Planetary Protection: Preventing Space Probes from Transporting Microbes to and from the Planets

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COSPAR

- Committee on Space Research
  www.cosparhq.org
- promote on an international level scientific research in space
- emphasis on the exchange of results, information and opinions

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NASA

NPD 8020.7E

Biological Contamination Control for Outbound and Inbound Planetary Spacecraft

NPG 8020.12B

Planetary Protection Provisions for Robotic Extraterrestrial Missions

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Application

- All robotic missions except Earth-orbit & lunar
- Priority: Mars & Europa

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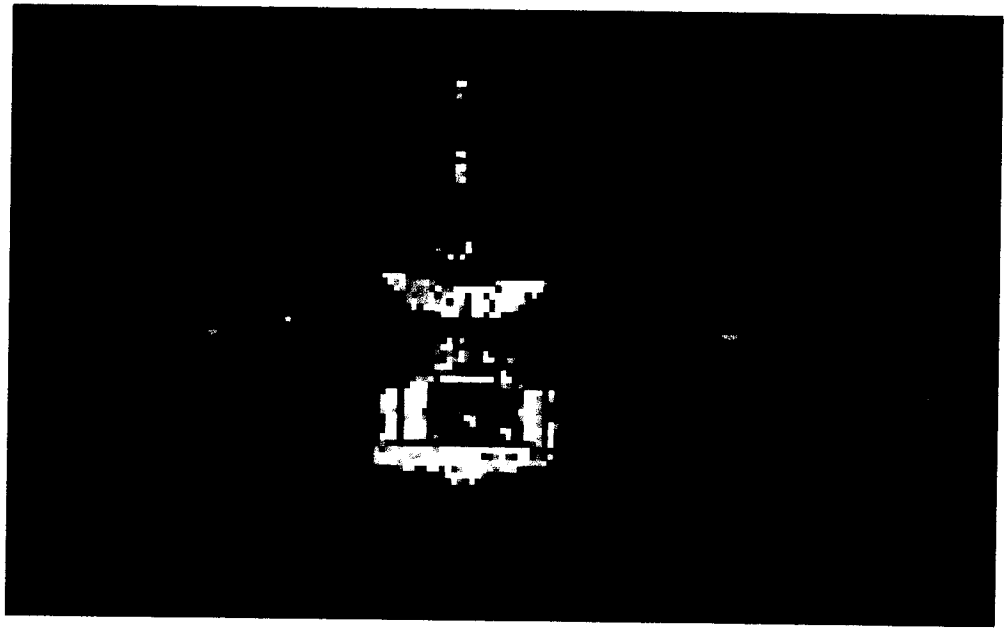
Category I	Any Mission Type	Not of direct interest for understanding chemical evolution. No protection of such planets is warranted. No requirements imposed.
Category II	Any Mission Type	Of significant interest to the process of chemical evolution but only a remote chance that contamination by spacecraft could jeopardize future exploration.
Category III	Flyby, Orbiter	Of significant interest to the process of chemical evolution and/or the origin of life or for which scientific opinion provides a significant chance of contamination which would jeopardize a future biological experiment.
Category IV	Lander, Probe	
Category V	Earth Return	Any Solar System body

