The Meaning of Life and Close Encounters of the Commercial Kind

George Anthony Long[*]

Abstract

Science fiction abounds with contact and interaction between humans and extraterrestrial life. In science fiction any such contact or interaction is known as a "close encounter." With non-state actors now becoming a staple in the exploration and use of space, if extraterrestrial life exists, then the percentages increase that there will be a close encounter between non-state actors and extraterrestrial organisms, especially at the microbial level. The possibility of contact with extraterrestrial microbes from asteroid mining or other commercial space activities is a potential reality given the discovery of microbial organisms on the exterior of the International Space Station. This paper will analyze the space law principles which may impact and govern the intentional contact and interaction between non-state actors and extraterrestrial microbes by an analysis of the subplot in the movie *Aliens* starring Sigourney Weaver.

The Outer Space Treaty of 1967 does not establish protocols governing contact with any type of extraterrestrial life. For instance, Article V of the treaty requires immediate notification be given concerning the discovery of "any phenomena" which could pose "a danger to the life and health of astronauts." Outer Space Treaty Article IX obligates the conducting of space activities in such a manner so as to avoid "adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and where necessary, shall adopt appropriate measures for this purpose." Article 5(3) of the Moon Treaty, on the other hand, specifically references the duty to disclose "any indication of organic life," but it does not place any restraint or limitation on an encounter with NTMs or the performing tests and experiments on NTMs.

Aliens involve a terrorizing encounter between humans and an extraterrestrial bio form. An underlying plot of *Alien*s concerns the manipulation by the corporate owner of a commercial spacecraft to capture the alien life form and transport it to Earth so it can be studied and examined. Accordingly, the movie presents a scenario for exploring what legal duties space law imposes on corporate commercial interests relating to the discovery of, contact with and experimentation on extraterrestrial microbes. The analysis will also include a brief discussion on what constitutes extraterrestrial life.

* Fountain Hills, AZ United States, gal@spacejurist.com.

I. Introduction

In the realm of science fiction the phrase "close encounter" refers to the level or degree of human exposure to a nonterrestrial life form. Those who believe in an alien visitation to Earth have generally divided human encounters with a nonterrestrial life form into seven categories.[1] A close encounter of the first kind means sighting of mechanical or technology evidence of a nonterrestrial life form.[2] The second kind occurs when physical manifestation of nonterrestrial life is observable in or on animate and/or inanimate objects, with the third kind being optical observation of a nonterrestrial life form.[3] A close encounter of the fourth kind is said to occur when a human is abducted for experimentation or any other purpose while a close encounter of the fifth kind is human communication with a nonterrestrial.[4] Death or injury resulting from an encounter of any kind with an alien is said to be a close encounter of the sixth kind.[5] Lastly, intimate relations with a nonterrestrial life form is said to be a close encounter of the seventh kind.[6] Generally, these various stages are premised on the existence of an intelligent or sentient carbon based multi-celluar nonterrestrial organism. Nevertheless, close encounters of the second, third, and sixth kind can apply with respect to human contact and interaction with insentient nonterrestrial life such as microorganisms, commonly referred to as microbes, provided such life forms exist.[7] At this point, it should be noted that the scientific odds are greater regarding the existence of and an encounter with a nonterrestrial microbe ("NTM") than an intelli-

1 Lynette Alice, The 7 Classes of Extraterrestrial Close Encounters, available at www.actforlibraries.org/the-7-classes-of-extraterrestrial-close-encounters/ (last visited on Sept. 22, 2015).

2 Christine A. Corcos, Visits to A Small Planet: Rights Talk in Some Science Fiction Film and Television Series from the 1950s to the 1990s, 39 Stetson L. Rev. 183, 185 n. 6 (2009).

3 *Id*.

4 See S.P.S. Jain, "What're close encounters of the first, second, third, fourth and fifth kind?" The Times of India, March 22, 2003.

5 Alice, *supra* note 1.

6 *Id*.

7 A "microorganism is a life form that requires magnification to See and resolve its structure. *Microorganisms* at 1-2, encyclopedia.com, www.encyclopedia.com/topic/Microorganisms.aspx (Last visited on September 29, 2015). See *What is a Microbe*, www.microbeworld.org/what-is-a-microbe (last visited on Sept. 29, 2015). are the oldest form of life known. *Id*. Most microbes are unicelluar. *Id*. Commonly known microbes include bacteria, yeasts, molds, protozoa, algae, rickettsia and viruses. Id. A virus is different from other microbes in that it does not have DNA or RNA and can not live or replicate on its own, instead it uses the genetic and metabolic processes of a host to replicate. *Id*. Rickettsia are similar to viruses in that it can only grow and multiply inside other living cells. *Id*. Microbes which cause or transit a disease are referred to as pathogens. *Id*.

gent multi-celluar nonterrestrial life form.[8] As Stephen Hawking has aptly noted, "[p]rimitive life is very common and intelligent life is fairly rare."[9]

Given the ascending participation of non-state actors in the commercialization of space, if NTMs exist, then the possibility arises that a non-state commercial entity may very well discover, stumble upon or otherwise learn of NTMs while engaging in space activities. Such an awakening can occur by noticing chemical or biological traces of an NTM embedded in the soil, dust, rocks, or other non-organic matter extracted from an asteroid, comet, moon, or planet.[10] An encounter can also happen if a living NTM is observed while examining or testing the soil, dust, rocks, or other non-organic matter extracted from an asteroid, comet, moon, or planet. The opportunity for a potential encounter with an NTM will substantially increase once commercial space activity such as asteroid mining or a Mars settlement comes into fruition. If a non-state actor encounters an NTM, then the occurrence presents an economic potential that may prove to be just as valuable as the elements and minerals being extracted from a commercial operation on a Solar System body. Such an additional financial opportunity arises from the possibility of obtaining intellectual property rights derived from an NTM.[11] This presents the issue of what legal obligations a non-state actor has if it encounters an NTM while engaging in commercial space activities.

This paper will explore the space law parameters associated with a non-state actor encountering an NTM while engaging in a commercial space activity and subsequently desiring to study and examine the NTM to determine if it has any potential economic value. In doing so, the paper will initially draw upon the factual background in the science fiction film *Aliens*[12] to give some context to the analysis.

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8 Stephen Hawking, Stephen Hawking on Non-Carbon-Based Alien Life" dailygalaxy.com, (March 18, 2011) www.dailygalaxy.com/my_weblog/2011/05/stephen-hawking-on-non-carbon-based-alien-life.html Indeed, if there are or if one believes that an intelligent multi-celluar life form exists on a celestial body other than Earth, then logic dictates that there are also nonterrestrial microbes. Even more so, given the complexity and temporal expanse needed for multi-celluar life to develop, it seems the scientific odds rests with the discovery of nonterrestrial microbial life rather than multi-celluar life forms.

9 *Id.*

10 This is the type of analysis being conducted by the Mars Rover. See Ian Sample, "Nasa Curiosity rover tests suggest life may have existed on Mars," theguardian.com, March 13, 2013, www.theguardian.com/science/2013/mar/12/nasa-curiosity-mars-rover-rock-samples.

11 *See supra* at 2-4.

