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The Goldilocks Theory

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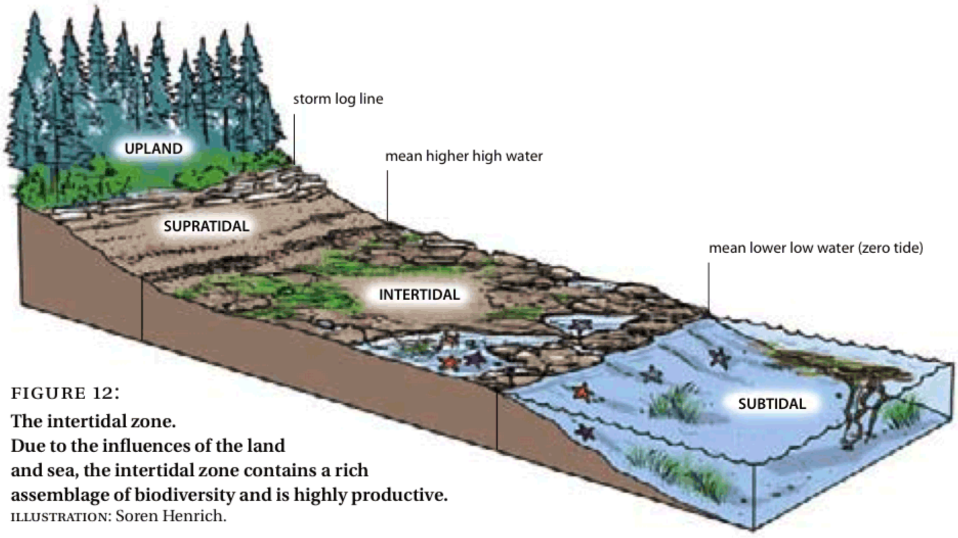
"It's a world not too big, not too small. It's just right."
-Stu Spath, Lockheed Martin Space Systems Company

I frequently come across the 'Goldilocks' analogy in popular reporting on space science. It's used to describe the kind of planet where scientists expect to find life – not a planet that is "too hot" or "too cold," not too far from a sun nor too close… not too large in which case the atmosphere would be crushing and not too small in which case there would be no atmosphere at all.

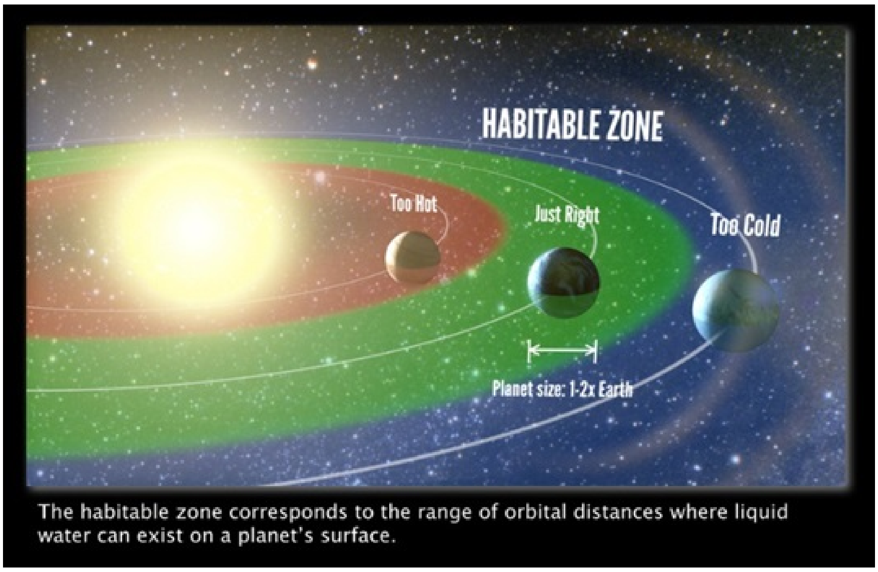
This summer I was sitting on rocky outcrops at the Oregon coast during low tide and watching the sea crash back in over the dense bands of abundant life on the rocks. As I sat, keeping a close eye on whether the tide was going to strand me, I was thinking about the idea in Marine Biology of "intertidal zonation" – that there are bands of life at different zones each of which is adapted to precisely balanced ratios of time underwater and time exposed to the air and sun. There appeared to be, from my position, a band that was particularly dense with life – full of mussels, barnacles, anemones, kelps, and more. This dense band, I imagined, was in a sort of intertidal "Goldilocks" zone, not constantly wet, and not always exposed – but 'just right" to encourage so much life to gather there.



