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A Values Framework for Evaluating Alienation in Off-Earth Food Systems

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Abstract: Given the technological constraints of long-duration space travel and planetary settlement, off-Earth humans will likely need to employ food systems very different from their terrestrial counterparts, and newly emerging food technologies are being developed that will shape novel food systems in these off-Earth contexts. Projected off-Earth food systems may therefore potentially "alienate" their users in new ways compared to Earth-based food systems. They will be susceptible to alienation in ways that are similar to such potential on Earth, where there are points of overlap between off-Earth food systems and any of the multitudes of ways in which food systems on Earth are structured. They will also be susceptible to new forms of alienation, as we encounter scenarios that are genuinely structurally novel to humanity. These are especially important to consider since there are comparatively fewer analyses of these food systems where they differ from existing ones. We propose five non-exhaustive sources of value beyond nutrition our individual relationships with a food may possess: gustatory, social, cultural, epistemic, and authorial value. Using these, we offer examples of ways in which an off-Earth food system may exacerbate or alleviate alienation for humans in long-term off-Earth food systems.

Keywords: alienation; space-based food systems; epistemic; authorial; gustatory; social/cultural value

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Introduction

The systems we employ to produce, distribute, and consume food are more than just ways to deliver calories to human bodies; rather, our direct interactions with food systems and the social and cultural activities these systems facilitate are an important source of meaning-making and identity-shaping in the lives of many. When the psychological, social, and spatial aspects of food are distanced, there is potential for alienation, that is, separation between subjects and a potential source of value. Princen (2002) has defined distancing as the separation of primary resource extraction from final consumption decisions, which he argues results in mental distancing as we become more spatially distanced. As it pertains to distancing, the possibility of alienation is especially pronounced in projected off-Earth food systems. Off-Earth food systems are those without direct contact with systems on Earth: for example, long-duration space missions or human settlements on other planets, or even the moon. The mobilization of the vision toward off-Earth settlements and accompanying research on outer space food systems has grown rapidly (Meinen et al., 2018; NASA, 2021). Given the technological constraints of long-duration space travel and planetary settlement, off-Earth humans will likely need to employ food systems very different from their terrestrial counterparts.

These systems may therefore potentially alienate their users in new ways compared to Earth-based food systems, insofar as they will involve novel approaches to food provisioning such as with new technologies, and therefore chart new practices and relationships between consumers and systems of food production, distribution, and consumption compared to terrestrial systems. They will be susceptible to alienation in ways that are similar to such potential on Earth, where there are points of overlap between off-Earth food systems and any of the multitudes of ways in which food systems on Earth are structured. They will also be susceptible to new forms of alienation, as we encounter scenarios that are genuinely structurally novel to humanity. These are especially important to consider since there are comparatively fewer analyses of these food systems where they differ from existing ones. Finally, there are new opportunities for alienation in the context of food systems on Earth where the technologies being developed for off-Earth settings are also deployed in existing Earth food systems as well.

In order to critically assess the ways in which off-Earth food systems may alienate their users, it is therefore helpful to develop explicit criteria for the food-related values from which users may be alienated. Such a values framework for food alienation allows for comparative assessments of particular points of alienation in different food systems, while also providing the basis for critical assessment of specific food systems.

Some authors, especially Newman and Fraser (2022) have recently suggested that advances in food technology will greatly reduce off-Earth humans' alienation from their food and may even connect them to their food systems in a way humans on Earth seldom are. In this paper, we aim to critically examine these claims. This includes assessing (not exhaustively) several major differences and similarities between these settings that are germane to the issue of alienation from food, determining what would be required for an off-Earth food system to be non-alienating, and the extent to which recent advances in food technology are sufficient to achieve such a system. One major difference in the food systems envisioned for off-Earth contexts is the way in which they attempt to mitigate what we are describing as alienation from food by tying prepared food back to familiar items or products from Earth settings. We argue that existing food technology of the sort described by Newman and Fraser (2022) may mitigate alienation for extraterrestrial humans who have a pre-existing connection with food on Earth. However, technological advances are insufficiently focused on creating non-alienating food systems for those who will have no direct connection to Earth's food traditions (e.g., children born on long-duration space missions or on other planets). What is needed are food systems that extraterrestrial humans can dynamically develop and adapt, thereby creating food traditions independent of those on Earth. Recognizing distinctive ways in which these food systems can exacerbate or alleviate alienation from such a central part of the human experience enables better planning in advance of any such missions.

