THE PLANETARY EXPERIMENT:

On Artificial Intelligence, Habitat, and the Future of Life

It has been over a decade since the pathbreaking book *The Shock Doctrine* was published. A supposed "letter' or message from the "frontlines" of neo-liberalism, Naomi Klein's tour de force provided a new vocabulary, and more important a new tactical map, a topographical representation, an image if we will, as to how contemporary forms of capitalism operate. Labelled "disaster capitalism," Klein took thirty some odd years of history and discovered a pattern in the data. One that made the actions of psychiatrists electrically shocking and torturing patients in the 1950's similar to the torture and massacre of political dissidents and the violent reorganization of economy in the name of structural re-adjustment happening throughout the 1970's globally.[1]

Today, the doctrine of shock has never appeared more pertinent, particularly in the midst of the COVID-19 global pandemic. In our current moment, market volatility, planetary scale disease tracking, and human suffering appear to be "naturally" connected. Saving the stock market has been more important than saving human lives.

[1] Naomi Klein, *The Shock Doctrine: The Rise of Disaster Capitalism* (New York: Picador, 2007).

While there have been pandemics in the past, never has the threat of disease and species wide danger been so *synchronically* shared through media. It is computational and digital technologies that mark this event. We track curves, analytics, numbers, and assume that big data will manage the coming plague. Automated platforms and social networks deliver our goods, mediate our work and friendships, trade stocks, and maintain what might have once been labelled the "social". Artificial intelligence and machine learning are also being deployed (or at least imagined) to predict future disease curves, and to rapidly discover, test, and simulate the molecular structures and compounds that might serve as treatments or vaccinations. This turn to computation as salvation is unique, I argue, to our present. Since so little of it is actualized, it says much about our future imaginaries of life on this, and perhaps soon to be, other planets. This machine dream signifies a new phase in both betting and experimenting with possible futures through computational techniques.

Our current situation thus begs the question of what has or has not changed over the last 50 years, since the era of the 1970's that marked the emergence of disaster capitalism. Above all, Klein's argument focuses on how natural and political disasters are made commensurable through the logic of experiment. For torturers the experiment

was in the transformation of the psyche and its reprogramming, for the Chicago Boys entire economies were test-beds for economic theories that would become realities.

I want, therefore, to return to the site originally mapped as the first "experiment" in shock and economy—Chile—and the Atacama Desert in particular. I return now asking a new set of questions about how technology and life are currently governed, and more importantly how we are e*xperimenting* with the future of life through new forms of computational design and infrastructures. I label this next version, perhaps extension, or test, of the shock doctrine, the *"smartness mandate"*[2]. Its marker is *the hope* for the penetration of computation and automation into every segment of human life and perhaps other lives in the interest of managing uncertain and unrepresentable futures,

In the course of this piece, I will survey a series of sites traversing scientific inquiry, energy, and extraction, and calculative techniques. In contemplating our present, I will link the ALMA installation, an astronomical observatory that was part of the event horizon telescope with the lithium beds in the Salar de Atacama and the Center for Mathematical Modelling at the University of Chile, Santiago. This landscape will

[2] The Smartness Mandate is a term developed with my colleague Robert Mitchell at Duke University and is the title of our current joint book project.

bridge data and matter; these sites are the producers of some of the largest non-proprietary data sets on earth and provide many of the very materials that create the information age. In this essay I will argue that collectively these sites form the landscape of a *planetary testbed*–a petri dish cultivating potential futures of life, politics, and technology on both Earth and beyond. Following the lead of architectural theorist Alessandra Ponte, I understand this desert as a unique landscape that permits inquiry and mapping of the broader cultural logic of experimentation and testing that shapes technical futures across the planet.[3] These sites produce a plateau, in a Deleuzian manner, that assembles histories of science, technology, and extraction to reformulate futures. This desert is a landscape that confuses figure ground relations, reworking conceptions of observation, measurement, and experiment, and linking extremely local conditions with exo-planetary concerns; although never homogenously or seamlessly. We are entering an ecology that is fundamentally about new forms of calculation at scale to manage, or short, futures.

[3] Alessandra Ponte, *The House of Light and Entropy*, Architecture Words Ii (The Netherlands: Architectural Association, 2014).pp. 93-134.

EVENT HORIZONS

"a point of no return"[4]

"a boundary beyond which events cannot affect an observer on the opposite side of it..."[5]

Image 1: Event Horizon

On April 10, 2019 this first image of a black hole appeared to humanity. To produce this miracle demanded that scientists and engineers from a team spanning the globe turn the Earth itself into a vast sensor to gather data from black holes. The Event Horizon Telescope (E.H.T). Only a dish the size of this planet could create a sensor sensitive enough to collect weak electro-magnetic signals from 50 million plus light years away in order to provide at long last empirical evidence supporting Einstein's general theory of relativity.

When the image was released it circulated at literally the speeds of light across that most human and social of networks—the Internet. Comments online ranged from amazement to vast frustration that the black hole did indeed look just like we thought it

[4] Oxford English Dictionary, "Event Horizon (N)," (Oxford: Oxford University Press, 2019).
[5] Wikipedia, "Event Horizon," Wikipedia, ttps://en.wikipedia.org/wiki/Event_horizon.

might. "Awesome," "amazing," "mystical," "capable of making humans fall in love" jockeyed with "anticlimactic," "really?", and "it looks like the Eye of Sauron from Lord of the Rings." Maybe, such commentators suggest, the culmination of having turned our whole planet into a technology is just a fake artifact of computer graphics algorithms; merely another stereotypical image recalling longstanding standard Western cultural tropes of radically alien and powerful forces?[6] In combining both mythic aesthetic conceptions of outer-space and the power of the gods with the dream of objectivity and perfect vision through technology, the image conjures a dual temporality. The event-image crystallizing both new imaginaries of a planetary (and even post-planetary) scale future integrated through data and machine sensing and mobilized our oldest and most repeated conventions of what extreme non-human alterity might appear like, returning us to the legacies of myth and g-ds.

