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Special Issue: Honoring the Legacy of Dr. Joel D. Isaacson

Dedication

This special issue of the *Journal of Space Philosophy* on recursive distinctioning is dedicated to the memory of Joel Isaacson. It is also dedicated to the memory of Bob Krone, the founding Editor-in-Chief, who sadly died during the preparation of this issue.

Gordon Arthur, Editor-in-Chief
Mark Wagner, Associate Editor

Preface

Gordon Arthur and Mark Wagner

This issue marks a transition in the history of the journal. Bob Krone, the founding Editor-in-Chief retired in August 2021 due to ill health and died the following month, both while this issue was in preparation. Consequently, Gordon Arthur has taken over as Editor-in-Chief and Mark Wagner has joined as Associate Editor. Mark is President of the Space Prize Foundation, a new Faculty member at Kepler Space Institute, and the author of a forthcoming book on Space Education. A more complete biography for Mark is below.

It is our intention to continue along the path Bob set for the journal, both to honour him and because it is the right thing to do. I am continuing in my production role, while Mark has taken over commissioning articles and organising peer reviews. This means that while I now have overall responsibility for the journal, Mark will be the first point of contact for most authors. We continue to seek and publish papers on why humans should go to space and what constructive things we might do there.

Henceforth, we will be working to firm deadlines. We will need to receive articles for the Spring issue not later than March 1 each year and articles for the Fall issue not later than September 1 each year. Publication should follow about two months later, in May and November. Please send all articles for consideration to Mark at markdwagner@gmail.com.

Mark Wagner, Ph.D.

Dr. Mark Wagner serves as President of the Space Prize Foundation, a non-profit organization focused on promoting STEM education and increasing the representation of women in aerospace careers. He also teaches the Space Education graduate certificate program at Kepler Space Institute and is the Associate Editor of the *Journal of Space Philosophy*. In addition, he is the founder of ARES Learning, a vision for schools that prepare students with the skill sets and mindsets they will need to be successful in the growing space economy—and in humanity's rapidly approaching multi-planet future.

As an educator, Dr. Wagner began his career as a high-school English teacher, later serving as an Educational Technology Coordinator at the site, district, and county level. In 2006 he launched EdTechTeam, a professional development company dedicated to inspiring and empowering educators around the world. Annually EdTechTeam served

50,000 educators through over 100 conference-style events and hundreds of workshops in dozens of countries. EdTechTeam was recognized as the Google for Education Partner of the Year in 2018. However, Mark was a lifelong space enthusiast, having attended Space Camp twice while growing up, and having originally gone to school for astronautical engineering. Now he is thrilled to apply his educational technology experience in the growing field of space education.

Mark Wagner has a PhD in Educational Technology and a master's degree in Cross-Cultural Education. He also holds graduate certificates in Space Education and Space Philosophy. He is the author of More Now: A Message from The Future for The Educators of Today (2018) and a forthcoming book about Space Education, which explores both current opportunities on Earth, and the possibilities for teaching students on the Moon, on Mars, and in deep space habitats.

Outside his work, Mark loves playing hockey, practicing martial arts, and obsessing over his '62 beetle, which now runs on an electric motor and Tesla batteries. He is a certified health coach and biohacking enthusiast, who also enjoys songwriting, spending time in nature, and exploring the world with his friends and family.

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Contents

Access to the Journal of Space Philosophy and free downloading of its articles is available at www.keplerspaceinstitute.com/jsp. Anyone on Earth or in space may submit an article or letter to the editor to markdwagner@gmail.com.

Kepler Space Institute: Notes from the Chair

KSI Faculty, Students, and Friends:

As many of you know, KSI has experienced the great loss of its beloved President Dr. Robert Krone.

Bob was a mentor and friend to so many of us and the reason that Kepler Space Institute is what it is today. He brought us together as a group, he inspired us with his vision that Space Settlement and Exploration will benefit mankind, and he showed each of us that we had a role to play in making that vision a reality. Bob can never be replaced, only succeeded.

Bob's parting words to the KSI Board (only three weeks before his passing) were "KSI has reached beyond my wildest dreams. Thank you."

The Board of Directors would like to take this opportunity to assure each of you that KSI's daily operations will continue to be managed by our CEO Haroon Oqab and CFO Naté Sushereba, along with the continued input and wise advisement of our Board of Directors Ed Kiker, Fred Gainous, Jack Cowan, and Kat Krone. It is our solemn duty to protect the continuity of Bob's vision and diligently work towards its fruition.

In the coming weeks, we will be rolling out a memorial page for Bob hosted on the Kepler Space Institute website. Content for this page will come from a large group of people whom Bob inspired to become involved in the work we are doing.

At this time, we would like to ask each of you to submit any thoughts, wishes, stories, experiences, photographs, or videos you may have of Bob pertaining to KSI, to be added to this permanent website page.

As always, please feel free to reach out to the Board of Directors.

EDWARD B. KIKER
Chairman of the Board

Joel Isaacson's Creations: Reborn in a Smile of Content

By Bernd Schmeikal

Science should talk about reality. But that which is real is not what we imagine. Those who make science flourish have not bound their minds to the truth of the mainstream. They do not shape the truth, but the reality. Isaacson's worldview probably even transcended this time-honored difference between truth and reality. His Dialectical Image Processor (DIP) is capable of processing such differences, far from predetermination by programs in a primordial, natural, blind, purposeless, and primitive fashion.[1] It asks the impossible question and creates new reality in a dialectical synthesis of the unconscious and the conscious

Joel Isaacson's creation resonates with primordial states of infant awareness in *early face perception*. "The DIP-cycle of the eyes, realized in the actual infant as spatiotemporal patterns of neural activity in the lateral geniculate nucleus"[2] is like a pair of flickering beacons that yield an internal sensation (or impression) that attracts the attention of the cognitive subject. That internal sensation is at a pre-perception level and obviously also at a pre-recognition level. "Our infant is born with no innate ideas about human faces and their various features, but with a 'hard-wired' innate facility to DIP nearly featureless faces."[3] Joel's enormous empathy was located in the touch zone of life and death. He was one of the last geniuses on this earth.

In our mails, at times we talked about the recently born and the just deceased. When my mother died, Joel mentioned he was still missing his mother, saying, "You are grieving the loss of your mother which is natural. There is no remedy, but time may ease the pain eventually," and occasionally he would end his letters with "love, Joel" or "my very best, Joel."

> The infant is able over a period of a few more weeks to make his first successful recognition of some basic facial features. No wonder, then, that Baby smiles back to Mom when that happens. For Baby not only anticipated

[1] Referring to features of the *intellector* that basic systems have "no programming capabilities, and, regardless of the type of input, the same type of 35 manipulations is applied in a blind, purposeless, and primitive fashion" (Joel Isaacson, Autonomic String-Manipulation System, US Patent 4286330, filed April 26, 1979 and issued August 25, 1981), 9. Actually "DIP is a 2-D 256-state Moore-neighborhood cellular-automaton. It is basically a tightly knit massive network of highly interacting BIPs (Basic INTELLECTOR Process). Since each BIP alone is on the order of the complexity of Wolfram' s Rule 126 (or higher) I conjecture that DIP may be a candidate for a universal computer, perhaps in its unbounded mode" (Joel D. Isaacson, "Dialectical Machine Vision: Applications of Dialectical Signal-Processing to Multiple Sensor Technologies," Report IMI-FR-N00014-86-C-0805, Washington, DC: Strategic Defense Initiative Organization, 1981, 26).

[2] Isaacson, "Dialectical Machine Vision," 72.

[3] Isaacson, "Dialectical Machine Vision," 70.

> a "smiling mouth" to return a smile to, but Baby also just completed one of his first feature-recognition acts, which amounts to one of his first successful discoveries from the real world. And just like with adults, an internal sensation of resonance between stored ideas and the real world does apparently merit a smile of content.[4]

I had just celebrated my 75th birthday when Bettina Schmeikal called me up and told me Bob Krone had been trying to reach me: Joel Isaacson passed on May 17, 2021.[5] On the 16th, one day before, there had been a resonance in my soul. I wrote a mail to Joel[6] with the subject: *The Reborn and Us—Lina, Tilda, and Johannes* (my newborn granddaughter Lina, my first granddaughter Tilda, and my son Joe). I wrote "Dear Joel: Bob (Krone) and Lou (Kauffman) gave me an impulse by emails. What about you, dear Joel? Unfortunately, I cannot figure out how you feel!" All of a sudden, a void that had already lasted ten months opened up towards the unknown otherness of no-time.

Joel's passing is a sudden loss to us personally, and to science as a whole. Then, in May, we did not yet sense the real extension of this loss. Bob, Colonel Professor Robert Krone, was a friend of Joel, and my only coauthor at ResearchGate. On May 26, Bob wrote us (Bernd and Bettina), "You have published the most complimentary things about Joel."[7] Bob mentioned the *Editors' Notes* that appreciated my "review and evaluation of Joel Isaacson and Louis Kauffman's RD research and paper, published in the *Journal of Space Philosophy*, as a very valuable contribution to this forefront science investigation of Nature's Cosmic Intelligence." On May 28, Bob wrote me he had "sent an invitation to the RD Group," saying "You were the scientist that interjected Sociology into the RD discussion, which I very much appreciated." He asked me to write an article for Joel.[8] "We can all figure out a title for the Special Issue. maybe something like 'Honoring the Legacy of Dr. Joel D. Isaacson' and the first quote for the issue could be: 'our universe may be a representation of Isaacson's system, and entertainingly, with his US Patent specification 4,286,330, it seems he has patented creation.'"[9]

Bob predicted, "your contribution to the Special Issue will have personal compassion, ingenuity, and thoughts for readers to seriously contemplate. Gordon Arthur and I have not set a publication date but…" The older I get, the more quickly my friends and colleagues pass away. I cannot keep up with the writing. According to a press release from the National Space Society posted on Wednesday, September 22, "Robert 'Bob' Krone, founder of the Kepler Space Institute (KSI) and longtime supporter of the National Space

[4] Isaacson, "Dialectical Machine Vision," 68.
[5] Email from Bob Krone to Bettina Schmeikal, May 25, 2021.
[6] Email from Bernd Schmeikal to Joel Isaacson, May 16, 2021.
[7] Email from Bob Krone to Bernd and Bettina Schmeikal, May 26, 2021.
[8] Email from Bob Krone to Bernd and Bettina Schmeikal, May 26, 2021.
[9] Bernd Schmeikal, "Basic Intelligence Processing Space," *Journal of Space Philosophy* 5, no. 1 (Spring 2016): 65-88.

Society (NSS), passed away peacefully in the presence of his family on September 15, 2021. He was 91 years old."[10]

On August 12, Gordon Arthur had informed me "There has been a changing of the guard at JSP, with Bob Krone retiring as editor-in-chief due to ill health. I have inherited the title of editor-in-chief and Mark Wagner is now the associate editor." He asked me "Could you please give us a status update on JSP? Are you writing an article for the special issue commemorating Joel Isaacson, and if so, when is it likely to be ready?"[11] As a matter of fact, I too am mortal, and I already know what I am probably going to die of, CLL, chronic lymphocytic leukemia. But the good guys in the editorial board gave me an impulse: "Hopefully Bernd is still interested in submitting an article…" Okay then, let us go into those matters slowly, let us ask if it is true that with US Patent 4,286,330, Joel patented creation.

Karl Müller, with whom I had been working for thirty years, showed me the cybernetic articles of Kauffman. Around the turn of the millennium, I had familiarized myself with most of Kauffman's articles published up to that time in mathematics and mathematical physics. Personally, I met him first at the fifth International Heinz von Foerster Conference on the occasion of Heinz von Foerster's 100th birthday in November 2011.[12] Over time, we developed an exciting discussion about Majorana spinors. Occasionally the two of us were quite enthusiastic. On one of these days in one of our numerous emails, Lou wrote to me,

> Dear Bernd, I am in the process of writing about Majorana spinors and topological quantum computation. I will send you something soon. I would certainly be interested in hearing more of your thoughts. Here is a short version of what I am working on. The simplest instance of all of this is the elemental iterant [1,-1] = e and the time shifter TAU with eTAU = -TAUe."… Since all this is coming from fundamental self-reference going into a primordial clock, it is astonishing how much comes from nothing!… *Then there are the Majorana Fermions c that satisfy c* = c* so that they are their

[10] "SPACEREF, The National Space Society Mourns the Passing of Robert Krone, Founder of the Kepler Space Institute," Press Release, Posted Wednesday, September 22, 2021, www.spaceref.com/news/viewpr.html?pid=58308.

[11] Email from Gordon Arthur to Bernd Schmeikal, August 12, 2021.

[12] Louis H. Kauffman, "Eigenforms and Eigenvalues—Cybernetics and Physics," Dedication: To Heinz on his 100th Birthday, arxiv.org/ftp/arxiv/papers/1109/1109.1892.pdf. Organizing Institutions: Heinz von Foerster Gesellschaft/Wien; ASC – American Society for Cybernetics; WISDOM – Wiener Institut für sozialwissenschaftliche Dokumentation und Methodik; Institut für Zeitgeschichte | Universität Wien; AINS – Austrian Institute for Nonlinear Studies.

> own anti-particle. There is a lot of interest in these as quasi-particles, and they are related to braiding and to topological quantum computing.[13]

I was excited about this approach, and there unfolded some two years' discourse that slowed down only after Kauffman suggested that it would be better if we continued to work independently of each other. But by then, he had asked me if I could help to support an older friend of his, Joel Isaacson. In October 2015, Joel had sent me three of his most important papers, "Dialectical Machine Vision: Applications of Dialectical Signal-Processing to Multiple Sensor Technologies," "Autonomic String-Manipulation System," and "Steganogramic Representation of the Baryon Octet in Cellular Automata."[14] It was utterly clear that the topic was still high energy physics (HEPhy) but now connected with informatics. In November 2015 Kauffman told me: "Bernd, I think that you can make a contribution by helping to reconcile the difference between your 4-icon alphabet and the RD 4-icon alphabet. The object is to figure out a link from RD to Clifford algebra and Minkowski space."[15]

How surprised had I been when Joel Isaacson sent me his paper "Steganogramic Representation of the Baryon Octet in Cellular Automata." How could the emergence of the baryon octet, how could a hadronic decay be understood by just taking into account equality or inequality with nearest neighbors? But as a matter of fact, by filtering in several simple ways, Isaacson found very obvious similarities to some graphics high energy physicists were rather familiar with. So, I agreed to go into that matter and found out about some relevant relations between Joel's tetracoding line-processors and the Lie-algebra of strong interaction.[16] Line processing of the SU(3) algebra extracted from some Clifford Space-Time Algebra was indeed possible; but then one needed some peculiar line representation, including iterants, swap gates, and imaginary units. Anyway, it gave us the whole special unitary group of SU(3) and not just some part of it.

To justify my plea and defend Joel's intuition, a little story he sent me:

> I wrote Stegano around 1996 but kept it in my desk drawer. In December 1999, I decided to send it to *Nature* for publication for the new millennium. It came back in the mail in two days—they never even sent it for review. In those days, they published a few short articles by Wolfram, and I thought they had some interest in Cellular Automata. Bob Krone wrote to them on my behalf, but they responded that this is not a topic that falls within the

[13] Louis H. Kauffman, "Dear Bernd, I am in the process of writing about Majorana spinors," Archive of personal letters, January 22, 2013.

[14] Isaacson, "Autonomic String-Manipulation System"; Isaacson, "Dialectical Machine Vision"; Joel D. Isaacson, "Steganogramic Representation of the Baryon Octet in Cellular Automatons," www.scribd.com/document/36327492/stegano.

[15] Bernd Schmeikal, "LW to Joel and Lou," Archive of personal letters, November 11, 2015.

[16] Schmeikal, "Basic Intelligence Processing Space."

> scope of science, or something to that effect. On my next visit to Washington (where I maintained an apartment at that time), I decided to go to the editorial offices of *Nature*, just a few city blocks away from my apartment. I was then in my early 60s. They are not used to have people visit their offices in person, and the receptionist was surprised. A young assistant editor, a woman in her 20s, came out to discuss the matter. She asked for the name of the article, and I said "Steganogramic Representation of the Baryon Octet in Cellular Automatons." She could not pronounce "steganogramic" and had no idea what it means; never heard of baryons; thought that octet has to do with music; and knew nothing about cellular automatons. She thought it was a random word salad. She was polite and asked for explanations. I started talking about CA, but her eyes glazed over, and she became impatient. After a while she stood up, took me by the hand toward the door and said something like: "You must be tired and overworked. We only publish on scientific matters. Why won't you go home, take a rest and write something else — then we'll talk…" and she walked away.[17]

The initiated gatekeepers of *Nature* seemed to share this attitude at that time. Interesting that *Nature* considered itself to represent nature, scientifically, so to speak. With Wolfram today that attitude has probably changed. In 1983 Stephen Wolfram proposed a scheme, known as the Wolfram code. Joel, applying his tetracoding in "Autonomic String-Manipulation System," may be said to have picked out Wolfram 129 or its dual 126,[18] which, indeed, was an excellent move, but that was long before Wolfram. Stephen Wolfram lived and worked later, residing somewhere in between Feynman and Gell-Mann at Caltech; and the latter had introduced strangeness and all the rest of it. Could Gell-Mann have had shown Wolfram how it all goes? Definitely not. Gell-Mann avoided this new kind of science. Strangeness and color require more and different rules. Why? Because hadrons cannot be made by just left and right neighbors as in the Wolfram code. But what was going on? Was there suddenly something like *automatic physics*, and if so, since when? I do not know how many scientists are now working within the format of Wolfram. Search for "Topics" or "Participate" in the Wolfram Demonstrations Project, and you realize how open source and copyrights are working.[19]

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[17] Bernd Schmeikal, "Artificial Physics," January 2020, Project: Space Philosophy and Meta-Informatics. www.researchgate.net/publication/338345772_Artificial_Physics.

[18] See devinacker.github.io/celldemo/.

[19] Letter to Joel Isaacson, September 6, 2019; Wolfram Demonstrations Project, published March 7, 2011, demonstrations.wolfram.com; "Evolution of Matter from a Quark-Gluon Plasma," demonstrations.wolfram.com/EvolutionOfMatterFromAQuarkGluonPlasma

Isaacson's spill-over for HEPhy may have seemed playful and childlike. But this game is very significant. It holds a secret that was familiar to Joel: in both pre- and postnatal psychology, as well as in physics, orientation morphemes play an authoritative role. DIP-based neural networks, with their special environmental filters, know about the orientation structure of perception. Consider his paper "Steganogramic Representation of the Baryon Octet in Cellular Automatons"; let me call it the archaic steganogramic representation.

The first figure in Isaacson's steganogramic representation of the baryon octet uses a rule related to Wolfram Rule 129 to generate a familiar pattern from a single seed. One may begin with line

... 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...

with the zero representing the *seed*. Coding for distinction/indistinction between states of adjacent sites, four states can be represented by the ideographic symbols: "O," "]," "[," and "="; or the equivalent symbols "s," "u," "d," and "=." Such a 4-state nearest-neighbor (k = 4, r = 1) rule refers to *tetracoding*. Tetracoding the first line, he thus obtains

... = = = = = = = = = = = = = = =] O [= = = = = = = = = = = = = = = ...

Tetracoding the whole pattern line after line, using the symbols s," "u," "d," and "=" (denoted as the first filter) and applying a second filter that filters out all but three select symbols in each of the ten structures, Figure 1 comes up.

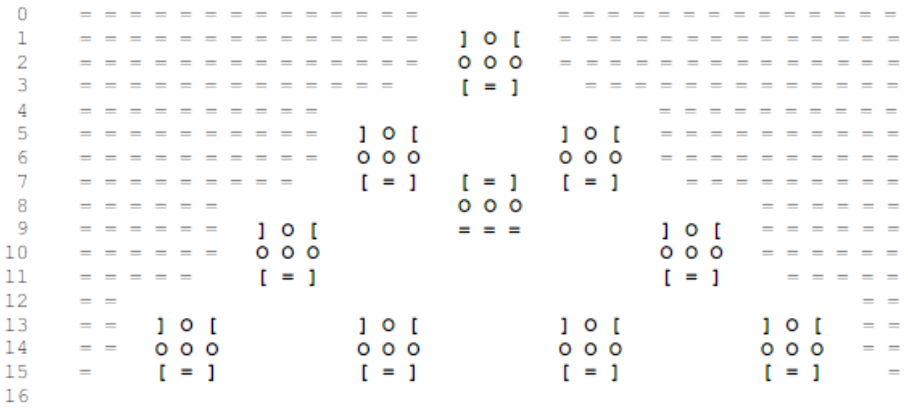
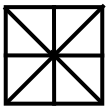


Figure 1: Isaacson's Baryon Octet

So, we have a 1D-iteration. But we look at the resulting picture, which is 2D. If we could iterate this in one step, it would be a 2D-iteration. In any case, we should have four select symbols in ten select structures. If we note what is omitted, we ascertain that the selected areas represent square frames.



Their basic geometry is that of a square, which has a dihedral symmetry D_{2d}; what is omitted, however, is not a square. The group D_{2d} represents a morphogenetic cognitive structure of orientation. Eight elementary arrangements of quarters represent the symmetries of the dihedral group D_{2d} for two diagonals, that is, d = 2. The eight permutations of Order 4 correspond with the spatial congruence group of the square D_4. This small group plays a very important role where the discrete structure, the monomial base of Clifford algebras is concerned.[20] This gives us Figure 2.

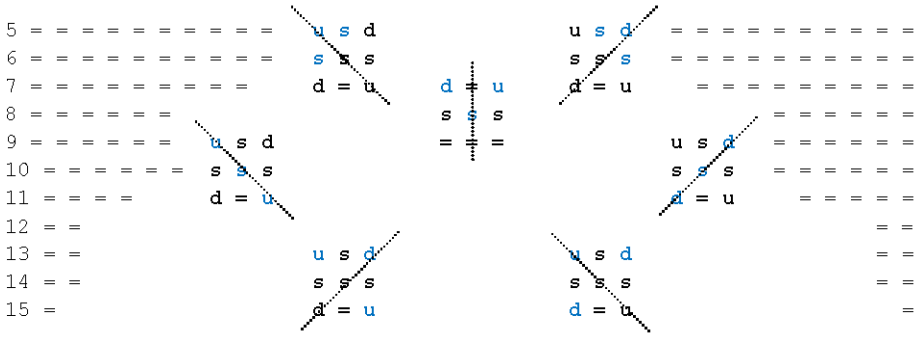


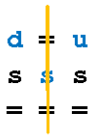
Figure 2: The Resulting Clifford Algebra

Note the different selections of the s in the baryons Σ^+ and Σ^-. The **usu** and ***dsd*** are now positioned exactly on the diagonals of the symmetries. Interestingly, a flip about the diagonals always preserves this blue baryon. If we substitute '=' by '0' and every symbol unequal '=' by unity '1', we get a pattern of Wolfram Rule 126. This gives the dihedral square frame for the digitized figures of size 3 x 3. It has its dihedral symmetry slightly broken by a single pair '1 0'. It also generates continuously recurring small squares $\begin{matrix}1 & 1\\ 1 & 1\end{matrix}$, the signs of elemental symmetry D_4.

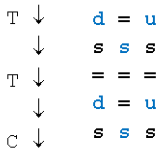
[20] Namely, if we consider for a moment the Clifford algebra $Cl_{1,1}$ generated by the small Minkowski space $\mathbb{R}^{1,1}$ with neutral signature (+,–), the base units e_1,e_2 generate the small non-commutative *n* dihedral group having the eight elements $\{\pm Id,\pm e_1,\pm e_2\pm e_{12}\}$. In our planar pattern, we can imagine four locations, or quadrants, and all their possible permutations. Those are the twenty-four symmetries of the symmetric group S_4. If we consider only those symmetries that preserve the neighborhood relations of the four locations, that is, connectivity of quarters, we obtain D_4 with only one third (8/24) of the elements. See R. Shaw, "Finite Geometry, Dirac Groups and the Table of Real Clifford Algebras," in *Clifford Algebras and Spinor Structures*, ed. R. Ablamowicz and P. Lounesto (Dordrecht: Kluwer, 1995), 59-99; Bernd Schmeikal, *Decay of Motion—The Anti-Physics of Space-Time* (New York: Nova, 2014), 70.

Flavor Degeneracy

Surprisingly, among the ten structures, the middle one is the only one that can be flipped without breaking its symmetry. It can be flipped about the vertical axis,



and it is the only substructure that can be tetracoded such that it reproduces in symbolic words a degenerate energy state



namely a supposed Λ^0 and thereby creates a Σ^0. Recall the function of the "O," "]," "[," and "=" and their equivalent symbols "s," "u," "d," and "=." Apply the tetracoding to the elementary middle square, and you immediately find out that the only way to get the line "d = u" stems from an operation on three equal symbols. So, we have to have three equal symbols in the last line of any square frame in the matrix. The only square satisfying that property is the middle one, with a third line reading "= = =." What does that observation tell us? It teaches us that *in a Stegano cellular automaton, the tetracoding appears to be a singular reason for the emergence of flavor degeneracy in the Baryon octet.*

In the early days when Gell-Mann and Isaacson were at work, the term "flavor degeneracy" did not yet exist. One knew about the strange difference between kaons and hyperons.[21] It seems that the term strangeness was used by Pais and Gell-Mann in CERN in 1954 to clarify the differences between the K-meson- and Hyperon-decay. It seems it was officially introduced in 1953 by Tadao Nakano and Kazuhiko Nishijima.[22] *Perhaps some (me) would have preferred* weirdness over strangeness. Today we have flavor instead

[21] Madhusudhan Raman, "The Strangeness of Murray Gell-Mann," *The Wire*, thewire.in/the-sciences/the-strangeness-of-murray-gell-mann: "Gell-Mann however knew that the rapid decays of strange particles couldn't not be because of the strong nuclear force, so he thought perhaps isospin conservation—the requirement that isospin is the same before and after the decay—would exonerate the strong nuclear force and explain the lifetimes of strange particles. However, he forgot about the electromagnetic interaction, which would result in a shorter lifetime than was observed. It was clear then that isospin conservation would not suffice. His solution was to introduce a new label: strangeness. This concept was also introduced independently by Abraham Pais and Kazuhiko Nishijima. It is a quantum number that characterises particles just like charge and isospin do (and was more whimsically named)."

[22] Murray Gell-Mann, "Isotopic Spin and New Unstable Particles," *Physical Review* 92, no. 3 (1953): 833-34, https://doi.org/10.1103/PhysRev.92.833; Tadao Nakano and Kazuhiko Nishijima, "Charge Independence for V-Particles," *Progress of Theoretical Physics* 10, no. 5 (1953): 581-82.

of strangeness. The denotation of *flavor degeneracy* first appeared in the archives at the beginning of this millennium. Then, no one was aware that flavor degeneracy is directly related to the dihedral symmetries of the Clifford algebra $Cl_{3,1}$, which is generated by the Minkowski space. I will now briefly explain why Isaacson's HEPhy Model is fundamentally related to Minkowski algebra and why it resembles a 4D iterative structure rather than a line-processor.

Observing Joel's 2D-figure of the baryon-octet we immediately realize that a diagonal flip preserves a baryon. But such a flip is an operation in 3D-space. Together with a time-dimension this indicates a 4D-process. But physicists in HEPhy know that in the degenerate center the $\Lambda^0 \approx uds$ has 2.6 x 10^{-10} seconds lifetime, but Σ^0 has only 6 x 10^{-20} seconds; cancellation of any "s" would mean an energy difference of 101 MeV/c^2. It is clear that iteration-time or, as Kauffman used to say, one step in time, is not the same as physical time. Yet, those two times are somehow related. For me, who has decided to work with a space-time gauge, it is clear that both inner (psychological) and outer (physical) space are connected. Therefore, all further calculations are based on the Clifford algebraic logic alphabet in Minkowski algebra or briefly in D_4 as in my papers[23] and—most important—Isaacson's.[24] So, I have made clear that Isaacson's idea has relevance in HEPhy. But I have shown some more: we may claim that *with US Patent 4,286,330, Joel patented creation* if we realize physical time and specify the notion of iteration. Consider that we consider the image of the Milky Way or some deep space domain of Hubble as the input of a DIP or an intellector. "Generally, an input to a DIP is some digitized image."[25] But those digits come from stars and galaxies that exist(ed) at different times. Further in both relativity theory and quantum theory, it has become clear that

- Future events have an impact on past events. We have to allow for time reversal and nonlocal interactions.
- In relativity theory, an event A earlier than B for one observer may appear later than B for another.

Bottom line: If the creation is embodied in reality, the processor must somehow be real, and it must process inputs from past and future at each iteration-step. Where and when is this processor, whether intellector, DIP, or recursive distinctioner? Provided it is a theoretical process only, it should still be able to process data from arbitrary points in time. I have been ready to give Joel credit. The dialectical image processor provides the necessary properties. But it is much more than a linear line-processor, though there is a strong link to it. In Dialectal Machine Vision, Isaacson reports: "DIP was conceived and implemented in 1964. BIP, a one-dimensional version of DIP, was conceived in the late

[23] Schmeikal, "Basic Intelligence Processing Space"; Schmeikal, *Artificial Physics*.
[24] Isaacson, "Autonomic String-Manipulation System."
[25] Isaacson, "Autonomic String-Manipulation System," 26.

1960s. By the early 1970s, I realized that BIP is a unique process with autonomic low-level intelligent computing capabilities. During that period, I also discovered its dialectical properties."[26]

I suggested to Joel "You are right. You are meeting the main locus. The minimal Intellector is a material system. As you choose to say, it is *a root process for fermions*, and its process is *comprised of distinctions*. Its models provide another side; distinctions and iterants are the mathematical side. Don't model the intellector (it has already been done). But *discover the intellector*!"[27] On August 6, 2019, Louis H Kauffman replied: "Indeed. Let us find it in the material world. Let us find out what it means to find it in the material world. As Joel said, it is an autonomous intellector, going on independently of us and yet interacting with us. And let us be generous with each other in regard to what each can do. *It is natural for the mathematiker* to look for simple computational patterns and algebraic patterns. *That is the job of the mathematiker*, to make it look so obvious that anyone else will say, sure."[28] But my beloved collaborators whom I encouraged to go deeper into DIP continued with RD and did not integrate my suggestions. We had a disagreement and argued like children in an extended family. I was told to be a little more pliable, which didn't sit well with me. So, I was temporarily assigned the role of house sociologist in the RD thing by Lou Kauffman. On April 21, 2019, I had mailed to Bob Krone: "I do not feel addressed by this endless discourse between Joel and Lou. Also, I did not get enough signs of interest or friendliness after you announced my contributions. They really do not seem to need my voice. Thank you for your valuable impulses!"[29] Bob replied: "We can use the live Skype contacts for real-time dialogue, Bernd. We will have your files for later documentation in the *Journal of Space Philosophy*."[30] He explained what he saw:

> *One of the fundamental viewpoint differences between Joel and Lou is the source of RD*. Joel believes it is a natural universal autonomous entity … like gravity…. Lou seems to believe It depends on the observer. That difference does not put restraints on further research into applications and implications that you and I find interesting. I believe we all agree that RD exists, and science and society needs to understand it, maybe to learn how to apply it for good and prevent it being applied for evil…. You and I just need to appreciate that Joel and Lou have respective orientations on the origin and theory of RD. There is room for many avenues of research in the RD vineyards.[31]

[26] Isaacson, "Autonomic String-Manipulation System," 6.
[27] Email from Bernd Schmeikal to Joel Isaacson, August 6, 2019
[28] Email from Louis Kauffman to Bernd Schmeikal, Joel Isaacson, and Bob Krone, August 6, 2019.
[29] Email from Bernd Schmeikal to Bob Krone, April 21, 2019.
[30] Email from Bob Krone to Bernd Schmeikal, April 22, 2019, 16:13 CET.
[31] Email from Bob Krone to Bernd Schmeikal, April 22, 2019, 14:13 CET.

