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The Axiological Dimension of Planetary Protection

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Abstract

Planetary protection is not just a matter of science. It is also a matter of value. This is so independently of whether we only include the protection of science or if we also include other goals. Excluding other values than the protection of science is thus a value statement, not a scientific statement and it does not make planetary protection value neutral. It just makes the axiological basis (that is, the value basis) for planetary protection more limited in a way that is inconsistent with the axiological grounds for back contamination, ethically questionable and strategically unwise. However we look at it, we cannot get away from the conclusion that the axiological dimension of planetary protection is a task that needs to involve experts on value theory as well as experts from a range of different sciences and also include opinions from outside the academic community.

***Keywords*:** Planetary protection, Outer Space Treaty, environmental space ethics, epistemic values, axiology

14.1 Introduction

Rules, standards and practical decisions about planetary protection need to be based in good, solid science. Reliable information about the survivability of Earth life on the target bodies and in interplanetary space is obviously very important. So is knowledge about trajectory biasing and decontamination of spacecraft and payloads as well as a good account of the remaining bioload after decontamination. I will call this the "epistemic" (that is, knowledge)

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dimension of planetary protection. As is the case when I write this chapter, the epistemic basis for planetary protection is far from complete. There is still a large amount of uncertainty and science constantly makes new discoveries of microbes surviving in extreme environments, including in circumstances similar to those in clean room facilities, interplanetary space and on Mars. These things aside, even with a much better epistemic basis, in fact, even if we (per impossibility) had complete knowledge about all the things listed above, that would not be enough to make rational decisions about planetary protection. That a decision is rational, typically means, or at least implies, purposefulness. That is, in order to make rational decisions about planetary protection, we need to know its purpose. What is the purpose of planetary protection? What is it that we want to protect and why? If we do not know what it is we want to protect, why we want to protect it, for how long, to what extent and its importance in relation to other values, rational decisions are impossible, no matter how much and how good the knowledge we have.

We therefore need answers to both the epistemic questions and the value, or "axiological" questions. The axiological questions about planetary protection also need to be considered in a wider perspective: What other values are at stake and how does planetary protection relate to them? These questions in turn lead to yet other questions: Why should we spend resources on planetary protection, and what amount of resources are justified? The axiological dimension of planetary protection is thus no less complex than the epistemic dimension. It is also central to all decisions regarding planetary protection and needs to be considered thoroughly, carefully and transparently.

In this chapter, I am going to explore the axiological dimension of planetary protection. I will try to identify the stated and unstated axiological basis for planetary protection the way it looks today and I will try to put it in a historical context. In addition, I will say a little bit about what I see as the future of the axiological dimension of planetary protection.

In his chapter, I am going to stick to planetary protection in our own solar system. If and when we start sending spacecraft aimed at particular bodies beyond our solar system, we will not just face unprecedented levels of uncertainty but also a different set of axiological questions. This situation, though interesting in its own right, will not be covered in this chapter.

14.2 The Relation Between the Epistemic and the Axiological Dimensions of Planetary Protection

Planetary protection is about avoiding contamination of other worlds with invasive Earth microbes in connection with missions to these worlds, and

about avoiding contamination of the Earth biota by invasive microbes form other worlds in connection with sample return missions. Complete sterilization of spacecraft and other equipment is not possible with present technology, however, and it might never be. We also do not yet know everything we need to know about our target bodies to be able to say exactly what it would take for Earth microbes to survive there [14.13] [14.57]. In addition, we keep discovering Earth microorganisms that are hardier than expected. Smith *et al.* [14.57] found for instance that several microorganisms found on the Mars Science Laboratory were resistant to multiple physiological stress factors, that many were resistant to desiccation and UVC, and that a small number also could make use of chemical energy sources available on Mars (perchlorate and sulphate). Nicholson *et al.* [14.33] conclude from their study that the regolith at the Phoenix landing site "would likely prove rather benign to potential terrestrial spacecraft contaminants such as spores of *Bacillus* spp., and indeed may even support their germination and growth."