Whatever the "truth" of this image, I argue that this image provides evidence of a radical reformulation of perception. This image presents *both* the figure of the terminal limits of human perception while simultaneously embodying a new form of experience comprised not of any one human or even technical installation but through the literal

[6] Dennis Overbye, "Darkness Visible Finally," *The New York Times*, April 10 2019.

networking of the entire planet into a sensor-perception instrument and experiment. This image is an allegory therefore of the very artificial intelligence and machine learning systems that underpin it. It simultaneously embodying a classic problem in both physics and computation—mainly, the impossibility of objectivity and the limits of being able to calculate or access infinity.

OBJECTIVITY

These problems have a history in science. As many scholars have demonstrated, the concept of mechanical objectivity first emerged in the 19th century with photography and film, and was linked to recognizing the fallibility of the human body, the impossibility of *human* objectivity, that simultaneously birthed a new desire for perfect, perhaps divine like objectivity, inherited from renaissance perspectivalism. This G-d like objectivity would now arrive not through the celebration of the human but through prosthesis and mechanical reproduction.[7] The latest forms of big data analytics– what I

[7] For an extensive discussion on the history of objectivity, and on the relationship between objectivity, perception, and technology see: Lorraine Daston and Peter Galison, "Image of Objectivity," Representations 40, no. Fall (1992); Jonathan Crary, Techniques of the Observer :

have termed in my past work as *communicative objectivity*—push this history to a new scale and intensity, transforming the management of time and life.[8] The event horizon abandons a return to the liberal subject and offers a new model, not of objectivity as certainty, but as the management of uncertainty, the production in fact of new zones by which to increase the penetration of computation and expand the frontiers of both science and capital. In the case of the event horizon the frontier is to reconcile and integrate two radically different forms of math and theory—general relativity and quantum mechanics. This is a scalar question—gravity is not understood similarly at the large scale in the same way that it acts at a sub-atomic or nano-scale. The hope is that these experiments will allow a unification of these two scales. In doing so, event horizon experiments are logistical in their logic, attempting to unify and syncopate the extremely local and specific with the very large and generic.

At stake are questions of chance and what constitutes evidence and objectivity for science. Black holes were predicted, but even Einstein did not believe his own prediction, because he refused to accept so radical a mutation of time and space.

On Vision and Modernity in the Nineteenth Century (Cambridge, Mass.: Cambridge, Mass. : MIT Press, 1990).

[8] Orit Halpern, Beautiful Data: A History of Vision and Reason since 1945, ed. Joseph Dumit, Experimental Futures (Durham: Duke University Press, 2015).p. 1.

Einstein, it appears, still wanted to know the truth. The idea of a space beyond which his own laws no longer applied was unthinkable. The event horizon, however, is not the realm of surety, but rather that of probabilities and uncertainties. Physicists can define or speculate on certain state spaces but can never know the exact movement of any one particle or element. Furthermore, it is the territory of histories. Black holes may contain keys, "a backward film", according to physicist and historian of science Peter Galison, of the Universe's entire history. Time can reverse in the black hole, and the faint glimpse of the vast energies that cluster around the event horizon suggest possible past trajectories, but never just one.[9]

In response to this situation of imperfect visualizations and radical scalar and temporal indetermination, the call now is to increase computational power, and to add more dishes, perhaps in space, in order to increase the resolution of this massive instrument. This is the logic of *communicative objectivity*; the turn to automation and big data as modes of managing extreme uncertainty. The limits of knowledge are an imperative for technical progress.[10] Furthermore, the very apparatus of the E.H.T

[9] Dennis Overbye, "Infinite Visions Were Hiding in the First Black Hole Image's Rings," *The New York Times* 2020
[10] Ibid.

demonstrates the new integration between the scales of the earth and those of the stars to produce new economies and forms of knowledge. As I will show, both problems—those of the limits of human objectivity and the emergence of new forms of experience, analytics, and sensing—are deeply intertwined in how we are currently governing and managing life on earth through computation.

Image 2: High Altitude Sub millimeter wave array

SUBLIMITY

One of the key installations in this project was the Atacama Large Millimeter/Submillimeter Array (ALMA)installation. On March 13, 2017, I visited this installation. Located on the Chajnantor Plateau in the Atacama Desert in Chile, the radio telescopes are 5050 meters up high in one of the driest and most extreme environments on earth. [11]

[11] The installation is run by a consortium headed by the European Southern Observatory, a number of universities in the United States, and a series of Japanese institutions. Chile granted concessions to the European Southern Observatory in 1963 across the Atacama for observatories, and in 1990 ALMA was officially bequeathed to the international consortium that runs it as an

The entire installation appears to be designed to provoke a radical awe of scale, of human insignificance, and of the possibility of technical mastery of, and perhaps through, the vast vistas of the desert, and beyond that the stars. The vehicles that tow these machines are massive, specifically built by space agencies for their function. But even these machines, each tailor made with tires two stories tall, seem almost tiny when viewed in comparison to the rest of the plateau.