I. Alienation and Food

Alienation is, very roughly, the separation of a subject and an object resulting in psychological or social ill on the part of the subject (e.g., Leopold, 2022). For example, according to Marx, a worker (the subject) is alienated from her labor (the object) if she takes no pleasure in her job and works only as a means to earn a wage and survive (Marx, 2007). Implicit in this characterization is the idea that the worker *ought* to, and under appropriate circumstances

can, find fulfillment in her labor. Describing a relationship as alienated is therefore normative in that one asserts a subject and object *should* be connected in a way they currently are not (Gilabert, 2020) yet are capable of. A wide variety of relationships might be described as alienated—one could be alienated from other people, from a culture, from nature, from morality, or even from oneself. Our goal in this paper is not to endorse a general theory of alienation or describe what (if anything) various alienated relationships have in common. Rather, we aim to articulate one particular form of alienated relationship, that between humans and the food they consume, only in the context where technology might exacerbate such alienation for some humans by dint of current attempts to alleviate alienation for other humans. More specifically, our focus is on the psychological and social values that individuals may gain in preparing and consuming their food.[1] In this section, we identify several sources of value an individual's relationship with their food might possess and articulate how alienated food-relationships may fail to instantiate these values. In the following sections, we apply these insights to food systems in off-Earth contexts.

A *food system* comprises all the various elements and processes related to food production, distribution, consumption, as well as waste management (See Sobal et al. 1998 for more discussion). Food systems may be more or less alienating to the degree that they produce alienated relationships between humans and their food. Therefore, to assess food systems, we must first describe at least some features in which alienated and non-alienated relationships with food consist. To this end, consider the following two cases:

> **Oatmeal**: Oscar, a student, is running behind on his work and decides to spend all weekend in the library studying. Knowing he'll need to eat lunch at the library, Oscar brings some oatmeal in a microwavable packet from home that morning. At lunchtime, Oscar adds water and microwaves the oatmeal. By the time he sits down with the bowl, the oatmeal is somewhat congealed, lukewarm, and relatively flavorless. When Oscar

[1] There is need for a further treatment related to values that takes up ways in which alienation can be more systematic, including institutional structures that mediate access and social structures that shape food preparation and consumption. For reasons of space, we focus here on a specific kind of alienated relationship that an individual may experience, which lays useful groundwork for subsequent development of a more thorough framework that draws in social and institutional values as well as individual ones.

eats the oatmeal (book in hand)—while not a particularly satisfying experience—his hunger is sated, and he can continue studying.

Leftover stew: Anne, a student, is running behind on her work and decides to spend all weekend in the library studying. Knowing she'll need to eat lunch at the library, Anne makes a pot of *lapskaus*[2] for dinner during the week. Her father grew up in Norway and used to make it for family meals. His cultural upbringing also emphasized the importance of frugality by bringing food from home rather than buying fast food for lunch. Anne has been improving her own version of it, since she likes a different combination of vegetables than her father's version. It takes a long time to cook but the time mostly involves leaving it alone on low heat, so she also does homework on the evening she prepares it. She brings a container of leftover stew to the library with her, and while it doesn't taste as good as take-out from the nearby fast food place might, it gets the job done, she thinks her father would be pleased at the result. Her hunger is sated, and she can continue studying.

How does Oscar's relationship to his oatmeal differ from Anne's relationship to her stew? Both dishes provide some part of the calories and nutrients Oscar and Anne need to survive. However, Oscar's relationship with his food is alienated in a way Anne's is not. Unlike the oatmeal, the stew provides value to Anne over and above nourishment in the form of calories and nutrients. In what does this additional value consist?

We propose five sources of value beyond nutrition our relationships with a food may possess. These are not exhaustive; there are surely additional values that preparing and consuming a meal may engender.[3] Nevertheless, we believe these five values capture much of the immediate psychological and social benefits individuals might derive from their food.

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[2] This is a traditional stew made with potatoes and meat, usually beef or a mixture of pork and beef, and other root vegetables such as carrots, onions, and turnips.

[3] For example, one may have personal values of various sorts that shape one's relationship to food in various ways, such as valuing ethically sourced ingredients, or choosing to be vegetarian or vegan as part of valuing the lives of animals, or even simply choosing to prepare food at home instead of eating out because one values saving that money for a different, higher-valued, purpose. We set these aside here: they are legitimate values that shape food consumption but are more aptly characterized from an institutional perspective in ways that makes the case of off-Earth food systems relevantly different than many on-Earth contexts.

Moreover, these values provide a useful starting point by which to identify key elements in the two vignettes above for the purposes of subsequently applying them in the off-Earth context. To begin, there is the *gustatory value* of a meal; when we eat, we usually hope to find our food tastes pleasant and interesting (as Anne finds her stew tasty, rather than flavorless or unappetizing as Oscar finds his oatmeal). In addition to the properties of the food itself, there are also the communal activities that a meal facilitates. While Oscar eats his oatmeal alone, the lapskaus provides an opportunity for Anne to refine a family recipe that she has spent much time, over the years, watching it being prepared and learning to help, with her family. Insofar as food facilitates our positive interactions with other people, we might say it has *social value*. In addition to connecting us directly to our dining partners, a food may also have *cultural value* in connecting us to broader cultural traditions and performing cultural identities. For example, Anne's stew forms part of her family's cultural food heritage, and involves cultural food practices beyond just the recipe, such as bringing lunches from home rather than eating out. Anne also gains knowledge in actually preparing the lapskaus herself. Unlike Oscar who only microwaves a premade packet, Anne gains some *epistemic value* in practicing preparation of the dish. Lastly, there is a sense in which Anne's stew is *hers*. Whereas everyone who bought the same packaged oatmeal as Oscar will end up with roughly the same meal, Anne adapts the recipe in light of her preferences and creates a version of the stew that is unique to her and her place-based circumstances, such as availability of various ingredients. We might say she derives some *authorial value* from the dish. Putting all this together, while both meals provide nutrition, Anne's relationship to her lapskaus stew instantiates these five values that Oscar's relationship to his oatmeal does not:

1. Gustatory value: pleasant and interesting, beyond satisfaction of hunger and containing basic nutrients
2. Social value: facilitating or involved with positive social interactions with others, including family
3. Cultural value: situating the eater in broader cultural traditions to which they are connected
4. Epistemic value: involving the cultivation of skill and knowledge in food preparation techniques and in preparing the recipe

5. Authorial value: successful creativity and skill in preparing a distinctive version of a meal[4]

A person has an alienated relationship to food to the degree that this relationship fails to instantiate sources of value outlined above. Before moving to consider how off-Earth food systems relate to alienation, there are four clarifications to make regarding our characterization of alienated food-relationships. First, to reiterate, the five values listed above are not exhaustive of the sources of values that are related to food. For example, there may also be *moral value* gained by consuming ethically produced food or *environmental value* gained by growing and transporting food in an ecologically sustainable manner. These two values are unquestionably worthy of consideration along with many additional categories of food-related value. We restrict ourselves to the five values listed above as we are primarily concerned with how consuming food may be psychologically valuable for individual people. Thus, we focus on the sources of food-based value we consider most directly related to an individual's psychological and social well-being, while acknowledging that relationships to food may also be sources of other sorts of value (e.g., moral, or ecological value) that require social or institutional settings to be fully characterized. Despite these potential shortcomings, we think the above categorization captures much of what is potentially missing in alienated relationships to food consumption.[5] Second, we acknowledge that the five values we do list are not always entirely distinct from one another and it may be hard to neatly distinguish one category from another. For example, part of the authorial value Anne has in perfecting the stew recipe plausibly derives from the epistemic value she gained learning to cook it or from her place-based context away from Norway as a child of an immigrant. Nevertheless, we maintain that five categories listed are conceptually distinct, and highlight useful points of comparison across examples. .

Third , we cannot and may not always relate to our meals in ways that instantiate all the values listed. Not all meals are special occasions and sometimes it is desirable to trade off one

[4] This is a narrower value than that of food sovereignty. "Food sovereignty, broadly defined as the right of nations and peoples to control their own food systems, including their own markets, production modes, food cultures and environments..." (Wittman et al., 2010). Authorial value applies to individuals specifically, rather than to nations or peoples. Authorial value for individuals is a necessary though insufficient condition for food sovereignty.

[5] We wish to thank two anonymous reviewers for pushing us to be clearer on this point.

kind of value for another. For example, the epistemic and authorial value gained by developing a new recipe might require you to cook it for yourself alone a few times before you gain the social value of sharing it with others. Additionally, not everyone views the food they eat as a key source of value in their lives and may instead prefer to focus on other pursuits. We don't think everyone must become a foodie or take up cooking as a hobby to avoid alienation. However, it does seem plausible that *something* important would be missing from most lives if every meal was like Oscar's oatmeal. Fourth , it is important to stress that having an alienated relationship to food does not mean that individuals are *blameworthy*. There are a variety of interconnected forces that might unjustly alienate a certain person or group from their food. Through a system of "food apartheids," (a term coined by Bronx-based food activist Karen Washington, and more commonly known as "food deserts") typically low-income areas are planned and designed with minimal access to fresh and affordable food. As such, people may be unable to express themselves or their cultures or preferences through food (for case studies see Corcoran 2021, Joyner et al. 2022 and Gripper et al. 2022). Though these people may have alienated relationships to their food, this in no way reflects negatively on them as individuals. Individuals interact with these systems in ways they may lack control to meaningfully change.

Fifth and finally, there are ample examples of other ways in which individuals can be alienated from their food, such as lack of any meaningful connection with the circumstances under which the food is produced or distributed. Regularly eating products where one is unable to ascertain the circumstances under which the food is produced or who grows the food and the associated labor conditions is a kind of alienation. Having access only to limited ranges of local food because of limited production nearby, and having to rely on foods grown far away and transported long distances and/or for long periods, is a further form of alienation from food. Alienation can be forceful and intentional, as was the case through colonization in Canada, with children in Indigenous residential schools prohibited from eating their traditional foods, taken away from home, and alienated from their traditional food practices (fishing, hunting, foraging, etc.) (Mosby and Galloway, 2017). While these further forms of alienation have clear implications for off-Earth food systems, we are setting them aside for reasons of space here, and focusing on the preparation and consumption of food as a locus for considerations of alienation.