12 A 20th Century Fox film directed by James Cameron released on July 18, 1886.

II. The Factual Scenario of *Aliens*

Aliens is a sequel to the 1979 film *Alien.*[13] The subplot to *Aliens* involves a conglomerate named Weyland-Yutani which engages in commercial space activities such as mining and terra-forming. The crew of a Weyland-Yutani space cargo vessel named *Nostromo* first learned of and had initial contact with a nonterrestrial life form after it landed on an unsurveyed planet designated as LV 426. This initial encounter with the nonterrestrial life form is depicted in the film *Alien*, in which a *Nostromo's* crew member named Ripley was the sole survivor. To escape the life form and prevent it from reaching Earth, Ripley, overloaded the *Nostromo's* engines causing it to explode. Prior to the explosion, Ripley evacuated the vessel in one of its "life boats." Ripley faced a legal inquest on her actions upon her return to Earth.
A period of 57 years transpired between the *Nostromo's* encounter with the nonterrestrial life form and Ripley's return to Earth.[14] During this time frame, Weyland-Yutani, in partnership with a governmental entity, had established a terra forming colony on LV 426. Weyland-Yutani's survey of LV 426 prior to undertaking the terra forming operation did not uncover any indigenous life forms on the planet. Following a legal inquest on Ripley's decision to destroy the *Nostromo*, Weyland-Yutani lost communication with the terra forming colony. Weyland-Yutani apparently determined that if Ripley's account of the nonterrestrial life form was true, then it wanted to capture the life form and return it to Earth for purposes of performing scientific and industrial examination and analysis to ascertain whether it presented any economic value. The company's secret plan was embedded within a government-supported mission to determine the fate of the terra forming colonists. As part of the company's plan, it sent a representative on the mission as an observer given the financial stake it had in the terra forming operation. Ripley accompanied the mission as an advisor and initially lacked knowledge of Weyland-Yutani's intentions. Ripley wanted to ensure the eradication of the unnamed life form. One point of high drama in the film was the means by which Weyland-Yutani's agent intended to smuggle the nonterrestrial life form through quarantine upon returning to Earth.[15]

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13 A 20th Century Fox Film directed by Ridley Scott released on May 25, 1979.

14 The distance of LV 426 from Earth required Ripley to go into hypersleep onboard the "lifeboat" she used evacuate the *Nostromo* prior to destroying the expansive cargo vessel in order to eradicate the alien life form that had killed her fellow crew members.

15 The non terrestrial life form replicated by using other life forms as a host for its embryos. The plan was to impregnate Ripley an another female with the alien seed and smuggle the nonterrestrial life form back to Earth in their bodies. The nonterrestrial off-spring would be preserved by placing the "infected" persons into hypersleep for the return to Earth.

Although *Aliens* concerns an intelligent, non-microscopic multi-celluar life form, it nevertheless provides an ample setting for the relevant legal considerations associated with a non-state actor encountering an NTM during a commercial space activity. The nonterrestrial life form in *Aliens* presents a good metaphor for NTM similar to a virus or rickettsias given the manner of its replication.[16] This paper will analyze the existing rudimentary space law framework in the context of a non-state commercial actor encountering an NTM, which is a potentially realistic 21st Century scenario. It is meant to further engage thought and consideration to the necessity for international agreement on binding parameters and protocols relating to a non-state actors discovering, studying, testing and/or modifying NTMs.

III. Intellectual Property Rights and NTMs

Biotechnology is a growing and sophisticated frontier industry. "After information technology, biotechnology is increasingly recognized as the next wave in the knowledge-based economy."[17] Biotechnology is the alteration of the "processes of life at the molecular level in order to yield new products and applications."[18] In other words, biotechnology uses "organisms or parts of organisms to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses."[19] Biotechnology is not new as it has been present at a fundamental level since the "dawn of civilization when humans first began to systematically use microorganisms to ferment beer, leaven bread, or curdle milk into yogurt and cheese."[20] Moreover, biotechnology also includes the traditional breeding techniques used to improve plants and animals.[21] Now, technology allows the manipulation of microorganisms, plants and animals at the celluar or molecular level. This technological advance allows for the development and enhancement of products and processes in diverse industries including pharmaceuticals,[22] food,[23] fuel,[24] and environ-

16 See *Id* and Note 7.
17 Esteban Burrone, Patents at the Core: The Biotech Business, World Intellectual Property Organization available at www.wipo.int/sme/en/documents/patents_biotech_fulltext.html (last visited Sept. 21, 2015).
18 Alvin R. Chin"The Misapplication of Innovation Market Analysis to Biotechnology Mergers," 3 Boston University Journal of Science & Technology, 6, 6 (1997).
19 Insoon Song, *Old Knowledge into New Patent Law: The Impact of United States Patent Law on Less-Developed Countries*, 16 Ind. Intl. & Comp. L. Rev. 261 (2005).
20 Dan L. Burk, "Misappropriation of Trade Secrets in Biotechnology Licensing," 4 Albany Law Journal of Science & Technology, 121, 133 (1994).
21 Thomas Connor, Genetically Modified Torts: Enlisting the Tort System to Regulate Agricultural Contamination by Biotech Crops, 75 University of Cincinnati Law Review, 1187, 1190 n. 16 (2007).
22 Randy Berholtz, Richard H. Schurman, Vince Davies, Katherine MacFarlane, Derek & Midkiff, Sumant Pathak, "Where to File: A Framework for Pharmaceutical and

mental preservation processes.[25] The manipulation is of genetic material found in animals, plants, and microorganisms.[26] In science, there is no distinction between the molecular manipulation of plants or animals.[27]

Biotech advocates assert that advancements in biotechnology are probably the single most important immediate economic benefit of the space industry as it can lead to very profitable returns as well as provide humanitarian value.[28] The economic potential for biotechnology is apparent given that in 2011, the biotech industry generated revenues of more than $ 83.6 billion.[29] The United States is the industry leader as the majority of biotech research is conducted there, the most venture capital for biotech research originates in the United States and the United States has the largest commercial market for biotechnology.[30] The core of the biotech industry rests on patents.[31]

In the United States, patent protection is generally available for products or processes derived from all levels of life except for humans.[32] Indeed, the United States Supreme Court has ruled that when Congress enacted 35 U.S.C. §101, it intended to "'include anything under the sun that is made by man," 'including the modification of microorganisms, as being within the scope of

Biotechnology Companies to Develop an International Patent Filing Strategy," 37 Thomas Jefferson L. Rev. 225 (2015).

23 Robert C. Bird & Daniel R. Cahoy, Human Rights, Technology, and Food: Coordinating Access and Innovation for 2050 and Beyond, 52 Am. Bus. L.J. 435 (2015).

24 Nathan K. Shrewsbury, Patentability of Living Matter Related to Biofuel Production in the U.S., 6 Oklahoma Journal of Law & Technology 46 (Oct. 2009).

25 *Diamond v. Chakrabarty*, 447 U.S. 303, 100 S.Ct. 2204 (1980)(case involving genetically engineered bacterium capable of breaking down crude oil).

26 Michael Woods, "Food for Thought: The Biopiracy of Jasmine and Basmati Rice, 13 Albany Law Journal of Science and Technology" 123, 128 (2002).

27 Susan J. Timian & D. Michael Connolly, The Regulation and Development of Bioremediation, 7 Risk: Health, Safety and Environment 279, 289 n. 42 (1996) quoting National Academy of Sciences, Field Testing Genetically Modified Organisms: Framework for Decisions (1989) ["[N]o conceptual distinction exists between genetic modification of plants and microorganisms by classical methods or by molecular methods that modify DNA and transfer genes."].

28 *See* Ty S. Twibell, Space Law: Legal Restraints on Commercialization and Development of Outer Space, 65 UMKC L. Rev. 589, 627-28 (1997).

29 William D. Sprott, "From Pine Straw to Cdna: The History of the "Product of Nature' Doctrine," 14 Houston Business & Tax Law Journal," 290, 291 (2014).

30 Omid E. Khalifeh, "The Gene Wars: Science, the Law and the Human Genome," 9 Loyola Law and Technology Annual 91, 123 (2009-2010).