Image 3: Towing Vehicles

In my mind, the high-altitude array reflected and advanced every fantasy of extraplanetary exploration I read as a child in science fiction fantasy books and watched on NASA sponsored public programming on TV. This analogy is not just fiction. NASA and other space agencies use this desert to test equipment, train astronauts, and study

extra-territorial jurisdiction, often outside of local police jurisdiction. ALMA is also part of the history of scientific infrastructures with political implications. Located in the Global South, historically the ESO was founded to aid in bringing the European Union into being through scientific cooperation in the post-World War II years. ALMA is thus the producer of new forms of territory serving also as an allegory for the post-planetary imaginaries which its science envisions. European Southern Observatory, "Eso & Chile — a Scientific and Cultural Bridge," https://www.eso.org/public/about-eso/eso-and-chile/.

the possible astrobiology of the future planets we will colonize.[12] If the event horizon is the point of no-return, the Atacama is the landscape of that horizon, the infrastructure for our imaginaries of abandoning Earth and never ever returning to the past. But again, this is an irony, for ALMA collects history. Every signal processed here is aeons old, millions if not billions of light years in time-space.

This technical infrastructure combined with an environment among the most arid on earth produces strange aesthetic effects in a viewer. Such infinitude brought to us by the gift of our machines might be labelled "sublime." What incites such emotions at one moment in history, however, may not in another. The sublime is a series of emotional configurations that come into being through historically different social and technological assemblages. My sentiments of extreme awe and desire for these infrastructures, a sense of vertigo and loss of figure ground relations, a descent into the landscape, recalls the work of historian David Nye on the 'technological sublime'. For North Americans, according to Nye, the later 19th century offered a new industrial landscape that incited extreme awe and concepts of beauty through structures like

[12] NASA, "Cooking up the World's Driest Desert - Atacama Rover Astrobiology Drilling Studies," no. June 20, 2018 (2018), https://www.nasa.gov/image-feature/ames/cooking-up-the-world-s-driest-desert-atacama-rover-astrobiology-drilling-studies

extension bridges. Structures such as the Brooklyn Bridge were deliberately built over the longest part of the river to prove the technical competence of its builders. Other constructions—skyscrapers, dams, canals, and so forth—were all part of this new "nature" that came into being at the time. Sites that produced a vertigo between figure and ground and reorganized social comprehensions of what constituted "nature" and "culture," or objects and subjects. The sublime after all is loss of self into the landscape.[13]

Post-World War II environments saw a subtle shift in this aesthetic condition; becoming increasingly mediated through television and other communication devices making technical mediation a site of desire and aesthetic production. ALMA takes the informational situation to a new extreme. Here technology produces a new landscape that turns infrastructure into a site of sublimity, confusing the boundaries of the technical and "natural," and refocusing our perception towards a post-planetary aesthetic that is both about transforming scale (the earth is small) and time. The discourse surrounding ALMA suggests that all planets, including ours, and all their

[13] David Nye, *American Technological Sublime* (Cambridge, MA. : MIT Press, 1994); Halpern, *Beautiful Data: A History of Vision and Reason since 1945*.

component landscapes are recording instruments surveying temporalities far outside of and beyond human experience.[14]

MACHINE VISION

To process the most ancient of signals demands the latest in machine learning methods and other analytic techniques. These data sets are utilized in partnership by Microsoft and other similar organizations as training sets for their complexity and difficulty to clean noise from signals, and as environments providing sites for testing algorithms and experimenting with both new approaches to supervised and especially unsupervised learning.[15] The image was produced through a massive integrated effort, analogous to the scientific images produced by other remote sensing devices such as the Mars rovers in Janet Vertesi's account of machine vision at NASA. These rovers are coordinated, and their data synthesized and analyzed into signification thorough a large

[14] *Beautiful Data: A History of Vision and Reason since 1945*.
[15] Yanxia Zhang and Yongheng Zhao, "Astronomy in the Big Data Era," *Data Science Journal* 14, no. 11 (2015).

process that is not the work of individuals but rather groups. [16] The same can be said for the E.H.T.

To produce the event horizon image scientists used interferometry, a process that correlates radio waves seen by many telescopes into a singular description. The trick is to find repeat patterns that can be correlated between sites of the E.H.T and to remove the massive amounts of "noise" in the data, in order to produce this singular "image" of what the NSF labelled the "invisible." Since black holes are very small in the scale of space, and a large amount of other data from different phenomena in space enter the dishes as well, only machines have the capacity to analyze the quantity of signals and attempt to remove the supplementary data. Signals are picked up from an array of observatories around the world, those that match what the theory of relativity predicted would be an event horizon must be correlated. To find these signals demands the data be "cleaned." This is a critical component of finding the signals that are going to be correlated.

This process happened in many different sites. I visited the data cleaners for ALMA at the European Space Observatory base in Santiago, where we discussed the

[16] Janet Vertesi, *Seeing Like a Rover: How Robots, Teams and Images Craft Knowledge of Mars* (Chicago: University of Chicago Press, 2015).

process. Many of the teams worked with different machine learning approaches to use unsupervised learning methods to identify artifacts in the data and remove them. The process being quite difficult since no one had ever "seen" an event horizon or knew exactly what was being sought out information-wise.[17] Having never seen a black hole, and never being able to, what should we look for? Our machines are helping us decide.