Food systems may lead to more or less alienated relationships to food among those who partake in them. For example, as just mentioned, food systems that create food apartheid will

tend to increase alienation. Alternatively, food systems that tend to supply consumers with fresh produce and connection to the land, all other things being equal, will tend to produce less alienation. Having established what values alienated food-relationships lack, we can now examine how food systems may either mitigate or exacerbate alienation. More specifically, we are in a position to critically examine two ways technological advancements may reduce alienation from food in space. First, technology may aid off-Earth food systems in mimicking the foods we have on Earth. Second, the fact that food-systems in space must minimize waste, may more fully connect individuals to their food in a way that is impossible on Earth. We examine each of these suggestions in turn.

II. Reproducing Terrestrial Foods in Off-Earth Contexts:

The goal of much space food technology is to reproduce Earth-like foods in off-Earth contexts (Newman and Fraser, 2022; Shaw and Soma, 2022). In this section we give examples of such technology, both extant and hypothetical, and argue that Off-Earth food systems aimed at reproducing Earthly cuisine have the potential to both decrease and increase alienation. Specifically, while such systems may *decrease* alienation for those coming from Earth or those who will eventually return to the planet, they may actually *increase* alienation for extraterrestrial humans who have no direct connections to Earth. Those born off-world will be eating imitations of foods they can never truly taste, and will be alienated from such food in ways classifiable with the five listed values (see previous section).

Why might we want to create food systems that mimic terrestrial foods in off-Earth contexts? Given that everyone who has traveled to space so far has had a previous relationship with Earthly cuisine, mimicking these foods in space has the potential to reduce alienation and psychology wellbeing. For example, consider an account of contemporary off-Earth cuisine by former NASA astronaut Karen Nyberg: “food comes in these white bags that we just have to hydrate, like powdered milk and that sort of thing… I was craving the smell of garlic sauté and olive oil, and it's just something we don't have. And so, anything we can have to kind of bring back home I think would be great” (Clayton, 2022, np). In terms of the framework outlined above, Nyberg describes the bagged dehydrated food as lacking in social and cultural value for her; it doesn’t connect her to home or her fellow astronauts the way that the smell of sauteed garlic and olive oil in a pan would. Nyberg also describes food in space as lacking gustatory

value (i.e., tastes worse) when compared to food on Earth. There is no epistemic value in the preparation of the food: it strongly resembles the Oatmeal example above. And, there is certainly no opportunity for authorial value. Thus, she is alienated from the food she ate in space to the degree that these meals lacked social, cultural, gustatory, epistemic, and authorial value for her. As Nyberg herself suggests, implementing a food system in space that mimicked or more closely replicated foods on Earth could alleviate this alienation.

While Nyberg's desired food was hypothetical—she never actually got to taste real garlic and olive oil in space—there have been cases where technology has enabled the reproduction of terrestrial food in off-Earth contexts. For example, to feed their astronauts, the South Korean government prepared kimchi specially for space travel, by first irradiating the dish to kill all its probiotic microorganisms. Astronaut Yi So-yeon remarked: "When you eat your own traditional food, it makes you feel emotionally supported… After radiation the kimchi became so saggy. [It] looked like it was 100 years old…I cannot say it's a really tasteful kimchi, but still I like it because I can feel my home" (Nelson and Silva, 2016, np). While perhaps still missing out on some gustatory value, like Nyberg, Yi found genuine cultural value in having food similar to culturally familiar cuisine on Earth.

Given these first person reports, it's clear why food systems in space might aim to produce foods that mimic those on Earth. Such food systems could potentially reduce alienation in at least two ways. First, these systems could help off-Earth travelers maintain a cultural connection with their home planet. Second, given that people generally enjoy the taste of many foods on Earth, these systems could increase the gustatory value people derive from the foods they eat in space. Because of these potential benefits, much discussion of food systems in space presupposes that *the goal* of these systems should be to mimic terrestrial cuisine. For example, in a hypothetical menu for a day on Mars, Fraser and Newman (2022) list only recreations of foods we have on Earth: granola bars, coffee, green salad, milk shake, salmon and boiled potatoes. Gustatory and cultural values are clearly being prioritized in these discussions, in ways that are aptly described as aiming to reduce alienation from food.

Both of these two sources of value, gustatory and cultural, rely in part on a pre-existing relationship with Earth-based food traditions. The cultural value of reproduced foods derives in part from the fact they are attempting to imitate or replace specific foods developed in actual cultural settings, often over long time periods, from the places on Earth that off-Earth travelers

consider home. Moreover, their gustatory value seems to derive in part from the fact that certain tastes are antecedently familiar. While recreations of Earthly cuisine may have some gustatory value independent of our previous culinary experiences, part of the reason people enjoy a certain food is that they have previously acquired a taste for it. For astronauts who have never tasted kimchi, the irradiated kimchi will not have the same gustatory value for them as it does for the Korean astronauts, because they are not familiar with the kind of food the irradiated kimchi is aiming at or imitating. In short, much of the value of recreating specific terrestrial cuisines in space depends on the fact that those who will consume it have a pre-existing relationship with such foods on Earth.

