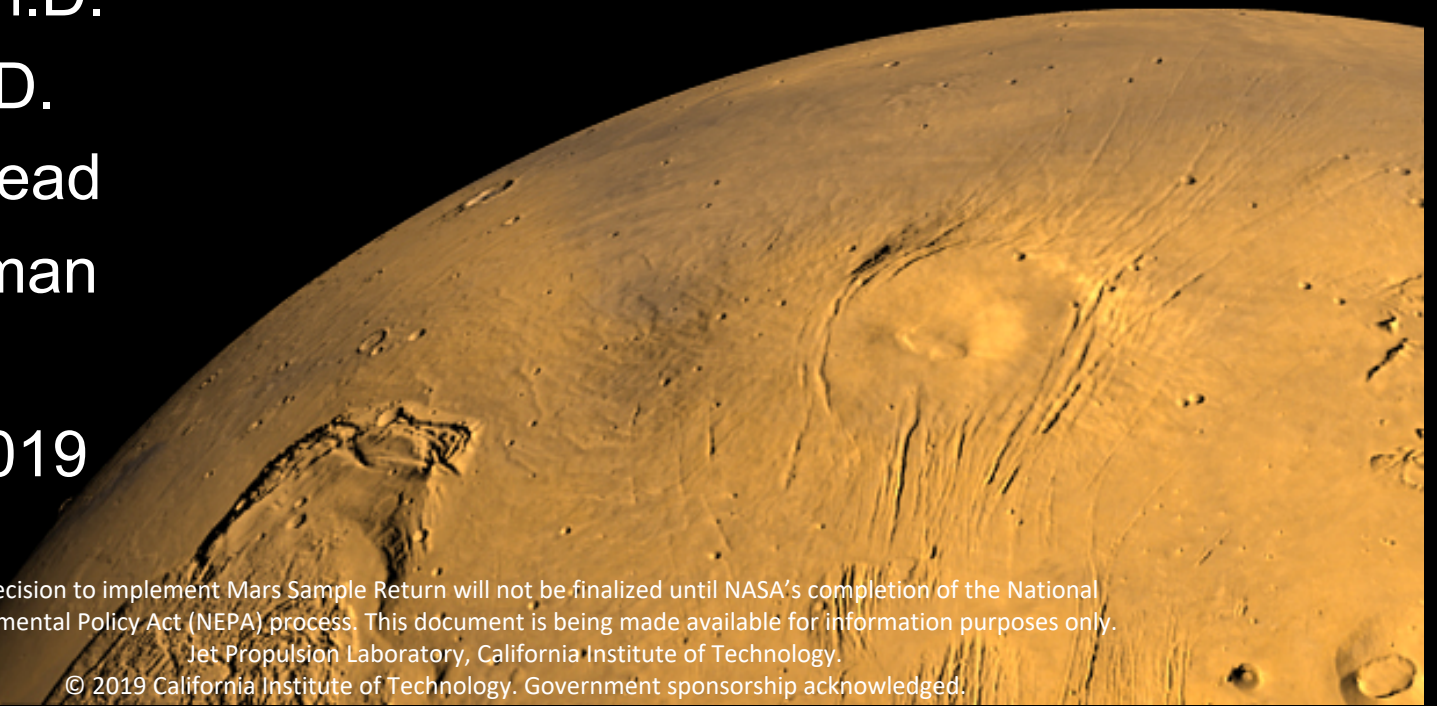
Mars Sample Return Planning Sterilization Working Group 2nd Meeting

Alvin Smith, Ph.D.
Lisa Pratt, Ph.D.
Brian K. Muirhead
Robert Gershman

June 10-11, 2019



The decision to implement Mars Sample Return will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This document is being made available for information purposes only.
Jet Propulsion Laboratory, California Institute of Technology.
© 2019 California Institute of Technology. Government sponsorship acknowledged.