31 Esteban Burrone, *supra* note 17. See David C. Hoffman, Note, A Modest Proposal: Toward Improved Access to Biotechnology Research Tools by Implementing a Broad Experimental Use Exception, 89 Cornell L. Rev. 993, 1022 (2004) ("For many [biotech] companies, a patent portfolio is the only potentially lucrative asset available for exploitation.

32 Robert C. Bird & Daniel R. Cahoy, *supra* note 23, 52 Am. Bus. L.J. at 453.

patent law.[33] For example, a patent on microbial life forms can be obtained by showing genetic modification or purification.[34] Genetic modification, also known as genetic engineering, is the modification of an organism's DNA genome, transferring genetic material from one organism to another species or cloning.[35] Purification is referred to as the isolation of a microorganism from its natural environment.[36] The rationale for allowing a patent for "a purified form of a naturally occurring microbe is that a microbe does not exist in an isolated state in nature."[37]

The United States is not alone in allowing patents on microorganisms. The European Patent Office allows issuance of a patent for "any inventions which are susceptible of industrial application, which are new and which involve an inventive step."[38] This requires an invention to be novel, industrially applicable and comprised an inventive step to be eligible for a patent.[39] However, since European law was unclear regarding biotech patents, in 1998 the European Union issued Directive 98/44[40] which was designed to provide legal protection for biotechnological inventions.[41] China does not allow patents on life forms,

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33 *Chakrabarty*, 447 U.S. at 309, 100 S.Ct. 2204. Section 101 reads as follows: "Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title."

34 Shrewsbury, *supra* note 24, 5 Okla. J. L. Tech. at 46–47.

35 See Dr. Andrew W. Torrance, Intellectual Property As the Third Dimension of Gmo Regulation, 16 Kan. J.L. & Pub. Policy 257, 267 (Spring 2007); Timian & Connolly, 7 Risk: Health, Safety and Environment at 289 n. 42.

36 Shrewsbury, *supra* note 24, 5 Okla. J.L. Tech. 46.

37 *Id*. Although purification is recognized by the U.S. patent office as a basis for obtaining a patent on a microorganism, this approach is not well received by some scholars as isolating microbes is essentially plucking the microbes "from their surroundings" rather than being altered by human hands. Cliff Brazil, You Didn't Build That: The Case Against Patentability of Isolated Organisms, 63 University of Kansas law Review 761, 762 (2015).

38 Jerzy Koopman, The Patentability of Transgenic Animals in the United States of America and the European Union: A Proposal for Harmonization, 13 Fordham Intellectual Property Media & Entertainment Law Journal 103, 146 (2002) quoting Convention on the Grant of European Patents, Art. 52(1), October 5, 1973, 1065 U.N.T.S. 199.

39 *Id*., at 146.

40 Council Directive 98/44/EC, 1998 O.J. (L 213) 13 (EC).

41 Koopman, *supra* note 38, 13 Fordham Intell. Prop. Media & Ent. L. J. at 145. While biotech patents remain valid under European law, it is unsettled as to the limits or parameters of after the patents after the 2010 decision in issued by the Court of Justice of the European Union in *Monsanto Technology LLC v. Cefetra BV*, 2010 ECJ EUR-Lex LEXIS 396 (Jul. 6, 2010) which limited a DNA based patent to the functionality of the DNA at the time of the alleged infringement. *Id*.

but allows the patenting of genes.[42] While India allows patenting of genetic materials, it is unclear if a patent can be obtained on genes.[43] Thus, the majority of the space faring governments treat biotech products as intellectual property subject to patent protection.

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies ("Outer Space Treaty")[44] which is the cornerstone for space law, is silent about intellectual property rights and does not provide any express protection for such rights.[45] Patent rights and protection, therefore, rest in Outer Space Treaty Article VII which grants a State jurisdiction and control over a space object that it launches.[46] Based on Article VIII, the United States enacted domestic legislation extending its patent jurisdiction and coverage to outer space.[47]

The essence of the statute provides that "[a]ny invention made, used or sold in outer space on a space object or component thereof under the jurisdiction or control of the United States shall be considered to be made, used or sold within the United States."[48] The statute further provides that "[a]ny invention made, used or sold in outer space on a space object or component thereof that is carried on the registry of a foreign state" shall be deemed to be made, used or sold within the United States if so provided in an agreement between the United States and the foreign state.[49]

This statutory provision is consistent with the intellectual property rights provisions contained in Article 21 of the Agreement Among The Government Of Canada, Governments Of Member States Of The European Space Agency, The Government Of Japan, The Government Of The Russian Federation, And The Government Of The United States Of America Concerning Cooperation On The Civil International Space Station ("1998 ISS Agreement.")[50]

42 Molly Jamison, Patent Harmonization in Biotechnology: Towards International Reconciliation of the Gene Patent Debate, 15 Chicago Journal of International Law 688, 699 (2015).
43 *Id.*
44 Entered into Force Oct. 10, 1967, 18 UST 2410; TIAS 6347; 610 UNTS 205; 6 ILM 386 (1967).
45 Leo B. Malagar and Marlo Apalisok Magdoza-Malagar, International Law of Outer Space and the Protection of Intellectual Property Rights, 17 Boston University International Law Journal 311, 360 (1999).
46 *Id.*
47 35 U.S.C. §105(a) (2012).
48 *Id*. The statute contains an exception based on a treaty provision which provides otherwise.
49 35 U.S.C. §105(b) (2012).
50 Entered into force on March 27, 2001, T.I.A.S. No. 12, 927, State Dept No. 01-52, 2001 WL 679938.https://a.next.westlaw.com/Link/Document/FullText?findType =Y&pubNum=100856&cite=41INTLLEGALMAT1481&originatingDoc=Ied1be92

Specifically, ISS Article 21(1) provides that "for purposes of intellectual property law, an activity occurring in or on a Space Station flight element shall be deemed to have occurred only in the territory of the Partner State of that element's registry [...]."[51]

Shortly after the effective date of the 1998 ISS Agreement, NASA and the Biotechnology Industry Organization entered into a Memorandum of Understanding ("MOU") "to expand cooperation between NASA and the biotechnology industry."[52] The MOU[53] not only symbolized the "convergence of space technology and biotechnology," but it also recognized "the importance of biotechnology as an expanding industry with increasing significance for health care, agriculture, economics and space exploration."[54] Section 1 of the MOU recognizes that "[b]iotechnology research has been performed on the Space Shuttle and other platforms. The advent of the International Space Station (ISS) offers new opportunities for expanded research and commercial development." Apparently, based on the MOU, in 2008 NASA and a space biotech company named Astrogenetix entered into a Space Act Agreement which granted Astrogenetix room for biotech experiments and projects on all remaining space shuttle missions until the shuttle's retirement.[55] Astrogenetix and NASA subsequently signed an additional agreement in 2011.[56]

Biotech research on the ISS has shown that the space environment induces key changes in microbial cells that are directly relevant to infectious disease.[57] The changes include alterations of microbial growth rates, antibiotic resistance, microbial invasion of host tissue, genetic changes within a microbe, and

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136ed11db8382aef8d8e33c97&refType=NA&originationContext=document&transitionType=DocumentItem&contextData=(sc.Search).

51 Of course there are a few exceptions but none are relevant for purposes of this paper.

52 The BIO and NASA – Expanding Biotech Cooperation in Space, available at https://www.bio.org/media/press-release/bio-and-nasa-expanding-biotech-cooperation-space (last visted on Sept. 21, 2015). The Biotechnology Industry Organization "is the world's largest trade association representing biotechnology companies, academic institutions, state biotechnology centers and related organizations across the United States and in more than 30 other nations." *Id.*

53 A copy of the MOU is available at www.spaceref.com/news/viewpr.html?pid=8496 (Last visited on Sept. 23, 2015).

54 *Id.*

55 Corporate Overview, astrogenetix.com www.astrogenetix.com/files/agen/u1/Astrogenetix_Overview_web.pdf (last visited Sept. 30, 2015).