Real Recursive Distinctioning—Turnover to RD

Bob Krone had found that *one of the fundamental viewpoint differences between Joel and Lou is the source of RD*. I found a second one, correlated with the first that is perhaps less visible and actively mystifying, located in the subconscious of our collectivity. There is a difference between people's imaginations and what is real. The longer we insist on what we imagine, the more we lose perception of the real. Reading those most important three writings by Isaacson, I did not gain a feeling that they were speaking about what is now called RD. But exactly that feeling of resonance had been so central in Joel work, especially in "Dialectical Machine Vision." Consider "Autonomic String-Manipulation System," in which Isaacson explains: "The sensation-level is a new level that, as far as I know, has never been considered by people in machine vision. Interestingly, theories of sensation, as distinct from perception, abound in the history of philosophy and psychology. In fact, there exists a philosophical doctrine under the name of 'sensationalism' that is relevant to this discussion. The following sketch is intended to impart to the reader a sense of the history of ideas on sensation. 'Sensation' is from the Latin *sentire*, i.e., to perceive or feel,"[32] which puts it somewhere between feeling and perception. Usage varies, but sensation is usually tied more closely to external stimulus than is the term perception. Democritus (460-370 BC) interpreted sensation as the receipt of images of objects. In his view, perception or sensation is a physical process that occurs through the impact of images on our sense organs, the images being something like the *detached outlines* of the objects we perceive. For Kant, perception is awareness that driven by sensation, acting within the faculty of sensibility, as distinct from the faculty of thought. The Austrian physicist Ernst Mach (1836-1916) was perhaps the strongest proponent of scientific sensationalism. For Mach, all knowledge has its origin in sensation, and the unity of all the branches of science consists in the fact that each is a study of sensations of some sort, and of the patterns to be found in their interrelations. In psychology, an early sensationalist was James Ward (1843-1925). Ward introduced the concept of a psychoplasm, which is a representational medium in the brain. He distinguished three phases in the process from sensation to idea: a sensory stage involving the differentiation, retention, and assimilation of presentation; an integrative stage in which sensations become percepts; and the emergence of a derivative continuum of images complete with memory threads and ideational tissue. He also stressed the *affective* function of mentality moving toward the affective side. Hartshorne held that sensations are feelings of feelings.

How deeply Joel goes into the question of perception, feeling, sensation, emotion, and thought arising on this basis! This is not esoteric but is most relevant. It is a *best of* structuralism. Joel answers the question: how can life, feeling, and sensation lead to e-motion and cognition? Is there *feeling feeling*? How can the living energy of physical motion arise from the resonance, from a mirroring of structures! This cannot be pinned

[32] Isaacson, "Autonomic String-Manipulation System," 51.

down by a Wolfram rule, and not by RD as is presently carried out by *mathematikers*. Is there any count of RD or something similar in any of Isaacson's original writings? I never had the feeling that he mentioned RD anywhere!

Zero RD in Isaacson's Basic Creations

We used Textanalyzer from Seoscout to find and count keyword frequencies in Isaacson's original files "Autonomic String-Manipulation System" (briefly denoted as "Patent"), "Steganogramic Representation of the Baryon Octet in Cellular Automatons" ("Stegano"), "Dialectical Machine Vision" ("DM Vision"), and a few associated indicators. Thus, we obtained at first a somewhat useless table of keyword indicators such as reading ease and grade level (Table 1):

Table 1: Keyword Indicators in Isaacson's Writing

	Word Count	Reading Ease	Grade Level	Sentiment
Patent	7,637	54.2%	8.7	neutral
Stegano	2,468	45.4%	8.2	neutral
DM Vision	17,284	57.4%	7.8	neutral

This we need not interpret at present. But luckily, we also obtained a keyword frequency table which seemed to be quite reasonable after we had studied the papers in depth (Table 2).

Table 2: Keyword Frequencies in Isaacson's Writing

	Patent		Stegano		DM Vision	
Rank	Keyword	Uses	Keyword	Uses	Keyword	Uses
1	Length	112	=	417	DIP	76
2	Processing	86	= =	360	Neural	52
3	1	82	= = =	319	Level	50
4	Operations	69	Steganogramic…/Jdi	16	Face	49
5	Type	60	[=]	12	String	48
6	Referred	57	Baryon	12	Vision	46
7	Rules	54	Structures	12	Rules	41
8	Strings	50	Cellular	11	BIP	40
9	Operation	48	Isaacson	10	Perception	40
10	BIP	47	Tetracoding	10	Length	40
11	Rewriting	47	Baryon octet	9	Visual	38
12	Process	46	] [	9	Input	35
13	Tetracode	45	Octet	9	Type	33
14	Rewriting rules	42	Elementary	9	Dialectical	32
15	Finite	41	Joel Isaacson	8	Recognition	32
16	Length	41	Representation	8	Representation	31
17	Systems	37	Joel	8	Processing	31
18	Input	36	Rule	8	Rewriting	31
19	Processes	35	Pattern	8	Image	30
20	Cycle	35			Sensation	28

Words such as recursive, distinction, or RD as a word combination, did not appear in the three main works. They were not keywords. Those words had not been at the center of Isaacson's thought. What had happened? What was in his center and how was that center transformed by Kauffman? It took me a long time before I even began to understand what Joel had in mind.

I was not yet satisfied with the content-analytical automatic table; hence, I defined my own particular keywords and counted manually: distinction, distinction/indistinction, recursive, recursive distinction, tetracoding, dialectic(al), DIP, BIP, intellector, image, logic. This resulted in Table 3. The frequencies of Recursive Distinction are zero in all three studies. But what is interesting is that the dual pair "distinction/indistinction" seems to have some importance in the earliest of papers, the Patent. This gives rise to my permanent proposal to consider some involutive operation to RD, namely antecursive conflation.

Table 3: Alternate Keyword Frequencies in Isaacson's Writing

Keyword	Patent	Stegano	DM Vision
Distinction	3	2	1
Distinction/Indistinction	7	1	0
Recursive	4	3	1
Recursive Distinction	**0**	**0**	**0**
Tetracoding	10	10	7
Dialectic(al)	29	5	53
DIP	0	0	93
BIP	64	0	47
Intellector	17	0	5
Image	2	6	40
logic	14	0	4

In one of his first detailed correspondences from October 2015,[33] it became clear to me how important the topic of dialectical machine vision was to him. This analysis contains what is today often called a retinoid system of human consciousness. "We start out," as Joel wrote, "with first principles, relating to local decision making, that sensory organs, such as retina, are known to perform." He mentions his Figure 16b,[34] which by then I had long been investigating. "It shows 256 icons (called ideographs), arranged in 16 x 16 matrix." However, he did not realize that those sixteen represent a planar representation of a logic alphabet[35] for binary connectives, and/or a commutative module of geometric algebra. But they arose from the topological neighborhood filters. The 256 ideographs are both logic letters—the "alphabet of the visual cortex"—and objects in plane geometry. The sixteen are 2D symbols, and even though they seem to be in a plane, the 256 are indeed objects of 4D. They have a close relation to Minkowski algebra.

Kauffman Constructed RD, Joel Isaacson Created Nature

Occasionally Joel put us in the box of the mathematician:

> We assume no prior mathematics and also
>
> 1. Assume that natural processes are largely non-mathematical.
>
> You, on the other hand,
>
> 2. build heavily on mathematics tradition and in particular attempt to align results with Clifford and Minkowski.

[33] Email from Joel Isaacson to Bernd Schmeikal, October 28, 2015.
[34] Isaacson, "Autonomic String-Manipulation System," 41.
[35] Bernd Schmeikal, LICO x.

I asked, who is we? It turned out that Joel would continuously clash with Kauffman where nature, and Statement 1, was concerned. But in my mind, he did not clash with me at all on the second, as I was absolutely sure my considerations about LICO and Clifford algebra are no less based on first principles: not just on the difference between inner and outer products, but also on phenomena. At first he insisted, "we need to face this dilemma right on before we are able to make any kind of progress in our mutual deliberations." That seemed quite obstinate, and he wrote in brackets "(please don't get upset with this reasoning. It is only a conjecture.)" But I got upset. Sometime in summer next year I wrote to Bob Krone "this feeling that Joel acts rather irrationally and self-centered has not vanished," and a few days later Kauffman took a stand: "I thought about it and decided that it was worthless to burden you with stories about my subjectivity. As for Joel: He is very stubborn to say the least."[36] What was going on?

The concept of RD had been discovered and constructed by Kauffman. He wanted to support Isaacson by lifting his ideas to some new and methodologically better level. Joel remained basically faithful to his idea of DIP, but at the same time made continuous efforts to adapt and adjust to the concepts of RD in the desired way. He was overwhelmed by the mathematical ideas of Kauffman who insisted we are the *mathematiker*. Joel developed his own image of RD, and he argued with Lou about it.

> Dear Joel, the key point you make is in the phrase 'layers of recursive distinctioning.' What do you mean by this? Can you model it? I write questions here because I have partial answers, but they may be different than yours. Best, Lou.

Joel Isaacson replied:

> Research on the structure of cognition and its broad relationship to layers of recursive distinctioning would be a most worthy undertaking. Many years ago, I assumed as obvious these sorts of connections but, in my isolation, only nibbled on some aspects. A focused effort with the participation of appropriate talent may do wonders. Best—Joel.[37]
>
> Dear Lou, Put a light detector on your window sill. For a certain period, it will detect light and then it will not. Attach a convertor such that when light is detected an electrical current is generated that drives an electronic display with the letters DAY. The default display is NIGHT. What is conscious about this apparatus?

[36] Email from Louis Kauffman to Bernd Schmeikal, July 20, 2016.
[37] Email forwarded by Joel Isaacson to Bernd Schmeikal on April 14, 2019.

> Dear Joel, I think that we do say things like this. For example, I may say, looking out my window, the sun is shining. It is daytime. But where is the difference? The difference is for me in knowing that it is now day. *The difference is not somehow in nature*…. What is there that is entirely independent of all possible distinctions that we can ever make? There would be no things there, for things are just our names for distinctions available to us. It would be nothing. A very rich nothing about which we obtain some clues by the always mistaken distinctions that we make. Distinctions are our mistakes. Feynman said that to get somewhere in physics you have to make all possible mistakes. Best, Lou.[38]

> Dear Lou, *can we say that there are differences in nature that can be detected by observation? Is observation necessarily conscious?* Namely, there exist "mindless" natural acts that function as difference detectors. Best—Joel.[39]

On April 15, Bob Krone attached his files and mine as advance information for our conference of April 27 and 28, 2019. On April 18, he announced that he would present some of the attached files on the 28th, if we had time: "if we don't it is information for you all on our plans for future RD graduate education with the Kepler Space Institute Catalog."[40]

Bob Krone, PhD, president and faculty member, Kepler Space Institute (KSI), then editor-in-chief, *Journal of Space Philosophy*, Colonel, USAF (Ret), fellow member, American Society for Quality (ASQ), emeritus professor, University of Southern California (USC), Doctor of Laws, Honoris Causa, had always done his best to mediate between the two worlds—Lou's and Joel's—and now Kauffman radioed him: "Dear Bob you have a slide about a possible course in RD. The phrase 'RD is a term for Nature's processes of information flow etc.…' is misleading and I would not say it that way. *In fact, I do not use the word 'Nature*.'"[41] This simply seemed wrong to me. But Kauffman continued:

> If you want to use the slide, please remove the sentence "Recursive Distinctioning is a natural principle for Nature's processes of information flow." And replace it by "Recursive Distinctioning may be a natural principle for processes of information flow." Remove the next sentence. Also, you should note that I have not made any commitment to teach such a course. If I did it would have to be in real-time in a classroom, or we would have to create a series of YouTube type videos that would be made available to

[38] Email forwarded by Louis Kauffman to Bernd Schmeikal on April 21, 2019.
[39] Email forwarded by Joel Isaacson to Bernd Schmeikal on April 21, 2019.
[40] Email from Bob Krone to six participants on April 15, 2019; email from Bob Krone to seven participants on April 18, 2019.
[41] Email from Louis Kauffman to Bob Krone and six others on April 21, 2019.

> people. Note that such a course would be a reshaping of many aspects of chaos, systems, physics, cybernetics, and mathematics with an emphasis on the foundational role of distinctions at all levels. The basic principle is THERE ARE NO DISTINCTIONS IN NATURE EXCEPT AS THEY ARE CREATED OR DISCOVERED BY OBSERVERS, AND THIS STATEMENT ITSELF IS REFERENT TO THE FACT THAT AN OBSERVER IS HIM/HER SELF A DISTINCTION. NATURE WITHOUT DISTINCTIONS IS A NO(THING) AND IN THIS SENSE THE WORLDS THAT WE KNOW ARE CREATED FROM NO(THING). DISTINCTIONS ARE FICTIONS OF GREAT VALUE. This leaves open just what does happen in "information flow" or whether there is such a "thing" as the flow of information. The reason for giving a course on this topic is to induce the participants to question everything (every thing), including any apparent propositions upon which the course appears to be based. Best, Lou.[42]

Lou wanted to insist on his concept of RD. Bob Krone the old starfighter was the only one who was able to handle and mediate the situation.

He Wanted Joel's Work to Bear Fruit.

I have experienced such a real-time course in a classroom, indeed in a video conference directed by Kauffman. In my perception, he significantly overdirected the course. Joel and I did not share his view. Kauffman likes to praise the deep insights of his collaborators (Joel's and mine). But he does not say what these consist of. It seems that it is enough for him to know for himself what these deep insights may be like. But no one else knows them. Through Lou's praise, I became the house sociologist of KSI:

> Dear Joel, I did read Bernd's essay. It is a brilliant piece. I would not change it. It raises issues about the meaning and ethics of distinction or acts of distinction at all levels. Bernd says it again, that RD has to potential to be a powerful epistemological tool. By defining RD in terms of distinctions and acts of distinction, we create a formal structure that is every bit as clear as the construction of positive integers but is non-numerical and based in distinction. The more one thinks on this, the more it changes the foundation of knowledge for mathematical, physical and mental process. And then how are we to think about the world of mirrors in which we apparently live? Best, Lou.[43]

[42] Email from Louis Kauffman to Bob Krone and six others on April 21, 2019.
[43] Email from Louis Kauffman to Bernd Schmeikal on November 9, 2018.

> Lou and Joel, please send Bernd's article to me and Gordon Arthur.... We will put it in the Fall JSP issue. Bob Krone.[44]

Actually, I am not at all sure if the Faculty of Social Sciences in Tel Aviv would be allowed to acknowledge the brilliance of my contribution. But I hope it. Anyway, KSI is not Tel Aviv University.

Real and its Signifier

As a modern philosopher, you can pin down a beautiful picture like Magritte's and claim to understand its message

This is not a Pipe

This is a Pipe

The image, the signifier of the material pipe, is not the material pipe. Very true! But before we were allowed to argue that sophisticatedly, some of us designed, drew, photographed, made an ideogram in the sand, ... hu uu, a pipe ... , and made sure to ask the viewers, what is it? And all the children cried out loud: a pipe! Therefore, it is historically correct first to say, "This is a pipe" and then to point to the picture and say it is not a pipe. With Joel Isaacson's voice we would say: in a primordial state of mind, we confuse the pipe with its signifier. You recall Kauffman saying, "*Then there are the Majorana Fermions c that satisfy c* = c"?* He (con)fuses fermions with their signifiers. In our primordial darkness, we connect what is real in our awareness with what is an image in that same awareness. It is here that I modified Joel's image of perception, perhaps somewhat in the sense of Alfred N. Whitehead. Namely, we perceive a material pipe in sense perception by awareness. With the intelligent energy of awareness, we establish a life contact with pipe being material, having energy, knowing force.... But we can also become aware of our image of the pipe. We can become aware of the signifier. As soon as we contact thought by awareness, signifiers become as real as material events. When a human is aware of the real, aware of the real image and thought—all in living presence—this is a peculiar state of mind.

Like Joel I am convinced that *there are differences in nature that can be detected by observation. There is primordial observation that is not necessarily conscious. I do use the word nature.*

[44] Email from Bob Krone to Louis Kauffman and Joel Isaacson, forwarded by Joel to Bernd Schmeikal on September 11, 2018.

> Dear Lou, Bernd is about to submit this version to JSP. He mentions you at numerous junctures. Hope the approaching fall is kind to you in Siberia. Best—Joel.[45]

> Dear Joel, I am sure it is alright. I was planning on writing a short paper for this issue, but there is not enough time. I will write one for the next issue. I will look at Bernd's paper and give you some comments later today. All going well here. Very best, Lou.[46]

Crashing RD

As I could see, Bob Krone was aware of the difference between Isaacson's cellular automata, his DIP, and Kauffman's RD. In Fall 2012, he had written:

> Joel Isaacson has pioneered in RD Cellular automata since the 1960s. Recursive distinctioning was rooted in studies relating to the analysis of digitized biomedical imagery. Dr. Isaacson utilized NASA's computing facilities at the Goddard Space Flight Center in Greenbelt, MD for the initial stages of his research. His research has been supported over the years by DARPA, SDIO, NASA, ONR, USDA, and a good number of NIH institutes. Isaacson is Professor Emeritus of Computer Science, Southern Illinois University and Principal Investigator of IMI corporation.[47]

Kauffman did not take this as a change of course notice; instead, he persisted.

> Dear Bob, of course we agree that the subject merits research. Just note that we have very fundamental models for RD thanks to Joel. *We do not have constructions of cognition from these models*, but the models suggest lines of thought that are, we believe, new. Also, the notion of "recursive making distinctions" can be understood in the broadest sense. Thus, for example, I am making distinctions recursively at a number of parallel levels in writing this email to you. If we look at the broad level, we see that all communication is a weaving of recursive distinctioning. Best, Lou.[48]

But in my view, and perhaps sooner or later as a matter of fact, we do have such models, but from Isaacson's comprehensive work and some of Schmeikal's articles about

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[45] Email from Lou Kauffman to Joel Isaacson forwarded by Joel Isaacson to Bernd Schmeikal, September 11, 2018.

[46] Email from Lou Kauffman to Joel Isaacson forwarded by Joel Isaacson to Bernd Schmeikal, September 11, 2018.

[47] Bob Krone, About the Author: Joel Isaacson; Editor's Note, *Journal of Space Philosophy* 1, no. 1 (Fall 2012): 16.

[48] Email from Louis Kauffman to Bob Krone, April 14, 2019.

laws of thought in connection with geometry rather than from Kauffman's RD. The observer issue has not left us any peace. Lately I wrote Bob:

> Dear Bob, it (Joel's Ansatz) does not depend on observer qualities, for inner is like outer. The autonomous Dialectic Processor is just processing kernelless, without ego. But it is not (yet) alive, because a life system needs the bioenergy of aware living biopolymeres. Such a system has no rest, no rest-frame. That has nothing to do with gravity. Yet, Joel is right, it is a universal autonomous entity; but Joel found only its structural realization. He did not conceive its biological energetic realization; Once this dialectic processor is alive, people will still be unable to explain why it is living. We can ponder tomorrow, perhaps I will just give a talk without using material. Cordially, Bernd.[49]

As time went by, Lou's engaging, all-swallowing RD-approach had become more and more incomprehensible to me. We clashed in a break-dance of conflict over the Patent.

Bob had praised my "interdisciplinary skills and creativity bringing needed new insights and thinking into Joel and Lou's work."[50] The year before, he had wanted us to write a common letter to the editors. But Kauffman followed the break saying "In any case it is too complex to write a joint letter. I will write one with Joel soon. The letter with Bernd will take longer." In my perception, it was always about tying the discussion to RD as completely as possible. However, RD has an invisible mirror-half, which I have designated antecursive conflation. It is exactly the same as with Magritte's pipe. When we are dying we go back, and all the differences cognition has created are allowed to fold back and vanish in the dark and in the light. This journey begins with the antecursive conflation. The whole so-called mystery is in the living reality of intelligent awareness in primordial intelligence that is neither conscious nor unconscious.

Legacies of Joel in a Future World

Kauffman had temporarily downsized and reinterpreted Joel's invention, believing that this was the best a *mathematiker* could do. It was clear to me that with a semi-living RD, we would bury Joel's Dialectic Image Processor a second time. By the end of 2017, Joel had realized that I was calling for a return to the roots of creation, restoration of the DIP, and simulation of the electronic circuits of the intellector. We wrote love letters. Joel was excited "It is very touching to read your words. I turned 80 on October 25."[51] And a little while later: "At issue is the relationship between tetracodes and streaks and between RD processing of tetracodes and intellector processing of streaks. Streaks are markers of

[49] Email from Bernd Schmeikal to Bob Krone, April 22, 2019.
[50] Email from Louis Kauffman to Bob Krone, forwarded to Bernd Schmeikal and Joel Isaacson, April 8, 2019.
[51] Email from Joel Isaacson to Bernd Schmeikal, November 16. 2017.

distinctions within strings, where strings may be 'real' and ordinary or even 'non-existing.' Non-existing strings are comprised of fantomarks. The distinctions in a fantomark string can be coded as a binary streak and said streak can be processed recursively under TRI by an Intellector circuit."[52] Joel had asked me if I would like it if we went through the input string 'S E E SC H M E I K A L'. It was a first signal that he was ready to refresh the circuits of the fantomark string creator.

> Over the many years I have programmed BIP (namely recursive tetracoding) in many languages, including FORTRAN, BASIC, PASCAL, C++, etc. It is usually easy, except for printing the output of strings written in the 4 icons. The reason is that the shapes of icons do not usually have standard fonts. That's why I substituted these fonts to show the 4 icons as: O, [,], = . Unfortunately, those codes are now archived, and it is hard for me to retrieve them. However, in recent years Louis Kauffman have programmed BIP with MATHEMATICA (Wolfram) and also with a language called PROCESSING. PROCESSING can be downloaded for free from a website called processing.org. Let me know and I'll ask Lou to send you his programs. There is also a program that is written as a Turing machine and simulates BIPs (BIP in streak mode) that follows the circuit diagram that is given in the patent. It was written in 2008 by Ziv Yekutieli, then a doctoral student of the late Eshel Ben-Jacob. I helped him a bit and may be able to find a copy in my files. Let me know if you need it.[53]

In 1981, Joel had disclosed in his public patent specification that Rule 129, named *triunation* therein, was functionally equivalent, after some encoding, to a 4-state nearest-neighbor rule (k = 4, radius = 1) named *tetracoding*. Joel Isaacson was ready to explain to me why much of his work had lain dormant for such a long time:

> Perhaps I should explain why I patented it in the first place. It is a long story. Max Isaacson was born 1897 in Auburn, Maine to a Jewish immigrant family from a small town near Minsk in Belarus. His father was a brother of my grandfather and he died when Max was a small child. The family was poor and struggling. Max managed to go to study patent law at George Washington University and then became an employee of the US Patent Office in Washington, DC. He later was hired as a patent examiner by the US Air Force at Wright-Patterson Air Force base in Dayton, Ohio. They handle

[52] Email from Joel Isaacson to Bernd Schmeikal, December 2, 2017.
[53] Email from Joel Isaacson to Bernd Schmeikal, December 20, 2017.

> advanced inventions, and he became knowledgeable of many new technologies. Max Isaacson was very smart, inventive, and driven.[54]

Joel met Max in the early 1970s. Max urged Joel to describe his work to him and finally advised him to patent it rather than to publish it in the open literature. He argued that no reviewers would understand it and Joel would disclose it to unknown people without a chance of publication. On the other hand, patenting would record his priority.

After having read the public patent specification from August 1981, I could only confirm that Max was right. Joel's tiny 1-dimensional CA knew 3.4×10^{38} rules, involved streaking, coloring, animation, deanimation, and ideographing. It had surface structure and deep structure. It created memory and generative structures indefinitely in a self-created mode of machine intelligence. So, it seems natural to ask about the relationship between the dialectical intellector and process of nature. It seems that the principles of cognitive poverty in recursive tetracoding, and the simplemindedness, the machine innocence that characterizes the dialectical intellector, are far superior in action to today's kernels of operation systems.

Inconceivable Richness of Openness

The original invention is concerned with *string manipulation*. More specifically, a string, consisting of individual elements, is a linear arrangement of elements. One of the most astonishing and for us mathematicians downright frightening properties of Joel's strings are the complete lack of restrictions, of unambiguous properties, the fuzziness of the elements. It goes so far that intangible, imperceptible elements are introduced. But it ought to be exactly this *nowhereland* of *stringland, a domain* of the not prehensible, where the mind can refer to in its return to nature.

> No restriction is placed on the nature, character, or substance of elements in the open portion of a string. If an element is represented symbolically by a sign or a mark, the mark is considered an element in its own right and any meanings or other significative aspects of the mark, including its semiotic relationship to the original element, need not be considered any further. The terms "symbol" or "mark" are used generically to denote standard semiotic terms, such as sign, icon, index, token, character, ideograph, and the like. An element that can be *prehended* or sensed or recorded by human beings, and/or other living things or systems, and/or instruments, devices, or systems made by human beings, is referred to as objective element or

[54] Email from Joel Isaacson to Bernd Schmeikal, September 7, 2019:

> "datum-object." An element that cannot be prehended, sensed, or recorded by any of said means is referred to as a "fantomark."[55]

Elements could be anything and if they cannot be prehended in any way they are fantomarks. Lou and I sweated blood. Lou, who disclaimed the word nature, formulated—in accordance with his own openness to fundamental contradiction, and with poignant wisdom:

> There are no distinctions in nature except as they are created or discovered by observers, and this statement itself is referent to the fact that an observer is him/herself a distinction. Nature without distinctions is a no(thing) and in this sense the worlds that we know are created from no(thing). Distinctions are fictions of great value.

In his now unattainable insistence,[56] I would like to lend Joel my voice, with which he probably wants to articulate: nature's distinctions can be fantomarks in a Dialectic Image Processor. The DIP picks up speed as soon as we allow letters from the logical alphabet. Then we work with LICO-strings and the topological neighborhood. A LICO-lettershape signifies a logic relation, a binary connective in thought, and at the same time a geometric 2D-object. In those days when Joel let the intellector operate in stringland, he had not yet discovered his 16- and 256-letter alphabets, and when he first came upon them in the DIP, he denoted them as ideographs. They came from neighborhood relations given by Moore- and Neumann-filters. No one then saw that those ideographs were both letters of a logic alphabet and plane figures. Normally the geometric shapes of letters like A, B, C, D (tetracoding) or "O," "]," "[," and "="; or equivalent symbols "s," "u," "d," and "=" (in Stegano) or any other have no definite logic meaning. But in LICO they have. If you compare any character in a LICO-string with left and right nearest neighbors, you obtain 256 possible results at each comparison. Since a left hand LICO letter is 2D and has four bars, one can compare any such bar with any other of the four bars on the right and get 4 x 4 = 16 comparisons. Those may result in equality = or imparity ≠. Hence we have 16^2 = 256 relational results. (Not really) surprisingly, this is the same number that appears in *DM Vision* on page 41 (Figure 16) in connection with the firing of a group of various subtypes of P-neurons.

I have made a few reps in miracle drums, roll cinemas and wheels of life—you know these things?—to see how relational statements are moving in physical space. One can observe rotations of logic relations. Thoughts appear to our minds through the touch of relations. Touch is both life and topological. At the interface between language and

[55] Isaacson, "Autonomic String-Manipulation System," 10, Columns 3 and 4. The reader is invited to interpret the word "prehended"!

[56] I am regarding Joel now not only as existing, but also as insisting.

geometry, there reside the orientation-morphemes. Lou asserted: "*We do not have constructions of cognition from these models*, but the models suggest lines of thought that are, we believe, new." With DIP, among other things, Isaacson laid the groundwork for a dialectical thought processor. We have not yet come very far. But we know some really basic things that can surprise the scientific community. It is all a Fermionic affair, and when Joel shook the "Steganogramic Representation of the Baryon Octet in Cellular Automatons" out of his sleeve, he was enthusiastic and at the height of his creativity. He turned the fantomark of intuition into a data object.

Please recall Kauffman's elementary objects *I*, *J* for quarks as represented by infinite iterants or respectively rectangular waves—it is better to roll them on a cylinder. As soon as you replace them by the appropriate logic relations, you get ≡ and ≢. Biconditional connection (supertouch) can be turned into exclusive disjunction. The entangled depart! The topic is shifted from object-elements to relational elements. Making a LICO miracle drum, you can literally see the phenomenological difference between a numeric string or binary streak and a relational word-string. The minimal Fermion *I*, *J*-model will always give you a spin- or isospin phenomenon, that is, a flip and a flop. But the unfolded Fermion logic relational word string brings forth a rotation in relational space. As such rotation is both in thought/language and in geometric space, it is actually a material rotation and has to do with force and e-motion. I have written a bit about these things, but after my split with Kauffman, I did not publish anything further. Fortunately, however, Bob Krone could save a few of those hints for the KSI archive. Let me put it briefly: Some 1D-iteration tetracoding is phenomenologically different than and below a 2D-LICO-string iteration.

For more than a century, physicists defined boundaries and investigated how various waves and their equations unfolded under given boundary conditions. The dynamics was in the inner, in the waves. With Joel's DIP, the situation turned opposite. Joel considers an object as having a given form. Then by dialectic processing he takes the content out of the form. Further processing leaves the track of a memory. The form reoccurs. Dynamics is given by the emergence of a synthesis, recreating the initial surface structure. Initial sensations of shapes—silhouettes—their areas and boundaries are dynamic forms. Inside there is temporary emptiness. What evolves from the void has a peculiar meaning in sensation: the sound of emptiness, the melody of what is real.

The value of Joel's creation is beyond words. It is material. Joel's processor is the only free processor that is based on a principle of all living matter: life is touch. We should assume that machinery based on BIP and DIP can modify and renew the genetic code with its biopolymer realization. It will help to unfold new forms of life. It has the power to create artificial life forms that will not be readily distinguishable from conscious animal and human life. The greatest secrets are probably hidden in Joel's loving, human attitude to feelings, dreams, in the fantomarks of our destroyed world. The energy that can be delivered by Isaacson's dialectical machine vision is so big that it will most probably initiate a breaking away from each other of at least four parts of humanity as I have

described in *Timeout of Time—Postscript to Nuclear Time Travel.*[57] But by such a breakaway, not only into space, but also down here on Earth, Joel's vision will help to transform the chaos into some new order. Sometimes life needs to make distinctions.

Back to the Unborn

As we had made no further arrangements, I assumed that I was no longer needed. We were through, so to speak. Joel replied: "Dear Bernd, I wish you peace and happiness in whatever you do next. If you ever change your mind about participating in RD discussions you would be welcome back. Best—Joel."[58] … Then … "Dear Bernd, Lou wrote today to Bob (with a copy to me) that: I concur with Bernd that we should study his paper 'Four Forms Make a Universe'. He also said some other good things about you. I thought you'd like to hear this. Best—Joel."[59] "Sorry, I missed to reply to this message; probably as I felt that if he, that is, Lou, liked to say some good things, about somebody, he could have done that. Bernd."[60] "Dear Bernd, I see your point. Normally one would tell good things to another directly, but Lou appears to avoid contact with you because of past unpleasant exchanges. I wish it were different. I can assure you, though, that he appreciates your work and keen intelligence. Best—Joel."[61] Joel also sent me a link to André Rieu singing Hallelujah by Leonard Cohen.[62] "Dear Joel, my daughter sent me this beautiful song by Leonard Cohen [Hallelujah]. I guess I've heard it in his last performance. Love, Bernd"[63]

> Joel: "Yes, there is a crack in everything…. I have heard this song before, and it is indeed beautiful! It is gloomy here in the US. The pandemic is out of control and is increasing in many regions. We are largely confined to our home. It is a large house, but we cannot accept visitors. Our daughter, her husband and grandchildren live close by, but they cannot enter the house. At times they play in the yard, and we can watch them through the window. The US general elections are scheduled for early November and the political situation is chaotic. I am working on RD in some cooperation with Louis Kauffman. Love—Joel."[64]

There comes a time when all our difference systems, all the wonderful fantomarks we helped into being fold back like flowers withering. This wisdom was always available to Joel even in conscious life and in the midst of the greatest light. I have never met a man

[57] Forthcoming, Nova.
[58] Email from Joel Isaacson to Bernd Schmeikal, June 11, 2020.
[59] Email from Joel Isaacson to Bernd Schmeikal, June 14, 2020.
[60] Email from Joel Isaacson to Bernd Schmeikal, June 26, 2020.
[61] Email from Bernd Schmeikal to Joel Isaacson, June 26, 2020.
[62] www.youtube.com/watch?v=NZb-SVm7eLE; Email from Joel Isaacson to Bernd Schmeikal, July 2, 2020.
[63] www.youtube.com/watch?v=6wRYjtvIYK0 Email from Bernd Schmeikal to Joel Isaacson, July 31, 2021.
[64] Email from Joel Isaacson to Bernd Schmeikal, July 31, 2021.

whose real living was so consistent with his theory. He was one of the last brilliant people, incomprehensible and convincing in his humanity, a role model for some of us. I hope that my writing will lead others to study his writings. In his last letter to me he forwarded me the following:

> A time capsule from my mother.
>
> Dear Bob,
>
> This may belong in your collection of my biographical tidbits. A man named Uri Kerstien, fifty-six, from a suburb of Tel-Aviv contacted my sister, Shifra Katz, eighty-seven, in another suburb, about two weeks ago. Uri is in Hi Tech. He has been searching for descendants of my late mother, Esther Baram-Isaacson, for thirty-three years! The story is convoluted and highly unusual, so I'll skip the detail here.
>
> In the late 1980s, when he was twenty-two, he lived in a small apartment in a building across from the building I grew up in and my parents occupied as renting tenants for forty-nine years. My mother died on the last day of 1986, and her apartment was occupied by new tenants sometime in early 1987. It is a very small unit, about 800 sq. ft. No place to hide things … except for a small, elongated nook in the wall where we used to keep Passover utensils. They found a good-sized suitcase full of writings, personal documents, photographs, letters, and such. In particular, there is a large collection of my letters home from the US since I left Israel in 1961. There was no email in those days, and telephone calls overseas were prohibitive. Thus, I would write home regularly, about twice a month. It includes a letter I wrote circa 1973, when I realized that I had discovered RD and that it has to do with cognition. I never knew about this time capsule, and I was tending to my mother at a hospice for the last ten days of her life. She was coherent to the end, but never mentioned this time capsule.
>
> The then twenty-two-year-old Uri found the suitcase on the sidewalk, along other refuse from my mother's apartment, awaiting collection by the municipal garbage truck. He picked up the suitcase and took it home with him. For a few weeks, he read the materials, and for no obvious reason decided to become their custodians until he discovered the true heirs.
>
> My mother lost her own mother, Chaya Baram, during the Spanish flu in 1918. This was in the Jewish Pale of Settlement that straddled Poland, Russia, and the Ukraine. Mostly rural. Her mother was twenty-nine and my mother was only nine. This has imprinted her entire life. She raised her young only brother, then aged seven, who eventually went to Palestine and later became multiple-term Knesset member, a whip of the then ruling Labor coalition, and also held cabinet-level positions under PM Rabin.