Identifying Indicator Organisms

J. Nick Benardini, PhD
Planetary Protection Engineer
Spacecraft Mechanical Engineer
Jet Propulsion Laboratory, California Institute of Technology

Pre-decisional. For planning and discussion purposes only. Do not distribute

Agenda

- Desired Outcomes
- Biological Indicator Selection
- Evaluation of the Microbial Community
- Additional Points for Thought / Parking Lot
- Identifying Indicators
- Test Method
- Next Steps
- Back-up
  - References
  - Consolidated List
  - Email List
  - Example of JPL Cleanroom Associated Isolates and Environmental Tolerances

Desired Outcomes

Short-term (THIS workshop – next charts)

1. Identification a subset of organisms to start sterilization testing and design?
   - For each category is there a consensus of selected strains?
   - For each category are there other indicators that we need to consider?
2. If additional input is deemed necessary, is there a group censuses in how to solicit additional input (e.g. poll additional SMEs? RFI?)?
3. Establish plan for down selection process for indicator organisms (e.g. timeline, trade, etc)

Long-term (post workshop; months)

1. Conduct a detailed Investigation and Biological Trade / Recommendation
   - Evaluate - relevant to sterilization modality
   - Understand detailed reference experimentation
   - Ability to work with organism (e.g. accessibility, ease of final assay)

"I would want to include representatives from multiple domains of microbial life (Archae, eubacteria, viruses, etc) that are known to withstand extremes encountered on the surface of Mars and/or space" – K. Frey

Biological Indicator Selection

- Objective: To determine a broad-spectrum list of biological indicators for developing and refining spacecraft microbial reduction technologies for back planetary protection.
- Goal – to have the broadest engagement of the microbial community to ensure the back planetary protection sterilization story is robust to the public and regulatory communities.
- Identification / Exploration of biological indicator candidates
  1. Literature review and understanding of current peer-reviewed literature space (JPL Lead - M. Stricker presentation)
  2. Evaluation within the microbial community – polling. With the objectives to compile a list of indicators, look for consensus organisms and pursue the feasibility of the non-consensus organisms (discovery / expanded knowledge set from SME's in the field).
  3. Expand input from External Community (outside this poll)
     1. Expanded input from other sterilization SME's
     2. NASA RFI release to poll external community further.
- Discussion of biological indicator candidates and down select to occur in Sterilization Workshop.
  - Note that due to timing of items #2 and #3 above the consensus list of organisms can be discussed and we are recommending that experimentation should start.

Evaluation of the Microbial Community

- Question posted to Community (5/21/19 and reminder 5/31)
  - " …we are polling several laboratories with expertise in sterilization or working with hardy (potentially pathogenic) organisms to help us capture a broad understanding of biological indicators one would choose for a sterilization study, based on your laboratory's unique experience. These indicators could encompass multiple domains of life (bacterial spores, viruses, proteinaceous particles, etc.). As the first step in this polling process, we ask that you:
    - Identify your top five microbial sterilization/reduction/inactivation indicators (or hardiest of hardies). Another way to think about this could be as follows: If you had to design a microbial indicator set for your lab what would they be; are there hardy organisms in your lab or that you have come across that could be comparable to acceptable gold standards?"
- 34 labs were polled
  - 11 academic partners, 4 US Army, 4 DHS, 2 ESA, 3 FDA, 2 National Labs, 2 industry, 6 NASA, and 1 NIH potential collaborator
    - US, European
    - ALL NASA Microbiology Labs – KSC, GSFC, JSC ISS, JSC Astromaterials, AMES
    - ALL ESA Microbiology Labs - German and Austrian
- 17 responses collected (6/3/19)
  - 7 academia, 2 army, 2 NASA, 2 ESA, 1 industry, and 3 FDA

Additional Points for Thought / Parking Lot

- Need input for prions
- Consideration of Killed Controls - USP 51 “Challenge” Test – Antimicrobial Efficacy Test / Preservative Effectiveness Test
- Single point coupons studies scaled up to complex matrices (e.g. soil sterilization)
- Viable but non-cultivable states –
  - Resistant to culture but still infective in animals (e.g. mouse model for *Francisella tularensis*)
- Customized indicators
  - “we produced our own bio-indicators by filling sealed tubes with a bacterial spore mix placed in mail trays along with radiation dosimeters to verify the radiation dose that was delivered”
- How broad should this list fundamentally be?
  - Should it encompass - spacecraft associated, environmental (specific types), NASA and ESA, others?