56 Nonreimbursable Space Act Agreement Between Astrogenetix, Inc., and the National Space Aeronautics and Space Administration, NASA for Utilization of the International Space Station as a National Lab available at https://www.nasa.gov/sites/default/files/files/SAA0-SOMD-11096_signed.pdf (last visited on Sept. 30, 2015).

57 Tara Ruttley, International Space Station Plays Role in Vaccine Development, NASA.gov available at www.nasa.gov/mission_pages/station/research/benefits/vaccine_development_prt.htm (last visited on Sept. 21, 2015).

organism virulence, which is the relative ability of a microbe to cause disease.[58] Discovering the factors responsible for growth and virulence of bacteria contributes to the development of novel therapeutic treatments, including vaccines as well as biological and pharmaceutical agents aimed specifically at eradicating a particular pathogen.[59] For instance, salmonella diarrhea is one of the top three causes of infant mortality in the world.[60] Research and experimentation on the ISS with the Salmonella bacteria led to identifying specific targets for anti-microbial therapeutics to counter the pathogen. This has resulted in the discovery of a potential candidate vaccine for the pathogen which is currently in the planning stages for review and commercial development.[61]

Similarly, Streptococcus pneumonia is a bacterial pathogen that causes life-threatening diseases, such as pneumonia, meningitis, and bacteremia.[62] This organism causes more than 10 million deaths annually and is particularly dangerous for newborns and the elderly.[63] Research is being conducted on the ISS to develop an enhanced vaccine for the pathogen.[64]

Biotech research on the ISS has now matured and diversified to the point where microbial experiments and research are the source of a “crowd funding” experiment known as Project MERCCURI which utilizes participation among “citizen scientists.”[65] Project MERCCURI collects microbial samples from surface areas in various buildings and public venues. The microbes are then transported to the University of California-Davis which then sends a portion of the sample to the ISS and retains the balance in its laboratory. The growth rates of the microbes in the ISS’ micro gravity are then simultaneously compared to the growth of the corresponding microbes in the laboratory at the University of California-Davis.[66] The experiment can be followed online as well as on social media.[67] The apparent purpose of this project is to add to the body of knowledge concerning microbial life and possibly “advance future biological and pharmaceutical micro gravity research, which could help scientists better understand bacteria and improve treatments for afflictions caused by various pathogens” This project demonstrates that biotech research on microbial life has become a routine and pedestrian event in outer space.

58 *Id.*
59 *Id.*
60 *Id.*
61 *Id.*
62 *Id.*
63 *Id.*
64 *Id.*
65 Jessica Nimon, Project MERCCURI “Crowdsourced” Space Station Samples Take Flight, NASA.gov (March 12, 2014) available at https://www.nasa.gov/mission_pages/station/research/news/merccuri (last visited on Sept. 21, 2015).
66 *Id.*
67 *Id.*

IV. NTMs and Planetary Protection

Planetary protection is the phrase which refers to efforts to prevent biological cross contamination involving Earth and other solar system bodies from exposure to non-native microorganisms due to human use of outer space. This effort consists of preventing "backward contamination" and "forward contamination." Backward contamination refers to Earth being exposed to a nonterrestrial microorganism brought back to the planet "in samples of soil, rocks, and other materials collected from extra-terrestrial bodies during scientific space exploration."[68] Forward contamination means exposing outer space and all celestial bodies, including all moons, asteroids, and comets with terrestrial microorganisms.[69] The current planetary protection procedures place more emphasis on forward contamination than backward contamination as in the scientific community, planetary protection "usually means protecting other planets from contamination by microbes originating on Earth."[70] Some view this emphasis on forward contamination, rather than on backward contamination, as a misguided concern. One scholar has opined that:

> "[w]e must not be concerned about causing harm to outer space. It will destroy us much quicker than we would destroy it. We should be concerned about causing harm to ourselves by wasting the considerable and wonderful wealth we have received from Mother Nature."[71]

This fundamental understanding of planetary protection provides some insight into the treatment of NTMs under current planetary protection measures.

The Outer Space Treaty does not contain any reference to nonterrestrial life. Nevertheless, there is a consensus that Outer Space Treaty Article IX provides some guidance on an encounter with an NTM or planetary protection.[72] The guidelines extend to non-state actors pursuant to Outer Space Treaty Article VI.[73]

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68 Molly K. Macauley, Flying in the Face of Uncertainty: Human Risk in Space Activities, 6 Chi. J. Intl. L. 131, 143 (2005).

69 *Id.*

70 Clara Moskowitz, New Bacterial Life-Form Discovered in NASA and ESA Spacecraft Clean Rooms, at 2, (Nov. 20, 2013) available at www.scientificamerican.com/article/bacteria-discovered-spacecraft-clean-rooms/ (last visited on Sept. 23, 2015).

71 Jean-François Mayence, "Article IX of the Outer Space Treaty and the Concept of Planetary Protection: Toward a Space Environment Law" at 8.

72 Jeb Butler, "Unearthly Microbes and the Laws Designed to Resist Them," 41 Ga. L. Rev. 1355, 1376-1377 (Summer, 2007).

73 Article VI imposes international responsibility on a State for its national's activities in outer space. This essentially obligates a State to regulate and monitor the space activities of its nationals.

Outer Space Treaty Article IX, which reads in relevant part, as follows:

> "[...] States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, *where necessary, shall adopt appropriate measures for this purpose*". (Emphasis supplied)

Article IX addresses forward contamination by obligating States to strive to avoid harmful contamination of celestial bodies other than Earth when engaging in space activities. It addresses backward contamination by requiring States to avoid causing "adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter." While Article IX at least recognizes the concern of backward contamination, it suffers from the common affliction of most space treaty provisions, vagueness. The lack of specificity is evident as neither Article IX nor any other Outer Space Treaty provision defines what constitutes "harmful contamination,"[74] the phrase "adverse changes," or specify the procedures to ensure the safe containment of nonterrestrial samples brought back to Earth.[75] Likewise, Article IX fails to articulate "what 'measures" might be "appropriate for preventing contamination."[76] Lastly, the generalized language Article IX employs does not mandate any specific State action.[77] At best, Article IX establishes generalized guidelines that States should avoid backward contamination but delegates to each State the discretion to decide whether it should enact domestic laws prohibiting and enforcing such conduct. In other words, the Outer Space Treaty declines to exercise planetary protection measures at the international level. Rather, it delegates planetary protection authority to the State level.
Scholarly debate exists over whether Outer Space Treaty Article III provides a legal basis for mandating planetary protection against backward contamination at the international level.[78] Pursuant to Article III, outer space activities must be conducted in accordance with international law. This extension of international law to outer space is the genesis for the debate over whether the terrestrial international environmental law applies to space activities. The

74 Patricia M. Sterns and Lesile I. Tennen, Exobiology and the Outer Space Treaty From Planetary Protection to the Search for Extraterrestrial Life, Proceedings of the Fortieth Colloquium on the Law of Outer Space 141, 145 (Amer. Inst. of Aeronautics and Astronautics 1997).
75 Butler, *supra* note 72, at 1376-1377; Gérardine Meishan Goh, Softly, Softly Catchee Monkey: Informalism and the Quiet Development of International Space Law, 87 Neb. L. Rev. 725, 738 (2009).
76 *Id.*
77 Butler, *supra* note 72, at 1376; Goh, *supra* note 75 at 738.
78 See Butler *supra* note 72, at 1381-1384; Mayence, *supra* note 71, at 4-6; Sergio Marchisio "Protecting the Space Environment," 46 L. Outer Space 9, 13 (2003).

