In Life's Likeness: Biomimicry and the Imitation of Nature

by

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ABSTRACT

The Argument of the Dissertation

This anthropological study of biomimicry examines how nature has been imagined and mobilized by American management consultants at the dawn of 21st century. Whereas culture has been invested with economic potential in "human-centered design," consultants who name themselves "biomimics" valorize nature, specifically "life," as a site of technological innovation. In their folk epistemology of biology, 3.8 billion years of evolution have designed "adaptations" to the environment that are superior to human artifice: more powerful, more efficient, and more sustainable. Following the author-turned-consultant Janine Benyus, an ecosystem of innovation consultancies has arisen around the orthodoxy that the imitation of biological "design principles" would generate "sustainable innovation." Despite their promise, however, little has materialized.

Based on six years of ethnographic fieldwork in North America, with an emphasis on the United States, I analyze how biomimics construe, produce, and evaluate imitations to understand the cultural dimensions of this gap between vision and circumstance. Drawing on interviews with over forty biomimics and participant observation at consulting workshops, design competitions, and related public events, I document how consultants appraise the fidelity between originals and copies, life and design. While biomimics aspire toward artifacts that truthfully resemble nature, I demonstrate that, in practice, the meaning of resemblance—i.e. of *life's likeness*—is multiple and situated. Specifically, I discern three *mimetic stances*: the *pragmatic*, *idealistic*, & *performative*. I argue that this dissensus around valid imitations betrays the subsumption of biomimicry, and green design in general, by capitalist profit logics. In conversation with anthropologists of nature, design, & imitation, I show how the "bio" in biomimicry, or the "nature" in nature-based design, has become a capacious term that consultants manipulate to justify the status quo. Biomimicry, I reflect, exposes contemporary tensions of pragmatism/utopia, capital/ecology, and ethics/design.

In biomimicry, "Western" design is often contrasted with its antonym: "native" design. Biomimics believe that "native" design is ecologically harmonious because "native cultures" are intrinsically mimetic. In five interludes that alternate with the main chapters of the dissertation, I outline the anthropological figure of thought their belief rests upon—a romantic figure that I call *Homo mimesis*—and critically excavates its traces in their notions of time, value, sensation, and the nature of the human. Extrapolating from biomimicry to design more broadly, I contend that designers reflexively understand their own practices through empirical or speculative knowledge about how other societies make their material worlds. As so-called social, human, user, and other kinds of "cultural" design multiply, I invite anthropologists to attend to *design's anthropologies*: the epistemologies of *anthropos* in design, epistemologies oft reduced to essentialized difference.

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For Kevin

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Imitation: The Sincerest of Flattery

In Vol. 1 of *Lacon: or, many things in few words, addressed to those who think* (1820), the Anglican clergyman Charles Caleb Colton counseled readers of this book on manners about the norms of Georgian England through a series of pithy aphorisms, including the often mocked and much maligned meme that "imitation is the sincerest of flattery." Inadvisable as it may be to take lessons on civility from a man described as having "little to no principle," who "took to gaming, and had to leave the country"[1]—a man who once abandoned his liturgy to hunt partridge, whose place of residence was "littered with books" (pot kettle black), and who was accused by his peers of plagiarizing (…flattering?) Francis Bacon and William Burdon—I would be remiss if I did not mention Colton in this dissertation about imitation.[2] I would doubly remiss if I did not voice my most heartfelt gratitude to the individuals named below who have nourished my maturation as an intellectual, as a fieldworker, as a writer, and as a person. If, in any way, I have begun to emulate their virtues in the content of this work or in the conduct of my life, I would consider it a success of the highest order, and I would hope that they, in turn, recognize it as the "sincerest of flattery."

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[1] John William Cousin. "Colton, Charles Caleb (1780-1832)." *A Short Biographical Dictionary of English Literature*. London, England: J.M. Dent & Sons Ltd (1910). Pp. 93.

2 [Anon.], and John D. Haigh. "Colton, (Charles) Caleb (bap. 1777, d. 1832), writer and Church of England clergyman." Oxford Dictionary of National Biography. 23 Sep. 2004; Accessed 12 Aug. 2021. https://www-oxforddnb-com.libproxy.mit.edu/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-5999.

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[3] Arranged in no particular order except to avoid the dreaded orphan text.

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[4] Arranged in a very particular order: alphabetical.

in the MIT Department of Architecture Design and Computation Forum and to engineers at the Women and Honeywell Engineering Network, and I thank them for their perceptive comments and thank Katia Zolotovsky and Staci Neilson, respectively, for invitations to share my research. Outside of these smaller fora, I ought to thank my fellow panelists and panel chairs, discussants, and moderators at the 2014, 2015, and 2019 conferences of the Society for the Social Studies of Science as well as the 2018 conference of the American Anthropological Association. Finally, I am grateful to various members of the Committee on the Anthropology of Science, Technology, and Computing—Nandita Badami, Baird Campbell, Rebecca Perry, and Beth Reddy—for their efforts with editing my contribution to *Platypus*, in addition to general professional advisement.

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[5] Arranged in order of biographical appearance to *not* face mortal retribution for angering friends.

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[6] Redacted for a professional audience.
[7] Our extensive kinship diagram would make W.H.R. Rivers sweat.

would also be the first to reject the Christian telos of "becoming one," or what Roger Caillois, in a different key, thought of as the desire or "lure" to "become assimilated."[8] Together, we have become more than two, evolving side-by-side—he, growing his business, creating our destiny, & I, multiplying the number of footnotes in this text. What I admire most about Kevin is that, in his act of encouraging my independent academic pursuits (he jokes that he still does not know what I am studying, "jellyfish something or other"), he reminds me that I cannot be reduced to my work on the page or my research in the field. Kevin and our dogs, (Opti)müs and Meg(atron), together with all the Luthers (Alice, Chris, Jerry, Michelle, Riley, and Reyna), have embraced me in their family regardless, and for that I am eternally grateful. I also apologize in advance, Kevin, for the menace I will invariably become once more as I go write this book, and the next one, and the…

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Land Acknowledgements[9]

In the interludes to this dissertation, the reader will encounter the revival of colonial tropes of Indigenous design within biomimicry. As I confronted these in my fieldwork, joined by recent anthropological critiques of ethnography, I had to reckon with my positionality, not only as the practitioner of a science that played a role in the formation of these tropes, but also as a person, as a white scholar of mixed European descent (English, Lithuanian, Norwegian, Ukrainian) who benefits from occupying stolen, forcibly dispossessed Native land. I recognize the Native peoples whose ancestors were removed from these lands, or killed, and to whom these lands still belong:

Cambridge, Massachusetts, is Pawtucket and Massa-adchu-es-et land
Gloucester, Massachusetts, is Pawtucket land
Phoenix, Arizona, is Hohokam, Akimel O'odham (Upper Pima), and O'oodham Jewed land
Mexico City, Mexico, is Mexihcah (Triple Alliance) land
Veracruz, Mexico, is Mexihcah (Triple Alliance) and Nahua land
Berkeley, California, is Chochenyo, Muwekma, and Ohlone land
San Diego, California, is Kumeyaay land

[8] Roger Caillois, "Mimicry and Legendary Psychasthenia," in *The Edge of Surrealism: A Roger Caillois Reader* (Durham: Duke University Press, 2003), 99, 98.
[9] Native land names are from Native Land, a crowd-sourced digital map. Thanks to Claire Webb and Elena Sobrino for sharing. See "Native Land," Native Land Digital. Accessed September 27, 2021. https://native-land.ca/

INTRODUCTION

The Culture of the Copy of Nature: Capitalist Utopia and the Magic of Mimesis

> The perception of similarity is in every case bound to a flashing up. It flits past, can possibly be won again, but cannot really be held fast as can other perceptions. It offers itself to the eye as fleetingly and transitorily as a constellation of stars. The perception of similarities thus seems to be bound to a moment in time.
> —WALTER BENJAMIN, "The Doctrine of the Similar" (1933)[1]

> The durability of the 'non-organic' can be combined with the intelligence of the organic in the future construction of machines. Soon the place will be crawling with stone jackals…What should the stone jackals be like if they are not to tear us apart and if we ourselves are not to be like jackals? Naturally, we can design them in such a way that they lick us instead of biting us. But do we really want to be licked?
> —VILEM FLUSSER, "The Lever Strikes Back" (1999)[2]

Prologue: Licking and Biting

An eyewitness to the dawn of the third millennium would have sensed that stone jackals seemed everywhere afoot—or, rather, apaw. Newsstands across the metropolitan United States (perhaps I should say newsfeeds) stacked with articles from *The New York Times*, *Fortune, Forbes, Time, National Geographic, Bloomberg, The Wall Street Journal, Newsweek, The Economist,* and other periodicals rumored that "the secret to the next big technological breakthrough," as one journalist for *CNN* phrased it, could "be all around us – slithering, crawling or flowering among our natural surroundings."[3] In a field indiscriminately named "biomimicry," "biomimetics," or "bio-inspired

[1] See Walter Benjamin, "Doctrine of the Similar," in *Selected Writings, Volume 2, Part 2, 1931-1934* (Cambridge: Belknap Press, 1999), 695.
[2] Vilem Flusser, "The Lever Strikes Back," in *The Shape of Things* (London: Reaktion Books, 1999[1993]), 52.
[3] "Biomimicry: Inspired by Nature." *CNN* online, May 28, 2014, https://www.cnn.com/2014/05/07/tech/gallery/biomimicry-nature-inspired/index.html. For a small selection of other articles on biomimicry, see Rob Turner, "Salient Facts: Biomimicry," *The New York Times* online, January 13, 2002, https://www.nytimes.com/2002/01/13/

design," scientists, engineers, designers, and business professionals from disciplines as diverse as landscape architecture and mechanical engineering were said to be "looking to nature to emulate the ingenuity of the living world," imitating "life's design principles" in artifacts of "natural" origin: sharkskin-like wetsuits, photosynthetic solar cells, and butterfly-inspired computer fans.[4]

As biomimicry's just-so story goes, organisms have attained "functional" adaptations to the environment over 3.8 billion years of evolution—embodied "technologies" or "bio-logics," as Kevin Kelly and Eugene Thacker term them—that researchers in this field can copy over into inorganic media.[5] Superior to human-made design in every manner desirable—more powerful, more efficient, more sustainable—nature's artifacts were avowed to usher in a technological and even civilizational revolution on par with the advent of genetics, only in reverse, collapsing the "made" into the "born," artifice into nature.[6] In 1997, Janine Benyus published *Biomimicry*—a literary event credited with catalyzing the field's growth. While it is now commonplace to find popular nonfiction about biomimicry (e.g. *The Shark's Paintbrush*, *Teeming*, *The Gecko's Foot, Bulletproof Feathers, and Nature's Operating Instructions)*, when she visited her local bookstore

magazine/the-way-we-live-now-1-13-02-salient-facts-biomimicry-super-fly.html; Verne Harnish, "5 Trends to Ride in 2017," *Fortune* online, March 17, 2017, https://fortune.com/2017/03/17/trends-business-career-benefits/; Rebecca Bagley, "Biomimicry: How Nature Can Streamline Your Business for Innovation," *Forbes* online, April 15, 2014, https://www.forbes.com/sites/rebeccabagley/2014/04/15/biomimicry-how-nature-can-streamline-your-business-for-innovation/?sh=144f08543809; Amory Lovins, "Janine Benyus," *Time* online, October 17, 2007, http://content.time.com/time/specials/2007/article/0,28804,1663317_1663319_1669888,00.html; Johnny Langenheim, "The Biomimicry Innovations Inspired by Earth's Colder Climes," *National Geographic* online, https://www.nationalgeographic.com/environment/article/partner-content-earths-colder-climes; Amelia Hennighausen and Eric Roston, "Inspired by Nature: Biomimicry," *Bloomberg* online, February 23, 2015, https://www.bloomberg.com/news/photo-essays/2015-02-23/14-smart-inventions-inspired-by-nature-biomimicry; Michael Freedman, "Biomimicry Turns Nature into a Factory," *Newsweek* online, May 27, 2010, https://www.newsweek.com/biomimicry-turns-nature-factory-72815; *The Economist* online, "Technology that Imitates Nature," June 11, 2005, https://www.economist.com/technology-quarterly/2005/06/11/technology-that-imitates-nature.

[4] *CNN* online, "Biomimicry: Inspired by Nature."

[5] Kevin Kelly, *Out of Control: The New Biology of Machines, Social Systems, and the Economic World* (New York: Basic Books, 1995); Eugene Thacker, *Biomedia* (Minneapolis: University of Minnesota Press, 2004).

[6] Kelly, *Out of Control,* 6. Compare his notion of the "neo-biological civilization" with Lewis Mumford's concept of "biotechnics." See Lewis Mumford, *Technics and Civilization* (Chicago: University of Chicago Press, 2010[1934]).

to admire her work after its release, *Biomimicry* was not in the nature or the technology sections. Biomimicry was a categorical anomaly, one that portended technologies *of* nature, *by* nature.[7]

Economic pundits were especially vocal about the potential of biomimicry. Writing for *Forbes*, Rebecca Bagley named "biomimicry" as one of "five tech trends that can drive company success," ranking it with additive manufacturing, the Internet of Things, Big Data, and software.[8] The *Harvard Business Review* twice celebrated biomimicry as one of its "breakthrough ideas for today's business agenda."[9] In 2001, the magazine reprised the American design icon Steve Jobs' maxim that "the biggest innovations of the 21st century will be at the intersection of biology and technology" to declare that the "source of business innovation may soon be…biology," eyeing biomimicry as the key to the "treasure trove hiding in the life sciences."[10] Even in the wake of the 2008 global financial crisis, they retained their belief in biomimicry, confidently stating, "We believe that now is an opportune time for global businesses to develop profitably around some of the ideas nature offers."[11] In a 2010 report paid for by the San Diego Zoo, the Fermian Business and Economic Institute concurred, hailing biomimicry as a "game changer" and a "revolutionary change in our economy," with a capacity to yield $300 billion in gross domestic product and 1.6

[7] Janine Benyus, *Biomimicry: Innovation Inspired by Nature* (New York: Harper Perennial, 2002[1997]). See also Robert Allen, *Bulletproof Feathers: How Science Uses Nature's Secrets to Design Cutting-Edge Technology* (Chicago: University of Chicago Press, 2010); Kenny Ausubel, ed., *Nature's Operating Instructions: The True Biotechnologies* (Berkeley: Sierra Club, 2004); Peter Forbes, *The Gecko's Foot: Bio-Inspiration – Engineering New Materials from Nature* (New York: W.W. Norton & Company, 2006); Jay Harman, *The Shark's Paintbrush: Biomimicry and How Nature Is Inspiring Innovation* (Ashland, OR: White Cloud Press, 2013); Tamsin Woolley-Barker, *Teeming: How Superorganisms Work Together to Build Infinite Wealth on a Finite Planet* (*and Your Company Can Too*) (Ashland, OR: White Cloud Press, 2017).
[8] Bagley, "Biomimicry: How Nature Can Streamline Your Business for Innovation."
[9] *Harvard Business Review*, "The 2001 HBR List: Breakthrough Ideas for Today's Business Agenda," April 2001, 123-128; *Harvard Business Review,* "Breakthrough Ideas for 2009: Our Annual Snapshot of the Emerging Shape of Business," February 2009, 19-40.
[10] *Harvard Business Review,* "The 2001 HBR List," 128.
[11] *Harvard Business Review,* "Breakthrough Ideas for 2009," 28.

billion jobs for the United States by 2025.[12] As a mirror image to the bioeconomy of DNA, cells, hormones, and other living "substances," an emerging market for the traffic of "life's principles" and the profitable trade of new mimetic designs appeared imminent, irresistible, and inevitable.[13]

Just as hyperbolic as these hype-men and women were the cultural prophets who presaged in the economy of tomorrow a future of doom and gloom, where the logics of life had been redeployed as agents of American militarism and capitalist exploitation. Biomimetic robots developed by the Department of Defense—a "mechanical dragonfly and butterfly"—augured the "instrumentalization of life" for the anthropologist Joseph Masco.[14] Other critical scholars after Masco have expressed similar apprehensions. Charles Zerner read in robotic insects a tendency toward the "militarization of nature" and the "weaponization of life" while Roger Stahl predicted that "drone-beetle swarms," "surveillance pigeonbots," and other troops of "biomimetic warfare" will "map the martial sphere onto the ecological sphere."[15] Likewise, Elizabeth Johnson forecast that the RoboLobster project will terminate in the "respatialization of warfare from territory into the bodies of organisms."[16] Retreating from the front lines of the battlefield to the bottom lines of the corporate world, Johnson, writing with Jesse Goldstein, has also surmised that a spider-

[12] Randy Ataide, *Global Biomimicry Efforts: An Economic Game Changer* (San Diego: Fermian Business and Economic Institute, 2010), 5. See also Randy Ataide, *Bioinspiration: An Economic Progress Report* (San Diego: Fermian Business and Economic Institute, 2013).

[13] For a review of social scientific literature on the bioeconomy of substances, see Stefan Helmreich and Nicole Labruto, "Species of Biocapital, 2008, and Speciating Biocapital, 2017," in *The Palgrave Handbook of Biology and Society,* eds. Maurizio Meloni, John Cromby, Des Fitzgerald, and Stephanie Lloyd (London: Palgrave Macmillan, 2018), 851-876.

[14] In an ethnographic history of the "mutant ecology" leftover from United States nuclear project, Masco identifies these robots as "genealogical descendent[s]" of the live pigs used by Los Alamos scientists to test for radioactivity. See Joseph Masco, "Mutant Ecologies: Radioactive Life in Post-Cold War New Mexico," *Cultural Anthropology* 19.4 (2004): 517-550, 537. See also Jake Kosek, "Ecologies of Empire: On the New Uses of the Honeybee," *Cultural Anthropology* 25.4 (2010), 650-678; Colin Salter, "Animals and War: Anthropocentrism and Technoscience," *Nanoethics* 9 (2015): 11-21.

[15] Charles Zerner, "Stealth Nature: Biomimesis and the Weaponization of Life," in *In the Name of Humanity: The Goernment of Threat and Care,* eds. Ilana Feldman and Miriam Ticktin (Durham: University Press, 2010), 290-324, 295; Roger Stahl, "Life Is War: The Rhetoric of Biomimesis and the Future Military," *Democratic Communiqué* 26.2 (2014): 122-137, 122, 122, 129, 123.

[16] Elizabeth Johnson, "Biomimetic Geopolitics: The Earth, Inside Out," *Techniques & Culture* online, Suppléments au 73 (2020), 1-20, 5.

inspired thread and a beetle-inspired coating harkens a "new industrial paradigm" that values life as a landscape of "potential capital" through enclosure and privatization—an opinion echoed by Veronica Davidov, for whom biomimicry regards "nature as a meta-resource on a mega-scale."[17] In a frightful prognostication of the political economy of biomimicry, Elizabeth Johnson opined:

> Biomimicry, then, serves to legitimize production, a way to insist that life *is* production, is productive, ought to be relentlessly producing goods and services for the earth…The discourse of biomimicry may simply make all forms of life, and our knowledge of them, equivalent through the measure of exchange…As forms of life fall under this regime of measure, so too do the times in and through which we interact with them. Rather than produce spaces outside the times of capitalist production, every moment…becomes moments in which innovation for capital can be produced, in which exchange value can be made and accumulated. Every moment becomes a moment of potential labor and potential production; innovation is latent in every instant.[18]

Indeed, a dreadful, dystopian fate! But perhaps, as I explore in the pages that follow, there is another critique to be made of biomimicry, one attuned not just to what is *said* about biomimicry, but to what practitioners of biomimicry *do* in the consulting spaces that circumscribe this field.

Toward an Anthropology of Biomimicry: Practice(s), Ethics, Language, Stance, and Utopia

Between the Scylla of promise and the Charybdis of peril, this dissertation, *In Life's Likeness: Biomimicry and the Imitation of Nature*, navigates and sails a more "modest" passage by ethnographically following biomimicry in practice.[19] Research began in the fall of 2014 on my

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[17] Jesse Goldstein and Elizabeth Johnson, "Biomimicry: New Natures, New Enclosures," *Theory, Culture & Society* 32(1): 61-81, 61, 72; Veronica Davidov, "Biomimicry as a Meta-Resource and Megaproject: A Literature Review," *Environment and Society: Advances in Research* 10 (2019): 29-47, 29. For another take on the capitalization of life through biomimicry, see Elizabeth Johnson and Jesse Goldstein, "Biomimetic Futures: Life, Death, and the Enclosure of a More-than-Human Intellect," *Annals of the Association of American Geographers* 105.2 (2015): 387-396. On the relationship of the militaristic and economic dimensions of biomimicry, see Elizabeth Johnson, "Reanimating *Bios*: Biomimetic Science and Empire," PhD diss., (University of Minnesota, 2011).

[18] Elizabeth Johnson, "Reconsidering Mimesis: Freedom and Acquiescence in the Anthropocene," *South Atlantic Quarterly* 115.2 (2016): 267-289, 283.

[19] On "modest" knowledge, see Donna Haraway, *Modest_Witness@Second_Millenium.FemaleMan?_Meets_OncoMouseTM* (New York: Routledge, 1997). On the dialectic of promise and peril, see Heather Paxson and Stefan Helmreich, "The Perils and Promises of Microbial Abundance: Novel Natures and Model Ecosystems, from Artisanal Cheese to Alien Seas," *Social Studies of Science* 44(2): 165-193. On promise and the promissory in the bioeconomy, see Joseph Dumit, *Drugs for Life: How Pharmaceutical Companies Define Our Health* (Durham:

way to teach a class on science and society. As I strolled down the Infinite Corridor, an enclosed, labyrinthine thoroughfare that spans the campus of the Massachusetts Institute of Technology, I noticed a research report about biomimicry between bulletin boards pinned with student leaflets on meetings, parties, and recitals. Led by Christine Ortiz, students in this materials science and engineering laboratory had copied the "hierarchical and heterogeneous composite structure" of *Polypterus senegalus.* Just as this eel-like fish defends itself from attacks with its durable, flexible scales, a reticulated set of analogous plates would, the lab hypothesized, protect soldiers with "biomimetic armor." Fascinated by their work, by the rhetoric of biomimicry, and by theoretical concerns that have animated other scholars on the topic (i.e. nature/artifice relations), I conducted fieldwork in Ortiz's lab for six months. In the summer of 2015, I flew to Phoenix to spend three months at Arizona State University's (ASU) Biodesign Institute, a "collaborative" research center based on "nature-inspired solutions to global health, sustainability, and security."

Locating biomimicry in practice, however, proved to be an ethnographic conundrum. Among the researchers that I interviewed, none of the students had heard of "biomimicry," and the principal investigators of the labs I studied admitted that the term was mostly used in grants. When I met with Charles Arntzen, a molecular biologist and founding director of the Biodesign Institute, he confirmed that "biomimicry" and "nature-inspired" were buzzwords for what was in reality biomedical science-as-usual. As we drank coffee in the small, affluent suburb of Verrado, a planned community designed to resemble a "great American town," Arntzen recalled that these slogans were used to distinguish the institute from their competitors at the University of Arizona. My search continued. A year prior, ASU had partnered with Janine Benyus's Biomimicry 3.8,

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Duke University Press, 2012); Michael Fortun, *Promising Genomics: Iceland and deCODE Genetics in a World of Speculation* (Berkeley: University of California Press, 2008); Kaushik Sunder Rajan, *Biocapital: The Constitution of Postgenomic Life* (Durham: Duke University Press, 2006).

"the world's leading bioinspired consultancy," to "facilitate biomimicry education and research endeavors locally and globally" through the ASU Biomimicry Center. After emailing its assistant director, Heidi Fischer, I scheduled a visit that summer to talk about conducting fieldwork there.

Institutionally and physically housed in the Herberger Institute for Design and the Arts, the Biomimicry Center comprised two main rooms. From fieldwork with engineers and a passing familiarity with design's material culture, I envisaged sketches, models, "working artefacts," and other tools messily piled atop and spilling down from too-few shelves.[20] Instead, I walked into a quiet gallery of undergraduate posters on class projects. In the adjacent suite, a clutter-free table and a tidy row of desks was in want of people and "stuff."[21] While I found Heidi in a small office tucked away in the back, I could not find biomimicry, at least as a design practice. Heidi told me there was "nothing" at the Biomimicry Center for me. By this, she did not merely mean that the newly founded space had yet to fill up. Rather, the center was not a place of design but education support and seed grant administration.[22] What was more perplexing than the evanescent design practice of biomimicry was that Heidi invalidated research I thought had been about biomimicry.

"That's not biomimicry," she said. "That's biomimetics." While popular media and the researchers I met referred to biomimicry, biomimetics, and bio-inspired design interchangeably, Heidi corrected my use of the word "biomimicry" to describe the Ortiz lab's fish-inspired armor. From her perspective, nature might have been a "model" for this militaristic artifact, but it could not have been its "measure" because this mimetic technology did not show any "respect" for life.

