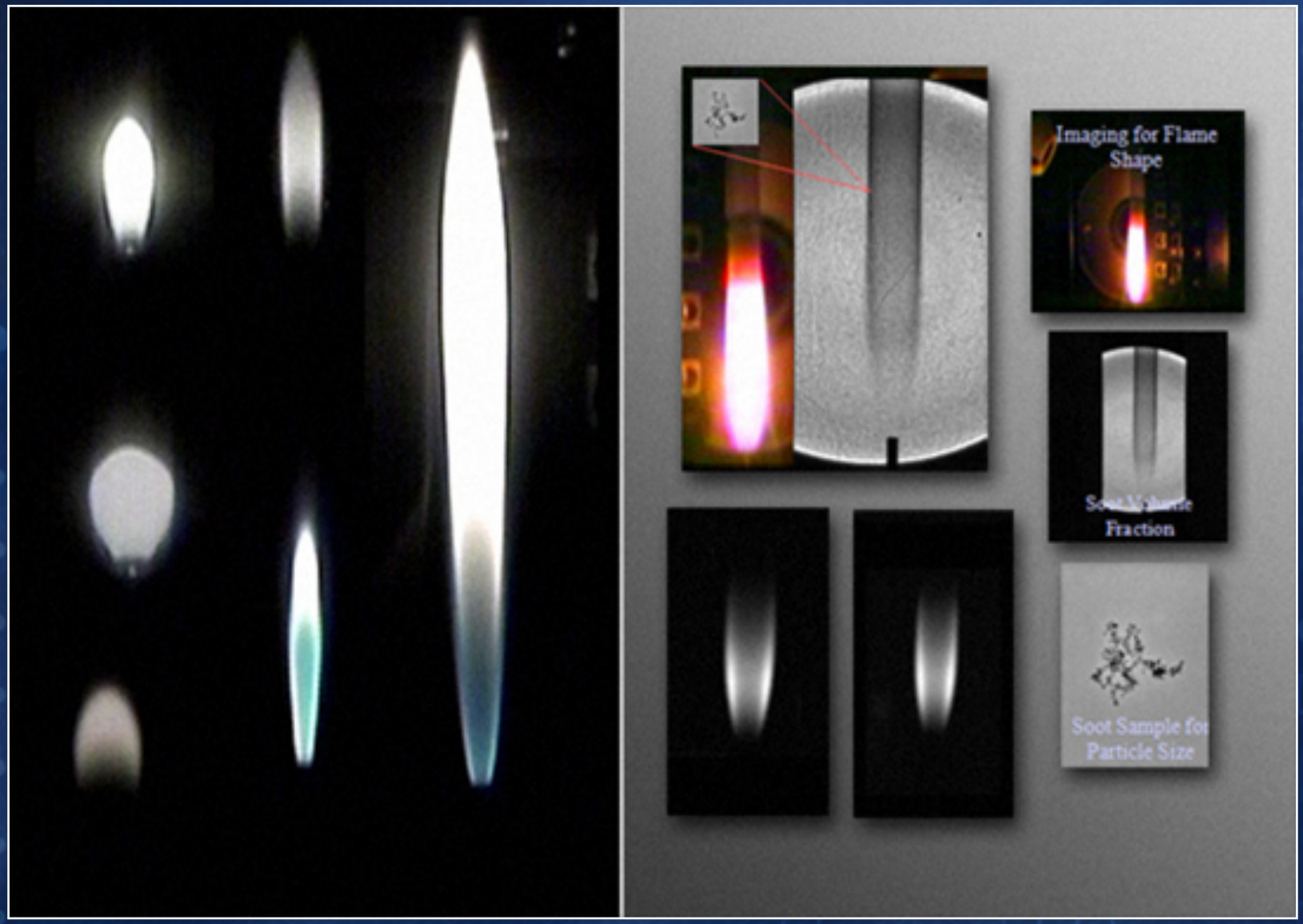
Models of lean burning hydrogen engines are being improved

STS-83, 94, 107: Laminar Soot Processes

Sooty: Health Hazard… Smoke Damage… Carbon Black… Nanotubes…

NASA Hits

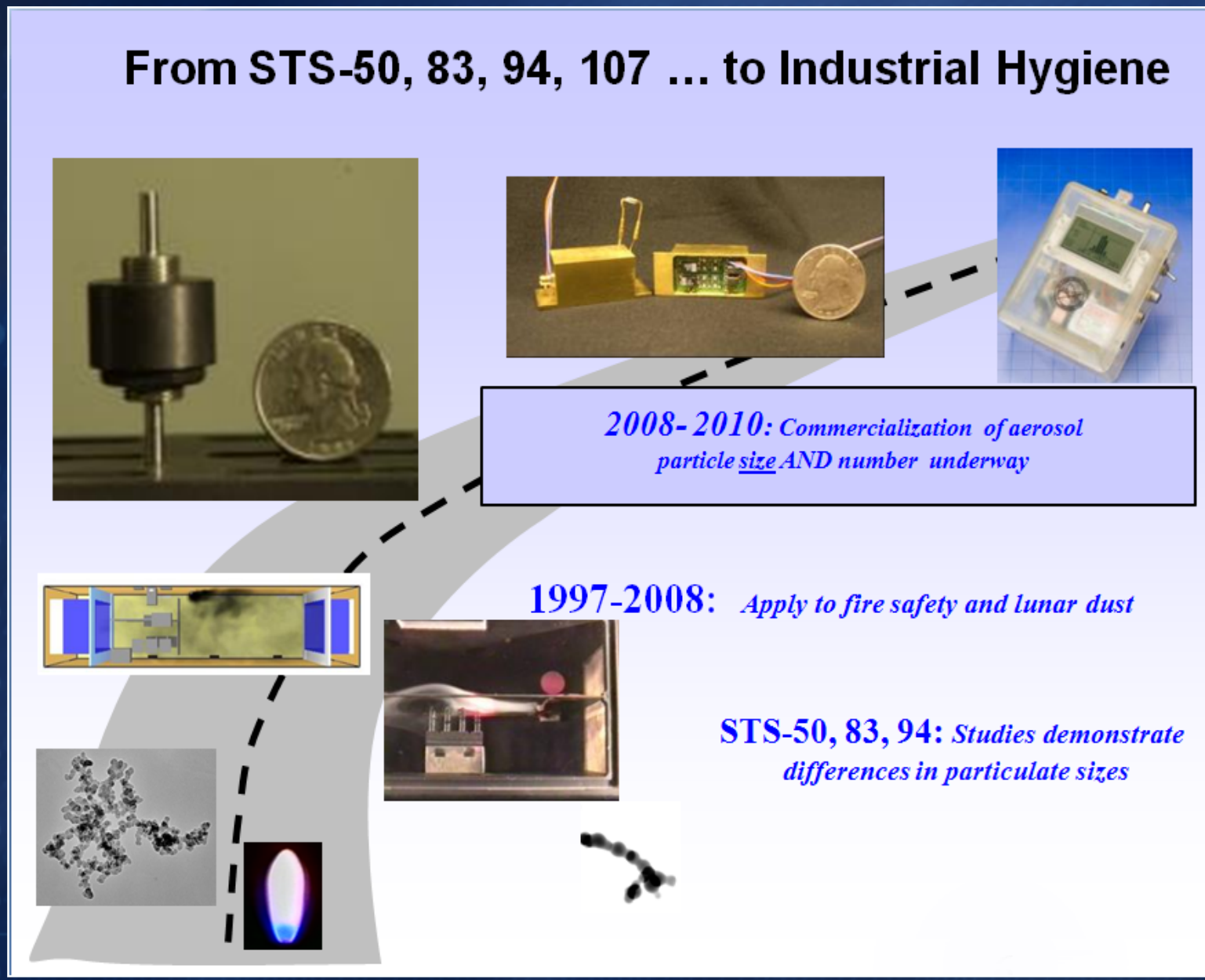
STS-83, 94, 107: Laminar Soot Processes



Results "rewrote textbooks" per NAS G. Faeth

NASA Hits

From STS-50, 83, 94, 107… to Industrial Hygiene



NASA Hits

Combustion Science

Droplet Combustion Experiment (DCE)

NASA Hits

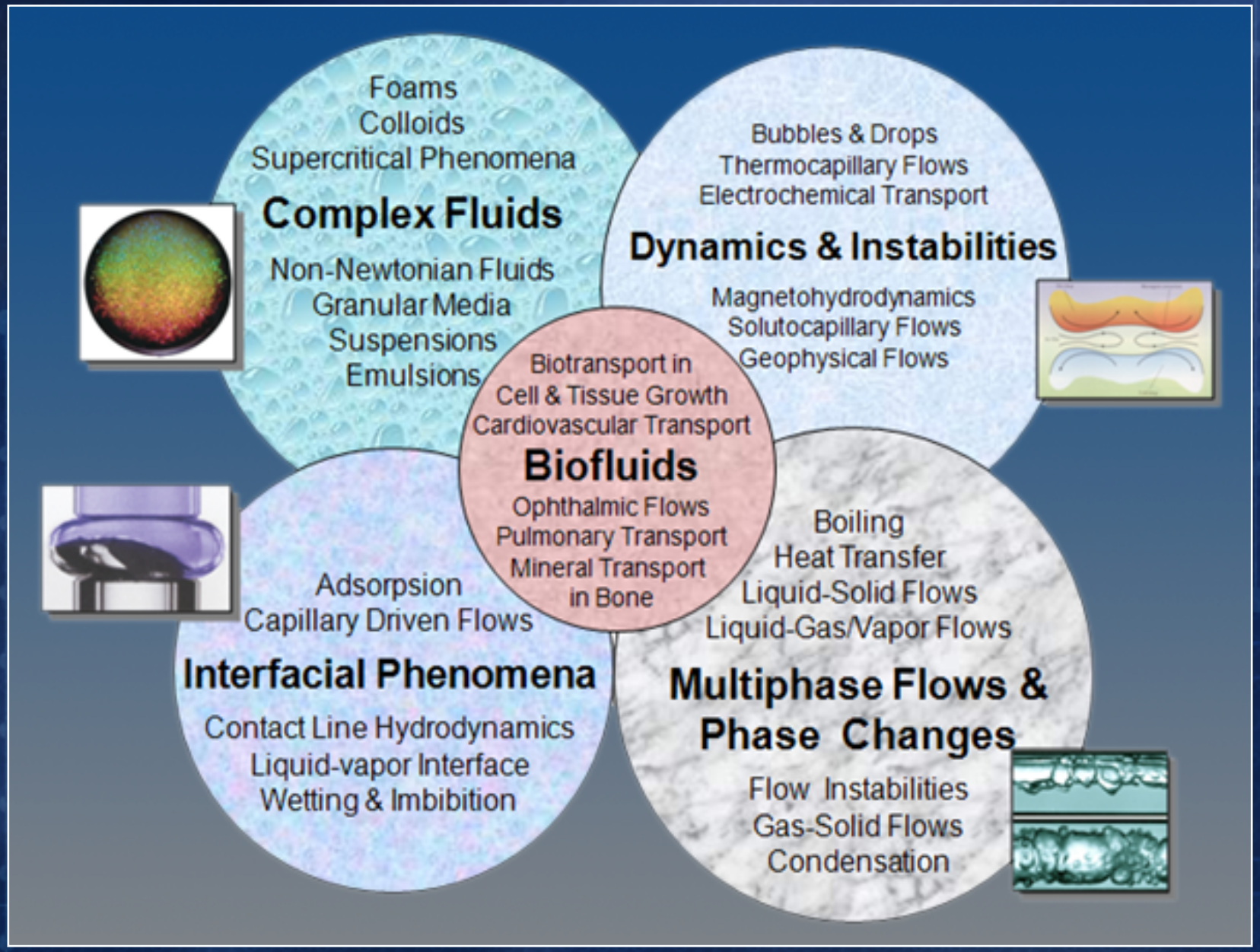
STS-83, 94: Droplet Combustion

Pratt and Whitney: "NASA-sponsored microgravity research… had a direct impact on our engine design efforts…"

GE Engines: "I read with keen interest your publications[5,6] on conducting fundamental investigations on droplets and sprays under controlled environment, e.g., microgravity. In-depth studies of this type will help us immensely in addressing spray evaporation and combustion related issued for the next-generation ultra-low emissions gas turbine combustors. "