disagreement centers on Principle 21 of the 1972 United Nations Stockholm Declaration on the Human Environment ("Stockholm Declaration")[79] and Principle 2 of the 1992 United States Nations Rio Declaration on Environment and Development ("Rio Declaration")[80] apply to outer space activities. Stockholm Declaration Principle 21 and Rio Declaration Principle 2 each assert that pursuant to the United Nations Charter and principles of international law a State possesses the sovereign right to exploit its own resources in accordance with its own laws and "the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction." This language in conjunction with the contextual background for the two declarations suggests that the better legal position is that the declarations are limited to terrestrial activities and do not apply outer space activities and the prevention of backward contamination.[81]

In addition to the Outer Space Treaty, the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies ("Moon Agreement")[82] also contains language addressing backward contamination. First, unlike any other space treaty, the Moon Treaty expressly recognizes the potential for nonterrestrial life. Specifically, Moon Treaty Article 5(3) mandates that a State shall promptly inform the Secretary-General, as well as the public and the international scientific community, of any phenomena it discovers in outer space, including the Moon, which could endanger human life or health, as well as of any indication of organic life."[83]

Additionally, Article 7(1) requires States to take "measures to avoid harmfully affecting the environment of the Earth through the introduction of extraterrestrial matter or otherwise."[84] Pursuant to Article 7(1), the Moon Agreement, as contrasted with the Outer Space Treaty, affirmatively obligates a State to enact backward contamination prevention laws. However, the Moon Agreement is "neither positive nor customary international law" since it has been ratified by only 13 States none of which are any of the major spacefaring States.[85] Never-

79 Declaration on the Human Environment, U.N. Doc. A/CONF.48/14 and Corr. 1, 11 I.L.M. 1416 (1972).
80 UN Doc. A/CONF.151/26 (Vol. I), 31 I.L.M. 874 (1992).
81 Butler, *supra* note 72, at 1381-1384.
82 Entered into force July 1, 1984, 1363 UNTS 3; 18 ILM 1434 (1979).
83 Since Article 5(3) uses the terms "phenomena" and "organic life," this suggests that organic life is not a phenomena for purposes of the Moon Agreement.
84 The Agreement does not articulate or explain what constitutes "harmfully affecting the environment. However, given Article 5(3)'s express reference to "organic life," the word "otherwise" can reasonably be construed to include the possibility of contamination by nonterrestrial life, even though such a life form has not been not been scientifically proven to exist.
85 Austin C. Murnane, The Prospector's Guide to the Galaxy, 37 Fordham Intl. L.J. 235, 264 (2013). See *also* Butler, *supra* note 72 at 1380.

theless, the Outer Space Treaty and the Moon Agreement share some harmony in that neither establishes standards for planetary protection at the international level. They each delegate the promulgation of planetary protection measures to States. A significant point of divergence is that since the Outer Space Treaty is binding and the Moon Treaty is not binding law of any kind, space law lacks meaningful or significant report or disclosure obligations relating to the discovery of an NTM.

Outer Space Treaty Article IX requires international consultation only when a State "has reason to believe" that an activity or experiment planned by it or by its nationals in outer space or on the Moon or other celestial body "would cause potentially harmful interference with activities of other States" use of outer space, the Moon or other celestial body for peaceful exploration. It does not require prior consultation for activities when a State "has reason to believe" a space activity may have backward contamination consequences. Article IX also allows another State to request prior consultation only when it "has reason to believe" that another's space activity or experiment "would potentially cause harmful interference" with the peaceful use and exploration of space, the Moon and other celestial bodies. It does not allow another State to request consultation in connection with another's planned activity or experiment on the basis of potentially harmful backward contamination concerns.

Similarly, Outer Space Treaty XI provides that a State agrees "to inform" the United Nations Secretary-General, the public and the international scientific community, "*to the greatest extent feasible and practicable*, of the nature, conduct, locations and results" of its space activities. To the extent the "agreement" to disclose is mandatory, it is noted that the standard of "*to the greatest extent feasible and practicable*," does not specify the timing, manner or details of any such disclosure.[86] Accordingly, Article XI is deemed to establish a disclosure standard which "is sufficiently elastic to accommodate the withholding of proprietary business information which otherwise may be protected intellectual property."[87] This "withholding of proprietary business information" can potentially complicate formulating effective backward contamination measures associated with NTMs.

V. Planetary Protection at the State Level

V.1. Initial Backward Contamination Measures

On July 16, 1969, the launch date of the Apollo 11 moon landing mission, the United States National Aeronautical and Space Administration ("NASA") promulgated regulations to govern extraterrestrial exposure to prevent back-

86 Leslie I. Tennen, Esq., *Towards A New Regime for Exploitation of Outer Space Mineral Resources*, 88 Neb. L. Rev. 794, 818 (2010).

87 *Id.*

ward contamination.[88] The regulations were premised, in part, on the discretionary power authorized by Outer Space Treaty Article IX.[89] Although NASA formally removed the extraterrestrial exposure regulations from the Code of Federal Regulations on April 26, 1991,[90] examining the regulations will give some insight into the initial exercise of Article IX's delegated authority.

The extraterrestrial exposure regulations were promulgated to establish NASA's "policy, responsibility and authority to guard the Earth against any harmful contamination or adverse changes in its environment resulting from personnel, spacecraft and other property returning to the Earth after landing on or coming within the atmospheric envelope of a celestial body."[91] Additionally, the regulations were meant to establish "security requirements, restrictions and safeguards that are necessary in the interest of national security."[92] The regulations did not apply to all NASA space missions. Instead they were limited to "all NASA manned and unmanned space missions which land or come within the atmospheric envelop of a celestial body and return to the Earth."[93] The regulations' substantive content focuses on extraterrestrial exposure, quarantine, limited due process and the penalty for violating the regulations.

The regulations outline two methods for extraterrestrial exposure. Such exposure occurs when "the state of condition of any person, property, animal or other form of life or matter whatever, who or which has" (1) directly touched or come within the atmospheric envelope of any other celestial body or (2) directly touched or "been in close proximity to (or been exposed indirectly to) any person, property, animal or other form of life or matter who or which has been extra-terrestrially exposed" by direct touch or coming within the atmospheric envelope of any other celestial body.[94] NASA possessed the sole discretion to determine whether a "particular person, property, animal, or other form of life or matter, whatever" had been subject to extra-terrestrial exposure.[95] Such a determination could be made "with or without a hearing."[96] The determination was not wholly arbitrary as it there had to be "probable cause to believe that such person, property, animal or other life form or matter" had experienced extraterrestrial exposure.[97] A person, prop-

