Table 1. Potential chemolithoautotrophic pathways relevant to microbial life on Mars. Bolded electron acceptors indicate pathways that have been confirmed for terrestrial microorganisms (see references).

Energy source	**Potential electron acceptor(s)[a]**	**Example Reference(s)[b]**
H_2 (hydrogen)	**ClO_4^-, O_2, NO_3^-, MnO_2, $Fe(OH)_3$, SO_4^{2-}, S^0, CO_2**	Giblin *et al.*, 2000; Schwartz and Friedrich, 2006
CH_4 (methane)	**O_2, NO_3^-**, MnO_2, $Fe(OH)_3$, **SO_4^{2-}**	Beal *et al.*, 2009; Conrad, 2009; Ettwig *et al.*, 2010; Offre *et al.*, 2013
CO (carbon monoxide)	**ClO_4^-, O_2**, NO_3^-, MnO_2, $Fe(OH)_3$, **SO_4^{2-}, CO_2**	King and Weber, 2007; Balk *et al.*, 2008; Techtmann *et al.*, 2009
Aqueous Fe(II)	**O_2, NO_3^-**	Emerson *et al.*, 2010
Aqueous HS^-	**O_2, NO_3^-**	Kelly and Wood, 2006
$Fe^{II}CO_3$ (siderite), Fe_3O_4 (magnetite)	**NO_3^-** (direct oxidation)	Weber et al., 2001
$K(Mg,Fe^{II})_3(AlSi_3O_{10})(F,OH)_2$ (biotite)	**O_2, NO_3^-** (direct oxidation)	Shelobolina et al., 2012a
$Na_{0.3}Fe^{II}_2((Si,Al)_4O_{10})(OH)2\cdot nH_2O$ (Fe(II)-bearing smectite)	**NO_3^-** (direct oxidation)	Shelobolina *et al.*, 2012b; Xiong, 2013
$(Fe^{II},Mg)SiO_2$ (basalt glass)	**O_2,** NO_3^- (direct oxidation)	Bach and Edwards, 2003; Edwards *et al.*, 2003
$Fe^{II}S_x$ (Fe(II)-sulfides, e.g., FeS, FeS_2)	**O_2, NO_3^-, MnO_2**	Aller and Rude, 1988; Schippers and Jorgensen, 2001; Rohwerder et al., 2003; Jorgensen *et al.*, 2009; Bosch *et al.*, 2012; Percak-Dennett *et al.*, 2013
S^0 (elemental sulfur)	**O_2, NO_3^-, MnO_2, Fe^{3+}** (direct oxidation), **$Fe(OH)_3$** (disproportionation)	Jorgensen, 1989; Thamdrup *et al.*, 1993; Lovley and Phillips, 1994; Kelly and Wood, 2006
NH_4^+, NO_2^-	**O_2, NO_3^-, Fe(III)**, MnO_2, SO_4^{2-}	Bock and Wagner, 2006; Bartlett *et al.*, 2008; Schrum *et al.*, 2009 Yang *et al.*, 2012

[a] MnO_2 and $Fe(OH)_3$ represent iron and manganese oxides, respectively.
[b] Not exhaustive; in some cases many additional references are available.

Table 2. Low temperature metabolism of microorganisms. (Studies highlighted in gray were included in the 2006 MEPAG SR-SAG report.)

T (°C)	Activity	Method	Environment	Time (days)	Reference
Brines					
-12	Cell division DT 10 days	Turbidity measurement	Culture of sea ice isolate *Psychromonas ingrahamii* in 5% glycerol	42	Breezee *et al.*, 2004
-13.5	Protein synthesis	Uptake of ^{3}H-leucine	Lake Vida samples (188 psu salinity, primarily Cl^-, Na^+, Mg^{2+})	6-30	Murray *et al.*, 2012
-15	Cell division DT 50 days	Plate counts	Culture of permafrost isolate *Planococcus halocryophilus* Or1 in 18% NaCl, 7% glycerol	200?	Mykytczuk *et al.*, 2013
Ices and Frozen environments					
-5	Respiration (maybe cell division, DT 43 days)	CTC reduction, cell numbers, respiration of ^{14}C-acetate, incorporation of ^{3}H-adenine, ^{3}H-leucine	Frozen cultures of glacial ice isolate *Paenisporoarcina* sp. and *Chryseobacterium*	50	Bakermans and Skidmore, 2011a
-10	CH_4 production	Reduction of $H^{14}CO_3^-$	Arctic permafrost	21	Rivkina *et al.*, 2007
-18	Metabolism	Incorporation of $^{14}CO_2$	Frozen cultures of permafrost isolates	90	Panikov and Sizova, 2007
-18	Cell division DT 34 days	Plate counts	*Rhodotorula glutinis* (yeast) inoculated onto surface of frozen peas	200	Collins and Buick, 1989
-20	Metabolism	Incorporation of ^{14}C-acetate into lipids	Permafrost microcosms	550	Rivkina *et al.*, 2000
-20	Protein synthesis	Uptake of ^{3}H-leucine	Frozen culture of sea ice isolate *Colwellia psychroerythraea* 34H	6	Junge *et al.*, 2006