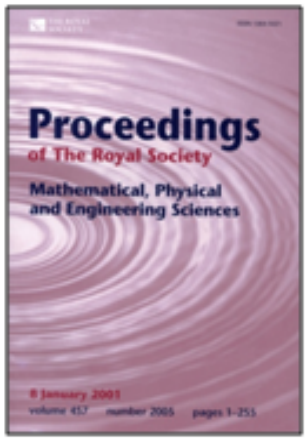
And now it's on ISS…

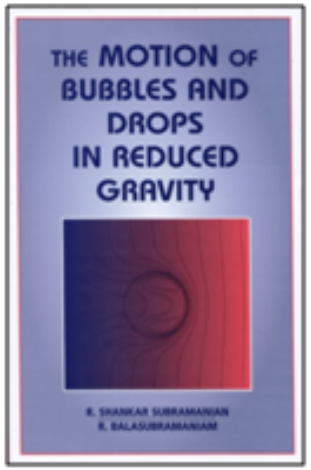
Fluid Physics

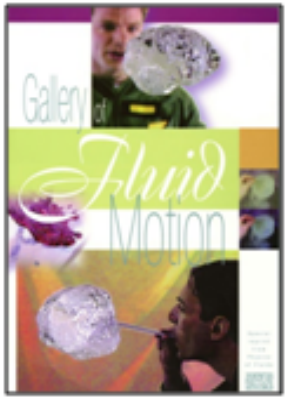


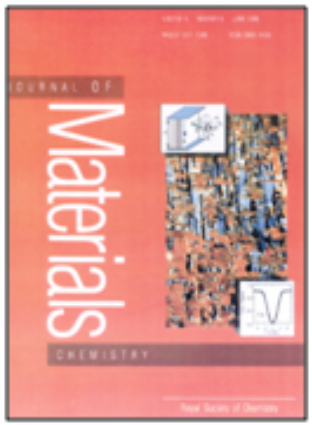
NASA Hits

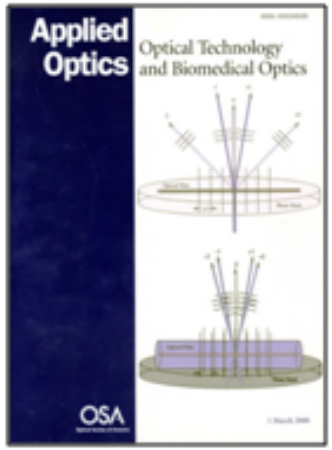
Lots of Covers, Lots of Publications

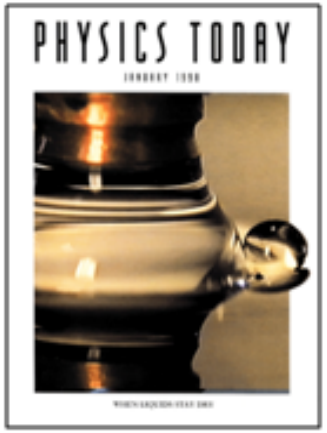










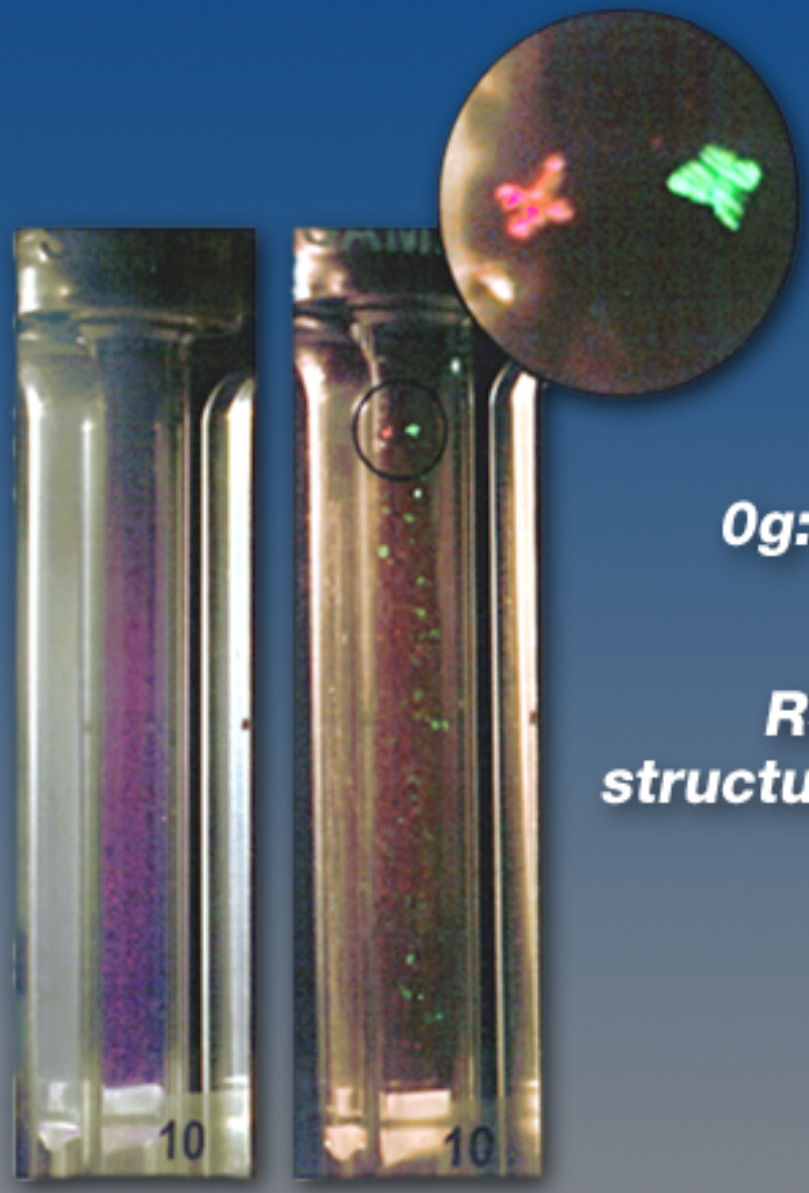


Colloidal Science & Engineering (particles in liquids)

Paint, shampoo, soap, detergent, fabric enhances, milk…

NASA Hits

Colloidal Science & Engineering (particles in liquids)



0g: no sedimentation, no convection

Revealed dendritic structures no previously seen

NASA Hits

Colloidal Science & Engineering (particles in liquids)

In 0g, order naturally arises from disorder, and crystals form. Phase separation theory was "way off"…

NASA Hits

Colloidal Science & Engineering (particles in liquids)

"Procter & Gamble develops and maintains a portfolio of products composed of dispersions-particles dispersed in a continuum fluid, including shampoo, hair conditioner, fabric enhancer, soap and detergent. There continues to be a fundamental challenge in stabilizing these dispersions, to prevent creaming or sedimentation. The inability to stabilize these dispersions often leads to years of additional reformulation for EACH new initiative…. As noted above, **such dispersions represent a class of products that, between Procter and other Companies, conservatively reflects more than $100 billion in world-wide sales. For Procter & Gamble alone, this represents more than 100,000 jobs globally….**

"This work provides some very unique opportunities to study this problem."

…the present model for phase separation used by companies like P&G for product development is at best incomplete. A better theory is likely to lead to better products that don't need as much expensive stabilizer (and the stabilizer takes up volume that does not contribute to real intent of the product)."

NASA Hits

Physics of Colloids – Application Example

Early detection of cataracts and other diseases

NASA Hits

Physics of Colloids – Application Example

Highlighted as a key technology to Congress by the National Institute of Health (NIH)

NASA Hits

Physics of Colloids – Application Example

Device is used to assess new, non-surgical therapies

NASA Hits

Physics of Colloids – Application Example

Early detection of cataracts in astronauts is vital

NASA Hits

Physics of Colloids – Application Example

The instrument is being adapted to painlessly identify diabetes, and Alzheimer's disease

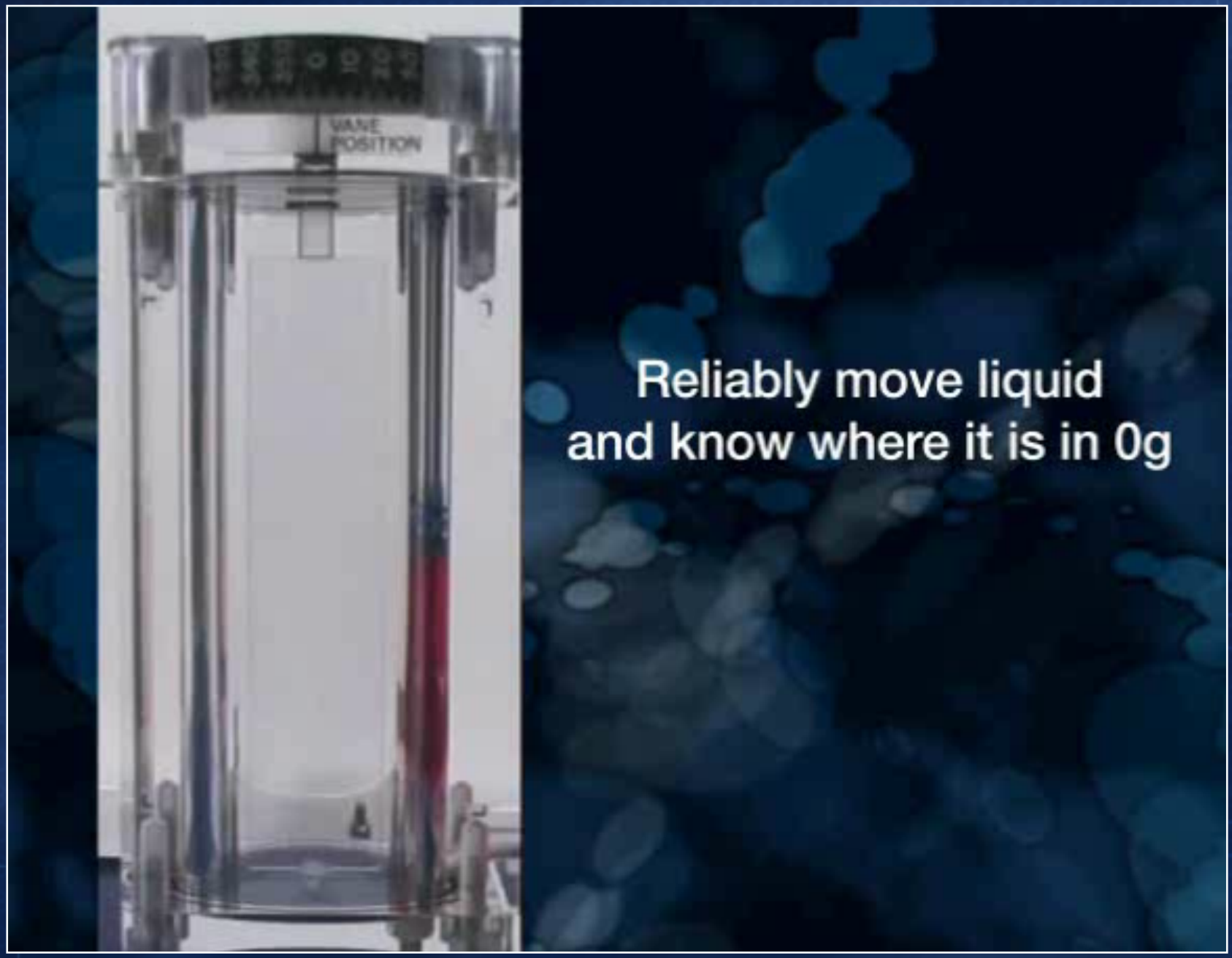
NASA Hits

Exploration Inspires

NASA Hits

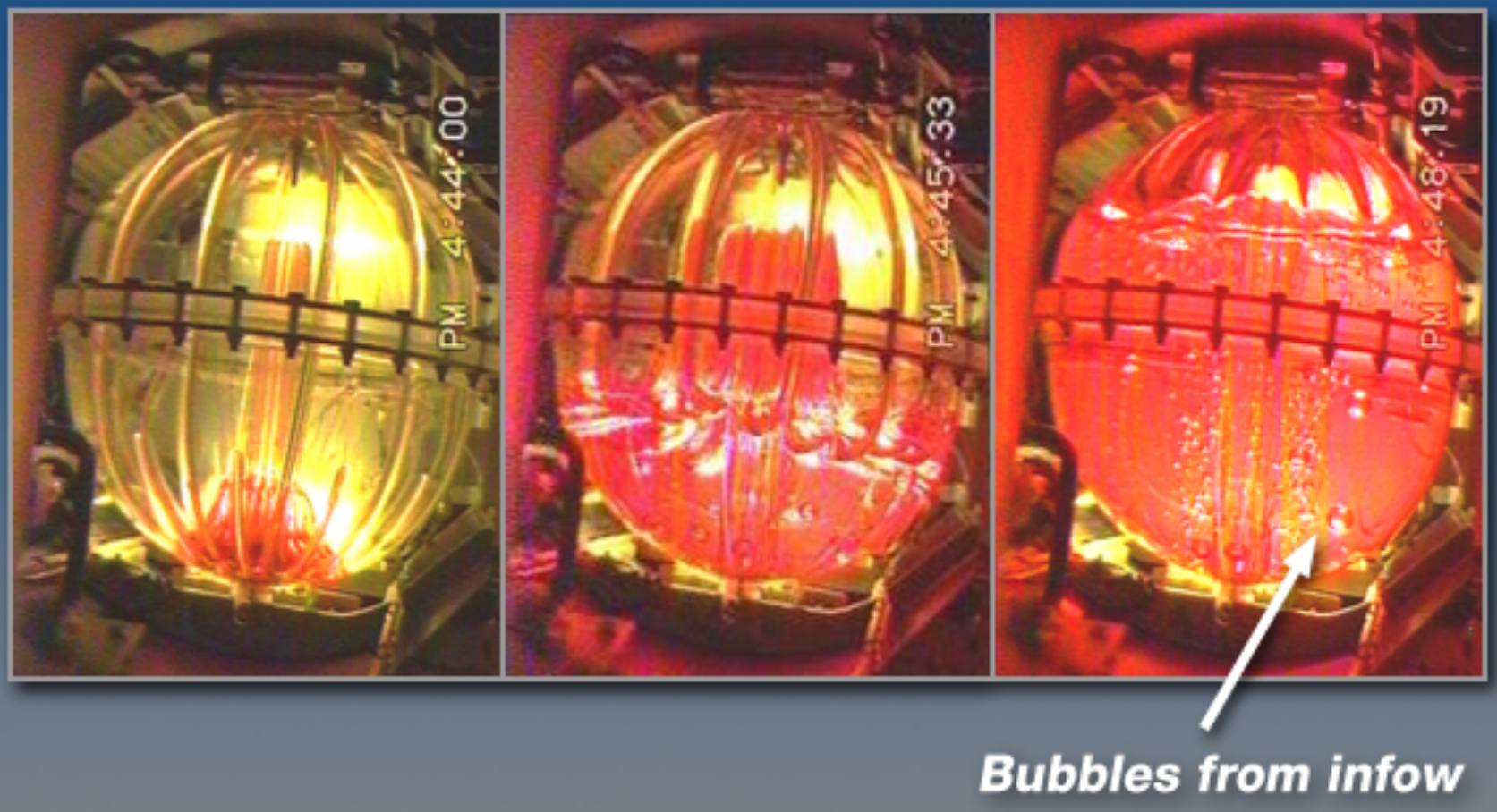
Exploration Inspires People Toward Careers in Science