88 14 C.F.R. §1211.100 – §1211.108 (1990) removal effective on April 26, 1991.
89 14 C.F.R. §1211.103(c) (1990) removal effective on April 26, 1991.
90 56 FR 19259. The public notice of removal stated that NASA "is removing 14 CFR Part 1211 since it has served its purpose and is no longer in keeping with current policy." *Id.*
91 14 C.F.R. §1211.100(a) (1990) removal effective on April 26, 1991.
92 *Id* at §1211.100(b) (1990) removal effective on April 26, 1991.
93 *Id* at §1211.101 (1990) removal effective on April 26, 1991.
94 *Id* at §1211.102(b)(1)&(2) (1990) removal effective on April 26, 1991.
95 *Id* at §1211.104(a)(3) (1990) removal effective on April 26, 1991.
96 *Id.*
97 *Id.*

erty, animal or other life form or matter determined to have been extraterrestrially exposed was subject to quarantine.[98]
Quarantine was defined as the "detention, examination and decontamination of any person, property, animal or other form of life or matter whatever that is extra-terrestrially exposed, and includes the apprehension or seizure of such person, property, animal or other form of life or matter whatever."[99]
NASA possessed the discretion to determine the length as well as the terms and conditions of any such quarantine. NASA, however, did not possess the sole discretion to quarantine a person, property, animal or other form of life or matter that was subject to extraterrestrial exposure. The Department of Health, Education and Welfare and the Department of Agriculture also possessed the authority to quarantine provided the quarantine did not involve NASA astronauts, personnel, or property.[100] If HEW or DOA decided to exercise its quarantine authority, then NASA would refrain from exercising its quarantine authority with respect to the same person, property, animal or other form of life or matter.[101] If NASA quarantine's, then any person subject to the quarantine would be given "a reasonable opportunity to communicate by telephone with legal counsel or other person of his choice."[102] However, NASA was prohibited from releasing any person, property, animal or other form of life or matter from the quarantine "without the prior approval" of NASA's General Counsel and NASA's Administrator.[103] If the prior approval was denied or otherwise not obtained, then NASA could not release any person, property, animal or other form of life or matter from quarantine even if there was a court order or an order from any other authority to do so.[104] In such an event, the person to whom any such court order or other order is directed would "if possible, appear in court or before the other authority and respectfully state his inability to comply, relying for his action upon this §1211.107."[105]
Lastly, any person who willfully violated, attempted to violate, or conspired to violate any provision of the regulations or order issued pursuant to the regulations or who enters or departs from a quarantine station without proper authorization was subject to no more than one year imprisonment, or a $ 5,000.00 fine or both.[106]

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98 *Id.*
99 *Id.*, at §1211.102(b)(3) (1990) removal effective on April 26, 1991.
100 *Id.*, at §1211.105(a) – (c) (1990) removal effective on April 26, 1991.
101 *Id.*, at §1211.105(a) & (b) (1990) removal effective on April 26, 1991.
102 *Id.*, at §1211.105(b)(5) (1990) removal effective on April 26, 1991.
103 *Id.*, at §1211.107(a) (1990) removal effective on April 26, 1991.
104 *Id.*
105 *Id.*, at §1211.107(b) (1990) removal effective on April 26, 1991.
106 *Id.*, at §1211.108 (1990) removal effective on April 26, 1991.

V.2. Current Planetary Protection Policy

Prior to the United States implementing the extraterrestrial exposure regulations, the Committee on Space Research (COSPAR) of the International Council of Scientific Unions had taken up the mantle of planetary protection.[107] However COSPAR's primary focus was, and apparently still is, on forward contamination rather than backward contamination. In the mid-1960s and early 1970s COSPAR began issuing recommended protocols with the purpose of preventing forward contamination.[108] NASA adopted the COSPAR procedures in a series of NASA Management Instructions and NASA Policy Directives ("NPD").[109] Subsequently, in the 1970's when NASA's focus shifted from the Moon to Mars in anticipation of the Viking Mars missions, NASA developed a renewed interest in planetary protection.[110] This renewed interest in planetary protection arose out of a concern to "avoid contamination on introducing life from Earth into the Martian environment and thereby confounding analysis of the soils on the surface of Mars in looking for evidence of life.[111] In other words, the concern was for forward contamination rather than backward contamination principally because the Viking missions were one way and did not involve a return to Earth of the spacecraft or of any soil or rock sample. To address the planetary protection concerns, in 1976 NASA established a Planetary Protection Office ("PPO") to deal with contamination issues associated with the Viking missions to Mars.[112]

Since its formation, the PPO has become responsible for ensuring that every NASA related space mission implements the relevant planetary protection policies.[113] The PPO, then and now, establishes its planetary protection policies, forward and backward, in conformity with COSPAR's guidelines.[114] Indeed, NASA explicitly acknowledges that its planetary protection policies are "well aligned" with COSPAR Planetary Protection Policy and consistent with Outer Space Treaty Article IX.[115] The relevant policies exhibiting this alignment and

107 Sterns and Tennen, *supra* note 74, Fortieth Colloquium on the Law of Outer Space at 142.
108 See Sterns and Tennen, *supra* note 74, at 142.
109 *Id* at 142-143.
110 Macauley, *supra* note 68, 6 Chi. J. Int'l. L. at 144.
111 *Id.*
112 Brenda Koerner, Who's our planetary protection officer?, slate.com (Aug. 20, 2004) available at www.slate.com/articles/news_and_politics/explainer/2004/04/your_planetary_protection_officer.html (last visited on Sept. 22, 2015).
113 Macauley, *supra* note 68, 6 Chi. J. Int'l. L. at 144.
114 Catharine A. Conley, Gerhard Kminek, and John D. Rummel, Planetary Protection and Article IX of the Outer Space Treaty at 4-5 available at www.spacelaw.olemiss.edu/events/pdfs/2010/galloway-conely-paper-2010.pdf (last visited on Sept. 22, 2015).
115 Office of Planetary Protection, nasa.gov available at http://planetaryprotection.nasa.gov/overview (Last visited on Sept. 22, 2015). See NASA Policy Instructions ("NPI") 8020.7, NASA Policy on Planetary Protection Requirements for Human

consistency are NPD 8020.7G: "Biological Contamination Control for Outbound and Inbound Planetary Spacecraft" and NASA Procedural Requirements (NPR) 8020.12D: "Planetary Protection Provisions for Robotic Extraterrestrial Missions." [116] NASA is not alone in conforming its planetary protection policy with the COSPAR guidelines as the European Space Agency ("ESA") also adheres to COSPAR's guidelines,[117] and has its own Planetary Protection Office.[118] Other States have also adopted some aspects of COSPAR's planetary protection policy into their own domestic legislation.[119] Although some aspect or portion of COSPAR's policy and guidelines have been adopted by the vast majority of space faring States, the adopted and implemented measures are voluntary and often vary among States.[120] This lack of uniformity in State practice and the absence of a legal obligation to adopt any such measure precludes COSPAR's policy and guidelines from being customary international law.[121] Thus, COSPAR's planetary protection measures are non binding and do not have the effect of law unless adopted, in some form, as part of a State's domestic law.
The current COSPAR Planetary Protection Policy, approved on October 20, 2002 and amended on March 24, 2011,[122] divides all space missions into five categories.[123] The categories are distinguished by (1) the degree of contact with a body in our Solar System other than Earth, including asteroids, comets and planetoids and (2) whether the space mission entails a return to Earth.[124] Category I involves a mission to undifferentiated, metamorphosed asteroids[125]

Extraterrestrial Missions at 2-3, (May 28, 2014) available at nodis3.gsfc.nasa.gov /OPD_docs/NPI_8020_7_.doc (last visited on Sept. 22, 2015).

116 *Id*.

117 NPI 8020.7, *supra* note 115, at 2; Butler, *supra* note 72, 41 Ga. L. Rev. at 1390 & 1393.

118 Planetary Protection: Preventing Microbes Hitching To Space, space engineering and technology, esa.int www.esa.int/Our_Activities/Space_Engineering_Technology /Planetary_protection_preventing_microbes_hitchhiking_to_space.

119 Gustavo Boccardo, Planetary Protection Obligations of States Pursuant to the Space Treaties and with Special Emphasis on National Legislations Provisions at 12-21, nyulawglobal.org, www.nyulawglobal.org/globalex/Planetary_Protection _Obligations_States.html (last visited Dec. 1, 2015).