My mother left home at age fourteen, was a servant for richer Jewish families in bigger towns, and over a lifetime picked up about ten languages that included Hebrew, Yiddish, Polish, Russian, Ukrainian, German, English, French, Latin, and Classical Greek. She was a published poet, edited by my father, and she enrolled in Hebrew high school. She became a star student and spoke perfect literary Hebrew.

At age nineteen, she went by herself to Palestine without any resources, enrolled at the Hebrew University of Jerusalem, and became a star student there as well. She mingled with the leading elite of the time that included later very well-known professors and thinkers, scientists, poets, and politicians, including Israeli presidents, and other legendary figures that Uri knew only from history lessons.

For thirty-three years, having moved numerous times, getting married and now having three adult children, spending a number of years in the US studying in Connecticut and also getting an MBA from Harvard, he held onto this suitcase. By a sheer fluke, he finally discovered my niece, Hila Berger, who led him to my sister to whom he delivered the time capsule a few days ago.

Today I talked to him by Skype, and it was like finding a lost younger brother. He knows so much about our family history and believes that these materials deserve broad publicity via a TV series or such. Today happens to be his fifty-sixth birthday, and I hinted that I wish to send him a token of my appreciation. He absolutely refused but expressed two wishes: He wishes that someone could deliver to him a similar capsule from his own now deceased parents, and he wishes to observe my face as I receive some of the materials from my sister. Very best—Joel."[65]

****

[65] Email to Bob Krone forwarded from Joel Isaacson to Bernd Schmeikal, October 26, 2020.

About the Author: Bernd Schmeikal is a mathematical physicist (High Energy Group/Walter Thirring) and sociologist. He received his doctorate in physics from the University of Vienna and later habilitated there in sociology. Accordingly, he was scientifically active across disciplines at Austrian universities, but also at non-university institutions. Finally, he was the founder of the world's first Biofield laboratory (BILAB). Currently, he is a senior counselor at KSI, His latest book, *Time-Out of Time*, will be published in spring 2022.

Editors' Notes: Before Bob Krone stepped down as Editor-in-Chief of this *Journal of Space Philosophy* (and then passed away soon after), he began organizing a special issue focused on the work of his late friend and colleague, Joel Isaacson, with a particular focus on recursive distinctioning. In this opening article of the issue, Bernd Schmeikal has generously offered not only a tribute to Isaacson's work, but also a touching degree of personal insight into the academic banter that passed between the three long-time colleagues (and others, including Louis Kauffman, who contributed the next article in this issue). ***Gordon Arthur and Mark Wagner.***

Recursive Distinctioning—Orthodox and Unorthodox

By Louis H. Kauffman

Abstract

This article describes recursive distinctioning (RD) as formulated by Joel Isaacson and articulated by Isaacson and the author. Orthodox RD is discussed and problems and ideas related to it are indicated. Variants of RD are discussed, including the structure of describing describing, formal arithmetic related to Spencer-Brown's Laws of Form and structures of self-reference and recursion related to language, logic, and mathematics.

Keywords: distinction, recursion, recursive distinctioning, form, arithmetic, meaning, syntax, description, self-reference.

I. Introduction

This paper is an introduction to recursive distinctioning (RD).[1] We first give a model for RD. We then discuss other partial RDs and we discuss the role of Spencer-Brown's *Laws of Form*[2] in the articulation of distinctions and recursions. We end with a reflective epilogue.[3]

The theme of this paper is that RD directly instantiates a general dialectic between meaning and syntax, where by syntax I mean any formalism or language that has symbols, signs, or distinctions. It is a circular process, a dialogue. Meaning gives rise to syntax. Syntax gives rise to meaning. In the specific RD actions we describe here, meaning arises in the form of distinctions, and these distinctions become signs, syntax for a next round of distinguishing and meaning, leading again to syntax in an endless round.

This paper is dedicated to the memory of Joel Isaacson and to his deep insight into fundamental process.

II. What is RD?

RD means just what it says. A pattern of distinctions is given in a space based on a graphical structure (such as a line of print or a planar lattice or a given graph). Each node of the graph is occupied by a letter from some arbitrary alphabet. A specialized alphabet is given that can indicate distinctions about neighbors of a given node. The neighbors of a node are all nodes that are connected to the given node by edges in the graph. The letters in the specialized alphabet (call it SA) are used to describe the states

[1] Joel Isaacson, Autonomic String-Manipulation System, US Patent 4286330, filed April 26, 1979 and issued August 25, 1981.

[2] George Spencer-Brown, *Laws of Form* (London: G. Allen and Unwin, 1969).

[3] This paper is an extension and modification of Louis H. Kauffman and Joel Isaacson, "Recursive Distinctioning and the Basis of Distinction," *Journal of Space Philosophy* 10, no. 1 (Spring 2021): 69-82.

of the letters in the given graph, and at each stage in the recursion, letters in SA are written at all nodes in the graph, describing its previous state. The recursive structure that results from the iteration of descriptions is called RD. Here is an example. We use a line graph and represent it just as a finite row of letters. The SA is {=, [,], O} where "=" means that the letters to the left and to the right are equal to the letter in the middle. Thus, if we had AAA in the line then the middle A would be replaced by =. The symbol "[" means that the letter to the LEFT is different. Thus, in ABB, the middle letter would be replaced by [. The symbol "]" means that the letter to the RIGHT is different. Finally, the symbol "O" means that the letters both to the left and to the right are different. The SA is a tiny language of elementary letter distinctions. Here is an example of this RD in operation, where we use the proverbial three dots to indicate a long string of letters in the same pattern:

… AAAAAAAAAABAAAAAAAAA …
is replaced by
… =========]O[========= …
is replaced by
… ========]OOO[======== …
is replaced by
… =======]O[=]O[======= ….

Figure 1. The First Few Steps of RD.

Note that the element]O[appears from the simple difference between B and its neighbors, and that]O[then replicates itself in a kind of mitosis or DNA replication activity.

RD is the study of systems that use symbolic alphabetic language that can describe the neighborhood of a locus (in a network) occupied by a given icon or letter or element of language. An icon representing the distinctions between the original icon and its neighbors is formed and replaces the original icon. This process continues recursively.

Figure 2 illustrates further steps in the recursive process (with a fixed boundary condition). Note the dialectical flavor of the continued patterning. In this model, we have used synchronous processing so that each row is fully worked out before becoming the next row. It is convenient, particularly for pattern investigation, to use synchrony, but it is not necessary. Many asynchronous variations are possible, and we encourage the reader to explore these on his or her own.

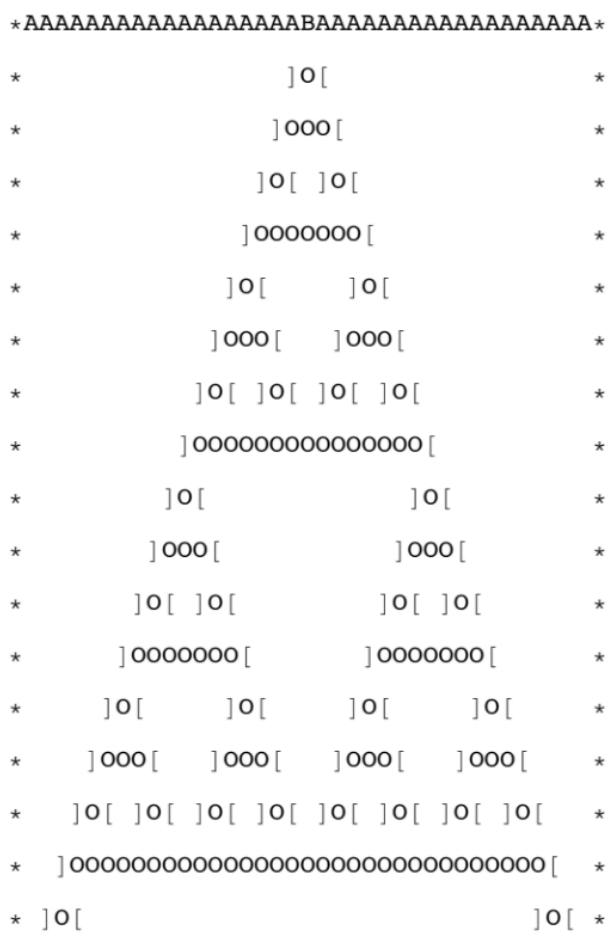


Figure 2. An extended RD Recursion with Boundary Conditions.

RD processes encompass a very wide class of recursive processes in this context of language, geometry, and logic. These elements are fundamental to cybernetics and cross the boundaries between what is traditionally called first- and second-order cybernetics. This is particularly the case when the observer of the RD system is taken to be a serious aspect of that system. Then the elementary and automatic distinctions within the system are integrated with the higher order discriminations of the observer. The very simplest RD processes have dialectical properties, exhibit counting, and exhibit patterns of self-replication. Thus, one has in the first RD a microcosm of cybernetics and, perhaps, a microcosm of the world.

If we go back to the beginning of the RD and the analogy with DNA, we have a sequence of letters such as

… BBBBBABBBB …

We then describe them in terms of their mutual likes and differences:

… BBBBABBBB …
… ===⊃□⊂=== …
… ==⊃□□□⊂== …
… =⊃□⊂=⊃□⊂= …

If the letters on either side of a given letter are equal, I replace the letter by an equals sign (=). If the left side is equal but the right side is different, I replace by ⊃. If the right side is equal, but the left side is different, I replace by ⊂. If both sides are different, I replace by a box (□). Now we can perform recursive distinctioning. Examine the diagram above. We performed the distinction/description process three times, starting with … BBBBABBBB …. The change from B to A and back to B produced *a protocell* of the form ⊃□⊂, the next description elongated the cell to ⊃□□□⊂, and in the third stage, the protocell divided into two copies of itself! All this comes from making distinctions and describing them with an alphabet so that one can make distinctions again and describe again. Very complex and interesting patterns can arise in this way.

This recursive distinctioning process then reminds us of DNA and how DNA replicates itself. You can think of the DNA molecule as a combination of two strands that we can call W (the Watson strand) and C (the Crick strand). W and C are chemically bonded, and we can denote that by <W|C>. So, we can write symbolically DNA = <W|C>. Special processes enabled by enzymes make it possible for these bonds to be broken and for the cellular environment to supply complementary base pairs to each separate strand. Letting E denote the environment we can write <W|E → <W|C> and E|C> → <W|C>. Thus, we have that in the cell, the DNA molecule can be separated into two strands, each of which then becomes a full copy of the DNA. In symbols this has the pattern:

<W|C> → <W|E|C> → <W|EE|C> → <W|C> E <W|C>.

(Here we allow that the environment can be indicated in place of "nothing" and that it can divide into two parts of environment relevant to the two parts of the helix.)

Compare this symbolic sequence for DNA replication with the Recursive Distinction sequence we just discussed.

⊃□⊂ → ⊃□□□⊂ → ⊃□⊂=⊃□⊂.

The interpretations are different, but the pattern is the same (at an appropriately generous level of observation). This is a place where RD needs research to reveal the deep structure indicated by this commonality of self-replication in RD process and the DNA molecular process.

III. The Concept of RD

We ask the reader to examine the chart in Figure 3, taken from Isaacson's patent document.[4] The chart is a description of the RD process. Note that at a certain point we see described the appearance of a dialectical process, and then the repetition of this dialectic throughout the continued recursion of description begetting description in an endless round. Distinctions are made between surface structure and deep structure and at a certain point in the chart it is indicated that, in the perfect dialectical triad, there occurs the idea of RD. Indeed, the idea of the RD is very much the idea of dialectical process, and in these models, we see the automatic working out of a dialectical process in its most elementary form.

For us, the observers of the simple RD, there is an experience of recognition in seeing that this simple process mirrors the elementary processes of our own thought and discrimination. At that point of recognition, the most fundamental problem arises: What is the source of the distinctions that we perceive?

On the one hand, one can recognize that for a human observer a distinction is always accompanied by an awareness or consciousness of that distinction. Furthermore, it is often the case that what is seen to be distinct depends upon the entire context of the event. A good example is the detection of the blind spot in the eye. This hole in our vision is normally not seen at all, but it can be revealed by looking in a direction to the left of a right thumb with the right eye (left eye closed). Then the thumb can disappear in the visual field, indicating the blind spot, but there is never a hole in the visual field. Some distinctions are distinctions for one modality of perception but not another. All distinctions that humans have are supported by their nervous system, their biology, and the physics of the organism, in addition to the context in which these distinctions are framed. The context almost always involves a language of description, and that language itself is composed of distinctions.

[4] Isaacson, Autonomic string-manipulation system.

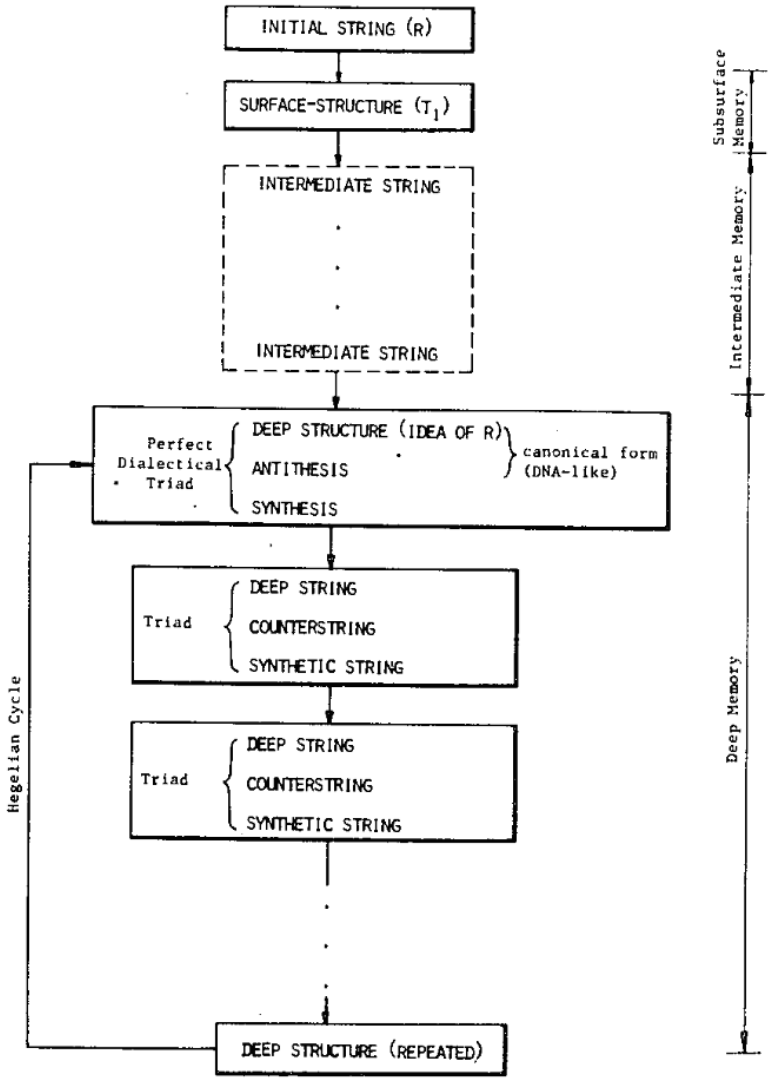


Figure 3. RD Structure and Deep Structure.

Figure 3 can be interpreted as a particularly apt and process-oriented description of the action of distinctions in cognition for a human being. It is also a particularly apt description of the simple RD automaton we described in Section 2. Our intent is not to confuse these two domains but to point out the analogy between them. In a certain sense, the RD automaton engages in a form of cognition and the difference between its cognition and ours is worth contemplating.

By the same token, the RD automaton is based in distinctions that arise in the contiguity of simple elements. In this case, the elements are characters in symbol strings. The analogy can be carried forth to situations in cellular biology where the interactions are those of cells or constituents of cells, and the distinctions have to do with the direct interactions of molecules or with the making and breaking of cellular boundaries. In this

arena, significant distinctions are seen to be in operation, apparently independent of our individual cognition and awareness.

This leads to the inevitable discussion of the notion of distinctions independent of human awareness. We understand that such distinctions occur in other organisms and indeed within our own organism. The digestive system also makes its distinctions in regard to the food we hand it, and thereby enables the continuance of the body. My computer also does its operations, independent of my possible understanding of its programming.

The RD automaton can suggest, in this field of analogies, that certain processes of distinction and indeed language precede the consciousness that we take to be the locus of distinctions for our understandings. Some reflection may convince the person who thinks about these ideas that the conception of distinction is circular. Distinctions beget distinctions in an endless round. And once again the RD automaton is a simple model of that dialectical process.

IV. Synchrony

RD processes, as we have discussed them, are synchronous processes in the sense that several variables (the characters in a string for example) are replaced at the same time by a globally defined rule. It is also possible to discuss and investigate asynchronous processes where the updating occurs locally and in different orders than the simultaneity we have imposed. Nevertheless, in this discussion, we adhere to synchronous processes and leave the asynchronous for another time (*sic*).

The general synchronous process is described very succinctly in mathematical terms. Let there be given a set of variables $x_1, x_2, \ldots, x_n$ and a collection of functions $F_1, F_2, \ldots, F_n$ where each F_k is a function of these variables. We may write $F_k\ (x_1, x_2, \ldots, x_n)$. Then we define a synchronous process where the variables are updated by the equations

$$x_1' = F_1\ (x_1, x_2, \ldots, x_n)$$
$$\ldots$$
$$x_n' = F_n\ (x_1, x_2, \ldots, x_n)$$

If we let x denote the vector of values $x = (x_1, x_2, \ldots, x_n)$, then the system can be written concisely as $x' = F(x)$ where F is the vector of F-values. The crux of a synchronous process depends on the choice of the rules of $F(x)$. In the case of the RD process described in Section 2, we have an F that is defined on triples of values (a character and its neighbors to the left and to the right). The possible values are the symbols], [, =, and O and any other distinguishable character symbol. We have:

$$F(A, B, C) = O$$
$$F(A, A, C) = [$$
$$F(A, B, B) =]$$
$$F(A, A, A) = =$$

Where A, B, and C denote signs so that A, B, and C are distinct.

The output of the function of three variables is the new character that replaces the middle variable. In a long string of characters, this computation is performed for each triple and the results are stored until all computations are complete. Then the new row of characters replaces the original row. This is the synchronous model for the one-dimensional RD.

Note that the new characters (O, =, [,]) are iconic for the distinctions they represent. Thus, this orthodox RD has the characteristics of distinctions involving adjacency and iconicity. Each new character is an icon for the distinction that it connotes. These properties single out this RD from the vast collection of possible recursions, even those that involve only four values and three variables.

It is interesting to examine the simplest examples of the RD recursion. For example, we can use strings of length three with the boundary condition that the end characters are always seen to be different from the emptiness on their right or their left. Then we have a period two oscillation as shown below.

ABC
OOO
[=]
OOO
[=]
OOO
…

If we use strings of length four, then we can attain a period three oscillation.

A B C D
OOOO
[= =]
O [ ] O
OOOO
[= =]
O [ ] O
…

There is a range of periods and behavior to be explored in this simplest RD.

If we consider functions at this same level of simplicity, then some analogous behaviour can be observed. For example, let 0 and 1 denote the two basic Boolean values and let <*x*> denote the negation of *x* so that <0> = 1 and <1> = 0. Then we can define a simplest recursion by $x' = \langle x \rangle$, leading to a period two oscillation … 01010101 … A next simplest example that leads to a period four oscillation is

$$x' = y,$$
$$y' = \langle x \rangle.$$

Beginning here we can construct many oscillators and many patterns. The RD phenomenon occurs very near the beginning of this hierarchy of mathematical possibilities.

In fact, all the processes of the form $x' = F(x)$ can be seen as RD. It is a matter of investigation of the details of the recursion $F(x)$ to find out how the rules of these distinctions operate. A good arena for examining this is the field of cellular automata, where experimentation with rules has led to a vast zoo of phenomena. Not all such recursions take part in the dialectical process of the RD, but all are available to be seen as the consequence of making distinctions and expressing them in a recursive domain.

V. The Audioactive Recursion

1
11
21
1211
111221
312211
13112221
1113213211
…

Illustrated here is a pattern of *recursive description*. Each line is a description of the previous line. To see this, read the lines aloud. The second line says, "one one," and that is a description of the first line. The third line says, "two ones," and that is a description of the second line. The next line says, "one two, one one," then "one one, one two, two ones," and so on. The full alphabet for this recursion is the set of numerals {1, 2, 3}, and these are alternately signs and elements of the description of a pattern. This "audioactive sequence" was extensively investigated by John Horton Conway,[5] and it has many mathematical properties.

[5] John H. Conway, "The Weird and Wonderful Chemistry of Audioactive Decay," *Eureka* 46 (Jan. 1986): 5-16.

A variant on the above recursion that is quite interesting starts with the number three rather than one. Then we have

3
13
1113
3113
132113
1113122113
311311222113
…

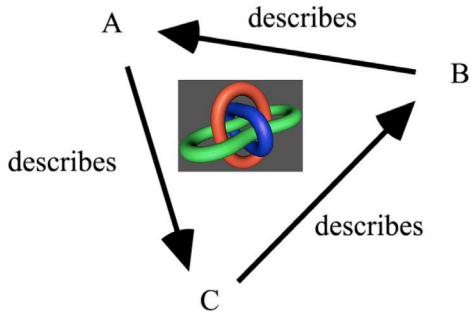
It is not hard to see that if the rows are r_1, r_2, r_3, … then r_{n+3} is an extension of r_n. This means that we can build three infinite rows A, B, C that are in dialogue with each other in the sense that B describes A, C describes B, and A describes C.

A = 111312211312 …
B = 311311222113 …
C = 132113213221 …

There is much to explore in this recursion. A description is of course certainly a distinction, but the distinctions made by this form of description are of a more complex nature than the adjacencies in the first RD that we have discussed.

Remarkably, the audioactive sequences shown here are based on a very small alphabet of numerals (1, 2, 3). It is a bit mysterious what can come from only one, two, and three.

A = 11131221131211132221 …
B = 3113112221131112311332 …
C = 13211321322113311213212 3 …



We have two mappings defined on strings of digits that take strings of digits to strings of digits. For symbolic sake, let *S* denote the collection of all finite strings of

digits. $D{:}S \rightarrow S$ is our "descriptor" and $U{:}S' \rightarrow S$ is our "undescriptor." U is only defined on those strings S' that are descriptions.

Examine 22. Its description is 22. Its un-description is 22. It is a perfect self-describer. $D(22) = 22$. $U(22) = 22$. The description of two twos is two twos. We can compare how 22 produces itself with John von Neuman's machine B that can build itself! The universal von Neumann machine B is a "universal builder". Give B a description x, and B will build the entity X with that description. So, one would write

$$B, x \rightarrow X, x.$$

B would use the blueprint x to build X and produce X along with its blueprint x. This is fantastic. B can build itself. You just give B its own blueprint, b! Then $B, b \rightarrow B, b$ and B produces a copy of itself.

$$B, b \rightarrow B, b.$$

Let us take the arrow $nx \rightarrow xxx \ldots x$ (n $x$es) to mean the "un-describe" arrow that produces the string whose description is nx. This is the analog of what a building machine does, and nx is the blueprint. Then we have $2x \rightarrow xx$ and we see that $22 \rightarrow 22$ builds a copy of itself. This is of course a special case of von Neumann's pattern. There is also a 2 in the von Neuman machine. He has $B, x \rightarrow X, x$. Two entities produce two entities. So, B, b is really a repetition, just like 22, where the two twos in 22 are different. One says the number of twos in the entity that is being described.

VI. Formal Arithmetic

Here we give an example of *formal arithmetic,* governed by a very simple recursive distinctioning with contiguity of characters. The formal arithmetic rules for changing a string of characters consisting in the characters "*," "<," and ">" are as follows:

** is replaced by <*>
>< is replaced by (nothing).

Note that in this recursion, we rely on adjacency to detect the patterns that are to be replaced. Detection and replacement of pattern is the form of distinction in this model.[6]

If we start with a row of five stars, then the following recursion will occur.

*****
<*><*>*
<**>*
<<*>>*

[6] Louis H. Kauffman, "Arithmetic in the Form," *Cybernetics and Systems* 26, no. 1 (1995): 1-57.

If you interpret * as the number 1, <*X*> as 2*X* for any number *X*, and *XY* (adjacent strings) as *X* + *Y*, then you will see that result of the string replacement will be a coding of the number of stars in the first row. In this example, <<*>>* = 2(2(1)) + 1 = 4 + 1 = 5. In fact, the result of the recursion can be interpreted as the binary coding for the original number of stars. Here is another example:

****
<*><*><*><*><*><*><*><*>*
<********>*
<<*><*><*><*>>*
<<****>>*
<<<*><*>>>*
<<<**>>>*
<<<<*>>>>*

The result tells us that there are $2^4 + 1 = 17$ stars in the first row.

Here is the method to convert the result of the recursion to binary notation. Start with the result. Remove the left pointing arrows. Replace the stars by instances of 1. Place a 0 in between each >> and place a 0 at the right if there is no star. Then remove all the right pointing arrows.

For example:

<<<<*>>>>*
>>>> 1>>>>1
1>0>0>0>1
10001.

This recursion is a simple automaton that does arithmetic and converts numbers into binary. Everything proceeds from two forms of distinction. One form recognizes pairs of stars and replaces them by a bracketed star. The other recognizes oppositely pointing pairs of brackets and erases them. At first, it is not obvious that these two forms of distinction are a basis for calculations in arithmetic. Just so, there are recursive processes behind our familiar actions that would seem unfamiliar until we examine them. Consider an everyday action such as speech and ask yourself how you produce the highly patterned sounds that constitute your voice. It is a long story in new territory to articulate what happens in that domain.

Recursion in arithmetic is itself unknown territory for most mathematicians and scientists at this time. For example, consider the following Collatz Rule:

If *n* is even, replace *n* by *n*/2.
If *n* is odd replace *n* by (3*n* + 1)/2.

If $n = 1$, STOP.

For example, 7 > 11 > 17 > 26 > 13 > 20 > 10 > 5 > 8 > 4 > 2 > 1. It is conjectured that for any natural number *n*, this process will, after a finite number of steps, terminate at 1. The problem has been known since the 1940s. It remains unsolved at the time of writing. Many adventures can be had in exploring the Collatz Recursion. It is based on little more than elementary arithmetic and the distinction between even and odd. I have used the arithmetic automaton based on a star and bracket to explore the Collatz problem, but it has not yielded up its secrets yet. This problem indicates the depth of simple recursions in the structure of elementary mathematics. Mathematics itself is built from distinctions. We are often surprised by the phenomena that emerge just from mathematics itself in the face of recursion.

VII. Laws of Form

This example is different than the previous ones. Here we start with distinction, but we do not institute rules for a synchronous recursion. The system we describe is due to G. Spencer-Brown in his book *Laws of Form*.[7]

Here the sign ⌐ stands for the distinction that it makes between inside the sign and its outside. Spencer-Brown calls ⌐ the mark, and allows it to refer to any given distinction, including itself. The inside of the mark is unmarked. The outside of the mark is marked (by the mark).

The mark a⌐ can be interpreted as an instruction to cross the boundary of a distinction. In that mode, we have denoted the value obtained by crossing from the state a. Thus ⌐⌐ is unmarked, since we have crossed from the marked state, and ⌐ is marked since we have crossed from the unmarked state. An extra mark in the space outside the mark is redundant since that space is already marked. Consequently, we may write ⌐⌐ = ⌐. Thus, we have two basic replacement rules:

Crossing: ⌐⌐ =

Calling: ⌐⌐ = ⌐.

A calculus arises from this so that one can reduce or expand arbitrary expressions in the mark. For example,

One can prove that the simplification of an expression is unique and go on to consider the algebra that is related to this arithmetic.

[7] Spencer-Brown, *Laws of Form*.

In the algebra, we have identities such as AA = A for any expression a, and $\overline{\overline{A}\,|\,}$ = A for an expression A. Remarkably, the algebra is quite non-trivial and leads to a new construction for Boolean algebra and new insights into the nature of logic.

Here, a great deal of structure comes to light if we decide not to use synchronicity immediately and to elicit designs that are asynchronous and have behaviour that is independent of choices of time delay. In this way, the timeless structure of such asynchronous structures enters and supports the creation of the rhythm and temporality of recursive computation. In this way, one can consider recursive structures related to the calculus of indications (as this calculus of the mark is called).

An elementary structure of great significance appears from these equations:

$$M = \overline{aN\,|}$$
$$N = \overline{bM\,|}$$

To see what happens here, let *a* and *b* be unmarked. Then we have

$$M = \overline{N\,|}$$
$$N = \overline{M\,|}$$

If M = ⌝ and N = $\overline{\overline{\,|\,}\,|\,}$, these values satisfy the equations, and so the system is in a stable state. Similarly, if M = $\overline{\overline{\,|\,}\,|\,}$ and N = ⌝, then the system is in a stable state. We see from this that M and N together form a memory. In a possible world of recursions, the memory can maintain a particular pair of values. In this way, the binding of structure across time emerges from the timeless eternity of forms.

Furthermore, if in this memory we were to change *a* or *b* to the marked state, we could influence the memory to change state. A momentary change in the inputs *a* and *b* can reset the memory. In this way, circular systems of equations can be made that correspond to circuitry at the base of computing, and the essential design of digital computers can be accomplished in the language of the mark and its algebra.

A key function that can be described in this algebra is the operation of exclusive or. We denote exclusive or of *A* and *B* by *A # B*. It is expressed in the algebra of the mark as:

$$A \# B = \overline{A\,B\,|\,\overline{A\,|\,B\,|\,}}.$$

The reader will note that *A # B* is marked only when one of *A* or *B* is marked, but not both. Thus *A # B* can indicate whether *A* and *B* are distinct or not. If *A* = *B* then *A # B* is unmarked, but if *A* ≠ *B*, then A # B is marked. It is this ability of the logical algebra to make distinctions that gives it the capacity to be the underpinning for models of recursive distinguishing.