-20	DNA replication	Incorporation of ^{13}C-acetate into DNA	Microcosms of permafrost from Alaska, many bacterial species active	180	Tuorto *et al.*, 2014
-15, -33	Respiration	CTC reduction, respiration of ^{14}C-acetate	Frozen cultures of glacial ice isolates *Paenisporoarcina* sp. and *Chryseobacterium*	200	Bakermans and Skidmore, 2011b
-25	Respiration	Mineralization of ^{14}C-acetate to $^{14}CO_2$	Permafrost microcosms w/ *Planococcus halocryophilus* Or1 added	200	Mykytczuk *et al.*, 2013
-32	Ammonia oxidation	$^{15}N_2O$ production from ^{15}N-ammonia	Frozen culture of marine isolate *Nitrosomonas cryotolerans*	307	Miteva *et al.*, 2007
-15 to -40	Photosynthesis?	Fluorescence of chlorophyll a in photosystem II	Thalli of lichen *Pleopsidium chlorophanum* collected from Antarctica and incubated in Mars simulation chamber	35	de Vera *et al.*, 2014

DT, doubling time; CTC =5-cyano-2,3-ditolyl-tetrazolium chloride

NOTES: This table is not intended to be exhaustive. Entries reflect what the data support (after critical reading). Where there are questions about what the data represent, a question mark has been added.

Table 3. Solute- and matric-induced effects decrease water activity (a_w) and microbial responses.

Water activity (a_w)	**Condition or response**	**References**
1.0	Pure water	
Solute-induced effects		
0.98	Seawater	
0.98 to 0.91	Lower solute-induced a_w limit for growth of various plant pathogenic fungi	Cook and Duniway, 1981
0.75	Saturated NaCl solution -- Some members of the bacteria, archaea, and eukarya commonly grow in these habitats	Brown, 1976; Harris *et al*., 1981; Csonka, 1989; Potts, 1994; Grant, 2004
0.69	Lower solute-induced a_w limit for growth of *Aspergillus*, *Eurotium*, *Chrysosporium*, *Eremascus, Wallemia* (filamentous fungi)	Harris, 1981
0.647	Lowest a_w for growth (hyphal extension) of xerophilic fungi in growth medium amended with 6.19 M glycerol, 1.2 M NaCl, and 0.13 M KCl. Lowest a_w for growth of *X. bisporus* was 0.653, in 7.6 M glycerol.	Williams and Hallsworth, 2009
0.62	Lower solute-induced a_w limit for growth of *Xeromyces* (Ascomycete fungus) and *Saccharomyces* (Ascomycete yeast) (growth in 83% sucrose solution)	Harris, 1981
0.61	World record for reproduction at low a_w for the filamentous fungus *Xeromyces bisporus* is cited here. Excellent review of microbial responses to low $a_{w.}$	Grant, 2004
0.61	Lower a_w limit for *Monascus bisporus* (*Monascus* is another name for Xeromomyces) is cited here. This reference includes a nice table compiling lower a_w limits for proliferation of various other bacteria and fungi.	Fontana, 2007
0.605	Apparently the original source of the lower a_w limit of *Xeromomyces bisporus.* This is actually the lower limit for spore germination. Limit for growth is a_w =	Pitt and Christian, 1968