Intertidal Zonation (Image: biodiversitybc.org)

But then I wondered – what if we only looked at the intertidal zone the way the Goldilocks analogy describes potentially habitable planets or planets that might support life? If we did, would we believe that only that thin area on the ocean's coastline is capable of supporting life? Might we thereby rule out the possibility of life elsewhere, ignoring all the diversity of life further up on the land, and across the continents, or the great wealth of life under the sea all the way down to the almost unimaginable world of the thermal vents? We would, it seems, be missing most of the life on earth by focusing on this narrow band that appears to be in just the right zone.

What if the search for life is missing just as much by imagining a specific type of planet in a particular location as representing the "just right" conditions for life. What stops us from expanding our idea of what is possible for life and evolutionary adaptation out there in the vast universe of possibility?



"Just Right" (Image: theregister.co.uk)

When you're sitting on the coastline, it seems hard to imagine that someone might miss the trees on the land, the human cities in the interior, or the whales under the sea. But if you adjust that scene to the massive scale of space – which is, as Douglas Adams (1980) described it so well, "vastly, hugely, mind-bogglingly big" – it becomes easier to imagine. It may be just as challenging for us to imagine life forms that live outside of what we call "habitable planetary conditions" as it once was to imagine life in the the deepest sea. And yet, even now there are still depths of the oceans unexplored.

ASTROBIOLOGY TO ASTROANTHROPOLOGY

While doing research online, I happened across the US Library of Congress subject heading for "Exobiology":

> **Exobiology**
>
> "Here are entered works on the study of processes occurring in outer space that are relevant to biology, especially the origin and evolution of life. Works on the biology of humans or other earth life while in outer space are entered under [Space biology.] Works on life indigenous to outer space are entered under [Life on other planets.] Works on the prospective use of the science of anthropology in dealing with intelligent beings in outer space, or establishing earth colonies on extraterrestrial bodies, are entered under [Extraterrestrial anthropology.]"

That last part caught my eye. Extraterrestrial anthropology? They have a subject heading for that!? So I looked it up:

> **Extraterrestrial anthropology**
>
> "Here are entered works on the prospective use of the science of anthropology in dealing with intelligent beings in outer space, or establishing earth colonies on extraterrestrial bodies. Works on life indigenous to outer space are entered under [Life on other planets.] Works on the study of

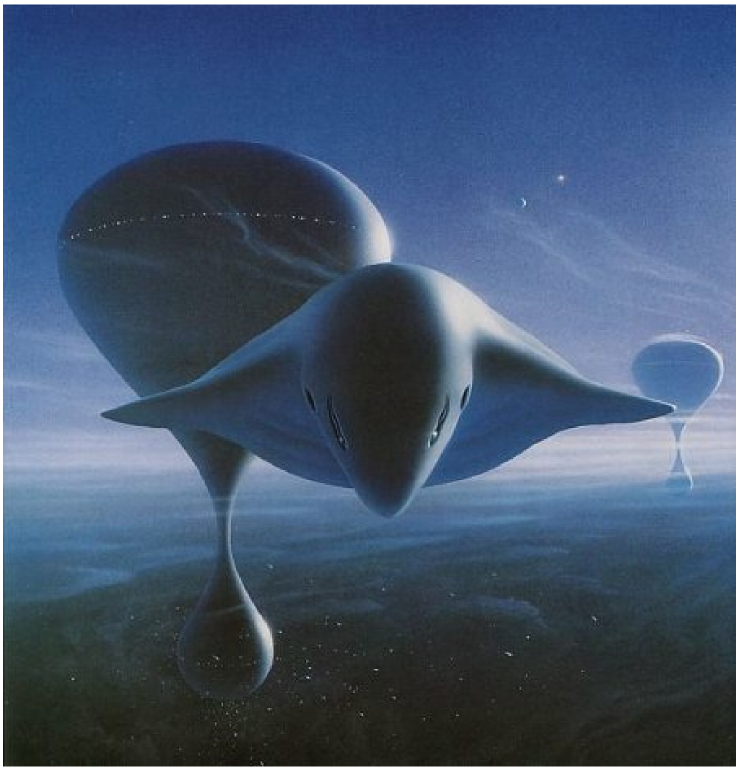
> processes occurring in outer space that are relevant to biology, especially the origin and evolution of life, are entered under [Exobiology.] Works on the biology of humans or other earth life while in outer space are entered under [Space biology.]"