These are only a couple of examples to illustrate the practical problems involved. We also have to consider the hardware that we want to "survive" the decontamination treatment. Some microbes seem to withstand a much harsher treatment than most of the hardware. Finally, we always have to take evolution into consideration. The fact is that cleanroom facilities exert a strong evolutionary pressure in favor of microbes that can survive the decontamination procedures we submit them to.

In other words, a probability of zero is clearly not compatible with visiting the targets in question at all. So, why not instead just aim for a level of probability for contamination that is as low as possible? The go to source of information for non-experts in any area, that is, Wikipedia, actually states that this is the aim of planetary protection. They acknowledge the impossibility of reaching a zero probability of contamination but instead they suggest that: "The aim of planetary protection is to make this probability (for contamination of the target body) as low as possible" [14.60].

If we accept this aim, we immediately have to ask, "as low as possible, given what circumstances?" What is possible depends on the context, including a whole range of value decisions. What is possible if you have unlimited funding, might be completely impossible if you have a tight budget. In the real world we do not have unlimited access to money, time or any other resource, and every resource we spend on realizing one value, often means less resources for realizing other values.

Given the present standards for planetary protection and overall mission costs, planetary protection stands for a few percent of the mission costs [14.18]. Though this does not seem unreasonable, there are those who think even this is too much [14.19] [14.52] [14.61]. There are also

many other worthwhile things to use our limited resources on and the competition for money, talent and other resources is harsh. It is therefore necessary to make trade-offs with other values. In addition to monetary costs, planetary protection also complicates experiments [14.29]. It is, in other words, necessary to make trade-offs with other values, both internal and external. If planetary protection, on the other hand, can satisfy more than one value, the costs will be much easier to motivate.

Either way, saying that planetary protection should aim to keep the risk of contamination as low as possible is not particularly helpful. What we need to do instead is to determine the maximum acceptable probability of contamination, given the instrumental value of planetary protection for the goal(s) it aims to facilitate, and the end value of those goals in relation to other end values that they compete with.

We can thus conclude that in addition to a strong epistemic basis, planetary protection also needs a strong axiological basis. Without the latter, it is in fact not even possible to set out criteria for what constitutes a strong epistemic basis, since without an axiological basis we do not even know what facts we need to consider to build a strong epistemic basis for planetary protection. Let us therefore see what some more official sources have to say about the axiological basis for planetary protection.

14.3 The Axiological Dimension of Planetary Protection Today

The organization that is put in charge of deciding the global standard for planetary protection is the Committee for Space Research (COSPAR) under the International Science Council (ISC). In the 2002 version of COSPAR's Planetary Protection Policy, the organization formulates the basis for its work as follows:

"Although the existence of life elsewhere in the Solar System may be unlikely, the conduct of scientific investigations of possible extraterrestrial life forms, precursors and remnants must not be jeopardized. Moreover, the Earth must be protected from the potential hazard posed by extraterrestrial matter carried by a spacecraft returning from another planet. Therefore, for certain space mission/target planet combinations, controls on contamination shall be imposed, in accordance with issuances implementing this policy" [14.15].

What does this mean? Let us leave the formulation about the Earth environment for the moment (we will come back to that later) and focus on the so-called forward contamination, that is, contamination of other worlds by

Earth microbes. COSPAR states that "the conduct of scientific investigations…must not be jeopardized." This indicates that the main goal of planetary protection has to do with protecting the science, while protecting extraterrestrial life is important only as a means to that goal. This interpretation finds additional support in the latest published version of COSPAR's planetary protection policy, according to which: "The conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants must not be jeopardized" [14.28]. In philosophical terms, this means that extraterrestrial life from the perspective of planetary protection, has "instrumental epistemic value."

