

# Biotechnology and Planetary Protection at JPL

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# Today's presentation

- What is planetary protection?
- What do we do?
- Why do we do it?
- Flight Projects
- Research

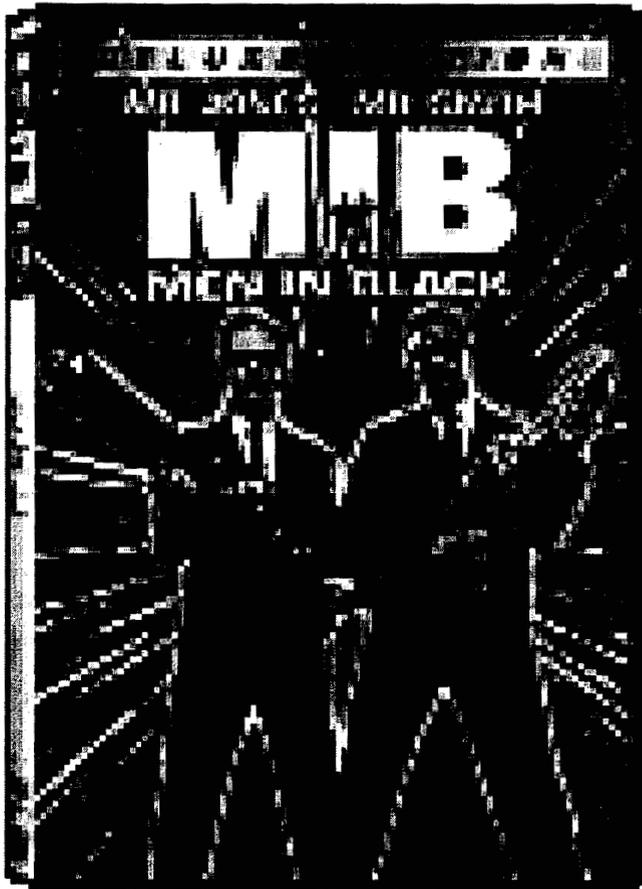
# What are the goals of planetary protection?

- To preserve biological and organic conditions of solar system bodies for future exploration
  - “Forward contamination”
    - Prevent contamination of extraterrestrial bodies by Earth microbes
- Protect Earth from extraterrestrial contamination
  - “Back contamination”
    - Prevent contamination of Earth by extraterrestrial matter from returned spacecraft samples
- Planetary Protection – All the planets, all the time

# What do we do?

- Inform, plan, implement, and confirm that the flight project meets the mission specific planetary protection requirements
- Identify, develop, and test new technologies for use to meet the planetary protection needs of flight projects

We are not (quite) the men and  
women in black!