It isn't that I hadn't thought about these things before. "Life indigenous to outer space" … "intelligent beings in outer space"…. these are topics that I've been thinking about for a while. I've previously written about what to call the field, this "anthropology of space" that I am proposing to both study and help to build. At the time of my blog post I made a distinction between two subfields: astroanthropology and exoanthropology. I decided on these terms by drawing from biology, where I imagined that a similar division exists.

In biology, astrobiology is the study of life – much of what I've read says it's concerned with the "origins, evolution and distribution" of life. Whereas I always thought of exobiology as more interested in life off of the planet Earth – life elsewhere, life *other*.

And so I argued in my blog post that astroanthropology should be the study of what I called "Terran culture" in space (because Terran sounds so much more sci-fi than the mundane and familiar "Earth"). And I chose exoanthropology for the study of culture elsewhere, culture *other*. This doesn't mirror the divisions in biology in which astrobiology encompasses exobiology – and yet in a sense it does reflect that idea of encompassing because, ostensibly, wherever exoanthropology is taking place we (or some robotic or other extension of us) is there doing it. So I suppose there is always astroanthropology wherever exoanthropology occurs – but not vice versa.

Why even bother with this distinction? As I think of them, exobiologists are the ones who not only look for life on Mars or on Europa – they are also the biologists who speculate. They wonder what life *might* look like elsewhere. They get to wear the "hard science" outfit while devoting a great deal of time to imagining (very scientifically of course) what kind of flying whales might live in the liquid atmosphere of a gas giant…



Speculative Gas Giant Life Forms as calculated by astrophysicists Carl Sagan and Edwin Ernest Salpeter in 1976 (Illustrattion by Adolf Schaller)

It turns out I did not have to look far to imagine the kind of critiques a field of exoanthropology might face, there is a precedent for it in exobiology. Biologist George Gaylord Simpson famous 1964 critique of exobiology was simply: “in view of the fact that this ‘science’ has yet to demonstrate that its subject matter exists!” Talk about a crisis of representation.

As I began to write about these terms astrobiology and exobiology, I realized that I did not know their history. A quick search online reveals one history of astrobiology compiled by Chyba and Hand (2005), who are affiliated with the SETI institute and Stanford’s Department of Geological and Environmental Sciences. They cite the NASA Astrobiology Institute (NAI) who define astrobiology as “the study of the living universe” (NAI 2004; Chyba and Hand 2005:31).