A closer look at COSPAR's planetary protection policy also tells us that the protection of a target body from contamination is assumed to be temporary. It states, for instance, that "the probability that a planetary body will be contaminated during the period of exploration should be no more than $1*10^{-3}$" [14.28]. The instrumental epistemic value of life on a planetary body will only last for the expected time it will take to find and sufficiently understand it. After that, any need for protection vanishes. This can only be interpreted as meaning extraterrestrial life has no value beyond its value as a study object, that is, beyond its instrumental epistemic value.

We can thus summarize COSPAR's position regarding the axiological basis for planetary protection as follows:

1. Knowledge of whether life exists or has existed in other worlds has a very high end value.
2. A thorough understanding of this life, if it exists, has a very high end value. (It cannot be conclusively determined from the guidelines alone whether the value in (1) and (2) is end value or instrumental value but since no attempt is made to motivate it by referring to its use, it may be assumed that it is a matter of end value.)
3. Extraterrestrial life on target bodies have instrumental value as sources of (1) and (2).
4. Extraterrestrial life does not have any other value than that stated in (3) or if it does it is negligible in relation to all other values that can be promoted by the same resources.
5. The Earth biota has a very high value that cannot be compromised.

Someone might be tempted to object that the present axiological basis for planetary protection does not explicitly deny that extraterrestrial life has value beyond its instrumental epistemic value, but this objection does

not work. Ignoring a value, explicitly or implicitly, is in fact the same as saying that it is non-existent or at least negligible. A description can afford to be silent about certain matters but a decision that clearly affects a certain phenomenon has to be either-or. Either we take measures to protect extraterrestrial life beyond the projected study time or not. If we decide not to, we have de facto denied that it has (other than negligible) value beyond their value as study objects, whether we do it explicitly or just implicitly.

Can the above list of values be taken to be the consensus view regarding the axiological basis for planetary protection? It seems so. Most scientists and all space agencies seem to accept and adhere to COSPAR's planetary protection guidelines (also noted by [14.16]). This also seems to be true regarding the axiological basis for those guidelines. Most research papers on planetary protection only mention the protection of science as motivation for planetary protection [14.34] [14.43], and the same seems to be true of space agencies and other influential organizations in this area. In 1992, the Space Studies Board of the U.S. National Academy of Sciences (NSA) recommended, for instance, that only Mars landers with life detection instruments have to be sterilized to the same level as the Viking landers. Other Mars landers may have a lower degree of sterilization, which do not include heat sterilization. These recommendations have been followed by all NASA missions to Mars since then [14.59], which indicates that NSA and NASA also accept that Mars life has instrumental value in relation to life detection and no or very low value beyond that.

14.4 The Nature of Epistemic Values

It is probably easy to confuse a decision to only consider epistemic value (values related to knowledge) with a decision to only consider epistemic aspects (knowledge). This is also in my experience a very common mistake. The truth is, however, that even if the two look alike, they are not. To only consider epistemic aspects is in fact not even an option, since any decision (contrary to a mere description) is per necessity a value statement. It is a statement that certain things should be pursued, protected, etcetera, while others should not. A decision that is only based on what is of use to the promotion of knowledge is a decision that only knowledge or the promotion of knowledge has value in itself. It is not a statement of a scientific fact. To put it in more technical terms, that something is epistemic means it has to do with knowledge. That a statement is branded as knowledge implies that it is supposedly true, that is, that it tells us something of how the world actually is. It is therefore easy to be trapped into thinking that epistemic values must be objectively true, so that if something has epistemic value it is objectively

true that it is valuable and if it does not have epistemic value, it is objectively true that it does not have value, or at least that if it has value, it is of no concern for science. The value of knowledge is, however, no different from any other value in this regard. I am, as a knowledge seeker, not saying this in order to diminish the value of knowledge, far from it. I am saying this to clear up a possible source of confusion about the axiological basis for planetary protection and to make this basis more transparent in accordance with the spirit of philosophy and science. Epistemic value is a value among other values and it is not possible to refer to or assume a set of epistemic values while also claiming that one does not concern oneself with values.

