The Develes Engynnes: Technological Textures of Life on Earth and in Space

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Abstract

The failure of a multiplicity of spacecraft designs in a variety of ways highlights some of the challenges for human beings utterly dependent upon technology for survival in space. A thought experiment is formulated to explore human dependency on technology in extraterrestrial space, in contrast to human survival on Earth. Don Ihde's conception of the technological texture of contemporary life is employed to examine the nature of human dependency upon technology in space. Technologies are shown to embody scientific presuppositions, and some scientific presuppositions are discussed. The consequences of human life shaped by technologies, in turn shaped by scientific presuppositions are examined, with their significance for human societies in space considered.

Keywords: Technology, technological texture, thought experiment, death by exposure, techno-dysphoria, Don Ihde, Nikolay Danilevsky, particularism.

> The develes engynnes wolde me take,
> If I my lorde wolde forsake.
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> *Romaunt of the Rose*, 4549–4550

I: Technology and its Gremlins

On September 23, 1999, the $327.6 million Mars Climate Orbiter (MCO) was supposed to be inserted into a Mars orbit; instead, all communication was lost with the spacecraft, and its fate is not known—it might have burned up in the Martian atmosphere or gone into a heliocentric orbit. What went wrong? The investigation of the failure of the MCO concluded that "the mission loss was precipitated by an error in the software program that generated the Angular Momentum Desaturation (AMD) files … the files containing the magnitudes of the small forces impulses applied to the spacecraft had been delivered in English units (pounds-force seconds) instead of metric units (Newton-seconds)."[1] Is this a philosophical problem? Certainly, it involved a difference in worldview between NASA and Lockheed Martin. While we might reasonably assume the worldviews of NASA and Lockheed Martin to be about as closely aligned as is possible in a public–private partnership, with similar institutional cultures

[1] JPL Special Review Board, "Report on the Loss of the Mars Climate Orbiter Mission," Jet Propulsion Laboratory, California Institute of Technology, 1999.

and almost identical conceptions of science, the minute difference in culture between NASA and Lockheed Martin resulted in a misunderstanding that was catastrophic for at least one mission.

How and why do we miscommunicate in a context ruled by precision and presumably efficient bureaucratic coordination? This might be better identified as a problem of management, or even as a problem of engineering, than any failure of philosophical interest, and indeed these failures have been attributed to management failures: "the choices made by managers, or more accurately, the constraints imposed on them under the policy of 'better, faster, cheaper', led the program to its inevitable failure."[2] However, technologies are always embedded in a social context, and management techniques could be identified as a social technology working in concert with a hardware technology. Certainly, project management would count as a technology according to Ferré's definition of technology as practical implementations of intelligence.[3] For a complex technology to perform without failure requires a coordination of the technology with the human community of users, and while the community of MCO users was not completely fragmented, it also was not entirely on the same page.

The MCO was an automated spacecraft, so no lives were lost as a direct result of the failure, but there is another more elusive sense in which lives were lost—the working lives of all the scientists and engineers who collaborated on the design and construction of the MCO, and all those who had arranged their careers around this spacecraft (such scientific spacecraft are expensive, and there are only a few in each generation, so that space scientists are likely to focus their research around the capacities of a given science mission). The financial loss is relatively small in comparison to the scientific careers that never happened due to the loss of the MCO.

Soon after the MCO failure, on December 3, 1999, the Mars Polar Lander (MPL, also known as the Mars Surveyor '98 Lander) experienced a catastrophic failure. In the case of MPL, more than one mode of failure has been identified. Understanding the failure of a complex technology such as that of a spacecraft poses significant challenges. When communication with a spacecraft is lost, the most we can do from Earth is to attempt to reconstruct the failure from data received prior to the failure, a process that involves extrapolation under conditions of uncertainty. Distinct but empirically equivalent reconstructions are often possible. In the case of the MPL, it has been argued both that the spacecraft crash landed[4] and that it bounced off the Martian atmosphere and later

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[2] Brian J. Sauser, Richard R. Reilly, and Aaron J. Shenhar, "Why Projects Fail? How Contingency Theory Can Provide New Insights—A Comparative Analysis of NASA's Mars Climate Orbiter Loss," *International Journal of Project Management* 27, no. 7 (2009): 665–79. doi.org/10.1016/j.ijproman.2009.01.004.