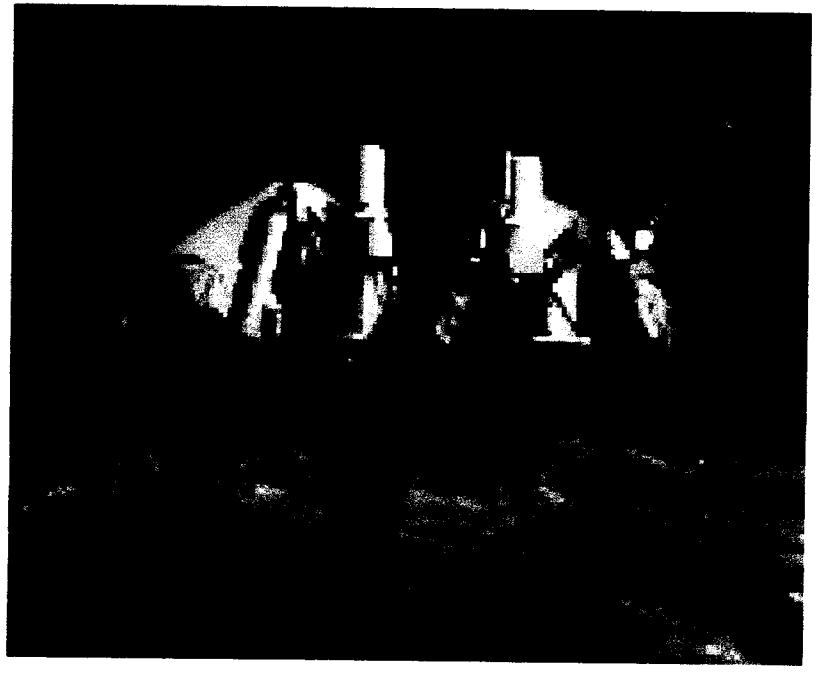
Mariner 4

- Launch: November 28, 1964
- Flyby : July 14, 1965



Viking 1 & 2

- Launch: August 20, 1975 (Viking 1); September 9, 1975 (Viking 2)
- Landing: July 20, 1976 (Viking 1); September 3, 1976 (Viking 2)



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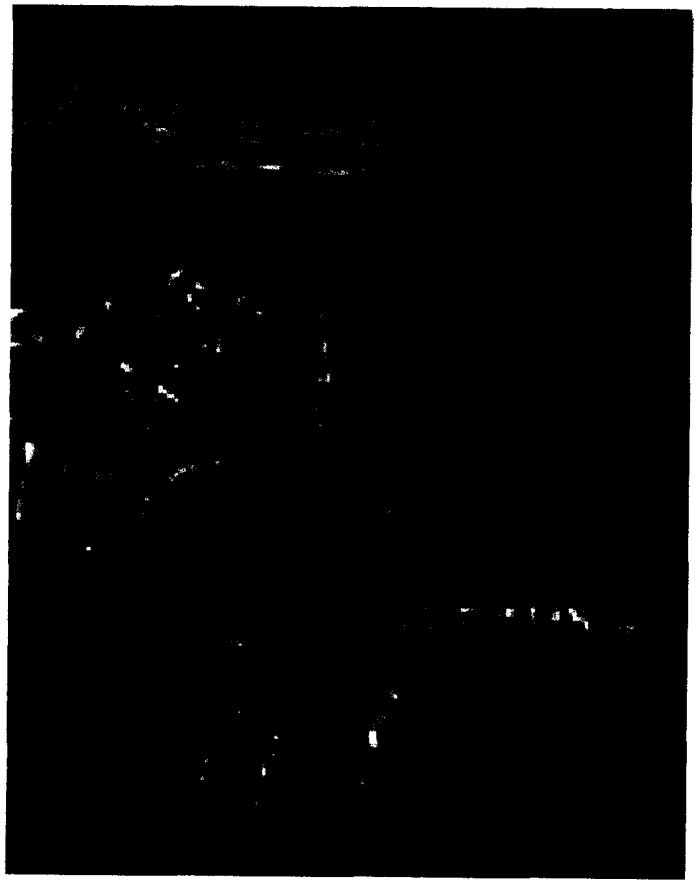
Pathfinder