So far, we have established that there is a rather strong consensus in the scientific community that the axiological basis for planetary protection is to protect science, or more specifically, the axiological basis for planetary protection is the search for and eventual understanding of extraterrestrial life, through protection of the instrumental epistemic value of extraterrestrial life. The next thing we need to do is to try to understand its background and its implications. Why does the axiological dimension of planetary protection look the way it does and where does it come from? Is it based in international law or is it an internal construction within the research community? Is it binding or is it possible to be more or less strict, and is there room for adding values just as the epistemic basis is sometimes upgraded with increased knowledge?

14.5 The Outer Space Treaty and the Axiological Dimension of Planetary Protection

According to COSPAR's planetary protection policy, their guidelines are based on the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (also known as the Outer Space Treaty, or for short, OST) [14.28]. Also, other reports as well as academic papers about planetary protection almost unequivocally describe COSPAR's work as following directly from OST [14.12] [14.21] [14.42] [14.43]. Cockell and Horneck [14.10] even go so far as claiming that COSPAR's planetary protection policy "is merely based on a scientific interpretation of the Outer Space Treaty."

The article in the Outer Space Treaty that deals with planetary protection and that is commonly stated as making up the legal basis for COSPAR's planetary protection policy is Article IX. The relevant part reads:

> "In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by

> the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. 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…" [14.58].

An obvious problem when trying to interpret what this means for our question is that OST, including Article IX, is notoriously vague. Some have interpreted the fuzziness as evidence that one cannot really draw any conclusions about the axiological basis for planetary protection from OST. The U.S. National Academy of Sciences, in fact, claims that "Article IX of the Outer Space Treaty, however, is ambiguous with respect to whether its focus is on protecting celestial bodies themselves or the scientific interests of those countries exploring them" [14.32].

This is not an assessment that is shared by everyone, however. Cypser [14.17] claims that "While these policies [COSPAR's planetary protection policies] have been criticized by some as inadequate, they are consistent with current terrestrial international space law which recognizes no absolute protection for alien life-forms or alien environments."

That COSPAR's policies are consistent with OST as well as international space law in general does not seem surprising considering the vagueness of the latter, but more interesting are the questions whether COSPAR's policy originates from OST and international space law or if the axiological basis, completely or partly, comes from somewhere else and, if so, how much freedom does OST leave COSPAR to formulate its policy including its axiological dimension.

Cypser [14.17] argues that the focus of OST (and of international space law in general) is to respect the interests of the states that are party to the treaty. This interpretation is supported by the following quote from Article IX: "Parties to the Treaty shall…conduct all their activities in outer space,… with due regard to the corresponding interests of all other States Parties to the Treaty" [14.58]. It is also supported by the frequent mentioning of the importance of respecting the interests of other states also in other parts of OST, as well as in international law in general [14.17] [14.58].

Where does this leave us regarding the axiological basis for planetary protection? Cypser [14.17] takes her reasoning a couple of steps further. The only interest of the states parties to the treaty that she mentions, is

to protect their ongoing space programs, and this also seems to be the only interest that according to her is relevant for planetary protection. Why does she draw this conclusion? An obvious answer could be: "What other national interests could there be?" This answer is not completely satisfying, however. Why can the states that signed and ratified the treaty only be interested in their ongoing space programs? For starters, the term "ongoing" seems a bit inappropriate in relation to planetary protection that to a large extent is about protecting future missions against unwanted effects of present missions. I also cannot find any clear evidence in OST or anywhere else for why the frequent urges to respect the interests of other states would exclusively refer to the interest in space programs. One thing to consider here is that the OST is signed and ratified by several nations without an active space program. Why would they sign and ratify the treaty if it is only about protecting ongoing space programs? It may be because they hope to start space programs later, but I do not find anything that excludes the possibility that they could have other interests in space; for instance, that the people of these countries find other values worth protecting in space.