[3] Frederick Ferré, *Philosophy of Technology* (Englewood Cliffs, NJ: Prentice Hall, 1988), 26.

[4] The official JPL report identified seven plausible modes of failure (20) but focused on premature shutdown of descent engines as the most probable: "The touchdown sensing logic is enabled at 40

came to rest at a distant location on the Martian surface;[5] we do not know for certain whether the wreckage of the MPL lies on the surface of Mars, or if the spacecraft eventually landed relatively intact but at the wrong location, or if the spacecraft skipped off the atmosphere and returned to space.

Mars has been called a spacecraft graveyard due to the many missions that have failed on the Red Planet or attempting to reach the Red Planet, so there are many failures from which to choose. In the case of the failure of Mars Beagle 2 (MB2), an ESA spacecraft that arrived on the Martian surface on December 25, 2003, a later mission to Mars, the Mars Reconnaissance Orbiter, using its High Resolution Imaging Science Experiment, captured several images of MB2 on the Martian surface, apparently having safely landed, but not having successfully deployed all its solar panels.[6] As the UHF communications antenna was positioned under the final solar panel that was to deploy, the failure to deploy all the solar panels disabled the spacecraft's ability to communicate from the surface.

Why the solar panels failed to deploy fully is not known. However, this failure is in principle one that could be repaired, like the repair of the Hubble Space Telescope. A Mars rover mission with a robotic arm plausibly could be sent (or, rather, could have been sent) to the location of MB2 and facilitated the full deployment of that spacecraft's solar array, possibly freeing the undeployed solar panels and allowing the spacecraft to transmit from the Martian surface and function as intended.

MCO, MPL, and MB2 each represent a distinct mode of technological failure, which might be summarized, respectively, as management failure, irretrievable equipment failure, and repairable equipment failure.[7] Whatever taxonomy we employ to make sense of failures (and it should be noted that an adequate failure taxonomy might prove helpful in avoiding future failures), it is clear that once a technology becomes sufficiently complex, it may or may not manifest *emergent* properties, but it will almost certainly

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meters altitude, and the software would have issued a descent engine thrust termination at this time in response to a (spurious) touchdown indication" (26). JPL Special Review Board, "Report on the Loss of the Mars Polar Lander and Deep Space 2 Missions," Jet Propulsion Laboratory, California Institute of Technology, 2000.

[5] "The Mars Polar Lander entry vehicle might have skipped into a large region of the Martian surface. It would be virtually impossible to communicate with the landed spacecraft in this scenario, even if it had recovered during a descent to the surface." Manuel Cruz and Clyde Chadwick, "A Mars Polar Lander Failure Assessment," Atmospheric Flight Mechanics Conference, 2000. doi.org/10.2514/6.2000-4118.

[6] J. C. Bridges, J. Clemmet, M. Croon, M. R. Sims, D. Pullan, J.-P. Muller, Y. Tao, S. Xiong, A. R. Putri, T. Parker, S. M. R. Turner, and J. M. Pillinger, "Identification of the Beagle 2 Lander on Mars," *Royal Society Open Science* 4, no. 10 (2017): 170785. doi.org/10.1098/rsos.170785.

[7] One might also make a distinction between retrievable and irretrievable management failures, given that if the MCO error had been discovered in time, it is entirely possible that the discrepancy could have been corrected prior to the orbital insertion maneuver. Given this distinction, MCO was a retrievable management failure, so that we lack only an instance of an irretrievable management failure, of which there are no doubt many.

manifest *submergent* properties, meaning failures to function according to design parameters. The functionality of a technology frequently becomes *less* reliable as the technology becomes more complex, which entails the loss of properties that reliably obtain in simpler technologies.[8] Multiple modalities of failure, in addition to the submergent properties of a complex technological infrastructure, mean that technologies often fail us in surprising ways that a review of possible failure points may fail to identify. Responses to problems such as these have included more robust engineering design than is apparently required (design according to the "margin of ignorance"[9]) and the use of multiple backup systems in case a primary system fails.