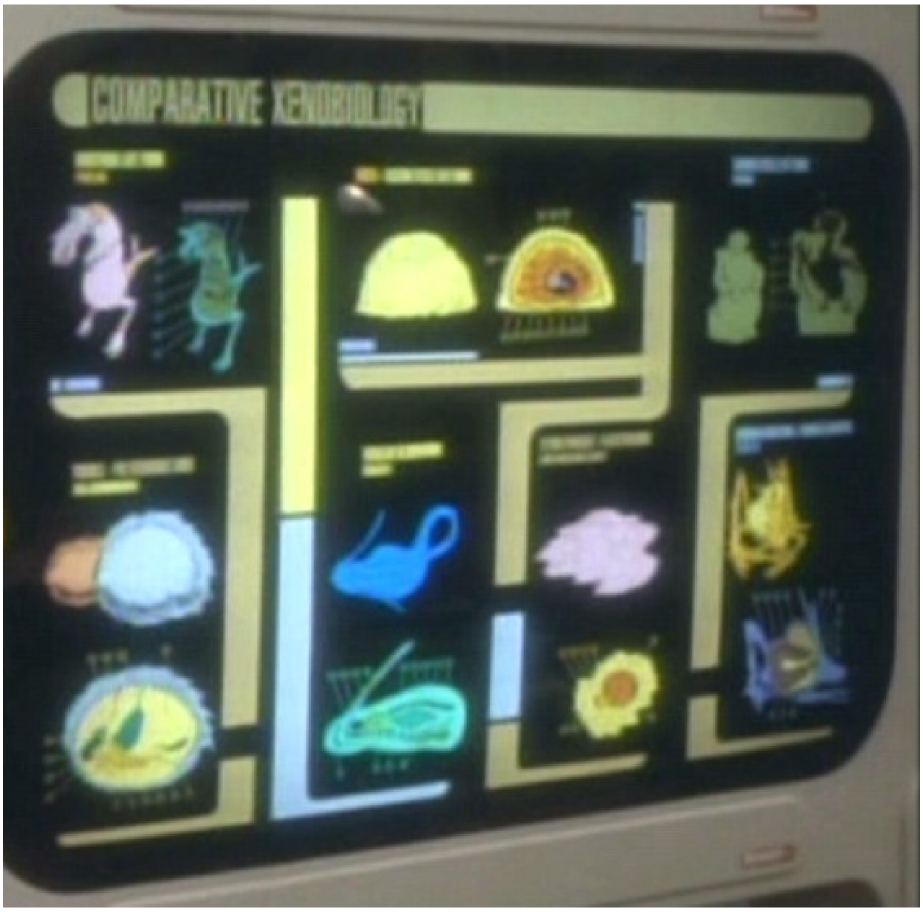
Chyba and Hand also dig up the origin of the word “exobiology” which they place with the biologist Joshua Lederberg (1960) and they note it continues to be used, however, more often by the European Space Agency (ESA) than by the U.S. agency NASA (2005:31).

Chyba and Hand also offer a great response to George Gaylord Simpson’s critique of astrobiology/exobiology. Their response highlights the ways in which discussing the subject of alien life without evidence of its existence is far more loaded than discussing other scientific research areas that may be just as ontologically challenged:

“If exobiology (or astrobiology) were understood to mean solely the study of extraterrestrial life—which it is not—Simpson’s criticism would remain strictly true but might nevertheless seem bizarre to many astronomers or physicists. Astro-physicists, after all, spent decades studying and searching for black holes before accumulating today’s compelling evidence that they exist (Melia & Falcke 2001). The same can be said for the search for room-temperature superconductors, proton decay, violations of special relativity, or for that matter the Higgs boson. Indeed, much of the most important and exciting research in astronomy and physics is concerned exactly with the study of objects or phenomena whose existence has not been demonstrated—and that may, in fact, turn out not to exist. In this sense astrobiology merely confronts what is a familiar, even commonplace situation in many of its sister sciences.” (2005:32)

When Joshua Lederberg coined the term “exobiology” in his 1960 article, I wonder what he meant? Turning to that 1960 issue of “Science” I find that at the time of publication Lederberg was a professor of genetics at Stanford University Medical Center, in Palo Alto, California. The article, titled “Exobiology: Approaches to Life beyond the Earth,” was a paper presented at the “1st International Space Science Symposium” in Nice, France. In the paper he makes a case for beginning “exobiological studies” prior to any ability to travel to and investigate other planets, arguing that “we are obliged to weigh the most productive experiments that we can do by remote instrumentation in early flights, whether or not manned [sic] space flight eventually plays a role in scientific exploration” (1960:393). Imagine an anthropologist saying “we should begin the participant observation before we arrive at the fieldsite” – the first question might be: ok, but… how?

Lederberg laments the inability of biology to find an “abstract definition of life” which would allow for the discipline to construct a “theoretical biology as a cognate of theoretical physics or chemistry” (1960:394). He wonders what might be required to come up with a “theory of life,” or a “potentially universal principle” in biology – noting the only candidate at the time is the “Darwinian concept of evolution through natural selection” (Lederberg 1960:394). What would “theoretical anthropology” look like? Or do we already have it in the works of authors like Le Guin?