Cypser in fact takes her reasoning one more step. She states: "The history of international planetary protection standards and the policies and practices of the space-faring nations make it clear that the stipulation to 'avoid harmful contamination' contained in the Outer Space Treaty was intended to protect the integrity of future scientific experiments and not to guarantee the preservation of alien environments" [14.17].

It is true that scientific experiments are an important motivation for space missions, but it is far from the only one. In the beginning of the space race, political and military motives played a very important role (though military use of other planets is ruled out in the treaty). For instance, in the future, the motivations for space missions will probably include more business ventures.

Contrary to this, one might say that biocontamination is only a threat to missions aimed at finding and understanding extraterrestrial life, which means it still makes sense to claim that planetary protection only aims at protecting scientific experiments. This is not necessarily true, however. There may, for instance, be commercial interests that are affected by planetary protection in both positive and negative directions. Positive because extraterrestrial life may have commercial value [14.9] [14.39], negative because planetary protection may impose limitations that get in the way of commercial exploitation. It also seems entirely plausible that to many people extraterrestrial life could have value in its own right, independently of its instrumental value for science or business [14.39].

There is also another important point that needs to be made here. The OST, just like any other international treaty, can be seen as a contract between the parties of the treaty regulating the parties' behavior towards each other. In that sense, it is obvious that respect for the interests of the other parties is key to understanding the treaty. However, this also means that it has to be acknowledged that OST does not cover all interests that may be relevant to consider and can thus not be taken as the only thing determining the actual guidelines. In particular, there is no contract or treaty that can put itself above ethics, especially ethical considerations regarding the parties' relation to non-signatories, and especially in relation to entities that cannot be signatories, including for obvious reasons, extra-terrestrial organisms. In other words, even though it is probably correct that the axiological basis for COSPAR's guidelines is consistent with OST, there is nothing, and there can be nothing in this or any other treaty that excludes an inclusion of other values in the axiological basis for planetary protection, especially not values that are morally required. Ignoring the ethical aspects of any issue is just not an option, no matter what it is about, why one is doing it, what kind of instructions one got, or what the law happens to say about it.

Before we go on to investigate the ethical aspects, however, let me point out another problem with the assumption that the axiological basis for planetary protection used by COSPAR is directly provided by OST, namely that COSPAR existed and had already issued recommendations before the formulation of OST. In fact, these recommendations did not even change substantially after the establishment of OST. What sense can we make of these curious facts?

14.6 The Axiological Dimension of Planetary Protection – Historical Background

A look at some of the earliest documents, including for instance, early documents from COSPAR and the NAS, as well as articles in space science journals, might help us understand how the axiological basis for planetary protection has developed.

The scientific community started to be concerned about potential contamination of other worlds in the mid-fifties. The International Astronautical Federation started looking into the question in 1956 [14.17] [14.30], and the NAS started their investigations in 1957 [14.17]. It is thus safe to say that concerns about contamination was present in the history of space flight from the start.

Based on these early initiatives, it also seems clear that concern about future search for life in the solar system was the driving motive. An early official statement about planetary protection that includes a motivation came in 1958 when the NAS urged scientists to "… plan lunar and planetary studies with great care and deep concern so that initial operations do not compromise and make impossible forever after critical scientific experiments" [14.31]. The initiative behind NAS's engagement in contamination issues came from the scientific community through a letter from Joshua Lederberg sent to NAS in 1957 [14.32]. Lederberg was very active in advocating for planetary protection, for instance, through the West Coast Committee on Extraterrestrial Life (WESTEX), which in addition to Lederberg counted several other very famous scientists among its members, including Nobel Laureate Melvin Calvin and Carl Sagan, whose influence on planetary protection we will say more about shortly [14.30].

On NAS's initiative, the International Council of Scientific Unions (ICSU) set up an ad hoc committee called the Committee on Contamination by Extraterrestrial Exploration (CETEX) specifically tasked with the construction of guidelines for avoiding contamination [14.17] [14.30] [14.32]. CETEX reported their work in a paper in *Nature* the coming year where they also stated: "The need for sterilization is only temporary. Mars and possibly Venus need to remain uncontaminated only until study by manned ships becomes possible" [14.8]. It was also CETEX that recommended that the responsibility for formulating future planetary protection policies should fall on COSPAR [14.32].