1.a Identification of spore formers to start sterilization testing and design?

Genus	Species	Strain	Microbial Reduction Modality	Contributor
Bacillus	*pumilus*	SAFR-032	UV, steam	JPL, Nicholson, Smith
Bacillus	*sp.*	ATCC 29669	NASA heat hardy	JPL
Bacillus	*sp. E24*	DSM 30879	ESA spacecraft strain, cold plasma, H202, ClO2,	P. Rettberg
Clostridium	*sporogenes*	ATCC 11437D-5	heat resistant, sporeformer	FDA/ORA, Lindsay, JPL
Geobacillus	*stearothermophilus*	ATCC 12980	steam sterilization	JPL, Keim, Bakermans, Smith
Bacillus	*atrophaeus*	ATCC 9372	dry heat, ethylene oxide (also steam and radiation)	Bakermans, Lindsay
Bacillus	*atrophaeus*	GU084158	steam, filtering, H202, uv, hypochlorite, sterilization	Keim
Bacillus	*cereus*	ISSFR-3F	steam sterilization	K Frey, Keim
Bacillus	*pumilis*	ATCC27142	Gamma radiation	J. Lindsay
Bacillus	*thuringensis*		steam, filtering, H202, uv, hypochlorite, etc sterilization	Keim
Bacillus	*anthracis*	Sterne	steam, filtering, H202, uv, hypochlorite, etc sterilization	Keim
Bacillus	*licheniformis*	ATCC 9945	heat, cold, radiation and other environmental stresses	FDA/ORA
Bacillus	*subtilis*	ATCC 12980	steam sterilization	A. Regberg
Bacillus	*subtilis*	ATCC 39093	forms endospore and tolerant of extreme conditions	FDA/ORA, Smith
Geobacillus	*stearothermophilus*	ATCC7953	steam sterilization	J. Lindsay
Geobacillus	*stearothermophilus*	JPL-2	>65C	JPL

Proposed Strains

Need to add any of these?

1.b Identification of gram-positives to start sterilization testing and design?

Genus	Species	Strain	Microbial Reduction Modality	Contributor
Staphylococcus	*aureus*	ATCC 6538	USP 51 standard kill control	C. Bakermans
Arthrobacter	*sp.*		steam sterilization	C.M. Jung
Nocardia	*sp*		steam sterilization	C.M. Jung
Nocardioides	*luteus*	BAFB	steam sterilization	C.M. Jung
Plannococcus	*sp.*	ATCC 25977	Thrives in temps -20C	FDA/ORA
Rhodococcus	*sp.*		steam sterilization	C.M. Jung
Staphylococcus	*capitis*	ATCC 27840		FDA/ORA
Staphylococcus	*hominis*	ATCC 2785		FDA/ORA

Proposed Strains

Need to add any of these?

1.c Identification of gram-negatives to start sterilization testing and design?

Genus	Species	Strain	Microbial Reduction Modality	Contributor
Brevundimonas	*diminuta*	ATCC 19146	Used for sterile filtration validation	FDA/ORA
Deinococcus	*radiodurans*	ATCC 35073	resistant to radiation	FDA/ORA
Escherichia	*coli*	ATCC 8739	USP 51 Standard Kill Control	C. Bakermans
Aeromonas	*hydrophila*	ATCC 15467	avid biofilm former	FDA/ORA
Burkholderia	*cepacia*	ATCC 25416	biofilm former	FDA/ORA
Deinococcus	*radiodurans*	DSM 20539	up to 30 kGy	P. Rettberg
Elizabethkingia	*meningoseptica*	ATCC 13253	Can survive alcohol	FDA/ORA
Methylobacterium	*radiotolerans*	ATCC 27329	steam sterilization	A. Regberg
Thermus	*thermophilus*	ATCC 27634	thrives in temps between 149 and 161F	FDA/ORA
Thermus	*aquaticus*	ATCC 25104	thermophile, inhabit sufur springs	FDA/ORA

Proposed Strains

Need to add any of these?

1.d Identification of fungi to start sterilization testing and design?