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[20] Lucy Suchman, Randall Trigg, and Jeanette Blomberg, "Working Artefacts: Ethnomethods of the Prototype," *British Journal of Sociology* 53.2 (2002): 163-179.

[21] On "stuff," see Eitan Wilf, *Creativity on Demand: The Dilemmas of Innovation in an Accelerated Age* (Chicago: University of Chicago Press, 2019), esp. Chapter 5. On the material culture of architecture, consider Albena Yaneva, *Made by the Office for Metropolitan Architecture* (New York: 010, 2009).

[22] At the time of writing, the Biomimicry Center features a biomimicry "maker space" named "NatureMaker," described as a "hands-on learning library" for students to "discover innovative solutions to sustainability challenges" through "natural history artifacts," visualization tools (e.g. binoculars), and books. Biomimicry Center, "NatureMaker," https://lib.asu.edu/naturemaker, accessed September 27, 2021.

Heidi's thinking, which drew from the philosophy of "design" Benyus articulated in *Biomimicry*, presented biomimicry—"the conscious emulation of life's genius"—as a "new relation" to nature as design's "mentor." The philosopher Sanne van der Hout calls this their "tutorial narrative."[23]

In Heidi's anthropology of the human, "native cultures" do it "nature's way," copying life's design principles, but "Western culture" manipulates nature as a resource or utility. While the armor might have been modelled on nature, it was not "respectful imitation" because its planned use in war treats life as expendable. Led by Benyus, devotees of biomimicry like Heidi recant the "anthropocentric model" of design—a model they implicate in the ecological crises of the Anthropocene—and proclaim that imitation concerns not just the "process" of design, but its "outcome."[24] Life, they say, should govern how our artifacts work *and* how we judge them. What Lorraine Daston and Fernando Vidal called the "moral authority of nature" has manifested anew in biomimicry—a moral authority that is, simultaneously, technical, a morality of design.[25]

Following Heidi's cue, this dissertation is an anthropological study of the politics of imitation in the "field" of biomimicry.[26] As Heidi alerted me, biomimicry is comprised of not just imitation—a universal action—but multiple *mimetic practices*, each with distinct notions of what constitutes a "good" imitation.[27] In this study, I rely upon the linguistic anthropologist Michael Lempert's concept of "mimetic practice" to pluralize "events of behavioral imitation in

[23] Sanne van der Hout, "Organisms as Teachers? The Promise of Biomimicry," in *Animal Ethics in the Age of Humans,* eds. B. Bovenkerk and J. Keulartz (London: Springer, 2016), 39-51, 39.
[24] Emily Kennedy, Daphne Fecheyr-Lippens, Bor-Kai Hsiung, Peter H. Niewiarowski, and Matthew Kolodziej, "Biomimicry: A Path to Sustainable Innovation," *Design Issues* 31.3 (2015): 66-73, 67.
[25] Lorraine Daston and Fernando Vidal, "Introduction: Doing What Comes Naturally," in *The Moral Authority of Nature*, eds. Lorraine Daston and Fernando Vidal (Chicago: University of Chicago Press, 2004).
[26] While the prologue uses "biomimicry" to name biomimicry, biomimetics, and bioinspired design, from here out I use the term biomimicry to describe Janine Benyus's school of thought. I say field to describe this school of thought, and "field," in quotation marks, when referring to biomimicry along with its cognates—i.e. the "field" in the minds of popular media and scholarship.
[27] Unless otherwise noted, I use the words "imitation" and "mimesis" interchangeably.

which such imitation is reflexively grasped and understood to count as social action."[28] Thus, I distinguish "biomimicry" from its cognates "biomimetics" and "bioinspired design" by tracking how persons in these fields evaluate imitation as a category of social action, with an emphasis on how biomimicry practitioners value the functions of mimetic artifacts.[29] If imitation, as Lempert theorizes, entails the "comparison of two or more object signs (original and copy) between which some differential is felt to exist," then how, in the comparison of nature and technology, do these individuals appraise this apparent "differential"?[30] And why, for instance, is it vital for adherents to biomimicry that "life" inform the functions of their copies as well as their modes of appraisal?

At stake between the mimetic practices of biomimicry, biomimetics, and, to a lesser extent, bioinspired design is the meaning of "life's likeness"—the title of this dissertation. More than mere semantic pedantry, the resemblance between nature and artifice entails, for people like Heidi, deep ramification for sustainability. The reasoning behind biomimicry was this: If life has survived through 3.8 billion years of adaptation, then technologies that emulate nature's "adaptive capabilities"—functions *and* their environmental "fit"—will, analogously, "return" the human to nature, and design to a more "sustainable" mode of production.[31] This rationale evokes one sense of Michael Taussig's elucidation of mimesis as "the copy drawing on the character and

[28] Michael Lempert, "Imitation," *Annual Review of Anthropology* 43 (2014): 379-395, 380. Lempert contrasts his concept of "mimetic practice" against the "monofunctionalism" he ascribes to other social theorists of imitation. For example, see Gabriel Tarde, *The Laws of Imitation* (New York: Holt, 1903); Walter Benjamin, "The Work of art in the age of mechanical reproduction," in *Illuminations: Essays and Reflections,* ed. Hannah Arendt (New York: Schocken, 1985[1936]); Jean Baudrillard, *Simulacra and Simulation* (Ann Arbor: University of Michigan Press, 1994[1980]); Michael Taussig, *Mimesis and Alterity: A Particular History of the Senses* (New York: Routledge, 1994); Homi Bhabha, "Of Mimicry and Man: The Ambivalence of Colonial Discourse," in *The Location of Culture* (London: Routledge, 1994), 85-92; James Ferguson, "Of Mimicry and Membership: Africans and the "New World Society," *Cultural Anthropology* 17: 551-569.

[29] For a theory of value and review of the anthropological literature on the topic, see David Graeber, *Towards the Anthropology of Value: The False Coin of Our Dreams* (New York: Palgrave Macmillan, 2001).

[30] Lempert, "Imitation," 381.

[31] On function and fit, see Illaria Mazzoleni, *Architecture Follows Nature: Biomimetic Principles for Innovative Design* (New York: CRC Press, 2013).

power of the original."[32] For believers of biomimicry, the subject of life's likeness is therefore entangled in cultural webs of human/nature, life/technology, and mimesis/design—relations of ecological, even planetary, significance. Just as scholars of imitation like Magdalena Crăciun, Cori Hayden, Laikwan Pang, and Winnie Wong have examined the cultural grammar of "proper" and "improper" copies, so too do I ask in this dissertation how actors in the field of biomimicry determine what counts as a "good" copy of nature, and why.[33] In particular, I question why their mimetic fidelity to life, in functionality and fit, is seen as a moral issue—in other words, why Heidi would tell me that "biomimicry is biomimetics with an ethical aspect." In the United States, where an anti-mimetic "tradition of invention"[34] and innovation is counterpoised against the alleged fakery of making elsewhere (e.g. knock-offs), particularly in China, how has mimesis been signified as virtuous design?

If advocates of biomimicry idealize the copy of nature, then what interests me in this dissertation is the "culture of the copy" of nature—the culture of biomimicry.[35] More specifically, I am interested in how their "Romantic conception of life"[36] underwrites a "politics of the similar" as well as an ethic of the similar—a *mimetic ethic*.[37] Based on six years of intermittent fieldwork with experts in biomimicry across North America, with a focus on the United States, I ethnographically ask

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[32] Taussig, *Mimesis and Alterity*, xiii.
[33] Magdalena Crăciun, "Rethinking Fakes, Authenticating Selves," *Journal of the Royal Anthropological Institute* 18 (2012): 846-863; Cori Hayden, "The Proper Copy: The Insides and Outsides of Domains Made Public," *Cultural Economy* 3.1 (2010): 85-102; Laikwan Pang, *Creativity and Its Discontents: China's Creative Industries and Intellectual Property Rights Offenses* (Durham: Duke Univeristy Press, 2012); Winnie Wong, *Van Gogh on Demand: China and the Readymade* (Chicago: University of Chicago Press, 2013).
[34] Heather Paxson, *The Life of Cheese: Crafting Food and Value in America* (Berkeley: University of California Press, 2013), esp. Chapter 4.
[35] In his magisterial catalogue of the Western obsession with imitations, Schwarz coined the phrase the "culture of the copy" to name the West's ongoing predilection for the mimetic in twins, doppelgänger, clones, and other mimes. Notwithstanding the reductionism inherent in reducing a culture to a trait, Schwarz's study is a necessary corrective to the ideological and ethnocentric delusions that the United States is solely a place of innovation, not imitation. On the contrary, Schwarz shows that imitations are ubiquitous, *especially* here in the United States. See Hillel Schwarz, *The Culture of the Copy: Striking Likenesses, Unreasonable Facsimilies* (New York: Verso Books, 1996).
[36] Robert Richards, *The Romantic Conception of Life: Science and Philosophy in the Age of Goethe* (Chicago: University of Chicago Press, 2002).
[37] Cori Hayden, "A Generic Solution? Pharmaceuticals and the Politics of the Similar in Mexico," *Current Anthropology* 48.4 (2007): 475-495.

how "biomimics," a term I define below, envision and evaluate the design of mimetic technologies on the basis of its perceived similitude to a biological Nature imagined to be inherently harmonious and "efficient." In so doing, I draw on anthropologies of nature in literatures on biology and ecology.[38] How biomimics construct life's likeness, then, constitutes the first ethnographic problem of this study, which I resolve in three chapters on biomimicry's methodology, philosophy, and marketing strategies. What is "life" to practitioners of biomimicry, and how is it mobilized within "sites of moral testing"?[39]

But where is biomimicry? It was neither in the Ortiz laboratory, nor was it in the Biodesign Institute. It was also not in the Biomimicry Center, where I had expected it most. As I recall in some detail later in this introductory chapter, every lead I followed to "biomimicry" as a design practice was revealed to be either "biomimetics" (or some other species of nature-based design), or had vanished as I was arriving. As design, biomimicry was fleeting. This constitutes the second ethnographic problem of this study. Why was biomimicry everywhere in media and scholarship yet still nowhere in practice?

The nowhere-ness of biomimicry is, perhaps, only partially true. While I could not locate it as a *design* practice, it was abundant as a *consulting* and *teaching* practice. Before 1997, biomimetics and bionics were scientific and engineering practices institutionalized in academic departments. In 1997, the American author and natural historian Janine Benyus wrote *Biomimicry*, reporting on "fascinating people, working at the edges of their disciplines," among them: biomimetics and bionics researchers.[40] These "biomimics," she named them, "know that nature, imaginative by necessity, has already solved the problems we are struggling to solve."[41] Recasting what had been languages about the "efficiency" of biological organisms into a new discourse about the "sustainable innovation" nature might provide,

[38] For a review of this literature, see Stefan Helmreich, "What Was Life? Answers from Three Limit Biologies," *Critical Inquiry* 37.4 (2011): 671-696.
[39] Michael Fischer, *Anthropological Futures* (Durham: Duke University Press, 2009), x.
[40] Benyus, *Biomimicry*, 4.
[41] *Ibid*.

Benyus invented biomimicry. I refer to biomimicry as a *metalanguage*: an ideological discourse *about* the pragmatics of mimetic practice(s), its functions and its values. For Benyus, biomimicry would turn product "design" into a medium of profitable sustainability, or green capital. In 1998, Benyus founded a consultancy known as the Biomimicry Guild, and then the Biomimicry Institute & Biomimicry 3.8. Through what I call the Biomimicry Conglomeration™, Benyus has proselytized the metalanguage of biomimicry, selling her expertise on nature's design principles to companies but also converting more "biomimics" to her cause and its mimetic ethic with training workshops and educational programs.[42] As a result of her consulting and teaching work, Benyus has given rise to a national and global system of consultancies that, like Benyus, counsel and teach biomimicry. Paradoxically, this emerging field of "biomimicry" positioned itself against "biomimetics," even as, historically, Benyus drew upon it to legitimize biomimicry. Even today, practitioners of biomimicry still refer to biomimetics cases as "biomimicry"—a second sense of "the copy drawing on the character and power of the original."[43] Within this dissertation, I refer to this illusory mirage of the "field" of biomimicry as the *mimetic field*.

In Life's Likeness is an ethnographic study of these "biomimics" who believe and promote the metalanguage of biomimicry: mostly consultants, but also managers, biologists, engineers, as well as designers from various disciplines (architectural, industrial, software).[44] To say that biomimicry has no location as a design practice is *not* to say that biomimicry is *only* talk—only speech practices in the

[42] By the Biomimicry Conglomeration™, I refer to the family of organizations that Benyus created around the idea of "biomimicry, including the Biomimicry Guild, Biomimicry 3.8, and the Biomimicry Institute. Following Donna Haraway's citation of corporate symbolism to index the capitalist origins of "OncoMouse™," I mean to reference the branded nature of biomimicry and its primary existence as a commodity in consulting and teaching practices. The Biomimicry Institute holds a trademark over its online database of biological design principles: AskNature. See Haraway, *Modest_Witness*.

[43] Taussig, *Mimesis and Alterity*, xiii.

[44] I use the term "biomimic" to refer to practitioners of *biomimicry* who work for, or were trained by, the Biomimicry Conglomeration™—*not* to the practitioners of bionics and biomimetics whom Benyus has referred to as "biomimics." My use of this word in this manner aims to bring analytical focus to the "community of practice" organized around the metalanguage of biomimicry. To call attention to their specific disciplinary backgrounds, I will, on occasion, refer to them instead as consultants, managers, designers (i.e. architects, industrial designers, etc.). For "communities of practice," see Etienne Wenger, *Communities of Practice: Learning, Meaning, and Identity* (Cambridge: Cambridge University Press, 1999).

world of innovation consulting and its orbital pedagogies. Over the past two decades, the Biomimicry Conglomeration™ has fashioned a proprietary innovation methodology called "biomimicry thinking." Enacted by Benyus and her followers as a "design" method, I propose to think of it instead as a *meta-design* method. Design, as I argue in this introduction, has the ideation and, sometimes, the realization of form as its practical telos.[45] On the contrary, biomimicry, as a "design" practice, is about inducing, but not specifying, form, and evaluating it. In simpler terms, biomimicry does not produce "things."[46] *Pace* Heidi, biomimicry is not merely "biomimetics with ethics" because biomimicry is an altogether different mimetic practice, or method, than its predecessor, biomimetics, upon which it is modelled. Biomimicry is, in other words, a mimetic practice made mimetically after another mimetic practice(s), with its own routines and criteria of evaluation (e.g. Nature's Unifying Principles, see Chapter Two).

To say that biomimicry has no location as a design practice *is*, however, to say that biomimicry is *mostly* talk in consulting and education. By my definition, biomimicry does not exist as a design practice, yet it also does not exist—stably, at least—as a "design"[47] practice outside of its use in consulting sessions, for reasons I will examine. It has never taken root in centers of science, design, or engineering. Biomimicry is, contrary to what Benyus says, not a field of "design" or "science." It is, rather, a field of consulting and education. *In Life's Likeness* is, therefore, the first ethnographic study of biomimicry as a consulting practice. In addition, *In Life's Likeness* is, by virtue of the sole existence of biomimicry *as* a consulting practice, the first ethnographic study of biomimicry *in* practice.[48] Much

[45] "Sometimes": As historians and anthropologists of design have shown, the labor of "design," the creation of form, is often institutionally, socially, and geographically distinct from form's manufacture/materialization into an object. For instance, see Adrian Forty, *Words and Buildings: A Vocabulary of Modern Architecture* (London: Thames & Hudson, 2000).
[46] Biomimics might make things, but not *through* biomimicry. On "things," see Bill Brown, eds. *Things* (Chicago: University of Chicago Press, 2004).
[47] When I reference biomimicry as a "design" practice, I am quoting their enactment of biomimicry as design. The reader should understand it, as I will argue, as a meta-design method.
[48] On anthropological studies of consulting, see Pamela Stewart and Andrew Strathern, eds., *Anthropology and Consultancy* (New York: Berghahn Books, 2004). On anthropological studies of corporate actors, refer to Melissa

of the existing scholarship on biomimicry centers on its discourse, what I call its metalanguage, with a textual focus on its cultural representations of nature, often but not always conflating it with its related mimetic practices of biomimetics and bionics.[49] Still, even ethnographic studies that recognize the distinctions between the discourses of biomimicry and biomimetics confuse them in practice, mis-representing biomimetics as biomimicry.[50] Using this lexicon of *mimetic practice*, *metalanguage*, and *meta-design*, my dissertation aims to clarify the historical and cultural specificity of biomimicry today, a specificity obscured by the *lack* of specificity with which biomimics themselves discuss biomimicry.

As an ethnography of consultants, this dissertation joins recent conversations in the anthropology of design about how "innovation" is enacted as a cultural category.[51] In particular, I am interested in how consultants in the 21st century mobilize ideas about biology (or, rather, their "folk" epistemology of biology[52]) to perform the innovativeness of life's imitations. Why has nature become a zone of value for innovation consultants, and how are notions of "life" transformed as they travel out of the laboratories of biologists and into the meeting spaces of business management professionals?

Cekfin, ed., *Ethnography and the Corporate Encounter: Reflections on Research in and of Corporations* (New York: Berghahn, 2009).

[49] See footnotes 14-18 and Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham: Duke University Press, 2007), esp. Chapter 8; Vincent Blok, "Biomimicry and the Materiality of Ecological Technology and Innovation," *Environmental Philosophy* 13.2 (2016): 195-214; Henry Dicks, "The Philosophy of Biomimicry," *Philosophy and Technology* 29 (2016): 223-243; Michael Fisch, "The Nature of Biomimicry: Toward a Novel Technological Culture," *Science, Technology, & Human Values* 42.5 (2017): 795-821; Elizabeth Johnson, "Reinventing Biological Life, Reinventing the Human," *Ephemera: Theory and Politics in Organization* 10.2 (2010): 177-193; Freya Mathews, "Toward a Deeper Philosophy of Biomimicry," *Organization & Environment* 24.4 (2011): 364-387; Jan Mueggenburg, "Clean by Nature: Lively Surfaces and the Holistic-Systemic Heritage of Contemporary Bionik," *communication +1* (2014), 3(9).

[50] Masco, Stahl, and Zerner correctly identify and analyze "biomimetics." Johnson acknowledges discursive differences between biomimicry and biomimetics but often conflates examples of the two (esp. Johnson 2011, see footnote 49). Davidov rightly notes that there *are* distinctions in discourse vs. "praxis" but then conflates the two.

[51] Lucy Suchman, "Anthropological Relocations and the Limits of Design," *Annual Review of Anthropology* 40 (2011): 1-18. See also Lilly Irani, *Chasing Innovation: Making Entrepreneurial Citizens in Modern India* (Princeton: Princeton University Press, 2019).

[52] On folk epistemologies of biology, see Sophia Roosth, "Evolutionary Yarns in Seahorse Valley: Living Tissues, Wooly Textiles, Theoretical Biologies," *differences* 23.3: 9-41. On ethnobiology or "folkbiology," see Douglas Medin and Scott Atran, eds., *Folkbiology* (Cambridge: MIT Press, 1999).

From the summer of 2015 to the fall of 2020, I conducted peripatetic fieldwork among the biomimics. Whereas biomimicry as "design" practice was nonexistent, my access to consulting spaces where trade secrets might be leaked was explicitly forbidden. To overcome this challenge, I attended lectures, workshops, conferences, competitions, and other public events and interviewed biomimics in sites outside their consulting firms—a methodology I theorize later in this chapter. Following these practitioners around the continental United States, from Boston to Berkeley, and Mexico and Canada, I found not one single mode of evaluation derived from the mimetic ethic that Benyus had articulated. Instead, as I watched and listened to biomimics as they assessed what matters in an artifact, I realized that biomimics alternated between different evaluative attitudes toward mimesis. "The original-copy relationship," writes Michael Lempert, "has been imagined variously through different ideologies."[53] To distinguish these local, situational "regimes of value" that I noticed from biomimicry's ideological metalanguage, I call them *mimetic stances*, and I define three: *pragmatic*, *idealistic*, and *performative.*

Mimetic stances take as their object of consideration the fidelity between an original and a copy—in biomimicry's case, the fidelity between biological and technological functions. In the pragmatic stance, common among biomimics working for clients, fidelity is secondary to the propensity for mimesis to generate new, useful functions. In the idealistic stance, which was prevalent in conversations *about* biomimicry, perfect fidelity to nature is paramount to the return of design to a state of harmony. In the performative stance, fidelity "matters," by which I mean that the appearance of mimeticism is held up as a source of what really counts: profit through the comparative advantage of an artifact over its economic competitors. While I situate these stances in the statements of specific individuals with particular disciplinary pedigrees, attitudes toward a copy do not map cleanly on a one-to-one-basis with discipline, context, or person. They manifest

[53] Lempert, "Imitation," 385.

in the flow of interaction, fluctuating by day, or hour, even in the same biomimic. The empirical crux of *In Life's Likeness* is thus: The "field" of biomimicry and its cognates is not a unified kind of design practice, as biomimics would agree, yet neither is biomimicry. Internal to this restricted community of practice is its own political field of contradiction and contestation—a multiplicity. Where Heidi portrayed the "field" as an (estranged) Wittgensteinian family of resemblances, I conjecture that, even within this family, each member contains in them, as it were, multitudes.[54]

The multiplication and proliferation of stances toward mimesis—the splintering or breaking down of the mimetic ethic into utilitarian criteria of evaluation characteristic of the design that biomimicry rejects—is a symptom of the impossible demand that designers face in a practice constrained by client preferences, time restrictions, and the profit imperative.[55] Within the chapters of this dissertation, anecdotes of shelved proposals, disinterested customers, and the cyclical temporality of project turnover tell a story about the failure of biomimicry to blossom as a "design" practice in architecture, engineering, and other contexts of a capitalist mode of design production. "In capitalist societies," the historian Adrian Forty reminds us, "the primary purpose of the manufacture of artefacts, a process of which design is a part, has to be to make a profit for the manufacturer."[56] For most of the designers that I spoke with, biomimicry was referred to as a "tool," a "technique," or a "heuristic" to be employed occasionally within a conventional process of design, mostly as a source of inspiration—not evaluation. Full adherence to the mimetic ethic, which requires designers to engage in an indefinite dialectic between and nature and technology, was structurally precluded by the economic sociality of contemporary design practice. Due to its

[54] Ludwig Wittgenstein, *Philosophical Investigations* (London: Pearson, 1973[1953]).
[55] I thank Mike Fischer for the language of "breaking down."
[56] Adrian Forty, *Objects of Desires: Design and Society Since 1750* (London: Thames & Hudson, 1992[1986]), 7. See also Regina Lee Blaszczyk, *Imagining Consumers: Design and Innovation from Wedgwood to Corning* (Baltimore: Johns Hopkins University Press, 2002) and Jeffrey Meickle, *Twentieth Century Limited: Industrial Design in America* 1925-1939 (Philadelphia: Temple University Press, 1979).

practical impossibility, designers and other biomimics reverted back to traditional design norms. What had appeared as separate ethnographic problems—the absence, or *non-space,* of "design" practices of biomimicry and the ethics of the copy—was thereby reduced to one "social fact" that biomimicry has not been realized, practically, *due to* the unbearable onus of the mimetic ethic.[57]

In Life's Likeness contends that attaining life's total likeness is a *utopian* ideal—the "desire called Utopia," as Frederic Jameson described it.[58] I use the word "utopia" to describe the mimetic ethic for its dual connotations as both a halcyon imaginary for the human but also, true to its linguistic origins, as a *non-space*, from the Greek words for not (*ou*) and space (*topos*). Unlike the "everyday utopias" that concern Davina Cooper, biomimicry exists primarily in dreams, thought, and speech, rarely materializing for long as production.[59] Ernst Bloch, in *The Principle of Hope*, distinguishes between "abstract utopias," or fantasies, and "concrete utopias," which obtain a material presence in the here-and-now.[60] While Benyus and her biomimics depict biomimicry as a concrete utopia within reach *through* everyday revisions within product design, in reality, biomimicry devolves into an abstract utopia. Less an object set than it is an orientation or ethic, biomimicry occupies no place because it places an impossible demand upon designers.[61]

The two forms of value biomimics negotiate, the mimetic ethic and Protestant ethic, are, as Keith Murphy might say, "always in an uncomfortable relationship."[62] In contradistinction to Adrian Forty's reduction of designers to "agents of ideology," Murphy has shown how designers