COSPAR's first resolution [14.14] [14.17] followed the same lines as the NAS statement but with a slight but significant change of the time constraint. NAS wanted to keep Mars uncontaminated until manned missions become possible. COSPAR wanted to keep the planet uncontaminated "until such time as this search can have been satisfactorily carried out."

In 1963, the United Nations General Assembly unanimously accepted a suggestion from the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) founded four years earlier, for a Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space [14.17]. This declaration was later to become the basis for the OST. COPUOS did not manage to reach an agreement regarding the part of the suggested declaration most relevant for planetary protection, the regulation of harmful experiments in space, and it was never included in the declaration. Instead, COPUOS acknowledged and came "close to outright endorsement of COSPAR's standards" [14.17]. The UN General Assembly, however, only took note of COSPAR's work but it was

not mentioned in the declaration or in the OST, and the COSPAR guidelines are therefore still not legally binding in a formal sense [14.17].

The most elaborate early suggestion in the academic literature for an axiological basis for planetary protection, here in the case of Mars, as well as the most detailed suggestion for how to operationalize these values, was presented in an article by Carl Sagan and Sidney Coleman in *Astronautics and Aeronautics* in 1965. In this paper, the authors provide some concrete numbers as well as the calculations and the epistemic as well as the axiological assumptions behind the calculations [14.51]. They are also clear that "[t]he type and duration of sterilization procedure must depend on some estimate of what constitutes an acceptable risk of planetary contamination." They suggest "a probability very close to unity that N biological experiments be successfully completed on Mars before biological contamination occurs… [where N stands for] the desired number of experiments for a thorough survey of Martian biology." They explain that N needs to be very high but do not wish to take a definite stand on the exact number. In their own calculations they set N to 1000 and aim for a probability of 99.9% that 1000 experiments can be performed before contamination [14.51].

As Greenberg points out, the calculations of Sagan and Coleman are based on "pre-space-age" knowledge [14.25]. This is of course unavoidable, and Sagan and Coleman are aware of this weakness. They therefore emphasize the need to continuously update the numbers [14.51]. In that way, their paper is a good role model. They do not suggest any opening for a continuous update of the axiological basis, however.

Regarding the axiological basis for their calculations, there is not much room for doubt from Sagan and Coleman's formulations that the only value they acknowledge for the Martian environment and possible Martian life, is as study objects. They do not mention any other value but they do set a time limit for protection that is only based on the value these environments and possible life have as study objects [14.51].

Overall, it seems safe to conclude that the four axiological principles that guide planetary protection today have been the same from the start, long before the Outer Space Treaty. It also seems clear that these values came directly from the science community. This is also the conclusion of Cypser [14.17] [14.22].

This seems like a good explanation for how the present axiological basis for planetary protection has come about, though it does not fully explain or justify why these concerns still make up the entire axiological basis for planetary protection, and it does, of course, not show that this will always

be the case, in particular since the composition of the players on the space arena is quickly widening. More about this point later.

What does it mean that the practical guidelines as well as the axiological basis for planetary protection clearly predates OST and that none of these are included in the OST or the declaration behind the OST? In international law, "practice makes principle." That is, if a practice is followed by a sufficient number of sufficiently influential players, it eventually gets the status of a binding legal principle. This means that as long as the most influential players in the form of space agencies and space researchers in space-faring nations accept that following COSPAR's planetary protection policy is what it takes to live up to Article IX in OST, then COSPAR's guidelines have a fairly strong de facto legal status.