	0.656	
0.61-0.62	Authors claim to have reproduced growth of *Xeromyces bisporus* at this low a_w, but data are not shown. They do report growth (linear extension of hyphae) of *X. bisporus* and *Chrysosporium xerophilum* at a_w = 0.66.	Leong *et al.*, 2011
0.60-0.65	Cites growth of yeast *Sacharomyces* rouxii and filamentous fungi *X. bisporus* and *Aspergillus* echinulatus at low a_w. Good review of the principles of water activity plus tables of a_w limits, especially as related to food spoilage and food-borne disease.	Rahman, 2007
0.29	Saturated $CaCl_2$ solution	Potts, 1994
Matric-induced effects		
0.999	Matric-induced a_w at which microbial motility ceases in a porous medium	Griffin, 1981
0.97 to 0.95	Lower matric-induced a_w limit for growth of *Bacillus* spp.	Potts, 1994
0.88	Lower matric-induced a_w limit for growth of *Arthrobacter* spp.	Potts, 1994
0.93 to 0.86	Matric-induced a_w at which microbial respiration becomes negligible in soil	Sommers *et al.*, 1981
0.92-0.93	Lower desiccation limit for growth of *Bacillus subtilis*. Interesting experimental set-up with relative humidity gradient. Apparenttlty, the external a_w limit can be slightly lower than the internal a_w limit (0.94). The difference is attributed to metabolically generated water.	De Goffau *et al.*, 2011
0.89	Moyano et al. 2013 says that the matric water potential threshold below which CO_2 production in soils ceases is -15,800 kPa. At 20°C this corresponds to a water activity of 0.89.	Moyano *et al.*, 2012, 2013
0.77	a_w below which activity (CO_2 production) ceases in soil litter layers (presumably dominated by filamentous fungi). Matric	Manzoni *et al*., 2012

	water potential at this a_w is -36 MPa. Activity in mineral soils ceased at a_w = 0.90 (water potential = -14 MPa) .	
0.75	Lower limit for fungal growth: *Rhizopus*, *Chaetomium*, *Aspergillus*, *Scopulariopsis*, *Penicillium*	Harris *et al.*, 1981
0.53	Desiccation stress at which double-stranded DNA breaks were induced in *Escherichia coli* DNA; no breaks were observed at a water activity of 0.75.	Asada *et al.*, 1979

Table 4. Survival of various microorganisms to simulated Mars UV spectrum and intensity[A].

Organism	"Mars" LD_{90} Unshielded (kJ/m^2) / Time on Mars[C]	"Mars" LD_{90} Shielded (kJ/m^2) / Time on Mars	Shielding Material	Thickness	Reference
Bacillus subtilis spores, monolayers	0.35 kJ/m^2 7 s	64 kJ/m^2 21 min	neutral density filter *tau*=3.5 (global dust storm)	-	Schuerger *et al.*, 2003
		essentially 100% survival "forever"	pelagonite dust	0.5 mm	
Chroococcidiopsis sp., monolayers	10 kJ/m^2 3 min, 20 s	essentially 100% survival "forever"	Mars soil simulant or gneiss	1 mm	Cockell *et al.*, 2005
B. pumilus SAFR-032 spores, in water	16 kJ/m^2 5 min, 20 s	n.t.[B]	-	-	Newcombe et al., 2005
B. subtilis spores, multilayers	12 kJ/m^2 4 min	n.t.	-	-	Tauscher *et al.*, 2006
Deinococcus radiodurans	28 kJ/m2 9 min, 20 s	n.t.	-	-	Pogoda *et al.*, 2005
D. radiodurans	no survival at 145 kJ/m^2 48 min, 20 s	no survival at 145 kJ/m2 48 min, 20 s	nanophase hematite	8-10 nm	Pogoda *et al.*, 2007
		97.5% survival at 145 kJ/m2 48 min, 20 sec	Goldenrod hematite	300 nm	
Psychrobacter cryohalolentis	30 kJ/m^2 10 min	720 kJ/m2 1 hour, 20 min	Mars simulation (-) UV	-	Smith *et al.*, 2009
Halococcus dombrowskii	0.0-0.9 kJ/m^2 0-18 s	30 kJ/m2 3 min	halite	5 mm	Fendrihan *et al.*, 2009
Natronorubrum sp. strain HG-1	8 kJ/m^2 2 min, 40 s	cells did not survive drying	Atacama soil	-	Peeters *et al.*, 2010

[A]Experiments were performed in various Mars simulation chambers (600-850 Pa, either 100% CO_2 or Mars gas mixture, temperatures ranging from -35˚C to ambient).
[B]n.t. = not tested
[C]Conversion factor: Total UV (200-400 nm) dose on clear-sky, noonday Mars is ~0.05 kJ/m^2 s. So, for example, a dose of 10 kJ/m^2 corresponds to 200 s, or 3 min 20 s

Table 5. Limited examples of polyextremophile isolates and their tolerances. Major gaps in our understanding of these organisms exist.