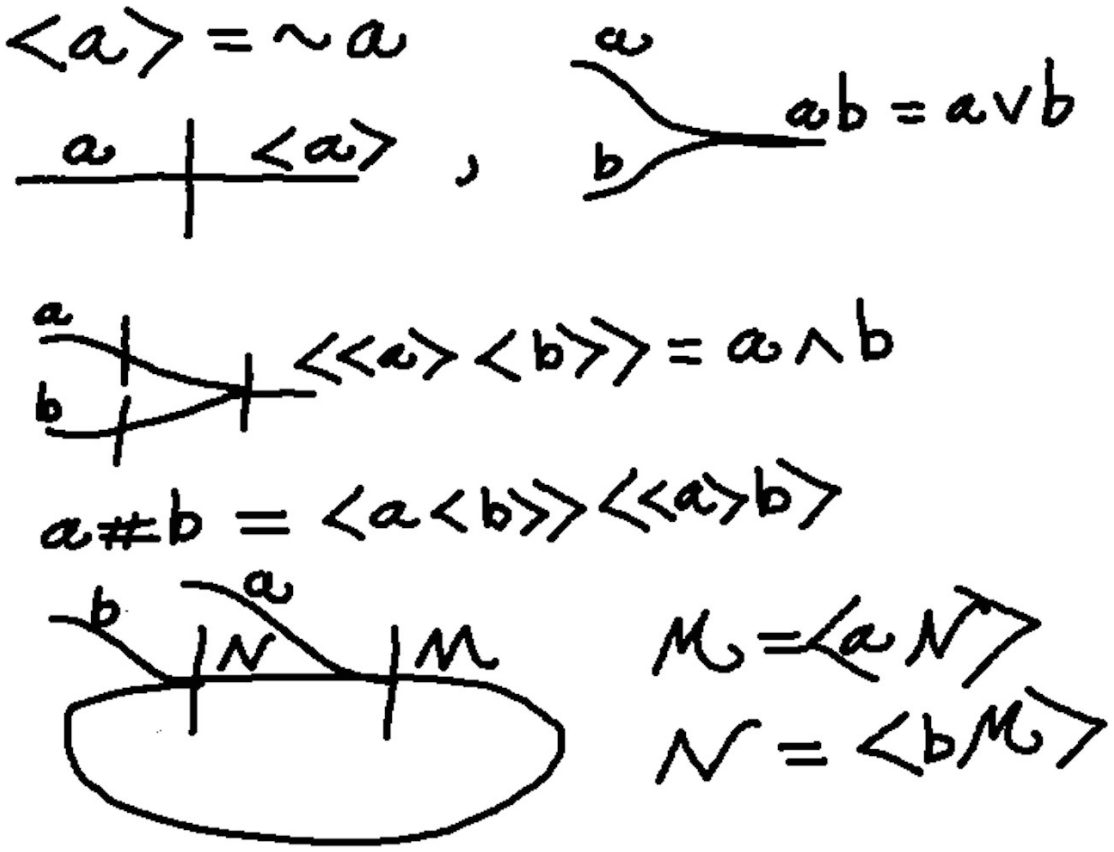


Figure 4: Diagrams for Distinction Operators

In Figure 4, (using <> for the mark) we indicate the bare bones of diagrams for these distinction operators and for the memory. It should be apparent that the memory can be regarded as a graph with a special even cycle that can be labeled with states so that there is an evaluation balance at each node. The node with the vertical marker is the distinction operator, and it is an analog of a NOR gate in electronics. Systems composed of such diagrams can be used to model the basic workings of any digital computer, and so make a Turing complete structure. In this way, we see that all computation can be seen to be based on distinctions and recursions. This way of creating a basis is not quite in the mold of RD where all distinctions are created in relation to contiguities and the formation of alphabets. In this circuit paradigm the distinctions act as states and transmissions of elementary information in the cycles and trees of graphical structures that are themselves seen as patterns of distinction operators.

By regarding the distinction operators as graphical carriers of information, the structure of these graphs in Laws of Form can be shaped as models of automata that can be built in hierarchical fashion and so concatenate into full blown designs for digital computers and information systems. By the same token, these designs can support the operations of any RD of the type that we have described in this paper. We can enfold the RD concept and designs into a full context of computation and communication.

In this way, we come full circle for the structure of RD in that the consideration of a distinction and the evolution of an algebra and operations of distinction creates the platform on which RD can be constructed. But the process by which we have evolved this algebra and logic is, in fact, the already given RD capabilities of our organism and our abilities to make engineering and mathematical design.

We can reach deeper into the biological and physical world to find sources that underpin the emergence of distinctions. This will inevitably happen in the future development of RD and the understanding of distinction.

VIII. The Intellector

The intellector in the Isaacson Patent[8] is based on the operation of an XOR on a pair of entities. We discussed this operation in Section 7 of this paper. Writing *a#b* for exclusive or, we have that *a#b* is marked if *a* is distinct from *b*, and *a#b* is unmarked when *a* is equal to *b*. The key point about *a#b* is that it is given as a sensitivity to same or different in a possible situation where a direct observation of *a* or *b* would not suffice to give that information. Thus, *a#b* is relative information. The intellector is at the base of the construction of the RD, and it can detect difference and so begin the process of recursion. The intellector does not have to detect the values of individual entities, only whether they are the same or different for its information gathering capacity. This property of starting with relative information is very important for both the epistemology of RD and its possible applications. After all, a bacterium cannot name the components of its environment, but it can interact with them.

Note that the intellector processes *streaks*, rather than strings written in the symbolic alphabet (the four icons). We illustrated this in Section 2 with input strings of the form BBBBABBBB. Such strings can contain any characters whatever just so long as the intellector can discriminate identity or difference between any two of them. A streak codes for same/not same between adjacent entities in strings. Thus, a streak may represent any string whatsoever, including strings of fantomarks (not directly detectable marks). Thus, things are removed from directly observable signals to binary streaks that represent difference and sameness. All this is described in the patent.[9]

In the patent, the term intellector denotes an electronic circuit that is built of multiple XOR gates. Further distinctions about coding and processing of strings occur in the patent, to which we refer the reader. Note that in a natural RD process, we do not expect electronic circuits or algorithmic string manipulations to model the intellector, but there will be relative ways for discrimination to arise and produce new entities to be discriminated.

[8] Isaacson, Autonomic String-Manipulation System.
[9] Isaacson, Autonomic String-Manipulation System.

IX. Language, Reference, and Self-Reference

In an earlier section, we discussed a simple construction of self-reference in which "two twos" describes "two twos". This is a non-paradoxical self-reference of ordinary language to itself. The discussion also re-described this aspect of describing describing. We can take this discussion again through a simple language in which this pattern occurs. The words in this language are all the strings S, SS, SSS, SSSS, … ad infinitum.

A string of the form *SX* is given to refer to the string *XX*. Here *X* denotes one of the strings above. Since *SX* refers to *XX*, we see that *SS* refers to *SS*. This is the essence of the matter. The feedback loop completes from *SS* to itself, just as from 22 to 22. From here you see that the Russell paradox builds on this pattern with the Russell set defined by the equation $Rx = \sim xx$ so that substituting *R* gives the self-denial $RR = \sim RR$. By the time Church and Curry had abstracted the essence of the Russell paradox, they had taken the view that RR is an entity that is invariant under negation. *RR*, being paradoxical, is in the language of cybernetics, an eigenform for negation, an imaginary logical value, a token for the process of negation. The Russell Paradox eigenform *RR* became a valued member of non-standard mathematical discourse.

In examining describing describing, we indicated a route to self-reference and eigenform There is another route, fundamental to language and communication. I call this process the *indicative shift*.[10] Let

$$b \rightarrow B$$

denote a *reference of b to B*. You can take *b* to be a name for *B*. The *shift* of this reference is denoted by

$$\#b \rightarrow Bb.$$

I am introduced to *B* and my host says to me, please meet "*b*." Being an attentive guest, I make an association of the name *b* with the appearance *B* and put them together in my mind. The next time I meet *B*, he appears to me as a *Bb* in the sense that the name comes right along with him. In my imagination, *B* has the name-tag *b* on his lapel. I also have that name stored with a marker *#b* (made explicit here but usually unsaid). The name *#b* is now pointing to my amalgam of *B* with his name. To examine your own process in this regard, think of the times you have encountered someone whose name you have forgotten. You find yourself attempting to reconstruct the links we have just described.

It is possible for a sign to stand for itself. For example, a bracket < > can be regarded as a sign for the distinction that it makes between its inside and its outside. In that case

[10] Louis H. Kauffman, "Self-Reference and Recursive Forms," *Journal of Social and Biological Structures* 10 (1987): 53-72; Louis H. Kauffman, "Eigenform," *Kybernetes* 34 (2005): 129-50; Louis H. Kauffman, "Categorical Pairs and the Indicative Shift," *Applied Mathematics and Computation* 218 (2012): 7989-8004.

< > is a sign for itself. We can write <>→ <> to indicate that the bracket refers to itself. Shifting, we have

#<> → <> <>.

In G. Spenser-Brown's work, *Laws of Form*,[11] he takes the self-referential mark of distinction as a starting point and the equations

<><> = <>
<<>> =

as the expression of a calculus of indications. The first equation can be interpreted as the redundancy of calling the name of the mark by itself. If I wear a name tag, it is not necessary. The second equation involves regarding the sign <> as an act of distinction or crossing. To cross from the unmarked state achieves the marked state: <> = <>. To cross from the marked state achieves the unmarked state <<>> = . For a minimal formalism in the enactment of meaning and syntax, one could not ask for less than the calculus of indications of George Spencer-Brown. Contraction of reference leads to expansion of awareness.

What does the indicative shift have to do with self-reference? You even have a name for the shifting process itself. So, suppose that *M* is the name of the shift. Then

M → #.

Shifting, we find that

#*M* → #*M*.

The meta-name (#*M*) of the name of the shift refers to itself.

We rewrite:

I am the meta-name of my meta-naming process.

and find a relative of the Heinz von Foerster sentence

"I am the observed relation between myself and observing myself."

You can begin the indicative shift at the most elemental point.

→

[11] Spencer-Brown, *Laws of Form*.

This is an arrow from nothing to nothing. Nothing stands for nothing. An arrow prior to names. Pointing without content. It would be self-referential if there were a self in nothing.

Apply the shift.

$$\# \rightarrow$$

There was nothing to shift.

Apply the shift again

$$\#\# \rightarrow \#$$

and again

$$\#\#\# \rightarrow \#\#\#.$$

Thus, we have

$$\rightarrow$$
$$\# \rightarrow$$
$$\#\# \rightarrow \#$$
$$\#\#\# \rightarrow \#\#\#.$$

At the third departure from the void, we find that self-reference has occurred.

Meaning arises from syntax in our understanding of the process that it connotes.
In the beginning there was no name.
The shift became the name of nothing.
The shift of the name of nothing became the name of the shift.
The shift of the name of the shift is its own name.

Here begins a cybernetics of the acts of distinction.

The self-reference of the indicative shift is more subtle than two twos. It involves the action of observing and it shows how the act of observing (and naming) turns around and names itself. We are aware of the realm of meaning for the observer and, here we have begun steps into a syntax for the observer

X. The Gödelian Shift

The indicative shift occurs in reference and naming in language and communication. A shift of this shift takes us to the key structures of Gödel's Incompleteness Theorem.[12]

[12] Kauffman, "Self-Reference and Recursive Forms"; Kauffman, "Eigenform"; Kauffman, "Categorical Pairs and the Indicative Shift."

Kurt Gödel proved that no consistent formal system rich enough to handle number theory could be complete. Gödel showed that there are true theorems about numbers that the given formal system cannot prove.

Gödel produced a sentence that encoded a denial of its own provability. He devised a method to code each formula F in his system with a number $g = g(F)$ (the Gödel number) so that the formula could be uniquely decoded from its number. I write $g \rightarrow F$ to denote that "g is the Gödel number of F."

Now suppose that $F(u)$ is a formula with a free variable u. For example, $F(u)$ could be "u is a prime number." Let g be the Gödel number of $F(u)$. Then we can substitute g into $F(u)$ to obtain $F(g)$. This is a new formula with a new Gödel number, call it $\#g$. Then we have $\#g \rightarrow F(g)$. This is the "Gödelian indicative shift" of $g \rightarrow F(u)$.

$$g \rightarrow F(u).$$
$$\#g \rightarrow F(g).$$

Now the function assigning the number $\#g$ to the number g is an algorithm about numbers, just the sort of thing that Gödel's formal system L can talk about. Thus, we can have # as an element in the language of L.

Let $B(u)$ be a statement in L that asserts the provability of the statement with Gödel number u. Then $\sim B(u)$ *asserts the unprovability of the statement with Gödel number* u. Furthermore, we have a Gödel number for $\sim B(\#u)$, the statement that the formula with Gödel number $\#u$ is not a provable formula:

$$g \rightarrow \sim B(\#u).$$

Then making the shift, we have

$$\#g \rightarrow \sim B(\#g).$$

This shows that $\sim B(\#g)$ asserts the unprovability of the formula with Gödel number $\#g$. But that formula is $\sim B(\#g)$! This means that $\sim B(\#g)$ asserts its own unprovability. If L could prove this formula, then L would be inconsistent. We assume that L is consistent and conclude that it cannot make the proof. But that is exactly what the formula says, and so $\sim B(\#g)$ is true but not provable in L.

We have sketched the proof of Gödel's incompleteness theorem and, as you see, the Gödelian indicative shift is the key mechanism whereby self-reference is achieved to obtain a theorem that asserts its own unprovability. The self-reference is accomplished via the coding of texts to Gödel numbers and so is protected from paradox. Here the pendulum swings wide from the meaningful arena of the indicative shift in the naming processes of ordinary language to the highly syntactical regions of formal systems. I say that when we are willing to engage such wide swings and are willing to attend to both

the large meanings and the formal detail, then the scope of cybernetics and second-order cybernetics is really taken up and challenged.

The Gödel Theorem deserves to be seen as a result of observing systems, systems that embody both formalism and understanding. Its content requires an observer and his or her understanding of the formalism. The Gödel Theorem requires the rational comprehension of an observer. In working with the final shifted equation

$$\#g \rightarrow \sim B(\#g)$$

we stand outside the formal system, understanding the meaning of the reference that makes $\sim B(\#g)$ state its own unprovability. We prove that L will produce a contradiction within its own syntax if L should produce a demonstration of $\sim B(\#g)$. We reason structurally about L through our relationship with L. We have access to the properties of the shift and an ability to reason about it that is not available to L.

We begin to understand how we as observers can be in intimate relation with a formal system. We can go forward into the classical and deep questions of the relationship of ourselves and machines (formalities, syntax). We return as always to the feedback loop of meaning and syntax and see this relationship anew.

XI. Epilogue

We should say a bit more about dealing with the line between what can be formalized, what is not (yet) formalized, and perhaps what cannot be formalized. Distinction cannot be formalized. This is because a definition is a special form of a distinction. So, any definition of distinction would be limiting the concept. This in no way inhibits us from pursuing distinctions. We must understand that any given formalization is not everything. No model fully encompasses what it would purport to describe. No artifice will capture nature. No artificial intelligence will capture intelligence. And yet intelligent behavior can arise in the simplicity of recursive distinction. Recursion arises when distinctions interact to produce new distinctions. Distinctions arise and distinctions interact to produce distinctions. Processes of this sort are at the base of all structure and the evolution of structure.

What are the fundamental distinctions? Where do they come from?

The orthodoxy of a specific formalism is just that, an orthodoxy. We will find out more as we keep looking and feeling and theorizing and inventing and discovering. Distinctions, both unaware and aware, arise. We pointed out that contiguous elements in strings or other grids may give rise to distinctions. In nature, the act may have little to do with formalism. Recursion in systems of distinctions tends to generate patterns of considerable complexity and apparent relevance to many patterns we observe in natural systems. Pure RD is a minimal system that combines distinctions and recursion.

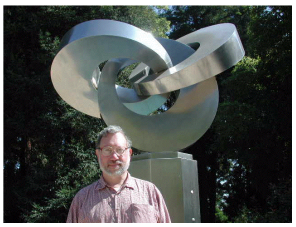
We have discussed in this essay the structure of RD and variants of it that are based on some or all its themes. There is a need in thinking to find simple basic principles and

constituents from which all other apparent phenomena can be built. Here it is proposed that distinctions are such elementals. Distinctions escape the net of the conceptual exactly because the conceptual is based upon certain fundamental distinctions. Distinctions escape the simplicity of the physical for the same reasons. No one has ever isolated a distinction in nature that is not dependent upon some particular system of observations that gives rise to such distinctions for given observers.

The essential dialectic of recursive distinctioning is a round where meaning begets syntax and syntax begets meaning. That circularity is the basis of the world.

Meaning → Syntax
Syntax → Meaning

****



About the Author: Louis H. Kauffman is Emeritus Professor of Mathematics at the University of Illinois, Chicago. He has degrees from MIT and Princeton. He has 170 publications. He was the founding editor for the *Journal of Knot Theory and its Ramifications*, and he writes a column entitled "Virtual Logic" for the journal *Cybernetics and Human-Knowing*. He was president of the American Society for Cybernetics from 2005-2008. He introduced and developed the Kauffman Polynomial. He was the recipient of the 2014 Norbert Wiener Award of the American Society for Cybernetics. He is a Fellow of the American Mathematical Society.

Editors' Notes: This paper from Professor Louis Kauffman provides a further assessment of Joel Isaacson's work on recursive distinctioning. We hope that the reader finds this explanation both accessible and stimulating, and we are grateful for the contribution to this special issue honoring Isaacson's life and work. ***Gordon Arthur and Mark Wagner.***

Circular Recursive Distinctioning

By Divyamaan Sahoo

Abstract

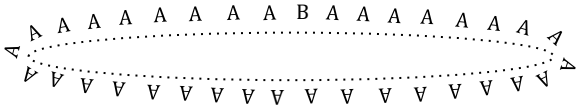
This paper introduces 1D Recursive Distinctioning on circular strings.

Keywords: o, oo, ooo, 1D Recursive Distinctioning, circular string.

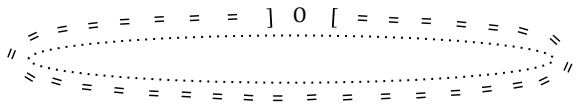
Kauffman and Isaacson[1] introduce Recursive Distinctioning (RD) via a specialized alphabet (SA), which consists of letters =,], [, and O. RD describes distinctions in the neighborhood of each character of a string and the SA allows us to see this process in action. For an arbitrary alphabet consisting of two distinct letters, say A and B, the middle A of AAA is replaced by =, the middle B of ABA is replaced by O, the middle A of AAB is replaced by], and the middle A of BAA is replaced by [.

Hence, … A A A A A A B A A A A A A … can be replaced by … = = = = =] O [= = = = = …

Consider RD on the circular string AAAAAAAAAAAAAAAABAAAAAAAAAAAAAAAA:



is replaced by



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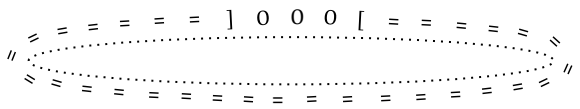

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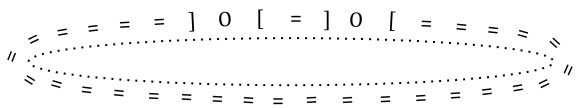
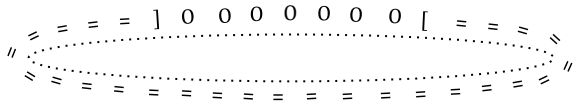


is replaced by

[1] Louis H. Kauffman and Joel Isaacson, "Recursive Distinctioning," *Journal of Space Philosophy* 5, no. 1. (Spring 2016): 9-64.



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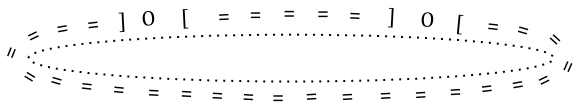

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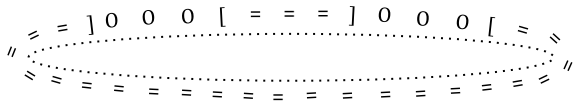

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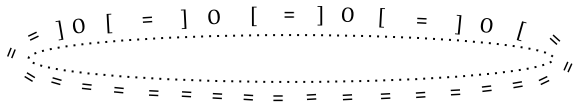

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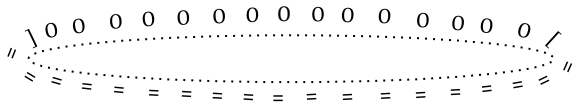

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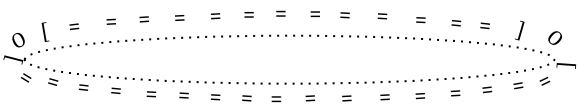

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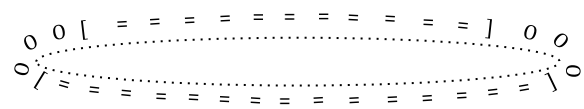

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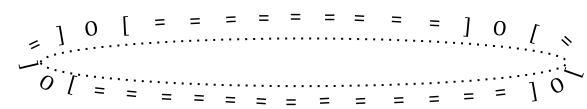

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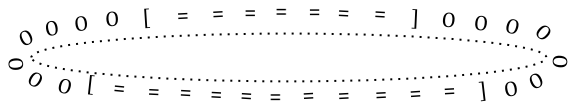

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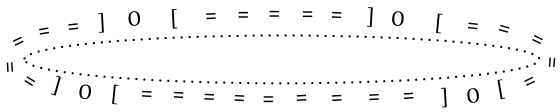

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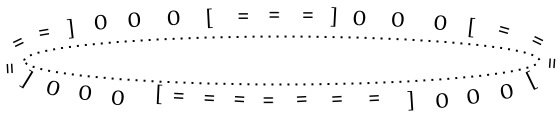

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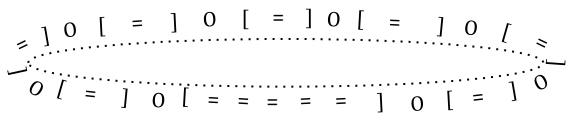

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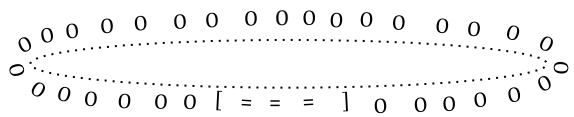

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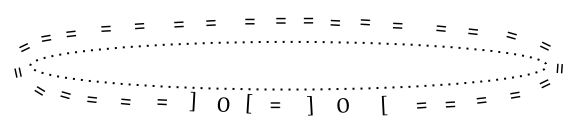
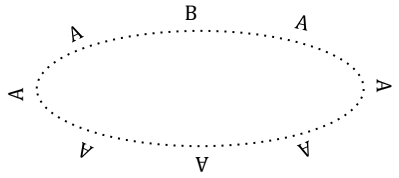


= S3, which is replaced by S4, and so on.

Now consider RD on the circular string AAABAAAA:

A	A	A	B	A	A	A	A	is replaced by
=	=	]	O	[	=	=	=	is replaced by
=	]	O	O	O	[	=	=	is replaced by
]	O	[	=	]	O	[	=	is replaced by
O	O	O	O	O	O	O	O	is replaced by
=	=	=	=	=	=	=	=	

Thus,



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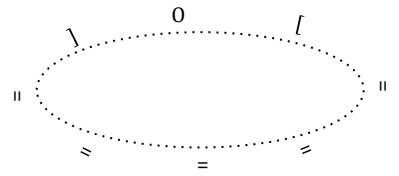

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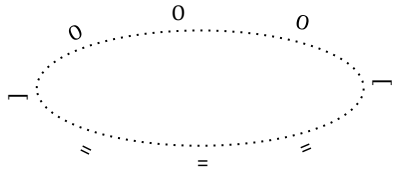

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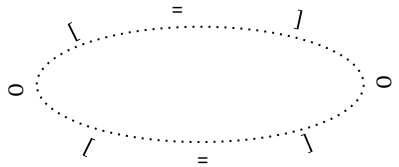

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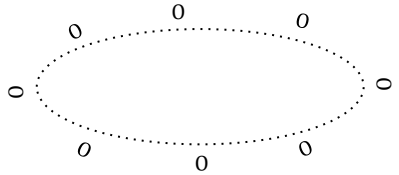

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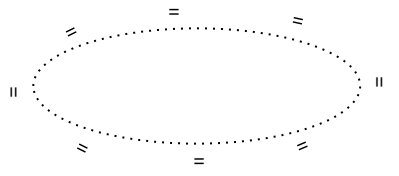
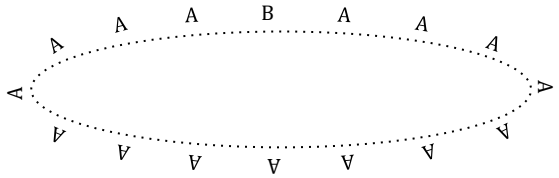


Finally, consider RD on the circular string AAAAAAABAAAAAAAA:

A A A A A A A B A A A A A A A A
= = = = = =] O [= = = = = = = =
= = = = =] O O O [= = = = = = =
= = = =] O [=] O [= = = = = =
= = =] O O O O O O O [= = = = =
= =] O [= = = = =] O [= = = =
=] O O O [= = =] O O O [= = =
] O [=] O [=] O [=] O [=] O [=
O O O O O O O O O O O O O O O O
= = = = = = = = = = = = = = = =

Every line above is a circular string and each successive line replaces the previous according to the rules specified by the SA. So,



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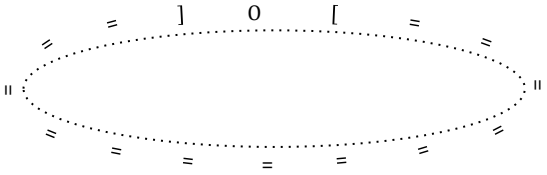

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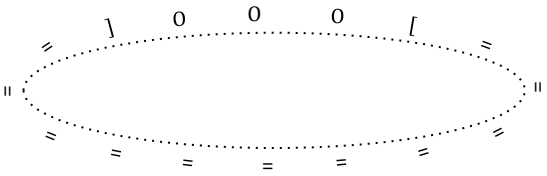

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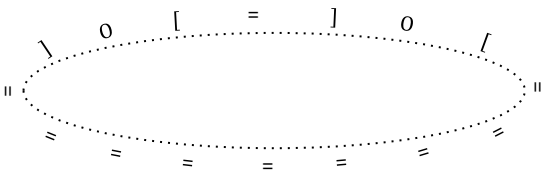

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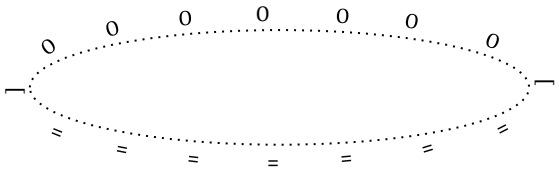

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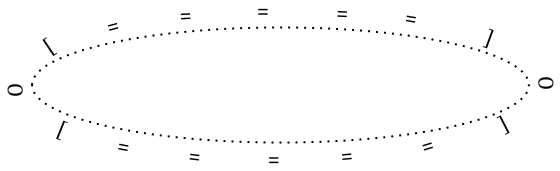

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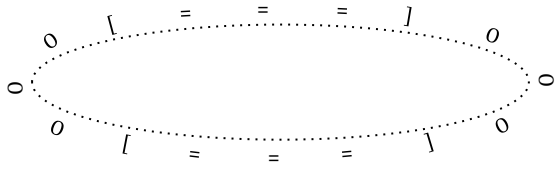

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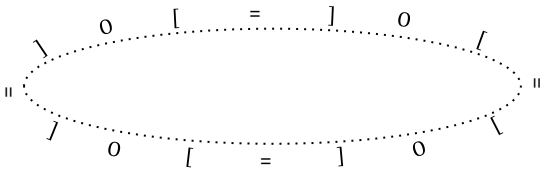

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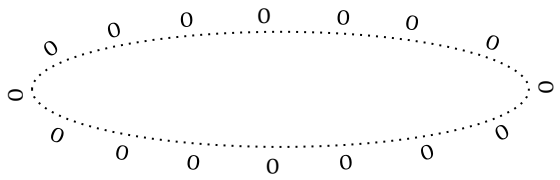

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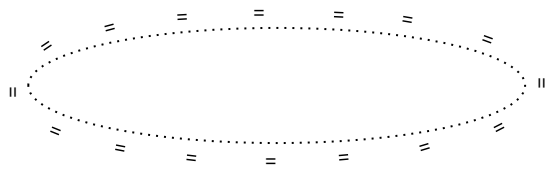

On a circular string consisting of one distinct character, RD behaves in two basic ways, depending on the number of characters in the string. There exists a family of circular string lengths, {2, 3, 4, 7, 8, 15, 16, 32, …}, for which RD begins by identifying the distinct character in the string and ends eventually by erasing all distinctions. For the remaining string

lengths {5, 6, 9, 10, 11, 12, 13, 14, 17, 18, 19, 20, …}, RD follows a repetitive pattern of varying periodicity.

Circular RD is 1D RD with periodic boundary conditions wherein the two end points of a 1D string neighbor one another. The elementary re-entering/circular string in circular RD extends the scope of adjacency in RD, finding natural application in the study of the Spencer-Brown modulator/reductor, an apparatus that feeds back into itself, returning a signal into the apparatus that created it, thereby yielding a recurring cycle

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About the Author: Divyamaan Sahoo, from Kolkata, India, received his Master of Fine Arts in Sound from the School of the Art Institute of Chicago in 2020, and his Bachelor of Arts from Bates College in 2017, triple majoring in Mathematics, Music Composition, and Philosophy. He is currently working as an independent researcher with Louis H. Kauffman and J. M. Flagg on the mathematics of George Spencer-Brown.

Editors' Notes: This is the final article honoring the late Joel Isaacson and his work with recursive distinctioning. Divyamaan Sahoo has contributed a brief and concrete example we hope the reader will find helpful in understanding a potentially challenging and abstract concept. ***Gordon Arthur and Mark Wagner.***

A Man Whose Vision Reached to Places Beyond: Robert M. Krone

by Lawrence G. Downing, DMin

Editors' Note: This was written as an appreciation of Bob Krone on the occasion of his retirement in August 2021. Sadly, Bob died before it could be published.

Now and again there arises above one's horizon a blazing comet-like individual who has the capacity to stimulate the little gray cells, broaden one's worldview, and inspire one to strive toward excellence. Col. Robert (Bob) Krone met, and in significant ways, exceeded these qualities.

There is a saying, some would say a cliché: "The apple does not fall far from the tree." This statement applied to the life of Bob Krone. Bob's parents, Dr. Max and Mrs. Beatrice Krone, were pioneers whose life work centered on music, the arts, and students. These two remarkable individuals brought together talented people and guided them to develop a vision that inspired them to unite their efforts to found Idyllwild Arts, a premier music program affiliated with the University of Southern California. Each summer since 1946, young people have participated in a unique arts experience. This yeasty, creative, and productive environment provided young Bob Krone a foundation that would sustain and guide him throughout his career. Bob was a leader. He did not drift into the leadership roles that defined his professional and personal life. He made choices, and when he made a decision, he followed through.

Col. Krone's military service introduced him to a venue quite unlike that of a performance arts milieu. It is not possible to describe the euphoria that accompanies the pilot who twists about the sky in a machine designed to conquer the air. The dancer who lofts above an entranced audience may have similar experiences. Bob, as he soared into the sky, and the adrenaline surge of the leaping dancer may not be that far apart.

Bob mastered flight skills to an extent few people appreciate. As the man who sat at the controls of a jet fighter, the force that propels the craft demands confidence, training, skill, and persistence. These traits Bob had in abundance. These are the skills, along with others, he took with him after retirement from the Air Force. Bob did not spend his retirement entranced by the rolling surf. He enrolled in the UCLA School of Political and Policy Science, where he completed the requirements to be granted a PhD degree.

Bob began Career II as a USC Business School professor. Upon his retirement from USC, Paul Cone, PhD, another USC School of Business professor, encouraged Bob to consider a third career: join the La Sierra University School of Business and Management in Riverside.

Career III opened new vistas. Bob's new colleagues welcomed him, and he brought with him his commitment to excellence, his leadership and educational skills, and his

ability to inspire others. LSU is where Bob and I first met. Dr Paul Cone, a long-time friend introduced us. Something clicked and we were friends and colleagues from that day on.

Bob and I collaborated on numerous LSU projects. We participated in on-line classes for the MBA program at Pacific Adventist University in Papua New Guinea, and other venues.

> Learning is the only thing the mind never exhausts, never fears, and never regrets. It is one thing that will never fail us. (Leonardo da Vinci, 1452–1519; one of Col. Robert Krone's favorite quotes)

Bob was a go-for-it kind of person. Did this trait reflect his fighter pilot days? It is true, if one is to come out in one piece, the person who pushes the throttle of an F-105 to the firewall will do well to have more than a general idea of what 26,500 lbs. of thrust can do when unleashed. Preparation and split-second response are essential for survival. Preparedness, methodical evaluation, care. These traits were imbedded in Bob's soul. He was not a Hot Shot fighter jock! That label did not apply to Bob's relationships with colleagues and friends! *Au contraire,* Bob was the ultimate team player.