While every space traveler so far has been raised on Earth, this will likely not always be the case. It is critical, therefore, to consider how off-Earth food systems aimed primarily at reproducing the foods of Earth might impact populations without pre-existing relationships to the planet that would establish the basis for non-alienated relationships to food involving gustatory and cultural values in particular.

For example, consider Stella, a hypothetical child born during a long duration space flight that has departed Earth and will never return. While Stella's parents might have such value-giving connections to Earthside cuisine, Stella will never actually taste foods as they are traditionally prepared on Earth. If she grows up only eating foods that are intended to mimic foods of Earth, this may actually *increase* alienation in her relationship with food. Given tight constraints on features such as wild biota involved in fermented foods, off-Earth recreations of Earthly foods will probably lag behind their originals for a substantial period time. Think back to the Kimchi that Yi described as so soggy it looked a century old; no matter how fond Stella's parents may be of the recreated version, an irradiated version does not provide the basis for cultivating a meaningful relationship with this particular food for Stella, compared to her parents.

Much of the gustatory and cultural value of recreated foods will be absent for Stella; she has no nostalgia for the foods of Earth and does not crave them as familiar reminders of home. Instead, she will constantly be reminded that the food she eats is a subpar recreation of something she can never experience.[6] This is a profoundly alienating experience, one made even

[6] Could it be that Stella comes to regard the recreated food as comforting and delicious, the same way her parents view the originals? Afterall, Stella has never experienced Earth so whatever the recreations consist in will be 'normal' for her and therefore just as good. While this is certainly

worse by the fact that Stella had no choice in the matter. Unlike current travelers who freely choose to venture into space, children born during long duration space flights or on off-Earth colonies did not decide to live away from Earth. The upshot is that designing food systems in space to reproduce foods from Earth is not a long-term solution to reducing alienation, even if it temporarily alleviates it for space travelers born on Earth.

How might this situation be rectified? We don't advocate concocting a new off-Earth cuisine from scratch. By their very nature, food traditions and their associated cultural practices are things that develop over time. However, given sufficient flexibility in an off-Earth food system, space travelers may be able to gradually develop their own unique cuisine—A cuisine that is unique to space but still meaningfully tied to Earth. As a model, we can consider how diasporic communities have adapted traditional cuisines to novel settings. For example, Romanian Jews prepared a dish called *pastramă* consisting in goose breasts, first cured in salt and spices, then smoked (Sax, 2009, p.42). When these Jews immigrated to New York in the mid 19th century, goose was hard to come by, but fatty beef brisket was cheap. Deli operators applied to the brisket the same techniques they had applied to the goose and produced what we now know as *pastrami*; the spelling and pronunciation were modified, perhaps to mimic *salami*, another deli staple.

While pastrami was not an exact reproduction of the Romanian pastramă, it still provided cultural and gustatory value like that associated with the original dish. The continuity between the dishes was important, but the second was able to develop into its own food tradition, not merely an ongoing semi-recreation of an unachievable dish. Adapting an old dish to a new environment can provide the other values discussed in Section I, as well, in addition to the gustatory and cultural values already discussed. A diasporic community might gain epistemic value from food by learning how to adapt traditional techniques to a new setting. They may also gain authorial value by creating something that is distinctly *theirs,* thereby helping to define themselves as a community in a way that also provides cultural value. Finally, developing novel

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possible, we think it is unlikely for two reasons. First, at least in the examples cited, the off-Earth food described lags behind its Earthly counterparts in flavor and texture. The fact that it is tied to Earthly nostalgia may somewhat compensate for these deficits, but again, Stella will never experience Earth. Second, Stella has less ability than her parents to adapt or change the recreated food to suit her tastes or situation. We discuss this issue further in the context of diasporic communities below.

food traditions may bring social value by engendering new communal practices of producing and consuming these dishes. In the present example, the development of pastrami helped form Jewish delis as unique social and cultural institutions.

When given the freedom to dynamically *adapt* traditional foods, as opposed to simply *reproducing* them, communities can recover value and reduce alienation in their relationships to food. We can apply these insights to the task of reducing alienation from food in off-Earth contexts.

For those who have no antecedent relationship to Earth's food traditions, like Stella, alienation can be reduced if there are opportunities to create new foods specific to off-Earth environments. As the example of diasporic communities shows, the freedom to adapt old food ways to novel contexts can maintain some of the gustatory and cultural value of the original dishes while also providing additional epistemic, authorial, and social value. All these sources of value contribute to achieving non-alienated relationships with food. Unlike food systems in new regions or countries, off-Earth food systems face the unique challenge of having less 'raw material' to work with, and a higher cost associated with failed attempts. When diasporic communities on Earth adapt traditional food ways to a new environment, there are already crops, animal products, and other existing food systems in the new context to utilize. In the off-Earth case, food supplies must either be carried with, or specific technologies must be developed in advance to harvest nutrients in space. The processes involved in epistemic value and in authorial value especially tend to involve experimentation and potential waste (or having to eat very unsatisfactory versions that failed), prior to achieving success. This means thought must be put into how precisely off-Earth humans can develop and adapt their food systems, including possible ways in which consumers in such systems have control over a variety of factors that without compromising the integrity of the overall food system. A lot of the work to bring in Earth systems have been explored by NASA through experiments in growing food plants in space at the International Space Station. NASA astronaut Megan MacArthur shared that the first chili peppers grown and harvested in space was then used to make space tacos to feed the crew (Baker, 2021). In fact, NASA is also studying the potential psychological benefits of gardening in space, i.e., a "space faring green thumb" (Halper, 2021).