The failures and malfunctions of technology are so familiar to us that we have anthropomorphized them as *gremlins*, probably because the human mind more easily understands the complexities of technology by embodying its idiosyncrasies as gremlins, to which we can attribute human-like agency, individual personalities, antagonistic conflicts with individual gremlins, malevolence, and so on, placing us in a peer-to-peer relationship with the technologies we have created. Social relationships are far older than relationships with technologies—older than our species by far—so that we understand technological failures more readily by placing them in a social context, as we do when we imagine our struggles with technology to be with technological gremlins.

II: Death by Exposure Thought Experiment

The struggles of scientists, technologists, engineers, and equipment operators with technological gremlins is made the more vivid by what is at stake. Mission-critical technological failures expose the users of technologies to harm and sometimes to death, often as a result of technology allowing human beings to inhabit environments otherwise hostile to human life. Many a pilot and many a submariner has struggled with persistent and recurrent technological failures (sometimes cursing gremlins as they do so) knowing that lives are at stake if the problem cannot be contained; a technological failure of sufficient magnitude in the air or underwater is likely to be fatal. The ever-present possibility of fatal technological failure as regards spacecraft (and spacesuits) suggests a thought experiment; we will call this the *death by exposure* thought experiment.

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[8] This was apparent from early in the development of technology: "For the more machinery there is in any instrument, it is the more liable to be broken, and the more difficult to get it mended." Adam Dickson, *A Treatise of Agriculture* (Edinburgh: A Donaldson and J. Reid, 1762), 197.

[9] "Because there are uncertainties, a certain safety margin is always taken into consideration—which reflects the margin of ignorance." Francisco C. Sercovich, "Design Engineering and Endogenous Technical Change," in *Technology Generation in Latin American Manufacturing Industries*, ed. Jorge M. Katz (London: Palgrave Macmillan, 1987), 241–80, doi.org/10.1007/978-1-349-07210-1_10.

It is possible, *in extremis*, for a naked human being to be set down at random on the surface of Earth—excluding bodies of water, high elevations, deserts, and Antarctica, *inter alia*[10]—and to survive. Many would fail this test and die, but some few capable individuals would survive, and in the course of survival and regaining access to some organized human society (return to society being the presumed objective), the successful survivor would contrive a number of technologies of increasing sophistication, as circumstances allowed for their construction, to assist in survival. This *ex post facto* technology is a catch-as-catch-can matter, and it is optional to a significant degree.[11]

It is *not* possible for any human being to do this in any known extraterrestrial environment. Exposure to extraterrestrial space is immediately (or nearly immediately) deadly to human beings; exposure to terrestrial climates (or extraterrestrial equivalents) is not necessarily immediately fatal. There may be clement environments on other worlds where it would be possible for a human being to survive, but none are known to us at present. Human survival in space—whether in space itself or on some astronomical body in space—is existentially dependent upon technology. Any scenario in which death by exposure is avoided in outer space must involve something like a spacesuit or a spacecraft. This *ex ante* technology must be in place and functioning before the fact, or it is to no avail.

Any participant in the above state-of-nature death by exposure thought experiment would construct technologies from immediately available materials—rocks, plant fibers, wood, and eventually bone, sinew, and hide—and then use tools so constructed to construct more sophisticated, effective, and robust tools, thus reenacting the phylogeny of human technological development as an ontogenic process. This approach could not be pursued in extraterrestrial space. In a parallel thought experiment for a human being in extraterrestrial space, we must imagine the participant already in possession of advanced technology constructed in the light of sophisticated scientific understanding. There are any number of such stories that follow through with this thought experiment in one form or another: an astronaut who is abandoned or who has crash landed on an alien world who must adapt and improvise technology to survive.[12] However, there is a

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[10] Even in the exceptions noted, survival would be possible in some cases. Set down in a body of water, but near a log raft, or set down in Antarctica, but with an animal nearby that could be killed for food and fur, survival would be possible. Note that the condition of survival is an improvised technology.