Genus	Species	Strain	Microbial Reduction Modality	Contributor
Aspergillus	*fumigatus*		ISS UV resistant, more than SAFR-032 spore	JPL
Aspergillus	*brasiliensis*	ATCC 16404	alcohol, detergents (non-spore kill)	C. Bakermans
Chaetomella	*raphigera*	ATCC 44497	heat resistant, sporeformer	FDA/ORA
Coccidiodes	*immitis*	2009	10% bleach, 70% ethanol, and Vesphene® Iise	Keim
Cryptococcus	*sp.*		alcohol, detergents (for methods that don't kill endospores)	C. Bakermans
Exserohilum	*rostratum*	ATCC 34172	heat resistant, sporeformer	FDA/ORA
Fusarium	*oxysporum*	ATCC 62506	steam sterilization	A. Regberg
Leptosphaerulina	*briosiana*	ATCC 28007	heat resistant, sporeformer	FDA/ORA

Proposed Strains

Need to add any of these?

1.e Identification of other indicators to start sterilization testing and design?

Genus	Species	Strain	Category	Microbial Reduction Modality	Contributor
Rhodotorula	*taiwanensis*	MD1149	yeast	>66 Gy/h	K Frey, JPL
Plasmd pBR322			plasmid		JPL
Arthrospira	*platensis*	ATCC 29408	algae	Cyanobactreia	FDA/ORA
Pyrococcus	*abysii*	GE5	Archaea	>103 C	K Frey
Thermococcus	*gammatolerans*		Archaea		JPL
Picornaviridae	*Enterovirus; rhinovirus*		other	steam sterilization	K Frey
T4 Bacteriophage			plasmid		JPL

Proposed Strains

Need to add any of these?

Indicator Test Method

- What test method should be applied?
- Proposal – Final “run for record” test method should be
  - ISO 11138 Sterilization of health care products – biological indicators (as relevant; particularly experimental design) as a minimum for testing
  - Coupon testing should be conducted using spacecraft materials

INTERNATIONAL STANDARD

ISO 11138-1

Third edition
2017-03

Sterilization of health care products — Biological indicators —

Part 1:
General requirements

Stérilisation des produits de santé — Indicateurs biologiques — Partie 1: Exigences générales

Table 2 — Minimum test samples according to method

Test method according to ISO 11138-1	Minimum number of test samples	Minimum number of exposure conditions	Minimum total number of test samples
Initial count of viable test organism[a]	4	—	4
Annex C survivor curve method	4	5	20
Annex D fraction negative method	20	5[b]	100[b]
Annex E survival-kill window	50	2	100
Minimum total number depending on choice of combination of methods:			124 or 204

NOTE Common test conditions for specific sterilisation methods have developed over time and are presented in relevant parts of ISO 11138.

[a] The viable count of the unprocessed inoculated carrier or biological indicator.

[b] The extra set of testing conditions at the exposure subsequent to t_6 (see Table D.1) is not used in the calculations, but is a condition for accepting the test results as valid.

Next Steps

Short-term (THIS workshop – next charts)

1. Identification a subset of organisms to start sterilization testing and design?
2. If additional input is deemed necessary, is there a group censuses in how to solicit additional input (e.g. poll additional SMEs? RFI?)?
3. Establish plan for down selection process for indicator organisms (e.g. timeline, trade, etc)

Long-term (post workshop; months)

1. Conduct a detailed Investigation and Biological Trade / Recommendation
   - Evaluate - relevant to sterilization modality
   - Understand detailed reference experimentation
   - Ability to work with organism (e.g. accessibility, ease of final assay)
   - Hardier isolates will be selected within same genera (e.g. *B. atrophaeus* ATCC 29669 used instead of *B. atrophaeus* ATCC 9372)

Back-up

References

- Moogega Stricker, Brian Shirey, Wayne Schubert, Parag Vaishampayan, and Melissa Jones, James N. Benardini. Biological indicators and Heat-based Sterilization Verification Strategies for Break the Chain Technologies. Mars Program Office White Paper. March 15, 2017.