There are myriads of ways in which food systems in off-Earth contexts can exacerbate or alleviate alienation with respect to food that emerge from the considerations in this section.

Features of food systems that enhance opportunities for meaningful social interaction, but which avoid forced social interaction, can alleviate alienation, while those which require all members of a group to eat the same thing for each meal will exacerbate it. Systems that allow for modification of the timing of meals would facilitate spiritual continuity such as the observation of Ramadan, while systems which require a set time-table for food consumption would exacerbate cultural alienation. Food systems which allow for multiple members of a group to engage in food preparation would enable epistemic value, while systems which restrict the ability of non-designated members to choose to participate in food preparation would increase alienation. Food systems that allow for creative control over various taste and texture combinations of food thereby allow for novel and innovative re-purposing of existing dishes and the kind of new versions of older dishes reflecting the material circumstances in which new consumers live. This would enable authorial control so that people of Stella's generation could innovate their food in ways that go beyond what their parents might have done. This dynamic adaptability will require a high level of control over various aspects of food production and consumption that will be harder to achieve in many off-Earth contexts, but which are as legitimate a goal in developing food systems for these contexts as is the reproduction of familiar foods for gustatory and cultural values for Earth-born food consumers.

In this section we have argued that attempting to reproduce terrestrial foods in space may reduce alienation for those who have pre-existing connections with Earth's food traditions. However, this cannot be the sole aim of food systems in space if there are to be human populations with no direct contact with Earth. To reduce alienation from food for these off-Earth humans, food technologies must be dynamically adaptable by their users. This requires foresight in the development of off-Earth food systems—there's more to non-alienating food in space than simply reproducing the foods of Earth.

III. Reconnecting to Food Systems

Mimicking the foods of Earth is not the only way technology has been claimed to reduce alienation from food in space. Another suggestion made by Newman and Fraser (2022) is that the technology developed for off-Earth food systems may reconnect humans with the cyclical nature of food production. Given the constraints of space travel, food systems in space must minimize waste and reuse as many nutrients as possible. The claim is that these constraints may

reduce alienation by putting consumers more in touch with the systems that produce their food. As Fraser has put it in a recent interview: "…every school kid knows, nature works in cycles, not in long, stretched out lines… By going to Mars, we reconnect ourselves with the logic of nature on Earth" (Brehaut, 2022, np). As in the previous section, we argue that the constrained nature of food systems in space may both increase and decrease alienation from food. Off-Earth food systems may indeed help reconnect us to "the logic of nature". However, if these systems preclude modification and adaption, they also have the potential to alienate their users.

Let's start with the positives: how might the constraints of an off-Earth food system reduce alienation in its users? We can begin to answer this question by contrasting *linear* and *circular* food systems (Dudziak et al., 2022). Linear food systems place an emphasis on delivering specialized food products to consumers quickly and cheaply, without regard to ecological cost. For example, consider drinking a glass of orange juice in the middle of winter in Alberta, Canada. To produce this orange juice, citrus fruits were grown in a distant warmer climate (e.g., Florida, United States). Of the oranges harvested, some fruits didn't meet quality control standards and were thrown away outright, others were juiced before their skins and pulp were disposed (Russo et al., 2021). The juice was then transported thousands of miles in a plastic container that will also eventually be thrown away. Linear food systems like the one just described employ a 'take, make, waste' model—any materials not involved in the end food product are simply discarded. In contrast, a circular food system aims to reduce, reuse, or recycle the byproducts of food production. In the case of oranges, discarded pulp and seeds might be repurposed into fertilizer, animal feed, essential oils, or vitamins (Suri et al., 2022). Circular and linear food systems don't form a strict binary; a given system might reuse some byproducts and treat others as waste. However, due to the technical constraints of long duration space-travel, off-Earth food systems will need maximize circularity and design waste out of the system as much as possible. Cargo space in space crafts is extremely limited and off-Earth systems will not have easy access to additional resource shipments. Given this, food waste will have to be minimized and the byproducts of food production must be reused or repurposed.