[11] An especially severe test of (potential) death by exposure is the story of John Colter (c. 1770–1813). Colter was captured by the Blackfeet, stripped naked, and was given a head start to run for his life. Pursued by several hundred Blackfeet warriors, Colter survived not only exposure, but also pursuit. After surviving the initial pursuit, he still had a seven-day walk to the nearest fur trading station. The story of Colter's run has been told in many sources; I encountered it in Peter Stark's *Astoria: Astor and Jefferson's Lost Pacific Empire: A Tale of Ambition and Survival on the Early American Frontier* (New York: Harper Collins, 2015), 103–04.

[12] The film *Robinson Crusoe on Mars* (Hollywood, CA: Paramount, 1964) is a paradigmatic example of this.

definite lower bound for both the quantity and quality of the technology available to the unlucky individual for survival—and eventual rescue—to be possible. If the technology to survive is not available, then the world in question must provide for the needs of the individual to a degree commensurate with that of Earth, in which case it is simply a rerun of a death by exposure thought experiment set in an Earth-like environment.

With human life existentially dependent upon technology in extraterrestrial space, the entire infrastructure upon which any given technology relies is implicated in human survival. A spacesuit could keep an astronaut alive in space for a given period, but beyond the ability of the spacesuit to provide air pressure, oxygen, and warmth, *inter alia*, for a given period of time, the resources of the spacesuit must be replenished at regular intervals. Moreover, the replenishing of air, water, and electricity necessary for the operation of a spacesuit must draw from some larger infrastructure than the spacesuit itself, and this larger infrastructure must either draw its resources from the terrestrial biosphere, or from a technologically sophisticated industry in extraterrestrial space that can produce sufficient air, water, and electricity to keep a spacesuit supplied to keep an astronaut alive.

Even then, a spacesuit is a short-term survival strategy. Human beings need food and need to eliminate wastes beyond the capacity of a spacesuit, which implies a more comprehensive environment maintained in extraterrestrial space than that provided by a spacesuit alone. Not only must the spacesuit be replenished, but it must also be cleaned, maintained, and repaired, which implies a technological infrastructure in which these tasks can be routinely undertaken. Thus, prevention of death by exposure in outer space requires an infrastructure that is an effective stand-in for the biosphere, and which would be the more effective as it approaches the extent of the terrestrial biosphere. Moreover, this technological infrastructure, being sufficiently large to serve as a stand-in for the biosphere and therefore sufficiently large to experience submergent properties, will be beset by technological gremlins that will threaten human lives even as the selfsame technology sustains these same lives.

III: Variations on the Theme of Exposure

The death by exposure thought experiment can be extended to cover the marginal habitability of both other worlds and artificial structures. Scenarios can be formulated in which human life on another world or on an artificial structure might more closely approximate conditions on Earth, thus allowing for the thought experiment to be run beyond the terrestrial biosphere. However, in these scenarios the approximation of terrestrial conditions provides a different stand-in for the terrestrial biosphere, allowing some resourceful individual to evade death by exposure.

Suppose a naked human being is set down on some world that approximates Earth but is not Earth. Further suppose that this world possesses all the resources at hand for an intelligent and motivated individual to survive. In this permutation of the thought experiment, an individual who could survive the death by exposure thought experiment on Earth would have a fair chance of surviving the ordeal on this Earth-approximating planet. The similarity to Earth of the world in question would constitute the crucial variable that would raise or lower the likelihood of the individual being able to survive. We could posit marginally habitable worlds that would constitute a much more severe test, and we could postulate clement worlds—perhaps superhabitable worlds—upon which survival could be easier than in a comparable terrestrial environment.