Examples	**Description**	**Reference**
Heat shock, desiccation, hydrogen peroxide, and ultraviolet irradiation	Isolate *Psychrobacter* L0S3S-03b (deep sea hydrothermal vents) *"critical to the investigation of putative hydrothermal environments on Europa or Enceladus"*	La Duc *et al.*, 2007
Gamma radiation, ultraviolet radiation	Resistance to both types of radiation appears to the related to same mechanisms in *Deinococcus gobiiensis*	Yuan *et al.*, 2012
Temperature and pressure	Use a phase space model of Mars and of terrestrial life to estimate the depths and extent of potential water on Mars that would be considered habitable for terrestrial life.	Jones *et al., 2011*
Temperature, pH, salt (NaCl) concentrations, and pressure	"*reveals a fundamental lack of information on the tolerance of microorganisms to multiple extremes that impedes several areas of science…*"	Harrison *et al.*, 2013
Extreme dryness, radiation, and temperatures down to -70°C	Structure and function of microorganisms in the Earth's stratosphere would experience these 3 simultaneous parameters.	Smith, 2013

Table 6. The translation of remotely sensed data taken by orbiting spacecraft to microscale environmental data pertinent to microbial life may require several steps and detailed ground-truth studies by landers, as well.

	Scale	**Data**	**Similarity required**	**Key missing data**
Orbiter Scale	Latitude band 65-72N	GRS hydrogen in top 1 m, polygonal terrain, boulder maps, thermal inertia at 2-4 pm	Similarity of ice, geology and polygonal terrain is observed across latitude band: detailed data collected for 4 large regions	Chlorine maps – Gamma Ray Spectrometer chlorine too noisy in presence of high hydrogen at high latitude
Lander Scale	Phoenix Site	Diurnal surface/air/soil temperature; near surface humidity, fog, cloud, snow	Polygon is representative of polygonal terrain. T and a_w should be successfully modeled across Latitude band; similarity should be demonstrated at analogue site.	Arm in shadow at midday; local control of humidity by soil, low cloud, snow not currently modeled; Dry Valley temperatures inevitably higher than Mars, snowmelt occurs
	Phoenix trench samples	Soil and ice layer sampled, perchlorate, wet chemistry and clay particles detected	Depth layers should be successfully modeled across polygon; similarity demonstrated at analogue site?	Mechanism of observed ice distribution is not understood
Micro Scale	Analogue trench samples	Detailed redox profile acquired	Similarity to Phoenix is somewhat demonstrated in constituent composition and distribution: perchlorate and wet chemistry	Alternative mechanisms may work on Mars, and other mechanisms at analogue site may obscure Mars processes
	Micro scale	Microbiology associated with redox profile analyzed	Understood history of analogue; past mechanisms may still leave imprint on current status of habitats	Past history and "real-time" microbial abundance and essential adaptations

Table 7. Summary of potential microscale environments on Mars of potential relevance to terrestrial microbes.

Potential habitat on Mars for a microbe from Earth	**Description**
Naturally occurring microenvironments	
Vapor phase water available	Vapor or aerosols in: planet's atmosphere; within soil cavities, porous rocks, etc; within or beneath spacecraft or spacecraft debris
Ice-related	Liquid or vapor-phase water coming off: frost; solid ice; regolith or subsurface ice crystals; glaciers
Brine-related	Liquid water in: deliquescing salts; channels within ice; on the surface of ice; within salt crystals within halite or other types of 'rock salt'
Aqueous films on rock or soil grains	Liquid water on: regolith particles of their components such as clay minerals; surface of ice; on and within rocks; surfaces of spacecraft
Groundwater & Thermal springs (macroenvironments)	Liquid water
Places receiving periodic condensation or dew	Liquid water on: regolith particles of their components such as clay minerals; surface of ice; on and within rocks; surfaces of spacecraft
Water in minerals	Liquid water bound to minerals
Exploration-induced microenvironments	
Microbial material	Vapor or liquid water: captured by a cell's own cell wall or absorbed due to hygroscopic nature of cellular metabolites; obtained from microbial necromass
Astronauts	In various forms (including generation of water via microbial metabolism) from: skin; dead skin; human hair; human waste; and microbes from gut microflora or respiratory surfaces including the lungs
Organic material released in a collision	In various forms (including generation of water via microbial metabolism) from: food; human; stored wastes; etc.
Melt water with a perennial heat source	Radioisotope components can melt subsurface ice on Mars, leading to liquid water microenvironments that can be stable for more than a martian year

Table 8. Measurements of bacterial and lichen metabolism and growth in desert or desert-like conditions on Earth.