120 *Id* at 12.

121 *Id*.

122 Available at https://cosparhq.cnes.fr/sites/default/files/pppolicy.pdf (Last visited on Sept. 22, 2015).

123 Butler, *supra* note 72, 41 Ga. L. Rev. at 1385.

124 *Id*.

125 "Undifferentiated, metamorphosed asteroids are those that were heated to temperatures of less than 1,000 K so that minerals did not segregate in a macroscopic way, but are also dehydrated (if ever hydrated in the first place) and were probably subject to temperatures at which biological materials could not survive." U.S. National Research Council's Space Studies Board, Evaluating the Biological Potential in Samples Returned from Planetary Satellites and Small Solar System Bodies: Frame-

and Jupiter's Moon Lo which do not contemplate a return to Earth.[126] Missions in Category II concerns one way to worlds deemed sterile such as the Moon, Venus, Jupiter, Saturn, Uranus, Neptune, Pluto, Charon, Ceres, Jupiter moons Ganymede and Callisto, Saturn moon Titan, Neptune's moon Triton, all comets, all Kuiper belt objects less then one-half the size of Pluto and certain Kuiper Belt objects which are larger than one-half the size of Pluto.[127] Missions designated as Category III concern bodies which scientists speculate could harbor life but involve only a fly-by or orbiting observation and do not contemplate any landing or direct physical or mechanical contact with the body. Missions to Mars, the Jupiter moon Europa, and the Saturn moon Enceladus come within the scope of Category III.[128] Category IV concerns missions involving direct physical or mechanical contact with a Category III body.[129] Category IV also separates missions to Mars from missions to other Category III bodies by dividing Mars missions into three subcategories.[130] Lastly, and most important for this paper, is Category V which encompasses a mission to any bodies which contemplate a return to Earth.[131]

A Category V mission is classified as either "unrestricted Earth return" or "restricted Earth return."[132] The concern for Category V missions is the protection of the terrestrial system of the Earth and Moon.[133] An "unrestricted Earth return" designation applies to missions to solar system bodies which scientific opinion deems to be void of any indigenous life forms.[134] All other Category V missions are designated as "restricted Earth return."[135] A mission to an asteroid or other small solar system body not specifically identified by COSPAR as being in Category I or Category II, is designated as unrestricted or restricted Earth return depending upon the answers to six questions.[136] An answer of "no" or "uncertain" to all of the six questions results in the mission being classified as 'Restricted Earth return."[137]

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work for Decision Making at 43 National Academy Press 1998) available at www.nap.edu/read/6281/chapter/6 (Last visited on Sept. 22, 2015).

126 COSPAR Planetary Protection Policy, *supra* note 115, Appendix at A-2.

127 COSPAR Planetary Protection Policy, *supra* note 115, Appendix at A-2.

128 *Id.,* See Butler, *supra* note 72, 41 Ga. L. Rev. at 1385.

129 Butler, *supra* note 72, 41 Ga. L. Rev. at 1385.

130 The distinction among the three sub-categories are set forth in COSPAR Planetary Protection Policy, *supra* note 115, Appendix at A-3-A-4.

131 COSPAR Planetary Protection Policy, *supra* note 115, at 2 & Appendix A-2. See Butler, *supra* note 72, 41 Ga. L. Rev. at 1385.

132 COSPAR Planetary Protection Policy, *supra* note 115, at 2 & Appendix A-2.

133 *Id.,* Appendix at 2.

134 *Id.*

135 *Id.*

136 *Id.,* at A-7.

137 *Id.* The six questions are:

"1. Does the preponderance of scientific evidence indicate that there was never liquid water in or on the target body?

For all Category V missions designated as "restricted Earth return," the "highest degree of concern" is expressed by (1) "the absolute prohibition of destructive impact upon return" to Earth, (2) "the need for containment throughout the return phase of all returned hardware which directly contacted the target body or unsterilized material from the body", and (3) "the need for containment of any unsterilized sample collected and returned to Earth."[138] After return to Earth, there must be a "timely analyses of any unsterilized sample collected" conducted "under strict containment, and using the most sensitive techniques."[139] If there is "any sign of the existence of a *nonterrestrial replicating entity*" then "the returned sample must remain contained unless treated by an effective sterilizing procedure."[140] Sterilization is an absolute term which requires the killing or other eradication of all microorganisms.[141]

If a mission originally designated as "unrestricted Earth return" is subsequently classified as "restricted Earth return" and safe return of a nonterrestrial sample cannot be assured, then the sample "shall be abandoned, and if already collected the spacecraft carrying the sample must not be allowed to return to the Earth or the Moon."[142] The same result applies if a sample containment system on a "restricted Earth return" mission is compromised and sterilization of the sample is impossible.[143]

COSPAR's planetary protection policy sparingly uses the term life, when referring to backwards contamination; it primarily utilizes the terms "sample" or "matter" instead of "life."[144] While it is uncertain why this is so, the logical

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2. Does the preponderance of scientific evidence indicate that metabolically useful energy sources were never present?
3. Does the preponderance of scientific evidence indicate that there was never sufficient organic matter (or CO2 or carbonates and an appropriate source of reducing equivalents) in or on the target body to support life?
4. Does the preponderance of scientific evidence indicate that subsequent to the disappearance of liquid water, the target body has been subjected to extreme temperatures (i.e., >160°C)?
5. Does the preponderance of scientific evidence indicate that there is or was sufficient radiation for biological sterilization of terrestrial life forms?
6. Does the preponderance of scientific evidence indicate that there has been a natural influx to Earth, e.g., via meteorites, of material equivalent to a sample returned from the target body?"

Id.

138 *Id.*, at 2.

139 *Id.*

140 *Id.* (emphasis supplied).

141 General Bacteriology available at http://generalbacteriology.weebly.com/sterilization-and-disinfection.html.

142 COSPAR Planetary Protection Policy, *supra* note 115, Appendix at A-1–A-2.

143 *Id.*

144 COSPAR Planetary Protection Policy, *supra* note 115, at 2, & A-1–A-8.

explanation appears to be that there is no scientific proof that life exists on a solar system body other than Earth and there is only scientific speculation about the possibility of life on other solar system bodies. This receives some support from the basis COSPAR uses in creating two subdivisions in Category V. In relation to Category V, COSPAR states that missions to solar system bodies "deemed by scientific opinion to have *no indigenous life forms*" are designated 'unrestricted Earth return" with all other Category V missions being deemed "restricted Earth return."[145]

Nevertheless, in setting the guidelines for "restricted Earth return" missions, COSPAR provides that the forward contamination procedures should also be complied with to avoid "false positives" in life detection protocols or in the search for life.[146] Thus, COSPAR's backward contamination protocols have the same purpose as the forward contamination protocols, i.e., searching for nonterrestrial life. However, COSPAR does not define the term "life." This is a crucial point in as much as if a non-state actor discovers an NTM, then it needs to know whether the NTM is alive. This is necessary in order for a determination to be made regarding the necessity of employing backward contamination containment procedures. Accordingly, many scientists hold the view that an effective search for nonterrestrial life requires "a concise, agreed on definition of life."[147] This is even more so given that without a definition of life, there cannot be any basis for determining when an NTM is dead or sterilized as contemplated by COSPAR.[148] Lastly, a definition of life is a prerequisite if planetary protection measures will subsequently require reporting the discovery of nonterrestrial life.