Interfacial Phenomena



NASA Hits

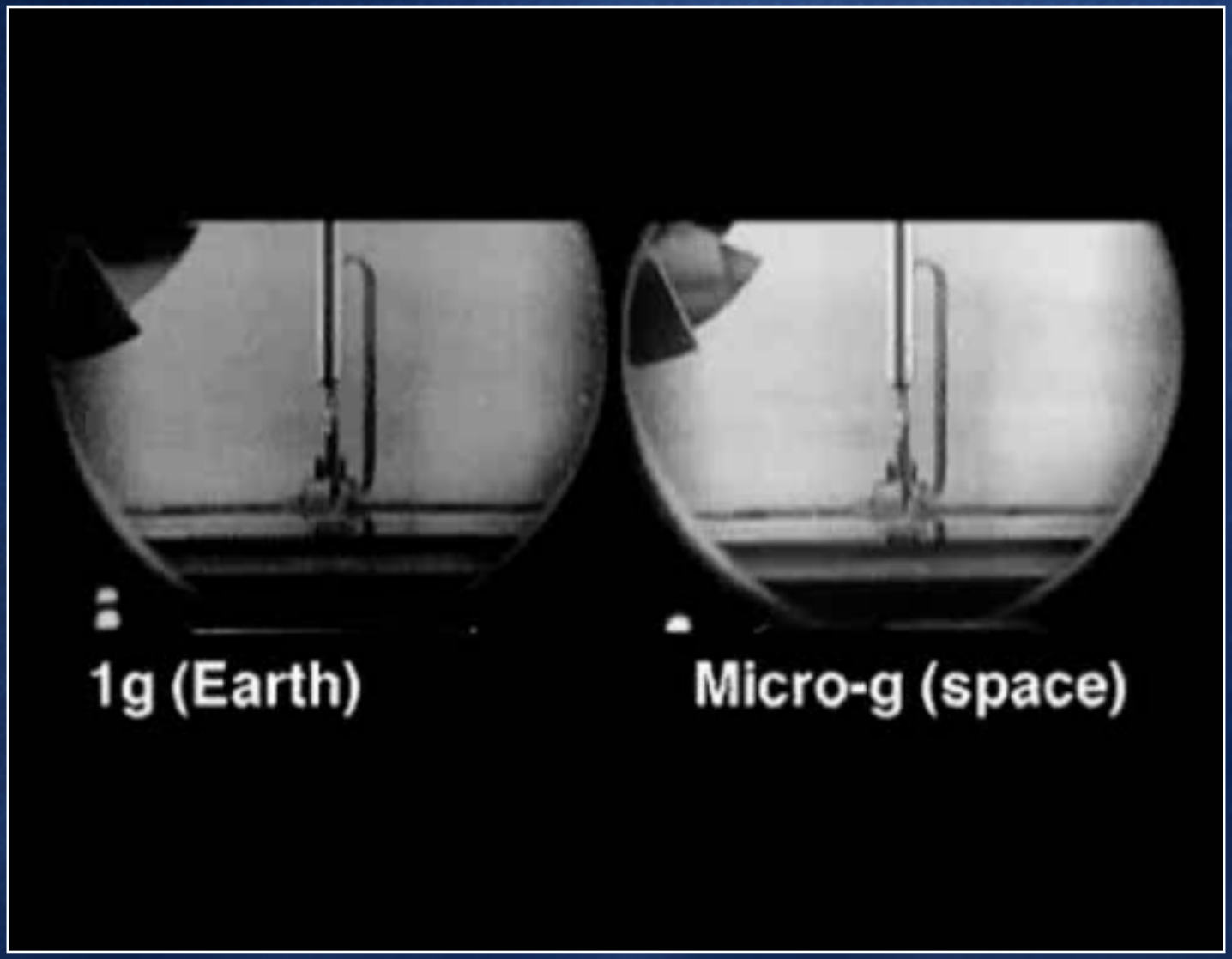
STS-77: Vented Tank Resupply Experiment



NASA Hits

Lockheed Martin is able to extend satellite life by months to years, producing millions of dollars of additional revenue

Five STS Flights: Pool Boiling Experiment



Steady state pool boiling is observed in microgravity!
Two-phase thermal control saves mass…

NASA Hits

STS-108: Collide

NASA Hits

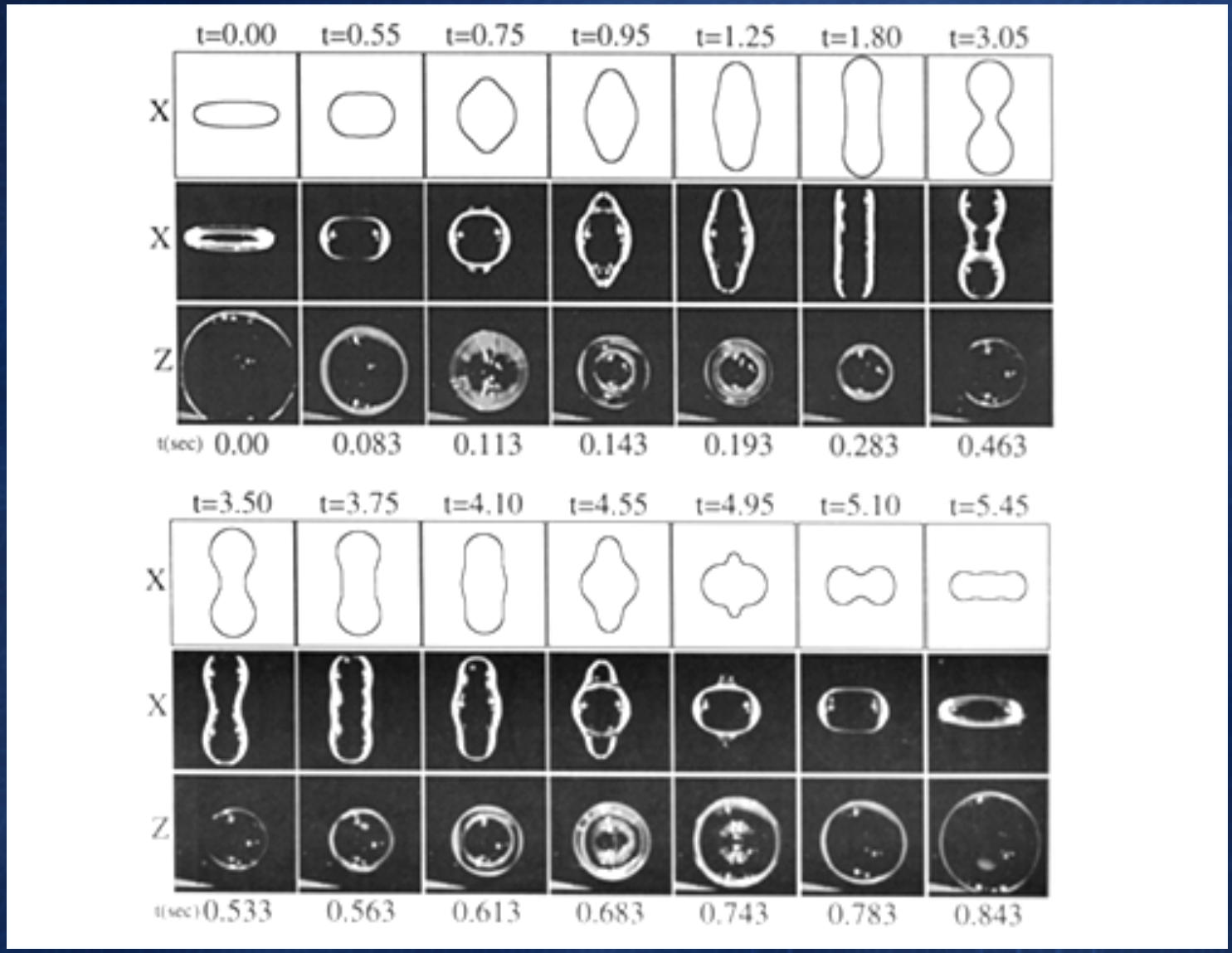
Impact into simulated planetary regolith… Helped explain how rings around planets form

STS-50 and STS-77: Drop Physics

NASA Hits

The complex motion, fission, and coalescence of drops have fascinated scientists for centuries

STS-50 and STS-77: Drop Physics



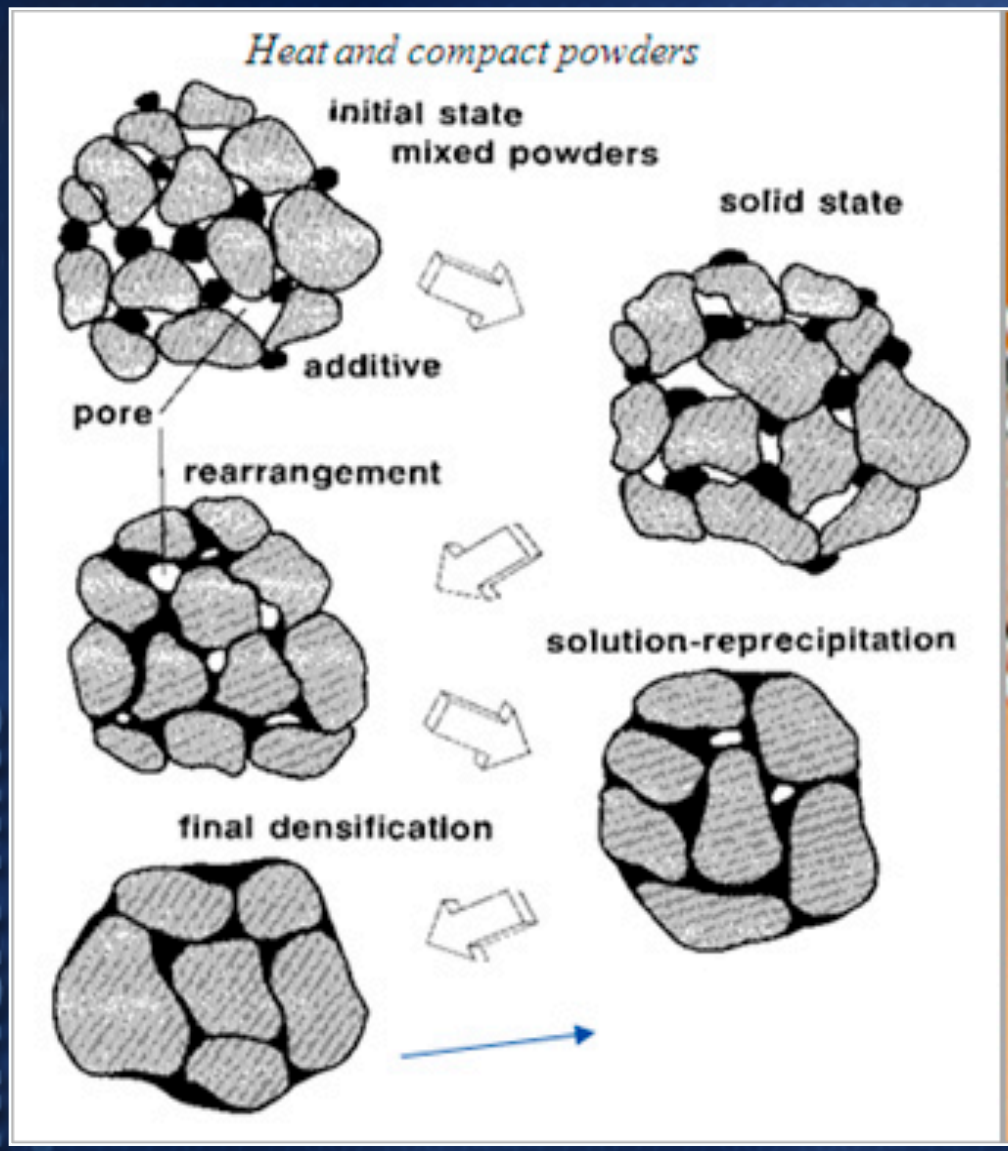
The complex motion, fission, and coalescence of drops have fascinated scientists for centuries

Metal-Cutting Tool Industry

Liquid phase sintering materials experiments

NASA Hits

STS-94: Liquid Phase Sintering – for Better Materials



Liquid Phase Sintering saves the industry many millions of dollars by eliminating machining costs