"Comparative Xenobiology" computer interface in a classroom. (Image: Star Trek: The Next Generation)

Lederberg concludes the "overriding objective of exobiological research is to compare the over-all patterns of chemical evolution of the planets, stressing those features which are globally characteristic of each them" (1960:394). In this way, Lederberg's exobiology begins with life on Earth and looks for patterns here – searching for shared biochemical components. Reading this far brought me to the first image in his article, molecular maps of the nucleic acids Adenine, Guanine, Thymine, and Cytosine – the building blocks of DNA.

If life on earth is made up of DNA, and this kind of DNA, would life elsewhere be the same? This depends, perhaps, on how that life originated. The origin of life turns out to be a question that astrobiology is interested in. Since the time Chyba and Hand quoted from NASA's definition of astrobiology, that definition has been updated. As of Sept 2014 it now says:

> "Astrobiology is the study of the origin, evolution, distribution, and future of life in the universe. This multidisciplinary field encompasses the search for habitable environments in our Solar System and habitable planets outside our Solar System, the search for evidence of prebiotic chemistry and life on Mars and other bodies in our Solar System, laboratory and field research into the origins and early evolution of life on Earth, and studies of the potential for life to adapt to challenges on Earth and in space."

Chyba and Hand's original link to the NASA page about astrobiology at NASA was old enough that the address had changed – but it resolved into a new page which led me to this fascinating citation:

> Dick, Steven J., and James E. Strick 2005 The Living Universe : NASA and the Development of Astrobiology. The Living Universe : NASA and the Development of Astrobiology, by S.J. Dick and J.E. Strick. New Brunswick, NJ: Rutgers University Press, 2005 -1.

The title peaked my interest and I looked up Steven Dick – it turns out he was the chief historian and Director of the History Division at NASA from 2003-2009 and that he has also written an even more interesting article titled "Anthropology and the Search for Extraterrestrial Intelligence: An Historical View" (2006) in which he writes:

> "In this paper I want to examine the role that anthropology has historically played in SETI, and how the two intellectual cultures of natural scientists and social scientists made contact. I argue that these historical interactions bode well for beneficial mutual interactions between anthropology and SETI in the future. What has been lacking is a systematic approach applying anthropology to the search for extraterrestrial intelligence. There is considerable evidence that such study would be rewarding for both disciplines." [2006:3]

My current major research project asks: How do we "apply anthropology" to SETI, to space science, and to space exploration? In trying to apply anthropology to projects like SETI, one approach might be to do the anthropology of science and technology – in which anthropological methods are used to study the scientists who in turn study space. Another complimentary approach could apply anthropological methods not only to those communities of scientists but to the *problems* they are working on. Again, however, we run into the question: how can we do an anthropological study of something we haven't found yet? Isn't that even worse than the armchair anthropology the discipline has been trying to escape for a century? And if we use the model of biologists for a speculative exoanthropology, my first concern is that we end up with something like Levi-Strass's idea of a periodic table of cultural elements from which any possible culture might be constructed. Some might like that idea – but it has always felt fundamentally misguided to me with its biologically deterministic assumptions about the driving forces behind emergent complexity.

Instead, I think we can start with inter-species relationships here on Earth. What are our relationships like with the other intelligent life around us? With Cetacea (dolphins and whales), with insects, with birds, and pigs, and other primates? Multispecies ethnography becomes an important launching point for an anthropology of the alien. If we imagine communicating with an extraterrestrial intelligence, we must imagine a challenge even greater than communicating with other life here on Earth with whom we share a great deal in common. There are efforts to this end, for example Denise Herzing's work on The Wild Dolphin Project which approaches dolphins as ethnographic subjects to gather "information on the natural history of these dolphins, including dolphin behaviors, social structure, dolphin communication, and habitat."