VI. The Meaning of Life – For Planetary Protection Purposes

Life, as we know it, is diverse and resilient. Terrestrial microorganisms have been found living a half mile under the West Antarctic Ice Antarctic Ice Sheet,[149] 75 meters below the Pacific Ocean floor,[150] around hot water vents

145 *Id*., at 2 (emphasis supplied).
146 *Id.,* at Appendix A-1-A-8.
147 Dr. Chris McKay, What Is Life? It's a Tricky, Often Confusing Question, at 3 Astrobiology Magazine, (Sept. 18, 2014) available at www.astrobio.net/news-exclusive/life-tricky-often-confusing-question/ (last visited on Sept. 23, 2015) ["In fact, in the search for life in our solar system what is needed more than a definition of *life* is a definition of *death*."]. Dr. McKay is a planetary scientist with NASA.
148 *Id*., at 4-5.
149 Michael D. Lemonick, Microbes Discovered in Subglacial Antarctic Lake May Hint at Life in Space, National Geographic (August 20, 2014) available at http://news.nationalgeographic.com/news/2014/08/140820-antarctic-microbe-lake-astrobiology-science (last visited on Sept. 23, 2015).

on the ocean floor,[151] in oil reservoirs in the North Sea,[152] in NASA and ESA spacecraft clean rooms after repeated sterilization procedures,[153] inside the ISS with micro gravity,[154] on the outside of the orbiting ISS for 1.5 years as part of an experiment,[155] and outside the ISS when not a part of an experiment.[156]
Life as we have historically understood it is carbon based and needs water and oxygen to survive. This historical view, however, is evolving. Terrestrial microorganisms have been found which "survive on sulfur rather than oxygen, by reducing sulfur to hydrogen sulfide."[157] Microbes have also been discovered which use arsenic instead of phosphorus as one of the six essential components traditionally recognized as necessary for carbon based life.[158] Also, science has determined that there are alternative liquids and solvents which can provide the biochemistry and building blocks for life in lieu of water.[159] For instance, there is scientific evidence that suggests a microorganism can exist that does not need or use DNA or RNA.[160] Also, it is recognized that "it is not beyond the realm of feasibility that our first encounter with extraterrestrial life will not be solely carbon-based fete."[161] The changing perspective of what is life has resulted in a NASA sponsored report recommending that the search for life in the universe should be "widened" to encompass

150 National Science Foundation Press Release 15-019: No limit to life in deep sediment of ocean's "deadest" region (March 16, 2015) available at www.nsf.gov/news/news_summ.jsp?cntn_id=134420 (Last visited on Sept. 23, 2015).

151 Staff, Oil-Dwelling Bacteria Are Social Creatures in Earth's Deep Biosphere, Astrobiology Magazine (Dec. 16, 2014) available at www.astrobio.net/topic/origins/extreme-life/oil-dwelling-bacteria-social-creatures-earths-deep-biosphere/.

152 *Id.*

153 Clara Moskowitz, *supra* note 70, at 1-3.

154 See *supra* at 4.

155 Aaron L. Gronstal, Lichen In Orbit, Astrobiology Magazine (Oct. 22, 2014) available at www.astrobio.net/topic/origins/extreme-life/lichen-orbit/ (last visited on Sept. 23, 2015).

156 Miriam Kramer, Sea Plankton on Space Station? Russian Official Claims It's So, space.com (Aug. 20, 2014) available at www.space.com/26888-sea-plankton-space-station-russian-claim.html (last visited on Sept. 22, 2015).

157 Hawking, *supra* note 8, at 3.

158 Staff, *NASA announcement: Arsenic-based life form discovered on Earth*, www.washingtonpost.com/wp-dyn/content/article/2010/12/02/AR2010120204183.html (last visited on Sept. 30, 2015).

159 See *Id.*, at 3 & 5. Such liquids and solvents consist of Additionally, solvents like ammonia, methane, and formamide hydrogen fluoride menthanol, hydrogen sulfide, and hydrogen chloride. *Id.*

160 Staff, "Extraterrestrial Life May Not be Based on DNA or RNA" – New Research, The Galaxy (April 28, 2012) available at www.dailygalaxy.com/my_weblog/2012/04/extraterrestrial-life-may-not-be-based-on-dna-or-rna-new-research-todays-most-popular.html last visited on Sept. 23, 2015).

161 Hawking, *supra* note 8, at 3.

the "possibility of 'weird' life,"[162] or life that is different from life as we traditionally know it.

The diversity of life, as we know it and as we may speculate, is leading to the development of instruments to search for biomarkers for known life and unknown nonterrestrial life.[163] A biomarker is essentially a natural product that can be traced to a particular biological origin.[164] To establish effective biomarkers, however, there has to be a working definition life.

Although COSPAR does not define life for planetary protection purposes, it does reference one biomarker of life which is the ability to replicate. Specifically, in relation to the post mission of a "restricted Earth return" Category V mission, COSPAR provides that if upon an analysis of an unsterilized sample "any sign of the existence of *a nonterrestrial replicating entity* is found, the returned sample must remain contained unless treated in by an effective sterilization procedure.[165] This suggests that for COSPAR planetary protection purposes, for an NTM to be subject to either containment or sterilization purposes, it should, at a minimum, be able to replicate. By contrast, if an NTM is like a virus, a mule, or the nonterrestrial life form in *Aliens*, and cannot independently replicate or if its replication ability has been "neutered" or otherwise genetically modified to prevent replication, then it apparently may be deemed sterilized for current planetary protection purposes and exempt from containment under COSPAR standards. Unfortunately, the inability to replicate, does not necessarily translate to being harmless to terrestrial life or the terrestrial environment.

V. Conclusion

Most "[p]eople have trouble understanding that we're embedded in an invisible microbial world,"[166] and that microbial life, like all known life, "is adaptable and resilient, and once it takes hold, it is embued with a *tenacious will to continue to exist*" in the environment in which it is located.[167] Thus, it should not be difficult to acknowledge that if NTMs exist, then they, like a terrestrial microbe, the nonterrestrial antagonist in *Aliens* and like humans, will do whatever is necessary to survive given the circumstance or environment in which it finds itself. This circumstance suggests that leaving backward contamination

162 *Id* at 5.
163 McKay, *supra* note 147 at 5.
164 The Lab Summons, What is a Biomarker?, Massachusetts Institute of Technology available at http://summons.mit.edu/biomarkers/what-is-a-biomarker/.
165 COSPAR Planetary Protection Policy, *supra* note 115, at 2.
166 Jon Cohen, *The International Space Station is home to potentially dangerous bacteria* at 4, AAAS.org, http://news.sciencemag.org/biology/2015/10/international-space-station-home-potentially-dangerous-bacteria (last visited Dec. 1, 2015).
167 Sterns and Tennen, *supra* note 74, at 144.

measures to a discretionary State level decision is essentially a porous and inefficient safety net for planetary protection purposes.

"One of the luxuries afforded to space law is that it allows for law to guide events, as contrasted to the situation on Earth where law often lags behind."[168] The law governing backward contamination should take advantage of this luxury as failure to do so may have detrimental consequences. If the law lags behind events concerning backward contamination measures, then events may render any subsequent backward protection measures inadequate or superfluous.

Prudently exercising the luxury afforded in connection with NTMs and backward contamination should involve the balancing, on the international level, of science, technology, economic opportunities, politics and moral considerations.[169] The focus of such a balancing regime should be formulating appropriate international compliant measures to ensure that Earth's biosphere does not become a host for a NTM which is or transforms into a pathogen.

168 Michael Allen Potter, Human Rights in the Space Age: An International and Legal Political Analysis, 4 Journal of Law and Technology 59, 63 (1989) (emphasis supplied).

169 S.G. Sreejith, *Whither International Law, Thither Space Law: A Discipline In Transition*, 38 California Western International Law Journal 331, 358-362 (Spring 2008).