Consolidated List (1 of 2)

Genus	Species	Strain	Microbial Reduction Modality	Contributor
Arthrospira	platensis	ATCC 29408	Cyanobactreia, Survives in extreme conditions	FDA/ORA
Pyrococcus	abysii	GE5	>103 C	K Frey
Thermococcus	gammatolerans			JPL
Aspergillus	brasiliensis	ATCC 16404	alcohol, detergents (for methods that don't kill endospores)	C. Bakermans
Aspergillus	fumigatus		ISS UV resistant, more than SAFR-032 spore	
Chaetomella	raphigera	ATCC 44497	heat resistant, sporeformer	FDA/ORA
Coccidiodes	immitis	2009	10% bleach, 70% ethanol, and Vesphene® Iise	Keim
Cryptococcus	sp.		alcohol, detergents (for methods that don't kill endospores)	C. Bakermans
Exserohilum	rostratum	ATCC 34172	heat resistant, sporeformer	FDA/ORA
Fusarium	oxysporum	ATCC 62506	steam sterilization	A. Regberg
Leptosphaerulina	briosiana	ATCC 28007	heat resistant, sporeformer	FDA/ORA
Aeromonas	hydrophila	ATCC 15467	avid biofilm former	FDA/ORA
Brevundimonas	diminuta	ATCC 19146	Used for sterile filtration validation	FDA/ORA
Burkholderia	cepacia	ATCC 25416	biofilm former	FDA/ORA
Elizabethkingia	meningoseptica	ATCC 13253	Can survive alcohol	FDA/ORA
Escherichia	coli	ATCC 8739	should definitely be killed control	C. Bakermans
Methylobacterium	radiotolerans	ATCC 27329	steam sterilization	A. Regberg
Thermus	thermophilus	ATCC 27634	thrives in temps between 149 and 161F	FDA/ORA
Thermus	aquaticus	ATCC 25104	thermophile, inhabit sufur springs	FDA/ORA
Deinococcus	radiodurans	ATCC 35073	resistant to radiation	FDA/ORA
Deinococcus	radiodurans	DSM 20539	up to 30 kGy	P. Rettberg
Arthrobacter	sp.		steam sterilization	C.M. Jung
Nocardia	sp		steam sterilization	C.M. Jung
Nocardioides	luteus	BAFB	steam sterilization	C.M. Jung
Plannococcus	sp.	ATCC 25977	Thrives in temps -20C	FDA/ORA
Rhodococcus	sp.		steam sterilization	C.M. Jung
Staphylococcus	aureus	ATCC 6538	should definitely be killed control	C. Bakermans
Staphylococcus	capitis	ATCC 27840		FDA/ORA
Staphylococcus	hominis	ATCC 2785		FDA/ORA
Picornaviridae	Enterovirus; rhinovirus		steam sterilization	K Frey
Plasmd pBR322				JPL
T4 Bacteriophage				JPL

Consolidated List (2 of 2)