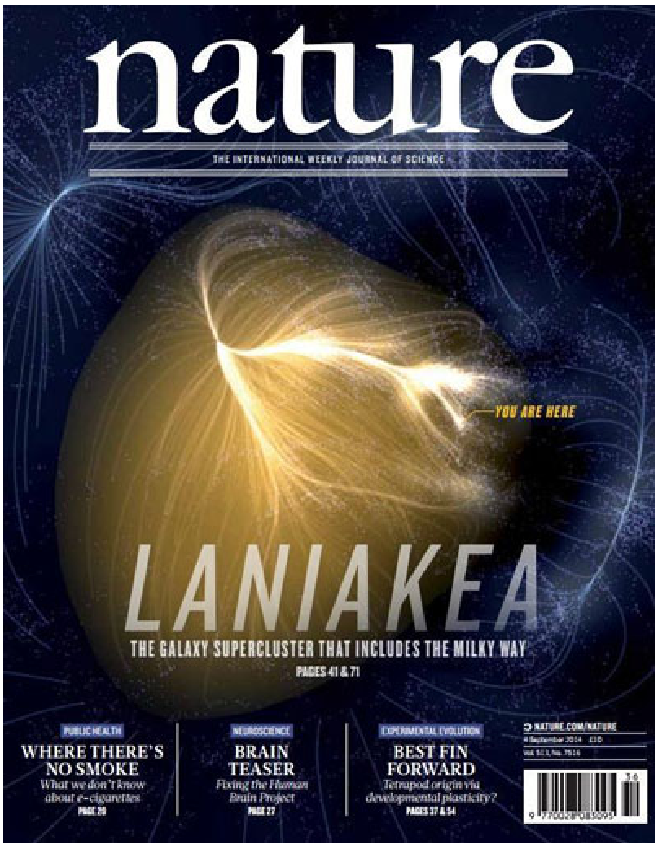
MAPPING INNER AND OUTER SPACE

In their introduction to "Extreme: Limits and Horizons in the Once and Future Cosmos," Valentine et al. propose one way to theorize and analyze around the tensions at the turbulent boundary areas of the existent and the speculative:

> " […] to move beyond the banalities of newness, analysts must examine how contemporary experiences of embodied extremity are co-productions of the actual and the unexpected, science and science fiction, the present and the future, and of humanness as an enduring and transitory status. the extreme, as site of analysis, is powerful precisely because it captures this relational co-productivity within the tension be- tween limit and horizon. We draw on the figure of extreme not to explain away fantasies of the future, or of the beginnings and ends of life, but to consider them seriously in their own relational terms." [2012:1020]

There is a precedent for a discipline theorizing at these boundaries of the "actual and unexpected," for doing work on a thing yet to be discovered: cartography. The meeting of cartography and space has led to recent efforts to map the universe by tackling expanses of space that are 500 million light-years across. R. Brent Tully and his team have mapped an area of the universe and named it "Laniakea" a Hawaiian word he translates as "immeasurable heaven" and which he describes as "Our Home Supercluster of Galaxies." I like the doubt he infuses in the measuring by naming it immeasurable.

Nice touch… While this is unimaginable for most of us – for Tully and his team it is everyday work. As Valentine et al. write: “the extreme is neither ephemeral nor exotic for its practitioners; they work daily in the extreme, and they are pragmatic about it” (2012:1020).



Cover of Nature showing a visualization of “Laniakea” (Image: Nature)

Mapping also provides a useful metaphor for thinking about how we*construct* space while we also *explore* it. We aren’t simply finding what’s there, we’re building it. That place is “Mars,” and that geologic feature on Mars where the Curiosity rover is exploring now is called “Gale Crater,” and so on. These processes of naming and mapping are part of what turn spaces into places.