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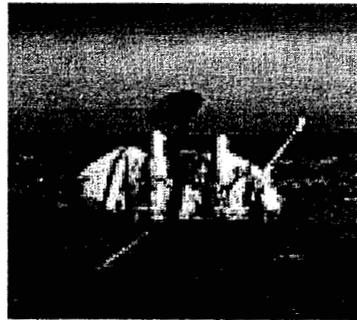
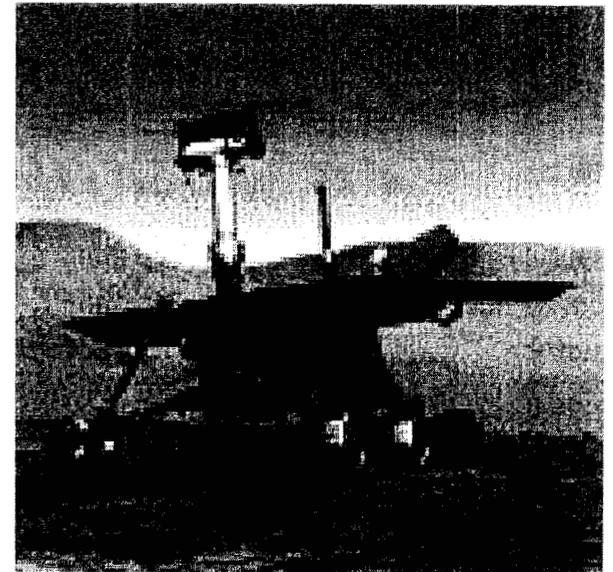
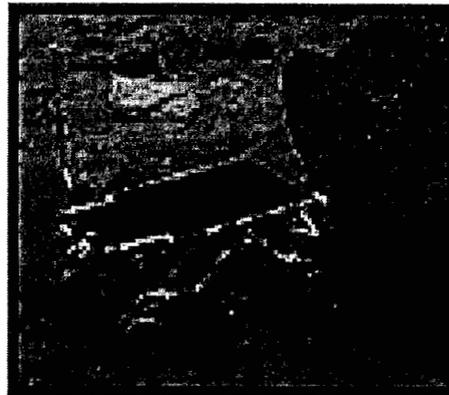
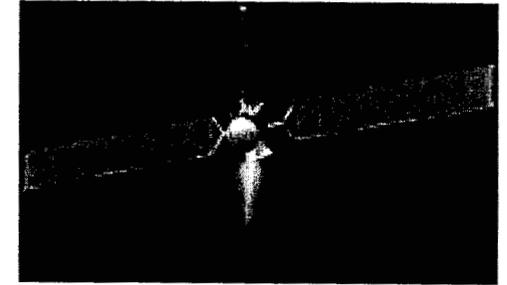
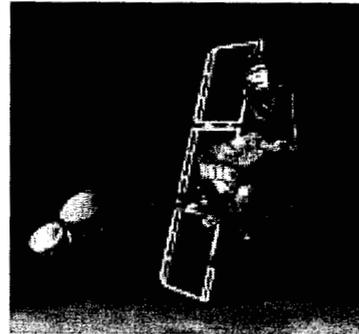
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# Why do we do it?

- Signed international treaty
- United Nations Committee on Space Research (COSPAR), 1967:
  - “the Earth must be protected from the potential hazard posed by extraterrestrial matter carried by a spacecraft returning from another planet. Therefore...controls on organic and biological contamination carried by spacecraft shall be imposed...”

# Planetary Protection for Flight Projects

- Requirements based on:
  - Destination of the mission
    - Planets
    - Moons
    - Asteroids
    - Comets
    - Sun
  - Type of encounter
    - Flyby
    - Orbiter
    - Lander
  - Goal of the mission
    - Life detection?
    - Science
    - Etc.