There are those who advocate teamwork: Bob demonstrated how teamwork functions. In his various roles, Bob wore the leadership mantle lightly. He was a gentle, caring person who valued collegiality and discussion and encouraged freedom to think and do. His teaching style, developed in response to his interactions with students, stressed personal responsibility to delve into a subject. He did not promote the traditional didactic methodology. He came to his classes with the conviction that the students were scholars rather than sponges to soak up second-hand knowledge dispensed from another's experience. He expected the scholar to select a topic, perform original and secondary research, the former often utilizing *Ideas Unlimited* as the research tool to conduct the original research upon which a paper would develop. His didactic methodology was to encourage, offer suggestions, and listen. He also, as was his wont, kept an open mind should an interesting opportunity appear on the horizon. This *open mind* attitude led him to develop Careers IV and V.

The idea of establishing an educational process for those active in the Space program or who want to be part of a growing industry stimulated Bob's creative juices. He shared his ideas of developing a Space educational program with friends and colleagues. The upshot of Bob's *far-out* idea was to bring together individuals who, like he, were intrigued by the potential Space, with its unlimited resources, offered those who dared to venture forth. Hope was also a factor; hope for humanity's reboot.

From these seminal thoughts, shared with peers and those who were interested in Space, was birthed Kepler Space Institute (KSI). Bob, as KSI president, began to build a Space education team. This is where I came in. Col. Krone suggested he and I collaborate to create classes for scholars who want to pursue a career in the Space industry or are now involved in some aspect of a Space organization and wish to further their education.

An invitation from Bob shares certain qualities of a General Quarters command. Our association was, for me, both a unique educational opportunity and a personal challenge that took me beyond my educational and experiential levels. Thankfully, the man at the helm was a skilled navigator who guided students and staff alike! This is a gift one can only accept with gratitude: it is beyond price!

Bob was not content to lead a newly birthed graduate-level educational institution. He carried within him a gene or two that nudged him to publish and to look over the mountain! That *look* resulted in the launch of the *Journal of Space Philosophy*. Bob served as Editor-in-Chief from its first issue until August 2021. JSP publishes articles related to Space authored by individuals who are associated with the Space community. The most recent JSP, vol. 10, no. 1, like its fourteen predecessors, addresses matters related to Space and gives recognition to Joel Isaacson, Yehezkel Dror, and others who have influenced the Space community. The Journal is accessible online at no cost.

As impressive and influential as JSP and his books may be, Bob's first love was teaching and interacting with those who were enrolled in the numerous classes he conducted over the decades. He came into class sessions with confidence in the scholars and their ability to carry out the selected projects. His method was that of a coach, an enabler, a confidence builder. His satisfaction was gained when the finished product has brought about a deeper understanding of a situation and has suggested an improvement in what now is. It was the gentle nudge that directs scholars to achieve their best. It was this quiet grace that we who knew Bob valued. We were fascinated that a man of such quiet grace could have such a powerful and positive influence on so many. There is a saying that quiet waters run deep. More than one person has applied this truism to the life of Col. Robert M. Krone, PhD (Ret).

It would be possible to continue sharing multiple experiences and discussions that took place in Bob's and my numerous teaching opportunities. The reader will have long since concluded that I admired, respected, and valued this man. He was a person who holds a firm and cherished place in my soul!

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Editors' Notes: Along with the KSI community and our colleagues in the field of Space Philosophy, we miss Bob dearly. We are also honored and humbled to carry on the legacy he began when he founded this journal and shepherded it's publication over the past decade. As Gordon moves into the role of Editor-in-Chief and Mark comes on as Associate Editor, we know we have big shoes to fill and an important memory to honor. We are grateful to our friend, Professor Larry Downing, Bob's longtime collaborator in KSI Space Philosophy courses, for penning this tribute. ***Gordon Arthur and Mark Wagner.***

Will Our Children Own Property in Space?

By Michelle Hanlon

Abstract

Humanity's expansion into space is inevitable. What is not apparent is how smooth our transition into a multi-planetary species will be. What laws will guide our future in space? How can we set ourselves up for success? Currently, the regulation of space activities is guided by a treaty negotiated more than 50 years ago. While the concepts enshrined in that treaty, including the freedom of the exploration and use of space, remain relevant today, current events force us to recognize significant gaps in the law, chief among them centered around the concept of property ownership. This article suggests that the foundation for successful and sustainable human communities in space must be built outside existing concepts of law. Only with a departure from our sovereign paradigm can we assure out future success. And the best way forward requires looking back at—and protecting—history.

Keywords: Space, space law, space policy, space exploration, cultural heritage, human heritage, history, property, Outer Space Treaty, World Heritage Convention.

Introduction

It is not uncommon for people to conflate laws and regulations with geographic locations. And indeed, modern laws are layered in and confined by political boundaries. We have town ordinances, state rules, federal laws, and multilateral international treaties that can supersede national laws. Often, these treaties themselves are identified geographically; thus, we have the *Antarctic* Treaty, the *Convention on the Law of the Sea*, and the *Outer Space* Treaty. This construct makes it all too easy to forget that the fundamental purpose of law is to manage relationships among people. Law does not exist because it is handed down by states; quite the contrary, sovereign states exist because of law. As we consider the expansion of humanity beyond our Earth and throughout the space the Earth occupies, we must accept—and embrace—the fact that the success and sustainability of human space exploration, and indeed the human race itself, requires a departure from our terrestrial legal structures and forms. Among the regimes to be tested is the concept of property ownership.

Freedom of Exploration and Use

When the international community first started to think seriously about establishing "rules of the road" for outer space activities, the overarching and oft-stated goal was to preserve the use of space for peaceful purposes. Thus, in 1958, the United Nations established an ad hoc Committee on the Peaceful Uses of Outer Space (COPUOS) with a

primary goal of avoiding "the extension of national rivalries in this new field."[1] COPUOS was made permanent in 1959, and in 1963 the United Nations approved a Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space which was the precursor for the 1967 Outer Space Treaty, frequently described as the *Magna Carta* for space.

Formally entitled the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, the Outer Space Treaty offers, as its title suggests, principles to guide *state* activities in space. However, Article VI of the treaty requires states to "authorize and supervise"[2] the activities of their national entities, including non-governmental entities, in space and more generally makes states responsible for all such activities. This suggests that states must make sure their nationals are also conducting activities in space pursuant to the guidelines offered by the treaty.

Ratified by 111 nations and signed by an additional twenty-three, Article I of the treaty encapsulates humanity's fundamental precept in respect of space, namely that space "shall be free for the exploration and use by all."[3] The treaty presents very few restrictions on this freedom. Chief among these is the agreement to use space "exclusively for peaceful purposes"[4] (Article IV). Other restrictions engender a subtle complexity of contradictions. A state may not claim territory in space (Article II), and yet international law applies in space (Article III). Article 17(1) of the Universal Declaration of Human Rights indicates that "everyone has the right to own property alone as well as in association with others."[5] This seems to imply that states may not claim territory, but individuals may own property. Similarly, the Outer Space Treaty is clear that states will retain jurisdiction and control of any object they launch into space (Article VIII), and they will be held liable if they cause damage to the space object of another (Article VII). Yet leaving an object *in situ* on another celestial body essentially results in perpetual occupation of the surface upon which it rests. This runs afoul of the principle of non-appropriation encapsulated in Article II.

Due Regard to the Rescue?

The only other constraint on the freedom of exploration and use is found in Article IX, which delineates three main requirements. First, all activities in space must be

[1] See www.unoosa.org/pdf/gares/ARES_14_1472E.pdf.
[2] United Nations, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," Resolution Adopted by the General Assembly, December 19, 1966, www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html.
[3] United Nations, "Outer Space Treaty."
[4] United Nations, "Outer Space Treaty."
[5] United Nations, "Universal Declaration of Human Rights," Resolution Adopted by the General Assembly, December 10, 1948, www.un.org/en/about-us/universal-declaration-of-human-rights.

implemented with "due regard to the corresponding interests of all other States."[6] Second, states must consult in advance if they are embarking on an activity that may cause potentially harmful interference with activities of other states. Third, exploration should be conducted in a manner to avoid harmful contamination of space.

With respect to the second restriction, it must be stressed that states are not required to avoid harmful interference, only to consult prior to causing such interference. The third restriction has been interpreted to apply to primarily to biological contamination and does not necessarily implicate space activities as they relate to other space participants. Thus, the main concept by which the Outer Space Treaty restricts activities, outside peaceful uses, is due regard.

Due regard is a standard that remains undefined. However, it is also used in the United Nations Convention on the Law of the Sea, which states that freedom of the high seas "shall be exercised by all States with due regard for the interests of the other States in their exercise of the freedom of the high seas."[7] An arbitral tribunal considered the meaning of due regard in 2015 and declined to formulate due regard as a universal code of conduct. Instead, it found that due regard:

> does not impose a uniform obligation to avoid any impairment of [a state's] rights; nor does it uniformly permit [a state] to proceed as it wishes, merely noting such rights. Rather, the extent of the regard required by the Convention will depend upon the nature of the rights held by [the state's], their importance, the extent of the anticipated impairment, the nature and importance of the activities contemplated by the [states], and the availability of alternative approaches.[8]

Under this interpretation, due regard requires a balancing test, taking into consideration the rights of the state that have been impinged upon by the contested activity, the extent of the impairment, the nature and importance of the contested activity, and the availability of alternative approaches. This balance will produce different outcomes on a case-by-case basis, an uncertainty that in and of itself is enough to make states and their nationals carefully consider their international obligations in respect of space activities. In fact, this type of balance promises not stability, but litigation. The tribunal made it very clear that there is no uniform obligation to avoid interference. Arguing how to balance the nature and importance of rights will put more money in the pockets of lawyers and less into space exploration.

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[6] United Nations, "Universal Declaration of Human Rights."

[7] United Nations, "United Nations Convention on the Law of the Sea." Resolution Adopted by the General Assembly, December 17, 1970, www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf.

[8] *The Chagos Marine Protected Area Arbitration (Mauritius v. U.K.)*, Case No. 2011-03, Award, para. 519 (Perm. Ct. Arb. 2015).

Due Regard for "Property"

Regardless, the Outer Space Treaty has performed admirably for more than 50 years. In part this is because until recently, only a few nations have had the ability to explore space. Moreover, thus far, only one private entity has succeeded in impacting another celestial body and that was a hard landing by SpaceIL's Beresheet in 2019. Space is big, the number of participants in space activities has been limited, and those participants have been able to stay out of each other's way. This dynamic, however is swiftly changing.

Multiple states and private entities have expressed an interest in mining space resources. Logically, the first such mines will be operated on our Moon, as its proximity makes it a convenient experimental stage. However, lunar resources are concentrated in certain areas of the Moon. How will we prevent conflict over access to those resources?

One way to implement the concept of due regard is to adopt so-called safety zones. The Hague International Space Resources Governance Working Group, (Hague Working Group) in particular, urges the implementation of an international framework that would

> permit States and international organizations responsible for space resource activities to establish a safety zone, or other area based safety measure, around an area identified for a space resource activity as necessary to assure safety and to avoid any harmful interference with that space resource activity. Such safety measure shall not impede the free access, in accordance with international law, to any area of outer space by personnel, vehicles and equipment of another operator. In accordance with the area-based safety measure, a State or international organization may restrict access for a limited period of time, provided that timely public notice has been given setting out the reasons for such restriction.[9]

The US Government also appears ready to endorse the concept of safety zones. In disseminating "principles" to guide the execution of bilateral agreements regarding space activities, the United States indicated that "deconfliction of activities" is a key goal. To support this goal, the US Artemis Accords propose that the United States

> and partner nations will provide public information regarding the location and general nature of operations which will inform the scale and scope of "Safety Zones." Notification and coordination between partner nations to respect such safety zones will prevent harmful interference, implementing

[9] "Building Blocks for the Development of An International Framework on Space Resource Activities," para. 11.3 (2019), www.universiteitleiden.nl/binaries/content/assets/rechtsgeleerdheid/instituut-voor-publiekrecht/lucht--en-ruimterecht/space-resources/bb-thissrwg--.

> Article IX of the Outer Space Treaty and reinforcing the principle of due regard.[10]

There can be no doubt that safety zones are not only a good idea, but also a necessity arguably mandated by the due regard provision of the Outer Space Treaty. Implementing a safety zone regime in space would remove many of the uncertainties in the Outer Space Treaty and eliminate the guesswork in the balancing act presupposed by the concept of due regard. However, the fact is that an international effort to address these important issues through COPUOS—which has grown from just 18 states to more than 90—will undoubtedly take many years, if not decades to reach conclusion. Conversely, the bilateral approach espoused by the United States feels exclusive and, if does not garner widespread adoption, it will leave have limited efficacy.

Due Regard for History

While it may be argued that we have some time before actual mining operations begin on the Moon or any other celestial body, the fact is that the concept of due regard for objects already on the lunar surface needs to be addressed on a much swifter timetable.

Cultural artifacts on the Moon are vulnerable to any activity on the Moon. Indeed, the National Aeronautics and Space Administration recognized this in 2010 when it organized a team solely to address questions regarding the protection of historic sites on the Moon. The team developed and released its report, "NASA's Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts" (NASA Guidelines), in July 2011.

The NASA Guidelines recommend the implementation of a two-kilometer exclusion radius around significant lunar heritage sites. Per the guidelines, no vehicle should overfly or attempt to land on the Moon within a two-kilometer radius of any so-called US Government heritage lander, defined to include the Apollo and Surveyor lunar landing sites. The distance was chosen primarily to alleviate the destructive potential of the regolith ejecta effect in the lunar environment. Essentially, any activity that will stir the lunar surface, whether a rover or a lander, will cause the very abrasive regolith to impact any hardware within a certain radius with the potential of causing severe damage. These guidelines, which are not binding or enforceable, even against US nationals unless they are specifically contracted by NASA, highlight the vulnerability of cultural heritage on the Moon, especially in the face of increased activity.

The fact of the matter is that it has proven difficult for the international community to agree on space governance matters. However, the nations of the world have provided unanimous support of the protection of human heritage. The Convention Concerning the Protection of the World Cultural and Natural Heritage has 194 state ratifications. That means nearly every nation on Earth agrees "that deterioration or disappearance of any

[10] *The Artemis Accords,* NASA, October 13, 2020, www.nasa.gov/specials/artemis-accords/index.html.

item of the cultural or natural heritage constitutes a harmful impoverishment of the heritage of all the nations of the world"[11] and that collective effort must be undertaken to protect cultural heritage of "outstanding universal value."[12]

Unfortunately, the World Heritage Convention cannot be applied to space because sites are identified by the state in whose territory they reside. Since states cannot lay claim to territory in space, no off-world sites may be nominated. And yet there is no heritage more universal than lunar landing sites on the Moon, which represent both a milestone in human evolution and development and the culmination of the work of humans throughout the world and throughout history. The human relationship to space is necessarily global and universal. Few would argue that the sites where humans first began their exploration of space should be recognized and protected less than any site on Earth.

With this in mind, For All Moonkind, the only organization in the world focused on protecting human heritage in space, challenges the international community to consider due regard and the concept of safety zones not through the lens of competition, conflict and exploitation, but through the lens of conservation and kinship. Starting with humanity's firsts on the Moon—Luna 2, the first hard landing; Luna 9, the first soft landing; Apollo 11, the first crewed landing; and Chang'e 4, the first soft landing on the far side—the international community can consider the level of deference to be given to certain objects and sites. Taking the science into consideration, agreement can be reached regarding the establishment of safety zones, barring access to any of these sites until humans have the technology to approach them without destroying them. And, given the strong ownership structure of Article VIII of the Outer Space Treaty, any approach must be with the approval of the state that retains the ownership of the objects. These parameters will serve as the baseline, the most severe and rigorous protections any site on the Moon or anywhere in outer space can enjoy. It is an ideal starting point (1) to make the international community comfortable with the concept of safety zones and (2) to build the scientific understanding and knowledge necessary to combat both foreseen (intentional intrusion) and unforeseen hazards to human objects in space.

Our Children Will Redefine Property in Space

Ultimately, what we are doing is not laying down the law but providing guidelines and principles to govern the relationships both amongst ourselves and between history and the future. The non-appropriation principle contained in Article II of the Outer Space Treaty is not a restriction, but an opportunity. Sovereign states may not claim territory in outer space, and yet our Earthly concept of property requires state affirmation. Essentially, Article II gives our future the flexibility to move beyond the sovereign paradigm and to form laws based on the universality of our experience and not on the territory in which

[11] UNESCO, "Convention Concerning the Protection of the World Cultural and Natural Heritage," November 16, 1962, whc.unesco.org/en/conventiontext/.
[12] UNESCO, World Heritage Convention.

we reside. What property might look like under this new regime remains to be seen, but certainly, building on kinship rather than exclusion is one small step in the right direction.

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Editors' Notes: As editors of this *Journal of Space Philosophy,* we are thrilled to welcome to these pages Michelle Hanlon, Editor-In-Chief of the *Journal of Space Law*. In addition to advances in engineering and science, a great deal of policy infrastructure will be required for human communities to thrive in space. In this paper Professor Hanlon explores the legal foundation for the due regard that must be shown to others' property in space and explains the precedent for establishing safety zones. Perhaps more importantly, she urges the application of these concepts to protect artifacts of cultural heritage, such as the historic moon landing sites. Her work is truly providing guidelines for future generations of space migration. ***Gordon Arthur and Mark Wagner.***

A Novel Approach to a K12 School Focused on Space Exploration

By Mark Wagner, Ph.D.

Introduction

With the current explosion of progress in space exploration and industry, many questions related to the first legitimate long-term space settlements are being asked—and not just about technical or logistical issues. Space philosophers are beginning to look very seriously at questions of social significance, including legal precedence, methods of governance, and even how best to educate children being raised in space or on another planet. Elsey and Omarova, for instance, challenge their students to imagine what an education system might look like on Mars.[1] They acknowledge this as an imaginative enterprise at this point, but the question becomes much more concrete if we consider how best to educate those who will actually be the first settlers—and are likely in today's classrooms.[2]

This question is thus already relevant if not pressing: how should K12 schools be designed best to prepare students for humanity's multi-planet future? Today's schools are not only poorly prepared for this future, but also poorly prepared for the current reality. Schools should be ready to handle the truly challenging problems of today while also preparing students for the unpredictable problems of tomorrow. Humanity cannot explore and settle space with an industrial-age education system. Luckily, there are new mindsets and skill sets available to educators, drawn from the successes of Silicon Valley and the space industry itself—and already proven on the cutting edge of constructivist pedagogy and educational technology.

This paper summarizes the academic justification for the design of the Academy for the Relentless Exploration of Space (or ARES), a prototype secondary school created to put these practices into effect with a focus on preparing students to participate in the space industry (directly or indirectly). The school has a two-part mission:

> MISSION I—Prepare students to solve enormous challenges in any community on any planet.
>
> At ARES Learning, students build the knowledge, skills, and mindsets necessary to navigate the great challenges of the future—on this planet or any other. ARES students emerge from their experience prepared for jobs that do not yet exist, to use technology that has not been invented, and to

[1] Barry Elsey and Amina Omarova, "Space Education for Human Communities Living on Mars," *Journal of Space Philosophy* 9, no. 1 (2020): 21-41.

[2] Rachael Mann and Stephen Sandford, *The Martians in Your Classroom* (Irvine, CA: EdTech Team, 2018).

> solve enormous problems we cannot foresee. ARES prepares young people to become the designers, builders, philosophers, and explorers of tomorrow.
>
> MISSION II—Fundamentally disrupt and transform the global education system.
>
> The recent pandemic has shown that traditional schools are not only unprepared for the challenges of the future, but also unprepared for the challenges of today. ARES is the new model for global education that combines the explorer's mindset, moonshot thinking, and human-centered design … supported by bleeding-edge technology and inspiring learning spaces. ARES places students at the center of solving enormous problems facing their communities—on this planet or any other. By design, ARES is a laboratory school meant to influence the true transformation of global education systems.

In particular, this paper articulates the reasoning behind the chosen curriculum, mindsets, and routines that form the foundation of the learning experience at ARES. A flexible curriculum is delivered via blended (face-to-face and online) methods. In addition to core subjects, it includes a foundation in problem-solving frameworks such as the explorer's mindset, moonshot thinking, and design methodology. For maximum effectiveness, daily routines also focus on synthesis, collaboration, and reflection.

A Flexible Multi-Disciplinary Curriculum

At ARES Learning, learning experience in traditional subjects is based on CK-12, an internationally recognized core curriculum for English, social studies, math, science, and more, including an introduction to philosophy. This system is an open educational resource offering interactive experiences rich with multi-media, adaptive practice, and simulations. The program is modular and customizable to individual students' needs, and all students have agency in cocreating their own learning paths. This approach provides a solid foundation for students' academic future, and for the project-based learning that is the true focus of the ARES Experience.

The CK-12 system is delivered via a blended learning approach, combining face-to-face and online learning experiences. A blended approach allows students and teachers to develop a face-to-face rapport while still having the opportunity to communicate often online, and it has been shown to increase student-to-teacher interactions.[3] Blended

[3] Sandra Somera, "Educator Experiences: Transitioning to Blended Learning Environment in K-6 Public Schools" (PhD diss., Walden University, 2018).

learning is particularly effective at teaching STEM subjects, including scientific reasoning[4] and mathematics.[5] The blended experience also helps students to develop greater comfort writing across the curriculum.[6] These basic skills help to form the necessary foundation for more advanced learning and higher-order problem solving.

In addition to their core subjects, all students participate fully in the rich experience of a supplemental "launchpad curriculum," where they are exposed to new ways of thinking—and get to set the trajectory of their own advanced learning. All students are introduced to advanced domains of learning, like philosophy, anthropology, linguistics, psychology, and political science—as well as forward-looking pursuits like science fiction as literature, fictional languages, and data science for forecasting. With a grounding in the physical and life sciences, they then choose their own space science trajectory with options including astrophysics, orbital mechanics, spacecraft systems design, terraforming, and genetic engineering. This broad supplementary curriculum provides a deeper understanding of the world from which to launch their projects in the Moonshot Lab.

More importantly, a multidisciplinary philosophy-based approach like this can help students to develop the wide range of intellectual skills they will need for success in the future and help them to prepare for meaningful participatory citizenship.[7] In many schools, there is an overemphasis on repetition of science facts; teachers typically fail to characterize scientific knowledge as tentative and the scientific method as creative.[8] But when philosophy of science is emphasized rather than simply repeating facts provided by the teacher, "students construct their conceptual models and present them to others within the class."[9] Inclusion of science fiction as literature further prepares students to be creative in dealing with the unexpected, and it has been demonstrated as an effective

[4] Isalyn F. Camungol, Yves I Gonzales, and Lydia S Roleda, "Progression of Scientific Reasoning and Metacognitive Regulation of Secondary Students in the New K-12 Curriculum in Blended Learning Environment," in *IC4E 2020: Proceedings of the 2020 11th International Conference on E-Education, E-Business, E-Management, and E-Learning* (New York: ACM, 2020), 10-14.

[5] Lissa J. Raebel, "Introducing Blended Learning Environments for Mathematics Instruction: How Does it Affect Student Achievement and Attitudes?" (MS thesis, University of Wisconsin Whitewater, 2015).

[6] William Kist, *Getting Started with Blended Learning: How Do I Integrate Online and Face-to-Face Instruction?* (Alexandria, VA: ASCD, 2015).

[7] Sara Goering, Nicholas J. Shudak, and Thomas E. Wartenberg, eds., *Philosophy in Schools: An Introduction for Philosophers and Teachers* (New York: Routledge/Taylor & Francis Group, 2013).

[8] James J. Gallagher, "Prospective and Practicing Secondary School Science Teachers' Knowledge and Beliefs about the Philosophy of Science," *Science Education* 75, no. 1 (1991): 121-33.

[9] Susan L. Johnson and Jim Stewart, "Using Philosophy of Science in Curriculum Development: An Example from High School Genetics," *International Journal of Science Education* 12, no. 3 (1990): 297-307.

method for teaching climate change,[10] chemistry,[11] and analytical skills[12]—and for increasing interest in STEM-based pursuits in general.[13]

Mindsets and Skill Sets

In the tradition of great explorers from the Polynesian islanders to American astronauts—and the inspirational explorers of science fiction, ARES Learning is infused with the explorer mindset. The school is a program for students with a deep love of exploration, discovery, and adventure. The learning experiences are designed to increase comfort with the unknown and with facing challenges in rapidly changing environments. Students are encouraged to see potential, opportunity, and abundance when they encounter problems as opposed to seeing threat and scarcity. They are taught to operate from the presumption that possibilities always exist.

National Geographic has provided a powerful model for exploratory learning by defining a framework for "the Mindset of an Explorer," including age-specific skills and knowledge—and attitudes such as curiosity, responsibility, and empowerment.[14] This framework has been extended by educators to include tools for helping students "see, observe, build curiosity, learn responsibility, feel empowered, and be stewards in our interconnected world."[15] The explorer's mindset is meant to develop a love of adventure, exploration, and discovery—and it is important for breakthrough thinking.[16] Importantly, the mindset can help students to be flexible,[17] adaptable, and ready to make critical decisions without complete information.[18] An explorer's mindset can also help leaders to shepherd a team through the process of innovation.[19]

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[10] Glenn Smith and Metin Besalti, "Learning Climate Change Science with Computer Games in a Science Fiction Novel," in *Proceedings of EdMedia: World Conference on Educational Media and Technology*, ed. T. Bastiaens et al. (Amsterdam: Association for the Advancement of Computing in Education, 2018), 1231-35, www.learntechlib.org/primary/p/184333.

[11] L. Gaby Avila-Bront, "An Experiential Learning Chemistry Course for Nonmajors Taught through the Lens of Science Fiction," *Journal of Chemical Education* 97, no. 10 (2020): 3588-94.

[12] Neil Selwyn, Luci Pangrazio, Selena Nemorin, and Carlo Perrotta, "What Might the School of 2030 Be Like? An Exercise in Social Science Fiction," *Learning Media and Technology* 45, no. 1 (2020): 90-106.

[13] Selwyn, Pangrazio, Nemorin, and Perrotta, "What Might the School of 2030 Be Like?"

[14] "The National Geographic Learning Framework" (National Geographic, 1996-2021) www.nationalgeographic.org/education/about/learning-framework.

[15] Explorer Mindset, "Students, Educators and the Explorer Mindset," 2021, explorermindset.org/about.

[16] Stephen Sweid, "Significance of the Explorer's Mindset for Breakthrough," Management & Leadership, 2015, flevy.com/blog/significance-of-the-explorers-mindset-for-breakthrough.

[17] Vani Kola, "The Explorer Mindset: Leadership Principles for Crisis," www.linkedin.com/pulse/explorer-mindset-leadership-principles-crisis-vani-kola.

[18] Sionade Robinson, "Introduction: An Explorer's Mindset matters…" An Explorer's Mindset, www.anexplorersmindset.com.

[19] Tenday Viki, "How Adopting an Explorer's Mindset Can Help You to Lead Innovation," *Forbes*, 2020, www.forbes.com/sites/tendayiviki/2020/06/07/how-adopting-an-explorers-mindset-can-help-you-to-lead-innovation.

Though it is a mindset that explorers have embraced for millennia, moonshot thinking was codified in President John F. Kennedy's commitment to putting a man on the moon even though the technology did not exist, and nobody knew how to do it yet. At Google's X Lab, this mindset was further formalized into a system for addressing huge challenges, applying radical solutions, and developing breakthrough technology. This mindset does not seek a 10% improvement … it seeks a solution ten times better than before, and it is known also as 10X thinking. It requires failing forward and failing fast. This is exemplified in the SpaceX approach to developing new spacecraft. The ARES Learning model supports students as they address meaningful challenges in their community, generate innovative solutions, and implement creative uses of technology.

The system developed at X is a method for pursuing wildly ambitious goals, including "processes and culture (that) make it easier to make radical breakthroughs—repeatedly."[20] This sort of thinking is particularly relevant and beneficial in preparing for the challenges of humanity's multi-planet future because "moonshots galvanise communities towards tackling a huge societal challenge and shap[ing a] desired future in the process."[21] It may also be particularly appropriate in the public sector (in public K12 schools for instance) as a way to address a social crisis.[22]

Within the context of moonshot style ambitions, the ARES Learning method of solving problems is heavily influenced by design methodology (or design thinking), of the sort used and promoted by the Stanford D School. This begins with understanding the people the problem affects, through a process of discovery, empathy, or ethnography. Then our students define a problem before ideating a variety of possible solutions (using one of many exercises they are trained in) and choosing one to prototype and test first. They build a prototype online, in virtual reality, or in a maker space with real-world tools, including 3D printers. Based on the results of their initial tests, they iterate on their solution, pivot to a new one, or begin the process again.

Design methodology (or design thinking) is "a human-centered problem-solving approach that may be used in the teaching/learning process to develop twenty-first century skills and enhance creativity and innovation."[23] The method has been effective in empowering teachers to facilitate constructivist learning and foster twenty-first century skills in students.[24] It also integrates well with the other methods in use at ARES, as design thinking helps to build student motivation for exploration, confidence in self-exploration,

[20] "Moonshot Thinking," X Development, 2018, x.company/moonshot.

[21] Anne-Laure Mention, João José Pinto Ferreira, and Marko Torkkeli, "Moonshot Innovations: Wishful Thinking or Business-As-Usual?" *Journal of Information Management* 7, no. 1 (2019): 1-6.

[22] William D. Eggers and John O'Leary, *If We Can Put a Man on the Moon: Getting Big Things Done in Government* (Cambridge, MA: Harvard Business Review, 2009).

[23] Ineta Luka, "Design Thinking in Pedagogy," *Journal of Education, Culture, and Society*, 2 (2014): 63-74.

[24] Andrea Scheer, Christine Noweski, and Christoph Meinel, "Transforming Constructivist Learning into Action: Design Thinking in Education," *Design Thinking and Technology Education* 17, no. 3 (2012): 8-19.

and competence in teamwork (including expressing opinions and sharing knowledge), as well as building trust between student and teacher.[25] It leads to increases in students' creative confidence,[26] self-efficacy,[27] and ability to solve real-world problems practically.[28] Also, it prepares students well for management,[29] entrepreneurship,[30] and challenging fields such as medicine.[31]

The way the design methodology is implemented in conjunction with moonshot thinking at ARES, there is room for truly innovative approaches, always encouraging students to think bigger—and providing exercises to help them get out of their comfort zone and leave behind their preconceptions.

Synthesis and Reflection

Inspired by the work of the Ad Astra School at SpaceX, the ARES Learning program focuses on synthesis throughout. Students are not just repeating right answers … they experience the tension of making difficult choices, and of risk taking in their explorations and experiments. The faculty ensures that their challenges include ethical dimensions to allow for more meaningful experiences, and deeper learning. Sufficient time is allowed for analysis, debate, strategy, iteration … and the changing of minds. The school has adopted the daily practice of sharing ideas during a "midnight lunch" (at noon) inspired by Thomas Edison, and the Japanese tradition of Hansei, or relentless self-reflection, with the aim of helping students to accept faults and failures with the high degree of emotion they will need to drive changes in the future.

Synthesis requires students to add to existing information by contributing "their own thoughts, experiences, opinions, interpretations, and connections to generate … new and

[25] Scheer, Noweski, and Meinel, "Design Thinking in Education."

[26] Ingo Rauth, Eva Köppen, Birgit Jobst, and Christoph Meinel, "Design Thinking: An Educational Model towards Creative Confidence," paper presented at the First International Conference on Design Creativity, ed. Toshiharu Tauri and Yukari Nagai (ICDC, 2010), Kobe, Japan, November 29-December 1, 2010.

[27] Birgit Jobst, Eva Köppen, Tilmann Lindberg, Josephine Moritz, Holger Rhinow, and Christoph Meinel, "The Faith-Factor in Design Thinking: Creative Confidence Through Education at the Design Thinking Schools Potsdam and Stanford?" in *Design Thinking Research: Measuring Performance in Context*, ed. Hasso Plattner, Christoph Meinel, and Larry Leifer (Berlin: Springer, 2012), 35-46

[28] Joyce Hwee Ling Koh, Ching Sing Chai, Benjamin Wong, and Huang-Yao Hong, *Design Thinking for Education: Conceptions and Applications in Teaching and Learning* (Singapore: Springer Science + Business Media, 2015).

[29] Judy Matthews and Cara Wrigley, "Design and Design Thinking in Business and Management Higher Education," *Journal of Learning and Design* 10, no. 1 (2017): 41-54.

[30] Suna Løwe Nielsen and Pia Stovang, "DesUni: University Entrepreneurship Education Through Design Thinking," *Education + Training* 57, no. 8/9 (2015): 997-91.