- Launch: December 4, 1996
- Landing: July 4, 1997



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Requirements

$P_{I(L \text{ to } L+20)} < 0.01$ and $P_{I(L+20 \text{ to } L+50)} < 0.05$

OR

Total bioburden < 5×10^5 spores at launch

Sampling Viking for Bio Assay

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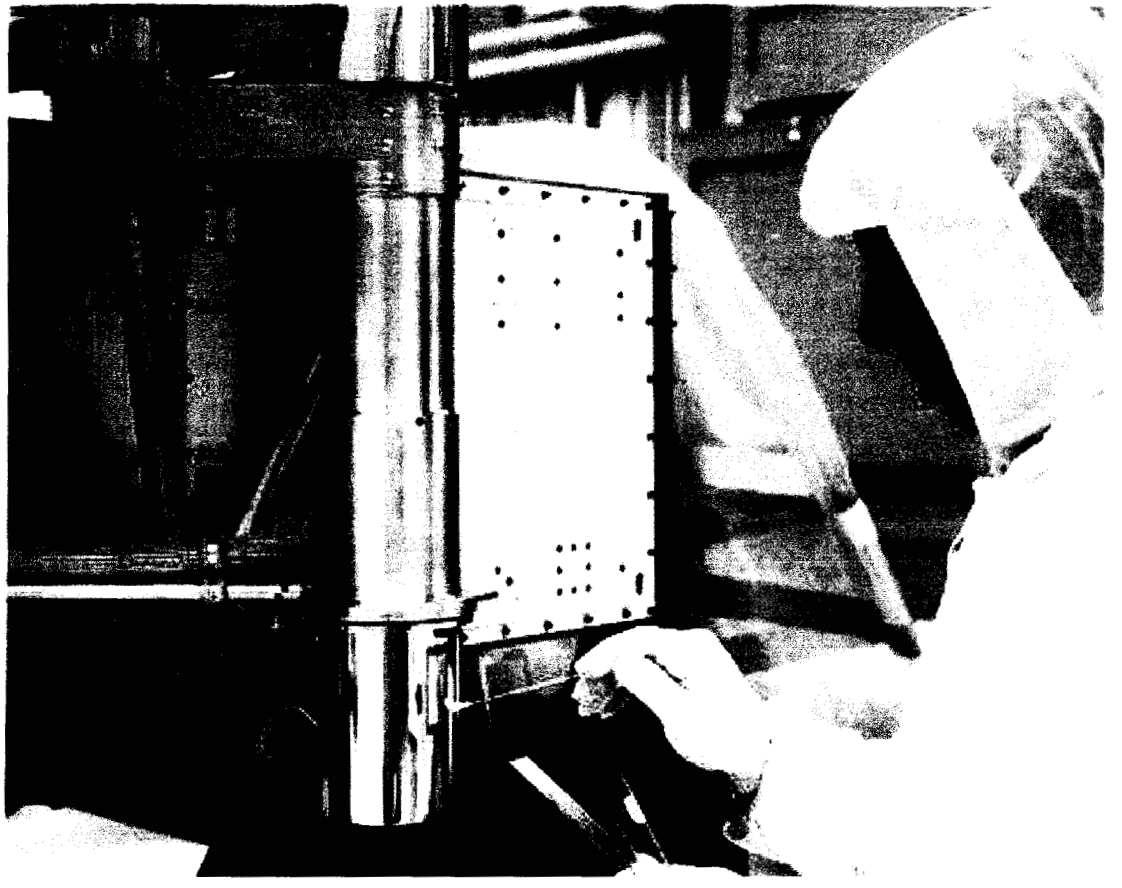

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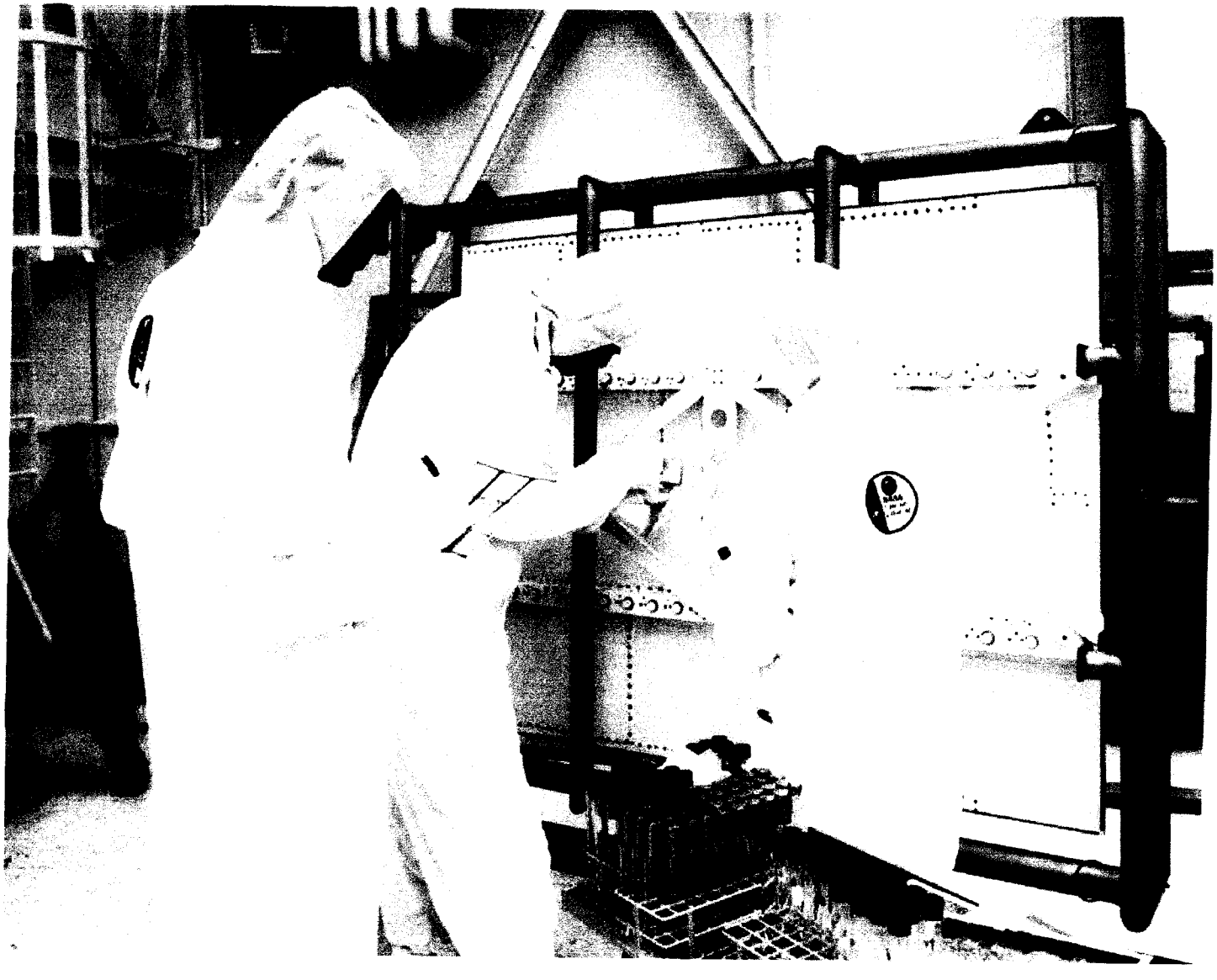