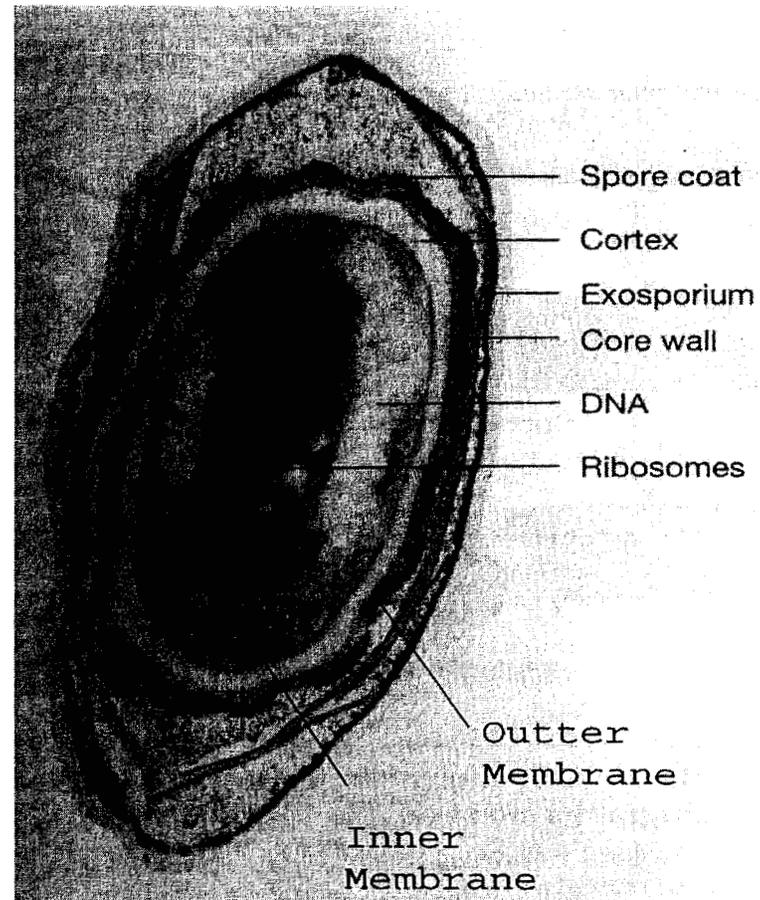


# BPPG Research

- Sterilization
- Cleaning/Validation/Detection
- Microbial Diversity
- Archiving

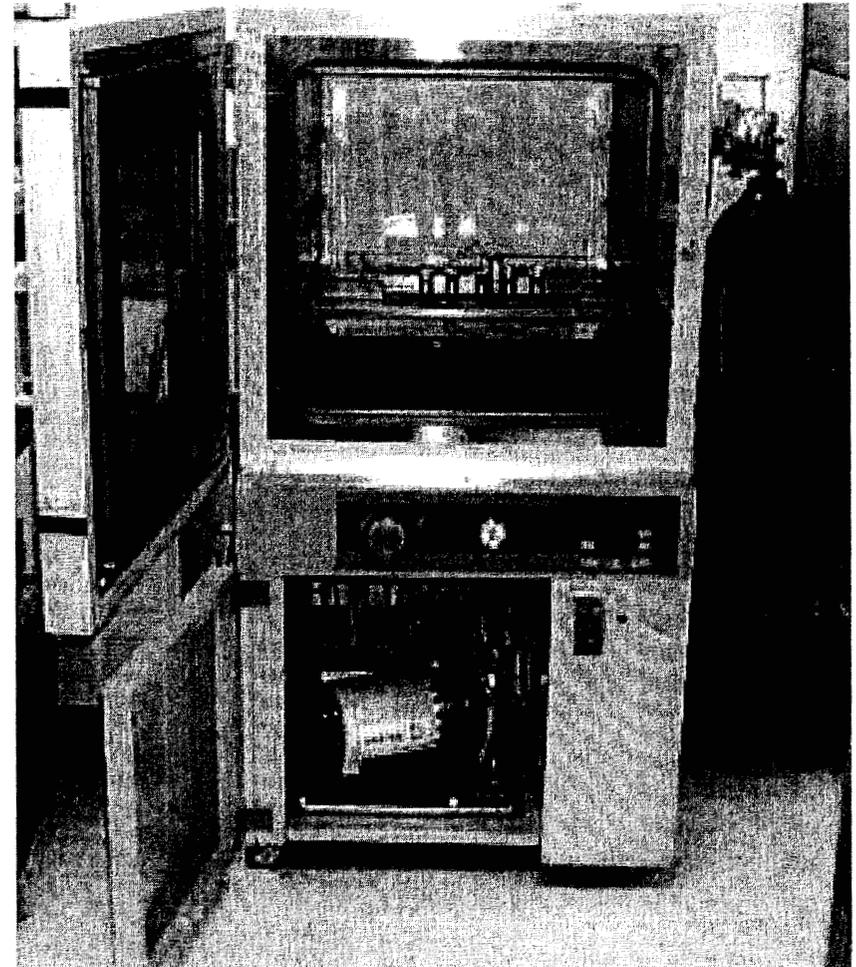
# Bacterial endospores

- *Bacillus* spores:
  - Survival structure (dormant)
  - 4 main components (core, cortex, inner spore coat, outer spore coat)
  - Resistant to various chemical and physical agents (i.e., desiccation, heat, oxidizing agents, and UV and  $\gamma$ -radiation)



# Sterilization

- Dry heat
  - Controlled humidity
  - Temperatures  $>100^{\circ}\text{C}$
- Hydrogen peroxide
  - New application
- Radiation
  - UV
  - Gamma radiation
- Concerns:
  - Materials compatibility
  - Cost
  - Time