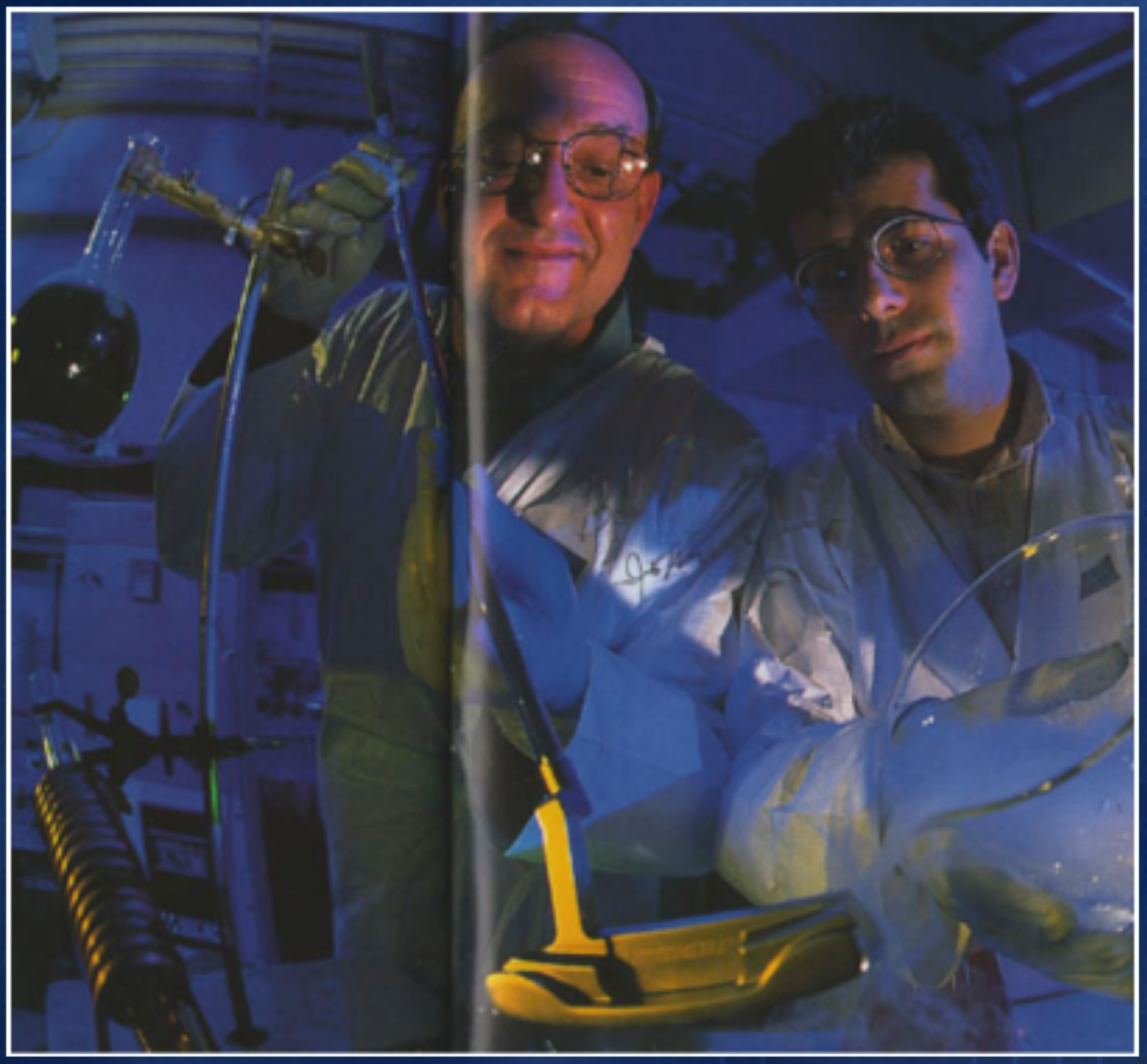
NASA Hits

Metal-Cutting Tool Industry

New knowledge gained saved approximately 40 percent of the production cost associated with post-sinter machining

NASA Hits

Three Shuttle Flights: Glass-forming Metallic Alloys



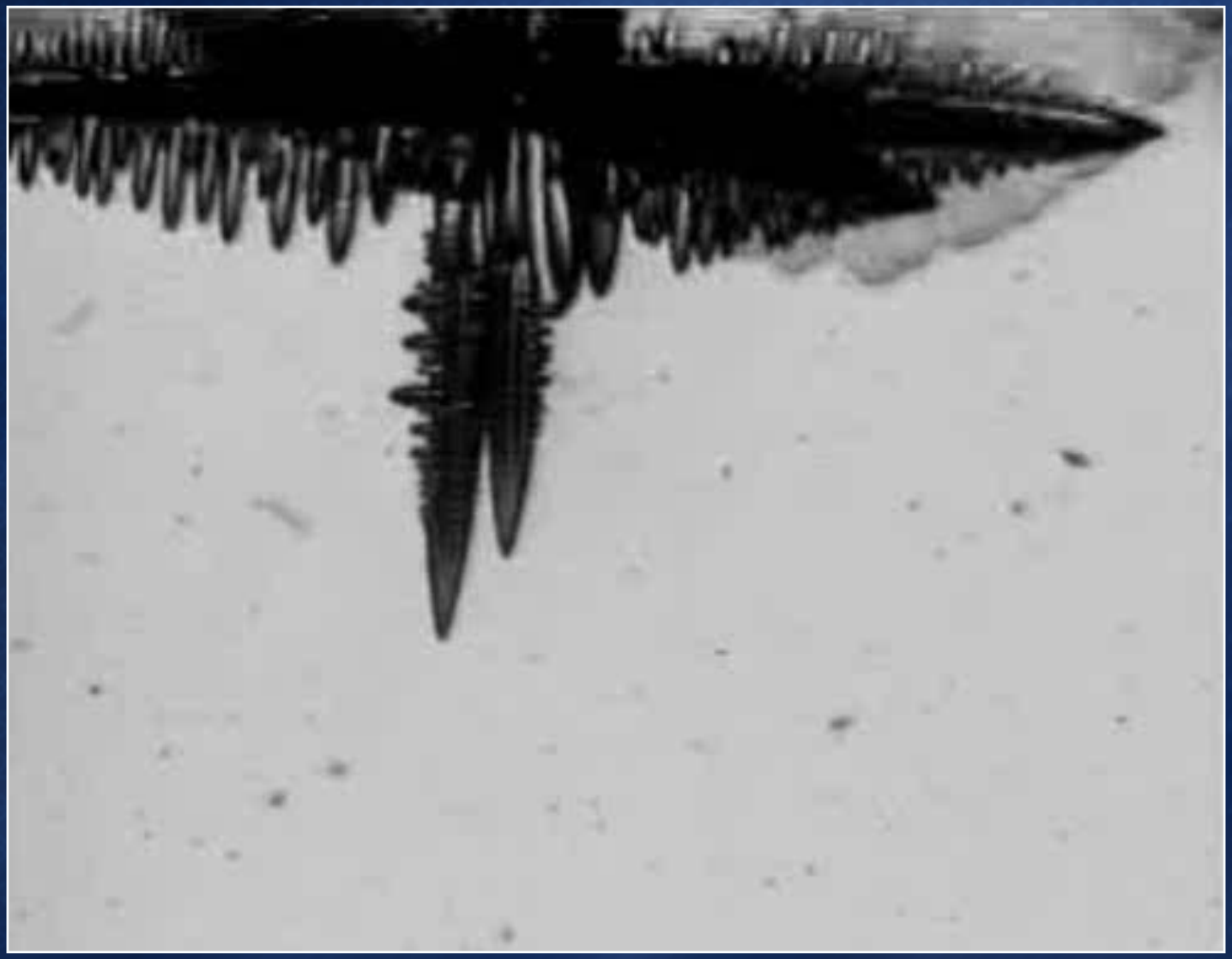
Resist corrosion, restore more energy – to golf clubs and defense applications

NASA Hits

Glass-forming Metallic Alloys

Metallic Glass Demonstration

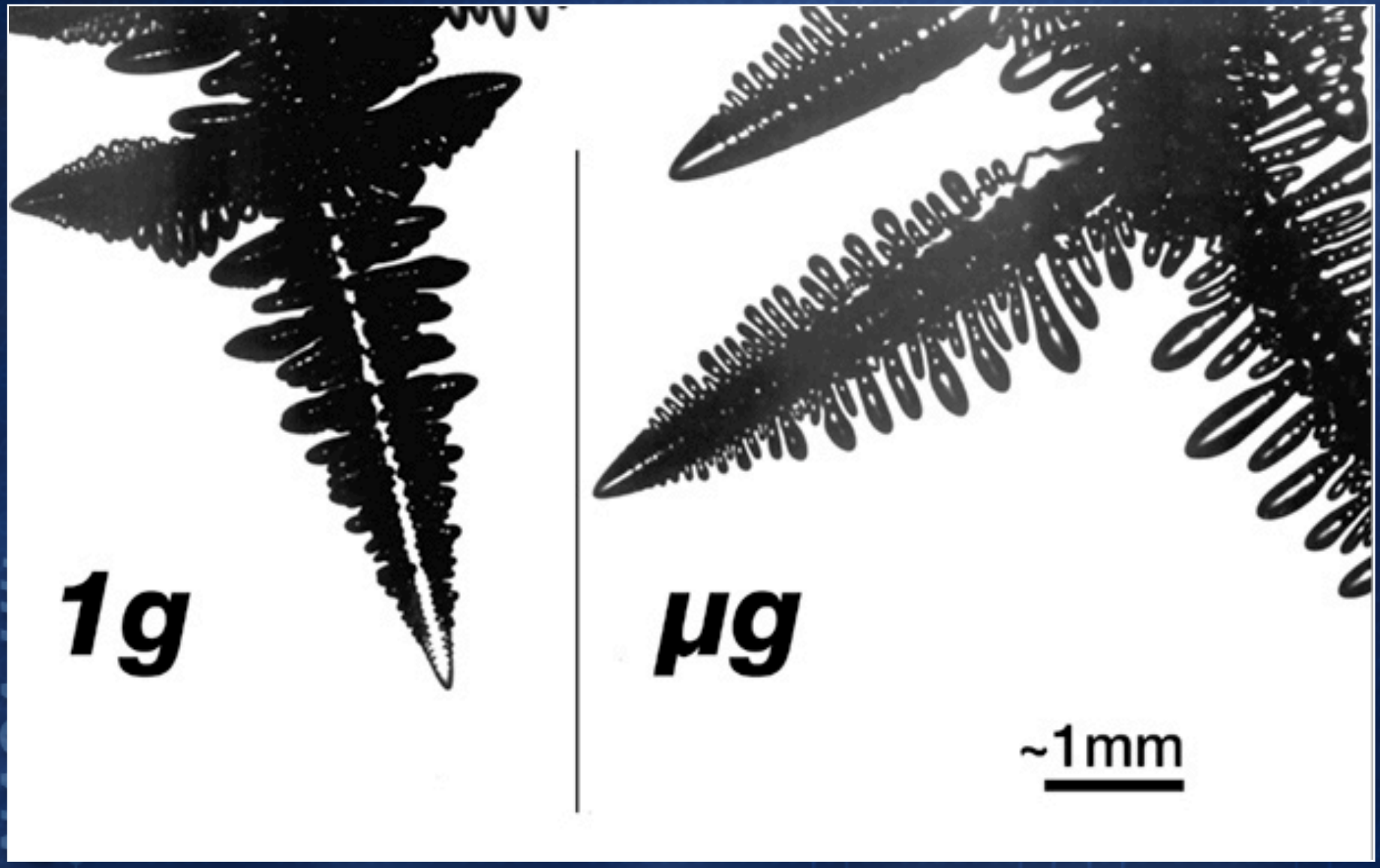
Isothermal Dendritic Growth Experiment



NASA Hits

Internationally recognized benchmark property data – critical to metallurgists and the casting industry

Isothermal Dendritic Growth Experiment



Internationally recognized benchmark property data – critical to metallurgists and the casting industry