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[57] Marcel Mauss, *The Gift: The Form and Reason for Exchange in Archaic Societies* (New York: Routledge, 2001[1925). On Mauss's concept of the "social fact," see Claude Levi-Strauss, *Introduction to the Work of Marcel Mauss* (New York: Routledge, 1987[1950]).
[58] Fredric Jameson, *Archaeologies of the Future: The Desire Called Utopia and Other Science Fictions* (New York: Verso, 2007).
[59] Davina Cooper, *Everyday Utopias: The Conceptual Life of Promising Spaces* (Durham: Duke University Press, 2013).
[60] Ernst Bloch, *The Principle of Hope* (Cambridge: MIT Press, 1995[1954]).
[61] On objects versus orientations in utopian studies, see Cooper, *Everyday Utopias*.
[62] Keith Murphy, *Swedish Design: An Ethnography* (Ithaca: Cornell University Press, 2015), 91.

navigate between conflicting priorities—an economic need to make money and personal interests in politicized aesthetics—by disaffiliating or disavowing the meanings of their designed artifacts, permitting semiotic latitude.[63] In this dissertation, I elaborate this contradiction in the contexts of economics and ethics—not (just) politics—by showing how the biomimicry community responds to the present unattainability of mimetic design by endlessly preaching and promoting the virtues of their vision of our ecological, technological future, "hoping" to reform their society's values.[64] The profession of biomimicry is thus, as Anne Rademacher has said it, a "vocation in waiting."[65]

My dissertation thus contributes to an anthropology of "the ethical" in design.[66] In his review of the "anthropology of design," Murphy opines that the rise of this subfield is an artefact of the "moral entanglements…of humans provisioning for one another the conditions of life,"[67] i.e., of the "expansion" of design in 21st century world-building.[68] Despite the causative role of morality in the genesis of "design" as an ethnographic object, or ethics as I prefer to call it,[69] an explicit analysis of ethics in design—the ethics *of* designers—has eluded anthropological theory. In conversation with anthropologists of ethics, a subfield that emerged around the same time as

[63] Forty, *Objects of Desire*, 242.
[64] For a review of the anthropological literature on hope, see Stefaan Jansen, "The Anthropology of Hope," in *Oxford Research Encyclopedia of Anthropology* (Oxford: Oxford University Press, 2021).
[65] Anne Rademacher, *Building Green: Environmental Architects and the Struggle for Sustainability in Mumbai* (Berkeley: University of California Press, 2018), 10.
[66] On the "ethical," see Michael Lambek, *The Ethical Condition: Essays on Action, Person, and Value* (Chicago: University of Chicago Press, 2015). I envision an anthropology of ethics in design in contradistinctions to what has been a predominant emphasis on technics. See, for instance, Zeynep Çelik Alexander and John May, eds., *Design Technics: Archaeologies of Architectural Practice* (Minneapolis: University of Minnesota Press, 2019). Within the anthropology of design, ethics has been an under-examined issue. A discipline-wide review of architecture made no mention of ethics; see Victor Buchi, *An Anthropology of Architecture* (New York: Routledge, 2013). Where "ethics" does occur, it is largely in passing, or else focused less on ethics as lived experience. See, for instance, Rademacher on "moral ecology," *Building Green*. Consider, also, Cassandra Hartblay, "Good Ramps, Bad Ramps; Centralized Design Standards and Disability Access in Urban Russian Infrastructure," *American Ethnologist* 44.1 (2017): 9-22.
[67] Keith Murphy, "Design and Anthropology," *Annual Review of Anthropology* 45 (2016): 433-449, 444. See also Flusser, *The Shape of Things*.
[68] Bruno Latour, "A Cautious Prometheus? A Few Steps Toward a Philosophy of Design (with Special Attention to Peter Sloterdijk)," Keynote lecture for the *Networks of Design* meeting of the Design History Society, 1-13.
[69] On ethics versus morality, see Lambek, *The Ethical Condition*.

the anthropology of design,[70] specifically those scholars who follow Michel Foucault in thinking about ethics as a relation to the self,[71] this dissertation asks how biomimics constitute themselves as "good" designers according to the mimetic ethic. While questions of the self are not unknown to anthropologists of design, I seek to analyze how the mimetic ethic directs biomimics toward a negation of the self that is seen as a prerequisite to post-anthropocentric design (Chapter Two).[72] In so doing, I aim to understand the phenomenology of design as an ethical domain but also how, at times, the ethical is materially foreclosed by the institutional realities of contemporary design. Just as relevant to an anthropology of the "good life" is an anthropology of the good enough life.

If there is any "magic" at play in the mimesis of biomimicry, and magic is what anthropologists have long affiliated with the mimetic, it is this: Biomimicry conjures the illusion of a quixotic mode of design that does not correspond with practice anywhere.[73] Through a focus on the *praxis* and *topoi* of biomimicry—what it is that biomimics do and where—my dissertation intends to dispel the illusion that has proven to be so enchanting, rousing the utopic fantasies and dystopic fears of the boosters and critics who open the chapter. It should be apparent that my aim

[70] For a review, see Cheryl Mattingly and Jason Throop, "The Anthropology of Ethics and Morality," *Annual Review of Anthropology* 47 (2018): 475-492.

[71] A representative but not exhaustive list would include: Heather Paxson, *Making Modern Mothers: Ethics and Family Planning in Urban Greece* (Berkeley: University of California Press, 2004); Saba Mahmood, *Politics of Piety: The Islamic Revival and the Feminist Subject* (Princeton: Princeton University Press, 2004); Joel Robbins, *Becoming Sinners: Christianity and Moral Torment in a Papua New Guinea Society* (Berkeley: University of California Press, 2004); Charles Hirschkind, *The Ethical Soundscape: Cassette Sermons and Islamic Counterpublics* (New York: Columbia University Press, 2006); James Faubion, *An Anthropology of Ethics* (Cambridge: Cambridge University Press, 2011); Rachel Prentice, *Bodies in Formation: An Ethnography of Anatomy and Surgery* (Durham: Duke University Press, 2012); James Laidlaw, *The Subject of Virtue: An Anthropology of Ethics and Freedom* (Cambridge: Cambridge University Press, 2014).

[72] For instance, Lily Chumley speaks of the "aesthetic self," Thomas Yarrow speaks of the "architectural self" (and, conversely, of "selfless design"), and Lilly Irani of the "entrepreneurial ethos." Nevertheless, their attention has been on the presentation of the self and less on the relation of the subject to the self—that is, a relation of judgment, of the weighing of one's actions against criteria of rightness, of, in short, ethics. See Lily Chumley, *Creativity Class: Art School and Culture Work in Postsocialist China* (Durham: Duke University Press, 2016); Lilly Irani, *Chasing Innovation*; Thomas Yarrow, *Architects: Portraits of a Practice* (Ithaca: Cornell University Press, 2019).

[73] The "magic" of mimesis is a reference to James Frazer's concept of "sympathetic magic." See James Frazer, *The Golden Bough* (Oxford: Oxford University Press, 2009[1890]), 26. Cf. Taussig, *Mimesis and Alterity*.

is not to conduct an ethnographic study of biomimicry's bioeconomy that would complement the existing literature on "biocapitalism,"[74] which Johnson and Goldstein have attempted, one quite significant reason being that this bioeconomy has not yet materialized. Instead, *In Life's Likeness* avers that Flusser's sensational query about licking or biting stone jackals is, really, a moot point. As of today, such "naturecultures" exist largely in the fictive space of the consultant's promise.[75] "Life," as biologists understand it, has not birthed many "technological breakthroughs" because biomimics in practice cannot normally imitate life in any deep or meaningful sense. Instead, they generate simulacra of life that reflect capitalist imperatives more than a post-human design logic.

In the remainder of this introduction, I survey the contemporary field of biomimicry. Opening with an intellectual, institutional history of biomimicry, I chronicle how Benyus spoke a new metalanguage out of the mimetic practices of biomimetics and bionics, re-presenting what had been a conversation about biological "efficiency" in the cybernetic milieu of the 1960s into a discourse about mimesis as a means of "sustainable innovation." Glossing what had been distinct mimetic practices as tokens of the same underlying type, Benyus gave this empty ideology a body during her work as an innovation consultant. Through an organizational sociology of what I refer to, collectively, as the Biomimicry Conglomeration™, I relay how Benyus and her business partner, Dayna Baumeister, devised their proprietary "design" methodology—a mimetic practice, unlike its predecessors, which I conceptualize as meta-design. This method, I show, circulates as a knowledge commodity in two forms: as paid counsel for product design and as a reproducible style of "design" expertise, learned at a cost. Around this latter form, these two consultants have gathered a community of biomimics who replicate the metalanguage and method of biomimicry.

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[74] See footnote 13.
[75] Donna Haraway, *The Companion Species Manifesto: Dogs, People, and Significant Otherness* (Chicago: University of Chicago Press, 2003).

The rise of biomimicry as a "meme" and "movement"—a community relying on bionics and biomimetics for legitimacy even as it renounces their ethics—has created a source of "friction" or ambivalence within the broader "field" of nature-based design.[76] Reflecting on this and other methodological challenges that come with the study of corporate secrets, I conclude with a look to the layout of the dissertation, told through the lens of mimetic stance, as well as the interludes.

"Bound to a Moment in Time": On the Historicity of Biomimicry

Histories of architecture, art, philosophy, and science have characterized the relations between nature and artifice as an "evolving polarity," in the words of Bernadette Bensaude-Vincent and William Newman.[77] In short, the meaning of "nature" and "artifice," as well as the form of their dis/union (i.e. mimesis), are culturally and historically contingent phenomena. Thus the sinuous nature of Art Nouveau and its curving decorative motifs is not the same nature invoked either by Frank Lloyd Wright's and Javier Senosian's organic architecture or by Paolo Soleri's arcology. It is for this reason that the sheer breadth of nature-inspired artifacts deters an exhaustively total genealogy of the technical mimesis of life, which, in the modern West alone, would have to flow from Filippo Brunelleschi, Leonardo da Vinci, Jakob Chrysostomus Praetorius, Rene-Antoine Reamur, George Cayley, Otto Lilienthal, Wilbur and Orville Wright, up till George de Mestral.[78]

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[76] Anna Lowenhaupt Tsing, *Friction: An Ethnography of Global Connection* (Princeton: Princeton University Press, 2004). As "biomimicry" has become a category describing mimetic practices, it often generates what Tsing calls "friction" between the universal and the particular, between biomimicry and, for instance, biomimetics or bionics.

[77] Bernadette Bensaude-Vincent and William Newman, eds., *The Artificial and the Natural: An Evolving Polarity* (Cambridge: MIT Press, 2007). On "nature" versus artifice, see Raymond Williams, *Keywords: A Vocabulary of Culture and Society* (London: Croom Helm, 1976). See also Forty, *Words and Buildings*, esp. the entry on "nature." For other studies of the relationship of nature and artifice in design, see Jessica Riskin, *Genesis Redux: Essays in the History and Philosophy of Artificial Life* (Chicago: University of Chicago Press, 2007); Sophia Roosth, *Synthetic: How Life Got Made* (Chicago: University of Chicago Press, 2017); Philip Steadman, *The Evolution of Designs: Biological Analogy in Architecture and the Applied Arts* (London: Routledge, 2008[1979]); Charissa Terranova and Meredith Tromble, eds., *The Routledge Companion to Biology in Art and Architecture* (London: Routledge, 2019).

[78] This is, of course, to say nothing about nature-inspired traditions in non-Western contexts, not merely in the recent past (i.e. the Japanese Metabolists), but, as Mike Fischer reminded me, in "vernacular design traditions being called on today by architects in Japan, Egypt, India, etc," including "the pols of Gujurat that were inspirations for the

Even a historical account of schools of thought in the technical mimesis of life runs against questions of justification. Does one begin with the explication of those *technē mimētikē*, or "mimetic arts," in Aristotle's *Poetics* and its later elaboration by modern aesthetic theorists into the maxim that "art imitates nature"?[79] Or does one, perhaps, start more recently, with the 19th-century parson-naturalist John George Wood, who defended natural theology from Darwin's evolutionism by identifying signs of divine handiwork in those "human inventions anticipated by Nature," among them the raft, saw, hut, and comb?[80] Closer still to the present, should one root biomimicry in the "romantic biology" of Raoul Francé, whose idea of *biotechnik* envisioned a return to the functional harmony of nature vis-à-vis the imitation of biological forms/functions?[81]

Examining how biomimics narrate their own histories—what Charles Stewart calls "historicities"—offers one inroad into a history of biomimicry.[82] In an article in *Design Studies*, the biomimic Emily Kennedy and her colleagues express one such historicity that I would hear throughout my fieldwork. "Biology has inspired design since prehistoric man fashioned spears from the teeth of animals and mimicked the effective sneak-and-pounce hunting technique of large predators," they write, "but the development of a methodological framework for translating

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architect Desai…the adobe architecture for affordable housing pioneered by Egyptian architect Hasan Fathy, or the adaptations of traditional wind towers…in the modern gulf…Douglas Cardinal's inspiration from his Indigenous roots in Canada (along with other influences), or indeed Nader Ardalan's buildings in Iran such as the Harvard Business School (now Jafaar Sadeq university, which profoundly draws on geometric design as does much of bio" (email correspondence).

[79] Francis Wolff, "The Three Pleasures of Mimēsis according to Aristotle's *Poetics*," in Bensaude-Vincent and Newman, eds., *The Natural and the Artificial*, 51-66.

[80] John George Wood, *Nature's Teachings: Human Invention Anticipated by Nature* (London: Daldy & Isbister, 1877). On Wood, see Bernard Lightman, *Victorian Popularizers of Science: Designing Nature for New Audiences* (Chicago: University of Chicago Press, 2009).

[81] On Francé's oeuvre, see Oliver Botar, "The Biocentric Bauhaus," in Terranova and Tromble, eds., *The Routledge Companion to Biology in Art and Architecture*; Robert Bud, *The Uses of Life: A History of Biotechnology* (Cambridge: Cambridge University Press, 1993), esp. Chapter 3; and Detlef Mertins, "Where Architecture Meets Biology: An Interview with Detlef Mertins," in *Interact or Die!*, eds. Joke Brouwer and Arjen Mulder (Rotterdam: V2, 2007), 110-131.

[82] Cultural perceptions of the past, or historicities, are less transparent glimpses of the objective time of Western historicism than they are points of entrée into the logics, politics, and affects that structure and surround the social experience of time. Charles Stewart, "Historicity and Anthropology," *Annual Review of Anthropology* 45: 79-94.

biological strategies into design innovations is a recent one."[83] As historians and anthropologists of history have noted, the interpretation of the past betrays cultural ideas of humanity, kinship, & value.[84] These biomimics, in their history of bioinspiration, simultaneously assert the continuities between the present and the past, ascribing an anthropological time*less*ness to biomimicry that I interrogate in the interludes, as well as its discontinuities. In this latter sense, biomimicry appears as a time*ly* method—a temporal novelty that invests their practice with cachet. On the "origin" of this "methodological framework," most annalists—advocates *and* detractors—trace an unbroken connection between biomimetics and biomimicry.[85] As I argue in this chapter, however, such ties of kinship are often severed by biomimics themselves. In what follows, I too begin with a history of midcentury cybernetics, but not to avouch a seamless progression from the one into the other. Moving from the past to the present, I instead show how the development of biomimicry created an ambivalent, ambiguous relationship to the past, making the question of origins a fraught one.

Meta-Science: The Cybernetic "Origin" of Biomimicry

Cybernetics, famously defined by one of its founders, Norbert Wiener, as the "scientific study of control and communication in the animal and the machine," brought together an interdisciplinary cast of mathematicians, engineers, biologists, and social scientists in an American postwar program convened to investigate the phenomena of feedback in communications engineering.[86] In Geoffrey Bowker's words, cybernetics was a "meta-science" or "universal discipline" that offered tools or terms applicable across disciplinary lines and, indeed, boldly crossed those lines

[83] Kennedy et al., "Biomimicry," 66.
[84] For a review, see Stewart, "Historicity and Anthropology."
[85] For instance, see Veronika Kapsali, *Biomimicry for Designers: Applying Nature's Processes and Materials in the Real World* (London: Thames & Hudson, 2016) and Michael Pawlyn, *Biomimicry in Architecture* (London: RIBA Publishing, 2016[2011]). Critics likewise see cybernetics as the origin. E.g., see Johnson, "Reanimating *Bios*."
[86] Norbert Wiener, *Cybernetics, or Control and Communication in the Animal and the Machine*, (Cambridge, MIT Press, 1948).

without trepidation, expanding the domain of communications engineering from telephones and other traditional media of communication to organic life.[87] For the cyberneticians who gathered at the inaugural Macy Conferences from 1946 to 1953, the concept uniting their diverse areas of expertise was Claude Shannon's idea of "information," a ratio that quantified signal to noise.[88]

These cyberneticians found, in information, a bridge to liken organism to machine, and vice versa; information analogized both as means of communication, their embodiment made secondary to their information-feedback behavior.[89] By the application of a communication engineering framework to the ontology of life, living organisms became icons of information. For some cyberneticians, information permitted more than analogy, birthing physical hybrids. Such cybernetic artifacts took diverse form, but the most salient one today remains the cyborg, a human mechanically outfitted to improve his survivability in hostile environments. In a short paper from 1960, Manfred Clynes and Nathan Kline coined the word "cyborg" to characterize products of non-hereditary, machine-assisted evolution.[90] Initially conceived for extraterrestrial travel, exploration, and, ultimately, colonization, the first cybernetic organism was, in actuality, a white rat, technologically retrofitted with a homeostatic pump for regulated hormone secretion.[91]

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[87] Geoffrey Bowker, "How to Be Universal: Some Cybernetic Strategies, 1943-1970," *Social Studies of Science* (1994), 23(1): 107-127.
[88] See N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*, (Chicago, University of Chicago Press, 1999). See also Ronald Kline, *The Cybernetics Moment: Why We Call Our Age the Information Age*, (Baltimore: Johns Hopkins University Press, 2015), for a detailed historical account of how Shannon's theory of information was selected over Wiener's as the lingua franca of cybernetics.
[89] A prerequisite to the analogy of organisms and machines was the construction of the neuronal model of information processing by Warren McCulloch and Walter Pitts. Henceforth, organisms and machines became instantiations of a universal process. See Hayles, *How We Became Posthuman*; Kline, *The Cybernetics Moment*. For an exceptional critique of the "disembodiment" theory of cybernetics, see Mara Mills, "On Disability and Cybernetics: Helen Keller, Norbert Wiener, and the Hearing Glove," *differences* 22(2-3): 74-111.
[90] Manfred E. Clynes and Nathan S. Kline, "Cyborgs and Space," in Chris Hables Gray, ed., *The Cyborg Handbook*, (New York: Routledge, 1995), 29-34.
[91] Donna Haraway, "Cyborgs and Symbionts: Living Together in the New World Order," in Gray, *The Cyborg Handbook*.

Cyborgs, however, were not the only artifacts manufactured across the better part of a century of cybernetic research. In fact, the cybernetic project to remake life through technology comprised only one half of its original ambitions, which also encompassed the use of biological models to remake technology in their like-ness, their life-ness.[92] This lesser-known lineage focuses on the transformation, not of the living through the technological, but the technological through the living, i.e., on the biological analogies that communications engineers, and then other engineers and scientists, would draw upon to imagine and construct new modes of artifice. Named *bionics* and *biomimetics*, this alternative tradition sprang from second-order cybernetics and acquired a life of its own, with research laboratories and academic centers dedicated to the discovery, and application, of the technical design principles embodied in biological organisms.

The word "bionics" was first coined by Colonel Jack E. Steele, then a major with the United States Air Force's Aerospace Medical Division. Drawing from the famed cyberneticians Heinz von Foerster and Warren McCulloch's research at MIT on "biological computers," a project which sought to mimic how frog eyes process visual stimuli, Steele created the term by merging *bios* (the Greek term for life that Steele chose for its connotations of "function") with electronics, as "the discipline of using principles derived from living systems in the solution of design problems."[93] Over the 1960s, Steele and others passionately explored the potential of this "biological-engineering science" to revolutionize military technologies, particularly in the areas of data processing and power efficiency, through a series of Bionics Symposia held in Dayton, Ohio, at the Wright Patterson Air Force Base.[94] At the first meeting, Steele offered his vision:

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[92] For a fuller explication of this duality, see Kline, *The Cybernetics Moment,* Ch. 6.
[93] Jack E. Steele, "An Interview with Jack E. Steele," 61-69, in Gray, ed., *The Cyborg Handbook*, 62. Steele first used the term in 1959, republished as Jack E. Steele, "How Do We Get There?" 55-59, in Gray, ed., *The Cyborg Handbook*. For histories of bionics, in particular von Foerster and McCulloch's research on frogs, see Kline, *The Cybernetics Moment*, Ch. 6, and Mueggenburg, "Clean by Nature."
[94] Rene Roth, "The Foundation of Bionics," *Perspectives in Biology and Medicine* (1983), 26(2): 229-42, 229. See Kline, *The Cybernetics Moment*, and Mueggenburg, "Clean by Nature," for a discussion of these symposia.

"Apparently we are going to design devices and systems, which to the naïve observer might appear to be alive. They will employ processes and techniques and accomplish functions, which hitherto have existed only in living systems."[95] To Steele, life exemplified functional efficiency.

The meaning of bionics as a discipline later shifted to connote biomechatronics (i.e. animalesque robots, such as mechanical cockroaches, lobsters, or cheetahs), medical prosthetics, and wearable computing, thanks in no small part to the popular success that Martin Caidin's science fiction novel *Cyborg* and its TV spin-off *The Six Million Dollar Man* had in capturing the public's imagination of the "Bionic Man," also known as Steve Austin, an esteemed pilot who suffers a violent and near-fatal accident that disfigures him, only to have his limbs and organs surgically replaced by mechanical analogues "better than the original" but "that could not be distinguished by the observer as artificial."[96] These fictional media redirected attention from biology as a model electronic circuit toward bio-mechanisms replacing once-anatomical parts.[97]

Also present at the first Bionics Symposium was the American polymath Otto Schmidt, who worried the word "bionics" sounded like "Sputnik," a pseudo-homophone that might take away from the perceived superiority of American technology. (Schmidt was also concerned that the word placed undue emphasis on the *functions* of life, excluding its materials and structures). While Schmitt did not publicize the word "biomimetics" until 1969, he conceived the idea in 1957 in reply to what he saw as the limited exploration of the possibilities of biophysics, which had matured, in his time, as a sub-field of biological research, and which he had pursued in his own doctoral work on a squid-inspired feedback circuit: the titular Schmitt trigger. "Biophysics

[95] Mueggenburg, "Clean by Nature," 12-13.
[96] Martin Caidin, *Cyborg*, (New York, Warner Books, 1972), 101, 73.
[97] In Germany, the word "*Bionik"* describes work that, in the US, would be called biomimetics. Ingo Rechenberg and Werner Nachtigall were key practitioners of this tradition. See Mueggenberg, "Clean by Nature." On the role that the Bionic Man character played in the semantics of bionics, reference Kline, *The Cybernetics Moment*, 167.

is not so much a subject matter as it is a point of view," he wrote. "It is an approach to problems of biological science utilizing the theory and technology of the physical sciences. Conversely, biophysics is also a biologist's approach to problems of physical science and engineering, although this aspect has largely been neglected."[98] Thus the science of biomimetics was born.

Over the 1970s and 1980s, biomimetics—"a biologist's approach to problems of physical science and engineering"—became a signifier for a diverse research program that recuperated the then-flagging meta-science of cybernetics. It fused the latter's practical interest in the design principles of living organisms with extant lines of inquiry in computer science, chemistry, and materials science, not just robotics.[99] In biomimetics, life's structure, materials, and processes are paragons of energy efficiency and multi-functionality. Spurred by the Revolution in Military Affairs (RMA), which used biological sciences to bolster operations research, the United States Armed Forces again visited the potential of cybernetics in the 1990s, with programs for research on biomimetics, not just from the Army, Air Force, and Navy, but also, and more heavily, from the Defense Advanced Research Projects Agency (DARPA).[100] These programs commanded large sums of federal money for research projects that advance the military's tactical objectives. Today, most biomimetics centers, programs, and studies owe their existence to DARPA funding, including the Ortiz laboratory and its interest in armor applications of the scales of *P. senegalus.*

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[98] Jon Harkness, "In Appreciation: A Lifetime of Connections, Otto Herbert Schmitt, 1913-1998," *Physics in Perspective* (2002), 4(4): 456-490, 481. Schmitt first uses the term "biomimetics" in Otto Schmitt, "Some Interesting and Useful Biomimetic Transforms," *Proceedings of the Third International Biophysics Congress* (1969), August 29 to September 3, 297.

[99] Much of this research played out in England, where the zoologist Julian Vincent and the engineer George Jeronimidis examined the structural and mechanical properties of animals and plants, later establishing the Centre for Biomimetics at Reading University in 1991 and the Centre for Biomimetics and Natural Technologies at Bath University in 2000. See Kapsali, *Biomimicry for Designers.*

[100] See Johnson, "Reinventing Biological Life, Reinventing the 'Human,'" for a full description of these programs and their relationship to the RMA. For an overview of the Revolution in Military Affairs, see Elinor C. Sloan, *The Revolution in Military Affairs* (Montreal, Canada: The McGill-Queen's University Press, 2002).