Genus	Species	Strain	Microbial Reduction Modality	Contributor
Bacillus	subtilis	ATCC 39093	forms endospore and tolerant of extreme conditions	FDA/ORA
Bacillus	atrophaeus	ATCC 9372	dry heat, ethylene oxide (also steam and radiation)	C. Bakermans
Bacillus	pumilis	ATCC27142	Gamma radiation	J. Lindsay
Bacillus	atropheus	ATCC9372	ETO, dry heat	J. Lindsay
Bacillus	atrophaeus	GU084158	steam, filtering, H202, uv, hypochlorite, etc sterilization	Keim
Bacillus	cereus	ISSFR-3F	steam sterilization	K Frey
Bacillus	pumilus	SAF-032	UV, steam	WLN
Bacillus	cereus		steam, filtering, H202, uv, hypochlorite, etc sterilization	Keim
Bacillus	thuringensis		steam, filtering, H202, uv, hypochlorite, etc sterilization	Keim
Bacillus	Subtilis	ATCC 12980	steam sterilization	A. Regberg
Bacillus	sp.	ATCC 29669	NASA heat hardy	JPL
Bacillus	licheniformis	ATCC 9945	spores can tolerate heat, cold, radiation and other environmental stresses	FDA/ORA
Bacillus	sp. E24	DSM 30879	ESA spacecraft strain, cold plasma, H202, ClO2,	P. Rettberg
Bacillus	pumilus	SAFR-032	UV, steam	JPL
Bacillus	anthracis	Sterne	steam, filtering, H202, uv, hypochlorite, etc sterilization	Keim
Clostridium	sporogenes	ATCC 11437D-5	heat resistant, sporeformer	FDA/ORA
Clostridium sporogenes		ATCC11437	steam sterilization	J. Lindsay
Clostridum	sporgenes			JPL
Geobacillus	stearothermophilus	ATCC 12980	steam sterilization	N. Benardini
Geobacillus	stearothermophilus	ATCC 12980	steam sterilization	Keim
Geobacillus	stearothermophilus	ATCC 12980	steam sterilization	C. Bakermans
Geobacillus	stearothermophilus	ATCC7953	steam sterilization	J. Lindsay
Geobacillus	stearothermophilus	JPL-2	>65C	JPL
Rhodotorula	taiwanensis	MD1149	>66 Gy/h	K Frey, JPL
Rhodotorula	taiwanensis	md1149		JPL
Mycobacterium			alcohol, detergents (for methods that don't kill endospores)	C. Bakermans

Email List

Name	Email	Affiliation	Specialty
Wayne Nicholson	WLN@ufl.edu	academia	environmental; spore
Christine Moissl	christine.moissl-eichinger@medunigraz.at	ESA	environmental; built environment
Aaron Regberg	aaron.b.regberg@nasa.gov	NASA	astromaterials
Heather Smith	heather.d.smith@nasa.gov	NASA	AMES - NAI
Petra Rettberg	Petra.Rettberg@dlr.de	ESA	environmental; spore
Sarah Wallace	sarah.wallace@nasa.gov	NASA	JSC Microbiology
David Coil	coil.david@gmail.com	Academia	environmental; built environment
Jason Johns	jason.w.johns@nasa.gov	NASA	KSC microbiology
David Smith	david.j.smith-3@nasa.gov	NASA	AMES - environmental microbiology; balloon
Corien Bakermans	cub21@psu.edu	Academia	environmental; cold environment
Erin Lalime	erin.lalime@nasa.gov	NASA	Goddard Microbiology
Alex Probst	alexander.j.probst@gmail.com	Academia	Environmental Micro
Kyle Landry	klandry@libertybiosecurity.com	Industry	Environmental Biodefense
Rob Knight	robknight@ucsd.edu	Academia	environmental; built environment
Chris Mason	christopher.e.mason@gmail.com	Academia	environmental; built environment
Paul Keim	Paul.Keim@nau.edu	Academia	Environmental Micro
Chris Bradburne	Chris.Bradburne@jhuapl.edu	APL	Environmental Biodefense
Stephanie Smith	steph.smith@wsu.edu	academia	environmental; food science
Janice Strap	Janice.Strap@uoit.ca	academia	plant/fungal; actino specialist
Carina Jung	Carina.M.Jung@usace.army.mil	Army	environmental; explosives degradation
Tamas Torok	ttorok@lbl.gov	LBL	Fungal
Ken Frey	kenneth.g.frey4.civ@mail.mil	Army	Environmental Biodefense
John Lindsay	jlindsay@asepticsolutions.com	Medical	sterilzation consultant for Baxter
Holly Bik	holly.bik@gmail.com	Academia	Eukaryotic
Donna Williams-Hill	donna.williamshill@fda.hhs.gov	FDA	Microbiology (Food Safety)
John Dye	john.m.dye1.civ@mail.mil	Army USAMRIID	Virology
Sina Bavari	sina.bavari.civ@mail.mil	Army USAMRIID	Virology
Lisa Hensley	lisa.hensley@nih.gov	NIH	Virology/Emerging Pathogens
Victoria Wahl-Jensen	victoria.jensen@nbacc.dhs.gov	DHS (NBACC)	Emerging Pathogens
Segaran Pillai	Segaran.pillai@HQ.DHS.GOV	DHS	Anthrax
Karl Thompson	karl.thompson@Howard.edu	Academia	Microbiology
Kevin Anderson	kevin.anderson@dhs.gov	DHS	Chem-Bio Defense
Kim Cruse	kim.thomas-cruse@fda.hhs.gov	FDA	Microbiology (Food Safety)
Elizabeth Claverie	elizabeth.claverie@fda.hhs.gov	FDA	Medical Devices