Humanity however insists on its liberal agency. Irrespective of infrastructural capacities, the final image was attributed to a young woman, Katie Bouman, a post-doctoral researcher at the Harvard-Smithsonian Center for Astrophysics. Bouman apparently created the algorithm that allowed the vast amounts of data coming from the E.H.T's many installations to be compared and synthesized into a singular image. In fact, Bouman herself, was not an astronomer or astrophysicist, but rather a computer scientist working on machine vision as a more generic problem.[18]

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[17] Interviews conducted at ALMA on my visit on March 13, 2019 and at the ESO Data Center in Santiago on March 20, 2017 revealed that many of the staff had been working on satellites and related information and communication problems before applying their research to the study of the stars. ALMA has pioneered work on exo-planets and finding asteroids and other potentially mineable objects on earth. Interviews with Yoshiharu Asaki, Associate Professor National Astronomical Observatory of Japan(at ALMA) and Chin-Shin Chang, Science Archive Content Manager (ESO Data Center, Santiago).

[18] Maria Temming, "How Scientists Took the First Pucture of a Black Hole," *Science News*, April 10, 2019 2019; Vertesi, *Seeing Like a Rover: How Robots, Teams and Images Craft Knowledge of Mars*; Lisa Grossman and Emily Conover, "The First Picture of a Black Hole Opens a New Era of Astrophysics," *Science News*, April 10, 2019.

This attribution gestures to our own human temporal problems with the new media networks within which we are caught. It is not that the algorithm was not important, but that obviously a great deal of work by many people went into setting up the data gathering experiment and developing methods to "clean" data. Bouman emerged as a progressive image that might translate the incoherence of a massive system into the identity politics of human history. The new discourse suggesting we ourselves, like Einstein, were not yet comfortable with the horizon to our own control and command over our networks. This tension between radical uncertainty and inhuman cognition, and our need to produce temporal command over data is one of the key features driving the growth of AI and its seemingly correlated discourses of mastery over futurity.

At ALMA objectivity is indeed an impossibility. To process this data figure ground relations were literally confused. The official tour guide tells me that these telescopes contain units at the base that are the temperature of deep space in order to isolate and process signals from space and separate them from "noise" from the earthly atmosphere. By returning the signal into its "original" temperature the appropriate wavelengths of the signals can be isolated. In this installation data is literally being

contextualized in an environment being built within the experimental set-up. The furthest outside to Earth being recreated within the machines. But perhaps this is the lesson of all scientific experiments… we create environments that are always already artificial and make nature from them.[19] Like the experiments of behavioral scientists and cyberneticians that produced new worlds in the name of depicting the planet, the ALMA telescopes recreate outer space within to produce visibility for the invisible, to reassemble aeons of galactic time in the space of scientific practice. And if we take the event horizon as the allegory for our present where we have turned the earth into and medium for information gathering and analysis then this is even more true. The sites of data production, data gathering, and analysis are increasingly blurry in their boundaries. The planet has become a medium for recording inscriptions.[20]

[19] Trevor Pinch David Gooding, and Simon Schaffer, ed. The Uses of Experiment: Studies in the Natural Sciences (New York: Cambridge University Press, 1989).
[20] See also Jennifer Gabrys work on the idea of the planet as programmable through sensor infrastructures. Jennifer Gabrys, Program Earth: Environmental Sensing Technology and the Making of a Computational Planet (Minneapolis: University of Minnesota Press, 2016).

ENERGY

The earth as medium is a truism in the Atacama that takes many forms. "Chile is copper" is an oft repeated mantra in this place I am told by Katie Detwiler, an anthropologist working on the Atacama and my guide to this place. And copper—the conductor of all our electricity—is in almost every machine. The Atacama has some of the largest copper mines on Earth. Copper is an industrial material, it also rests (although perhaps only for now) on an industrial economy. Copper markets are still relatively unleveraged—unlike some other energy, mineral, and metal markets, there is little futures or derivative action. As a commodity it suffers from modern economic concepts of business cycles, and its political economy is seemingly still grounded in terms like GDP and GNP along with concepts stretching from Thomas Malthus and Adam Smith in the 18th century of resource limitation, scarcity, demand, price, and above all population and nation. While the markets have changed, and copper like all commodities has futures, ETF's, derivatives, and other similar computational and algorithmic financial technologies involved, it is still largely correlated with supply and demand and seen as a direct conduit to assessing global economic health, not in terms of finance, but in terms of industrial production and housing construction due to its use in most construction

projects and "white goods".[21] In Chile, copper is equated above all with nationalism. Under Pinochet these mines were unionized (contrary to what we might expect), and the state corporation CODELCO continues to do all the smelting. This rather surprising history for a dictator whose name is synonymous with Milton Friedman and the Chicago Boys emerged from an alignment with right wing nationalists, authoritarianism, and neo-liberalism.[22]

But a few miles from ALMA is another landscape of extraction, metal, and energy. This one is linked to the stars and future(s). Space X, Tesla, and the high-tech industries that in theory will eventually replace the vestiges of our old heavy industrial and carbon-based economies all bank on the Atacama. For in this desert also lies the new gold. It is the future Saudi Arabia, I am told by business journals and newspapers: the Salar de Atacama .[23] These salt flats bear lithium. This is the lightest of metals and the supposed future of both machines and energy. The medium that will replace the carbon futures that financial markets and nations have so heavily bought into and leveraged.

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[21] Neil Hume, "Copper Price Reflects Grim Assessment of Global Economy: Red Metal Has Fallen in Price after Poor Manufacturing Data," *Financial Times*, October 4, 2019 2019.
[22] Naomi Klein, "Milton Friedman Did Not Save Chile," *The Guardian*, no. March 3 (2010), https://www.theguardian.com/commentisfree/cifamerica/2010/mar/03/chile-earthquake.
[23]Brendan I Kroener, "The Saudi Arabia of Lithium," *Forbes*, no. November 6, 2008 (2008).