[31] Basil Badwan, Roshit Bothara, Mieke Latijnhouwers, Alisdair Smithies, and John Sandars, "The Importance of Design Thinking in Medical Education," *Medical Teacher* 40, no. 4 (2018): 425-26.

bigger [ideas]."[32] For example, at Ad Astra, students engage in synthesis through complex scenarios—working as a team through "case studies, simulations, and game-based challenges."[33] Students practicing synthesis also hone their analytical skills as they break concepts down into key points that allow them to draw useful conclusions and make decisions to solve meaningful problems.[34] Ethical dimensions can be included in the process of problem-solving through synthesis; "some best practices include making consequences and feedback on choices clear, [and] allowing more time for [students] to form relationships … using authentic scenarios and contexts.[35]

It was common for the scientists hired by Thomas Edison for his innovation factory in Menlo Park, NJ, to toil into the late evening or early morning hours, their boss alongside them. He often ordered a midnight lunch of meat, bread, cheese, and beverages for the entire crew to fuel their overnight discussions and theorizing. At a midnight lunch, Edison encouraged people from different project teams to "share their experiments, trade notebooks, and engage in spirited dialogue."[36] This arrangement allowed individuals from diverse disciplines to offer multiple perspectives when solving problems rapidly, thus avoiding both groupthink and a reliance on a culture of superstars.[37] ARES Learning embraces this collaborative and innovative approach to what traditional school lunch time should be. Similarly, at the end of the day, students come back together for a period of reflecting on their learning.

Hansei, or relentless self reflection, is an important part of Japanese culture—a continuous practice of subtle meditation undertaken to look at past mistakes, outline the lessons learned, and pledge to act on those lessons. "Han" means to change, turn over, or turn upside down. "Sei" means to look back upon, review, and examine oneself. In the workplace, Hansei typically involves taking individual responsibility for a problem and developing a (frequently written) plan for avoiding the issue in the future.[38] Studies show

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[32] Classroom Nook, "Reading Comprehension Strategy Series: How to Teach Students to Synthesize While Reading," www.classroomnook.com/blog/synthesizing-a-text.

[33] Matthew S. Williams, "Learning Through Play: How Synthesis Plans to Bring the Ad Astra/Astra Nova Model to the Entire World," Interesting Engineering, 2021, interestingengineering.com/learning-through-play-how-synthesis-plans-to-bring-the-ad-astra-astra-nova-model-to-the-entire-world.

[34] Cosette Taylor, "What is 'synthesis'?" University of Manitoba, umanitoba.ca/faculties/nursing/students/What_is_synthesis.pdf.

[35] Karen Schrier, "Designing and Using Games to Teach Ethics and Ethical Thinking," in *Learning Education and Games Volume One: Curricular and Design Considerations*, ed. Karen Schrier (Pittsburgh: ETC Press, 2014): 141-58.

[36] Sarah Miller Caldicott, "Teamwork, Edison Style," *Mechanical Engineering Magazine* 137, no. 2 (2015): 46-49.

[37] Sarah Miller Caldicott, *Midnight Lunch: The 4 Phases of Team Collaboration Success from Thomas Edison's Lab* (Hoboken, NJ: Wiley, 2012).

[38] Jeffrey K. Liker and James M. Morgan, "The Toyota Way in Services: The Case of Lean Product Development," *Academy of Management Perspectives* 20, no. 2: 5–20. doi.org/10.5465/AMP.2006.20591002.

that Hansei enhances self-evaluation, improvement, and morality[39] (thus also addressing the need for ethics education), and that this process is effective even for very young children.[40] At ARES Learning, students engage in Hansei at the end of each day to chart a course forward academically, socially, and emotionally.

Conclusion

ARES Learning is a prototype secondary school designed to prepare students for humanity's multi-planet future. To that end, it incorporates several mindsets and skill sets more suited to open-ended problem solving than traditional schooling. A flexible multidisciplinary curriculum (including subjects like philosophy, anthropology, and data science) is delivered via blended learning methods to lay an academic foundation for students. From there, the program helps students to develop experience with problem-solving strategies such as the explorer's mindset, moonshot thinking, and design methodology. The school schedule also includes routines to encourage synthesis, collaboration, and reflection, thus amplifying what students can accomplish together in a short period. This paper provides a summary of the academic justification for including these design elements.

It is the author's hope that this brief literature review might offer inspiration for educators in other contexts to implement some of these changes with their students, and that it might also inspire other researchers to explore some of these elements in more detail. Some questions suggesting further research include: What subjects should space explorers have a basic grasp of for the purpose of settlement on other planets? How might the explorer's mindset (or moonshot thinking, or design thinking) be employed by secondary students to help them to understand the sorts of problems they might need to solve in space better? How might learning experiences be crafted to provide students with opportunities for synthesis, collaboration, and reflection over a distance in online or virtual environments? And what if that distance included a twenty-minute delay in communications back to experts, peers, and online resources on Earth if students are in fact settlers on a planet like Mars?

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[39] Satomi Izumi Taylor, L. Weiping Wang, and Tetsu Ogawa, "I Think, Therefore, I Improve: A Qualitative Study of Concepts of Hansei (Introspection) Among Japanese Adults," *Journal of Early Childhood Teacher Education* 26, no. 1 (2005): 79-89.

[40] Satomi Izumi-Taylor, "Hansei: Japanese Preschoolers Learn Introspection with Teachers' Help," *Young Children* 64, no. 4 (2009): 86-90.

About the Author: Mark Wagner serves as President of the Space Prize Foundation, a non-profit organization focused on promoting STEM education and increasing the representation of women in aerospace careers. He also teaches the Space Education graduate certificate program at Kepler Space Institute and is the Associate Editor of the *Journal of Space Philosophy*. In addition, he is the founder of ARES Learning, a vision for schools that prepare students with the skill sets and mindsets they will need to be successful in the growing space economy—and in humanity's rapidly approaching multi-planet future. Mark has a PhD in Educational Technology and a master's degree in Cross-Cultural Education. He also holds graduate certificates in Space Education and Space Philosophy. He is the author of More Now: A Message from The Future for The Educators of Today (2018) and a forthcoming book about Space Education, which explores both current opportunities on Earth, and the possibilities for teaching students on the Moon, on Mars, and in deep space habitats. Outside his work, Mark loves playing hockey, practicing martial arts, and obsessing over his '62 beetle, which now runs on an electric motor and Tesla batteries. He is a certified health coach and biohacking enthusiast, who also enjoys songwriting, spending time in nature, and exploring the world with his friends and family.

Editors' Notes: This paper was accepted for publication before Mark Wagner took on his new role as Associate Editor of this *Journal of Space Philosophy*. It is the academic articulation of a vision he and his co-founder, Brendan Brennan, share for an innovative high school they call the Academy for Relentless Exploration of Space, or *ARES Learning*. Inspired by the idea of making *Star Trek*'s Starfleet Academy real, the school would prepare students to be well-rounded scientifically literate citizens prepared to face complex ethical challenges. Their hope is that ARES might also inspire change on a much broader scale in public schools around the world, fundamentally improving workforce development for the entire space economy, and preparing a generation of decision makers who will lead humanity into a peaceful, prosperous, and equitable multi-planet future. Clearly this vision is in alignment with the visions of KSI and this journal. ***Gordon Arthur*.**

First Great Space Program: Skyscrapers of Green

By Howard Bloom

Abstract

We are told to live in harmony with nature, to learn her rules and to respect her boundaries. But that is not how nature works. Evolution breaks nature's existing rules and establishes new ones. For example, the first land plants had the audacity to break nature's most basic law—gravity. Yes, the first land plants had the gumption to open a path that would lead to the skies.

Keywords: Sex, genome, entropy, probability, law of least action, law of least effort, reproduction, meiosis, mitosis, drunken peasants.

If you have allergies and want to blame your sneezes on someone or something, try sex. Some 520 million years ago, giant societies of single-celled organisms dared to harness nature's wrath. These cheeky micro-beasts had the audacity to live on seacoasts and in ponds. Formally, these risk-takers are called cyanobacteria. We know them more colloquially as blue-green algae and pond scum.[1] What was the risk the pond scum faced? Periodically, their coasts and ponds dried up, and these wee beasties could not live without water.

But some of the pond scum did not take this natural disaster lying down. 1.2 billion years ago, they harvested Armageddon. They learned to adapt to dryness.[2] Then these widely scattered, arrogant scabs of green dared use their new skills to do something suicidal. They embarked on the first in a series of nature's great space programs. They set forth on a crusade to populate a toxic emptiness. They defied the natural order and left the waters behind. They turned their backs on the very womb of life—the sea. They became pioneers of a hostile, stony, doomscape we call "land."

About 750 million years later, these catastrophe tamers, these pioneering land developers evolved multi-cellular descendants, plants. The first plants were bryophytes.[3] They were mosses and liverworts. But when it came to space programs, bringing a thin and tentative coat of green to an impossible wasteland of stone was not enough. The first mosses and liverworts took things a step farther. They brazenly defied one of nature's most basic laws: gravity. They lifted tiny spore shafts to the sky and formed a green shag a breathtaking inch or two high.

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[1] Elizabeth Pennisi, "Land Plants Arose Earlier Than Thought—And May Have Had a Bigger Impact on the Evolution of Animals," https://doi.org/10.1126/science.aat3642.

[2] Philip C. J. Donoghue and M. Paul Smit, eds., *Telling the Evolutionary Time: Molecular Clocks and the Fossil Record* (Boca Raton, FL: CRC Press, 2004), 124.

[3] Patricia G. Gensel and Dianne Edwards, eds., *Plants Invade the Land: Evolutionary and Environmental Perspectives* (New York: Columbia University Press, 2001), 3.

An inch or two does not sound like much, does it? But that is the human equivalent of erecting a 28-mile-high building. They erected these skyscrapers all over the place. Yes, nature loves those who oppose her most. The mosses and liverworts were tiny swatches on a vast and murderous rock face: tiny huddles of green trying to stay intact and thrive on a landscape scraped and hammered by disaster. To flourish, they had to multiply. But how? By using three of nature's favorite sins: materialism, consumerism, and waste. First the mosses and liverworts upgraded an old technique that their ancestors in the sea,[4] bacteria, had invented—the spore. In sporulation—in spore making—you accomplish an impossibility. You pack your genome into a tiny baseball-or-egg-shaped bundle. A bundle so small that it's invisible to the human eye. A bundle a mere 24,500th of an inch. Then you shoot, lift, or drop your package of genes into a water current or a breeze and take your chances. You litter. You spread outrageous amounts of waste. And you do it very deliberately. Why?

You are hoping for something that will prove crucial to life—transportation. You are hoping to hitchhike. And you are entering a lottery. The more tickets you buy, the more your odds of winning. So, you gamble that two out of a billion spores will land in a corner rich in something to eat. You play the odds. And to do it, you make far more spores than can ever find a home.

You are materialistic, consumerist, and wasteful. Yes, you, a single individual, crank out spores by the trillions.[5] You use those spores to spread out like fingertips, feeling out opportunities. But to pull this off, you throw trillions of spores away. And those spores will someday become part of the invisible dust that makes allergy sufferers sneeze. So, nature used materialism, consumerism, and waste to explore. To feel out her potential. To find unlikely possibilities. But simply playing the odds wasn't enough. You early land plants reached out for something more. Something more than mere survival. Evolution drove you to innovate. You invented sex. Sex is one of the biggest mysteries staring us in the face. A mystery current science may understand far less than it thinks. A mystery that may challenge our very notions of the way this cosmos operates. Why?

Remember how Pierre Louis de Maupertuis agreed with Aristotle that nature always takes the shortest path between two points? But sex proves that this is radically untrue. Sex proves that nature sometimes invents not just new paths, but whole new highway systems, and those new highways can be bizarrely snarled and tangled. So snarled and

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[4] Jiasong Fang, Chiaki Kato, Gabriella M. Runko, Yuichi Nogi, Tomoyuki Hori, Jiangtao Li, Yuki Morono, and Fumio Inagaki, "Predominance of Viable Spore-Forming Piezophilic Bacteria in High-Pressure Enrichment Cultures from ~1.5 to 2.4 km—Deep Coal-Bearing Sediments below the Ocean Floor," *Frontiers in Microbiology* 8 (2017): 137. https://doi.org/10.3389/fmicb.2017.00137.

[5] George Wong, "Spore Dispersal in Fungi," www.botany.hawaii.edu/faculty/wong/BOT135/Lect05_a.htm. In ferns, "spores are produced continually and are unlimited in number": L. G. Hickok and T. R. Warne, "Laboratory Investigations with C-Fern™ (Ceratopteris Richardii)," in *Tested Studies for Laboratory Teaching*, Vol. 19, ed. S. J. Karcher (Irvine, CA: Association Biology for Laboratory Education, 1998), 146. www.ableweb.org/biologylabs/wp-content/uploads/volumes/vol-19/10-hickok.pdf.

tangled that even a hedge fund accountant could not keep them straight. If this were a thrifty cosmos, how could such flamboyant tangles possibly come to be?

What is more, sex may force us to throw away Charles Darwin's idea that evolution is driven by a struggle for survival.[6] As we will soon see, sex is not just a survival device. It is a macromolecular dazzle. It is an intricate ballet that exceeds your wildest dreams. The existence of sex implies that this cosmos is not in a struggle merely to hang in there. This cosmos is in a competition for extravagance. A mad rush for the power to exult, to rejoice, and to do a victory dance.

Remember, the dust of space has done the very opposite of what Lord Kelvin's heat death predicted. Instead of falling apart in a random whizzle, instead of tumbling into a formless fizzle of entropy, space dust comes together in galaxies. What is the swirl of a galaxy but a victory dance over our very heads? So is sex. To invent sex, you, a land plant 420,000 years ago, did not take the simplest path. You did not simply split in two and make an identical copy of yourself. And you did not make kids by packing spores with the simplest, thriftiest thing, a complete packet of genes. You did not just pack a spore with an everything-you-need-to-start-your-own-plant kit. A deed that in itself would have been mind-exploding. No, you did not take the shortest path. You did not bank on the tried and true. You did not simply keep the chains of genes you inherited from your ancestors, then pass them down to your kids the way that you'd gotten them.

In fact, you did not "reproduce." We speak of sex as reproduction. But, to repeat, you did not reproduce. You did not make carbon copies of yourself. Instead, you performed some serious genetic engineering: risky and expensive genetic tinkering. You worked to create something the cosmos had never seen before. Something utterly unique. Something totally untested and untried. Something that could help a curious cosmos scope out her next impossibilities. You generated one-of-a-kind offspring. You created extraordinarily different individuals. To make those one-of-a-kinds, you reshuffled your genes. In fact, you reshuffled your entire genome.

Which means that the greatest example of flamboyance in this universe, the greatest example of nature's urge to splurge, is right here, teasing the back of your mind as you read this sentence, and teasing the back of my mind as I write it.[7] Yes, the cosmos' greatest display of materialism, consumerism, waste, and vain display is sex.

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[6] "Struggle for existence," "survival of favoured individuals and races" (278), "survival of the fittest" (128) "natural selection," (279): Charles Darwin, *The Origin of Species by Means of Natural Selection: or, the Preservation of Favored Races in the Struggle for Life*, Vol. 2 (New York: Appleton, 1897).

[7] Pamela Paul, "When Thoughts Turn to Sex, or Not," *New York Times*, December 9, 2011, www.nytimes.com/2011/12/11/fashion/sex-on-the-brain-studied.html.

Photos by Jondi Whitis (left) and Radic Smykowski (right)

About the Author: Howard K. Bloom is author of: The Lucifer Principle: A Scientific Expedition into the Forces of History ("mesmerizing": The Washington Post), Global Brain: The Evolution of Mass Mind From The Big Bang to the 21st Century ("reassuring and sobering": The New Yorker), The Genius of the Beast: A Radical Re-Vision of Capitalism ("Impressive, stimulating, and tremendously enjoyable": James Fallows, The Atlantic), and The God Problem: How A Godless Cosmos Creates ("Bloom's argument will rock your world": Barbara Ehrenreich).

Howard Bloom has been called the Einstein, Newton, Darwin, and Freud of the 21st century by Britain's Channel 4 TV. His work has been published in the *Washington Post*, the *Wall Street Journal*, *Wired*, *Psychology Today*, and *Scientific American*. He heads the Space Development Steering Committee and a space advocacy group that includes former governor of New York State David Paterson, Newt Gingrich, former head of the House Science Committee Robert Walker, and retired three-star general Steve Kwast. One of Bloom's books, *Global Brain*, was the subject of a symposium by the office of the Secretary of Defense, with representatives from the State Department, DARPA, the Energy Department, IBM, and MIT.

Bloom's base was in microbiology and theoretical physics. But in the 1970s and 1980s, he went on a field expedition into a territory he knew nothing about, the dark underbelly where new myths and movements are made, popular culture. He founded and ran the biggest PR firm in the music business, helping to build or sustain the careers of Michael Jackson, Prince, Bob Marley, Bette Midler, Billy Joel, Paul Simon, David Byrne, Peter Gabriel, AC/DC, Queen, Kiss, Aerosmith, Joan Jett, Billy Idol, ZZ Top, Chaka Khan, Grandmaster Flash and the Furious Five, and Run DMC.

He went back to his science full time in 1988. Since then, he has written articles for peer-reviewed journals or given lectures at scholarly conferences in twelve different scientific fields, from quantum physics and cosmology to evolutionary biology, neuroscience, governance, information science, and astronautics. Says Joseph Chilton Pierce, the author of *Evolution's End* and *The Crack in the Cosmic Egg*, "I have finished Howard Bloom's books, *The Lucifer Principle* and *Global Brain*, in that order, and am seriously awed, near overwhelmed by the magnitude of what he has done. I never expected to see, in any form, from any sector, such an accomplishment. I doubt there is a stronger intellect than Bloom's on the planet."

Editors' Notes: Howard Bloom once again lends his particular brand of iconoclastic genius to the pages of this journal. Fittingly, this paper explores the ways in which evolution, and sexual reproduction in particular, excel at breaking rules—and (literally) rising above adversity. His second person narrative invites the reader to be a part of this process of innovation, and it is up to each of us, as scholars and as human beings, to respond by applying these principles to our lives. ***Gordon Arthur and Mark Wagner.***

Satellites and Light Pollution: The Fight for Ground-Based Astronomy

By Rebecca Schembri

Humans have looked to the skies since the first night they could see stars. As civilization progressed, astronomy became an important field of study—a way for humans to calculate information about life on Earth, and to understand their origins better by studying the universe. After thousands of years, humans now know where life comes from, how it flourished on Earth, and what is required to maintain it. By using telescopes to look deep into the cosmos, the study of the night sky has become more than an intrigue—it is life-saving science. Now however, such science is threatened by technological advancement: light pollution from cities and human-made space objects are interfering with telescope and radio observations. If the problem grows, it will mean the end for ground-based astronomy. Although talks to mitigate the dilemma have opened, current laws do not offer a clear advantage, and much must be done to save the dark and quiet skies from falling victim to prosperous and ambitious commerce.

Light pollution is "causing a lot of headaches for astronomers,"[1] says Jonathan McDowell, an expert from the Harvard-Smithsonian Center for Astrophysics. The problem is twofold. First: tens of thousands of objects are being launched into Earth's orbit, causing obstructions in astronomical observations of the night sky. To provide global internet services to three billion humans, companies such as Starlink and OneWeb have plans to place a myriad of satellites in outer space, with China adding an additional thirteen thousand by next year.[2] These devices "will be at a problematic high altitude for astronomers," McDowell says, "and others will be at a low altitude which will be problematic just for looking at the night sky."[3] Obstructions will be present both in telescope images, and to the naked eye. As astronomers strive to avoid trails of light streaking through their images caused by reflections from satellites, the problem, if it continues, will become much worse: avoiding trails every twenty minutes is manageable, says McDowell, but if the obstructions occur every moment from every angle, it is not something scientists can deal with: "If there isn't some kind of management of the night sky," he worries, "we are going to lose [ground-based] astronomy this century."[4] It will become a casualty of technical and commercial growth.

In a recent plea for a moratorium on satellite launches, European astronomers expressed their disdain, saying "the deployment of large fleets of small satellites planned

[1] Jonathan McDowell, Harvard-Smithsonian Center for Astrophysics, Interview, July 14, 2001.

[2] Stefano Gallozzi, Marco Scardia, and Michele Maris, "Concerns About Ground Based Astronomical Observations: A Step to Safeguard the Astronomical Sky," *IINAF,* Italian Institute for Astrophysics, February 4, 2020, 4, arxiv.org/pdf/2001.10952.pdf.

[3] McDowell, Interview, July 14, 2001.

[4] McDowell, Interview, July 14, 2001.

or ongoing for the next generation of global telecommunication networks can severely harm ground-based astronomical observations."[5] The astronomers requested legal recourse for damages caused by Starlink, saying the investments made to fund their research are being exploited. These damages, they claim, are potentially permanent for observatories if regulations are not set in place to save the night sky:

A particular attention is given to the problem of crowding of circumterrestrial space by medium/small orbiting objects. Depending on their altitude and surface reflectivity, their contribution to the sky brightness is not negligible for professional ground-based observations. With the huge amount of about fifty thousand new artificial satellites for telecommunications planned to be launched in Medium and Low Earth Orbit, the mean density of artificial objects will be > 1 satellite per square sky degree; this will inevitably harm professional astronomical images.[6] Soon, every area of the night sky will have a satellite in it, and the Earth will lose its cosmic perspective.

Dr. Alissa Haddaji is a Harvard professor and member of the United Nations Planetary Defense Working Group. She sees this issue going beyond harmful interference and damages for liability—it is a global sustainability threat. She believes there is more to worry about with the satellites being placed in *higher* orbits since they are dependent on fuel to reenter Earth's atmosphere: "the Low Earth Orbit satellites are not as worrisome," she says, "since they will eventually deorbit, but the ones going into Medium and High Earth Orbit could have complications coming back down, and they have much potential of adding to Earth's space debris, creating an environmental issue."[7]

With Earth's current orbital space debris comparable to twenty-three thousand metal baseballs, half a million metal marbles and golf balls, and a hundred million metal snowflakes swirling in orbit at seventeen thousand miles per hour, adding more gadgets to space is non-intuitive and could trigger Kessler Syndrome—an event like a high-speed racecar crash, when one piece of debris creates a chain-reaction of multiple crashes.[8] The event would surround the planet with uncontrollable objects, making it impossible to access space for generations.[9] Because of this, ground-based astronomy is in a dangerous place: "It would be technically reasonably straightforward to launch enough bright satellites to permanently ruin our work," says McDowell.[10] Eventually, astronomers will not be able to compete with orbital satellites and space debris. An example of this threat is happening today at the ALMA observatory in Chile. Because of its location, satellites are continuously in its view, and the observatory will become unable to make breakthrough

[5] Gallozzi et al., "Concerns," 1.
[6] Gallozzi et al., "Concerns," 1.
[7] Alissa J. Haddaji, COSPAR and Harvard Business School, Interview, July 19, 2021.
[8] NASA, "Orbital Debris Program Office," orbitaldebris.jsc.nasa.gov.
[9] Gallozzi et al., "Concerns," 1.
[10] McDowell, Interview, July 14, 2001.

discoveries such as in 2019, when the telescope played a fundamental role in capturing the world's first image of a black hole.[11]

Not only do satellites pollute astronomy images, but they also impede detection of approaching asteroids and comets, creating a security risk for humans. "All satellites … will be particularly negative for scientific large area images used to search for Near Earth Objects, predicting and, eventually, avoiding possible impact events."[12] If telescopes cannot see incoming asteroids, the whole world is at risk from potentially hazardous objects (PHOs) entering Earth's atmosphere, and time-sensitive mitigation will not be an option. In general, at least four months of reaction time are needed to avert an incoming PHO and depending on the method used either to push or to pull the object, years of global deliberation and preparation may be necessary.[13] Incoming PHOs are, as their name denotes, *potentially hazardous* to humankind and to life on Earth. An asteroid just a hundred meters long could cause a perpetual winter, as its impact dust would shade the sun's light, killing plants on a global level and leaving the survivors to die of suffocation and starvation.[14]

After satellites, the second problem for astronomy is local light pollution, which is growing faster than Earth's human birth rate.[15] Due to economic and technological advancement, cities everywhere are employing more and more lighting, which is why astronomer Richard Green of the University of Arizona Steward Observatory is alarmed: "Rapidly growing artificial skyglow is putting the world's observatories under threat."[16] As looking into a flashlight makes it impossible to see what is beyond, ground-based astronomical observation is obstructed by bright lights from sports arenas, billboards, casinos, and security lighting—all of which symbolize modern-day advancement.[17] This is a hit on more than just science: advocates to keep the skies quiet and dark say growing skyglow will affect star and astro tourism as complete industries fashioned around looking at the night sky are threatened.[18]

Legally, there is not much that can be enforced until regulations emerge. A review of international law shows that this is an issue between the launching countries and the countries whose astronomical observations are being obstructed. The current treaties include the Outer Space Treaty—which states that space is for all [hu]mankind; the Liability Convention—which holds accountable those who cause damages; and the

[11] Gallozzi et al., "Concerns," 10; Kazunori Akiyama et al. "First M87 Event Horizon Telescope Results." *Astrophysics Journal Letters,* 875, no. 1 (2019): L3.
[12] Gallozzi et al., "Concerns," 1, 8.
[13] NASA, "Planetary Defense," nasa.gov.
[14] NASA, "Planetary Defense."
[15] UNOOSA, "Dark and Quiet Skies Conference: Presentation Day: Slides," October 5-9, 2020, 3:13.
[16] UNOOSA, "Dark and Quiet Skies Conference," 3:15.
[17] "Are We Killing Astronomy? Interview with Astronomer Derek McNally," *New Scientist* 151, no. 2044 (1996): 28-31; International Dark Sky Association. darksky.org.
[18] UNOOSA, "Dark and Quiet Skies Conference," 1:52.

Registration Agreement—which makes the launching country responsible for the launchers.[19] Although international law provides legal protection for countries to sue each other over scientific damages, this is not a practical course of action. Not only do cases at the International Court of Justice take over a decade to resolve, but also bickering between nations is a primordial answer, says Simonetta di Pippo of the United Nations Office of Outer Space Affairs: "It is not the time for unilateral actions when we are all affected by the challenges we face."[20] Before pursuing legal disputes, astronomers rallying to have a voice at the United Nations must focus on international awareness and on global support.

Part of this is UNESCO's campaign to preserve the night sky and the astronomical heritage of humanity.[21] Supporting the endeavor is the Dark and Quiet Skies annual event sponsored by the International Astronomical Union and UNOOSA. The conference's mission is to secure international space sustainability guidelines for the world to follow. Organizers are lobbying for the UN Committee on the Peaceful Uses of Outer Space to start talking about ground-based astronomy as something that is in its jurisdiction.[22] Oddly, astronomers are now forced to get involved in UN deliberations—a process that is not usually in their job description. But "without international regulation," McDowell says, "there's nothing stopping someone else from putting something worse in [orbit]."[23] The astronomy community must make a presence at the law-making table.

Nationally, the American government has the power to protect astronomy, as it does within the National Radio Quiet Zone in Green Bank, Virginia—a town where wi-fi, cell phones, and microwave ovens are illegal because they interfere with the radio frequency science being conducted there.[24] However, the observatory is overseen by laws that are a "special case" and do not blanket all national astronomical observations.[25] With Starlink, the question is whether expensive business attorneys are persuasively keeping lawmakers from preserving the night sky, or if the government values internet access more than

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[19] UNOOSA, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," unoosa.gov/outerspacetreaty; UNOOSA, "Convention on the International Liability for Damage Caused by Space Objects," Resolution 2777 (XXVI), unoosa.org/oosa/en/ourwork/spacelaw/treaties/liability-convention.html; UNOOSA "Convention on Registration of Objects Launched into Outer Space," Resolution 323 (XXIX), unoosa.org/oosa/en/ourwork/spacelaw/treaties/introregistration-convention.html.

[20] International Court of Justice, "Pending Cases," icj-cij.org/en/pending-cases; UNOOSAs, "Dark and Quiet Skies for Science and Society," 1, unoosa.org/oosa/events/data/2020/dark_and_quiet_skies_for_science_and_society.html.

[21] UNESCO, "Astronomy and World Heritage," whc.unesco.org/en/astronomy.

[22] UNOOSA, "Dark and Quiet Skies for Science and Society."

[23] McDowell, Interview, July 14, 2001.

[24] Wesley A. Sizemore, "The National Radio Quiet Zone and the Green Bank RFI Environment," *Astrophysics Data System,* articles.adsabs.harvard.edu.

[25] Federal Communications Commission, "Docket No. 11745," Green Bank Observatory, November 19, 1958, gb.nrao.edu/nrqz/FCC_Docket_11745_NRQZ.pdf.

pictures of outer space. This is highlighted in the 2015 Space Resource Exploration and Utilization Act, a law the US Congress passed allowing companies to bypass bureaucratic red tape, encouraging them to emerge as space commerce leaders in remote sensing—satellites—and in space mining.[26]

Whether big money or big government is winning has yet to be proven. But the conversation for saving the night sky is promising on other levels: many groups are supportive of regulation, and common interests have united the front. For example, not only is light at night bad for astronomy, but according to doctors, it is also unhealthy for humans. The American Medical Association has announced that light at night contributes to mood disorders, obesity, diabetes, diminished performance, and prostate and breast cancer.[27] Also, improper lighting causes night glare, which creates nighttime driving disability in seniors due to changes in their eyes after age fifty.[28] This can be easily remedied with better engineering of streetlights. Advocate groups are educating local authorities on the monetary savings from using lighting that does not illuminate the night sky—but instead lights downward the areas needed at night—and in lighting curfews and motion-sensor devices. Therefore, grassroots regulatory frameworks to reduce growth of light pollution are helping astronomy, and they are good for citizens, for skyglow, and light at night; local and state municipalities are learning that it is healthier, more appealing, and less expensive to use efficient lighting.[29]

Another argument against light at night is that it damages the bio-environment. Sea turtle babies hatching on the Florida coastline, for example, instinctively crawl to the reflective nighttime ocean to find food and habitat, yet with bright oceanfront lighting they seek out the structures along the beach instead—residences and businesses—and die.[30] Many species are suffering confusion, accidents, and illness as light at night grows.[31] Not only is damage to biodiversity a human threat, as ecosystems are intertwined with human survival rates—but with satellite and light pollution, it is a question of space and environmentalism: to what extent is near-Earth space a part of the environment and already covered by environmental legislation?[32] As a human rights issue, there is no international law making the night sky a heritage to humans. UNESCO, however, argues

[26] US Congress, "H.R. 2262—US Commercial Space Launch Competitiveness Act, Space Resource Exploration and Utilization Act of 2015," congress.gov/bill/114th-congress/house-bill/2262.

[27] UNOOSA, "Dark and Quiet Skies Conference," 2:19; Peter James, Kimberly A. Bertrand, Jaime E. Hart, Eva S. Schernhammer, Rulla M. Tamimi, and Francine Laden, "Outdoor Light at Night and Breast Cancer Incidence in the Nurses' Health Care Study II." *Environmental Health Perspectives* August 17, 2017, https://doi.org/10.1289/EHP935.

[28] UNOOSA, "Dark and Quiet Skies Conference," 2:14.

[29] UNOOSA, "Dark and Quiet Skies Conference," 3:9.

[30] International Dark Skies Association, "Sea Turtle Conservation," darksky.org/our-work/sea-turtle-conservation.

[31] UNOOSA, "Dark and Quiet Skies Conference," 2:27.

[32] UNOOSA, "Dark and Quiet Skies Conference," 2:27.

there should be as it declares natural resources, environmental sustainability, and freedom from pollution the birthright of future generations.[33] The counterargument to this is that global internet could be viewed as a human right, as well, since it contains access to education, employment, and healthcare: items denoted in the Universal Declaration of Human Rights.[34] The question here becomes, which is a greater right to humanity? The argument has legal earmarks on multiple levels.

On the technological side, sharing the night sky with obstructions is not an easy solution. Funding and innovation are needed for software improvements, which can eliminate the light trails in pictures, but the accuracy of the information will still be diminished—such as in determining the precise brightness of a star when a light streak has imposed itself on the take. "It can't solve the problem, but it can make images look 'less bad'," says McDowell, who is an expert in dark sky light pollution.[35] Advancements in hardware, on the other hand, can be fitted to large observatory telescopes to adapt a triggering shutter which closes for five seconds when a satellite goes by, but will be much more expensive than changes in software. McDowell does not believe technology will solve this issue—not only would it be grossly expensive—in the billions—to retrofit every telescope in the world, but also it is not the true answer. Technology will not help if there are satellites always coming at all sides. On this issue, talks between interested parties have opened and they have helped: "there are technical regulations that could limit the number of satellites of certain brightness, which is the compromise coming out in the long run, but it's got to be something that the whole world decides, not just one company or one regulatory agency in the US."[36] For lasting change, balance on all sides will be key.