Does this mean that COSPAR can widen the axiological basis for planetary protection and following that amend their guidelines to accommodate for the new values (as would have to be the case if, for example, the time limit has to go)? This is a tricky question. A potentially important fact is that something of the kind has actually happened. In 1982, the COSPAR guidelines were quite substantially recast. The most salient change was the establishment of five categories or mission type/target body combinations and the connection of measures to these categories. This included a special category for sample return missions, including guidelines for how to avoid contamination of Earth by extraterrestrial biological material, something that had previously only been handled ad hoc by NASA in connection with the moon landings [14.22]. This means that a non-epistemic value was in fact added to the axiological basis for planetary protection, namely.

This is a value that was clearly stated in OST, Article IX, which means this update can justifiably be considered as merely an adaption to the OST. On the other hand, it also shows that non-epistemic values are not banned in principle from being part of the axiological basis for planetary protection. It also means that Cypser's conclusion [14.17] that only scientific experiments connected with ongoing space missions can be covered by the principle of respect for the other parties of the OST, has to be wrong.

14.7 Ethics and Planetary Protection

I have in other publications discussed different approaches to the question of moral status for extraterrestrial life. I am not going to repeat that discussion here but just summarize the main conclusions in very few words

and refer the interested reader to these earlier discussions [14.35] [14.36] [14.37] [14.38] [14.39].

There are different theories regarding who or what has moral standing on Earth and why. The historically most influential theory, anthropocentrism, claims that only humans can have moral standing [14.7] [14.56]. This theory is losing ground the more we learn about other life forms.

An alternative theory called sentientism states that all and only sentient beings can have moral standing [14.1] [14.24] [14.40] [14.41] [14.54] [14.55]. This theory is based on the idea that ethics is really about considering the interests of others. Therefore, if someone has interests, they automatically qualify as moral objects. If they do not have interests, they automatically disqualify.

The theory about moral standing that initially seems most promising for granting moral status to any extraterrestrial life we might find in our own solar system would be biocentrism, a theory that grants moral standing to all life [14.23] [14.53]. This theory is considerably more controversial, however. Also, and maybe initially unexpectedly, even though it is the only theory that grants moral standing to all extraterrestrial life, it may actually call for a weakening of planetary protection. The reason is that bioload reduction in the form of decontamination kills large numbers of Earth microbes. Biocentrism may, therefore, all things considered, not favor mass extermination of actual Earth microbes to protect merely possible extraterrestrial microbes.

This latter problem would be avoided if we instead accept the ecocentric theory of moral standing. This theory focuses primarily on species instead of individuals [14.3] [14.4] [14.5] [14.6] [14.26] [14.27] [14.44] [14.45] [14.46] [14.47] [14.48]. Killing large numbers of individuals from common species is not a problem according to this theory. On the other hand, it is even more controversial than biocentrism. It is generally considered highly implausible that species can have interests in a morally relevant sense. It also has other peculiarities. According to one version of this theory, extraterrestrial species do not count morally since they do not belong to the same biota as Earth life [14.5].

Sentientism is clearly the most plausible of these theories. The probability that we will find sentient life in our solar system outside Earth is considered extremely low, however. It therefore seems implausible that we would have any moral duties to any extraterrestrial life in our solar system. This does, however, not mean that there are no ethical considerations to be made. Greenberg expresses concern over how present standards of planetary protection affect future generations of astrobiologists. If we follow COSPAR and others and decide that planetary protection will only be

necessary for a limited period of time, we will rob future generations of astrobiologists of their chance to continue the exploration of extraterrestrial life [14.25].

Greenberg clearly has a point here. Considering that we have studied the biology of our own planet for countless generations and we are not close to being finished understanding Earth biology, we can probably be sure that it will take a long time to understand the biology of the solar system (if there is any biology off Earth) to a degree that would make the science community say, "yes we are finished, no more to see here." In fact, a seemingly inherent property of scientific research is that the more questions we answer, the more questions turn up.