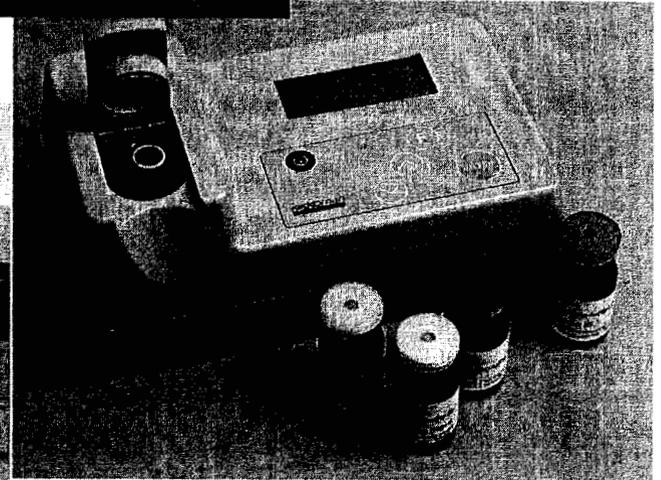
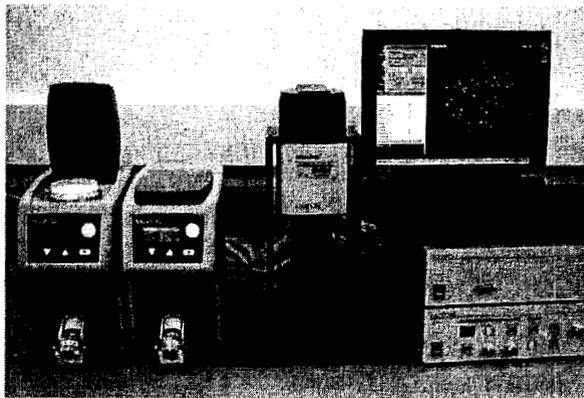
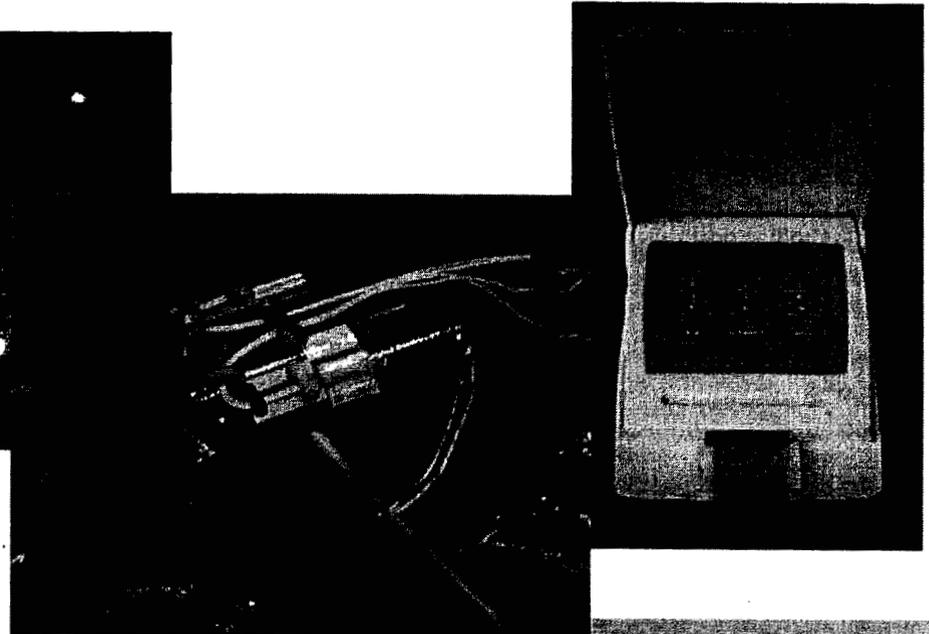
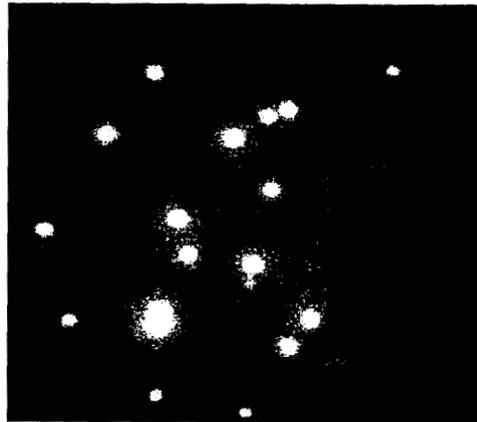