Bioreactor

Space yields more extensive tissue construct for tissue engineering

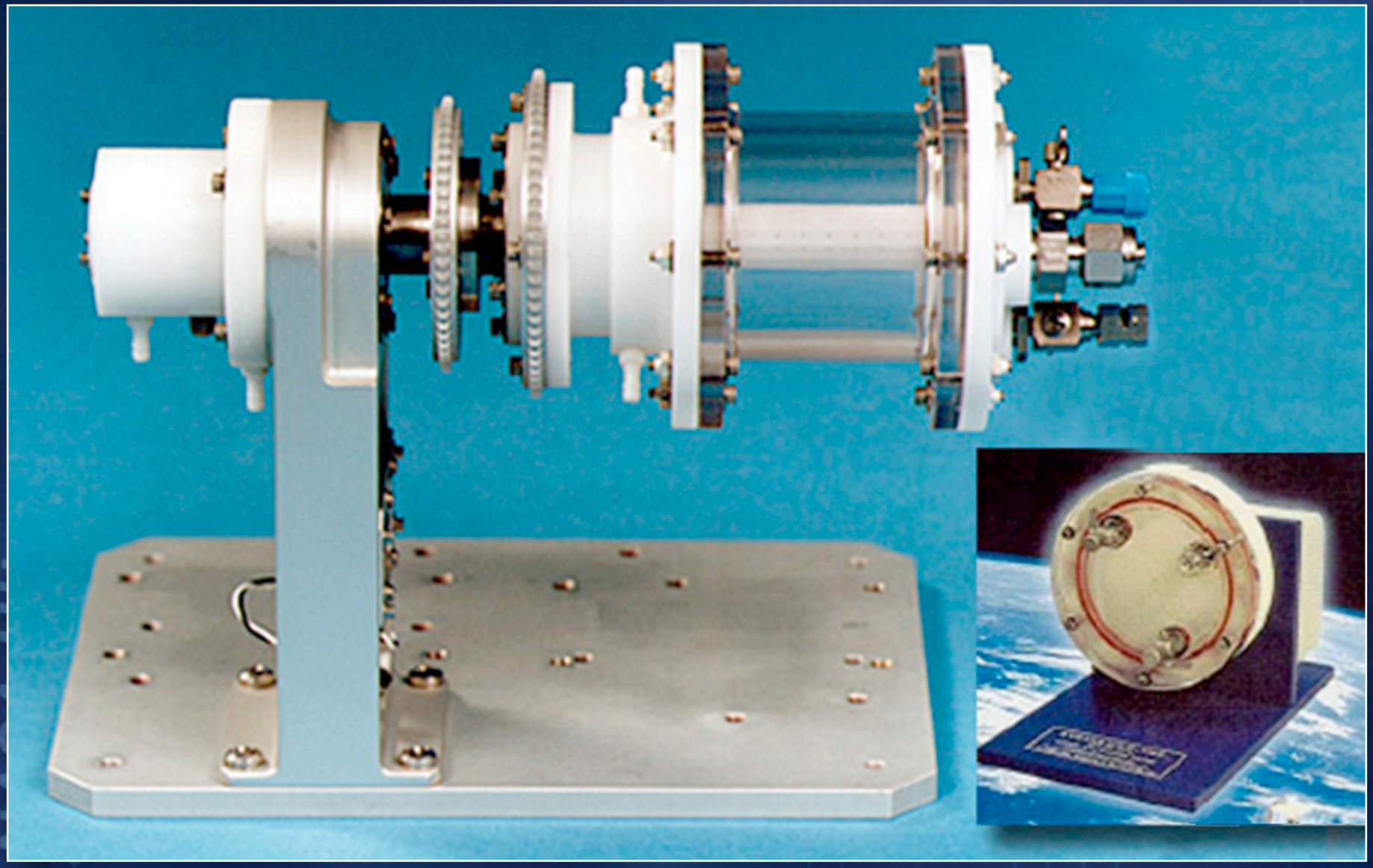
NASA Hits

Bioreactor

Prostate cancer and bone cells interact

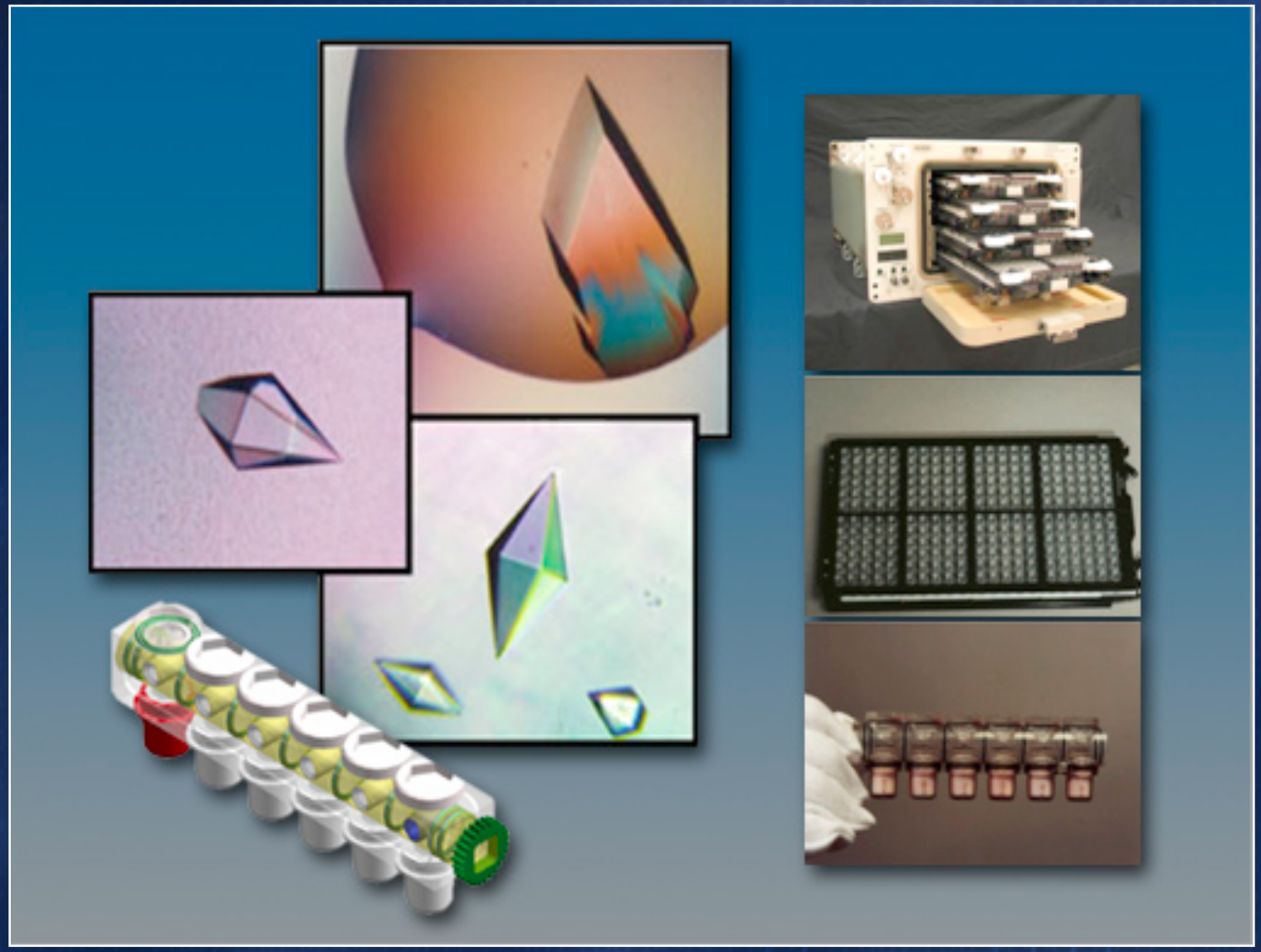
NASA Hits

Bioreactor



Over 25 patents and over 6000 units sold in the U.S. Marketplace

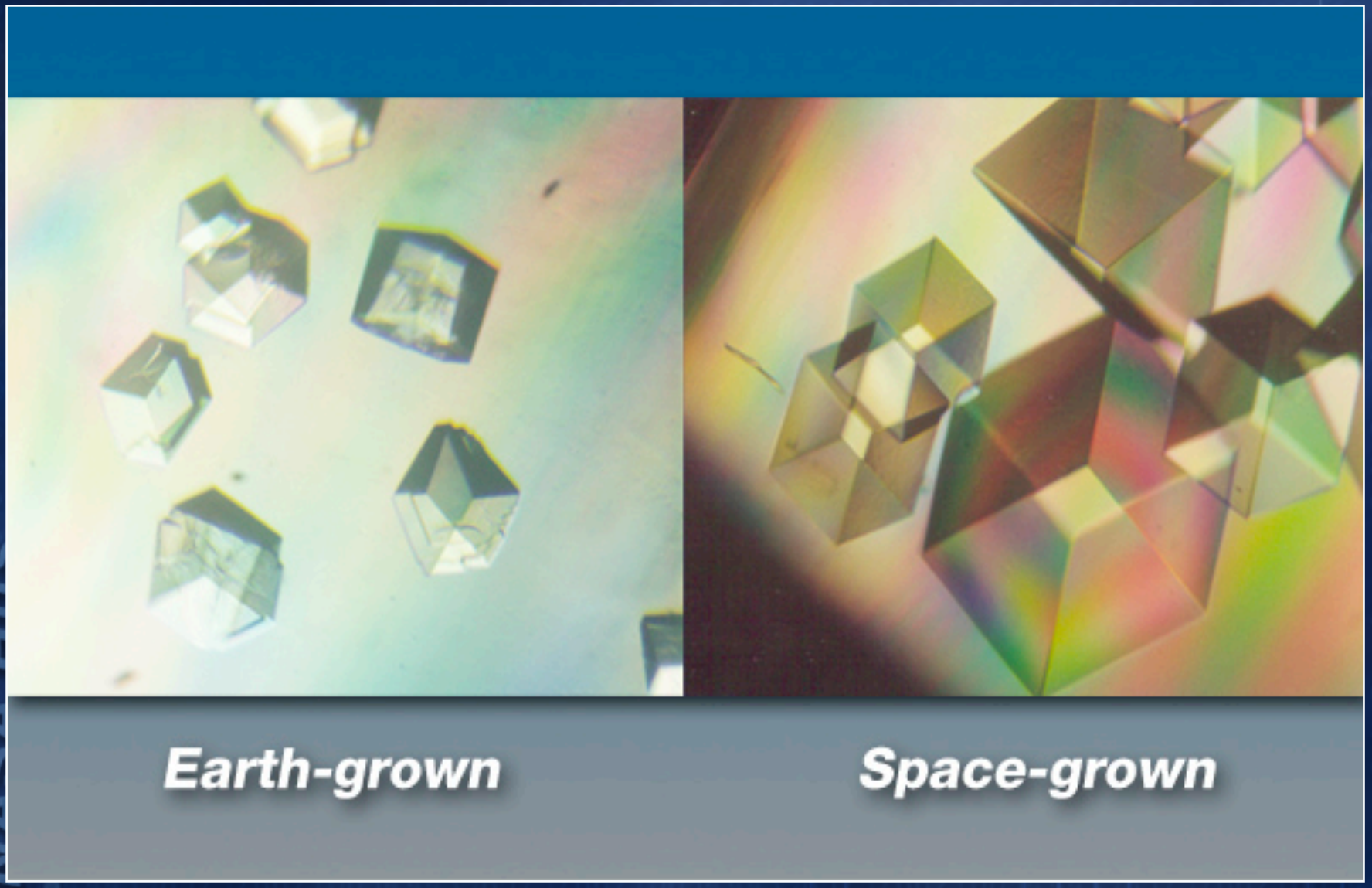
Microgravity Crystallization



For future drug design for chronic and infectious diseases

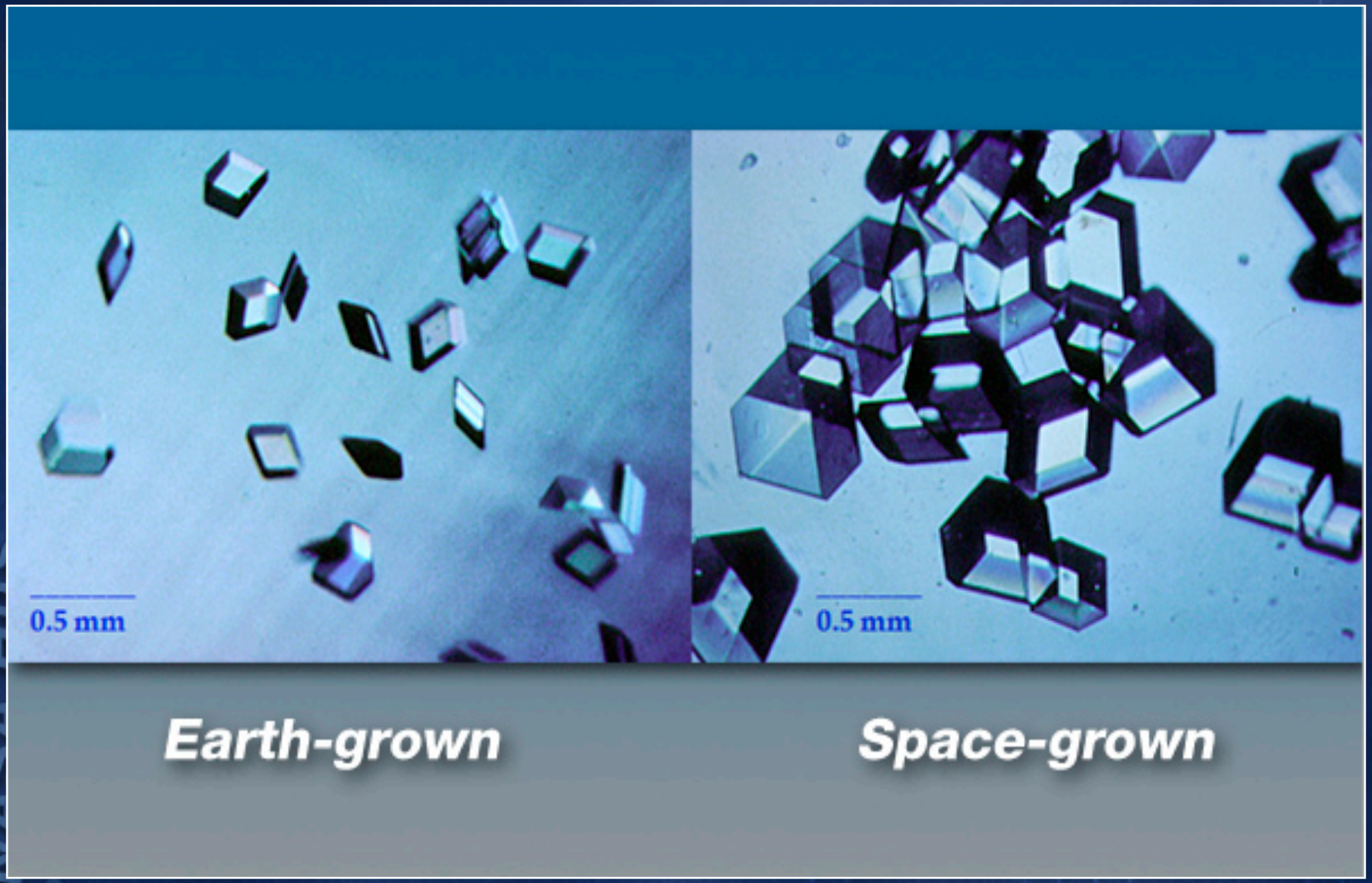
NASA Hits

Microgravity Crystallization



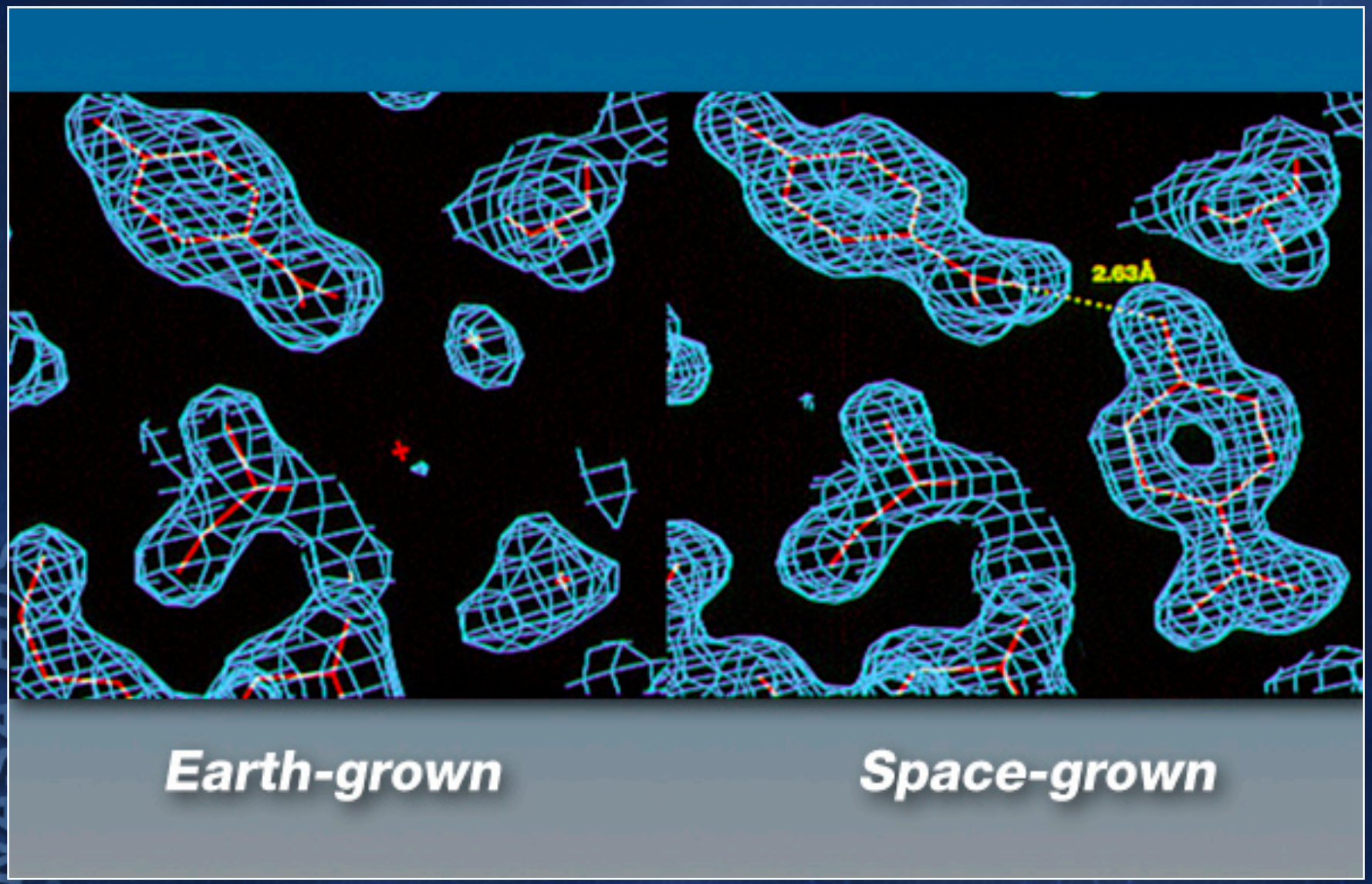
Human Insulin Crystals: STS-95

Human Insulin Crystals