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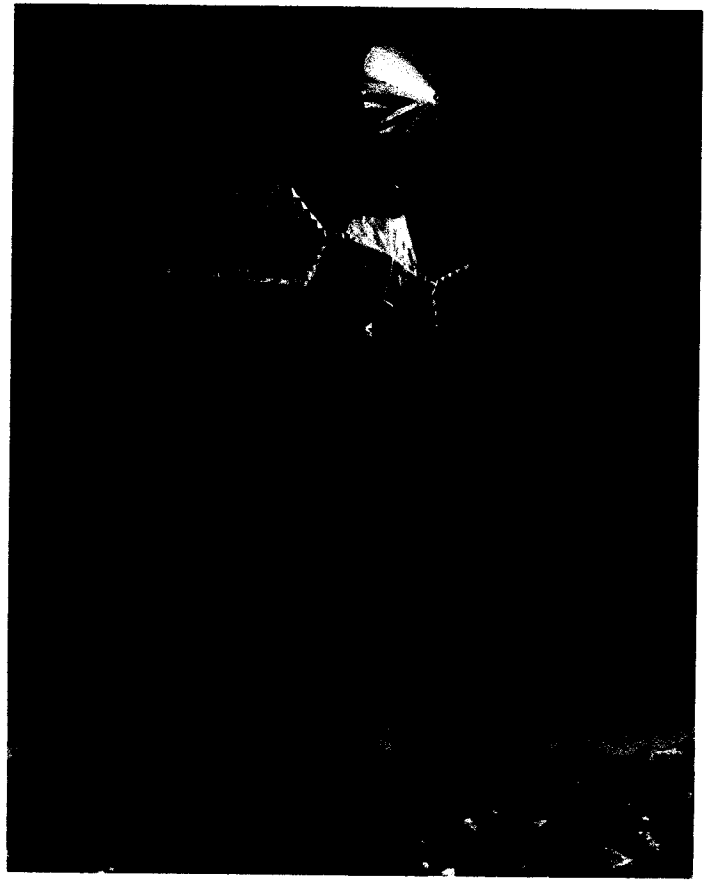
Bio Sampling for Pathfinder

Mars Reconnaissance Orbiter

- Launch: August 2005
- 320 x 255 Km orbit
- Will be the 1st orbiter to meet PP by total bioburden method



Planetary Protection Needs

	Where We Are Now		Where We Must Be
Cleaning & sterilization R&D	• H_2O_2 plasma, freon	Supercritical fluids Enhanced solvents Chemical destruction	• Map of biomarker contaminants • leading-edge kill/clean/validate methods
Verify/Validate procedures, criteria, & standards	Viking standards • Clean to 300 spores/m^2 • No viable spores if life detection	Non-culturable whole cells Macro biomolecules Small biomolecules	• Procedures satisfying scientific consensus regarding sample integrity
Flight Project cleaning processes & activities	• Wipedown with alcohol • Dry heat sterilization (Viking) • Monitor culturable spores • Can't clean sensitive parts	Advanced assembly facilities/procedures through launch	• Verify/Validate bioburden with latest technology • No detectable biomarkers • Biowitness procedures
Sample acquisition & containment	• Under study	Canister technologies, transfer to return s/c, quarantine methods	• System architectures & mechanical processes that ensure sample integrity • In situ life detection techniques
	1999	**1999–2003**	**2007**