While both bionics and biomimetics crystallized out of the same postwar cybernetic milieu, equating organisms and machines through the information concept and idealizing life's untold functional efficiencies, these two similar discourses diverged down distinct historical pathways. To paraphrase Michel Foucault, before the turn of the twenty-first century, there was no conception of biomimicry, all that existed was bionics and biomimetics—two genealogically related mimetic practices that drifted slowly across the institutional geography of disciplines.[101]

Meta-Language: The Invention of Biomimicry

In an interview almost twenty years after the publication of *Biomimicry* in 1997, Janine Benyus reflected on her motivation for creating the neologism "biomimicry": "What I did in *Biomimicry* was notice that a nature-inspired approach to innovation was starting to stir, but it had no name! I baptized it biomimicry, and to my surprise, it proved to be a catchy meme!"[102] Catchy, it was. For her popular work on biomimicry, Benyus has won numerous accolades, from environmental awards and business merits to recognitions of her influence in design, including BusinessWeek's "Most Influential Designer" and the Cooper-Hewitt National Design Mind Award, which, as the Smithsonian Institute explains, is "given in recognition of a visionary who has had a profound impact on design theory, practice, or public awareness."[103] Despite her public image as a design practitioner, however, Benyus's early biography reveals another personage—a natural historian.

Janine Benyus was born just outside New York City in 1958. Five years prior, Rachel Carson published *Silent Spring*, the book that galvanized the American environmentalism

[101] Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York, NY: Vintage, 1994). Another kind of "drift" can be seen in the "biosurgical arts." See Fischer, *Anthropological Futures*, esp. Chapter 4.
[102] Jared Green, "Interview with Janine Benyus on How to Design like Nature," *The Dirt,* November 4, 2015, https://dirt.asla.org/2015/11/04/interview-with-janine-benyus-on-how-to-design-like-nature/.
[103] Cooper Hewitt, "Award Categories," accessed September 27, 2021, https://www.cooperhewitt.org/national-design-awards/award-categories-2/.

movement. Among its ranks was Benyus, who read Carson's book at an early age. Growing up as a "nature nerd" in the suburbs of New Jersey, Benyus recounts a "story of loss"—the leveling of a precious meadow where she would chase after insects and collect flowers—as an inspiration to pursue sustainability. To begin this journey, Benyus enrolled at Rutgers University, where she double majored in natural resource management ("forestry," she says) as well as English writing and literature. After college, Benyus joined the United States Forest Service.[104] During that time, she edited the *Christmas Tree Pest Manual*, based on scientific research conducted at the North Central Forest Experiment Station in St. Paul, Minnesota.[105] Her career as an author of books on natural history thenceforth blossomed. From 1989 to 1992, she translated her experience leading backpacking tours into four "field guides" on the observation of wild- and zoo-life.[106] During this period, Benyus recalls that she became fascinated with environmental "adaptations" in biology versus technology and its mal-adaptions.[107] Starting in 1990, she started to clip and file away articles on researchers who were not just studying life's adaptations, but copying them, too.

In *Biomimicry*, Benyus showcased these individuals to advertise, not another story of "loss," but one of "hope," marshalling together a mixed company of biologists, engineers, architects, activists, economists, architects, and agriculturalists under the banner of biomimicry. These "biomimics," she reported, "are exploring nature's masterpieces…and then copying these

[104] Simon Richardson, "Natural Design," *Evolution* (October 1, 2014), https://evolution.skf.com/us/natural-design/. On natural resource management, particularly in the context of North America (specifically, Canada), see Tom Özden-Schilling, "Salvage Cartographies: Mapping, Futures, and Landscapes in Northwest British Columbia," PhD diss. (Massachusetts Institute of Technology, 2016). What Özden-Schilling's work makes visible is the conflict between state and Indigenous imaginaries of forest landscapes that Benyus's work metamorphoses into a conflict between "Western" and "native" design (see Interlude One).
[105] Janine Benyus, *Christmas Tree Pest Manual* (St. Paul: U.S. Department of Agriculture, 1983).
[106] Janine Benyus, *Northwoods Wildlife: A Watcher's Guide to Habitats* (UNKNO, 1989); Janine Benyus, *The Field Guide to Wildlife Habitats of the Eastern United States* (New York: Touchstone, 1989); Janine Benyus, *Wildlife in the Upper Great Lakes Region: A Community Profile* (St. Paul: US. Department of Agriculture, 1992); Janine Benyus, *Beastly Behaviors: A Zoo Lover's Companion* (Boston: Addison-Wesley, 1993)
[107] Richardson, "Natural Design."

designs…to solve our own problems," which she described as "innovation inspired by nature."[108] Alongside bionics and biomimetics researchers who had toiled away in scientific laboratories to imitate the efficiencies of biological functions (e.g. Steven Vogel), Benyus placed agriculturalists tilling the field of sustainable farming (e.g. Wes Jackson, Masanobu Fukuoka, Bill Mollison, and Michael Ableman) and ecological architects such as John and Nancy Todd and Ken Yeang.

Institutionally and ideologically, these mimetic practices could hardly be more dissimilar. If the technorationalism of cybernetics valued nature for its technical efficiencies, these other two communities of mimetic practice in agriculture and architecture construe the mimesis of life as a harmonious return to nature's unity—exemplars of a philosophy of nature that the historian Oliver Botar terms "biocentrism," the "early 20th century world view that, based on Darwinism, neo-Larmackism, biological determinism, Nietzcheanism, and a materialist nature romanticism, rejected anthropocentrism and espoused a Monist, neo-Vitalist, and ecological [world]view."[109]

What connects these multifarious "design" practices, as Benyus labeled them, each of which involved an expressed (albeit differentially valued) mimetic dimension, was their unity as modes of sustainable innovation. I view her discourse of biomimicry as an instance of what Michael Lempert identifies as a "metalanguage of imitation," a reflexive, denotationally explicit language *about* one or more mimetic practices.[110] Whereas metalanguages of imitation can name and judge people (e.g. "posers, frauds, phonies") or qualities (e.g. "sincerity and authenticity"), they can also, as in the case of biomimicry, comprise religious or philosophical doctrines that concern imitation or its family terms: repetition, analogy, mimesis. From an anthropological

[108] Benyus, *Biomimicry*, 2.
[109] Botar, "The Biocentric Bauhaus," 18.
[110] Lempert, "Imitation," 390.

perspective, metalanguages "matter," Lempert argues, "because they can publicly frame events as mimetic and invest them with value."[111] Likewise, Benyus re-framed imitation as innovation.

Through a syncretic, romantic reading of evolutionary biology, systems theory, and ecological science, Benyus fused post-cybernetic interests in life's technical efficiencies with environmental concerns for the "sustainability" of human existence—economic, technological, social—that arose after the UN Brundtland Commission of 1987.[112] If human technologies could imitate life's efficiencies, then, Benyus reasoned, we could sustain our livelihoods without the same degree of energy use and extraction.[113] Benyus thereby classified bionics and biomimetics, and natural agriculture and ecological architecture, as one species of imitation, erasing their practico-ideological differences in order to foreground the technological mimesis of nature as a "path for sustainable innovation." Essential to the synthesis of efficiency and sustainability was a New Age environmentalist reading of gendered Mother Nature as a being of mystical wisdom.[114]

Moreover, Benyus proposed that biomimicry could generate "guilt-free design" that facilitates perpetual consumption without environmental consequence.[115] Informed by books like

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[111] Lempert, "Imitation," 383. Like the "hegemonic master narrative" that Lily Kay described in her study of the informationalization of 20th century biology, the metalanguage of imitation controls public perceptions of the consulting practice of biomimicry by likening biomimicry to biomimetics. See Lily Kay, *Who Wrote the Book of Life?* (Stanford: Stanford University Press, 2000).

[112] Benyus cites living systems theorists like James Grier Miller and Fritjof Capra. She also cites environmentalists like Bill McKibben, Rachel Carson, James and Roberta Swan, Stewart Brand, Wendell Berry, and Daniel Chiras. On the history of sustainability discourse, see Jacobus A. Du Pisani, "Sustainable Development – Historical Roots of the Concept," *Environmental Sciences* 3.2 (2006): 83-96; Richard Hölzl, "Historicizing Sustainability: German Scientific Forestry in the Eighteenth and Nineteenth Centuries," *Science as Culture* 19.4 (2010): 431-460; Emma Rothschild, "Maintaining (Environmental) Capital Intact," *Modern Intellectual History* 8.1 (2011): 193-212; and Paul Warde, "The Invention of Sustainability," *Modern Intellectual History* 8.1 (2011): 153-170.

[113] The cybernetician Felix Patturi offers this link between efficiency and sustainability. See Felix Paturi, *Nature, Mother of Invention: The Engineering of Plant Life* (London: Harper & Row, 1976).

[114] On the gender of nature, see Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven: Yale University Press, 1985; Donna Haraway, "A Manifesto for Cyborgs: Science, Technology, and Socialist Feminism in the 1980s," *Socialist Review* 80 (1985): 65–108; Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (New York City: Harper, 1980); and Virginia Scharff, ed., *Seeing Nature through Gender* (Lawrence: University of Kansas Press, 2003).

[115] See also Kennedy et al., "Biomimicry," in which they praise that "biomimicry…allows designers to continue earning a living within a system dominated by consumer culture," 67. Cf. Johnson, "Reconsidering Mimesis."

The Ecology of Commerce, in which Paul Hawken (the founder of Erewhon Trading Company, a natural food wholesaler) advances the thesis that capitalism can advance environmentalist aims, Benyus contended that biomimicry was precisely what businesses needed to practice to conform to the ecological context of the planet. "The design of sustainable products" through biomimicry, she wrote, "may actually precede the sustainability revolution and help bring it into being," later adding that "designing may be the most powerful fulcrum from which we can move the economy and the culture toward a more sustainable place…Designers have been trained to capture the dreams and aspirations of society—what we are or hope to be."[116] While Benyus recollects that *Biomimicry* was intended as "just another book" in a series on nature's wonders, her stories resounded in boardrooms, studios, and beyond, where her message of "hope" heralded a future of profitability and planetary wellbeing.[117] Life, as one could say, had other designs for Benyus.

Meta-Design: Commodifying Biomimicry through Innovation Consulting

In *Biomimicry*, Benyus invented a mimetic metalanguage—biomimicry—that, strictly speaking, did not yet exist, subsuming extant terms and ideologies about hitherto distinct mimetic practices within a discursive assemblage about "design." Since 1997, she has spun a *new* mimetic practice from this metalanguage, devising a routine method for innovation consulting on product design (one that was epistemologically absent in previous mimetic practices: bionics, biomimetics, etc.)

After the release of *Biomimicry*, Benyus received multiple inquiries from major corporations such as Boeing, General Electric, and Nike, who all sought to consult her on how

[116] Benyus, *Biomimicry*, 282, 281.
[117] Mark Fishman, "Masters of Design," *Fast Company* online, June 1, 2005, https://www.fastcompany.com/53241/masters-design.

to incorporate mimesis into their product innovation processes. Since the 1930s, as the historian Christopher McKenna traces, management consulting or "engineering," as it was first known, has developed as a "particularly American form of professionalized corporate counsel."[118] Unlike Taylorism, which focused on the choreography of bodies on the factory floor, management consulting firms, such as McKinsey & Company, Bain & Company, and Boston Consulting Group (the Big Three), eyed corporate organization, strategy, and operation.[119] As product innovation, the management of technological change, became an object of consulting firms in the latter half of the 20th century, specialized innovation consultants advised businesses on how to retain or gain economic competitiveness in a political economy of newness by shifting internal company policies toward the rapid development of novel products and product lines.[120] Increasingly, as the anthropologist Lilly Irani has noted, this advice has been delivered through "design thinking" methods—a corporatized approach to the ideation of products and markets.[121] For some of the companies that contacted Benyus, mimesis promised a new "path" to innovation. For others, mimesis promised "sustainable innovation." With the rise of what Jesse Goldstein has termed "business environmentalism," many companies now seek ways to reduce their ecological impact while still turning profits, just as consumers have started to value "green" products.[122]

[118] Christopher McKenna, "The Origins of Modern Management Consulting," *Business and Economic History* 24.1 (1995): 51-58, 57.
[119] The Big Three in management consulting are distinct from the Big Four in accounting: Deloitte, Ernst & Young, KPMG, and PricewaterhouseCoopers.
[120] On the history of the concept of innovation, see Benoît Godin, *Models of Innovation: The History of an Idea* (Cambridge: MIT Press, 2017) and Michael North, *Novelty: A History of the New* (Chicago: University of Chicago Press, 2013). On the political economy of novelty, see Suchman, "Anthropological Relocations and the Limits of Design" and Greg Urban and Kyung-Nan Koh, "Ethnographic Research on Modern Business Corporations," *Annual Review of Anthropology* 42 (2013): 139-158.
[121] Lilly Irani, "View of 'Design Thinking': Defending Silicon Valley at the Apex of Global Labor Hierarchies," *Catalyst* 4.1 (2018): 1-19.
[122] Jesse Goldstein, *Planetary Improvement: Cleantech Entrepreneurship and the Contradictions of Green Capitalism* (Cambridge: MIT Press, 2018).

In an anecdote Benyus told at numerous lectures I attended (and seems predisposed to share with journalists, too), she was contacted by her business partner to-be, Dayna Baumeister, not long after *Biomimicry*, who called Benyus one night at her home in Stevensville, Montana:

> "She was getting her PhD at the University of Montana, studying one [eco]system on the Rocky Mountain Front, and studying it in detail. She saw what was happening in the world and said "I am fiddling while Rome burns." I am studying something that might not even be here when I finish my degree. She read *Biomimicry,* and she shook for three days, told her professor about it, and immediately went to a phone booth to call me."

Benyus invited Baumeister to visit and stay with her, and for three days, they talked and planned, self-fashioning anew as innovation consultants or, in their terms, "biologists at the design table."

In 1998, Benyus and Baumeister co-founded the Biomimicry Guild, an "innovation consultancy" specializing in the application of biological knowledge to technological problems, and, with the help of the Catherine Cramer, an expert in organizational management, launched it in 2000. The early work of the Biomimicry Guild with Interface, Nike, and General Mills mostly consisted of client-specific training workshops on biomimicry to teach their product developers how to innovate through imitation as well as problem-oriented "design charrettes" with teams of their designers and managers. In these charrettes, which were based off the "design thinking" workshops that the design firm IDEO popularized, the company would pose in-house design problems to the Guild, who would in turn brandish case studies of "biological intelligence" and propose recommended "concept applications" that the company could later develop themselves.

One example from the nascent days of the Biomimicry Guild limns their consulting process. Ray Anderson, the CEO of InterfaceFLOR (now Interface, Inc.), contacted Benyus and Baumeister in 1999 to steer his company toward the mixture of profit and sustainability that Paul Hawken, his mentor, had preached in *The Ecology of Commerce*—a pivotal text on the economic

philosophy of green capital.[123] The world's largest manufacturer of modular carpet tiles (contrast with broadloom-woven carpet), InterfaceFLOR found inspiration, with Benyus's help, in nature:

> "InterfaceFLOR's design team was asked to take a walk through the forest in search of ideas. It was not the shapes of flowers or leaves that stood out as the team examined the natural world around them, but the pattern of leaves on the forest floor. In nature, the team realized, a surface that appears homogeneous is actually made of many unique parts, arranged in a pattern of 'organized chaos.' Just as no two leaves on a forest floor have to be the same for the forest floor to appear homogeneous, the team imagined that no two modular tiles had to be the same for a carpet floor to appear homogeneous."[124]

With the Guild's "concept" of heterogeneous patterns, InterfaceFLOR developed a modular line of carpet tiles with "non-uniform design schemes." A case study expounds its ecological benefit:

> "Traditional carpet files must all match exactly, and must be installed uniformly and in the same direction. I2™ carpet tiles, on the other hand, are manufactured with a variety of patterns. Patterns that have a similar look are mixed and matched within each carpet installation, and are arranged in random order, creating the visually pleasing "organized chaos" that the design & development team observed on the forest floor. Because the tiles do not need to be identical, carpets in i2™ line can be composed of dye batches that are similar, but not necessarily identical. This eliminates an enormous amount of waste generated during the manufacturing process, since the requirement that all tiles be identical had previously resulted in the rejection of batches that looked slightly different. Because the i2™ line's modular tiles do not require a perfect fit or matching colors when fully assembled, the line also reduces waste generated during installation, going from approximately 4% wastage for standard carpet tiles to approximately 1.5% for i2™ tiles. With this innovation, InterfaceFLOR greatly improved their manufacturing efficiency."[125]

The logic of demonstration in this and other case studies obey a similar model: The "success" of biomimicry as a method of innovation is evinced through its production of "efficiencies" that are reductions in waste—an economic and environmental problem of uncommoditizable excess.[126]

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[123] Paul Hawken, *The Ecology of Commerce: A Declaration of Sustainability* (New York: Harper Business, 2010[1993]). See his later *Natural Capitalism: Creating the Next Industrial Revolution* (Boston: USGBC, 2000).
[124] Terrapin Bright Green, "InterfaceFlor® Business Case Study," accessed September 27, 2021, http://static.biomimicry.org/wp-content/uploads/2012/02/Case-Study-%E2%80%93-Interface-Biomimicry-Education-Network.pdf.
[125] Biomimicry Institute, "Entropy®: Non-Directional Carpet Tiles," accessed September 27, 2021, http://toolbox.biomimicry.org/wp-content/uploads/2016/03/CS_Interface_TBI_Toolbox-2.pdf.
[126] Other case studies include consulting work with Seventh Generation, Shell, HOK, Jacobs Engineering, Natura, LGA, Terrapin, P&G, and C40 Cities. See Biomimicry 3.8, "Work Examples," accessed September 27, 2021, https://biomimicry.net/work-examples/.

Over the first decade of the 2000s, the Biomimicry Guild's portfolio of Fortune 500 clients expanded from their first three to include Dial, General Electric, and Kohler, followed by Kraft, Procter & Gamble, and HOK. (Today, the team boasts a total of 250-plus past clients.)[127] As their partnerships multiplied, they hired botanists, environmental scientists, ecologists, and other individuals with biology-adjacent backgrounds to help them compile more case studies of "biological intelligence" that they could draw upon during their consulting work, later hiring, in addition, degreed architects, engineers, and business professionals.[128] During this time, the Guild began to articulate and routinize the signature "design" methodology that I detail in Chapter One: a "design spiral," modeled off diagrams of design thinking, which tells designers to "ask nature" for analogical solutions to technological problems of "function" that designers face at their work.

In *Biomimicry*, Benyus categorized this titular term as kind of "design," and in their consulting work at the Biomimicry Guild, Benyus and Baumeister have likewise cast biomimicry as "design." In her explication of the "Biomimicry DesignLens," Baumeister explains this logic:

> "We are all designers. While you may not have a design title or degree, we *all* design the elements of our work and personal lives…We use the term 'designer' broadly to refer to anyone responsible for conceiving of, creating, and implementing ideas that affect human cultural, technological, social, scientific, or financial systems at any scale. Perhaps you didn't realize you were designing, but when you create some new form that had not existed, that makes you a designer. The key to thoughtful design (and positive outcomes) is to draw upon a set of ethical, time-tested principles…We have found nature's strategies a wellspring of sustainable innovations. Working in this field since 1998, we have developed a non-linear methodology for understanding nature's solutions. It is a set of tools that we call Biomimicry DesignLens because it provides a different way of seeing the world. The result is a guided process for using nature's genius to inform human design."[129]

[127] The most common referenced are Boeing, Colgate-Palmolive, Nike, General Electric, Herman Miller, HOK, IDEO, Natura, Procter and Gamble, Levi's, Kohler, and General Mills. For a full list of their 250 or more clients, see Biomimicry 3.8, "Clients and Collaborators," accessed September 27, 2021, https://biomimicry.net/what-is-biomimicry/clients-collaborators/.
[128] The Guild now counts fourteen employees, including Benyus and Baumeister.
[129] Dayna Baumeister, *Biomimicry Resource Handbook: A Seed Bank of Best Practices* (Scotts Valley, CreateSpace Independent Publishing Platform, 2014), 273.

At first blush, Baumeister's catholic reading of the concept of design, and biomimicry *as* "design," agrees with Arjun Appadurai's motion toward design's democratization as a cultural practice. "From this point of view," Appadurai writes, "design is only partly a specialist activity, confined to an artisanal or digital class, and is better seen as a fundamental human capacity and a primary source of social order…a capacity that we all exercise, all the time."[130] Notwithstanding the analytical prudence of broadening design's meaning,[131] biomimicry does not, however, meet the conditions of "design" set by Baumeister, Appadurai, or any other anthropologists of design, for biomimicry does not, as Baumeister suggested, "create some new form that had not existed."

As a "design" practice,[132] biomimicry is fundamentally dissimilar to the "ecology of materials" that the anthropologist Tim Ingold finds in the craftwork of a whittler, ceramicist, or jewelry maker, or in the disciplinary methods of "design" specific to engineers in biomimetics or bionics, architects in ecological design, or farmers in sustainable agriculture.[133] For Ingold, this "ecology" is a dialectic, or "correspondence," between the sensuous materiality of clay, metal, or wood and the bodily motions of a designer. Through their "intra-action," as he says, after Karen Barad, "potentials immanent in a world of becoming" are teased into the stuff of material culture: vases, pendants, chairs.[134] Nor is biomimicry like the "active, almost teleological ordering of raw

[130] Arjun Appadurai, *The Future as Cultural Fact: Essays on the Global Condition* (London: Verso, 2013), 254.
[131] Here, I disagree with other scholars of design. Keith Murphy celebrates the turn to "design" as an emblem of intentionality for its foregrounding of responsibility. In a similar vein, Bruno Latour finds in the "expansion" of the commonsense usage of design a shift toward an incremental, not a revolutionary, philosophy of technology. On the contrary, I fail to see what "design" offers that "making" cannot, particularly in light of its ideological baggage as an agent of industrial capitalism and, increasingly, a "handmaiden" for vacuous business rhetoric. Collapsing all modes of cultural production into "design" only blurs its institutional, disciplinary, economic, and ideational particularities. Compare Murphy, "Design and Anthropology" with Latour, "A Cautious Prometheus?".
[132] My use of the word "design" here cites how Benyus conceived these practices as "design." Throughout this dissertation, I bookend the word "design" with quotation marks when referring to how biomimics, like Benyus and Baumeister, parse biomimicry or other practices as design.
[133] Timothy Ingold, "Toward an Ecology of Materials," *Annual Review of Anthropology* 41 (2012): 427-442.
[134] *Ibid*, 435.

materials into some resultant thing" Keith Murphy found among modern furniture designers in Sweden, to whom "design is…an intentional structuring of some portion of the lived world."[135]

Biomimicry is unlike Ingold's nonteleological "correspondence" or Murphy's "teleological ordering" because innovation consultants at the Biomimicry Guild are not familiar with practices of "making."[136] In line with the business innovation consultants observed by Eitan Wilf, "biomimics" do not have knowledge of the properties or propensities of matter that a designer would manipulate to create a material artifact. On the contrary, what biomimics sell in their consulting sessions are case studies of "biological intelligence" and "concept applications." For example, if a case study of biological intelligence were to stipulate that "transpiration moves water" in trees, then a concept application, or "design principle," might suggests that in a product water could be "pulled against gravity by adhesion and cohesion."[137] These applications could be thought of as proto-forms, based on biological function, that corporate designers would translate later into the form of an object—a description, sketch, render, or some other representation—and then, and only then, into an object in all its materiality, i.e. a prototype or final product.[138] This latter process is, strictly speaking, not biomimicry: It neither involves biomimics, the persons, nor any knowledge, technique, or equipment with which designers would not already be familiar.