Now suppose that an artificial structure has been constructed in space that involves no electromechanical or solid-state technologies. Consider, for example, a rotating habitat employing mirrors to focus sunlight on plant life growing within the structure. Human beings living inside this structure can breathe in virtue of the oxygen produced by the flora, and water is circulated passively throughout the ecosystem, giving human residents access to water and food from the plant life (and any livestock also maintained under similar circumstances). If such a structure could survive the irradiation of a coronal mass ejection, and the plant and animal life were sufficiently shielded from the radiation, human beings could survive a coronal mass ejection on such an artificial structure without using mediating technologies (i.e., any technologies other than the habitat itself), possibly long enough to begin the process of rebuilding electromechanical and solid-state technologies. A death by exposure thought experiment run in such an environment could well be more survivable than the same thought experiment set on Earth if the artificial habitat environment were more uniformly clement to human life than Earth's surface.

However, given the condition that human beings could survive in such an artificial habitat as long as they were sufficiently shielded also applies to electromechanical and solid-state technologies, if sufficiently shielded, they, too, could survive, and human life dependent upon these technologies could continue. This shielding is itself a technology that must be designed, constructed, and maintained so that it is available *ex ante* to be effective in ensuring the survival of human beings inhabiting this artificial environment.

Ultimately, technologies that would keep human beings alive in a survival scenario are the effective equivalent of the natural world; in designing this degree of survivability into extraterrestrial habitats, engineers would be building toward an approximation of the natural world. Thus, the survival of human beings in such circumstances could be expressed as survival indexed to approximation of the circumstances on an artificial habitat to circumstances on Earth, so that the death by exposure thought experiment in space becomes essentially equivalent to the death by exposure thought experiment on Earth.

IV: The Technological Texture of Life in Space

We have been prepared for the necessary dependence of human life in space upon technology by the technological infrastructure we have constructed on Earth. Don Ihde has called this pervasive, surrounding technological infrastructure the *technological texture* of contemporary life:

> Beginning with the first conscious event of the day, it is likely that the ringing of an alarm or the sound of a clock radio is our first awareness. This is followed by a whole series of interactions and uses, which may include turning off the electric blanket or turning up the heat and in either case throwing back the technologically produced bedclothes from the technologically produced bed, engaging the vast plumbing system, and entering a veritable technological jungle in the modern kitchen with stove, toaster, hot-water system, lighting, and so on. And even the philosopher takes this technological texture for granted in his or her daily use of telephone, Xerox machine, typewriter, automobile, *ad infinitum*.[13]

More than merely surrounding us, according to Ihde, technology has become an integral part of our lives:

> Machines become, in technological culture, part of our self-experience and self-expression. They become our familiar counterparts as quasi-others, and they surround us with their presence from which we rarely escape. They become a technological texture to the World and with it they carry a presumption toward totality. In this sense, at every turn, we encounter machines existentially.[14]

Further, Ihde explicitly recognized the *telos* of this technological texture in hostile environments such as space and under water, which so completely surrounds us that he calls this a *technosphere*:

> there is a "technosphere" within which we do a good deal of our living, surrounding us in part the way technological artifacts do literally for astronauts and deep sea investigators.[15]

The increasingly pervasive technological texture of life on Earth, while still, in a sense, optional, ultimately becomes the necessary technological texture of extraterrestrial life, at which threshold the technology is no longer optional. For the great mass of human beings on Earth, the technological texture of life is already necessary; eight billion individuals could not and would not survive were it not for the technological infrastructure constructed supervening upon the biosphere. Biosphere and

[13] Don Ihde, *Existential Technics* (Albany: State University of New York Press, 1983), 10–11.
[14] Don Ihde, *Technics and Praxis* (Dordrecht: D. Reidel, 1979), 15.
[15] Ihde, *Technics and Praxis*, 14.

technosphere are integral with each other for the practical purpose of human civilization, but in a thought experiment, the technosphere could be eliminated and some human beings would survive. In extraterrestrial space, the elimination of the technosphere would mean that *no* human beings would survive.