Image 4: SQM Lithium Beds

The beds are beautiful, they are created by brine, just bought to the surface. Lithium is never pure, it is mixed with other things, also all valuable—magnesium, potassium. As one looks over the fields, there is an array of colors going from yellow to the very bright blue. The first fields are still full of potassium that might serve as bedrocks for fertilizers, as the beds dry longer they turn bluer and then yellower, finally after almost a year they dry and lithium salt, LiCl emerges.[24] The salt is scraped from the bed, harvested, separated from trace boron and magnesium, and affixed with Sodium Carbonate for sale. Alejandro Bucher, the technical manager of the installation, takes us on a tour.[25] SQM, he tells us, is environmentally excellent, almost no chemicals are used in the process. The extraction of Lithium is solar powered. The sun dehydrates the water and draws off the salts. A pure process. Except it drains water. He assures us, however, that the latest expansions and technical advances will "optimize" this problem. Better

[24] An overview of the production process can be accessed here:
Terence Bell, "An Overview of Commercial Lithium Production," Dotdash, https://www.thebalance.com/lithium-production-2340123.
[25] Alejandro Bucher, Technical Manager SQM, March 23, 2017.

water evaporation capture systems and planned desalinization plants will reduce the impact on this desert, which is the driest on earth, and on these brine waters that are also the springs for supporting fragile ecosystems of shrimps, bacteria, and flamingos. Environmentalists, however, beg to differ; inquiries have gone into the environmental impact of the fields, and the general process of assessment has been critiqued as opaque.[26]

What Pinochet never did, privatize mining, is now fully private with lithium. While Sociedad Química y Minera SQM is Chilean, it is private. SQM has been attacked for anti-trade union practices, and unions are fighting to label lithium a matter of national security so the state can better regulate the material.[27] This corporation also partakes in planetary games of logistics around belt roads and resources. In 2018, the Chinese corporation Tianqi acquired a 24% share of SQM, essentially coming to dominate the corporation. While the government continues to monitor the situation and demand limits of Chinese participation on the board of the corporation, the situation

[26] Michelle Carrere, ""Chile Renews Contract with Lithium Company Criticized for Damaging Wetland"," *Mongabay: News and Inspiration from Nature's Frontline*, December 26 2018.
[27]" Industrial Chile Sponsors Bill to Declare Lithium a Strategic National Resource," *Industriall: global union* 2016. http://www.industriall-union.org/industral-chile-sponsors-bill-to-declare-lithium-a-strategic-national-resource Accessed March 23, 2020.

continues to fluctuate.[28] These games also demand even privatized water supplies. Water is a massive commodity. Some of the largest desalinization plants on earth will be built here a range of vendors servicing largely the mining sectors. These installations are built to fuel the mining in the region. Desalinization is yet another extractive technology that facilitates the transformation of seemingly finite boundaries and resources (of water in this case) into flexible eternally expandable frontiers through processes of removing salt from seawater through advanced technologies. This new infrastructure of corporate actors merging high tech with salt and water in order to support our fantasies of eternal growth, so that we may drive clean cars, and eventually arrive to the stars in order to extract ever more materials...[29]

These salts however are also the fragile infrastructures for unique ecosystems. It is in the service of imagining a future on other planets that drives another group of scientists—astrobiologists—to study the bacteria in these brines. These bacteria have evolved differently, in a manner seen almost nowhere else on earth, the extreme salts of

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[28] Lorena Gúzman, "The Fight for the Control of Chile's Lithium Business," *Diálogo Chino: https://dialogochino.net/15614-the-fight-for-control-of-chiles-lithium-business/* December 7, 2018. Accessed March 10, 2020.

[29]Paul Harris, "Chile Seawater Desalination to Grow 156%," *Mining Journal* (2020), https://www.mining-journal.com/copper-news/news/1379729/chile-seawater-desalination-to-grow-156.

the condition might offer clues, these scientists tell us, of life on Mars. These cellular creatures hold the key to survival in space, and to the liveliness that might exist on other planets. We cannot expect to be alone in the universe, and these bacteria allow us to envision in their novel metabolisms and capacity to live under PH conditions lethal to most other organisms, another way to live. These beds, the astrobiologists argue, cannot be taken away to make batteries. They harbor our key to space, the way to terraform.[30] What are we to do? In such cases where the future to be driven by these batteries disappear as we make them?

[30] NASA, "Salt Flats, Mountains, and Moisture," NASA, https://earthobservatory.nasa.gov/images/144826/salt-flats-mountains-and-moisture.
Graciela de Diego-Castilla Victor Parro, Mercedes Moreno-Paz, Yolanda Blanco, Patricia Cruz-Gil, José A. Rodríguez-Manfredi,2 David Fernández-Remolar, Felipe Gómez, Manuel J. Gómez,Luis A. Rivas, Cecilia Demergasso, Alex Echeverría,Viviana N. Urtuvia,Marta Ruiz-Bermejo, Miriam García-Villadangos, Marina Postigo,Mónica Sánchez-Román, Guillermo Chong-Díaz,Javier Gómez-Elvira, "A Microbial Oasis in the Hypersaline Atacama Subsurface Discovered by a Life Detector Chip: Implications for the Search for Life on Mars," *Astrobiology* December no. 10 (2011).
Rebecca Boyle, "The Search for Alien Life Begins in Earth's Oldest Desert," *The Atlantic*, no. November 28 (2018), https://www.theatlantic.com/science/archive/2018/11/searching-life-martian-landscape/576628/.

Optimization

The lithium mines, more than anything, suggest new attitudes or maybe practices of boundary making and market making. They demonstrate a move away from the perfect stabilities of supply and demand curves to the plasticity of another order of algorithmic finance and logistical management grounded in the computations of derivative pricing equations and debt capitalism.[31] The relationship between these very different and radically shifting territories of mining, salt harvesting, and astronomy can therefore only be realized in the turn to mathematics.