Generic across the disciplines of design, from industrial or product design to software or architectural design, biomimicry is better conceptualized as *meta-design*. If "meta-science"[139] for Geoffrey Bowker refers to a science that transcends disciplinary boundaries (in the example of cybernetics: biology, engineering, anthropology, etc.), then meta-design likewise traverses the

[135] Murphy, *Swedish Design*, 32.
[136] Timothy Ingold, *Making: Anthropology, Archaeology, Art and Architecture* (London: Routledge, 2013).
[137] Biomimicry 3.8 and HOK Group, *Genius of Biome: Temperate Broadleaf Forest* (2014), accessed September 27, 2021, https://issuu.com/hoknetwork/docs/geniusofbiome/69, 61-65.
[138] Continuing the example of transpiration provided earlier, this might mean "capillary faucets to pull water up through a building (cooling as it goes)."
[139] Bowker, "How to Be Universal."

borders of discipline, less concerned with how to handle materials than it is with how to generate provocations, or "lures," to new forms through analogies to the functions of living organisms.[140] If "the most central contribution designers make is in the continual reproduction of form," which Murphy argues, then the contribution of meta-design lies elsewhere, in the incitement to form.[141]

This ideational aspect of biomimicry does not, at first glance, seem altogether different from how a practitioner of bionics or biomimetics would seek analogical inspiration in functions of biological organisms, even if the biomimic does not partake in the materialization of products. But the meaning of function, for the Biomimicry Guild, is manifold. While the scope of early consults was hemmed by the design space of the product, the Guild later expanded their services. In addition to the sale of paid appearances at a circuit of conferences in the United States, from Bloomberg Business Week to Sustainable Brands and the Sustainability and Health Initiative for Net-Positive Enterprise, the Guild offered technical analyses of local environmental performance standards or metrics to which a true product of biomimicry should adhere.[142] In 2008, the Guild partnered with the global design, architecture, engineering, and planning firm HOK to create the *Genius of Biome: Temperate Broadleaf Forest* report, which outlines how this particular biome, which encompasses the majority of HOK's offices, could not only inspire new design functions but also establish an ecological baseline to which a mimetic building or bridge should adapt.[143]

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[140] Alfred North Whitehead, *Process and Reality: An Essay in Cosmology* (New York: Macmillan, 1929). On Whitehead's lures, see also Isabelle Stengers, *Thinking with Whitehead: A Free and Wild Creation* (Cambridge: Harvard University Press, 2011) and Nicholas Gaskill and A.J. Nocek, eds., *The Lure of Whitehead* (Minneapolis: University of Minnesota Press, 2014). For an example of "lures," see Natasha Myers, "Conversations on Plant Sensing: Notes from the Field," *NatureCulture* (2015): 35-66.

[141] Murphy, *Swedish Design*, 7.

[142] For a list of their services, see Biomimicry 3.8, "2011: A Complete Product and Service Reference," accessed September 27, 2021, https://issuu.com/biomimicry3.8/docs/consulting_catalog_2011. While the majority of their work has focused on individual artifacts or buildings (e.g. products or commodities), they have also sold consulting on management and other systems-level processes.

[143] Biomimicry 3.8 and HOK Group, "Genius of Biome."

Implicit in this turn to environmental performance is a duplication in the meaning of function—a double-ness that connotes not just the mimetic behavior of an artifact (it functions *like* an organism) but its adaptivity to a particular ecology (it functions like an organism would in *that* place). Analogy, then, operates at two levels: between organism and technology, first, and between an organism/environment and technology/context, second). In Benyus' parlance, this is the difference between life as "model" for and "measure" of artifice. Consequently, biomimicry, as an practice, pertains to the induction of forms and the functional *evaluation* of those forms, a "regime of value," or ethic of imitation, that assesses the quality of a mimetic artifact based on its conformity to environmental notions of context, variously named place, genius, or biome.[144] In other words, the Biomimicry Guild sells formal analogies and analogical metrics of judgment.

Assembling the Biomimicry Conglomeration™

Apart from selling biomimicry as case studies of biological intelligence, concept applications, and environmental performance standards, Benyus and Baumeister also sell biomimicry as a routinized system, i.e., as a replicable "design" method—a difference that Gilbert Ryle coded as "knowing that" versus "knowing how."[145] As their clientele grew, they perceived a market, not only for their expertise on sustainable innovation, but for the reproduction of that very expertise. Through the commoditization and institutionalization of a design pedagogy, the two consultants summoned a community around the metalanguage of biomimicry and its meta-design method. Whereas *Biomimicry* created a "meme" by "naming" biomimicry, the Biomimicry Guild, and

[144] Arjun Appadurai, "Introduction: Commodities and the Politics of Value," in Arjun Appadurai, ed., *The Social Life of Things: Commodities in Cultural Perspective* (Cambridge: Cambridge University Press, 1986), 3-63.
[145] Gilbert Ryle, "Knowing How and Knowing That: The Presidential Address," *Proceedings of the Aristotelian Society* 465 (1945-1946): 1-16.

later the Biomimicry Institute and Biomimicry 3.8, transformed biomimicry "from a meme to a movement" with a professionalization process that made innovation consultants: biomimics.[146]

In 2003, rising demand prompted the Biomimicry Guild to start selling week-long "immersive workshops" to parties interested in learning the biomimicry method, with titles like "Biomimicry and Design" and "Biologist at the Design Table." These workshops drew clients unfamiliar with biomimicry, but they also frequently attracted repeat customers—managers and designers—who had been present for their consulting sessions. À la American environmentalist binaries between "Nature" and modern urbanism (another nature), these workshops "reconnect," as they say, city-dwelling biomimicry novices with nature by schlepping them to exoticized and distant locales: tropical rainforests, glacier valleys, grassy prairies, deserts, and mountains, in the United States, but more often in foreign countries.[147] Past destinations have included Costa Rica, Slovenia, Spain, Australia, South Africa, Botswana, Canada, the Netherlands, and Mexico. From dusk until dawn, Benyus and Baumeister lead fledgling biomimics through morning lectures on the theories of how to "emulate" nature (i.e. the meta-language and meta-method of biomimicry) and on hiking, boating, and other outdoor recreation activities for the remainder of the day, often with the assistance of hired guides.[148] These excursions acquaint biomimics to nature's "genius,"

[146] Biomimicry Institute, "From a Meme to a Movement: Reflections on 20 Years of Biomimicry," *Medium* online, December 19, 2017, https://biomimicry.medium.com/from-a-meme-to-a-movement-reflections-on-20-years-of-biomimicry-e290ee1a363e.

[147] On nature and urban contrasts, see Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (Oxford: Oxford University Press, 1964).

[148] On the anthropology of nature recreation, see Robert Fletcher, *Romancing the Wild: Cultural Dimensions of Ecotourism* (Durham: Duke University Press, 2014) and Shiho Satsuka, *Nature in Translation: Japanese Tourism Encounters the Canadian Rockies* (Durham: Duke University Press, 2017). On the history of nature recreation, see Evan Berry, *Devoted to Nature: The Religious Roots of American Environmentalism* Berkeley: University of California Press, 2015), esp. Chapter 4. Despite what the language of immersion in biomimicry might suggest, the living accommodations of such workshops are decidedly *emersed* from nature. Architecturally divided from an environmental outside, participants rest in luxe sleeping quarters: shared or private rooms in "sustainable" lodges, farms, and retreat centers that conform to middle class standards of habitability. Thrice daily, biomimics dine on prepared, organic meals made by teams of caterers sensitive to vegan, vegetarian, and other dietary preferences.

its "biological intelligence," through paired naturalist commentary while nighttime activities and conversation promote experiential learning through simulations of "real-world" design problems.

While "immersion" in nature and its "emulation" in technology are two primary "elements" that are taught during workshops, a third element, "ethos," is equally, if not more, important to the pedagogy of biomimicry. As I argue in Chapter Two, workshops are important sites through which trainees internalize the ideological value of mimesis espoused by the meta-language of biomimicry. Through lessons on the philosophical underpinnings of biomimicry and somatic exercises designed to attune biomimics to biological functions, workshops inculcate a set of embodied dispositions—technical, affective, moral—and co-produce categories of nature, selfhood, humanity, and technology. Making new biomimics means making subjects who share a mimetic ethic—a process of "subjectivization" wherein trainees learn to evaluate technologies on the basis of their double analogical fidelity to organisms, and organisms in their environment.[149] A corollary of this tenet is that biomimics must be able to distinguish between biomimicry and "biomimetics," which they define as biomimicry *without* the ethical dimension—that is, mimesis of organismal function, but not its performance in ecological context. In tune with sentiments of anti-militarism that pervade American environmentalism (much of the environmentalist literature that Benyus cites in *Biomimicry* is anti-nuclear and anti-military), this sort of "boundary work" is grounded in the belief that biomimetics—the militarization of nature's genius—disposes function *against* life.[150] An ambivalence thus arises: Biomimicry, as Benyus articulated it, depends on the practice of biomimetics to legitimize imitation even as biomimics condemn an absent ethicality.

[149] Michel Foucault, "On the Genealogy of Ethics: An Overview of Work in Progress," in *The Foucault Reader*, ed. Paul Rabinow (New York: Vintage Books: 2010), 340-372, 353.
[150] Thomas Gieryn, "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review* 48.6 (1983): 781-795.

These workshops (and, later, four degrees) launched the professionalization of biomimicry as a "design" practice. Scheduled irregularly at first, workshops were soon made available more often. Then, in 2008, the Guild initiated what is now known as the "Biomimicry Professional Certification" ("BPro," for short): a degree certifying that an individual who attends a certain number of workshops is an expert in biomimicry—a biomimic. (To date, five cohorts of biomimics have graduated from this biannual program.) Next, in 2011, Benyus and Baumeister started the "Biomimicry Specialist Certification" or "BSpec": a short version of BPro with fewer workshops required and, as one might expect, more graduates. In 2014, Benyus and Baumeister were approached by ASU faculty (e.g. Heidi) to found the Biomimicry Center and a curriculum of online courses through which full-time workers can earn degrees in biomimicry part-time.[151] (After the center was established, the BPro and BSpec programs newly required coursework.) For students who cannot attend workshops, ASU provides a biomimicry master's and certificate.

As the Biomimicry Guild produced biomimics, biomimics reproduced biomimicry. Whereas Benyus and Baumeister themselves coordinated the first immersive workshops, alumni of their four programs returned to work for the Guild, leading workshops but also sitting "at the design table" and running consults with business clients. Some graduates resumed previous jobs, incorporating biomimicry into traditional modes of design or pushing for their companies to add biomimicry to their product design. Still more alumni have created spinoff consulting ventures of their own, with naturalesque names like Symbiosis, Wildability, and LikoLabs, to name three.[152] These spinoffs are functionally identical to the Guild, selling workshops, consultations, and talks.

[151] Topics include the "Essentials of Biomimicry," "Life's Principles," "Biology Taught Functionally," and "Biomimicry Thinking." For a full list of the essential and elective courses, see ASU Online, "Online Master of Science in Biomimicry," accessed September 27, 2021, https://asuonline.asu.edu/online-degree-programs/graduate/master-science-biomimicry/.

[152] Other examples include but are not limited to Biomimicry for Social Innovation, Biomimicry for Creative Innovation, Biomimicry Design, B-Collaborative, Chickadee Biomimicry, Biomimicry Frontiers, Regenerous Cities, Amazu Biomimicry, and Biomimicry Design Alliance.

Out of the Biomimicry Guild, therefore, a scattered ecosystem of copycat firms has spawned, propagating the "meme"—its values and practices—and mobilizing a professional "movement."

If "moving" biomimicry consisted of professionalization, it also depended on youth educational outreach. In 2005, Benyus and Baumeister founded the Biomimicry Institute at the advisement of Bryony Schwan, an organizational development consultant with eleven years of experience directing nonprofits, including Women's Voices for the Earth. With an expressed aim "to naturalize biomimicry in the educational system," the Institute received its nonprofit status in 2007 and quickly began to expand its reach with the Biomimicry Educator's Network (BEN): a web-based sodality of primary, secondary, and higher educators who teach biomimicry "design." Institutional support for this community has encompassed not merely a means of communication but curricular assistance on coursework that highlights biomimicry as well as two conferences.[153]

From this "web," a second community surfaced: the Biomimicry Global Network.[154] Comprised of local chapters founded by professional biomimics who are "working to practice, teach, and spread biomimicry in their region," these "regional networks" are 36 in number and span 21 countries, mostly clustered within the Global North: with 12 in the United States, and 8 in Northern and Western Europe alone. According to the Biomimicry Institute, the networks are "actively collaborating in the formation of regional and global structures that help spread the biomimicry meme."[155] Bringing together the constellation of independent consulting firms like the Biomimicry Guild and its progeny is this informal and "imagined" community united by the

[153] Part of this work has been focused on developing an elementary school curriculum. See Biomimicry Institute, "K-5 Biomimicry Education," accessed September 27, 2021, https://biomimicry.org/k-5/. The Institute also helped to develop curricula on biomimicry at California College of Art, Georgia Tech, Ontario College of Art and Design, Simon Fraser University, University of Strathclyde, University of Illinois, University of Maryland, University of Minnesota, University of Montana, and University of Toronto. For a review of the online courses available, refer to Jessica Berliner, "Mapping the Biomimicry Online Course Ecosystem," *Medium* online, April 23, 2021, https://biomimicry.medium.com/mapping-the-biomimicry-online-course-ecosystem-2029127607e7.
[154] Biomimicry Institute, "Global Network," accessed September 27, 2021, https://biomimicry.org/globalnetwork/.
[155] *Ibid*.

Biomimicry Global Network and by the circulation of biomimicry newsletters and magazines: the *Biomimicry Newsletter* (2003-2009), *BioInspire* (2003-2005), *BioInspired! Newsletter* (2010-present), and *Zygote Quarterly* (2012-present).[156] Blogs and other sites also connect its members.

Beyond its network building capacity, the Biomimicry Institute has promoted its meme through public competitions. In 2008, the Institute partnered with four "affiliate" universities to run its first "design challenge" (see Chapter Three): Iberoamericana University, Ontario College of Art and Design, Arizona State University (ASU), and Lipscomb University. The first iteration of this challenge encouraged affiliated students to use biomimicry for sustainable innovation, later including any university student, and, ultimately, any design professional. To promote the method of biomimicry to students in design challenges (and others), the Biomimicry Institute has made its design tools—at least some—available for free. In 2008, with funding from IBM, the Institute also launched AskNature, a digital library that publicized the case studies of biological intelligence Benyus and Baumeister had archived while consulting (reexamined in Chapter One). Lastly, the Institute relinquished the "Biomimicry Toolbox" on its website, making available various media, including primers on its concepts and a diagram of its characteristic design spiral.

The public distribution of methodological knowledge about the meta-design process of biomimicry—knowledge that had, up to that point, been protected, accessible only during paid consults or workshops—did not occur without criticism from consultants associated with the Guild. In 2010, Benyus and Baumeister conducted an "experiment," merging the Biomimicry Guild and the Biomimicry Institute into a for-profit/non-profit entity known as Biomimicry 3.8,

[156] Benedict Anderson, *Imagined Communities: Reflections on the Origin of Nationalism* (London: Verso, 2016[1983]).

which received B-Corp certification in 2011 for its environmentalism.[157] This experiment was short-lived: In 2014, Biomimicry 3.8 reverted back to its original dual organizational character: a consultancy (henceforth called Biomimicry 3.8) and the Biomimicry Institute. I was told by interlocutors familiar with the de-merger that a schism had risen over the free release of design representations that consultants at the Guild would have preferred to keep behind a paywall—a business drama affirming biomimicry's nature as a knowledge commodity sold by consultants.[158]

A New Meta-Science? Reassembling the Topology of the "Field"[159]

With the diffusion of the biomimicry meme into the popular consciousness vis-à-vis the efforts of the Biomimicry Conglomeration™, Benyus announced the present arrival of a "new science that studies nature's models."[160] A story that she often tells paints another picture. When Benyus wrote *Biomimicry*, evolutionary biologists estimated that life had existed on planet Earth for 3.8 billion years—hence the numerological symbolism associated with Biomimicry 3.8. More recent hypotheses antedate this number by 400 million years. Benyus has quipped that she will need to "rebrand" the consultancy every time scientists revise their estimations—a joke that makes manifest the latency or lag between biomimicry as a consulting practice and the biological science it wields for the commercial aim of product innovation. The efflorescence of biomimicry

[157] B Corporation certification (or "B-Corp") is a private certification system for companies on the basis of their social and environmental commitments and contributions. See Rae André, "Accessing the Accountability of the Benefit Corporation: Will This New Gray Sector Organization Enhance Corporate Social Responsibility?," *Journal of Business Ethics* 110.1 (2012): 133-150.

[158] In anthropology, the *locus classicus* on drama is, of course, Victor Turner, *The Forest of Symbols: Aspects of Ndembu Ritual* (Ithaca: Cornell University Press, 1967).

[159] For a review and critique of the "field" in anthropology, see Akhil Gupta and James Ferguson, *Anthropological Locations: Boundaries and Grounds of a Field Science* (Berkeley: University of California Press, 1997). For a more recent set of essays, see James D. Faubion and George E. Marcus, eds., *Fieldwork Is Not What It Used to Be: Learning Anthropology's Method in a Time of Transition* (Ithaca: Cornell University Press, 2009) or George Gmelch and Sharon Bohn Gmelch, *In the Field: Life and Work in Cultural Anthropology* (Berkeley: University of California Press, 2018).

[160] Benyus, *Biomimicry*, i.

over the 21st century is not because of the institution of a "new science" but the concerted efforts of a community of professional consultants to spread their ideological metalanguage of imitation.

This is not to say that the productivity of the discourse of biomimicry is restricted to the evolution of a business ecology of consultants, firms, and their services. Whereas biomimicry is dependent upon bionics and biomimetics to legitimize their "design" method, the two cybernetic sciences have become, in turn, dependent upon biomimicry. As the word "biomimicry" travelled around the corporate world and into public media, researchers in these scientific disciplines have profited from the ambiguity Benyus imbued in this now-popular term—a floating signifier for any nature-inspired design. To attract funds, scientists and engineers in bionics and biomimetics, Ortiz included, will often publicly label their work as "biomimicry" without practicing its meta-design method.[161] A rise in papers and patents on "biomimicry" indicates the growth of a science but, in reality, reflects newfound interest in pre-existing disciplines—*not* the extension of their "design method" into universities, even as the popularity of "biomimicry" has spurred a reflexive preoccupation with the systematization of a design method unique to practices of biomimetics.[162]

To complicate matters further, public appearances of biomimetics and bionics *as* biomimicry quickly dissipate behind closed doors. Just as practitioners of biomimicry draw on the authority of the cybernetic sciences even as they whisper rebukes of its moral intent, so too do biomimetics and bionics researchers have less sanguine feelings about biomimicry in private. During a conversation about the differences between biomimicry and its cognates, an employee of the Biomimicry Conglomeration™ conveyed that this happens with some degree of regularity:

"Yeah, there have been times…issues that come up. Some prominent bio-inspired

[161] While her discipline-specific research publications use the term "biomimetics" exclusively, public lectures and interviews use "biomimetics" and "biomimicry" interchangeably. Compare this with the ASU Biodesign Institute, who embraces terms like "biomimicry" and "nature-inspired design" even though not one of their labs practice it.
[162] See, for instance, Yoseph Bar-Cohen, "Biomimetics: Using Nature to Inspire Human Innovation," *Bioinspiration and Biomimetics* 1.1 (2006): P1-P12.

> engineer says, "We don't do biomimicry. That's like nature worship." How do we handle that as an organization? Yes, we are very much about the connection to nature and the change this paradigm of design means, but to write it off as a bunch of hippy crap is, ah! It's not completely fair…like everyone is trying to draw a line of distinction somewhere."

When I spoke with Dayna Baumeister, she relayed a more bellicose anecdote. After articulating a difference between "ethical" biomimicry and "unethical" biomimetics, she recollected that Julian Vincent, a prominent biomimetics practitioner in England, "verbally accosted" her at a restaurant in Amsterdam for misrepresenting biological facts, hinting that biomimicry was not scientific.[163] Baumeister was aghast, not realizing that she herself had partaken in the act of distinction in the same breath. If biomimics scorn the ethics of biomimetics, then the latter reject its metalanguage.

Where Benyus introduced an ambivalence into the notion of "biomimicry" and its epistemological and methodological relationship to the mimetic practices that preceded it, these ambivalences have only multiplied as practitioners of biomimetics and bionics have seized upon its name but shunned its beliefs, simultaneously. The fame of "biomimicry," its currency as a promise of green capitalist futures, has thereby, as Bruno Latour says, reassembled the social, composing a mutable topology of the field of biomimicry, at once symbiotic and yet competitive, its geometry shifting from moment to moment, person to person, conversation to conversation.[164] Biomimicry presents as biomimetics or bionics, and vice versa, only to recompose from another perspective, a contentious, contradictory field that confounded this fieldworker more than once. To provide analytic clarity on this nominal morass, this dissertation offers an ethnographic study of the community of "biomimics"—a community born from business management discourses, located primarily in consulting and education spaces, and bound by a metalanguage of imitation and a meta-design method—as they attempt to market the idea of "innovations based on nature."

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[163] On Vincent, see footnote 99.
[164] Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network Theory* (Oxford: Oxford University Press, 2007).

Surrounding Biomimicry: The Non-Space of Biomimicry as an Ethnographic Problem

In this section, I reflect on the challenges of "following" biomimicry into hard-to-reach areas—an ethnographic object whose origins as a consulting practice loomed over access to this field.[165]

Research for this dissertation occurred between Fall 2014 and Summer 2020, with the bulk of fieldwork conducted between 2017 and 2018. Six months of fieldwork in a biomimetics laboratory inaugurated this study, during which time I observed how materials scientists and engineers investigated the "biomaterials" of living organisms (e.g. the scales of *P. senegalus* or mollusk shells) for military applications.[166] In the summer of 2015, I spent three months at the ASU Biodesign Institute in Tempe, Arizona, rotating between two laboratories with programs in chemical sensing and remediation. One of five academic research centers in the United States focused entirely on "bio-inspired design, the ASU Biodesign Institute appeared to be the logical and representative successor to a fieldsite born of serendipity (recall the hallway stroll), and one that would afford ethnographic insights into the field of biomimicry.[167] For those three months, I was appointed a "visiting scholar," with the insignia of a graduate student: a cubicle, badge, and email address. Like a graduate student, I participated in group meetings, read journal articles, gossiped at lunch, attended parties and informal gatherings, and presented about my research. Unlike a graduate student, my data was not based on benchside experiments but on observations of the scientists conducting those experiments, and on my conversations and interviews with the

[165] Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge: Harvard University Press, 1988).
[166] For an expanded account, see Richard Fadok, "Cybernetics without the Cyborg: Biological Modernism(s) in Biomimetics and Biomimicry," in *Nature Remade* (Chicago: University of Chicago Press, 2021), 135-148.
[167] The other four centers include the Wyss Institute for Biologically Inspired Engineering at Harvard University, the Center for Biologically Inspired Design at the Georgia Institute of Technology, the Center for Interdisciplinary Bioinspiration in Education and Research at the University of California at Berkeley, and the Center for Bioinspired Engineering at the California Institute of Technology.

graduate students, postdoctoral researchers, and faculty who ran them—what seemed, at first, to be an uncomplicated entry in the (by now) familiar ethnographic genre of "laboratory studies."[168]

This was the first phase of my project, *before* Heidi designated my fieldwork on biomimicry as, rather, fieldwork on biomimetics. The second phase of my project on biomimicry thus began summer 2015, *after* Heidi. When Heidi declined my request to turn her center into a fieldsite, I thought perhaps that I could virtually "drop in" on the classes they taught, but she said I would have to enroll full-time. This proved impossible. Enrollment in one of their degrees is, at the low end, prohibitively expensive for a researcher: The cheapest "graduate certificate," a total of fifteen credit hours, costs $12,165; the master's degree, double the hours, $24,300; and the top BPro certificate, which involves a master's *and* 6 immersive workshops, over $43,080 (travel not included).[169] Needless to say, my research funds were not enough to cover access, so I moved on. Apart from the ASU Biomimicry Center, however, I could find no academic site that specialized in "biomimicry" and its ideology. (Later, Baumeister confirmed I had to "get out of academia.")

I then emailed Biomimicry 3.8 and Biomimicry Institute, neither of which returned multiple requests to parley. (Later, I would learn from an employee that their offices in the cities of Missoula and Helena, Montana, were vacant anyway. Had I even wanted to write an "office" ethnography, I would have found no one to fill its pages, for most everyone worked remotely.)[170] With the Biomimicry Conglomerate™ out of reach, I turned to the Biomimicry Global Network.

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[168] Despite my undergraduate credentials in biology, which I always mentioned in my emails for requesting access, I was never permitted to perform experiments under the hood. On the ethnographic genre of laboratory studies, see Steve Woolgar, "Laboratory Studies: A Comment on the State of the Art," *Social Studies of Science* 12.4 (1982): 481-498, and, more recently, Park Doing, "Give Me a Laboratory and I Will Raise a Discipline: The Past, Present, and Future Politics of Laboratory Studies in STS," in *The Handbook of Science and Technology Studies*, eds. Edward J. Hackett, Olga Amsterdamska, Michael E. Lynch, and Judy Wajcman (Cambridge: MIT Press, 2008), 279-295.

[169] Travel not included. For more information, see The Biomimicry Center, "Education," accessed September 27, 2021, https://biomimicry.asu.edu/education/.

[170] See, for instance, Cefkin, *Ethnography and the Corporate Encounter.*

Two regional networks were relatively close: BiomimicryNYC and Biomimicry New England.