V: The Procrustean Bed of Technology and Techno-Dysphoria

On Earth, the technological texture of life is a cumulative artifact of human activity, but it can be abandoned, and the individual can, in theory, return to nature and continue to enjoy differential survival and differential reproduction—the crucial factors in natural selection. The death by exposure thought experiment is intended to demonstrate that this is not true of outer space.

There is a history of social movements that advocate a return to nature, and which seek a fresh start through abandonment of the advanced technologies of the time. These technologies appear to coerce human beings into an artificial way of life (human life lived within a technosphere), such that the only escape from artificiality is the abandonment of the technological infrastructure that creates a *de facto* template to which our lives must conform. The desire to distance human life from the artificiality of technology is not unique to our post-scientific revolution, post-industrial revolution world: there is a famous story of Diogenes the Cynic casting away his drinking bowl when he saw a young man drink from a stream with his hand; the drinking bowl was dispensable, therefore it should be dispensed with.

This perennial desire for a blank slate upon which to write anew the human drama is now projected onto extraterrestrial space, but not only is the space frontier *not* a blank slate, it is *necessarily* not a blank slate because to survive in space, human beings will have to bring with us the science and technology that have enabled space exploration. Both scientific knowledge and technological artifacts incorporate into their structure and function presuppositions about human life, and even presuppositions about human purposes, meanings, valuations, and preferences, which, through their institutionalization in a technological artifact (especially those mass produced by industry and distributed to millions of users), innocently present the embodied purposes, meanings, values, and preferences as those proper to a human being as such.

Frederick Ferré has defined technology as practical implementations of intelligence, and as long as intelligence expresses pure rationality (or, if you prefer, pure reason), we have a nomothetic if somewhat artificial way to relate to this technology. However, insofar as the intelligence implemented by technology is colored by any human idiosyncrasy, that technology is equally colored by human idiosyncrasy.

Because technology is embodied human intelligence, with all the foibles and failings of the human intellect into the bargain, the designer and builder of a given technology may not share precisely the same set of foibles and failings of the intellect that afflict the user of a technology. We feel ourselves at a certain distance from such technologies, and we are not entirely at ease with them; we implicitly feel the presence of another intellect that is not *our* intellect. In using a balky software suite, for example, we are effectively living inside the head of a software engineer, and if we do not share the intuitions of the software engineer, we will zig when we should have zagged, and zag when we should have zigged. Early in the history of computing, it was urged that, "The planned general external language should be influenced as little as possible by the peculiarities of the machine; in other words, it should be as close as possible to the thinking of the programmer,"[16] without acknowledging that the thinking of one programmer would not necessarily be the thinking of another programmer.

We experience this frequently, but we have no word to express it, so the experience remains elusive. When the design of technology is counterintuitive, and our way of approaching the same problem, and the solution we would have implemented, would have been different if we had been the designer of the artifact in question, our use of the technology is against the grain of our own instincts, though in most cases we can get the hang of it and adapt ourselves to its use. However, we never fully lose our own intuitive sense of how the technology should have operated, so our adaptation is accompanied by certain unease. Let us call this *techno-dysphoria* and define it as the use of a counterintuitive technology accompanied by depression, anxiety, and agitation.

Techno-dysphoria is the consciousness of the artificiality and conventionality of technology, and, in a sense, the recognition of the difference of the implemented intelligence from our own intelligence. Initially this recognition is mere consciousness of psychic discomfort, elusive and difficult to pin down; only with repetition and an effort to make the discomfort explicit does the consciousness come to full and explicit recognition. The differences among intelligences need not be great to inspire our discomfiture; William James once quoted an acquaintance as saying, "There is very little difference between one man and another; but what little there is, *is very important*."[17]

However, we should also recognize that, while the discomfort of techno-dysphoria is often minimal, there are nonetheless occasions when it rises to revulsion and to the explicit rejection of the technology in question.