% Relative Humidity	**Microorganism(s)**	**Method**	**Author**
80	Lichens in hot deserts	CO_2 gas exchange	Lange, 1969
80	Negev Desert lichens	CO_2 gas exchange	Lange *et al.*, 1970
96.2	*P. maydis* conida incubated on glass slides	--	Bootsma *et al.*, 1973
> 97	*Chroococcidiopsis* sp. from Negev Desert	$^{14}CO_2$ incorporation	Potts and Friedmann, 1981
97	Numerous lichens with algal phytobionts; cyanobacterial phytobionts required liquid water	CO_2 gas exchange	Lange *et al.*, 1986
70	*Dendrographa minor*	CO_2 gas exchange	Nash *et al.*, 1990
70	Antarctic cryptoendolithic lichen	$^{14}CO_2$ incorporation	Palmer and Friedmann, 1990
> 90	Negev Desert *Chroococcidiopsis* sp.	$^{14}CO_2$ incorporation	Palmer and Friedmann, 1990
> 80	*Ramalina maciformis* and *Teloschistes lacunosus*	$^{14}CO_2$ incorporation	Palmer and Friedmann, 1990
96	*Microcoleus sociatus* isolated from biological soil crusts from Negev Desert	CO_2 gas exchange	Lange *et al.*, 1994
94 for alga photobiont	*Placopsis contortuplicata* (lichen)	Chlorophyll a fluorescence measurements	Schroeter, 1994
??	*Umbilicaria aprina* at Granite Harbor, Antarctica; net productivity lowered at -3˚C due to dehydration by ice formation in thallus (atmospheric humidity equilibrium)	CO_2 gas exchange	Schroeter *et al.*, 1994

??	*Umbilicaria aprina* under snow cover; water uptake in gaseous phase; increased humidity due to equilibrium with snow	CO_2 gas exchange	Schroeter and Scheidegger, 1995; Pannewitz *et al.*, 2003
82	*Teloschistes capensis* from central Namib Desert; integrated daily carbon income requires fog or dew	CO_2 gas exchange	Lange *et al.*, 2006
Inactive at > 90%; dew required	*Teloschistes lacunosus* (lichen) in Tabernas Desert (Spain)	Chlorophyll a fluorescence measurements	del Prado *et al.*, 2007
80.6 (1 bar) 82.7 (0.5 bar)	*S. epidermis*	Environmental control chamber	de Goffau *et al.*, 2011

Table 9. Taxonomy of youthful gullies on Mars, divided into categories with distinct implications for defining Special Regions.

Gully Type/Taxon		Where?	Comment	Proposed Special Region Classification
1	Gullies forming today at CO_2 frost point T	Southern mid-latitudes (Fig. 17)	No water involved, or extremely cold brines if they exist.	Not Special
2	Geologically very recent gullies in relatively warm locations spatially associated with ice.	North and South mid-latitudes	There is a significant possibility that they formed from past melting of snow/ice during or after high obliquity periods, and since ice still remains, there is potential for reactivation in next 500 years.	Uncertain
3	Geologically very recent gullies NOT spatially associated with ice.	Equatorial or mid-latitude equator-facing slopes. Rare near equator except in Valles Marineris	Not known to be active today, except perhaps in Penticton crater (40 S latitude equator-facing slope; season of new bright deposit unknown).	Low probability of being a Special Region
4	Small gullies associated with RSL	See Fig. 17.	RSL may gradually carve small gullies from water flow.	Uncertain

Table 10. Summary of martian resources and their relationship to Special Regions.

Resource/Activity	**Sources**	**Special Region Concerns**
H_2O Resources	Surface and near-surface	RSL sites and possibly active equatorial gullies are treated as Special Regions. Other regions may become special if ice is heated to melting.
In-Situ Resource Utilization (ISRU)	Atmosphere, H_2O deposits, hydrated minerals, perchlorate	Same as for H_2O Resources.
Radiation Shielding	Regolith and/or water over habitat; underground (caves/lava tubes).	Natural caves/lava tubes may be Special Regions.
Fuel and Power	Atmosphere, surface materials, perchlorates, solar energy, nuclear power	May become Special if surface/subsurface ice is heated to melting.