Image 5: The Logo for the Centre for Mathematical Modeling

[31] For work on debt and financialization as well as the place of ideas of information, computation, and algorithms in the production of these markets see: Philip Mirowski, Machine Dreams : Economics Becomes a Cyborg Science (New York: New York : Cambridge University Press, 2002). David Harvey, Limits to Capital (New York: Verso, 2007); Edward Lipuma Benjamin Lee, Financial Derivatives and the Globalization of Risk (Durham: Duke University Press, 2004). For an excellent summary of capital and extraction in Chile, including discussion of the way new information technologies and financial strategies are allowing a new "margin" of extraction and extension of mining capacities see: Martîn Arboleda, Planetary Mine: Territories of Extraction under Late Capitalism (New York: Verso, 2020).

The incommensurabilities in scale and materials between the operations of mines and the seeming metaphysically interests of astronomical sciences is unified at the Centre for Mathematical Modeling in the University of Chile, located in Santiago some 1600 kilometers south. It is one of the world's premier mathematics research centers for applied mathematics in mining. A few days after my time at Alma, I visited the center.

In the lecture room where we were bought to hear the presentations, several researchers presented to us on themes of how machine learning, big data, and complex modelling might transform mining. One of the lead scientists in mathematical modelling at the center, Alejandro Hofre, is trained in optimization and game theory. He explains that the center's mission is to bring the best in mathematical modelling to bear on questions of mine optimization, discovery, and supply chain management. Cheapening and improving exploration is critical, as it is the most expensive and difficult and expensive part of the extraction industry process, often bearing no return. This search for ways to do more with less is necessary as all the materials on earth, are, without question, running out. But this finitude in resources can be addressed through an infinity of data.

Image 6: Mathematics Model/Display

This new optimization economy is also aligned as Dr. Eduardo Vera, the executive manager of innovation and development at the CMM and in the National Laboratory for High Performance Computing, argued, with rethinking mining unions and labor. The hierarchies of mines must go, managed instead by regular feedback loops derived from billions of sensors and automated systems that sense and decide the best actions; the best manner to ventilate, heat, cool, dig, chemically separate, mix, dispose, and scavenge through material. The space of mining opened to the space of mathematics and abstraction; making Terran limits plastic, scavengable, optimizable, and ultimately grounded in the math of physics and astronomy. These communication systems, complex geological models, fluid and energy dynamics, and communication systems might also find themselves at use in other places. Over lunch, he tells me that entire computational infrastructures are being built at this moment. Large investments are being made by both corporate and government sources for the purposes of developing the computer power to be able to run advanced mathematical models and crunch vast data sets for the dual purposes of both modelling terrain geologies and extra-terrestrial phenomena. Ultimately, the math being generated through abstract models and astronomy may also discover new methods and predictive analytics for use in in asteroid and other mining.

Goldman Sachs released a report almost synchronously with my visit arguing for the future of asteroid mining, on April 6th, 2017. The Sachs report was "bullish" on asteroid mining. "While the psychological barrier," the report noted, "to mining asteroids is high, the actual financial and technological barriers are far lower." Spacecraft and space travel are getting cheaper, and asteroids could be grabbed and hauled into low earth orbit for mining. According to Caltech, the report cited, that building asteroid grabbing spacecraft would cost the same as setting up a mine on earth. Goldman Sachs definitively urges speculation on space. While the market may tank on Earth, there is no question that humanity will need the materials.[32] Back on earth, in Santiago, researchers speak of how astronomy's wealth of data and complicated analytics can be brought to bear on developing the complex mathematics for geological discovery and simulations of mine stability and resources.

The discussion also indicates a shift of economy, perhaps from extraction to optimization. Vast arrays of sensors, ever more refined chemistry, and reorganized labor and supply chains are developed whose main function is to produce big data for machine learning that will in theory rummage through the tailings, discarded materials,

[32]Hume, "Copper Price Reflects Grim Assessment of Global Economy: Red Metal Has Fallen in Price after Poor Manufacturing Data."

supplementary and surplus substances of older extractive processes in order to reorganize the production, distribution, and recycling of materials in the search for speculative (and financializable) uses for the detritus and excrement of mining.[33] These computational-industrial assemblages create new economies of scavenging, such as the search for other metals in tailing ponds, or the reuse of these waste materials for construction or other purposes, currently in vogue globally. In this logic the seeming final limits of life and resources become instead an extendable threshold that can be infinitely stretched through the application of ever finer and more environmentally pervasive forms of calculation and computation that facilitate the optimization and ever finer salvage and extraction of finite materials. One might argue that this optimization is the perverse parallel of the event horizon. If one watches a clock fall into the event horizon, all one will see is time forever slowing down, the horizon will never be reached. History is eternally deferred at the threshold of a black hole. Big data practices for extraction provide a grotesque doppelgänger of physical phenomena. Even as energy, water, and ore is running out, the terminal limits to the Terran ability to sustain capital is deferred through financial algorithms and machine learning practices. Better modelling and machine learning can

[33] For more on the specific use of AI and machine learning in mine reclamation programs see: Orit Halpern, Golden Futures, LIMN, April 10, 2018. https://limn.it/articles/golden-futures/

allow mines to extend their operations, discover ever more minute deposits of ore, and continue to expand extraction. In fact, the application of artificial intelligence and big data solutions in geology and in mine management has actually increased Chile's contribution to global copper markets. Chile actually expanded mining outputs despite degraded repositories going from providing 16% of global copper to 30% of copper for industrial use between the 1990's and the present.[34] Codelco, the state owned copper conglomerate, has entered major agreements with Uptake, a Chicago-based artificial intelligence and big data enterprise platform provider.[35] The only problem in this fantasy to stop or turn back time is that we are not travelling at the speed of light, and the Earth is not a black hole, rather these practices make crisis an impossibility, and blind us to the depletion of the ecosystem.