# Cleaning/Validation/Detection

- Detection (to find contaminants)
- Cleaning (to remove contaminants)
- Validation (to ensure cleanliness)
- Detection (to find contaminants)

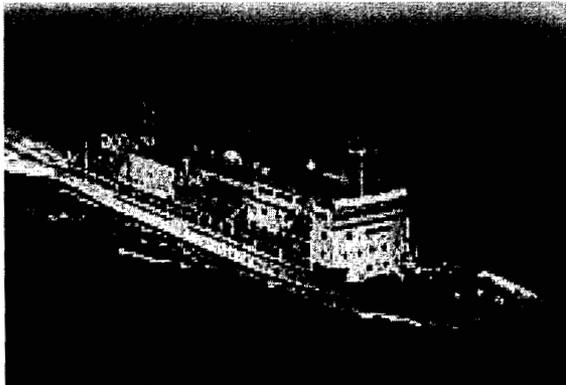
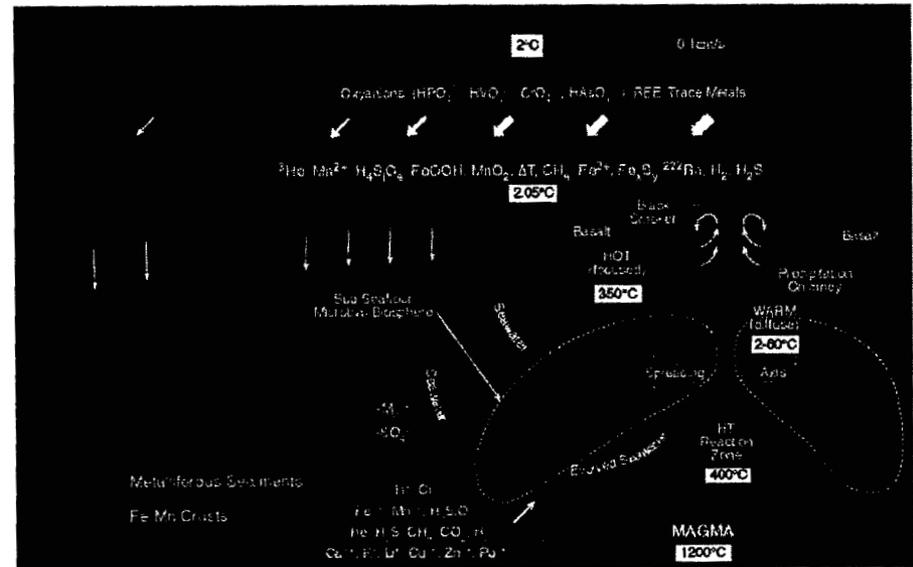
# Cleaning/Validation/Detection

- Technologies used:
  - Microscopy
  - Spore detection
  - Electrophoresis
  - Nucleic acid detection
  - Limulus amoebocyte lysate (LAL)
  - ATP analysis
  - RNase detection



# Microbial diversity

- Extreme environments
  - Hydrothermal vents
  - Ice core samples
  - Desert samples
  - Assembly facilities



From JAMSTEC (Japan Agency for Marine-Earth Science and Technology Center)

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# Microbial diversity

- Assembly facilities
- Flight hardware (spacecraft)