Cleanroom Associated Isolates Survey from JPL

Extremophilic spore-forming bacteria from several spacecraft associated surfaces isolated under several unique conditions

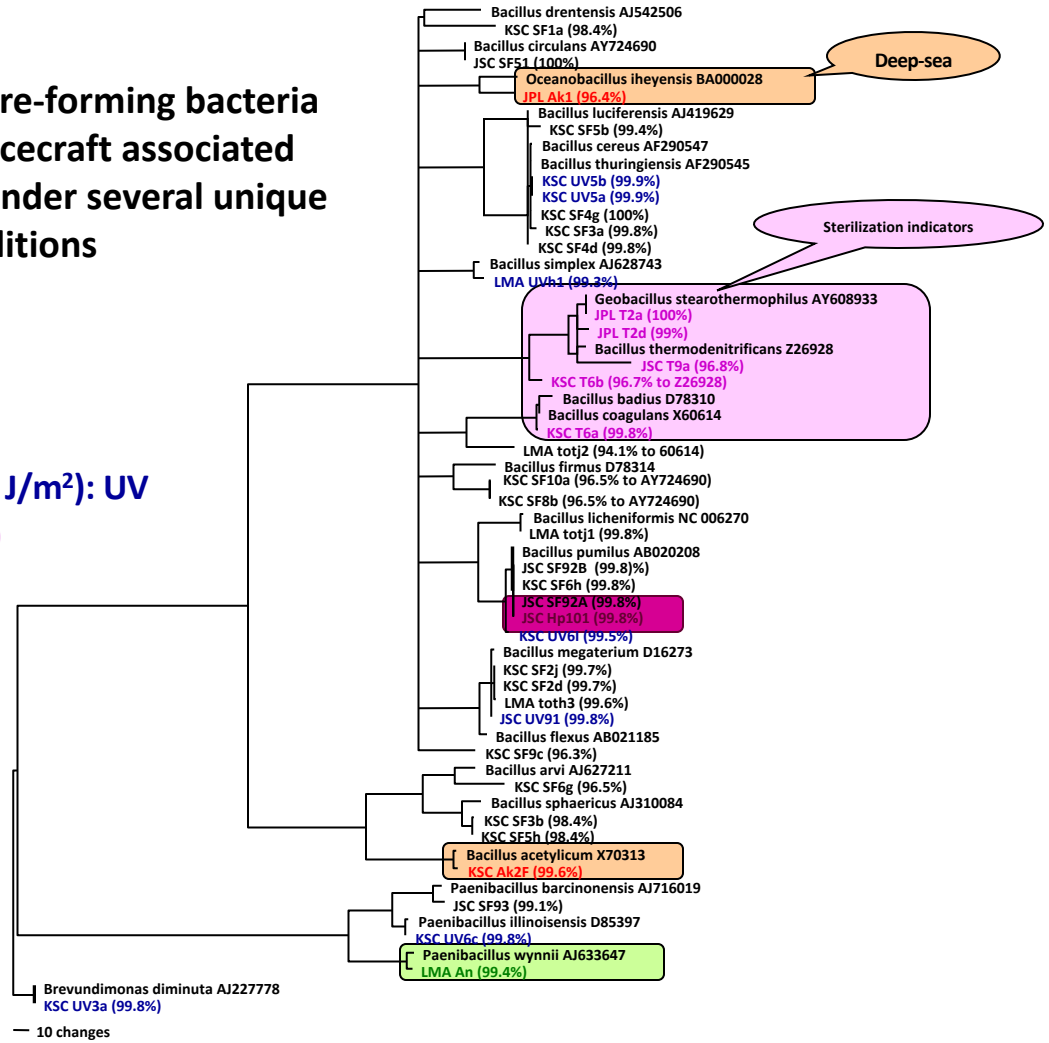
Alkaline (pH 11) : Al

UV-resistant (~1,000 J/m^2): UV

Thermophile (>65°C)