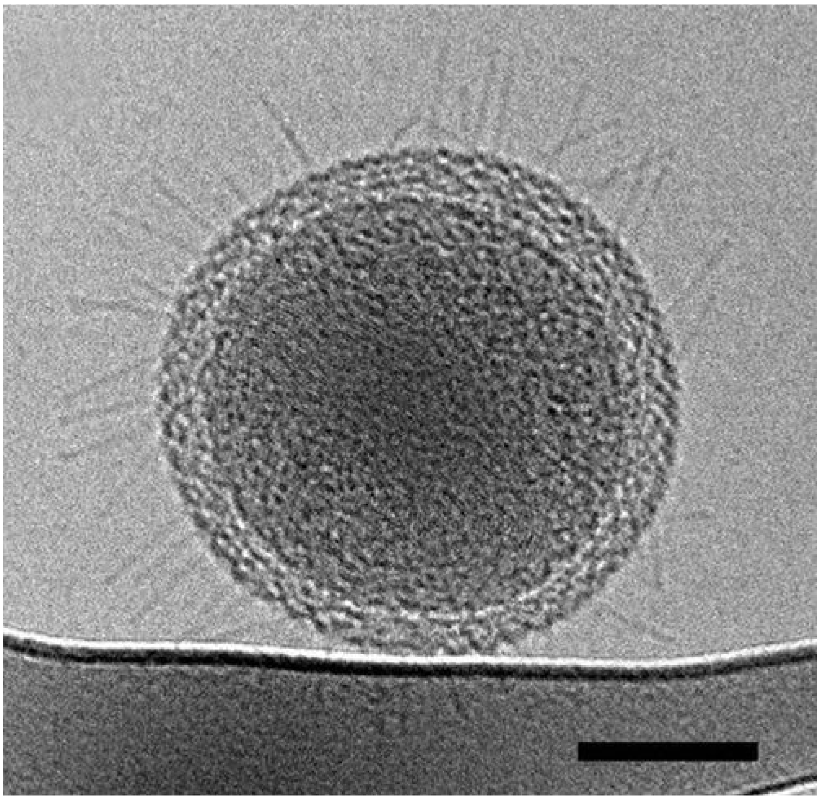
The construction of space as place is not only about geography and naming, but also the production of photography and other kinds of images. Images of space aren’t usually the same kind of “actual” photographs we’re used to seeing, but rather artist’s renditions, speculations, recreations, or other kinds of interpretations. Some are composites, some are colour-corrected or modified, edited, or changed into an image believed to be more like those viewers expect to see. Often they are colour-corrected so the surface of Mars or a galaxy, or whatever we’re looking at appears as it might if it were on Earth or if our eyes worked the same way as a telescope’s image processors.

Emission nebula NGC 604, in the nearby galaxy M33. Color as published (left) and as the human eye would see it (right). (Image: Donald E. Davis)

Why do we need this translation – this shift into a familiar experience? Is it because Mars might be disappointing if we looked at it as it is? But then again, how *is* it? No human has ever looked at it without some form of mediation – through a camera, through a telescope, through a computer which processes the camera data, through a satellite which transmits that data, and so on.

The space interested public seems to be more forgiving when it comes to images of space. Perhaps we do not demand the same kind of 'authentic' depiction that we do from other representations because space begins as an impossibly alien place in our imagination, such an *immeasurable heaven* that we welcome any help in conceptualizing it. The scope of acceptable modifications to images in popular culture seems to expand and constrict over time – but within science, outer space seems to be given a great deal of latitude for such modified images.

This is also true with the microscopic, atomic, and subatomic. Scientists from the Lawrence Berkeley National Laboratory and the University of California, Berkeley have captured the first detailed microscopy images of what are believed to be the smallest life on Earth. These ultra-small bacteria are cells with "an average volume of 0.009 cubic microns (one micron is one millionth of a meter)." This is a scale of life that we don't yet understand, we don't know the role it plays here on our own planet.



“Cryo-transmission electron microscopy of an ultra-small bacteria cell. The scale bar is 100 nanometers.” (Image: Berkeley Lab)

Both vast and tiny imaginative worlds are made *as* we imagine them, and understood only as they are modelled through imagination. We can not see or interact with them as we do with other things closer to our scale. Seeing them as we would see or not see them isn’t especially interesting or useful because they are mostly invisible to us and our perceptive senses, and so both inner and outer spaces become places we have to construct both conceptually and visually every time we talk about them. The popularly shared images in science are most often of things that can’t be percieved in the form they’re depicted, they are long exposures, x-ray or radio waves mapped to colour, celestial phenomena long since dead, cells stained and sliced, tardigrades in CGI, or cryo-transmission electron microscopy of an ultra-small bacteria cell. These manufactured, technological depictions ranging from the nano-scale to the hyperobject, demand our imagination to believe they exist and with that an ontology that can make friends with a scientific reality.

So as we imagine life elsewhere, life other, we also construct it and its possible parameters. Considering the possibility of such life outside of what we know or believe to be the conditions requisite for life, outside of the Goldilocks zone, might mean finding the wonderfully unexpected; if only because we managed to summon enough imagination to look elsewhere.

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