[34] Arboleda, Planetary Mine: Territories of Extraction under Late Capitalism.p.66.
[35] Staff Reporter, "Codelco to Deploy Ai Solution," *Mining Journal*, no. March 26 (2019), https://www.mining-journal.com/innovation/news/1359598/codelco-to-deploy-ai-solution.

Temporalities

The desert I visited is both the site of new capacities to recognize new forms of life in astrobiology for example, new mathematics for fluid and materials dynamics in the real-time monitoring and modelling of massive mines, or to produce new images of the universe. The Atacama maybe is always dying. Its flora and fauna vanishing, but as engineers at SQM tell me, the new technologies will allow them to optimize water usage, to recycle and collect what evaporates, and to make water in the desert. What was once a limited, finite resource in the desert–water–is now elastic and optimizable, and the environment is fortified and made resilient. The new minerals and economies of space and lithium envisioned to replace the older metals and energies of industrialism will be run on algorithmic finance markets, hyper speculation, and an embrace of transformation and shock. Resource limitations and catastrophic environmental events are no longer understood as a crisis necessitating a response through expertise and Milton Friedman fiscal policies, but rather as ongoing processes that can be incrementally experimented with and addressed through endless adjustments and manipulations in time and data collection.

Image 7: Memorial for Victims of Pinochet

But time and data can be manipulated in many ways. Back on earth there is a film that came out in 2010, "Waiting for the Light" by Patricio Guzman. In the immediate aftermath of the coup, on September 11th, 1973, there was subsequent torture and disappearance of thousands and the exile of nearly ten percent of the population, the paramilitary talked Chile. Traveling in a Puma helicopter from detention site to detention site, the so-called "Caravan of Death" carried out the executions of 26 people in Chile's south and seventy-one in the desert north. Their bodies were buried in unmarked graves or thrown from the sky into the desert. The desert was militarized and turned into a weapon for the killing of dissidents and for the training of troops. Its resources supporting this state. Guzman parallels the search for bodies by mothers of dissidents killed by Pinochet with astronomers watching and recording the stars in the Atacama's high-altitude observatories (the wave millimeter arrays had not yet been operational). Above all his theme is that the landscape is a recording machine for both human and inhuman memories, the trace of stars 50 million years away, and the search for loved ones within human lives. The implications of the film are that the desert itself provides some other

intelligence or maybe memory not only for humans. Guzman offers us a dangerous romance with the possibilities afforded by our non-human intelligences that might augment or supplant our human memories. His story ties together the tales of cybernetics, astronomy, and economy that offer both horror, and imagination for encounter with radical forms of difference.

When I hear scientists speak of the possibility of real-time decision making in mining and the optimization of energy and materials through the perfection of sensing technology and big data in the mine, I hear a dual fantasy of stretching finite resources into infinite horizons through big data and artificial intelligences. I also hear a smaller more embodied parallel fantasy of a new form of experience and cognition no longer nested in single human bodies, whether those of laborers or those of expert economists, and rather bequeathed to large networks of human-machines. These dreams of AI and machine learning managed extraction might herald back to the history of machine learning. [36]

[36] Frank Rosenblatt, "The Perceptron: A Probabilistic Model for Information Storage and Organization in the Brain," *Psychological Review* 65, no. November (1958).

This returns me to the question of non-human intelligences and memories. Machine learning since the 1950's has been about revising cognition, but also what might denote human history or perception. The very first model of a neural network—the perceptron—was never introduced as a model of "artificial intelligence." The author of the paper, the psychologist Frank Rosenblatt, argued it was to fulfill "neurodynamic" principals. The perceptron would teach about "natural intelligence." The perceptron was, 'not an invention for pattern recognition. As a brain model, its utility is in enabling us to determine therefore physical conditions for the emergence of various psychological opportunities'.[37]

Image 8: Perceptron

Arranged in layers that made decisions cumulatively and statistically. Conceptually it forwarded a new concept of intelligence as networked. Rosenblatt stated that, 'It is significant that the individual elements, or cells, of a nerve network have never been demonstrated to possess any specifically psychological functions, such as

[37] Ibid.p.1.

"memory," "awareness," or "intelligence. Such properties, therefore, presumably reside in the organization and functioning of the network as a whole rather than in its elementary parts'.[38] By induction, this intelligence, therefore, might not reside in anyone neuron, perhaps even one body.

While many mutations have occurred along the way to contemporary deep learning and neural nets, insofar as most machine learning methods required training data—computers could in principle be trained on population-level experience. Experience here is moved outside of the individual—it is the data set, the environment, the sensor system that becomes the object of design. These infrastructures are ubiquitous today; think of the MINST data set, or Google image training sets, or the massive geological data sets that monitor and make "decisions" in real-time to continue the extraction of ever rarer materials.[39]

The inspiration for this model of a networked cognition lay in many places, but above all in the work of economist Friedrich Hayek and psychologist Donald Hebb. Rosenblatt laudingly mentions Hayek as the most significant of psychological theorists to envision the subjective and non-hierarchical nervous system in his work *The Sensory*

[38] Ibid.p.9-10
[39] Arboleda, *Planetary Mine: Territories of Extraction under Late Capitalism.*