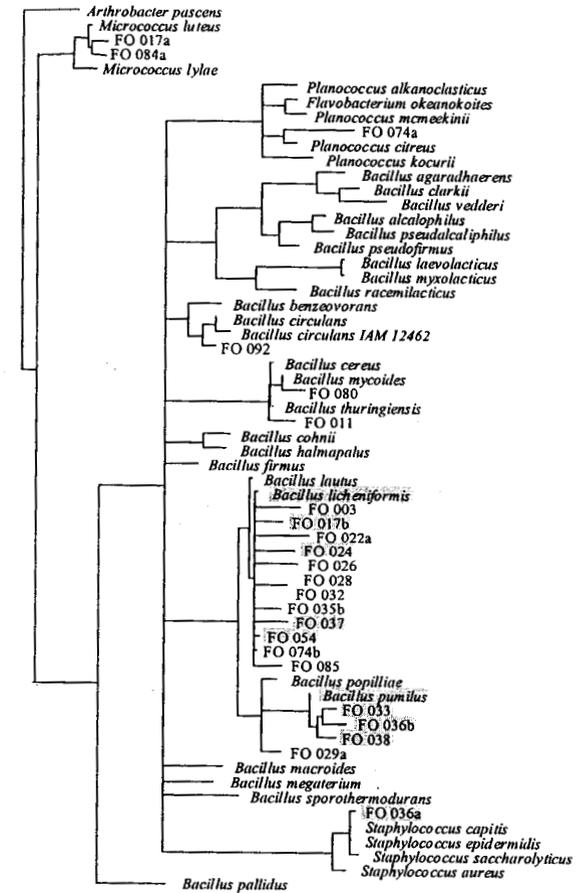
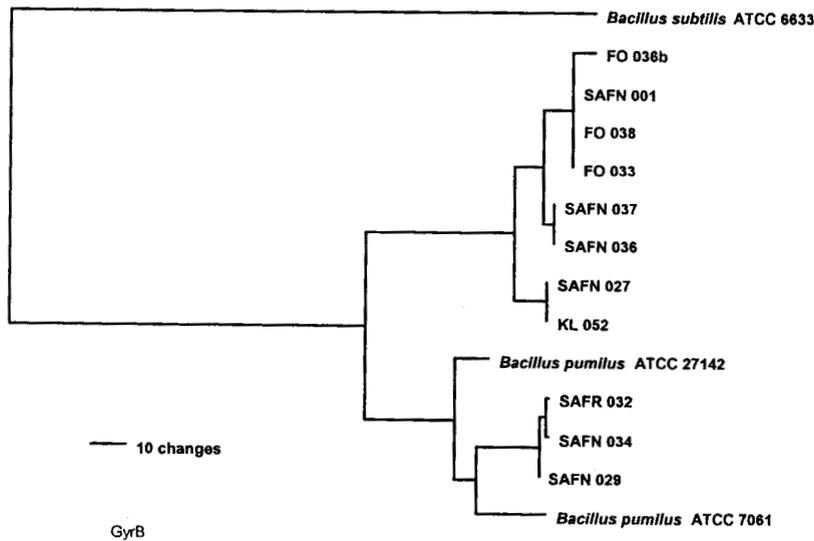
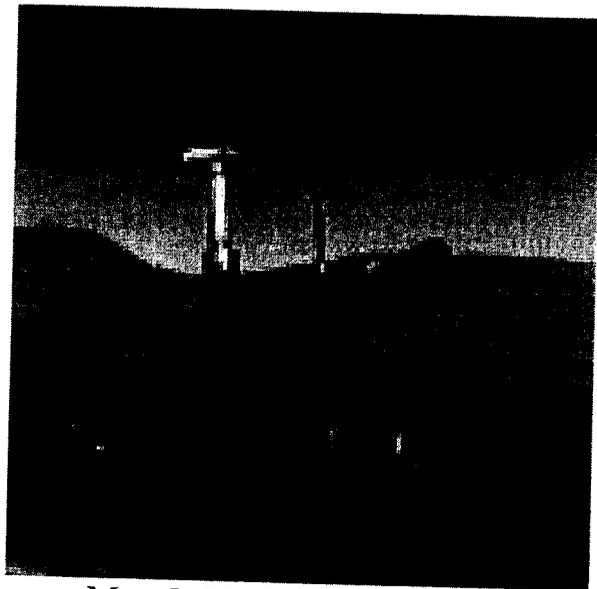
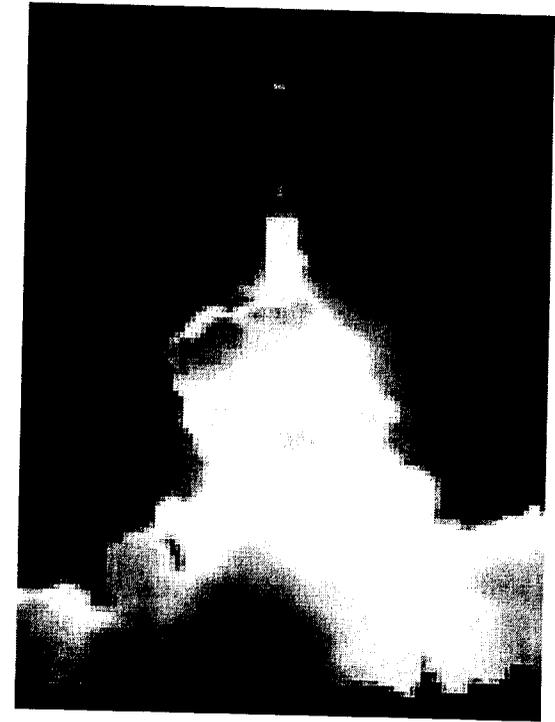
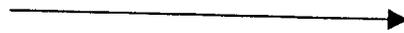