Anaerobic: Gaspak

H_2O_2: 5% liquid



Cleanroom Associated Isolates Survey from JPL

TABLE 6. Phylogenetic characterization of bacteria that are tolerant to several extreme conditions

Conditions[a]	Location	Certification	Bacterial species	Strain	Accession no.
Alkalophilic (pH 10.6)	JPL-1	Class 100K	*Oceanobacillus* sp.	JPL_AkK1	DQ870753
	LMA-3	Class 100K	*Microbacterium schleiferi*	LMA_AkK1	DQ870710
	LMA-4	Uncertified	*Brachybacterium paraconglomeratum*	LMA_AkL5	DQ870709
	JSC-7	Class 1K	*Bacillus* sp.	JSC_Ak7-1	DQ870739
	JSC-7	Class 1K	*Microbacterium aurum*	JSC_Ak7-2	DQ870743
	JSC-7	Class 1K	*Sphingomonas oligophenolica*	JSC_Ak7-4	DQ870741
	JSC-7	Class 1K	*Sphingomonas trueperi*	JSC_Ak7-3	DQ870742
	JSC-8	Class 5K	*Staphylococcus epidermidis*	JSC_Ak8-2	DQ870740
	JSC-9	Uncertified	*Bacillus pumilus*	JSC_Ak9-3	
	JSC-10	Uncertified	*Bacillus pumilus*	JSC_Ak10-3	
	KSC-2	Class 100K	*Arthrobacter* sp.	KSC_Ak2i	DQ870702
	KSC-2	Class 100K	*Microbacterium arborescens*	KSC_Ak2e	DQ870704
	KSC-2	Class 100K	*Exiguobacterium acetylicum*	KSC_Ak2f	DQ870703
	KSC-3	Class 100K	*Brevundimonas diminuta*	KSC_Ak3a	EF191247
	KSC-4	Class 100K	*Micrococcus mucilaginosus*	KSC_Ak4f	DQ870701
	KSC-6	Class 100K	*Kocuria rosea*	KSC_Ak6a	DQ870700
	KSC-10	Class 100K	*Pseudomonas stutzeri*	KSC_Ak10c	DQ870705
Anaerobic	LMA-1	Class 100K	*Paenibacillus wynnii*	LMA_An	DQ870708
	KSC-7	Class 100K	*Staphylococcus epidermidis*	KSC_Anb	DQ870706
Hydrogen peroxide (liquid 5%)	JSC-10	Uncertified	*Bacillus pumilus*	JSC_Hp10-1	DQ870738
Thermophilic (65°C)	JPL-2	Class 100K	*Geobacillus stearothermophilus*	JPL_T2a	DQ870752
	JPL-2	Class 100K	*Geobacillus kaustophilus*	JPL_T2d	DQ870751
	JSC-9	Uncertified	*Geobacillus thermodenitrificans*	JSC_T9a	DQ870732
	KSC-6	Class 100K	*Bacillus coagulans*	KSC_T6a	EF191245
	KSC-6	Class 100K	*Geobacillus caldoxylosilyticus*	KSC_T6b	DQ870685
UV-C (1,000 J m^{-2})	LMA-1	Class 100K	*Bacillus simplex*	LMA_UVH-1	EF191246
	JSC-9	Uncertified	*Bacillus megaterium*	JSC_UV9-1	DQ870724
	KSC-5	Class 100K	*Bacillus cereus*	KSC_UV5a	DQ870755
	KSC-5	Class 100K	*Bacillus cereus*	KSC_UV5b	DQ870756
	KSC-5	Class 100K	*Nocardioides* sp.	KSC_UV5c	DQ870757
	KSC-6	Class 100K	*Bacillus pumilus*	KSC_UV6i	DQ870758
	KSC-6	Class 100K	*Paenibacillus illinoisensis*	KSC_UV6c	DQ870759

[a] The bacteria isolated may be extremotolerant or extremophilic to the condition employed.