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Future Proposed Missions

- Mars Sample Return
- Europa

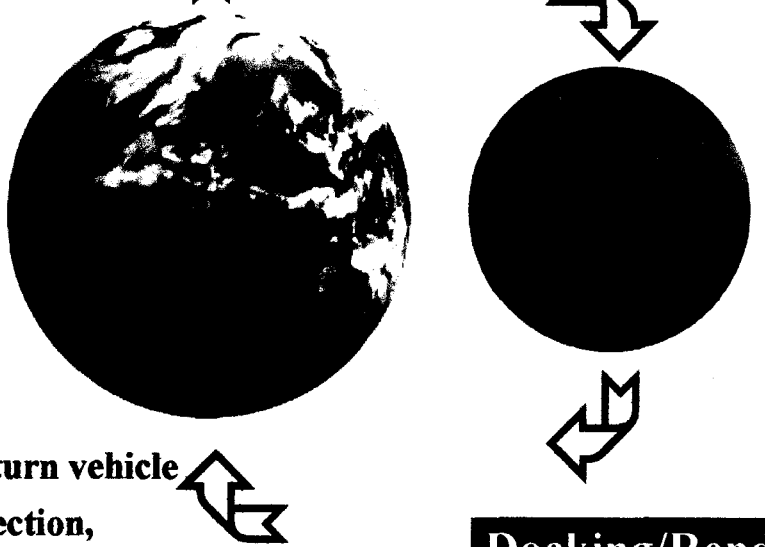
Planetary Protection Realm

Launch

- Maintain cleanliness during transit, test, & rework
- Avoid recontamination

Prior to launch

- Standards/Criteria
- Design of MSL
- Sterilize & clean
- Assemble
- Verify & validate



Mars Landing

- Landing/deployment w/o contamination from s/c
- Sample acquisition & containment
- In situ experiments to relieve some PP constraints?

Return to Earth

- Avoid contamination of return vehicle
- Site selection & entry protection, including crash protection
- Verify cleanliness of outer SR vessel & transport to protective environment
- Removal/validation/analysis of sample with clean equipment
- Sample distribution

Docking/Rendezvous for Return

- Avoid contamination of ascent vehicle during launch
- Avoid contamination of ascent vehicle by orbiter

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Past Cross-over Work

- Cleanroon technology applied to operating rooms - '70's
- Ventilator Sterilization - ethylene dioxode process took unit OTS for ~ a week. Redesign brought down time to hours