What struck me, after firing off numerous emails to these local biomimics between 2016 and 2017, was their willingness to *talk* about biomimicry. In her much-cited essay on "studying up," the anthropologist Laura Nader writes that "the powerful"—for her, bureaucrats, lawyers, bankers, and other members of the professional classes—"are out of reach on a number of different planes: they don't want to be studied; it is dangerous to study the powerful; they are busy people; they are not all in one place, etc."[171] Almost forty years later, Sherry Ortner, in a set of reflections on obtaining access to Hollywood film producers, concurred. "It is also difficult to get people to sit for interviews," she wrote, agreeing with Nader that "people like this are indeed very busy…and the anthropologist's needs are of very low priority for them."[172] On the contrary, the professional biomimics I spoke to—consultants, managers, designers—were, as one put it, "always happy to meet and share biomimicry."[173] We met for coffee, walked through parks and botanical gardens, communed over meals, and clinked pints of beers—quite informal interviews.

Part of their cooperativeness stemmed from the alignment of our "interests"—Ortner's term for the "world of knowledge, information, representation, interpretation, and criticism" that we held in common.[174] Inheritors of the same cultural resources and occupants of similar class positions and privileges, we swapped thoughts in a manner that aligned my research more to

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[171] Laura Nader, "Up the Anthropologist: Perspectives Gained from Studying Up," in *Reinventing Anthropology*, ed. Dell Hymes (New York: Vintage Books, 1974), 284-311, 302.
[172] Sherry Ortner, "Access: Reflections on Studying Up in Hollywood," *Ethnography* 11.2 (2010): 211-233, 221, 222.
[173] Everyone but Benyus, who did not reply to multiple requests by email to talk with her. After becoming a judge for the Biomimicry Global Design Challenge, she responded to my attempt to contact her, telling me to find her after the Biomimicry Launchpad Showcase (see Chapter Three). When the event finished, however, she was nowhere to be found, having already left the site.
[174] Ortner, "Access," 223. For other reflections on shared habitus, see Pierre Bourdieu, *The Logic of Practice* (Stanford: Stanford University Press, 1990); Joseph Casagrande, *In the Company of Man: Twenty Portraits by Anthropologists* (New York: Harper, 1960); Hugh Gusterson, *Nuclear Rites: A Weapons Laboratory at the End of the Cold War* (Berkeley: University of California Press, 1996); and Paul Rabinow, *Making PCR: A Story of Biotechnology* (Chicago: University of Chicago Press, 1996).

what Ortner renamed "studying sideways."[175] More concretely, we inhabited what George Marcus terms a "para-site," a mutual horizon of inquiry, insofar as we were concerned about design's ecologies, notwithstanding our numerous theoretical and methodological differences.[176]

Beyond the commonality of our habitus, something else appealed about the interview form to my informants: the opportunity to "help spread the biomimicry *meme*." Our exchanges became, I believe, a vector for the transmission of biomimicry's metalanguage. For this reason, I prefer to use the word "informant" in this dissertation when describing these biomimics that I spoke with during such one-off interviews, not just in homage to the informational origins of the discourse of biomimicry, but to stress that interviews were media of ideological reproduction.[177] When possible, I tried to steer our conversation through my informant's experiences—a hallmark of "person-centered interviewing"—but the reins were not always in my hands: My informants would revert back to discussing biomimicry in the abstract, recapitulating its orthodox beliefs.[178] With consent, I taped some interviews and transcribed them after fieldwork. Not everyone wanted to be recorded, for fear of reprisal, and these moments of "refusal" went hand-in-hand with criticisms of the Biomimicry Conglomeration™.[179] This dissertation uses these moments of resistance—along with my analytical stress on biomimicry as a consulting practice—in order to interrupt the ideological "complicity" that can otherwise occur when one inhabits a para-site.[180]

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[175] Ortner, "Access," 213.
[176] George Marcus, ed., *Para-Sites: A Casebook against Cynical Reason* (Chicago: University of Chicago Press, 2000).
[177] Accordingly, I refer to other individuals with whom I had more personal relationships as interlocutors.
[178] Robert Levy and Douglas Hollan, "Person-Centered Interviewing and Observation in Anthropology," in *Handbook of Methods in Cultural Anthropology,* ed. H.R. Bernard (Walnut Creek: Altamira Press, 1998), 333-364.
[179] On refusals of information, see Ruja Benjamin, "Informed Refusal: Toward a Justice-Based Bioethics," *Science, Technology and Human Values* 41.6 (2016): 967-990 and Audra Simpson, "On Ethnographic Refusal: Indigeneity, 'Voice,' and Colonial Citizenship," *Junctures* 9 (2007): 67-80.
[180] On anthropological complicity, see Paul Robert Gilbert, "Trouble in Para-Sites: Deference and Influence in the Ethnography of Epistemic Elites," *Anthropology in Action* 22.3 (2015): 52-62. See also Ortner, "Access," 226.

While obtaining interviews was not much of a methodological obstacle, what became arduous, despite studying sideways, was finding a site for participant observation. For biomimics at consultancies that advise corporations on "innovation inspired by nature," the proprietary nature of their knowledge prohibited, I was explicitly told, the presence of observers who might steal or spill their secrets. Where laboratory access had been facilitated by the cultural capital that I had accumulated as a fellow academic, the corporate occult was a forbidden domain.[181] The concealment of knowledge is, of course, as the anthropologist Graham Jones chronicles, a widespread human phenomenon, occluding swaths of social life from the fieldworker's view.[182] In his commentary on Nader's essay on "studying up," Hugh Gusterson arrives at a similar conclusion, remarking, "Participant observation…does not travel well up the social structure."[183] Furthermore, I was also told that biomimicry was just part-time. For almost all of the consultants that established their own spin-off ventures, they primarily worked in other positions: lecturers at business schools, managers or directors of sustainability-related nonprofit organizations, etc.[184] *Contra* Nader and Ortner, it was not that they were too "busy" for an ethnographer—they had, after all, agreed to meet—but that the nature of the practice of biomimicry made ethnographic study impossible. It was either a secret, or they were too "busy" with everything *but* biomimicry.

Nor was participant observation possible with the biomimics who returned from professional training in biomimicry to work in design studios and firms. For these architectural, industrial, graphic, and software designers, biomimicry was "just a tool" among many—a meta-design method, as I have been calling it—that was only sporadically integrated into a traditional

[181] On cultural capital, see Pierre Bourdieu, "The Forms of Capital," in *Handbook for Theory and and Research for the Sociology of Education*, ed. J.G. Richardson (Westport: Greenwood, 1986), 241-258.
[182] Graham Jones, "Secrecy," *Annual Review of Anthropology* 43 (2014): 53-69.
[183] Hugh Gusterson, "Studying Up Revisited," *Political and Legal Anthropology Review* 20.1 (2008): 114-119, 115.
[184] This fact reflects both the hegemony that the Biomimicry Conglomeration™ holds over the field of clients as well as the decline of corporate enthusiasm for nature-inspired innovation. I reexamine this point in the conclusion.

stepwise process of design. While most biomimics who were designers by trade were employed by bigger firms whose clients dictated their project types, even biomimics who helmed their own personal studios employed biomimicry in the context of a broader practice.[185] Michael Pawlyn, for instance, the principal of *Exploration Architecture* and author of *Biomimicry in Architecture*, describes biomimicry as one "approach" to "regenerative design."[186] Like the consultants that I interviewed, the ephemerality of biomimicry in practice stymied my ethnographic observations. No one—and I cannot underline this more—was practicing biomimicry's meta-design full-time.

Over time, I began to ask where I *could* find biomimicry or what biomimicry projects they considered paradigmatic. Over even more time, I began to ask what my informants thought about the examples that others had offered. The answers I heard were contradictory, with some invalidating what their predecessor had evoked as biomimicry as definitively *not "*biomimicry." Most often, I received examples of biomimetics or bionics inventions—a consequence or artefact of the ambivalence Benyus fomented in *Biomimicry*. Occasionally, I was led down a rabbit hole of introductions to "colleagues working on biomimicry" who were, actually, not working on it. In what first appeared to be a promising lead, I was referred to an eminent HOK architect known for his interest in biomimicry, and through him to his colleague, an architect at a big firm, HDR, who was also "working on biomimicry." Instead, he was piloting a regenerative design initiative.

As consulting, biomimicry was everywhere secreted, and as "design," biomimicry was always someplace else; every elsewhere to which I turned, turned out to be something otherwise,

[185] This is not to say that biomimics at firms were not actively promoting biomimicry when and where they could. Many had launched internal campaigns for biomimicry frameworks, initiatives, resources, teams, and departments.
[186] Nonetheless, I reached out to Pawlyn via email to request access. He responded that his was a "small studio" that did not hire "interns" because they had made it a point of paying a "livable wage"—a noble if misguided objection, considering that I had clearly stated I had my own research funds. Perhaps more importantly, it is less clear that he is practicing "biomimicry" in the Benyan sense, with its presuppositions, not using it synonymously for bioinspiration. On regenerative design, see Pamela Mang and Ben Haggard, *Regenerative Development and Design: A Framework for Evolving Sustainability* (Hoboken: Wiley, 2016).

in infinite regress. A paradox arose: "Biomimicry," as a discourse, was everywhere—in the news and lectures, classrooms, and meeting halls—but as a practice of "design," it was nowhere found. Biomimicry, it appeared, occupied a *non-space*. If a "non-place," for anthropologist Marc Auge, refers to those localities that lack cultural forms of meaning, identity, and attachment (e.g. malls, airports, hotels, and other spaces of "supermodernity"), a non-space is simpler.[187] It doesn't exist, even as its existence is presupposed by spaces and discourses of spaces that rely on its reality. In the "field" of biomimicry, consulting practices cited absent "design" practices for reference. This was not *a* methodological challenge, conundrum, but *the* ethnographic problem, my puzzle. The only reliable location of biomimicry was in its si(gh)ting as a consulting practice—spaces where the expansion of insideness (the replication of the "meme") was, at once, necessary to the growth of biomimicry as a "movement" but also impossible, or, at least, financially safeguarded.

Whereas my informants constantly pointed to an evanescent or forbidden practice, "public" events about biomimicry were abundant, ubiquitous, and accessible—at least at a cost. The Biomimicry Institute, for instance, schedules a regular calendar of programs available to anyone, with an emphasis on "design" workshops. These workshops mirror those that the BPro and BSpec students must attend, with the exception that they invite not "professionals" but teachers, students, professors, and other parties intrigued by the topic, but might not yet be able or willing to pay the price (the straying anthropologist periodically wanders his way in, as well). While their clientele is different, the lessons are nearly identical, as one leader told me, as each type of workshop pulls from the resources published in the *Biomimicry Resource Handbook*.[188]

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[187] Marc Augé, *Non-Places: An Introduction to Supermodernity* (New York: Verso, 2009). Compare with Arjun Appadurai on "the production of locality" in *Modernity at Large: Cultural Dimensions of Globalization* (Minneapolis: University of Minnesota Press, 1996).

[188] The *Biomimicry Resource Handbook*, subtitled *A Seed Bank of Best Practices*, is a "piecemeal assemblage of information, worksheets, and articles collected over the last 15 years, and used in one way or another to help teach biomimicry to people around the world," which Baumeister and her employees created "as a result of an impending

In the summer of 2017, I conducted fieldwork at two workshops: one outside of Boston, Massachusetts, and one that moved from Mexico City through the states of Puebla and Veracruz. The price of workshops ranges from $2000 to $5000, not including travel, and while scholarships for students are available, they are modest, a tenth of the tag, restricting "public" participation to middle-class professionals (funding strategies online suggest to "convince your boss" to pay).[189] As condensed pedagogical forms of the education that biomimics receive, such events afford an analytical proxy to the "immersive workshop" as a site, genre, and axis of professionalization.[190] Even though biomimics mobilize nature, *In Life's Likeness* is not a "multispecies ethnography" for the reason that consultants hardly interact with live organisms, sticking to representations.[191] Chapters One and Two of this dissertation are concerned with these workshops for biomimicry, showing how they are key spaces of methodological training as well as ethical subjectivization. I also read public documents from Biomimicry 3.8 and the Biomimicry Institute (e.g. blog posts, annual financial reports, advertisements, syllabi) and attended lectures, discussions, and other events offered by the Biomimicry Institute and by its subsidiary regional networks (who, apart from connecting local practitioners together, also coordinate workshops and even "incubators.")

In contrast to the informality evoked by the fieldwork style that Clifford Geertz colloquialized as "deep hanging out," which arises from the sustained observation of a single place, my research resembled what Gusterson has termed "polymorphous engagement" and what Ortner, in a similar key, names "interface ethnography"—a "multi-sited" progression through the

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lecture, workshop, client deliverable, or publication" and "over lunch, a random phone call, during staff meetings, or 'shop talk' at one social event or another." Baumeister, *Biomimicry Resource Handbook*, 258.

[189] Biomimicry 3.8, "Convince Your Boss," accessed September 27, 2021, https://b38.box.com/shared/static/4sqtnsev4shq6vhdttnsaxsvge1vsqvv.pdf.

[190] On the workshop genre, see Irani, *Chasing Innovation*, and Wilf, *Creativity on Demand*.

[191] Eben Kirksey and Stefan Helmreich, "The Emergence of Multispecies Ethnography," *Cultural Anthropology* 25.4 (2010): 545-576.

"halfway" spaces that comprise the formal face of the Biomimicry Institute and the Network.[192] This progression took me to Boston, New York City, Seattle, San Francisco, Toronto, St. Louis, Mexico City, Los Angeles, and San Diego, less "deep hanging out" than a "brief dropping by." Where Bruno Latour recommends "following" one's actors into the laboratory, my ethnographic practice seemed more a surrounding, swarming, of the spaces I was prohibited from entering.[193]

Public sites are, Ortner notes, predictably promotional, full of the "kinds of discourse professionals use to represent what they do and how they do, a discourse which may or may not correspond to real practices but nonetheless tells one something about the culture in question."[194] While "public" insofar as they were open to anyone wanting to register, such events, particularly the workshops, and membership in the biomimicry community in general were in effect private because of their cost. Access, for the fieldworker *and* aspiring biomimic, was mediated by the transfer of money. The purchase of access through gift economies of goods, services, and money is not new; the archive is rife with examples of ethnographic knowledge bought through trade. The *extent* to which access—mine and others—revolved around money did, however, make biomimicry feel less like an inclusive "community" or "movement" than it did a club or society.

In addition to workshops and lectures, I also attended conferences on sustainable architecture that featured presentations on biomimicry, including the Living Future unconference and the Greenbuild International Conference and Expo. As I met and interviewed biomimics, at and outside these conferences (or, sometimes, over the phone or videotelephony), I began to trace out a dispersed community united professionally by prior training from, or tenure with, the

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[192] On "deep hanging out," see Clifford Geertz, "Deep Hanging Out," *The New York Review* (October 22, 1998). On "polymorphous engagement," see Gusterson, "Studying Up Revisited." On "interface ethnography," see Ortner, "Access." On "multi-sited ethnography," see George Marcus, "The Emergence of Multi-Sited Ethnography: Ethnography in/of the World System," *Annual Review of Anthropology* 24 (1995): 95-117, and Ulf Hannerz, "Being There…and There…and There! Reflections on Multi-Site Ethnography," *Ethnography* 4.2 (2003): 201-216.
[193] Latour, *Science in Action*.
[194] Ortner, "Access," 219.

Biomimicry Conglomeration™. These biomimics would refer me to their colleagues, often graduates of the same cohort who spoke together at conferences and collaborated on projects. While the Network website counts 12,576 participants,[195] the community felt small; everyone knew each other, and it was a tactic of mine to mention the name of whomever I had interviewed recently, after which I would hear their collective biography and a request to send their regards. Across members from Biomimicry Los Angeles, San Diego, Great Lakes (in Ohio), Northern Forest, Puget Sound, Mexico City, South Africa, Germany, Taiwan, and Iberia, the biomimics I conversed with were all university graduates who had received degrees in architecture, biology, business and marketing, engineering, law, and design disciplines (product, software, & graphic). As scholars note of American environmentalism, biomimics were white, by supermajority—a fact I examine, obliquely, in interludes about white imaginaries of non-white design traditions.[196]

In the summer of 2018, the rapport I had developed through my attendance in these interface spaces facilitated my access to a new role: the judge. (I'm sure this was an effect, also, of the "universal" expertise assumed of a "researcher from MIT," as was my designated title).[197] In the teleology of apprenticeship that anthropologists imagine fieldworkers to ascend as they progress from a novice to an expert in the object of their ethnographic study (typically, a skill), training over an extended period of time at last permits entrée into the inner sancta of culture.[198] To the contrary, I had only trained at two immersive workshops and a handful of hour-long mini-

[195] I suspect that this number includes not just registered members of the regional network, wherein each region typically count some 4-12 members, but also anyone who has registered for or participated in one of their events. See Footnote 154. While I could find no public measure of the number of graduates of Biomimicry 3.8's programs, I estimate the number to be on the order of the hundreds, not thousands, considering how many people are in a cohort.
[196] See, for instance, Fletcher, *Romancing the Wild.*
[197] My use of the word "universal" references the "universal intellectual" that Michel Foucault criticize in "Truth and Power: An Interview with Michel Foucault," *Critique of Anthropology* 4 (1979): 131-137.
[198] The literature on apprenticeship in anthropology is vast and varied. For a review and analysis, see Greg Downey, Monica Dalidowicz, and Paul Mason, "Apprenticeship as Method: Embodied Learning in Ethnographic Practice," *Qualitative Research* 15.2 (2015): 183-200.

workshops at conferences before I was deemed worthy to evaluate how well the submissions to the Biomimicry Global Design Challenge conformed to the norms of biomimicry. Again in the summer of 2020, I was invited to judge this competition. As a first-time judge, I was allowed to participate only in the first round of judging; as a repeat judge, I was allowed to participate in further rounds, which culminated in a meeting among the judges and three employees from the Biomimicry Institute to deliberate over the top ten finalists. While these two sites were virtual, conducted over an online judging platform and, later, Zoom, I also attended, in the fall of 2018, a showcase with finalists from a 2017 competition. These three fieldsites appear in Chapter Three.

My last fieldsite, which anchors the conclusion, disappeared before I could arrive: the Centre for Bioinspiration, a collaboration between Biomimicry 3.8 and the San Diego Zoo. At the onset of my fieldwork in 2014, I repeatedly read about economic forecasts around this space and the boon it would bring to the city of San Diego, but when I attempted to research it later, in September of 2018, it had been replaced by the "Tech to Reconnect" initiative (as I write today, even this initiative is obsolete). This center was, quite literally, a non-space—nonexistent. During a week that I spent in San Diego, I toured the grounds of the zoo, including the "ruins" of the center, a tiny office building which had been repurposed for the initiative, and interviewed its former executive director as well as the San Diego Zoo's director of research and development.

As I moved across these public spaces and toward the void of non-space, I began to interrogate the existence, in biomimicry, of the "inside" that is assumed in interface ethnography. For Ortner, an interface is a boundary between two types of spaces: a private, inaccessible depth, an inside or interior, that stands apart from its public, accessible surface, an outside or exterior.[199] Ortner proposed the idea of interface ethnography as a methodological resolution (or resignation)

[199] On interfaces, see Lucy Suchman, *Human-Machine Reconfigurations: Plans and Situated Actions* (Cambridge: Cambridge University Press, 2007).

to the impossibility or improbability of obtaining insider access in certain fieldwork (in her case: Hollywood film studios)—a pragmatic suspension of the ethnographic ideal of "insiderness" that Marcus registered as the regnant norm of anthropological science.[200] Through close inspection of this "interface" between inside and outside, Ortner reasoned, fieldworkers could glean rumors, or whispers, of an interior that, while mouthed in "discourse which may or may not correspond to real practices," nevertheless hints at its protected secrets.[201] Nested beneath this binary of inside/ outside is another between ideology/practice, where ideology masks the "quiddity" of culture—a binary that rehearses modern tropes of ideological critique and the unmasking of cultural truth.[202]

I came to understand that the field of biomimicry does not abide by this topology of surfaces and depths, insides and outsides. If the surface was comprised of the metalanguage of biomimicry, its ideological veneer, then the alleged depths of its practice revealed either more surfaces—biomimicry in its promotional, consulting form—or smoke and mirrors—non-spaces of "design" (the execution of biomimicry's meta-design form) that went up in smoke as I neared, or mirrors to other mimetic practices (e.g. biomimetics, regenerative design, etc.) that did not, by their own reasoning, constitute "biomimicry." Ethnographic access was a challenge because, in a sense, there was no "inside" to "access"—no design (or "design") practice "behind" the ideology that was not itself an instance of the replication of that ideology, i.e. consulting. The ideology of biomimicry *was* its practice; the mask, its culture—consultants all the way down, one might say. In this Escherian *topos*, outsides folded into insides that folded back outside or otherwise brought me to illusory, vanishing places—a topology, not of surfaces and depths, but of phantasmagoria.

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[200] George Marcus, "The Uses of Complicity in the Changing Mise-en-Scene of Anthropological Fieldwork," *Representations* 59 (1997): 85-108.
[201] Ortner, "Access," 219.
[202] See Jones, "Secrecy." See also Bruno Latour, "Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern," *Critical Inquiry* 30.2 (2004): 225-248.

To "cut" this Gordian knot or "network," as Marilyn Strathern says, I sought to comprehend this split nature, that is, how it had come to pass that biomimicry as a consulting practice had proliferated at the same time that it had failed to take root as a "design" practice.[203] Doing so meant attending to the making of biomimics—i.e. how they (learn to) make analogies (the method), (re)make themselves (the ethics), and make sales (the pitch), a threefold process of making that is my own spinoff of the biomimicry trio of "emulation," "ethos," and "immersion." What became apparent was that the modes of evaluation through which biomimics assessed the functionality of imitations often deviated from the mimetic ethic that was supposed to distinguish biomimicry from biomimetics and bionics. In the section that follows, I analyze such moments of disjunction, or deviation, as *mimetic stances*, diagnosing them as symptoms of the impossibility of realizing biomimicry as a "design" practice within the economic realities of capitalist design.

Mimetic Stances: The Dissertation in Overview

The empirical argument of this dissertation stands on three ethnographic chapters, each centered on a different fieldsite that, read together, retrace the programs that the Biomimicry Institute makes available to the public. Chapters One and Two are based on one-week-long "immersive" training workshops that teach the methodology of biomimicry to interested parties. Chapter Three is grounded in a design competition and a showcase that aim to educate designers in "biomimicry thinking" and present "biomimicry" products to investors and other audiences. Chapters One and Three take place in the United States: in a town and surrounding landscapes just outside Boston, Massachusetts, and in Berkeley, California, plus an adjacent virtual "locale," respectively. Chapter Two transpires in Mexico City, in varied urban and rural areas across the

[203] Marilyn Strathern, "Cutting the Network," *The Journal of the Royal Anthropological Institute* 2.3 (1996): 517-535.

Mexican states of Puebla and Veracruz, and in a rainforest camp located by the Pacific Ocean. The distribution of these three fieldsites resembles the demographic characteristic of the Biomimicry Global Network and the geography of center and periphery that defines biomimicry and innovation in general:[204] Centered in the United States, activities sponsored by the Biomimicry Institute *outside* are mostly viewed as sites of discovery, inspiration, and expedition.

Over these three chapters, I document the cultural specificity of the mimetic practice of biomimicry through ethnographic analyses of its meta-design method, its ethic, and the sale and presentation of mimetic artifacts as sustainable innovations. In one sense, the reader moves along the dissertation as a biomimic might: learning its "design" methodology, its moral principles, and its value form—a movement that reflects my position at the nexus of the anthropology of design, ethics, and business innovation. Yet, during this course, the coherence of the mimetic ethic starts to unravel. Organized around three distinct mimetic stances, which I defined as attitudes toward the original-copy relationship, each chapter unveils a unique stance: in turn, the pragmatic (One), the idealistic (Two), and the performative (Three). Rather than naming chapters after the stances, which might reify them as stable categories or ideal types, I have embedded their explication into the body of the chapters to enact their transitory presence within the flow of social interaction.[205] In another sense, then, the reader moves along the dissertation as I did during my fieldwork: first detecting cracks in the ethic (One), learning this is an effect of its impossible demand (Two), and grasping that biomimics subordinate the complete realization of biomimicry to sell it (Three). There are, therefore, two foci to each chapter: the practices of biomimicry, and mimetic stances.

[204] Suchman, "Anthropological Relocations and the Limits of Design."
[205] Cf. the stable concept of "cultural models" put forth by Roy D'Andrade and Claudia Strauss, eds., in *Human Motives and Cultural Models* (Cambridge: Cambridge University Press, 1992).