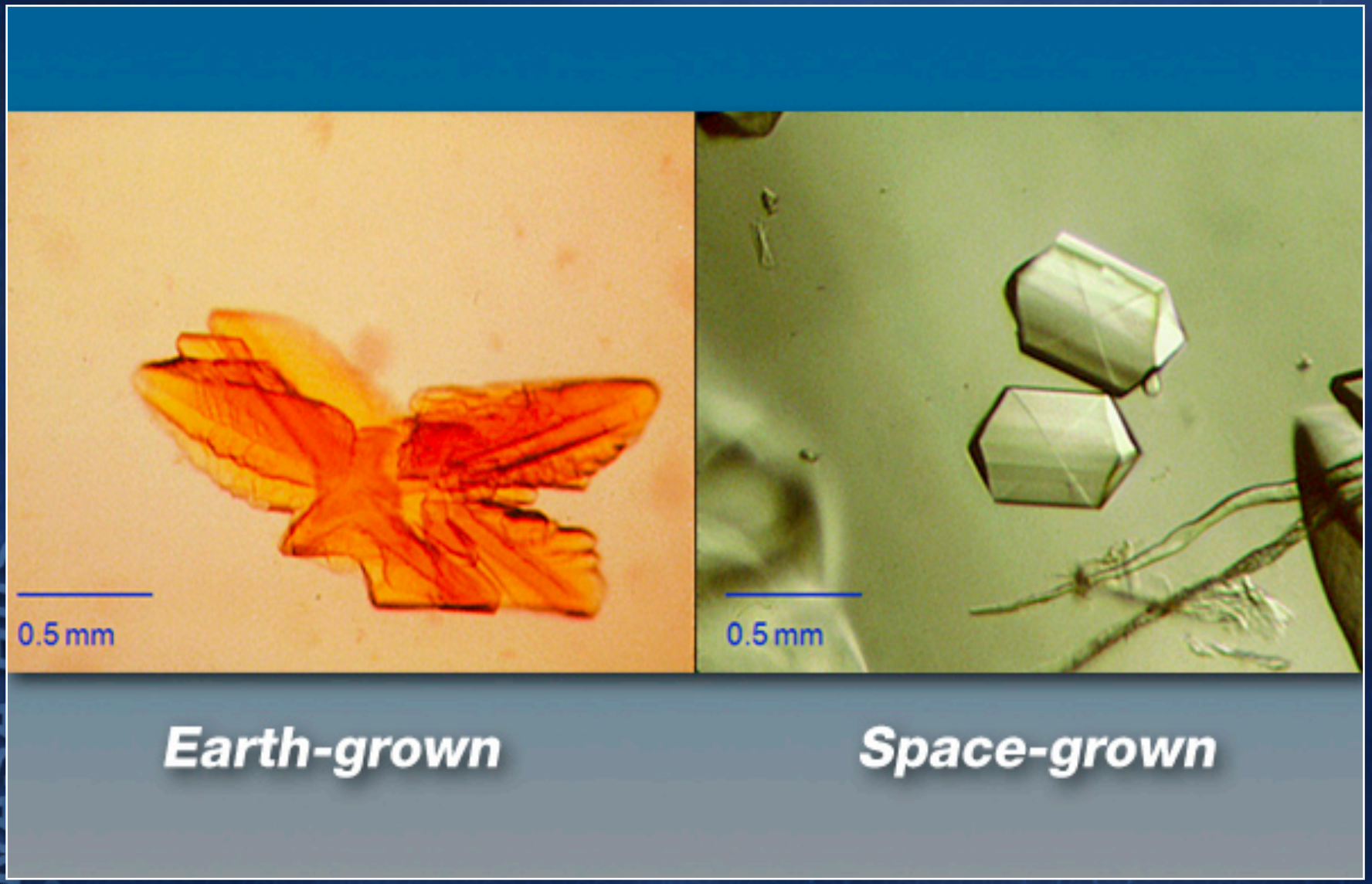


Human Insulin Crystals… target for improved treatment of diabetes

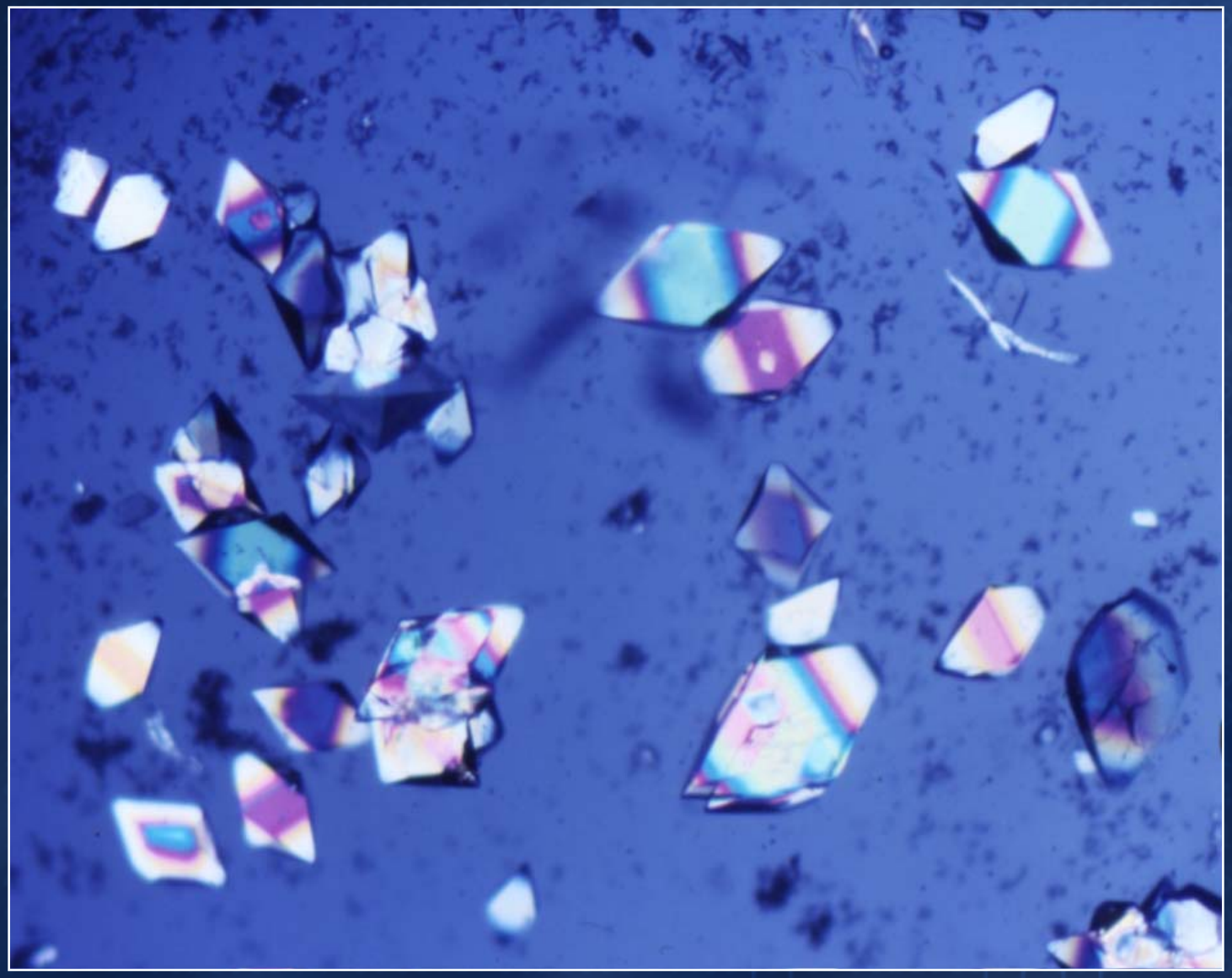
Electron Density Maps for Insulin Crystals



Isocitrate Lyase Target for Plant Fungicide



Microgravity Crystallization



8-oxo-DGTPase: Enzyme involved in DNA damage and repair

Dr.Stephen Quirk, Georgia Institute of Technology

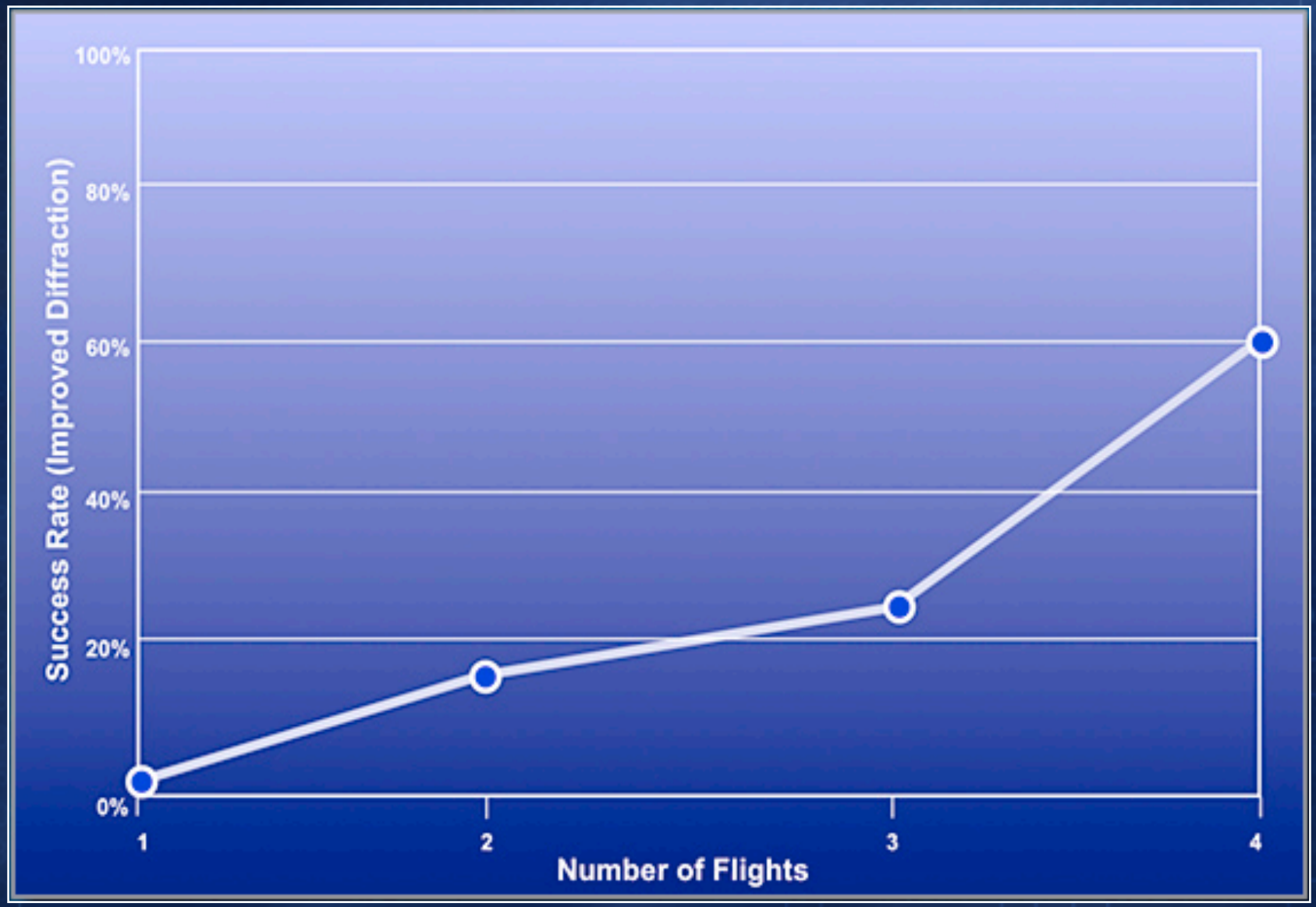
NASA Hits

Summary of Microgravity Vapor Diffusion Experiments

No Crystals	Crystals Too Small for X-ray Data Collection	Diffraction -Sized Crystals	Improved Diffraction Data
16.7%	26.2%	57.1%	27.2%