VI: Variations on the Theme of Science

The presuppositions of high technology, built upon the presuppositions of technologically advanced science, cut to the core of human identity, so that the Procrustean bed of technology—whether donned as a spacesuit, boarded as a spacecraft, harvested as a greenhouse, or glanced at as a watch—shapes us in ways that

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[16] "Institute for Advanced Study Electronic Computer Project Monthly Progress Report, January 1957," Quoted in George Dyson, *Turing's Cathedral: The Origins of the Digital Universe* (New York: Vintage Books, 2012), 318.

[17] William James, "The Importance of Individuals," in *The Will to Believe, and Other Essays in Popular Philosophy* (New York: Longmans Green & Co., 1912), 257.

we scarcely recognize. We start with an easy example and move on to a more elusive (and therefore easier to ignore, even if more fundamental) example.

Aristotle in his *On the Soul* (*De Anima*) distinguished five human senses (Book 3, Chapter 1)—sometimes called the five canonical senses—even arguing that no other senses are possible.[18] Sensory researchers today do not feel bound by Aristotle's schematism of the senses, and it has become commonplace to recognize forms of kinesthesia, proprioception, interoception, and the gut-brain axis, *inter alia*, as forms of sensation; still, our cognitive reflex is to invoke the five Aristotelian senses, and to be somewhat skeptical about experiences primarily shaped by senses that elude the Aristotelian schematism. In this way, Aristotle continues to shape our perceptions, and science is built upon perceptions, which afford us our evidence of the world.

Imagine a counterfactual science in which the observational terms are not objects seen or heard, but rather are the observations of proprioception and interoception: such a science might be dismissed out of hand as being based on evidence not open to public inspection—but one suspects that the suspicion that would be shown toward such a proposed science would run much deeper than merely a rejection of evidence that is not available to public inspection. In what way is interoception any more private than sight? We could, in theory, monitor and record all electrochemical signals involved in interoception no less than in sight, though this would be technically difficult. It would seem that interoception is only private in the sense that it is internal to our own bodies, though our bodies are in no sense private, being, as they are, corporeal artifacts.

We see (and notice that we *see*, rather than we *feel*), then, that perception, and thus the evidence that is the empirical content of science, is, in part, a cultural artifact formed by a particular tradition of thought. Given a distinct tradition, what counts as scientifically relevant perception, and therefore what counts as scientific evidence, may vary. This is not merely an unlikely possibility that must be admitted in theory, even if acknowledged as unlikely in fact.

Despite the amount of ink that has been spilled on philosophy of science over the past several decades, it is unusual for any philosopher to argue that there can be different forms of science, although it is implicit in Kuhnian philosophy of science that those working in distinct paradigms are engaged in different forms of science. In the Kuhnian framework we can identify diachronic sequences of forms of science, as in the transition from Ptolemaic cosmology to Copernican cosmology. Less familiar is to identify synchronic and competing visions of science, but this position has been argued by Nikolay Yakovlevich Danilevsky in his *Russia and Europe: The Slavic World's Political and Cultural Relations with the Germanic–Roman West* (originally published in 1869).

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[18] Hugh Lawson-Tancred, in a note to his translation, calls this, "a piece of baroque argumentation." Aristotle, *De Anima (On the Soul)* (London: Penguin Books, 1986), 189.

Danilevsky argues that distinct forms of science may be developed by distinct "cultural–historical types" due primarily to three factors:

> 1) the preference shown by different peoples for different branches of knowledge; 2) the natural one-sidedness of each people's distinctive abilities and worldview that cause it to see reality from a unique point of view; 3) a certain admixture of objective truth with individual, subjective peculiarities that (like all other moral qualities and traits) are not randomly distributed among all peoples, but grouped by nationality and, taken collectively, constitute what we call the national character.[19]

Insofar as we recognize that extant scientific knowledge is a finite formalization of a potentially infinite scientific field of knowledge, it should be expected that this finite fragment of potentially infinite knowledge will reflect the interests of the community of researchers engaged in science, overlapping with the science of other communities, but not precisely coinciding. If the community of researchers engaged in a scientific research program is bounded by a cultural–historical type, as Danilevsky argues, then the interests of this cultural–historical type will be expressed in science as Danilevsky has argued, with a preferentiality, a one-sidedness, and an admixture of idiosyncrasies such as were argued above to be the basis of techno-dysphoria.