Order.[40] For Hayek, an unregulated market and a decentralized nervous system were the "natural" order. Hebb invented Hebbian learning in neural networks, and pioneered studies in sensory deprivation.[41] These concepts of revising the interior and exterior of the human subject and modelling neurons as networks were ones to which Rosenblatt was greatly indebted along with McCulloch-Pitt's model of neurons.[42]

This genealogical relationship between Rosenblatt, Hayek and Hebb returns us to Chile, history, and its legacies in the present. Naomi Klein built her argument about "shock" by arguing methods derived from Hebb's research (even if not intentionally) became the template for torture at the hands of the CIA. This "shock" torture mirrored the neo-liberal mandate for creating disasters or "shocks" that served as the bedrock for structural readjustment policies. Chile in the 1970's was an experiment in these tactics, inaugurating a new world of planetary scale tests, to which the "shock" doctrine may have been the first, and experiments at population levels managed not through older

[40] Friedrich Hayek, *The Sensory Order: An Inquiry into the Foundations of Theoretical Psychology*, 2012 ed. (Chicago: University of Chicago Press, 1952).
[41] Donald Hebb, *The Organization of Behavior: A Neuropsychological Theory* (New York: Wiley, 1949).
[42] Rosenblatt, "The Perceptron: A Probabilistic Model for Information Storage and Organization in the Brain."; Warren McCulloch and Walter Pitts, "A Logical Calculus of Ideas Immanent in Nervous Activity," in *Embodiments of Mind*, ed. Warren McCulloch (Cambridge: MIT Press, 1943; reprint, 1970).pp.20-24.

calculus of territory, eugenics, and Malthusian economics, but through new economic calculative instruments closely attached to our intelligent machines.

I wonder, then, at this condition we live in and its link to artificial intelligences that have fundamentally positioned experience as a matter of extra-human or personal relations, perhaps beyond Terran experiences. We have turned our whole planet into a device for sensing the deepest coldest space; the first wager in perhaps the biggest gamble we are taking as a species. If optimization is the "event horizon" of earth bound ecologies, the very limit of the historical imaginary of economy by making it difficult to imagine running out of materials or suffering catastrophic events, then the event horizon appears as the very image to replace the finitude of the earth.

In a pessimistically optimistic vein, however, might this also be the final opportunity to undo the very fantasies of modern imperialism and anthropocentrism? There is hope in those infinitesimally specific signals found of a black hole from aeons ago, beyond human, even Terran time. The reminder that there are experiences that can only emerge through the global networks of sensory and measuring instrumentations; that there are radical possibilities in realizing that learning and experience might not be internal to subject but shared. Perhaps these are just realizations of what we have known

all along; that our worlds are comprised of relationships to Others. There is a possibility that never has this been more evident or been made more visible then through our new technologies, including those of finance and artificial intelligence. As they automate and traumatize us, they also reveal perhaps what has always been there—the socio-technical networks that exist beyond and outside of us. These are realities that are impossible to fully visualize; but possible to sense. Rosenblatt upon introducing the perceptron spoke of "psychological opportunities"; what might these be?

These new assemblages of machines, humans, physical force and matter also allow a reflexive critique, and create new worlds. We do not know what the E.H.T will yet unearth, but we do know, especially now as we are amid a global pandemic, that only our big data sets and simulations will guide us. For the first time in history as a species, perhaps, we are regularly offered different futures, charted from different data sets and global surveillance systems. Should we continue aggressive containment strategies against COVID-19? Do we prefer human life over market life? How can the sensor systems and experimental testing systems for this disease, be utilized in the future for equity or social justice? Our planet has become a vast dataset, every cell phone and many (although not all, invisibilities and darknesses are also appearing) bodies serving as

recording devices that allows us to track the this disease and with it the violence and inequities of our society but the question is how shall we mobilize this potential? The same distributed systems of sensors, analytics, and data collection offer many options. Totalitarian states and democratic governance through data, improved health and consciousness of social inequity, or terrible economic disenfranchisement through futures markets that even now play on disaster and use data simulations to make bets on negative futures for humanity. We are in a massive and ongoing test scenario, mirrored by the tests we are all taking for diseases. Different forms of governance are being experimented with, along with different understandings of data and what imaginaries they engender. But the planetary test is not a controlled experiment, its stakes cannot be fully known and may be terminal.

The event horizon telescope is an allegory for this condition. It presents us with a radical encounter with our inability to ever be fully objective and the possibility that there are things to learn and forms of experience that are beyond the demands of capital or economy in our present. In many ways it is one possible culmination of a history of rethinking sensation, perception, and scientific epistemologies. But it is not the only possibility in a world of probabilities. Reactionary politics and extreme extractionism

emerge from a perverse use of new media networks not to recognize our subjective and interconnected relatedness but rather towards valorizing older forms of knowledge and power; those of myth, cartesian perspectivalism, and "nature" as a resource for "human" endeavors. Those are the politics that separate figures from grounds, maintain the stability of objects, and understand the future as always already foreclosed and known.

When we discuss AI in terms of national competition or the ongoing abstraction and rationalization from an analogue world, are we taking seriously enough the reformulations of time and space facilitated by these very techniques? Or our own investment and entanglement with socio-technical systems? Or history? Do we ignore the landscape and the ecology of interactions when we frame ethics in terms of decisions made at singular points in time? Our dominant discourses on AI repeat ideas that we can still control the future, or that technology is not natural. These are logics of the event that ignore its horizon. My hope is that perhaps in encountering the impossibility of ever imaging the reality of the event horizon, we might finally be able to witness and engage the precarious reality of life on Earth.