19 Shuttle Missions - 221 Macromolecules

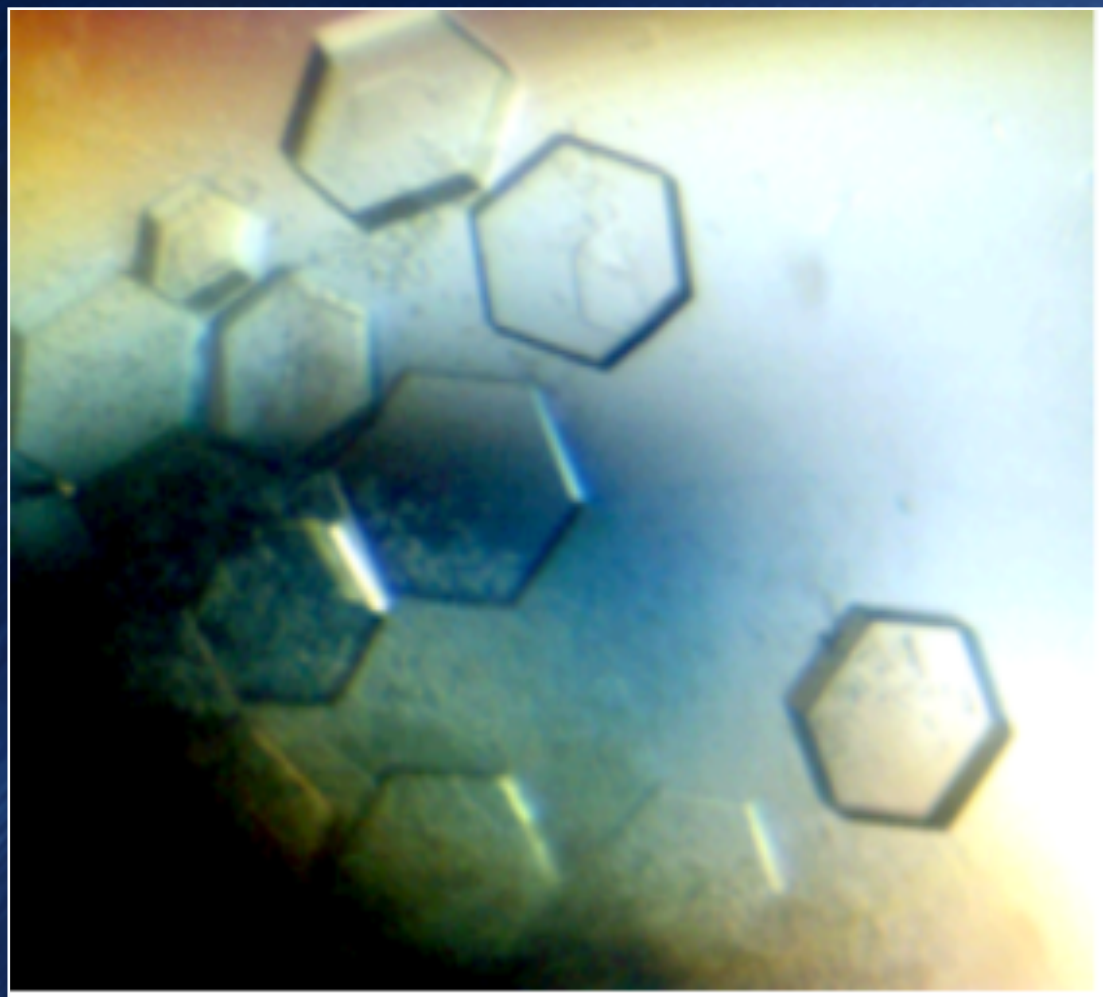
Microgravity Crystallization



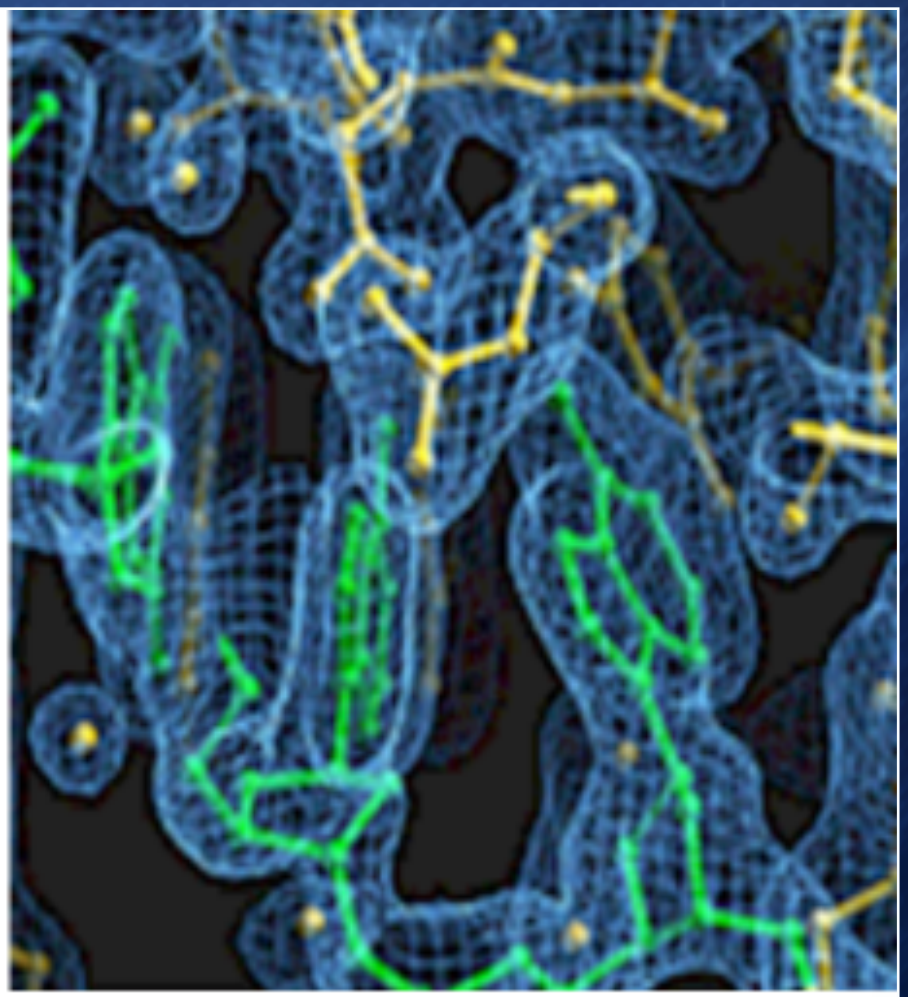
The success rate for obtaining improved diffraction quality increases with the number of flights

NASA Hits

Many Shuttle Flights: Protein Crystal Growth



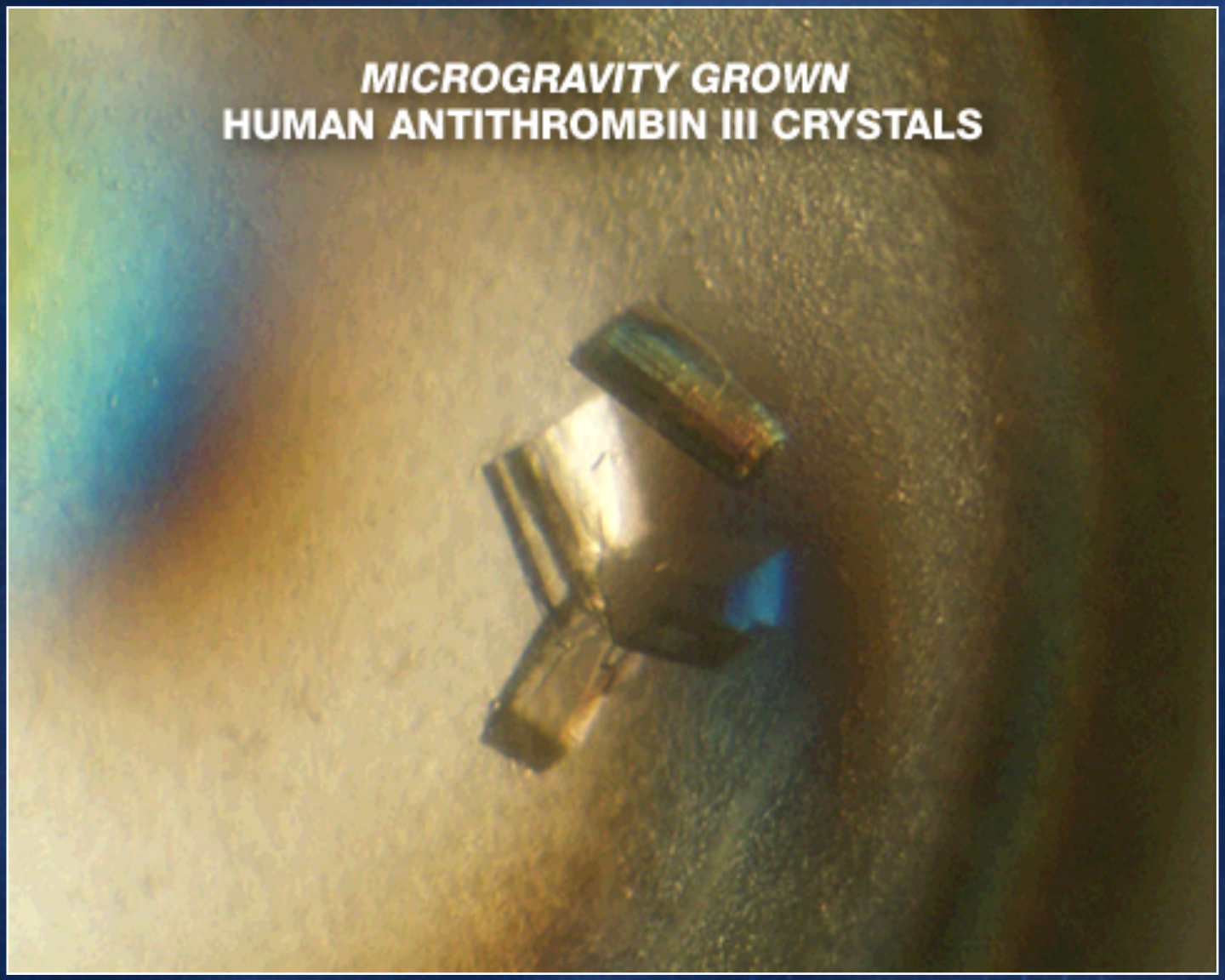
Eco RI Endonuclease crystals



Endonuclease structure

For use in structure-guided drug design

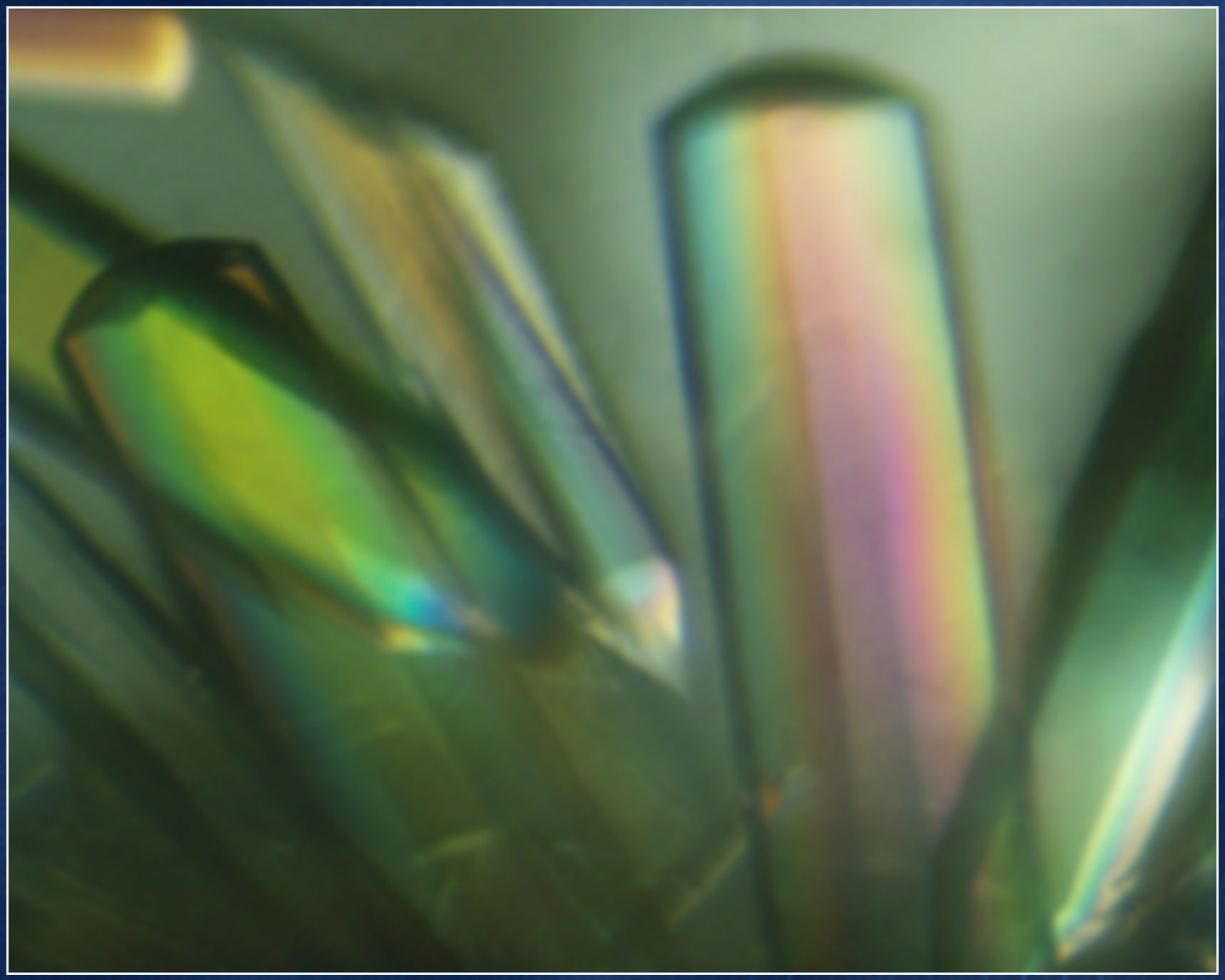
Many Shuttle Flights: Protein Crystal Growth