Chapter One listens to a trio of consultants who were employed by Biomimicry 3.8 as they introduce the methodology of biomimicry at a workshop in the seaport town of Gloucester. Heeding their folk biological ideas of *nature as innovation*, specifically the equivalence of survivability and sustainability, I recount how biomimicry was portrayed as a distinct form of "design"—or meta-design, as I argue—based on drawing analogies to biological functionalities, which are valued for their efficiency and resilience. By attending to how biomimics make novel design principles in interaction through analogy, I demonstrate how life's likeness is produced through what I call *mimetic labor*, in contrast to tropes of translation. During these interactions, an ambiguity arose in the meaning of "function": "self-organization" for biologists, and "use" for designers. For these consultants, who worked for clients who wanted fast results, function's former meaning was less important, as was fidelity to nature—a mimetic stance I call *pragmatic*. In this chapter, I argue that biomimicry is less "nature-based design" than it is *de-natured design*.

Where Chapter One asks how biomimics learn to create design principles, Chapter Two conveys how biomimics learn to create themselves anew as "designers" through a mimetic ethic. Beginning in Mexico City, I follow an architect, an urban designer, and an ecopsychologist down the watershed of the Bobos River as they taught attendees of a biomimicry workshop to "grow" their "state of being." With theories of sense, soma, and self, I examine the forms of subjectivity that biomimics are supposed to inhabit in order to imitate nature with fidelity—a stance that I am calling *idealistic*. For these biomimics, a good copy requires a good "designer," but attaining the epistemological conditions demanded—analogies to function *and* fit—is a utopic impossibility in the context of everyday design practice. To reside in the idealistic stance, biomimic must retreat to what I call *third nature*—a nature designed after the image of a wilderness that lacks people.

Chapter Three reports on my two experiences as a virtual judge for the Biomimicry Global Design Challenge and an attendee at the Biomimicry Launchpad Showcase in Berkeley. Depicting design competitions as crucial stages on which biomimics exhibit value propositions about mimetic artifacts to investors and other publics, I reveal how employees of the Biomimicry Institute, volunteer judges, and finalists negotiate and perform what I term the *imitative prestige* of products made through biomimicry. In front-stage presentations and back-stage deliberations, I show how biomimics market "sustainable innovation" to all kinds of businesses, environmental or otherwise, by presenting biomimicry as a posthuman mode of design. Drawing on theories of human and nonhuman agency, I argue that value in biomimicry depends on the erasure of human action in the design process. Reading what biomimics said in public versus what judges agreed in private, I argue that this performed posthumanism is a kind of *strategic animacy* and a sign of the stance I call *performative*, where the appearance of mimeticism is a sufficient sign of mimesis.

In the conclusion to the dissertation, I diagnose the failure to establish the Centre for Bioinspiration at the San Diego Zoo and a vague impression of dwindling interest in biomimicry as symptoms of its utopic ideals. Briefly analyzing a controversy between business professionals and scientists that unfolded at the zoo, I disclose a constitutive tension between the economic and the ecological that hinders their dream of materializing green capitalist utopia via product design, especially as the "workshop" genre has come to dominate the communication of biomimicry. The "magic" of mimesis in the United States, I argue, is subsumed by capitalist modes of design.

A Last Word on the Words Between: Design's Anthropologies

If, in light of the dramaturgical analysis of Chapter Three, the reader is inclined to view this dissertation as a play comprised of three acts, then staged between these main performances are

interludes depicting an epistemological story about the architecture of knowledge that supports biomimicry, as well as design more generally. The reader will also have noticed (and maybe objected) that I did not comment on the continuities that Heidi affirmed between biomimicry and "native cultures," cited earlier in this introduction, which ascribe a universal mimeticism to Indigenous technicity writ large, past and present.[206] In her literature review about biomimicry, Veronica Davidov requests "future exploration" on Heidi's rhetoric of "green primitivism," the "cooptation and marginalization of the idea of indigenous knowledge" and "human-nature relations," which pervades this mostly white field.[207] These interludes brave such an exploration.

Across its diverse manifestations, from books and blogs to workshops and lectures, biomimicry's discourse regularly espouses a distinction between "Western" and "native" design. While the main body of the dissertation explores how nature is mobilized by consultants, these interludes investigate how ideas about nature and, conversely, culture depend on this distinction. Whereas "Western" design split from the "sustainability" inherent to biological life by imposing human intents upon nature, "native cultures" have remained, biomimics claim, in environmental harmony because of their innate "cultural" tendency toward mimesis—a tropic figure that I label *Homo mimesis*. In the first interlude, I present *Biomimicry* as the *locus classicus* for this romantic impression of Indigenous design, and the reason for its circulation in the biomimicry community.

[206] Throughout this dissertation, I use the capitalized "Indigenous" as an adjective referring to people with ancestry in the pre-colonial societies of present-day North America. I also use it to refer to real, historical members of those societies. Following accepted conventions of self-identification, I use the terms "Indigenous" or "First Nation" to specify persons living in Canada, Native for persons living in the United States, or tribal endonyms when available. Where my text deviates from this standard, it is to reflect my informants' uses of the term(s), many of whom do not distinguish between Indigenous/Native, using "indigenous" or "native" indiscriminately (they never capitalize). This usage will always occur in quotation marks to cite their speech practices. When I say "indigenous" or "native" in the lower-case, it is to refer to autochthonous nonhuman biologies and ecologies. When I talk of "Indigeneity" as a noun in the abstract, I refer to biomimics' own reification, homogenization, and mystification of Indigenous knowledges.
[207] Davidov, "Biomimicry as a Meta-Resource and Megaproject," 33, 43.

Benyus did not, of course, invent *Homo mimesis* de novo. As Greg Johnson writes, "Romanticism with regard to Indigenous cultures has its roots in the Edenic episode wherein nature and culture were rent apart in the generative moment of the Western narrative."[208] In the reading of *Biomimicry* that I offer, Benyus recapitulated a representational convention that has its origins in colonial travelogues and their narratives of the "noble savage."[209] In the United States, this rhetoric has persisted as the fantasy of the "ecological Indian,"[210] which Benyus received via her relation with American New Age environmentalism.[211] Tinkering with this tradition, Benyus recast the romanticized, innately mimetic Indigenous person as a model for "sustainable design."

Since the publication of Bernard Rudofsky's *Architecture without Architects* in 1965,[212] white architects in the United States and Europe have taken an interest in the vernacular building techniques of Indigenous peoples as an alternative to Western design practices. Julia Watson, for instance, has surveyed construction methods in the Americas, Africa, and Asia through research collaborations with real Indigenous persons.[213] In contrast to cross-cultural conversation, what I observed in biomimicry was traffic in "disembodied representatives of an amorphous Indigeneity that serves European intellectual or political purposes," as the Red River Métis scholar Zoe Todd has put it.[214] Rather than engaging with and contributing to a "body of thinking that is living and

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[208] Greg Johnson, "Romanticism and Indigenous Peoples," in Bron Taylor, ed., *The Encyclopedia of Religion and Nature* (Oxford: Oxford University Press, 2006).
[209] See Shepard Krech, *The Ecological Indian: Myth and History* (New York: W.W. Norton & Company, 2000).
[210] *Ibid*.
[211] For a review and critique of the literature on the appropriation of Indigenous knowledges in the New Age movement, see David Waldron and Janice Newton, "Rethinking Appropriation of the Indigenous: A Critique of the Romanticist Approach," *Nova Religio* 16.2 (2012): 65-85.
[212] Bernard Rudofsky, *Architecture without Architects* (Albuquerque: University of New Mexico Press, 1987[1964]).
[213] Julia Watson, *Lo-TEK: Design by Radical Indigenism* (Cologne: Taschen, 2019). The Indigenous groups that Watson considers include: the Inca, Khasis, Ifugao, Subak, Maya, Chagga, Malayali, Enawenê-nawê, Kayapó, Zuni, Maasai, Persian, Ngisonyaka Turkana, Uros, Ma'dan, Bengalese, Tofinu, and Javanese peoples.
[214] Zoe Todd, "An Indigenous Feminist's Take on the Ontological Turn: 'Ontology' Is Just Another Word for Colonialism," *Journal of Historical Sociology* 29.1 (2016): 4-22. 17. See also Sarah Hunt, "Ontologies of Indigeneity: The Politics of Embodying a Concept," *Cultural Geographies in Practice* 21.1 (2014): 27-32.

practiced by peoples with whom we all share reciprocal duties as citizens of shared territories," biomimics have capitalized on fictive imaginaries of "Indigenous thinking…as…a well of ideas" without serious, meaningful engagement with the Indigenous people they cite in the abstract.[215]

Instead, within biomimicry, the recitation of *Homo mimesis* performs an ideological function. By framing their mimetic practice as a (re)turn away from "modern," "Western" design and "back" to "native" mimesis, biomimics authenticate their "nostalgic"[216] mode of innovation (interlude one) and sensation (interlude two) through "cultural" reference to essentialized images of Indigeneity, flattening differences *between* Indigenous peoples and depriving their agencies as historical actors. As I show in interlude three, such speculation about *Homo mimesis* dates to the origins of architectural theory in the first century B.C.E. In the *Ten Books of Architecture*, the Roman engineer Vitruvius supposed that architecture first arose through the imitation of nature, a hypothesis he corroborated with reports of near and distant tribes—what Johannes Fabian termed "difference [in time] as distance."[217] From Vitruvius to 20th century modernism(s), the figure of a mimetic Other—a logical fiction, or frame, through which real Indigenous persons are read—has persisted in biomimicry where imaginaries of Indigeneity set a cultural horizon of moral renewal.

As I encountered statements about "Western" and "native" design in biomimicry, it became clear that designers, biomimics among them, held certain understandings of "cultural" similarities and dissimilarities, often (but not always) drawing on knowledge from anthropology the discipline. As Micaela di Leonardo, Stefan Helmreich, and Graham Jones have argued, it is a frequent occurrence for anthropological discourses to circulate into other contexts of enunciation, where concepts of "primitivism," "culture," and "magic" are translated and transformed beyond,

[215] Todd, "An Indigenous Feminist's Take on the Ontological Turn," 17.
[216] Renato Rosaldo, "Imperialist Nostalgia," *Representations* 26 (1989): 107-122, 107, 109, 108.
[217] Johannes Fabian, *Time and the Other: How Anthropology Makes Its Object* (New York: Columbia University Press, 1983), 9.

or at the limit of, recognition.[218] As an anthropologist of design, I noticed that my informants had their own "anthropologies" of "design," differentiating "Western" and "native" technologies on the basis of mimesis. If, as Michael Fischer says, "anthropology is the proper name for…general questions about human beings, our societies, our cultural forms, our interactions with the world around us and that biologically also constitutes us, historically and in relation to our place in the world(s) to come," then these "anthropologies of design" were different: shades of anthropology, where shade connotes both a gradation of meaning and a ghostly presence.[219] Attuned less to a "pragmatic" anthropology of lived experience and the bootstrap mutability of human nature than to a *romantic anthropology* of hackneyed stereotypes and idealized behavior, the "anthropology" of design in biomimicry begged for analytic focus on the circuit I call *design's anthropologies*.[220]

In response to the inter-disciplinary exchange of ethnographic methods from anthropology to design at the close of the 20th century, cultural anthropologists have, over the past two decades, debated the real and ideal relations between the two disciplines. Most accounts permute their "arrangements" three ways: design anthropology (ethnography as design research), anthropology *as* design ("design" as logic or method), and anthropology *of* design (ethnographic research on designers).[221] In interlude four, I suggest a new relationship: design's anthropologies.

By this term, I mean to highlight the ways in which designers, and design theorists, have, then and now, relied upon speculative or empirical knowledge about how other peoples design to reflexively understand and refashion their own design practices. Whereas histories of the relation of design and anthropology situate their intersection in the 1980s, I believe that there is a sense in

[218] See Micaela di Leonardo, *Exotics at Home* (Chicago: University of Chicago Press, 1998); Stefan Helmreich, "After Culture: Reflections on the Apparition of Anthropology in Artificial Life, a Science of Simulation," *Cultural Anthropology* 16.4 (2001): 613-628; and Graham Jones, *Magic's Reason: An Anthropology of Analogy* (Chicago: University of Chicago Press, 2017).
[219] Fischer, *Anthropological Futures*, 229.
[220] *Ibid*.
[221] Murphy, "Design and Anthropology," 434.

which design has always been anthropological: from Vitruvius's "proto-anthropological"[222] ideas of overseas mimetic builders, through Benyus's *Homo mimesis*, and up to, and including, interest in so-called social, human-centered, user-centered, speculative, and participatory design. What unites these design philosophies is an anthropological calculus of human identity and difference. In the final interlude, the epilogue, this extends into biomimicry's "successor": material ecology.

This is *not* to say the "anthropology" in question is everywhere the same, as I hope to have made clear in the above text. But it *is* to say that, in the discrepancy between anthropology the discipline and anthropology the discourse (of which anthropology the discipline is sometimes but not always the author), there is room for critical ethnographies of design's anthropologies, in which attention is paid to the reduction of Anthropology's political and ethical cosmopolitanisms to tired, weakened notions of human culture and cultural difference. In *Anthropological Futures*, Fischer recalls that "there was a moment, in fact, in the 1960s and 1970s, when Anthropology seemed poised to…expand the university curriculum to be culturally more inclusive."[223] While "the moment has passed," he remains hopeful that "it may yet return in other guises."[224] Design, I suspect, might be that moment's return. Through inter-disciplinary dialogue attuned to design's anthropologies and cautious of anthropology's trivialization, anthropologists and designers might work together toward shared techno-pluralist futures. These interludes initiate that collaboration.

In recent years, interludes have appeared often in ethnographic writing, from Sophia Roosth's "keyword" entries on the word "synthetic" to Tulasi Srinivas's personal reflections on family, friends, and the familiar.[225] Such interludes furnish a space of intellectual freedom from

[222] Fischer, *Anthropological Futures,* esp. Chapter 6. See also Thomas Hylland Eriksen and Finn Sivert Nielson, *A History of Anthropology* (London: Pluto, 2013), esp. Chapter 1.
[223] Fischer, *Anthropological Futures*, 224.
[224] *Ibid*.
[225] See Roosth, *Synthetic.* See also Tulasi Srinivas, *The Cow in the Elevator: An Anthropology of Wonder* (Durham: Duke University Press, 2018). Perhaps the most demonstrative example is Annemarie Mol's *The Body Multiple: Ontology in Medical Practice* (Durham: Duke University Press, 2002), in which the doubling of the text mirrors the

the formal asylums of the genre's textual conventions. In *Synthetic*, for instance, Roosth illumes contemporary biological research through a series of short episodes about "prior enunciations" of the "synthetic" in clothing, food, art, and music—episodes that deviate from the temporal norms of the history of a scientific discipline.[226] Similarly, Srinivas uses interludes to introspectively examine the cultural phenomenon of wonder in her life, thus speaking in a biographical tongue often muted in the anthropological voice.[227] The popularity of interludes might reflect, too, the changing nature of the "field" and "fieldwork." As the singular "field" of ethnographic analysis disperses (or never existed) and "multi-sited" fieldwork subdivides still further, then perhaps the splintering of the ethnography, in which chapters are expected to analyze discrete fieldsites, into interludes that exist outside the bounds of these fieldsites now mirrors the evolution of fieldwork, from the long observation of one-plus places to the amassment of rapid, scattered encounters.[228]

Spanning from the concrete to the abstract, the present to the past, and the theoretical to the ethnographic and the historical, the thesis I stake here about design's anthropologies has been gathered in the interludes, in between the properly ethnographic chapters, in accordance with this literary antecedent. Comprised of snippets of talk and text from publications and interviews that I collected throughout my fieldwork and my interpretations thereof—too reflexive, too historical, too dis-located and, above all, too *dissimilar*—these interludes resist localization (or typification) even as their focus demands to be recognized as crucial to biomimicry's discourses about itself.

But my decision to include them in the marginalia is not merely a consequence of their disciplinary marginalization as textual forms. It stems too from the marginalization of talk *about*

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doubling of the body. Like Mol's text, my aim here is similar, using the interludes to perform a meta-epistemological commentary on the marginalization of Indigeneity through the marginalization of this textual genre.

[226] Roosth, *Synthetic*, 28.

[227] Srinivas, *The Cow in the Elevator*.

[228] See footnotes 159 and 192.

design's anthropologies, or Indigeneity more specifically, in the field of biomimicry. Rarely the subject of exposition and more usually the topic of asides and digressions, talk about and around biomimicry's purportedly Indigenous likeness played a minor role in any individual speech act. When I first sat down to write this dissertation, I hesitated whether to mention these occurrences. On a methodological level, I had doubts about the generality of such brief comments, and on an ethical level, I worried about misrepresenting the character of the many kind people who had given me their time, thoughts, and trust. Remaining silent, however, would amount to what Paul Robert Gilbert calls "deferent anthropology"—a "deferral" to "something morally questionable," as Sherry Ortner defines "complicity": "pulling one's punches…in writing the ethnography."[229]

During the months that intervened between the denouement of my fieldwork and the completion of this dissertation, heightening crises of a viral pandemic and a murderous summer of state-sponsored police brutality dramatized America's racial inequality to the watchful public. In response, the Biomimicry Institute published a memo of acknowledgement: "in Solidarity." After denouncing the atrocities and analogizing the nation to an ecosystem lacking biodiversity, the communiqué affirms, "We are committed to deepening our own education about the implicit biases we carry."[230] In the spirit of education, and of justice, then, let the evidence assembled in the dissertation's marginalia—marginalia about what Davidov portrays as the "marginalization" of Indigenous knowledges—expose the biases toward Indigenous peoples that are implicit within biomimicry's epistemic foundations. Together, the interludes tell a tale from words between the "original" text (its doubles, or imitations) that, as a keen reader should note, is no less significant.

[229] Marcus, *Para-Sites*; Gilbert, "Trouble in Para-Sites"; Ortner, "Access," 226.
[230] Biomimicry Institute, "In Solidarity," June 5, 2020, https://biomimicry.org/insolidarity/.

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Homo mimesis: An Anthropology of Design in *Biomimicry*

Published in 1997, *Biomimicry: Innovation Inspired by Nature* was presented to me time and time again as a "life-changing book," a profound, moving experience that compelled the people with whom I spoke to alter the trajectory of their careers toward biomimicry. The force of their convictions reminded me of what Susan Harding, describing conversion among fundamentalist Christians, called "generative belief, belief that indisputably transfigures you and your reality."[1]

This book—the *Urtext* of a community of "design" practice—opens with a distinction between "Western" and "indigenous" designers:

> It's not ordinary for a bare-chested man wearing jaguar teeth and owl feathers to grace the pages of *The New Yorker*, but these are not ordinary times. While I was writing this book, Moi, a Huaorani Indian leader whose name means "dream," traveled to Washington, D.C., to defend his Amazonian homeland against oil drilling. He *roared like a jaguar* [author's emphasis] in the hearings, teaching a roomful of jaded staffers where real power comes from and what homeland actually means.
>
> Meanwhile, in America's heartland, two books about aboriginal peoples were becoming word-of-mouth best-sellers, much to their publishers' surprise. Both were about urban Westerners whose lives are changed forever by the wise teachings of preindustrial societies.
>
> What's going on here? My guess is that *Homo industrialis,* having reached the limits of nature's tolerance, is seeing his shadow along the wall, along with the shadows of rhinos, condors, manatees, lady's slippers, and other species he is taking down with him. Shaken by the sight, he, we, are hungry for instructions about how to live sanely and sustainably on the Earth.
>
> The good news is that wisdom is widespread, not only in indigenous peoples but also in the species that have lived on Earth far longer than humans. […] In short, living things have done everything we want to do, without guzzling

[1] Susan Harding, "Convicted by the Holy Spirit: The Rhetoric of Fundamental Baptist Conversion," *American Ethologist* 14(1): 167-181, 180.

> fossil fuel, polluting the planet, or mortgaging their future. What better models could there be?[2]

Here, I ask: What does the primacy of rhetorics of Indigeneity in *Biomimicry* say about the transfigured realities of biomimics and their beliefs about nature, artifice, time, and the human?

In her romantic anthropology of design, Benyus counterpoises "Westerners" against what she considers to be their polar opposite, "indigenous peoples," which Benyus presents as exampling a unitary and monolithic Culture, powerful and wise. While Moi might descend, ethnically, from the Huaorani people of the Amazon, he equally stands as a token for all "preindustrial societies"—their synecdochic representative. He stands half-naked, garbed in the cloth of otherness, wearing "jaguar teeth" and "owl feathers."[3] In times of ecological crisis, times outside the "ordinary," Moi, an/the Indigene,[4] surfaces with passion and "grace," undertaking a heroic journey from his sylvan "homeland" to America's capital. He renounces the wonders of modernity—Benyus cites "hot showers, *The Washington Post*, and televised baseball"[5]—and leaves behind Indigenous "wisdom" about "what homeland really means" and "how to live sanely and sustainably on the Earth." Such lessons, Benyus continues, can also be found in other species, the nonhuman-ity before Man.[6] "This, of course, is not news to the Huaorani Indians," Benyus notes of symmetries between natural and "native" *techne*. "Virtually all native cultures

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[2] Janine Benyus, *Biomimicry: Innovation Inspired by Nature* (New York: Harper Perennial, 2002[1997]), 1.

[3] In her analysis of the bureaucratization of indigenist NGOs in Brazil, Alcida Rita Ramos calls this figure the "hyperreal Indian." Drawing on Max Weber and Jean Baudrillard, Ramos argues that "flesh-and-blood Indians" have ceased to occupy the concerns of white pan-Indian bureaucrats, who instead expect, plan for, and only respond to "hyperreal" or "model Indians" that exemplify fetishized cultural traits. Seeking recognition from authorities, some Indigenous persons strategically adopt these traits (like Moi's jaguar teeth and owl feathers) to "play up their hyperreal role on the interethnic stage. Alcida Rita Ramos, "The Hyperrreal Indian," *Critique of Anthropology* 14.2 (1994): 153-171, 163. On recognition, see Glen Coulthard, *Red Skin, White Masks: Rejecting the Colonial Politics of Recognition* (Minneapolis: University of Minnesota Press, 2014) and Audra Simpson, *Mohawk Interruptus: Political Life across the Borders of Settler States* (Durham: Duke University Press, 2014).

[4] Where I use the de-individualized term "Indigene," I do so to call attention to the lack of cultural particularity that biomimics themselves attribute to Indigenous peoples.

[5] Benyus, *Biomimicry,* 9.

[6] I use the gendered "Man" here in alignment with how biomimics gender nature/culture as female/male. See footnote 114 of the Introduction.

that have survived without fouling their nests," she writes, "have acknowledged that nature knows best, and have had the humility to ask the bears and wolves and ravens and redwoods for guidance." Imitating nature, Moi, the Indigene, "becomes animal,"[7] vocally emulating his animistic "fetish" in anthropomorphic form.[8] "*He roared like a jaguar*" from the page to Benyus.

Benyus's figuration of the Indigene as a symbol of environmentalism revives tropic histories of the "noble savage" and the "ignoble savage."[9] The anthropologist Shepard Krech explains that, etymologically, the word "savage" is derived from *silvaticus*, a "state of nature," that, in Latin, has "woodland, wooded, forest, and wild among [its] principal meanings," as well as in its Romance cognates: *sauvage*, *salvage*, and *selvaggio*.[10] (Recall Moi, from the Amazon.) In Latin, we also read about the first documented "savages," the Scythians, who appeared to the Roman historian Tacitus as "simple, frugal, honest, natural folk."[11] In its classical usage, the "savage" evoked the myth of a perfect elsewhere, "ideas of earthly paradise, eternal spring, and innocent life removed from space or time."[12] From an original unity, the "savage" became two: "noble" and "ignoble," "the first [emphasizing] the rationality, vigor, and morality of the nature-dwelling native; the second, the cannibalistic, bloodthirsty, inhuman aspects of savage life."[13] These meanings have persisted from colonial narratives of exploration and discovery, through the philosophies of the Enlightenment (e.g. Michel de Montaigne and Jean-Jacques Rousseau),

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[7] Gilles Deleuze and Felix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 1980).
[8] On the fetish, see J. Lorand Mattory, *The Fetish Revisited: Marx, Freud, and the Gods Black People Make* (Durham: Duke University Press, 2018), xii.
[9] Shepard Krech, *The Ecological Indian: Myth and History* (New York: W.W. Norton & Company, 2000).
[10] *Ibid*, 17.
[11] *Ibid*, 18.
[12] *Ibid*, 17. See also Richard Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600-1860* (Cambridge: Cambridge University Press, 1996).
[13] *Ibid*, 16

and, partially, into the social evolutionism that defined anthropology in the 19th century, in which "savages" were dismissively positioned "on the earliest and lowest rungs of human society."[14]

The "noble savage" trope persist in the United States, where white settlers often homogenize Indigenous peoples in their occupied territories, reducing all "Native Americans"—an exonym that admits scant individuality to the 574 federally registered tribes—to the role that Krech calls the "Ecological Indian," an empty signifier referring to whatever virtues are valued. As the nation debated land management and resource conservation at the turn of the 20th century, for instance, the "Ecological Indian" exuded "skill in nature."[15] During the 1970s, "harmony with nature" arose as the ideal of a "antitechnocratic" movement toward a pre-industrial past.[16] Krech concludes his genealogy with "humanitarians concerned about the global environment and health, so-called deep and spiritual ecologists, metaphysicians, and new biologists interested in the Gaia hypothesis of an organic earth, ecofeminists, the Rainbow Family, and other alternative groups, and self-help advocates," many of whom Benyus cited in *Biomimicry* as big influences.[17] (It should be noted as this point that such portrayals of the "Ecological Indian," as historians and anthropologists like Krech and William Cronon have repeatedly and conclusively shown, at best function as homogenizing stereotypes, and at worst are wielded as tools of racial animus).[18]

In *Biomimicry*, a new mutation in the role of the "Ecological Indian" has emerged, a resolution to the contradictions between "ecomodernist" fantasies of sustainability[19] and the political economy of innovation that rules contemporary American management ideologies.[20]

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[14] *Ibid*, 17
[15] *Ibid*, 18.
[16] *Ibid*, 20, 20.
[17] *Ibid*, 21.
[18] See Krech, *The Ecological Indian.* See also William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England* (New York: Hill & Wang, 2003[1983]). Cf. Carolyn Merchant, *Ecological Revolutions: Nature, Gender, and Science in New England* (Chapel Hill: University of North Carolina Press, 1989)
[19] See Jonathan Symons, *Ecomodernism: Technology, Politics, and the Climate Crisis* (Cambridge: Polity, 2019).
[20] See Benoit Godin, *Models of Innovation: The History of an Idea* (Cambridge: MIT Press, 2017).