Concern for future astrobiologists is not the only moral concern, however. We also need to consider the interests of the people of planet Earth outside the relatively small community of astrobiologists. If the future existence of extraterrestrial life after it has been discovered and studied has a sufficiently high positive value to a sufficiently high number of people outside the astrobiology community, it seems there is a moral prerogative to take this into account. That the interests of people outside the scientific community have to be taken into consideration is in fact pointed out, for example, by NAS and the National Research Council's Committee on Planetary and Lunar Exploration [14.11] [14.32]. There are also initiatives by NASA, for example, to include the wider society in dialogues about planetary protection [14.2] [14.49] [14.50]. I am not aware, however, of any large-scale attempts to really find out whether there is a sufficiently large interest among a sufficiently large number of people on planet Earth to make it morally required to include this in the axiological basis for planetary protection. Such surveys are, of course, difficult to perform since value questions are tricky to assess, but it may be worth the effort to get the ethics right. For any attempt to include the values of the wider population, it is also essential to make it clear that it is not just for show, but that additional values actually can be added to the axiological basis for planetary protection.

14.8 Competing Values – Planetary Protection and the Commercial Use of Space

In addition to the ethical implications, there is also a more pragmatic reason why astrobiologists should consider widening the axiological basis for planetary protection. Astrobiology is part of a bigger world where news regarding extraterrestrial life is met with great interest by the general

public, where funding is ultimately dependent on political decisions, and not least where the "old" space-faring nations and space agencies are being followed by new space-faring nations as well as by private initiatives.

The emergence of private initiatives in space with the explicit aim of landing on and performing operations in other worlds is particularly relevant for three reasons. 1) The total number of spacecraft aimed at bodies of interest to astrobiology will increase. 2) The competitive pressure will incentivize private actors to look at all possible ways of saving money. The necessity of strict non-contamination rules might be questioned as a result. 3) The main aim of the private actors is not to do science. Protecting the science might therefore not be a strong motivational factor for them to maintain high standards of planetary protection. This also has political implications. Both the USA and Luxembourg have recently passed laws with the explicit purpose of encouraging private space initiatives. If the only reason for planetary protection that is accepted in the scientific community is strictly internal to astrobiology, it will be very difficult for the scientific community to maintain the importance of planetary protection against the lobbying from the commercial sector. In connection with a hearing held by the space subcommittee of the US Senate Commerce Committee, US Senator Ted Cruz stated: "As we look to the future of American free enterprise and settlement in space, we should also thoroughly review the United Nations' Outer Space Treaty, which was written and enacted in a very different time and era in 1967.… It's important that Congress evaluate how that treaty, enacted 50 years ago, will impact new and innovative activity within space" [14.20].

In this situation, the great interest in questions about extraterrestrial life among the general public can be a great ally in the quest to keep extraterrestrial environments unspoiled, but in order to mobilize that support, it will be necessary to also include other values of relevance to the general public. In fact, a mobilization of the general public may be the only way for the scientific community to achieve the strengthened legal status necessary to withstand the push from the commercial sector to weaken planetary protection, and an active inclusion of other values more readily embraced by the general public may be the only way of achieving this.

14.9 Conclusions

Planetary protection needs a solid epistemic basis as well as a solid axiological basis. The almost universally accepted rules for planetary protection are formulated by COSPAR. The axiological basis for planetary protection assumes that the knowledge of whether there is life outside Earth and

understanding of that life has a very high end value, while the life as such has merely instrumental value in relation to the former. The Earth biota, on the other hand, seems to be assigned a very high end value.

COSPAR's guidelines have no formal legal status but have a fairly strong de facto legal status due to their general acceptance among space-faring nations. The axiological basis originates from the science community but is closely associated with the OST, the purpose of which is to protect the interests of the participating states. To be ethically sound, however, any planetary protection policy needs to include a wider set of relevant interests. This includes the interests of future scientists, other sectors of society and the general public. It seems implausible, however, that extraterrestrial organisms in our solar system are advanced enough to have interests of their own. There are strong reasons to believe that the business sector has an interest in weakening the guidelines for planetary protection but it is also plausible that the large interest in extraterrestrial life among the general public may be able to outweigh these interests.

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