Antithrombin III – control blood coagulation… for understanding thrombolytic disease and stroke

NASA Hits

Many Shuttle Flights: Protein Crystal Growth



Pike Parvalbumin – proteins found in the muscles, endocrine glands, skin cells… exploring muscle relaxation properties

NASA Hits

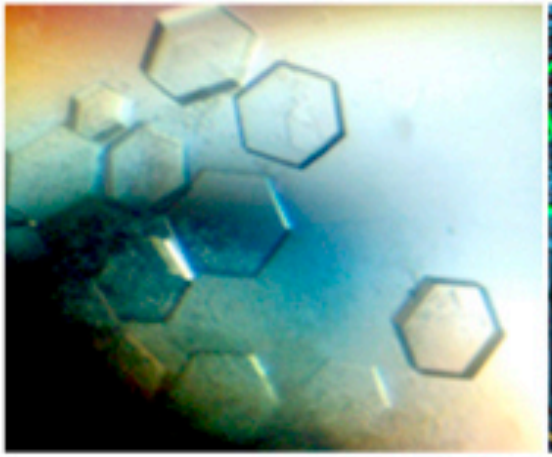
Many Shuttle Flights: Protein Crystal Growth

Improving the safety and efficacy of new and existing **pharmaceuticals**

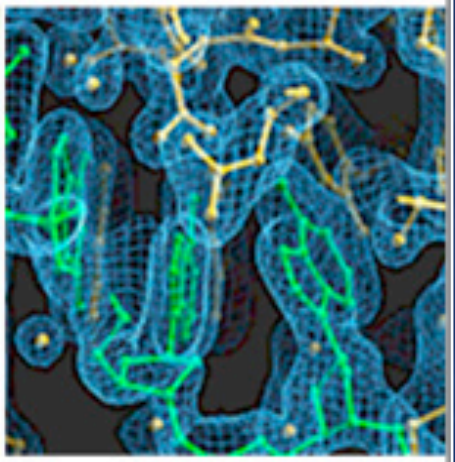
Drug Candidates developed: combinatorial platform for **cancer chemotherapeutics** – ready for clinical trials.

Novel **vaccine** and nano-material platforms developed and patented

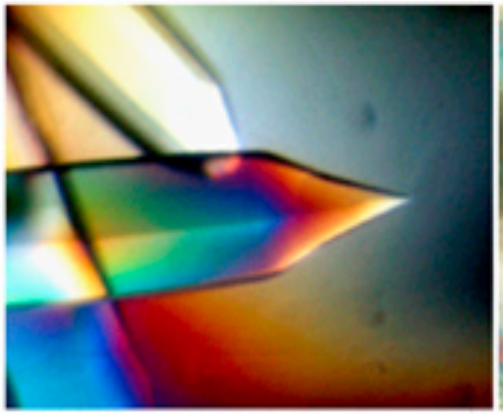
Worlds first biotechnology-based skin and hair products using recombinant human serum albumin – **product launch April 2010, licensed to Albumin Therapeutics**

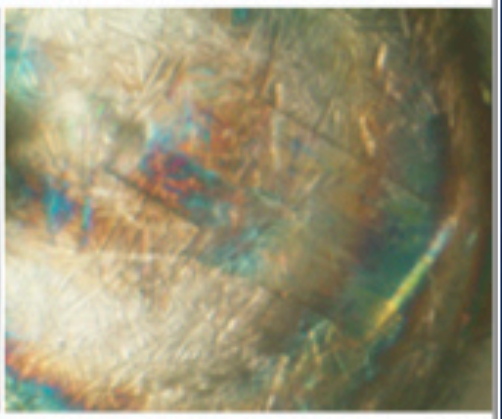


Eco RI Endonuclease crystals



Endonuclease structure





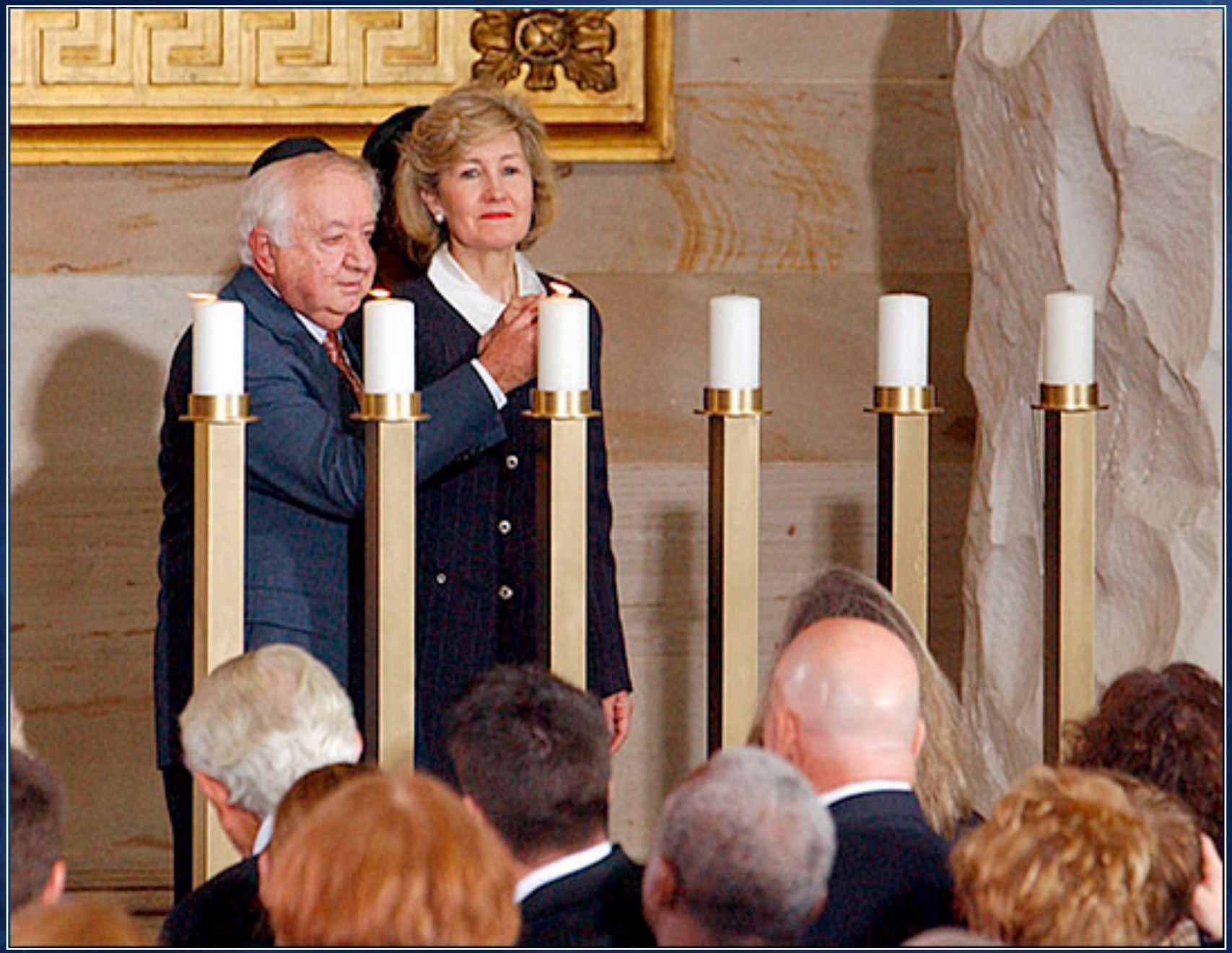
Examples of Microgravity Grown Human Serum Albumin Crystal

For use in structure-guided drug design

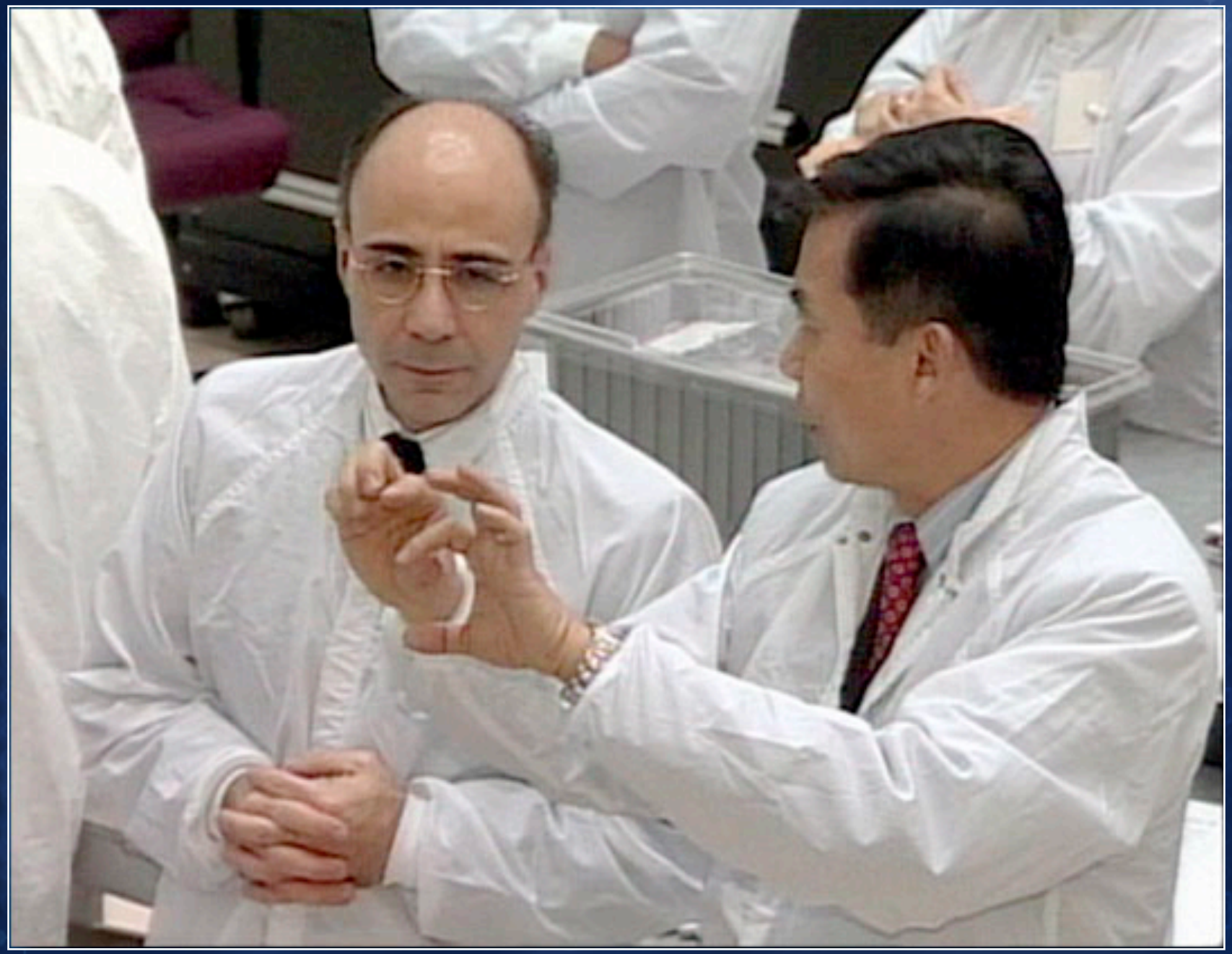

HUSBAND
MCCOOL

NASA Hits

NASA Hits



NASA Hits



NASA Hits

"…science is much more than just space and space is much more than just science."

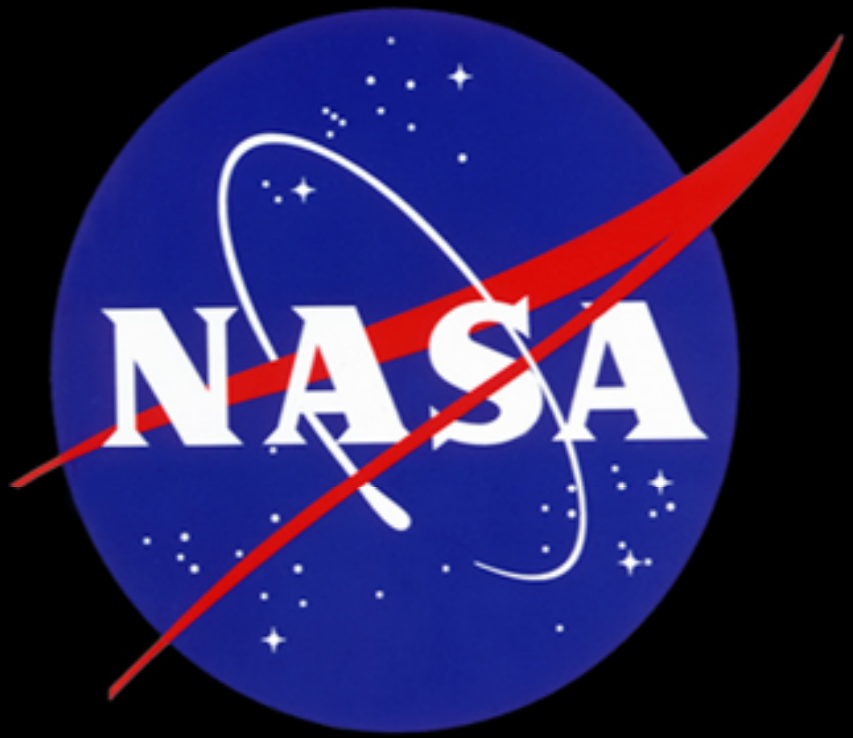
paraphrased from ***Freeman Dyson,***
Physicist

NASA Hits

Back to the Future

A Look at Some Shuttle Experiments

NASA Hits



www.nasa.gov