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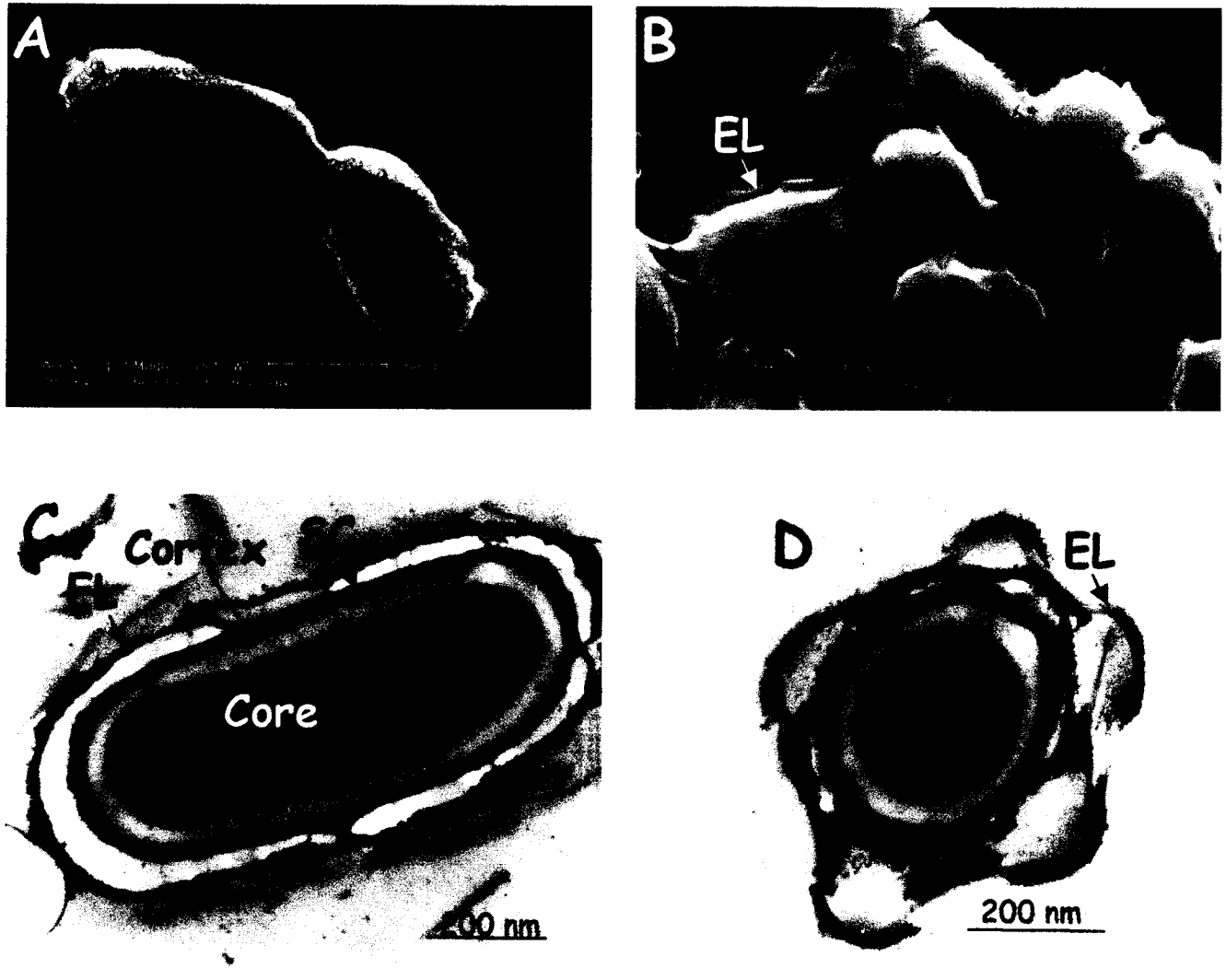
Research

- Bio Diversity Study
- Cleaning & Sterilization



Bacillus nealsonii

New *Bacillus* species

Control

γ-radiation (0.5 Mrad)

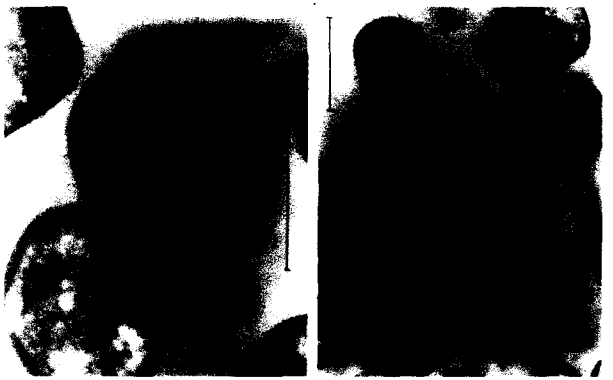
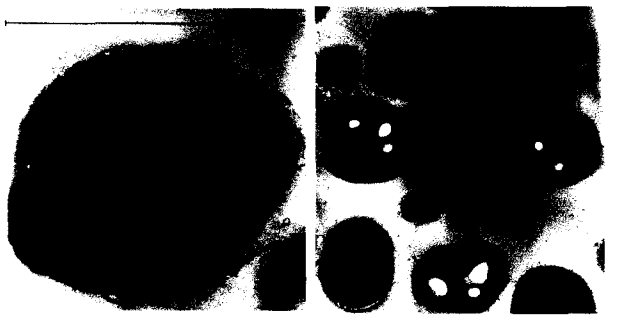
H_2O_2 (5% v/v)

$1x10^7$/mL [initial]

0.4% survival

20% survival

Acinetobacter radioresistens 50v1

Control	γ-radiation (0.5 Mrad)	H_2O_2 (5% v/v)
		
$1.7x10^{10}$/mL [initial]	~8 log reduction	11% survival
		

- ***Acinetobacter radioresistens*** **(ATCC # 43998) type strain not resistant to H_2O_2 at all.**


Shinkai

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Current Cross-over Opportunities

- SBIR – Small Business Innovation Research

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SBIR Example

Cold Plasma Sterilization