Newman and Fraser's (2022) claim is essentially that circular food systems are less alienating than linear ones. Since off-Earth systems will likely be circular, such systems have the potential to reduce alienation in their users. It is certainly plausible that circular food systems are less alienating than linear ones; or, in terms of our earlier framework, circular food systems have

greater potential to realize many values that linear food systems do not. To begin with a smaller scale terrestrial example, consider renting and cultivating a plot in a local community garden. In the early spring, you plan out your garden and choose which vegetables you'll grow in the coming year. As the season progresses you stop by the plot regularly to water and weed, occasionally chatting with the people attending to neighboring gardens. You harvest from your vegetable garden throughout the summer—when you have too much of one crop you share the extras with family and friends or compost them to be reused as fertilizer. You might even save some seeds from your plants to sow in your plot next spring. As opposed to simply picking up some vegetables at the supermarket, repeatedly cultivating a garden plot acquaints you with the circular 'logic of nature' and seasonality. How might becoming acquainted with such circular food systems decrease alienation?

Being in close proximity to a circular food system has the potential to bring many of the values discussed in our earlier framework. First, there is epistemic value in learning how your food is produced. This newly gained knowledge may be both propositional, e.g., you learn from a seed packet *that* carrots grow best in sandy soil, as well as practical, e.g., you learn intuitively *how* to judge when a carrot is ready to harvest (See Bengson, 2013, for more). Given that linear food systems focus solely on getting food to consumers as quickly and efficiently as possible, and may include processes such as automation, they are less likely to allow for their users to gain this sort of epistemic value (see also tacit knowledge, Carolan, 2011). Second, participating in a circular food system gives one authorial value (e.g., food sovereignty) with regard to the food produced. Unlike buying vegetables at the store, the vegetables you grow are *yours* in a more profound sense, through the choice of how to cultivate, what to cultivate, the inputs used, etc. Finally, circular food systems have greater potential to facilitate social and cultural activities of value. As we saw in the community garden example, personal involvement in the production of food allows for unique social interactions—it's one thing to run into a friend at the grocery store, but quite another to spend a few hours weeding alongside them. On a larger scale, many cultural activities, such as harvest festivals, dance, and other ceremonies, are tied to the cyclical nature of food production. Even within our hypothetical community garden, an annual potluck or party may arise from shared participation in a circular food system. In summary, participating in a circular food system has the potential to reduce alienation by facilitating multiple types of values. While more linear food systems do not necessarily preclude these values, their focus on

efficiency and specialization mean that users will likely not meaningfully engage in the process of food production or even be aware of how those processes work.

How might these insights apply to off-Earth contexts? As noted above, off-Earth food systems must minimize waste and maximize efficiency in terms of both nutritional outputs and physical space. In other words, Newman and Fraser are pointing that there won't be space to hide away the production of food or the reuse of food by-products. Just as cultivating a community garden plot brings one closer to multiple aspects of a food system (soil system, weather, pollinator biodiversity), humans living off-Earth will likely be better acquainted with how their food is produced, distributed, and recycled. For example, consider Newman and Fraser's discussion of food plants growing in a hypothetical Martian colony:

> …every photon of solar energy that enters [the colony] is put to multiple uses. Plants are encouraged to grow in all sunlit places. And each of these plants sucks up extra carbon dioxide, emits oxygen, purifies water, and turns organic molecules into food… These plants have been bred to deal with the low-gravity and low-pressure environment and all are nestled in a hydroponic solution… (Newman and Fraser, 2022, p.22)

In this hypothetical example, Martian colonists have a much better sense of where their food comes from than many of us on Earth. Every day these Martians will see the fruits and vegetables that end up on their plates being planted, grown, and harvested. Moreover, they will see how the byproducts of these plants are repurposed—Newman and Fraser describe how small robots will quickly scoop up any fallen leaves and recycle them as biomass (p. 193). In this description, the need for maximally efficient use of resources entails that Martian settlers will live in much closer proximity to all stages of their food systems. Given this, there is potential for off-Earth humans to gain many of the values outlined in the community garden example above. Closer contact with one's food system will likely lead to additional epistemic value, that is, increased knowledge of one's food. Additionally, more consistent awareness of one's food system may allow for such systems to facilitate unique social or cultural activities and provide associated sources of value.

However, as with the reproduction of terrestrial food products, the technologies that allow for closer contact with a food system may also increase alienation from one's food. To see

why, consider how a Martian garden differs from a terrestrial community garden. Whereas you could choose whatever seeds you wanted to plant in your plot, all the Martian plants were carefully bred and selected long before any settlers even arrived on Mars. Two gardeners in the same community garden might grow different vegetables from one another, based on their personal preferences and cooking styles. This is simply not an option in the Martian case described by Newman and Fraser. The features that enhance epistemic value may thus interfere with other values, such as gustatory and authorial value.

Other aspects of a maximally circular off-Earth food system may be likewise unalterable by their users. For example, many space food technologies rely on precision fermentation utilizing custom bioengineered bacteria and yeast (Llorente et al, 2022). As with the Martian garden, the processes to produce products like artificial meat or dairy cannot be easily altered in the same way as a home-cooked meal. Creating maximally circular food systems may put off-Earth humans in closer contact with 'the logic of nature', but they may also deprive such humans of the ability to meaningfully change or adapt their food. We think this latter consequence has the potential to be profoundly alienating, especially for later generations of off-Earth humans. While observing multiple parts of a food cycle may initially reduce alienation, this value is minimal if humans can never actually intervene in how a system produces their food. Moreover, with automation and digitization of agriculture, it is questionable whether human labor will be necessary at all (Rotz et al., 2019).