Table 11. Classification of natural features on Mars.

Special	Uncertain but Treated as Special	Non-Special	Would be Special if Found to Exist on Mars
	Caves*	Gullies – Taxon 1*	Groundwater (at any depth)
	Gullies – Taxon 2	Polar dark dune streaks	Thermal zones
	Gullies – Taxon 3	Slope streaks	Recent craters that are still warm
	Gullies – Taxon 4*		Thermal zones
	RSL*		

*Denotes update from 2006 SR-SAG1.

Table Appendix 2. Special Regions science analysis group committee members.

Last Name	First Name	Affiliation	Expertise
Co-Chairs*/Technical Support			
Beaty*	Dave	Mars Program Office, JPL	Mars Chief Scientist
Rummel*	John	East Carolina Unversity	Chair, COSPAR Panel on Planetary Protection
Jones	Melissa	JPL	Biotechnology and Planetary Protection Group Supervisor
Members of the Science Community			
Bakermans	Corien	Penn State, Altoona	Microbiology, microbial survival, growth, metabolism at subzero temperatures
Barlow	Nadine	Northern Arizona University	Cratering on Mars
Boston	Penny	New Mexico Tech	Life in caves, cave geomicrobiology, microbial life in highly mineralized environments, unique or characteristic biominerals and biosignature detection
Chevrier	Vincent	University of Arkansas	Thermodynamics, formation and stability of liquid brines
Clark	Ben	Space Science Institute	Geochemistry, PP, Viking and MER
de Vera	Jean-Pierre	DLR Institute of Planetary Research	Astrobiology, Mars simulation, space experiments, polar research, life detection
Gough	Raina	University of Colorado	Salt deliquescence; brine formation, stability and metastability
Hallsworth	John	Queen's University Belfast	Microbial-stress mechanisms & responses; solute activities of environmental & intracellular stressors; physicochemical limits of Earth's functional biosphere
Head	Jim	Brown	Mars ice, Antarctic analogs, linkages to human exploration
Hipkin	Vicky	Canadian	Mars atmosphere, Phoenix

		Space Agency	
Kieft	Tom	New Mexico Tech	Microbiology of deep subsurface environments (deep drilling, deep mines)
McEwen	Alfred	University of Arizona	Mars surface geology, processes, MRO
Mellon	Mike	Southwest Research Institute	Ice on Mars, observed & modeled, Phoenix, MRO
Mikucki	Jill	University of Tennessee	Microbiology, Antarctica, microbiology of Subglacial environments
Nicholson	Wayne	University of Florida	Responses of terrestrial microbes to space and Mars environments (radiation, pressure, temp, atmospheric gases, etc.)
Omelon	Chris	University of Texas	Geomicrobiology, bacteria-mineral interactions; microbial biosignatures; polar and desert environments; cyanobacteria; electron microscopy; synchrotron radiation
Peterson	Ronald	Queen's University Canada	Mineralogy, deliquescence
Roden	Eric	University of Wisconsin	Microbial geochemistry, anaerobic geomicrobiology of sediments, soils, groundwater
Sherwood Lollar	Barbara	University of Toronto	Astrobiology, stable isotopes, biogeochemistry of deep subsurface hydrosphere; search for life
Tanaka	Ken	USGS Flagstaff	Planetary mapping, geologic history
Viola	Donna	University of Arizona	Distribution of water ice in/around Arcadia Planitia, ice/permafrost environments, graduate student (A. McEwen)
Wray	James	Georgia Tech	Mars surface geology, spectroscopy, MRO, MSL
Ex Officio			

Buxbaum	Karen	Mars Program Office, JPL	Mars Program Office PP Manager (retired)
Conley	Cassie	NASA HQ	NASA Planetary Protection Officer
Kminek	Gerhard	ESA	ESA Planetary Protection Officer
Meyer	Michael	NASA HQ	Mars Exploration Program Lead Scientist
Pugel	Betsy	NASA HQ	Detailee to NASA HQ for Planetary Protection
Voytek	Mary	NASA HQ	Senior Scientist for Astrobiology