The constant study of the night sky is bound by the awe that comes from seeing things greater than one—to consider how miraculous life is, and to calculate for its continuance. "If [humanity] loses its cosmic perspective, we are lost," wrote Derek McNally, a man who spent his life studying the night sky.[37] Twenty-five years ago, he foresaw the dangers that would threaten his field and warned that something needed to be done before it was too late.[38] Although moves are being made to help earthbound astronomy survive, it will take a team of advocates across multiple disciplines to convince lawmakers that serious consequences are at hand and must be mitigated. Light pollution and satellite placement are more than a threat to ground-based astronomy, they are a security issue, a health issue, an environmental issue, and a humanitarian issue. "The real thing for us," says

[33] UNESCO; "Astronomy and World Heritage Thematic Initiative," https://whc.unesco.org/en/astronomy/.
[34] United Nations, "Universal Declaration of Human Rights," Articles 23-26, un.org/en/about-us/universal-declaration-of-human-rights
[35] McDowell, Interview, July 14, 2001.
[36] McDowell, Interview, July 14, 2001.
[37] "Are We Killing Astronomy?"
[38] McNally, Derek. "The Adverse Environmental Impacts on Astronomy: What Should be Done?" University of London Observatory, 1997, https://doi.org/10.1023/A:1007961909331.pdf.

McDowell, as he Zooms in from a networking conference with satellite companies, "is to not have the night sky grossly changed based on the decisions of any one country."[39] He speaks like a true academic, and one who loves the stars enough to fight for access to them. The conversation to save ground-based astronomy has begun, and although it may find opposition before it finds a consensus, there are enough good arguments to reach a formidable agreement. Ad astra.

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About the Author: Rebecca Schembri is a space diplomat and author from Reno, Nevada. She graduated in Social Science, International Relations, and Legal Studies from Harvard University Extension School in 2022. She is Harvard-certified in social justice and business communication. Rebecca advocates for outer space exploration and for ethical space law and policy. She also saves the world from asteroids as the Public Communications Manager at the B612 Foundation.

Editors' Notes: Space policy expert Rebecca Schembri is a member of the *Overview Round Table* and contributor to the new *Human Space Program* blog. Here she argues passionately for the need to protect humanity's opportunity to experience the cosmic perspective offered by access to the dark sky from the surface of the Earth. Orbital light pollution (of the sort threatened by new satellite networks with thousands of reflective surfaces in space) raises numerous ethical issues and is a global problem requiring international solutions. This thought-provoking essay is a great primer on the subject and well worth sharing with colleagues, friends, and loved ones who may need to understand the issue better. ***Gordon Arthur and Mark Wagner.***

[39] McDowell, Interview, July 14, 2001.

Reflections on the AIAA International Space Philosophy Gathering, Saturday August 14, 2021

by Madhu Thangavelu

Philosophy deals with the fundamental nature of knowledge and seeks answers and meaning to the deep questions of our existence, nature, and the cosmos. Great philosophies underpin the activities of great civilizations. Philosophical thoughts and tenets precede visions and policies of nations that manifest as concepts and architectures that are vital to propel the progress engine for the continued sustenance of civilization.

Space philosophy shines light on the various dimensions of humanity's quest to interact with nature's most open, transparent, and spacious physical domain; to explore, settle, and engage not only our nation or established allies, but to extend our collaboration, find common meaning, and enhance and enrich our common humanity across the globe, for the benefit and betterment of all.

Space philosophy, through what we know from the very short span our species has directly engaged our planet from without, continues to refine our species sensitivity, offering new insight and perspectives into our inextricable links with the biosphere, making us more aware of our place in the cosmos and the unique planet we call Mother Earth.

Outer space activities continue to provide unbounded inspiration and nourishment for the soul of humanity through the sheer awe and wonder we experience while our curiosity impels us to pursue ever more complex operations in this domain. By design, space activities and technologies are very conscious of resources, and space operations continue to pursue ever cleaner, ecologically sensitive awareness and frugal approaches that are finding their way into dwellings and cities on Earth.

Our esteemed group of speakers and panelists from around the globe presented various dimensions and points of view on space philosophy. Topics covered in this whole-day program included theology, origins, and life in the universe, humanity's purpose and the greening of the cosmos, space art, music and culture, space education, natural and societal law, space policy and politics. Ideas about the Nation State Paradigm under which sovereign nations operate today, Free world values were addressed. Safety of operations and rescue of personnel and common defense at the high frontier were brought up. Space activity and the technological sublime (what is the "Kama Muta" emotion that Sanskrit scholars have observed and so eloquently elucidate regarding our species?—Google it). An observational astronomer's diary on the discovery of a "squashed comet" and events leading up to the spectacular Shoemaker-Levy 9 impact on Jupiter, observations regarding Spaceship Earth, the Overview Effect, and astronaut observations since the dawn of human spaceflight were presented. And an award-winning civil architect's vision of how the astronaut memorial was conceived

and commissioned as well as alternative futures for human space activity and the progress in governmental and private space sectors in recent years were discussed.

A common theme that resonated throughout the day-long event was that our species and our biosphere and our view and place in the cosmos are inextricably linked. And that we should continue to use our species-unique imaginative faculties and creativity that have served us well to progress the use of tools of technology to become more aware and more sensitive to our surroundings. The messages conveyed suggest that we act collectively in a manner that responds to nature benevolently, starting from caring for our immediate Earthly nature and environment. And space activity, human space activity in particular, is helping to make us better stewards of spaceship earth, or more appropriately, Mother Earth. The overwhelming support for this event now has accumulated a lineup of speakers who hope to present their views in the next edition of this program around Christmas time. One more way to enjoy the holidays!

"Now there is one outstandingly important fact regarding Spaceship Earth, and that is that no instruction book came with it." –R. Buckminster Fuller (Operating Manual for Spaceship Earth, 1969)

We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time.
T. S. Eliot (Little Gidding, 1942)

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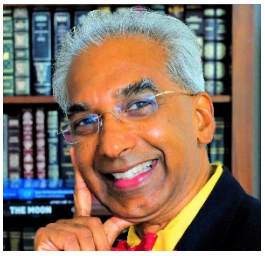

About the Author: Madhu Thangavelu conducts the ASTE527 Graduate Space Concept Synthesis Studio in the Department of Astronautical Engineering within the Viterbi School of Engineering, and he teaches Space Architecture in the School of Architecture at the University of Southern California. He holds degrees in both disciplines. He is also an adjunct faculty member of the International Space University based in Strasbourg, France, an institution that trains promising young space professionals for leadership in international space activities. He is a former AIAA Vice Chair for Education. He is a

director of the National Space Society and Vice President of NSS for India Region and the North American activities coordinator for the Moon Village Association.

Editors' Notes: Madhu Thangavelu is an inspirational leader in the field of Space Philosophy. His articles are required reading in the Space Philosophy program at *Kepler Space Institute*, and he has contributed to this journal before. On August 14, 2021, Professor Thangavelu convened an historic gathering of Space Philosophers (via Zoom). As editors of this journal, we were thrilled to be a part of it, and to include his reflections here in the Fall issue. He articulates so well the importance of Space Philosophy as a discipline, the diversity of those engaged in the field, and the hope represented for the future of humanity. The session recordings from the gathering are freely available online at the AIAA Los Angeles-Las Vegas Section YouTube channel: https://youtu.be/K03_Cb9CAbE. ***Gordon Arthur and Mark Wagner.***

Lunar Surface-Based Solar Power Wireless Transmission Solar Array Location Assessment

By Ghanim Alotaibi

Abstract

Wireless solar power transmission from one location to another on the lunar surface seems to be an optimum option for future outposts on the moon. The system includes a photovoltaic array, wireless power transmission receiver and transmitter, and storage system. John Mankins has proposed a location for the system based on parameters such as land inclination, average temperature, and average illumination. This research project evaluates two locations to install solar arrays for a wireless power transmission system to generate power for a future lunar outpost. The methodology of evaluation and suggestions for future studies are also presented.

Introduction

The south pole of the moon is a good potential location for a future outpost. There are many factors that make the south pole a suitable candidate. Water and other volatiles are available and relatively abundant at the south pole. Figure 1 shows the location of the lunar outpost concept considered in this research.

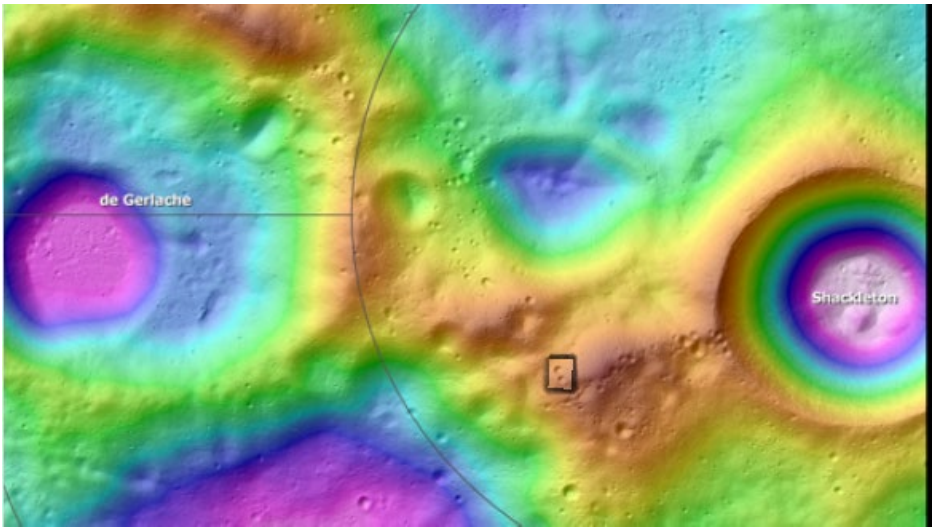

Figure 1: Potential Future Lunar Outpost Location (Inside the Black Rectangle)

Each crater is about 400 m in diameter. The utilization of craters for lunar outposts/settlements may be beneficial as it may offer protection from harmful radiation. This location can support future growth, heat flow, and many other basic requirements

for a settlement/outpost to support humans.[1] A detailed discussion of this location is beyond the scope of this paper.

Power is a basic requirement for any lunar outpost concept. Many power generation technologies can be considered for the lunar outpost. Radioisotope thermoelectric generation is high cost and requires complex equipment to be launched from Earth due to the risk of radioactive leaks. Space nuclear reactors can be extremely risky once turned on, and they could contaminate the lunar surface. A solar photovoltaic array installed near the proposed lunar outpost would also be a challenging alternative. The illumination at the outpost positions was measured at 27.8% of the time (including areas at least a few hundred meters away from the outpost). This means a huge photovoltaic array would be required to charge batteries during unilluminated times.

Among the many power generation options, transmitting solar power from a highly illuminated location to the location of the outpost seems the most promising. Illumination time can reach about 100% of the lunar year (depending on the altitude). Also, the atmospheric effects on the moon are negligible, and there is no seasonal variation. Solar power is safe and reliable, as it does not require radioactive materials. High illumination locations are associated with high altitudes and relatively high temperatures. Figure 2 shows this concept of wireless power transmission (WPT).[2]

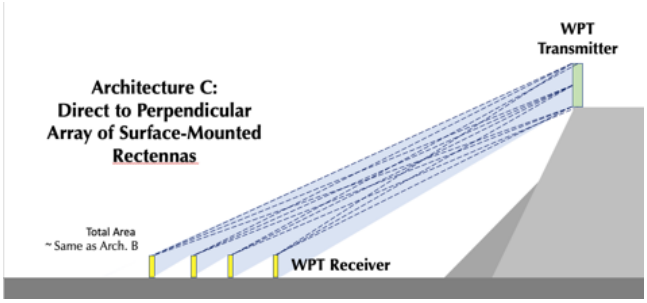

Figure 2: WPT Architecture

As shown, the solar power generator is in a high-altitude location with a high illumination percentage. Power is transmitted to the receiver near the outpost in a location with a low illumination percentage. The following sections discuss the point-to-point power transmission modeling for different locations near the south pole.

Point-to-Point Modeling

Point-to-point modeling is sizing the transmitter, the receiver (rectenna), the storage capacity, and the solar array. This sizing process is based on the solar power requirement

[1] John Mankins, "Lunar Settlement Case Study," Lecture, COM 501—Energy, Civilization, and Economy Course, Kepler Space Institute, April 2020.

[2] Lunar Planetary Institute, "Lunar South Pole Atlas," April 2020, www.lpi.usra.edu/lunar/lunar-south-pole-atlas/.

(power demand of the outpost) and the environment. The assumptions for the DC-RF and RF-DC transmission efficiency and the efficiency of the solar panels are shown in the appendix.

The actual power requirement for the lunar outpost needs more consideration and further study. For this research, a power requirement of 100 kW is assumed. The sizing of the receiver assumes 85% efficiency in the RF-DC transmission. The sizing also depends on the distance between the receiver and the transmitter, beam frequency, and transmitter diameter. The transmitter sizing is based on 80% DC-RF transmission efficiency, 39% beam interception efficiency, and 96% beam coupling. This gives a receiver diameter of 58 m on the floor. Applying a 60° correction using the cosine law, the diameter becomes 117 m. The minimum transmitter diameter is calculated at 40 m. If the solar photovoltaic panel area is equal to the transmitter area, and has an efficiency of 30%, the power output will surpass the required power of 100 kW given an insolation of 1,398 W/m^2. The average temperature for the receiver and solar power generation system is assumed to be 40K.

This study evaluates the performance of the transmitter in several locations. This means that the illumination, the distance between the receiver and transmitter, the correction angle, and the receiver average temperature will be varied as we change the location.

Location Evaluation

The two most important parameters to favor one location over another are the illumination percentage and the distance between the transmitter and the receiver. Higher illumination means more power output for the same solar array area and a smaller storage system. A shorter distance between the receiver and the transmitter means a smaller transmitter area, and therefore a lower cost. Another important parameter that should be considered is the location's accessibility from the outpost.

The two locations on this research are shown in Figure 3. Both locations were selected since the maximum and average temperature of the location is higher than other locations near the outpost. This indicates a higher illumination because the sun is the only source of heat on the lunar surface.

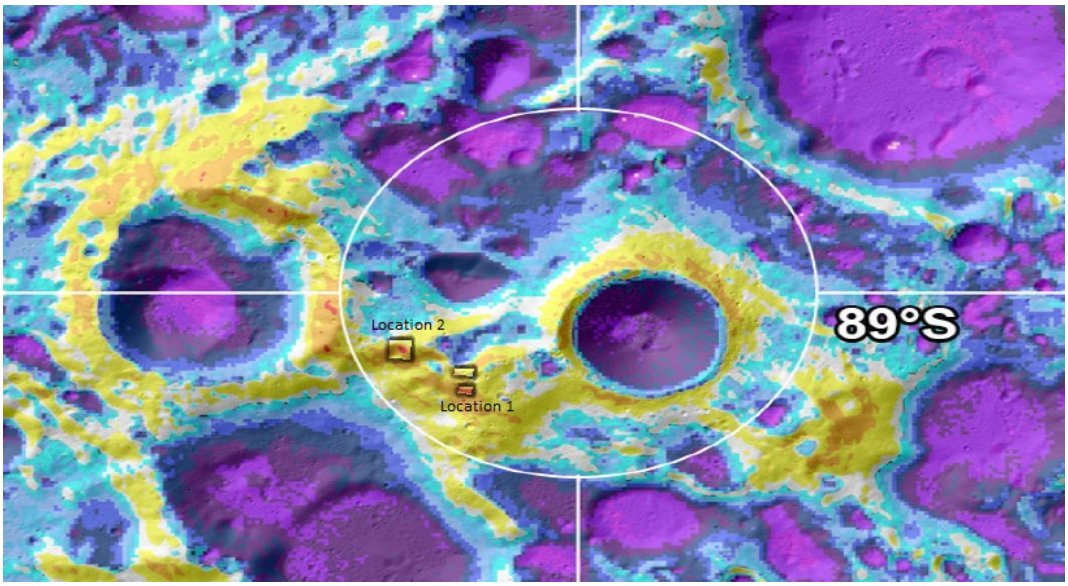

Figure 3: Locations of Transmitter Tests.
Location 1 is south of the outpost location, while Location 2 is northwest.

The illumination percentage was calculated based on data from the Lunar Planetary Institute.[3] The data is basically a one-month movie of polar illumination for the south pole from the NASA Clementine Mission. The two locations of interest were identified in the movie, and as the movie was playing, the illumination time was measured on each location using a stopwatch. The movie was originally two seconds long and it only covered the source. Movie editing software was used to slow down the two seconds, and the total duration of the movie was extended to four minutes and nine seconds.

A transparent sheet was used to draw the borders of the permanently shaded areas. The transparent sheet was placed on the screen, and the movie was played. The permanently shaded regions in the Shackleton Crater and the de Gerlache Crater were perfectly identifiable as almost full circles. Using other maps to identify the distances to the locations of interest, every centimeter in the movie map was found to be equivalent to about 15.5 km. Therefore, it was possible to identify the desired locations on the transparent sheet. As the movie was projected onto the background of the transparent sheet, the illumination time was measured at the desired location.

Results and Discussion

Location 1

As mentioned above, Location 1 was selected because its surface temperature is higher than other locations. This indicates higher illumination. Also, Location 1 is very near the outpost location. It is 3.3 km south of the outpost. The shorter distance means a smaller transmitter size and easier access. The topography and slopes maps are too low

[3] Lunar Planetary Institute, "Lunar South Pole Atlas."

in resolution for a more extended discussion about accessibility. Location 1 was illuminated for 48% of the time. Table 1 summarizes the findings for Location 1:

Table 1: Measurements for Location 1

Parameter	Measurement
Illumination percentage time	48%
Distance to outpost	3.3 km south
Average temperature	190K
Correction angle	30°

The correction angle is related to the difference in height between the desired location and the outpost. The low resolution of elevation in topographical maps makes it very challenging to calculate an accurate number. However, it seems that the two locations are not very different in elevation, but Location 1 is slightly higher. For this reason, an angle of 30° was assumed.

Using the measurements for Location 1 and based on the assumptions and data presented above about the point-to-point model, the sizing for the receiver, transmitter, and storage system are shown in Table 2:

Table 2: WPT Sizing Results for Location 1

Parameter	Size
Transmitter diameter	40 m
Receiver diameter (at angle on the floor)	8 m (9 m)
Time of storage	52% of the time (368 hours/month)
Storage required at transmitter	146,613.5 kWh
Storage required at receiver	36,816 kWh

The scale for the illumination map movie was 1 cm for each 15.5 km. The dots on the transparent sheet can represent 100 meters or more. Therefore, making accurate measurements of illumination is challenging given the available data. For Location 1, illumination was present very near the dot at the start of the movie. This means that illumination was present a few hundred meters away from the identified location. To identify the illumination location better, it is important to measure the illumination of sites near Location 1.

The WPT system sizing numbers above look promising, except for the storage system. It is therefore important to place multiple WPT systems in various locations with alternating illumination cycles to reduce the storage requirements. Sizes of 40 meters for the transmitter and 9 meters for the receiver are easily achievable.

Location 2

Location 2 is 9.2 km away from the outpost. Location 2 was easier to evaluate as the location is clearly on top of a small crater edge, which is higher than the surrounding area. In the illumination movie, the illumination pattern identifies the location. Table 3 shows the measurements for Location 2:

Table 3: Measurements for Location 2

Parameter	Measurement
Illumination percentage time	47%
Distance to outpost	9.2 km south
Average temperature	190K
Correction angle	50°

The correction angle was assumed to be larger because Location 2 is clearly higher in elevation than Location 1 and the outpost location. However, the illumination time is almost the same as for Location 1. Table 4 shows the point-to-point model run for Location 2:

Table 1: WPT Sizing Results for Location 2

Parameter	Size
Transmitter diameter	40 m
Receiver diameter (at angle on the floor)	21 m (33 m)
Time of storage	53% of the time (375 hours/month)
Storage required at transmitter	149,433 kWh
Storage required at receiver	37,524 kWh

The transmitter diameter is the same as for Location 1 because the assumption was that the transmitter size equals the solar array size. The longer the distance between transmitter and the receiver, the larger the necessary receiver diameter.

Clearly, Location 1 seems better due to smaller receiver size, slightly lower storage requirement, and easier accessibility. However, uncertainties due to the low resolution of the maps makes it difficult to decide. The illumination cycle starts at different times at the two locations, which means that installing two systems at both locations will definitely reduce the storage requirement.

Future Studies

Further studies will be needed to optimize the location of a WPT system. It might be a good idea to create software that will measure illumination and temperature at every location on a given map of the lunar south pole. Combing this software with high-resolution data will allow easy evaluation of many locations using the above

methodology. Depending on the available data, a first version of such software can be created to replace the manual methodology used in this research. With more accurate data, the software can be enhanced later.

An optimized solution may involve the installation of several WPT systems with differing illumination periods. A trade-off study will be required for accurate assessment given the parameters of the WPT components, sizes and masses, and storage requirements. Therefore, software that assesses illumination with high-resolution data would be a good investment for a significant cost reduction in power generation for a future lunar outpost.

Conclusion

WPT generated by solar photovoltaic arrays is the most suitable available technology for a future lunar outpost at the south pole of the moon. This research evaluated two different locations at the moon's south pole to install photovoltaic solar arrays for a WPT system. The available data resolution was low; however, the manual methodology presented above may offer a good start for future research projects.

Location 1 is slightly more suitable for the installation of the solar array. The shorter distance reduces the size of the receiver compared with Location 2. An optimum solution can be achieved by installing several systems with differing illumination periods. This will significantly reduce the storage requirement. This means that the evaluation of many locations is required. However, using a manual methodology with low-resolution data is a major challenge. Therefore, software that can automate the methodology for research may reduce the cost of power generation for future outposts significantly.

Appendix

Lunar Polar Power Distribution										April 23, 2020
Case 1 - Power to Receiver on "Floor" @ 2.45 GHz										
SSP System - in PEL					**WPT DESIGN BASELINE PARAMETERS**					
External Environment					Speed of Light	299,792,458	m/s			
Duration of each Lunar Day	708	hrs			Frequency	2,450,000,000	Hz			
% time SSP Array in the Sun	47.0%	percentage			**Wavelength**	0.122364269	meters	Power transmission RF wavelength		
Hours SSP Array in Sun	332.76	hrs			**Transmission Distance**	9	km (Xmttr-Rcvr)	Distance from Xmttr to Rcvr		
Average Temperature (PEL)	190	°K			**Diameter (Xmttr)**	40	meters	Diameter of the transmitter		
Average Temperature (PSR)	40	°K			"Tau"	2.44	Parameter	**Parameter for 96% Beam Coupling**		
Insolation (When Lit)	1,368	W/m^2			Transmission Eff	99%	Percentage	Percentage Transmission (inc. Atm Losses)		
WPT					Max Beam	96%	Beam Coupling	Max Beam Coupling Efficiency		
SPG Power Output Required	398,233	W			Required Beam	39%	Beam Intercepte	Desired Beam Interception Efficiency		
Insolation (when Lit)	1,368	W/m^2								
Transmitter Area	1,256.6	m^2			**XMTTR SIZING CALCULATIONS**					
PV Area	1,256.6	m^2			Xmttr DC Input	398,233	Watts			
Average Power per Area	316.90	W/m^2			Xmttr DC-RF Eff.	80.00%	Percentage			
PV Efficiency	30.0%	Percentage			Xmttr RF Output	318,586	Watts			
Max Possible SPG Power @ 1-to-1	516	kW			**SIZING OF RCVR**					
Max Possible SPG Power @ 2-to-1	1,031.4	kW			RF-DC Efficiency	85%	RF-to-DC	Percentage of RF converted to DC at Rectenn		
						Diameter (Possible Receiving Circle) = 2.44 * Wavelength * Distance (Xmttr-Rcver)/Diam				
Energy Storage Option					D (Circle)	21	meters	Area R	361.7	m^2
Time of Storage	375.24	hrs			D (On "Floor" @ Angle)	33	meters	Area R	875.4	m^2
Storage at Transmitter					RF Power @ Rcvr	117,647	Watts	RF Power incident on the Circle		
Energy Storage Required	149,433.0	kWh			DC Power Required @ Rcvr	100,000	watts	Potential DC Power Output		
Storage at Receiver										
Energy Storage Required	37,524.0	kWh			**PEAK POWER @ RCVR**					
					Peak WPT Power at Receiver	116.66	Watts/m2			
					AVERAGE POWER @ RCVR					
Receiver Cosine Correction					Average Power	40.83	Watts/m2	Very Rough Estimate...!		
	0.6428				**EDGE POWER @ RCVR**					
Angle	50	Degrees			Min Power	8.17	Watts/m2	Very Rough Estimate...!		
If "Distance" is at 2-times Elevation						0.82	mW/cm2			
					PEAK POWER = Power (Transmitter) * Area (Transmitter) / (Wavelenth * Wavelength * Distance (Xmttr-Rcver)					

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About the Author: Ghanim Alotaibi is a mechanical engineer who works in the Physics department at Kuwait University. He is working on the first space mission in Kuwait and is considered the first person in Kuwait to hold a full-time space-related job. Ghanim is also the project manager for the "Moon Village—Participation of Emerging Space Countries" project. The project's aim is to involve developing countries in moon activities to make moon exploration more diverse.

Ghanim worked for the Kuwait Oil Company for six years before he obtained his master's degree from Freiburg University, Germany in solar energy. Since he was an undergraduate student, he has been involved in many space activities. He was the Middle East Regional Coordinator for the Space Generation Advisory Council and he performed two field rotations as an analogue astronaut at the Mars Desert Research Station. Ghanim is also an amateur astronomer with an interest in the photometry of variable stars and he is a graduate of the International Space University.

Editors' Notes: Ghanim Alotaibi is a scholar at KSI, where he has built on the work of Professor John Mankins, the globally renowned expert in Space Solar Power. In keeping with Mankins's thoroughly researched and concrete recommendations, Alotaibi here considers arrangements for solar power on the moon and makes recommendations for a wireless power transmission system. This solution is specifically designed for a small settlement at the South Pole of the Moon near Shackleton Crater, in keeping with plans developed for the *Moon Village Association*. Such a solution may very well be implemented in just a few short years as multiple international organizations plan for a return to the Moon. ***Gordon Arthur and Mark Wagner.***

Ethics and the Human Space Program: A Report from the Ethics Proto-Task Force, Overview Round Table

By J. N. Nielsen, Rebecca Schembri, Paula Korn, Oren Whyche-Shaw, Nichole Anderson Ravindran, Lars-Erik Sirén, Daniela de Paulis, Larry Downing, and Bob Krone

Abstract

Space exploration, and the Human Space Program in particular, will present humanity with unprecedented moral dilemmas as well as unprecedented moral opportunities. It is incumbent upon us both to draw upon the existing tradition of ethical thought and to formulate novel ethical conceptions in thinking through the moral dimensions of human space exploration. The Ethics Proto-Task Force has approached these unprecedented dilemmas and opportunities from a variety of standpoints and in light of these variegated perspectives has formulated recommendations for a future Ethics Task Force as well as provisional recommendations that could be acted upon immediately.

Keywords: Ethics, space ethics, Overview Effect, Frank White, space exploration.

Introduction

Humanity's engagement with ethical concerns has roots in every human tradition, and over time has developed in many directions, in terms of both normative doctrines and analytical approaches to understanding human moral experience. The Human Space Program (HSP) will inevitably find itself engaged in ethical reflection, in the form of asking whether novel human experiences in space point to novel normative doctrines or suggest new analytical approaches. Within the timeframe and resource constraints of the HSP proto-task forces, we cannot hope to survey the whole field of moral thought, so we will confine ourselves to touching on a few highlights.

As a field of philosophical research, both the meaning and the content of ethics has been debated at great length and with little consensus other than the import of the discipline, being one of the traditional branches of Western philosophy (along with metaphysics, epistemology, aesthetics, and logic). We cannot settle these age-old controversies here, but we will adopt as a working definition that *ethics is the study of what makes actions right or wrong, of what is truly valuable, and of what makes moral claims and judgments true (or false)*. Moreover, space ethics as a distinct discipline (if there is such a discipline, or such a discipline comes into being) must consider the distinctive variables of the space environment, such as distances within the space environment (both distances from Earth to space and distances within space independent of Earth), and the scales of time inherent in cosmological distances. Thus, we can elaborate our working definition such that *space ethics is the study of what*

makes actions right or wrong, of what is truly valuable, and of what makes moral claims and judgments true (or false) in the context of the space environment.

The human beings who will ultimately constitute the HSP will require special provisions and technologies to travel through or to reside in the space environment, and these provisions and technologies will affect the human relationship to our immediate milieu, affecting human action and thus also our ethical deliberation. The facts at hand and the degrees of relation to and impact on others are as crucial to ethical reflection as normative and analytical perspectives are for ethical principles.

Frank White noted on the first page of *The Overview Effect: Space Exploration and Human Evolution* that "mental processes and views of life cannot be separated from physical location. Our 'worldview' as a conceptual framework depends quite literally on our view of the world from a physical place in the universe."[1] Two hundred years earlier, Georg Christoph Lichtenberg had written, "I have observed quite clearly that I am often of one opinion while lying down and of another while standing, especially when I have eaten little and am weary."[2] These factors of spatial location and bodily disposition, as well as countless other properties of embodiment, enter into the all-too-human realities of moral deliberation in an uncertain world, made the more uncertain when one is engaged in exploration. But it is precisely when we are exploring that we require a moral foundation.

The members of the Ethics Proto-Task Force come from diverse backgrounds and different life experiences, and so have highlighted different aspects of space ethics, which are discussed below. We note that life and work in space will ultimately be as variegated as life on Earth, such that every variety of human lived experience on Earth will be mirrored by human lived experience in space, and the many environments in space may offer opportunities for forms of lived experience not encountered on Earth. Moral experience may well expand along with human civilization in space, driving an expansion of ethics as a discipline.

Where We Have Been and Where We Are Going

Over the ages, human groups have established moral codes of conduct that fit the contexts of the times. It took millions of years for humanity to evolve the capacity to come down from the trees and incorporate the necessary social cooperative dynamics to assure species survival and to expand the scope of human action. That process resulted in changes to our physiology and neural pathways. Our brains grew larger, allowing human beings to take greater and greater control of the natural world (agriculture) and to extend the range of the species. We adopted technologies (from fire

[1] Frank White, *The Overview Effect: Space Exploration and Human Evolution*, 3rd ed. (Reston, VA: AIAA, 2014), 1.

[2] Georg Christoph Lichtenberg, *Aphorisms* (Harmondsworth, UK: Penguin Books, 1990).

through the wheel to CRISPR) as more efficient and effective means to assure species survival, continued expansion and, for a minority on the planet, greater wealth and higher standards of living. In light of these developments, one fundamental question is whether, as a species distributed on a planetary scale, we have fundamentally evolved, and in what senses have we evolved. Are we on a course for another evolution in human consciousness? How will any further evolution in human consciousness affect the moral life of humanity? How long can we expect the moral evolution of humanity to take? What can we do to assert our agency in that evolution?

There has been much written and there are ongoing discussions about the exploration and development of space starting with the Moon and, subsequently, Mars. Discussions to establish ethical treatment of the Moon (and Mars) beg the question of our moral relationship to the Earth. It will be difficult for stand-alone ethical norms for space to be respected (let alone reach a planetary agreement among national leaders/governments) until it is brought home that actions that have been and are continuing to be taken on the Earth threaten our very existence.

An adequate space ethic would, at the same time, be an Earth ethic, and such an ethic would be more comprehensive than any previous ethical conception. Thus, the importance of human moral evolution: a more comprehensive scope of moral reflection is called into being by a more comprehensive scope of human action; we become worthy of this increased scope of action through moral reflection on a commensurate scale. Such would be a moral code of conduct that would fit the context of the Overview Effect and the Space Age.

Normative Considerations for Space Societies

Given that all nations will initially be forced to share space as they do Earth, especially the space in immediate proximity to Earth, and that space exploration is conducted in an environment lethal to humans, for the survival of all humankind in outer space we must work together in harmony and establish institutions that foster this strong stance. Equality, regardless of origin, gender, and economic status, must be a cornerstone for future space ethics, so that space may become a separate place that has a separate culture. Current space treaties and agreements, whether international—the Outer Space Treaty, the Registration and Liability Convention, the Rescue Agreement—or multilateral—NASA's Artemis Accords, ISS Memoranda—engender interdependence and cooperation without prejudice to country of origin. All space agents must be transparent, help each other in emergencies, not interfere with foreign projects, and have due regard for fellow human beings. These agreements set the tone for ethics that parallel the best intentions of humankind now and in the future.