To see this point more clearly, let's return to Stella, a child born during a long duration space mission. To ensure maximally efficient resource use, the food system for the entire decades-long voyage has been carefully pre-planned. Bioreactors with precision designed strains of bacteria, yeast, and animal cells will produce meat and dairy substitutes. Plants bioengineered to withstand the harsh conditions of space provide fruits and vegetables. Daily meals for Stella and her fellow travelers are planned in advance to provide all essential nutrients. These meals are taken communally in a cafeteria setting—as Newman and Fraser (2022) note, home cooking is less efficient than bulk preparation (p. 195). In this scenario, Stella will likely be more acquainted with where her food comes from than many people on Earth. The food may be relatively tasty, and the communal setting may provide Stella with some social and cultural value. However, there is still something alienating about the food system in this scenario. Stella

didn't choose to be born in a spaceship, as her parents' generation chose, to some degree, to join the voyage, and she thus never got a chance to provide input on what food she would eat aboard.

As thoughtfully planned as the food system may be and as delicious as the end product may turn out, Stella lacks the freedom to meaningfully change her food system—she is locked into a particular food product that she didn't choose and cannot alter. In other words, while tying linear food systems into closed loops may reduce alienation, tying the loops too tight may increase it. In some sense, this is nothing new; the majority of people of earth have minimal ability to dynamically change their food systems. What makes the off-Earth context unique is that it provides opportunity to design a food system that allows people the ability to adapt the system to their needs. On the flip side, if no flexibility is built into the system at the outset, given the constraints of off-Earth travel, there may be no opportunity to add it later. Part of the value in acquainting ourselves more intimately with a food system is the opportunity to adapt this system to our needs and the needs of our communities. Without the freedom to dynamically change a system, we stand to become more alienated.[7]

In this section, we have examined how the circular nature of off-Earth food systems may impact their potential to alienate. We have argued that circular systems have the potential to reduce alienation by putting humans in closer contact with multiple stages of a food cycle and providing many of the values discussed in Section I. However, as with the reproductions of terrestrial foods discussed in Section II, if off-Earth humans cannot meaningfully adapt these systems their alienation may increase. This problem is especially pronounced for later generations of off-Earth humans who will have had no impact in designing the initial system. Once again, a potential solution is to allow humans the freedom to dynamically adapt systems.

IV Conclusion

We have articulated five values involving food, and discussed ways in which we can be alienated from food along each of these value parameters. These five values (central, though not exhaustive nor exclusive) are:

[7] There are further ramifications of this, to be explored in a further paper, regarding the potential limitations of terraforming not in terms of engineering and time scales, but in terms of bringing about a potentially overly 'literal' replication of Earth-based ecosystems that is not as well-suited to the needs or desires of humans in permanent off-Earth contexts such as Mars (see also Genta 2021).

1. Gustatory value: pleasant and interesting, beyond satisfaction of hunger and containing basic nutrients
2. Social value: facilitating or involved with positive social interactions with others, including family
3. Cultural value: situating the eater in broader cultural traditions to which they are connected
4. Epistemic value: involving the cultivation of skill and knowledge in food preparation techniques and in preparing the recipe
5. Authorial value: successful creativity and skill in preparing a distinctive version of a meal

The emphasis on reproduction of familiar Earth-based cuisine in off-Earth contexts can alleviate alienation, especially with respect to gustatory and cultural value. In some contexts, though, where consumers of food did not grow up with the cuisine being reproduced, these reproductions will exacerbate alienation instead, especially though not only with respect to epistemic and authorial value. Food systems can be planned in ways that allow for eaters to dynamically adapt food in ways that enhance these values for all consumers, including those with no connection to the foods being reproduced. This also arises in the case of closed circular food systems. Despite the ways in which they may enhance epistemic value in understanding where food comes from the cycles in which it is produced, can exacerbate alienation by precluding opportunities for choosing what to grow or the ability to interact with and adapt the systems for production.

Alienation from these five values is a useful way to approach this topic for several reasons. These food systems have not been developed to such a degree yet that they are settled with respect to these more fine-grained ways in which off-Earth humans could meaningfully control or adapt parts of them. Designing with these values in mind will facilitate more humane food systems in which humans will be more likely to thrive. Alienation from food is a subtler way to evaluate how these systems structure the experience of humans than simply labeling some parts moral or immoral, just or unjust. Alienation can be expected to some degree in all kinds of contexts–not every meal can be a meaningful social moment with delicious food, rich cultural context, knowledgeably prepared in an innovative way. Yet the goal of allowing for such meals

to occur more often, or not structurally precluding their possibility, and enhancing these values rather than inhibiting them, is a good one for this stage of thinking about off-Earth food systems.

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