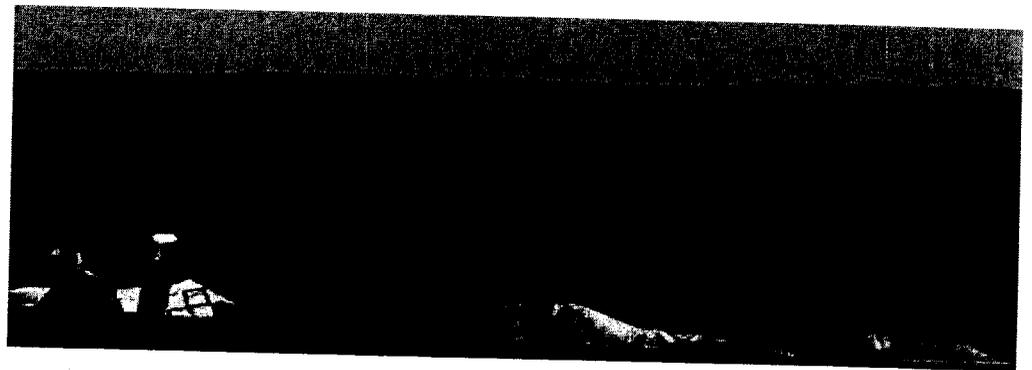
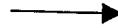
Figure 1. Phylogeny of microbes isolated from JPL's spacecraft assembly facility. Strains resistant to H<sub>2</sub>O<sub>2</sub> vapor sterilization are highlighted.

# Archiving

- To preserve samples
  - Isolates
  - Spacecraft samples
  - Other samples of interest
- I will not show you pictures of freezers and cabinets!!



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# Acknowledgements

- The research described in this presentation was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.
- Biotechnology and Planetary Protection Group
  - ~25 people
  - Biochemists, chemists, engineers, microbiologists, molecular biologists, physicists,

# Back-up slides

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# Education

- B.S. from St. Norbert College, De Pere, WI (1994)
- Ph. D. from University of Wisconsin-Milwaukee (1999)
  - Genetic analysis of *Flavobacterium johnsoniae* gliding motility
- Post-doctoral fellow at UCLA (2000)
  - Research on *Fusobacterium nucleatum*, an oral pathogen involved in periodontitis
- Post-doctoral scholar at California Institute of Technology (2001)
  - Hydrogen peroxide resistance of *Bacillus* spores
  - Indian Ocean hydrothermal vent study
- Member of the Technical Staff, BPPG, JPL (since 2002)
  - Dry heat sterilization
  - Member of Mars Exploration Rover (MER) PP implementation team
  - And more