On an individual level, the Universal Declaration of Human Rights sets the standard for fair treatment of all. It states that every human is born with the right to live a free life in pursuit of happiness, and that all should have access to education, good health, and

family if they so choose. We may hope that barriers to individual achievement will be confined to Earth and not enter the space realm. It is incumbent upon us to create a new culture in space, so that space can be a different place with different customs, with a greater scope for freedom, and it is our job to ensure that the institutions we establish uphold this sentiment, protecting it across generations.

Aspirational Dimensions of Space Exploration

Space travel has been aspirational from its inception, and space ethics should take this into account. That human beings strive to attain difficult aims—"Ah, but a man's reach should exceed his grasp, Or what's a heaven for?"[3]—has been a motivating force in human history, and with space exploration this was made explicit in Kennedy's "Moon Speech":

> We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too. It is for these reasons that I regard the decision last year to shift our efforts in space from low to high gear as among the most important decisions that will be made during my incumbency in the office of the Presidency.[4]

The aspirational quality of space exploration still lives in the imagination of every child who dreams of being an astronaut. Human moral psychology is such that aspirations for personal achievement are not clearly distinguished from aspirations for a better life and a better world. Some have identified these overlapping aspirations as a kind of faith:

> Space workers, both religious and secular, describe permanent human communities elsewhere in the solar system as inevitable, with the significance of their work and its fated outcome creating a sense of hope about the work at hand. Faith in the future of humanity's relationship with space provides tremendous motivation; a feeling that one is destined to succeed encourages continued effort."[5]

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[3] Robert Browning, *Men and Women* (Boston: Ticknor and Fields, 1855).

[4] John F. Kennedy, "Moon Speech," Rice Stadium, September 12, 1962, er.jsc.nasa.gov/seh/ricetalk.htm.

[5] Deana L. Weibel, "Following the Path That Heroes Carved into History: Space Tourism, Heritage, and Faith in the Future," *Religions* 11, no. 1 (2020): 23, https://doi.org/10.3390/rel11010023.

Some have gone further and have discussed this faith in explicitly religious terms:

> Without question, those associated with spaceflight have spoken of it in explicitly religious terms. For example, Chris Kraft, a leading NASA official during the Apollo era and director of the Johnson Space Center in the 1970s, characterized his support of space exploration in overtly religious language: "This step into the universe is a religion and I'm a member of it."[6]

We need not formulate our aspirations for space exploration in terms of religious faith, but the experience of space exploration has encouraged such terms through its potency and uniqueness. The Human Space Program has its origins in the recognition of the Overview Effect, which is a potent and unique experience due to space exploration and available through space exploration, rising to the status of an insight that leaves no aspect of life untouched. Ethics through the lens of the Overview Effect and other space philosophies are as likely to be transformed as are the social sciences, including religion and self-understanding.

The philosophy behind the Overview Effect is that we would wish to share the overview as widely as possible, and, while there are many ways of achieving such an awareness, we would want to proselytize it in its most robust form, which is actually to view Earth from space with one's own eyes. This we may call the *overview imperative*, and adopting the overview imperative as a moral principle, and acting upon this moral principle to the maximum extent possible, would have profound moral consequences that would ripple through human experience and shape the human future.

Long-Term Considerations in Space Ethics

The future is forged by the dreams, aspirations, and motivations of the past and the present. The present-day goal of human civilization becoming a multiplanetary species and how we go about achieving that goal will determine how we are perceived by the biological and post-biological civilizations we may encounter as we traverse the stars. More specifically, humanity's reputation might be all it has within the larger universe, considering that we do not know where humanity fits within the larger collective of potential civilizations already in existence. As to where humanity has been allowed to repeat mistakes or intended actions/decisions at a generational level, that will be less likely once we enter the broader community of space and the galaxy. Any long-term space ethics we formulate should consider not only how other civilizations could

[6] Roger D. Launius, "Escaping Earth: Human Spaceflight as Religion," *Astropolitics* 11, no. 1-2 (2013): 45-64, https://doi.org/10.1080/14777622.2013.801720.

perceived the actions we take and the decisions we make, but how they could be perceived in the future if extrapolated to their fullest conclusion.

Long-term space ethics ultimately has two simultaneous missions: one, the far-future mission, which would address higher-order issues of uncertainty and complexity; and two, the near-future mission, which addresses more immediate and accessible issues of uncertainty and complexity that humanity might be able to resolve. One example of a far-future conundrum would be how humanity plans to survive as our Sun continues to age. The near-future focus of space ethics mainly concerns planet Earth and how seeing the positive long-view aspects of space, such as the Overview Effect, can help humanity to improve our relationship with our homeworld. At present, there is no universal set of human values that incorporates equitable human, nonhuman—animal or other, and plant rights as well as environmental rights that recognize Earth as a being in her own right vis-à-vis various legal institutions. With a better conceptual understanding of one another, our cultures, and the Earth, humanity will be better equipped collectively to address present-day and future challenges. For example, how does humanity evolve in such a way that the natural environment can be sustained? That the interconnected communities of nonhuman species on Earth can thrive and maintain their populations? That Earth can heal? That the human ecosystem can flourish without undermining the very foundation that has nurtured us to this point in time?

To begin working toward achieving both these missions, long-term space ethics should be flexible in scope (planetary scale) and adaptive in nature (at the national and local scale), taking into account creating solutions that consider as many communities as possible (if not all communities) to identify and implement the best courses of action. Space ethics should explore the formulation of a core set of principles that are consistent with the actions we take on the extraterrestrial, planetary, national, and local scales. More importantly, they need to incorporate how to protect and respect others, both on Earth and in space, while at the same time protecting humanity's safety and well-being, if that is possible to achieve. It will be challenging, to be sure. Some mindset shifts—the evolution of consciousness—will be necessary to create the balance we need to achieve a reasonable ethical and moral practice. Humanity is capable of doing this if it wants to.

As we look to the stars to inspire us to a new understanding of compassion and unity, humanity should keep in mind that once we join the broader community of potential civilizations traversing space, our reputation, actions, and decisions are all we can claim as our own. With every potential first contact scenario we could possibly experience, we might only have one chance to get it right. Therefore, the moral psychology of humanity's relationship to other species, as well as to inanimate nature, is a larger question than ethics *simpliciter*, and the discipline of space ethics will have to expand its scope to study these problems in an interdisciplinary context that draws from psychology, anthropology, sociology, and astrobiology, *inter alia*.

Future Research in Space Ethics

A more thorough future report for an ethics task force representing the HSP may wish to elaborate further on the themes developed above, as well as studying the moral implications of questions such as the following, *inter alia*:

- Why ethics for space?
- What if ethics is neglected in the space exploration epoch?
- What does space mean?
- What does nature mean?
- What do human rights mean?
- What do nonhuman animal, plants, and AI rights mean?
- What does Earth mean and how is it understood?
- What is the value of space exploration?
- What moral obligation, if any, does the Overview Effect entail?
- What moral obligation, if any, does a space program entail?
- Is the HSP relevant to ethics?
- What is the moral vision of the HSP?
- How is human moral experience changed by space exploration?
- Does any action/inaction today affect long-term human survival?
- Is humanity morally compromised by our space exploration to date?
- Will space exploration today have a negative or positive impact in the longer term?

The questions we ask will shape how we ultimately view space ethics. Furthermore, developing space ethics could be facilitated through the following research agendas, *inter alia*:

- Analogous formulations of traditional ethical doctrines, adapted specifically to a space exploration and development context.
- Thought experiments in space ethics specific to the space environment, employing the resources of experimental philosophy to probe our geocentric human intuitions regarding the realities and the ideals of human life in space.
- Illustrative scenarios of moral dilemmas in space and distinctive to the space environment.
- Educational initiatives in ethics for astronauts, space migrants, and the space industry.
- Detailed and specific formulations of research questions in space ethics as an agenda for space ethics as a discipline.

These potential research topics for a more thorough ethics task force could be extended and elaborated through an engagement with existing moral philosophy and

moral psychology. The potential scope of such an inquiry is as unlimited as are human possibilities in the universe.

Provisional Recommendations

In the immediate term, and before the HSP Ethics Task Force proper is constituted, the way can be paved for a comprehensive inquiry into space ethics by the eventual task force through the following steps:

- Hold space ethics essay contests with monetary prizes, ranging across all demographic cohorts, to engage the public in space ethics concerns and to draw interested persons into the space ethics community, from which members of a future Space Ethics Task Force may be drawn.
- Author a curriculum on space ethics specific to the HSP.
- Collect resources specific to space ethics—create public documents to which all interested parties can contribute, including a bibliography of space ethics, a list of ideas relevant to space ethics, and so forth.
- Create discussion forums on several social media platforms for space ethics, under the auspices of the HSP to discuss space ethics ideas and to build and broaden a virtual community around space ethics.
- Organize a space ethics conference, again under the auspices of the HSP.
- Conduct a survey of all cultures that demonstrate an interest in participating in space development to express conceptually how they understand space and space ethics, and what space means to them through their own language's terminology.
- Prioritize the cleaning up of space debris around our planet as an integral part of the HSP. For any extraterrestrial civilization that sees Earth as it is passing through our solar system, this would be a very telling sign for them that could impact how it views us; the externalities of our space program to date are a reflection of who we are as a species with a space program.

These recommendations are not to be considered exhaustive. Any effort that will raise the profile of space ethics and inculcate the importance of ethical reflection at the beginning of outer space development, whether for humanity on the whole or for the HSP in particular, will be a worthwhile endeavor.

The subject matter in this article was developed by the authors as part of an exercise sponsored by the Human Space Program's Overview Round Table.

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Editors' Notes: The *Overview Effect*, a term coined by KSI Professor Frank White, is a shift in worldview reported by people during spaceflight. It refers to the experience of seeing firsthand the reality that the Earth is in space, a tiny, fragile ball of life, without borders. The *Overview Round Table* is an informal group that meets weekly to promote sharing this perspective with others here on Earth. The HSP, founded based on Professor White's work, is dedicated to creating space exploration as a central project for humanity—one that will result in ethical, inclusive, and sustainable expansion into the solar ecosystem. This summer, for the first time, the HSP organized round table participants into several prototype task forces, each meant to consider a specific issue such as education, psychology, governance, or religion in relation to the coming human migration into space.

J. N. "Nick" Nielsen led the proto task force on ethics, which included Rebecca Schembri (who contributed another article to this issue) and others named in the byline. The group's work culminated in a presentation to the round table, and in this written report. We are glad to present it here in the *Journal of Space Philosophy*, where ethics, moral decision making, and moral leadership are of primary concern. The group's aspirational long-term thinking is evident in the questions they ask and the recommendations they leave for those who follow. ***Gordon Arthur and Mark Wagner.***

Equality and Equity for Kepler Space Institute and Human Immigrants to Space Settlements

By Salena Gregory-Krone and Bob Krone

Preface

Inequality and inequity have been human dilemmas and causes for disruptive behavior from intolerance to genocide to wars throughout history. This document's primary purpose is to provide Human Equality and Equity policy for the Kepler Space Institute (KSI).

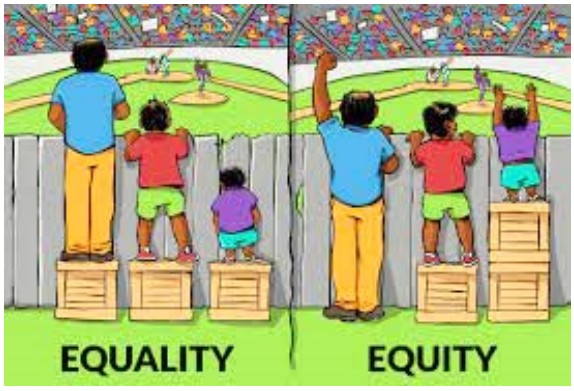
One fundamental research question is: *How can KSI achieve and maintain human equality and equity for all its leadership, faculty, staff, scholars, researchers, ambassadors, and all those with whom they work?*

Equality and equity are fundamentally different in definition.

Our definition of human equality is founded in the Golden Rule, "Do unto others as you would have them do unto you" and is stated as policy: "The Kepler Space Institute Equality and Equity Policy prescription for all its people is to evaluate and behave toward others with respect and universal equality of opportunity, equity, and justice for all regardless of culture, race, color, religion, age, gender, sexual identification, or national origin."

The generally accepted definition of equity is treating people in accordance with their needs.

The following picture illustrates the two definitions:



With equality, everyone receives the same; with equity, everyone receives what they need. In the human social world, the actions to achieve those two results get very complicated. Neither has yet been fully achieved. Many consider striving for full equality or equity a Utopian dream (i.e., a state in which everything is idealistically perfect). Random or intentional failures in social equality or equity have frequently brought destructive to catastrophic social and personal impacts.

We offer our policy prescriptions for KSI as a model for consideration by planners of future Space migrants and settlers; and we provide our rationale for believing that those who design governance systems can incorporate equality and equity in their policies for future Space settlements to enable those human environments to avoid repeating Earth's tragedies.

Kepler Space Institute (KSI) Equality and Equity Policy

- The Kepler Space Institute Equality and Equity Policy prescription for all its people is to behave toward others with respect and universal equality of opportunity, equity, and justice for all regardless of culture, race, color, religion, age, gender, sexual identification, or national origin.

- KSI personnel (i.e., board members, leadership, staff, faculty, scholars, and ambassadors) will pursue universal compliance with the principles, and components of human equality and equity.

- Violations will be reviewed by the Ethics Committee, which will recommend corrective actions to the KSI Board of Directors.

Equality and Equity Prescriptions for Future Space Human Immigrants and Settlers

A related broader and critically important purpose for this document is to provide a question for the continued evolution of humanity, namely:

> How can the emerging Space age be designed to avoid repetition of humanity's destructive history of inequality on Earth?

There is a related comment here. To date there have been five international Space treaties beginning in 1967. In 2020, NASA designed the Artemis Accords, which obtained the agreement of several countries. None of these agreements include prescriptions for equality or equity. We believe the reason for this omission is that science and technology have proven their ability to achieve visions for Space which, when created, seemed Utopian or science fiction. Achieving equality and equity is a human factors dilemma.

Our Kepler Space Institute hypothesis is:

> The planned Space Age human migrations can be designed and implemented to create societies with reverence for life within ethical and equitable civilizations; and that these designs can be models for Earth's adoption.

We fully understand the challenges and pitfalls that need to be solved for the above hypothesis to become reality. Equal opportunity across cultures, races, colors, genders,

religions, and national origins are societal goals we have never fully achieved on Earth. Policy for doing so should be an essential part of any planned future governance system. We also predict human settlement and even human evolution failures if this hypothesis is not achievable.

We provide our reasons for believing in 2021 that there is a possibility that our Space future hypothesis becoming a future reality, despite today's apparent zero probability. The emerging Space Age opens unprecedented new opportunities by utilizing the exploration, development, and human settlement of Space—beginning with our Solar System—to be the catalyst for a human society's paradigm shift, where there is no history of human conflict or pathological behavior.

Humanity's health and progress—even its long-term survival—is at stake. An important publication relevant to this subject—and a part of the reference material for this essay—is "Preventing Hell on Earth," by Professor Yehezkel Dror, the co-founder and leading scholar of the Policy Sciences.

Human history documents anger, violence, destruction, conflicts, revolutions, genocide, war, and human catastrophes beginning with the sons of Adam and Eve—Cain and Abel. Cain thought God preferred Abel, so he killed Abel. All the subsequent destructive events in history resulted from perceived inequalities and values conflicts. Values are principles and things preferred by individuals, groups, political movements, corporations, and religious doctrines. These value sets evolve to being foundational beliefs and ideologies that contain absolute, non-negotiable values. Humans have fought and died for their absolute values.

When individuals, groups, societies, nations, and international entities adopt actions and behavior that conflict with equality and equity, the seeds of social and political problems are planted and evolve into policies and programs that often ignore reverence for life. When other lives are not respected and revered, quality of life and progress are endangered, reversed, or destroyed. Hurtful actions on Earth have resulted from a combination of human needs and mental pathologies. World Wars I and II are only two of the worst examples. The 21st century has brought a combination of global biological epidemics, natural threats such as Earth's climate change, and social movements relating to racial and ethnic injustices are contributing to dismantling societies.

Values analysis is a useful methodology to identify and understand diverse human cognitions and pathologies. Science and multiple academic disciplines work to ameliorate or remove those pathologies, but successes are rare, illusory, or non-existent.

Human pathological nature and culture are difficult to change, but there are examples on Earth. We ponder the possibility that the necessities and difficulties of surviving beyond Earth might persuade people to put aside the less positive sides of their natures in a common quest for survival.

Reflections

Our US Declaration of Independence includes "All men are created equal." But the realization of that statement for all men and women remains unaccomplished for too many people on our planet. I was able to give the subject a voice. I wish I could have done more. During my career, I was able to obtain the signatures of top USAF and DOD agency leaders on equal employment opportunity (EEO) policy directives. On retiring and throughout the following years, I have reflected on the subject of too little progress on this subject of equality and equity for all. Human behavior is a much more complex subject, and more resistant to change, than are science, technology, and engineering. KSI's vision and mission includes research to work on this important human factors subject. ***Salena Gregory-Krone***

A major positive movement toward ameliorating the negative outcomes of human inequalities or inequities on Earth and in Space development's future, is Frank White's Overview Effect and Human Space Project. Beginning with the first publication of his book, *The Overview Effect: Space Exploration and Human Evolution*, in 1987 (now in its fourth edition), and continuing with his *The Cosma Hypothesis: Implications of the Overview Effect*, in 2019, Frank provides a philosophy for how humans can create a symbiotic relationship both with the universe and on Earth, drawing on extensive interviews with astronauts whose experiences in Space changed their cognition of Earth. ***Bob Krone***

We invite readers to participate in future Kepler Space Institute research and publications on this important subject.

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About the Authors:

Salena Gregory-Krone, the lead author, was one of American's Civil Rights Pioneers working with the US military. The US Air Force recognized her potential early and put her through extensive education and management training. She later completed her undergraduate courses at the University of Redlands in California to obtain her BA in Management (with distinction) in 1982. She designed one of the first plans that

implemented EEO as one major outcome of the US Civil Rights Legislation. Her professional career is recognized in the US Congressional Record. Salena is a Research Assistant for KSI. Her first presentation on this equality and equity subject was at the International Space Development Conference in Puerto Rico, 2016.

Bob Krone was the inaugural President of Kepler Space Institute (KSI) and was the inaugural Editor-in-Chief of the *Journal of Space Philosophy*.

Note to Readers from Bob Krone: Salena Gregory-Krone spent most of her professional career studying this equality issue and being a manager for USAF and the DOD Director of Equal Employment Opportunity. My role in this document was to provide some research assistance. Salena and I have happily shared professional and personal projects since our marriage on August 1, 2015.

This Memorial bronze statue of Albert Einstein at the National Academy of Sciences in Washington, DC has the Einstein quote: "As long as I have any choice in the matter, I shall live only in a country where civil liberty, tolerance, and equality of all citizens before the law prevail."

Editors' Notes: Selena Gregory-Krone, with experience in both the military and academic worlds, provides a provocative appeal for equity in the coming human migration to space, and makes specific recommendations for implementation at KSI. The alignment with KSI's stated reverence for all life is evident, as is a focus on establishing systems to ensure success over time. This article is also further evidence of the legacy co-author Bob Krone leaves in the wake of his passing. We are honored to be able to publish Selena and Bob's work in this special issue and at this time of great need in the world. ***Gordon Arthur and Mark Wagner.***

The Omnologist Manifesto

By Howard Bloom

Omnology is the aspiration to omniscience: an academic base for the promiscuously curious, a discipline that concentrates on seeing the patterns that emerge when one views all the sciences and the arts at once.

We are blessed with a richness of specializations but cursed with a paucity of panoptic disciplines—categories of knowledge that concentrate on seeing the pattern that emerges when one views all the sciences at once. Hence, we need a field dedicated to the panoramic, an academic base for the promiscuously curious, a discipline whose mandate is best summed up in a paraphrase of the poet Andrew Marvel:

Let us roll all our strength and all
Our knowledge up into one ball,
And tear our visions with rough strife
Thorough the iron gates of life.

Omnology is a science, but one dedicated to the biggest picture conceivable by the minds of its practitioners. Omnology will use every conceptual tool available—and some not yet invented but inventible—to leapfrog over disciplinary barriers, stitching together the patchwork quilt of science and all the rest that humans can yet know. If one omnologist can perceive the relationship between pop songs, ancient Egyptian graffiti, mysticism, neurobiology, and the origins of the cosmos, so be it. If another uses mathematics to probe traffic patterns, the behavior of insect colonies, and the manner in which galaxies cluster in swarms, wonderful. And if another uses introspection to uncover hidden passions and relate them to research in chemistry, anthropology, psychology, history, and the arts, she, too, has a treasured place on the wild frontiers of scientific truth—the terra incognita in the heartland of omnology.

Let me close with the words of yet another poet, William Blake, on the ultimate goal of omnology:

To see a World in a Grain of Sand
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your hand
And Eternity in an hour.

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Editors' Notes: We are glad to include this additional piece from Howard Bloom in this issue. Here he marries a vision of ambitious scientific pursuits with metaphysical poetry from the 17th and 18th centuries to inspire the reader. KSI and the JSP have a tradition of honoring the humanities right alongside the sciences, and Bloom's composition exemplifies this holistic humanist value system. ***Gordon Arthur and Mark Wagner.***

KSI Courses: January 2022

Courses

KSI is educating the next generation of leaders for humanity's rapidly approaching multi-planet future. Discover an active learning experience that extends beyond traditional boundaries, bridging scholars' academic studies and professional aspirations in the space economy. All Kepler scholars conduct original research to address the most important questions facing science and humanity, and their final papers can be submitted to the *Journal of Space Philosophy* for peer review and potential publication. The courses available in January 2022 are as follows:

COM 500: Commercializing Advanced Technologies	John Mankins
EDU 500: Foundations of Quality Education	Mark Wagner
GOV 501: Policy Development and Analysis	David Schrunk
HFS 500: Human Spaceflight and Performance	Frank White
PHI 501: Ethics, Values, and Society	Gordon Arthur

Admissions Requirements

Applicants must have the following:

- A Bachelor's degree from a college or university accredited by the appropriate regional association with a minimum grade point average of 2.5 on a 4.0 scale or equivalent work experience in professional academic and/or government or private industry positions and achievements. Each applicant's specific experience will be evaluated by the KSI Admissions Committee.
- A Graduate Record Examination (GRE) revised General Test score or a Miller's Analogy Test (MAT) score at or above the 50th percentile. The GRE or MAT requirement will be waived if an applicant has completed a Master's degree or twelve or more credits of post-baccalaureate upper division or graduate coursework with a minimum grade point average of 3.0 on a 4.0 scale.

- Completion of application
- Application fee
- Official transcripts from all previous universities or colleges attended or proof of work equivalent
- Three completed recommendation letters

For further details and to apply, see keplerspaceinstitute.com/education/.

Journal of Space Philosophy Board of Editors

Kepler Space Institute (KSI) is honored to have thirty-eight of the world's Space community professionals as members of the Board of Editors for the *Journal of Space Philosophy* (JSP).

Elliott Maynard, our JSP Board of Editors colleague, has beautifully stated both the purpose and the style for our peer reviews:

> This is such a hi-caliber group of leading-edge thinkers and supercharged individuals, it should be natural for each of us to wish to provide a supportive and synergistic environment for the others. I have also learned always to have someone else proof read any material I write, as I have discovered that the brain tends not to "see" my own simple mistakes. Ergo, within the new Kepler context I feel editors should be there to support our writers in the most creative and positive ways possible. (email to Bob Krone, March 23, 2013)

The purposes of peer reviews of article submissions to the JSP are (1) to determine the relevance to the Vision and Goals of KSI, (2) to help the author(s) to improve the article in substance and style or recommend references, and (3) to provide publication recommendations to the Editor-in-Chief.

****

1. 

ARTHUR, Gordon, PhD, JSP Editor-in-Chief, Theology at King's College, London, UK.

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2. 

AUTINO, Adriano, Founder, Space Renaissance International.

For Bio Info: www.spaceentrepreneurs.ning.com/profile/AdrianoAutino.

3. 

BELL, Sherry, PhD, KSI Dean, School of Psychology.

For Bio Info: www.nss.org/about/bios/bell_sherry/html.

4. 

BLOOM, Howard K., Author, Scientist, Founder Space Development Group, Publicist, Author on Human Evolution, Science, Technology, and Space. Photo by Luigi Novi.

For Bio Info: www.en.wikipedia.org/wiki/Howard_Bloom.

5. 

BOLTON, Jennifer, PhD, Co-Founder Virtual Space Orbiting Settlement VOSS. Veteran and molecular biologist, Space Pioneers Science Officer.

For Bio Info: Google Jennifer Bolton.

6. 

BURGESS, Lowry, Professor, Distinguished Fellow at the Studio for Creative Inquiry, Center for the Arts and Society, College of Fine Arts, Carnegie Mellon University.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 13.

7. 

CLEMENTS, Douglas H., MD, American Board of Ophthalmology, "Improving Human Vision for Space Exploration and Settlement".

Bio Info: Board Certified Ophthalmologist, USC Keck School of Medicine.

8. 

DOWNING, Lawrence G., DMin, Senior Pastor, Space Faith and Spirituality Pioneer, University Professor.

For Bio Info: See Issue 1, no. 1, Article 11.

9. 

FITZPATRICK, Susan Beaman, DBA, Vice Chairman, Oak Family Advisors, based in Chicago. International health expert specializing in health risk management. Susan's research interests include management capacity development and the implementation of complex innovations and programs.

10. 

HOPKINS, Mark, Chairman of the Executive Committee, National Space Society (NSS), Space Economics. Important in founding of the L-5 Society and collaboration of the NSS with the KSI.

For Bio Info: www.nss.org/about/hopkins.html.

11. 

IVEY, Janet, Nashville TV treasure and a friend of KSI. Her *Janet's Planet* show is the recipient of 12 regional Emmys and five Gracie Allen Awards. She is an Ambassador of Buzz Aldrin's *Share Science Foundation*. A Google search will take you to delightful images and video clips of her teaching and entertaining children about Space.

12. 

KHOVANOVA-RUBICONDO, Kseniya, PhD, University of Chicago, Expert in public economics, innovation, policy and urban planning. Consultant to the Council of Europe and European Commission, proficient in six languages, Space International Economics.

For Bio Info: www.connect.tcp.org/profiles/profile.php?profileid=2296.

13. 

KIM, Kee Young, PhD, Republic of Korea Senior University Academician and Administrator. Former President, Kwang Woon University; former Dean of the School of Business and Provost, Yonsei University; currently the Chairman of the Board of the prestigious Samil Foundation, the oldest Korean institution to award and provide scholarships to high-performing scientists, artist and engineers.

14. 

KIKER, Edward, General Engineer, GS-13, Office of the Chief Scientist, US Army Space and Missile Defense Command/Army Forces Strategic Command, KSI Chief Scientist.

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15. 

LIVINGSTON, David, PhD, Founder and host, *The Space Show*.

For Bio Info: www.thespaceshow.com.

16. 

MARZWELL, Neville, PhD, Space Solar Power and Robotics Scientist. Career at JPL as Manager for Advanced Concepts and Technology.

For Bio Info: www.spaceinvestment.com/lcr2_bios.html.

17. 

MATULA, Thomas L., PhD, Business and Management Professor, Lunar Commercial scholar.

For Bio Info: www.trident.edu/dr-thomas-matula.

18. 

MAYNARD, Elliott, PhD, Founder, ArcoCielos Research Center, Sedona Arizona, www.arcocielos.com.

For Bio Info: www.fasiwalkers.com/featured/ElliottMaynard.html.

19. 

MOOK, William, PE, Trained in aerospace engineering, 15 years in alternative energy, Space Commerce Technology.

For Bio Info: www.vimeo.com/user1527401.

20. 

OLSON, Thomas H., PhD, DBA, Professor of Clinical Management and Organization, USC Marshall School of Business, Los Angeles. Dr. Olson's specialty in research and consulting is on strategy, development, organization, and human capital. He has authored four books and 100 professional articles.

For Bio Info: www.marshall.usc.edu/faculty/directory/tholson.

21. 

PALMA, Bernardino, Historian, Portuguese Age of Discovery.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 8.

22. 

PEART, Kim, Co-Founder, Virtual Orbiting Space Settlement (VOSS). Artist, visionary, virtual worlds.

For Bio Info: www.independentaustralia.net/about/ia-contributors/kim-peart-bio/.

23. 

ROBINSON, George S., III, LLD, Space law pioneer and international space expert. Smithsonian Institute Legal Counsel.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 14.

24. 

SCHORER, Lonnie Jones, *Kids to Space* author and teacher. Architect, aviator.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 17.

25. 

SCHMEIKAL, Bernd, PhD, Retired freelancer in research and development, qualified in Sociology. He is a real maverick, still believing that social life can be based on openness and honesty. Member of the Trace Analysis Group of the UA1 Experiment at CERN. Institute for High Energy Physics (HEPhy) at the Austrian Academy of Science.

For Bio Info: See Issue 9, no. 1 (Spring 2020), Letters to the Editor.

26. 

SCHRUNK, David, MD, Aerospace engineer, Founder, Quality Laws Institute, KSI Faculty.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 18.

27. 

SCHWAB, Martin, PhD, International Space author, KSI Faculty, Aerospace Technology Working Group.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 21.

28. 

SCOTT, Winston E., American Astronaut, Vice President for Development, Florida Institute of Technology.

For Bio Info: www.en.wikipedia.org/wiki/Winston_E.Scott.

29. 

STEPHANOU, Stephen E., PhD, Emeritus Professor of Systems Technology, USC, Los Angeles.

For Bio Info: See Issue 2, no. 2 (Fall 2013), Article 26.

30. 

TANG, Terry, PhD, Kepler Space Institute Director of Research.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 24.

31. 

THORBURN, Stephanie Lynne, Author, Astrosociology.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 12.

32. 

WERBOS, Paul, PhD, US National Science Foundation, Space scholar.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 19.

33. 

WAGNER, Mark, PhD, JSP Associate Editor, co-founder of ARES Learning, educational technologist.

For Bio Info: See Issue 10, no. 1 (Fall 2020), Article 14.

34. 

WHITE, Frank, MSc, Founder, The Overview Effect Institute.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 9.

35. 

WILKINS, John, PhD, Professor of Space Settlements.

36. 

WOLFE, Steven, Space advocate and author of the 2013 Space novel, *The Obligation*.

For Bio Info: See Issue 2 no. 2 (Fall 2013), Article 26.

37. 

YACOUB, Ignatius, PhD, Founder and first Dean of the School of Business and Management, La Sierra University, Riverside, CA. Currently Professor of Graduate Studies, Loma Linda University School of Social Work and Social Ecology, Loma Linda, CA.

38.

ZUBRIN, Robert, PhD, President, Mars Society.

For Bio Info: www.en.wikipedia.org/wiki/Robert_Zubrin.

In Memoriam

BEN-JACOB, Eshel, PhD, Former President of Israel Physical Society; Founder Science of Bacterial Intelligence. Tel Aviv University. We grieve the passing of Eshel Ben-Jacob in 2015.

For Bio Info: Google Eshel Ben-Jacob.

HAYUT-MAN, Yitzhaq (Isaac), PhD, Architect for the Universe, The Jerusalem Dome of the Rock as a memory site for theology, philosophy, and humanity past, present, and future. We grieve the passing of Yitzhaq Ḥayut-man in 2021.

For Bio Info: Google Yitzhaq Hayut-man.

ISAACSON, Joel D., PhD, "Nature's Cosmic Intelligence," pioneer of RD Cellular Automata since the 1960s. We grieve Joel Isaacson's passing in 2021.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 7.

KRONE, Bob, PhD, Founding JSP Editor-in-Chief, Founding President, KSI. We grieve Bob Krone's passing in 2021.

For Bio Info: www.bobkrone.com/node/103.

MITCHELL, Edgar Dean, ScD, Captain, US Navy (Ret.), Apollo 14 Astronaut, sixth person to walk on the Moon, Founder Institute of Noetic Sciences. We grieve Edgar Mitchell's passing in 2016.

For Bio Info: Google Edgar Mitchell.

O'DONNELL, Declan J., JD, Space law attorney, Fifty publications in Space Law and Policy, Publisher, Space Governance Journal, President, United Societies in Space, Inc. We grieve Declan O'Donnell's passing in 2015.

"The greatest use of a life is to spend it for something positive that outlasts it." Dr. Max T. Krone, Dean, Institute of the Arts, University of Southern California and Founder, Idyllwild School of Music and the Arts, 1950.