In a more exhaustive treatment of the particularism of science, we would distinguish the use of distinct presuppositions, focusing on one finite region of knowledge rather than another finite region of knowledge, and the employment of distinct mathematical or logical formalisms for the construction of a theory, any of which might be due to the preferences, the one-sidedness, or the idiosyncrasies of a given research community. Suffice it to say for present purposes that science is not one, but many, although the increasing internationalization of science is converging upon a homogenous universalism.[20] In a future of expanding and diversifying space settlements, the pressure

[19] Nikolay Yakovlevich Danilevsky, *Russia and Europe: The Slavic World's Political and Cultural Relations with the Germanic–Roman West*, trans. and annotated by Stephen M. Woodburn (Bloomington, IN: Slavica, 2013), 112. Note that Woodburn transliterates Danilevsky's name as "Nikolai Iakovlevich Danilevskii."

[20] A recent examination of scientific particularism has been made by Veli Virmajoki, who asks whether science could be interestingly different. Virmajoki approaches the problem by way of contingency, defining the contingentist position as follows: "It could have been the case that science has the feature F* rather than the actual feature F, where the difference between F and F* is considered interesting in the given context of discussion" (Veli Virmajoki, "Could Science Be Interestingly Different?" *Journal of the Philosophy of History* 12, no. 2 (2018), 311. Virmajoki focuses on whether present science could have been different if its history had been contingently different, which implies that future science could be interestingly different if contingent forces in the present should alter its course. Science today, however, is interestingly different *from itself*. Mathematics is interestingly different from physics; moreover, it is interestingly different from physics in a way distinct from the way in which history is interestingly different

for the homogenization of thought will be lessened by an open frontier, and pre-modern degrees of cultural isolation on Earth will be reproduced, and perhaps exceeded, in extraterrestrial space.

VII: Wherever You Go, There You Are

The blank slate aspiration of much speculation on the human future in space openly yearns for a fresh start for humanity in space, in which we will avoid the signal failures of past human societies and instead we will build the utopia we have never been able to construct on Earth. Yet even if we set aside human evolutionary psychology, which we will bring with us wherever we go (unless or until we change human nature—and technology will eventually enable us to change human nature if we choose to develop those technologies). Even if we could somehow set aside the entire human tradition of extant laws and social organization (which seems unlikely, but which cannot be ruled out *a priori*), the fact that we will take our technology with us, and that we will build upon this technology, which is necessary for human life in space, means that we will take the presuppositions built into our technology along with us into space.

Because of human existential reliance upon technology to survive in space, our past, as embodied in science and technology, will necessarily be the basis of our life in space. But while necessary, technology need not be indiscriminate. As we have seen, the technosphere is not experienced uniformly; parts of it fit us like a glove, while other parts inspire us with techno-dysphoria. We are not subject arbitrarily to technology, except in the case where there is only a single technology available to address a given problem, but mostly we have a certain latitude in selecting the technology we will use. Already we do this on Earth by selecting the automobile we drive and the operating system that we use. When eventually there is a space economy, and a multiplicity of industries are in competition to produce the necessities required for human life in space, we will choose those technologies we prefer, insofar as they are available.

In this way, a new technological particularism will come into being. While transportation and communications among communities will need to be standardized to be functional, each individual settlement can be a technosphere unto itself, which is likely to include the technologies that each community will eventually build for its own use. Once the industrial infrastructure in outer space is capable of manufacturing technologies at scale, the peculiarities of the space environment, now all too familiar to space settlers, will enter into the conception and design of technologies for use in space, and a particularism not of Earth will come into being alongside the particularistic technological texture of human life in extraterrestrial space.

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from physics. These interesting differences among branches of science may be contrasted with the possibility of, say, physics that is interestingly different from physics as we know it.

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