The "Ecological Indian" that Benyus reads into Moi does not reject technology; instead, he offers a renewed pedagogy for innovation enacted via nature's imitation—by nature, with nature. Responsive to but not determined by formerly desirable traits of "skill" and "harmony," one might label the ecological virtue ascribed to the Indigene today as *innovation from nature*.[21] Versed in sustainable design principles, the "Ecological Indian" has become more technological.

Tropes are often conceived in opposing pairs, and *Biomimicry* is no exception to this structuralist heuristic. Encoding the indigenization of ecology in name, Krech terms the antonym of the "Ecological Indian" the "Nonecological White Man."[22] Benyus prefers *Homo industrialis.* True to her Linnaean heritage, Benyus recounts what reads in form as the *natural* history of this zoological species but in content turns out to be its inversion, an *unnatural* history of the "West":

> Though it seems perfectly sensible to echo our biological ancestors, we have been traveling in just the opposite direction, driven to gain our independence. Our journey began ten thousand years ago with the Agricultural Revolution, when we broke free from the vicissitudes of hunting and gathering and learned to stock our own pantries. It accelerated with the Scientific Revolution, when we learned, in Francis Bacon's words, to "torture nature for her secrets." Finally, when the afterburners of the Industrial Revolution kicked in, machines replaced muscles and we learned the rock the world. But these revolutions were only a warm-up for our real break from Earthly orbit—the Petrochemical and Genetic Engineering Revolutions. Now that we can synthesize what we need and rearrange the genetic alphabet to our liking, we have gained what we think as autonomy. Strapped to our juggernaut of technology, we fancy ourselves as gods.[23]

In contrast to the Indigene who models "closeness to nature, nobility, and ecological sainthood," Benyus demonizes the "Westerner," casting him as Earth's antagonist, locked in a Promethean struggle against life—a planetary "drama" she stages as a quintet of "ecological revolutions."[24]

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[21] The relationship of this virtue to its predecessors abides by a pattern of "innovation and proliferation." On this historiographical relation, see Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2010), 18.
[22] Krech, *The Ecological Indian*, 27.
[23] Benyus, *Biomimicry*, 5.
[24] Krech, *The Ecological Indian*, 22. On ecological revolutions, see Merchant, *Ecological Revolutions*. On social dramas, Victor Turner, *The Forest of Symbols: Aspects of Ndembu Ritual* (Ithaca: Cornell University Press, 1967).

If Moi the Huaorani imitated the jaguar in his cry for recognition from the federal government, the "Westerner" likewise adopts and models features of his corresponding "fetish": technology. So enamored are "Westerners" with the levers of their "independence" and "autonomy" that they became machines, bureaucratic "staffers" whose mechanical subjectivity is inscribed in name: *Homo industrialis*, a binomial classifying "Western" persons by their intimacy with machines.[25]

Taxonomic play, the renaming of *Homo sapiens*, is not an unfamiliar activity to philosophers and social theorists. Consider *Homo faber* ("the making human"), the nomenclature that Max Scheler, Hannah Arendt, and Henri Bergson each used, separately, to inscribe artifice as the unique signature of what it means to be human, the essence of our human-ness. Consider, also, some of humanity's more colorful appellations: *Homo ludens* ("the playful human"), *Homo economicus* ("the economical human"), or *homo narrans* ("the story-telling human")—all of which unveil a general truth about the human—a statement about species.[26] What separates the anthropological name game of biomimicry from its prior iterations is the distinction Benyus introduces *within* the human species—that is, between "industrial" and "preindustrial" humanity. Where fabrication, play, rationality, and narration denote the behaviors of *a* particular human that reflect qualities intrinsic to *the* human, *Homo industrialis* is an altogether different beast. To Benyus, Industrial Man is the effect of an externality, the capitalist mode of production, which bifurcates the anthropological category of the human, generating a mutant distinct from its

[25] One thinks, for instance, of Max Weber on the "iron cage," *The Protestant Ethic and the Spirit of Capitalism* (London: Routledge, 1992[1905]).

[26] I allude to the evolutionary genetic notion of a "wild type" here, that is, the "normal" phenotype of a species against which a "mutant" is measured, not merely as a metaphor for the tensions between sameness and difference that threaten to undo the integrity of "species," but also to underscore the "wild" characteristics against which the category of *Homo industrialis* is opposed. *Homo industrialis* is defined in contradistinction to "wilderness," which the historian William Cronon characterizes as "the last remaining place where civilization, the all too human disease, has not fully infected the earth […] an island in the polluted sea of urban-industrial modernity, the one place we can turn to escape from our too-muchness." Like "the idea of wilderness," *Homo industrialis* is fictive. See William Cronon, "The Trouble with Wilderness: or, Getting Back to the Wrong Nature," *in* William Cronon, ed., *Uncommon Ground: Toward Reinventing Nature* (New York: W.W. Norton & Company, 1995), 69.

"wild" nature-imitating type.[27] *Homo industrialis* is defined by a system that negates (its) nature. It is, to paraphrase the feminist philosopher of sex Luce Irigaray, the species which is not one.[28]

In his history of the idea of human history, Giorgio Agamben likewise recognizes a "schizmogenic" tendency in the category of *Homo sapiens*.[29] The enterprise of anthropology, the study of Man, is, for Agamben, dependent on the operation of a mechanism that separates the human from the animal. This "anthropological machine" creates the human as a discursive object that dwells both in animality, in its organicity, and outside it, by dint of its grasp on language.[30] Agamben writes, "The anthropological machine verifies the absence of a nature proper to *Homo*, holding him suspended between a celestial and a terrestrial nature, between animal and human—and thus, his being always less and more than himself."[31] Benyan anthropology works similarly: *Homo industrialis* frees itself from the nature that nevertheless remains the pretext for its being. "We are still beholden to ecological laws," Benyus argues, "the same as any other life-form."[32]

Yet, if, to Agamben, it is speech that distinguishes the human from animal, to Benyus, industrial capitalism as a socioeconomic form is the motor that runs the anthropological machine. Her anthropological history criticizes industrialism from the view of a moral epistemology in which rationality, which Benyus parses as "cleverness," suppresses an animalistic desire to copy. And, just as Agamben observes the termination of the anthropological machine in biopolitics, in the contemporary "animalization of man,"[33] so too does Benyus anticipate an animal return,

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[27] Intentionally or not (I'm inclined toward the latter), Benyus borrows a central tenet of Marxist analyses, that is, the alienation of the worker from the self, objectified via labor, and elevates it to the status of anthropological fact.
[28] Luce Irigaray, *This Sex Which Is Not One* (Ithaca: Cornell University Press, 1985).
[29] Giorgio Agamben, *The Open: Man and Animal* (Stanford: Stanford University Press, 2004[2002]). The *locus classicus* of schizmogenesis is in Gregory Bateson, *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology* (Chicago: University of Chicago Press, 2000[1972]).
[30] Agamben, *The Open*, 26.
[31] *Ibid*, 29.
[32] Benyus, *Biomimicry*, 5.
[33] Agamben, *The Open*, 77.

albeit less as sociological commentary than as design manifesto. "As we discover what nature already knows," she writes, "we will remember how it feels to roar like a jaguar—to be a part of, not apart from, the genius that surrounds us."[34] From *Homo industrialis* back to something else.[35]

In *Biomimicry*, this something else is mimesis, which Benyus frames as the original epistemology of technology. "We as a species are well shaped to mimic what we see and hear," Benyus speaks of mimicry, distilling millennia of heterogeneous mimetic practices into one universal psychological faculty.[36] Alongside self-consciousness and memory, Benyus regards imitation as one of humanity's three "evolutionary gifts." As in phylogeny, so too in ontogeny: "Children learn language and gender roles and acceptable behavior by mimicking adults, and as mimes they prove to be uncanny."[37] She considers prehistoric art alongside "native Alaskan" hunting techniques to prove this: "The first artists were also practicing mimics, re-presenting the natural world in painting, song, and dance. The art of survival itself has probably always hinged on an ability to imitate the traits of the best and brightest in any habitat in which we found ourselves. Ice ages ago, hunters doused themselves in musk to smell like their prey, and today, native Alaskans still stalk seals by stretching flat on the ice like their polar bear mentors."[38] Between the past and present, Benyus attributes an air of timelessness to Indigenous mimicry.

In contrast to *Homo industrialis*, the *anthropos* that doubles as the *telos* of biomimicry eludes signification—a *telos* that is as much an end or destination as it is a return to beginnings.

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[34] Benyus, *Biomimicry*, 10.
[35] Glib zoomorphisms such as this trivialize how social processes of animalization often mark particular bodies as different through Western categories of race and Indigeneity—markings that are rarely neutral, often inciting and legitimizing violence against those designated less- or more-than Eurocentric definitions of the "human." Consider Clapperton Chakanetsa Mavhunga's history of humans classified as "vermin being" in present-day Zimbabwe. Clapperton Chakanetsa Mavhunga, "Vermin Beings: On Pestiferous Animals and Human Game," *Social Text* 29.1 (2011): 151-176. On Native Americans animalization, see Lauren Eichler and David Baumeister, "Predators and Pests: Settler Colonialism and the Animalization of Native Americans," *Environmental Ethics* 42.4 (2020): 295-311.
[36] Benyus, *Biomimicry*, 296.
[37] *Ibid*, 296.
[38] *Ibid*.

This is in spite of its role as the mirror image of *Homo industrialis*, its anthropological obverse. To best scrutinize the contours of this romantic figure, I name it *Homo mimesis,* Imitating Man. If *Homo industrialis* abounds in its difference from nature, *Homo mimesis* revels in its similitude, an anthropological proximity to nature that borders on animality vis-à-vis its mimetic technicity. Analytically, *Homo mimesis* is an ideal type, a concatenation of disparate and often dispersed elements of discourse in *Biomimicry* that were drawn on by biomimics during my field research. It is an anthropological history about human anteriority (*Homo mimesis* is imagined as both prior to, and contemporaneous with, *Homo industrialis*) that is also a cultural psychology about human interiority (an inclination, or innate mental capacity, to copy and emulate nature in technology). While scholars of biomimicry have noted its discursive construction of humanity versus nature, the machinery of dichotomization *internal* to the category of the "human" has been overlooked.[39] This is a significant lacuna considering that the equivalences of the Indigene, *Homo mimesis,* and "preindustrial societies," together with their distinction from *Homo industrialis*, the "Westerner," implicates biomimicry's historicity in representational economies inherited from colonial eras.[40]

It is thus not only true that these equivalences rob Indigenous people of any cultural particularity by hypostasizing mimicry as a universal element of their techno-epistemologies—a flattening that is tantamount to the reduction of technical diversity, depicting Indigenous persons as everywhere one and the same. It is also true that these equivalences, *especially* the descriptor "pre-industrial," exile Indigenous people from the present, denying them historical qualities of

[39] See footnote 49 in Introduction.

[40] It is also significant considering the real historical dangers of inscribing (imagined) cultural differences at the level of species. Inscribing mimicry in the order of natural, specifically natural historical, kinds (*Homo mimesis* vs. *Homo industrialis*) is one side of a coin whose other surface exposes a violent history. The historian Londa Schiebinger writes in the case of *Mammalia* that assignations of the "place of humankind within nature" are political acts that reflect embedded systems and hierarchies of value. While the anthropological figure of *Homo mimesis* is, to biomimics, an ideal and an emblem of sustainable innovation, a positive value, the use of "species" and "race" often leads to nefarious results. On *Mammalia*, see Londa Schiebinger, "Why Mammals Are Called Mammals: Gender Politics in Eighteenth-Century Natural History," *The American Historical Review* 98.2 (1993): 382-411, 411.

mutability, creativity, and temporality. Within ritualized histories about the role of mimicry in "native cultures" that I heard during workshops (see Chapter One), the Indigene is an a-historical figure devoid of history and any ontology of human becoming—every-when mimetic, by nature. Such histories derive from the "cultural model" of time that Benyus articulated in *Biomimicry*.[41]

Johannes Fabian named her mode of "temporalization"[42] the "denial of co-evalness,"[43] which affords mutability only to the colonizer, the Western subject, not to the colonized—a "schizogenic use of time."[44] Fabian criticized this as a kind of colonial stopclock that freezes the Other in the West's past, justifying their subordination to the imperial powers who would carry them into the present of civilization. In his ethnography of the Ayoreo people of Paraguay, Lucas Bessire finds that this absence of temporality leads to a feeling of "phantom objectivity"[45] that precludes Indigenous persons from swimming within the currents of Fabian's "universal time,"[46] dispossessing them of the historical agency to re-invent themselves, adapt to the contemporary.[47] As scholars of settler colonialism like Patrick Wolfe have explained, the denial of temporality to the Indigenous inhabitants of settled land contributes to their ongoing genocide: Consigned to the past, Indigenous persons living in the "present" are forgotten, neglected, and rendered invisible.[48]

In biomimicry, the simultaneous effacement of real, contemporary Indigenous persons and the New Age posturing of mimesis as culturally resonant with technological traditions in "all

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[41] Roy D'Andrade and Claudia Strauss, eds., in *Human Motives and Cultural Models* (Cambridge: Cambridge University Press, 1992).
[42] The anthropologist Nancy Munn defines "temporalization" as "everyday practices" by which "time as a symbolic process [is] continuously being produced." Nancy Munn, "The Cultural Anthropology of Time: A Critical Essay," *Annual Review of Anthropology* 21 (1992): 93-123, 116.
[43] Fabian, *Time and the Other*, 31
[44] *Ibid*, 21.
[45] Lucas Bessire, *Behold the Black Caiman: A Chronicle of Ayoreo Life* (Chicago: University of Chicago Press, 2014), 39.
[46] Fabian, *Time and the Other*, 3.
[47] Bessire, *Behold the Black Caiman,* 32.
[48] Patrick Wolfe, "Settler Colonialism and the Elimination of the Native," *Journal of Genocide Research* 8.4 (2006): 387-409. See also Scott Lauria Morgensen, "The Biopolitics of Settler Colonialism: Right Here, Right now," *Settler Colonial Studies* 1.1 (2011): 52-76.

native cultures" amounts to what the Standing Rock Sioux historian Philip Deloria has criticized as "playing Indian."[49] In such acts of cultural appropriation and imitation, or "going native," Shari Huhndorf's term, Americans perform authenticity—biomimics: Indigenous proximity to nature—by enacting themselves as inheritors of "past" traditions.[50] An inversion of the relations of power and pantomime that Homi Bhabha understood as "colonial mimicry," this is better said as settler mimicry.[51] In her history of the commodification of anthropological knowledge in the 20th century, Micaela Di Leonardo argues that Indigenous representations let Americans "escape modernity through immersion in the lives of those Others considered organically whole by virtue of their distance, in time and/or space, from the etiolated world of Western logic and progress."[52] This fantasy of escape is animated by an affect that Renato Rosaldo characterized as "imperialist nostalgia"—an "elegiac mode of perception" in which complicity is masked under the guise of a longing, or "innocent yearning," for the "passing of what they themselves have transformed."[53] In search of a retreat from ecological crises in which she is complicit, Benyus mourns the "past."

The veracity of these enacted traditions of Indigenous technicity—their basis in any historical or contemporary practice—matters little. Instead, they partake in what Eric Hobsbawm has called "the invention of tradition"—a "set of practices, normally governed by overtly or tacitly accepted rules and of a ritual or symbolic nature, which seek to inculcate certain values and norms of behavior by repetition, which automatically implies continuity with the past."[54] In

[49] Philip J. Deloria, *Playing Indian* (New Haven: Yale University Press, 1999).
[50] When I place "past" in quotation marks, I mean to signal that biomimics understand these traditions as in the past. On "going native," see Shari Huhndorf, *Going Native: Indians in the American Cultural Imagination* (Ithaca: Cornell University Press, 2001).
[51] Homi Bhabha, "Of Mimicry and Man: The Ambivalence of Colonial Discourse," in *The Location of Culture* (London: Routledge, 1994), 85-92.
[52] See Micaela di Leonardo, *Exotics at Home* (Chicago: University of Chicago Press, 1998), 2.
[53] Renato Rosaldo, "Imperialist Nostalgia," *Representations* 26 (1989): 107-122, 107, 109, 108.
[54] Eric Hobsbawm, "Introduction: Inventing Traditions," in Eric Hobsbawm and Terence Ranger, eds., *The Invention of Tradition* (Cambridge: Cambridge University Press, 1983), 1.

the invented traditions of technological mimicry, the relationship of Western contemporaneity to an Indigenous past (or present unchanged) is "factitious," a temporal fabrication that does more to assert a social identity around a fictive mimetic unity between humanity and nature than it does to disclose a historical truth about Indigenous design.[55] Mythologies about Indigeneity are, in other words, techniques of socialization through which biomimics understand time and value; such tales double time, plotting mimicry in Hobsbawm's "assumed mists of time" but also in the future that biomimics desire[56]—a future that is at once a return and a rupture from the "modern."

Within time's doubling is the duplicity of biomimicry's value. When Benyus narrates cultural history through a comparative anthropology of "native cultures" and "Westerners," she construes an invented past as a rhetorical resource—a source of a mystified technical authority.[57] On the one hand, biomimicry seems continuous with Indigenous mimicry. On the other hand, it is seen as *dis*continuous. In *Biomimicry* and in other sites of ideological enunciations, biomimics portray their design praxis as a critique of "modern" design (Chapter Two) that is unlike "native imitation" (Chapter One) because of the validity of biological science.[58] Where they "remember" Indigenous design as timeless, without history, they distinguish their own agency as creative, a

[55] *Ibid,* 2.
[56] *Ibid*, 2.
[57] If Jane Guyer posed the "near future" (and its evanescence) as an ethnographic object, what occupies biomimics (and me, here) is not (just) the near future, but the *distant past*. Like the near future, the distant past involves an affective relationship to the creep of technological uncertainty in the face of problems of the contemporary, a feeling of unease that is alleviated through nostalgia for proven pasts. See Jane Guyer, "Prophecy and the Near Future: Thoughts on Macroeconomic, Evangelical, and Punctuated Time," *American Ethnologist* 34.3 (2008): 409-421.
[58] This shift from continuity to discontinuity requires a rethinking of Hobsbawm's "invented tradition." This is precisely what the anthropologist Heather Paxson completes in her ethnography of American cheese production. In the political economy of the United States, the European polarity of the traditional and modern holds less sway for artisanal cheesemakers who signify their differences from traditional methods and values. If, for Hobsbawm, the invention of tradition forges a fictive connection with the past, among the artisans Paxson studied, it is the claim of change that dissimulates the similarity to the industrial. For such artisans, the "tradition of invention" supersedes the invention of tradition. In other words, the tradition invented is an American one of novelty and entrepreneurialism. See Heather Paxson, *The Life of Cheese: Crafting Food and Value in America* (Berkeley: University of California Press, 2013), 95. In biomimicry, practitioners rely on invented traditions *and* the (invented) tradition of invention.

paradox of continuity/discontinuity, regress/progress, and tradition/invention that I theorize as *nostalgic innovation*—a contradiction of terms that betrays a double crossing of time and value.

Anthropologists of capitalism have presented temporality in an either/or dichotomy: Capitalism is oriented to either the past or to the future. For instance, "millenarial capitalism" is recognized by John and Jean Comaroff for its "messianic, salvific, even magical manifestations" in which signs of heritage, like biomimicry's invented tradition, confer value and a sense of the "enchantments" of capital.[59] On the contrary, Nancy Munn has contended that a defining feature of capitalist phenomenology is its orientation to an indefinite future.[60] Likewise, Lucy Suchman observes that the ideology of innovation in the United States is directed toward the future.[61]

Nostalgic innovation is less about any constant alignment with the past or the present than it is about strategic dis/affiliations and dis/articulations. The question becomes, therefore, not who invents and who does not, which would only resurrect the contrast between "hot" and "cold" societies that Levi-Strauss once distinguished,[62] but who steers the wheels of time, that is, who wields "time as a technique," as Laura Bear asks, claiming anthropological relationships of similarity and dissimilarity, continuity and discontinuity, and fashioning the timeless as timely.[63] In a celebrated essay on design, Suchman attends to these dynamics of power through her notion of the "performative metaphysics of the new," where the category of the new is enacted through shows of sameness and difference.[64] Following her cue, Lilly Irani provocatively asks, "Can the

[59] Jean Comaroff and John Comaroff, "Millenial Capitalism: First Thoughts on a Second Coming," *Public Culture* 12.2 (2000): 291-343, 292.
[60] Nancy Munn, "The Cultural Anthropology of Time: A Critical Essay," *Annual Review of Anthropology* 21 (1992): 93-123.
[61] Lucy Suchman, "Anthropological Relocations and the Limits of Design," *Annual Review of Anthropology* 40 (2011): 1-18.
[62] Claude Levi-Strauss, *The Savage Mind* (Chicago: University of Chicago Press, 1966[1962]).
[63] Laura Bear, "Time as Technique," *Annual Review of Anthropology* 45 (2016): 1-16.
[64] Suchman, "Anthropological Relocations and the Limits of Design," 15.

subaltern innovate?"[65] I have a kindred query: Can the Indigene innovate? Reading *Biomimicry*, one leaves with the impression of a negative response. In the anthropology of design that Benyus charts, there is an indigenized economy of innovation in which Indigenous peoples are seen more like foils to "Westerners" and "modern" design than they are fully realized technological agents.

[65] Lilly Irani, *Chasing Innovation*; Thomas Yarrow, *Architects: Portraits of a Practice* (Ithaca: Cornell University Press, 2019).

I

De-Natured Design: Life, Analogy, and Labor in Biomimicry Thinking

"The more our world looks and functions like this natural world, the more likely we are to be accepted on this home that is ours, but not ours alone," Janine Benyus declared in *Biomimicry*. In June of 2017, I was aboard a northbound train from Boston, flipping through the book that put biomimicry to page. At my window, ocean views and reedy ponds unfurled in filmic succession. To learn what biomimics mean when they say "function" is the basis of life's likeness, I was on my way to an immersive workshop organized by Biomimicry New England and advertised by the Biomimicry Institute. How do biomimics make "design principles" from life's "functions"?

"America's oldest seaport," read the weathered plaque of the City of Gloucester as I stepped onto the railway platform. Located on Cape Ann at the northernmost reaches of the Massachusetts Bay, about thirty miles from Boston, Gloucester is a working-class fishing town that derives a maritime industry and identity from the Atlantic Ocean.[1] I ordered a Lyft to a destination inaccessible by public transit: the Brynmere Inn. My driver told me with pride and woe that he was the "only driver in Gloucester," a tiring ordeal for a man already employed as an arborist and a reserve firefighter. "Nice part of town," he commented, pointing to the groomed yards and grandiose colonials that appeared in sight as we crossed over a river into Annisquam.

Annisquam is a former artist colony with picturesque landscapes that attracted painters

[1] Increasingly, Gloucester has become a tourist destination and bedroom community for upper-class residents of the Boston metropolitan region. On Gloucester's history, see Christine Heyrman, *Commerce and Culture: The Maritime Communities of Colonial Massachusetts, 1690-1750* (New York: W.W. Norton & Company, 1986).

as different as Winslow Homer and Mark Rothko. Today, Annisquam is also a popular summer colony, with a seasonal population of upper-class Bostonians that swells threefold from June to August as they leave the city to vacation by the sea, peruse antique shops, daytrip amid its woods and on its waters, and dine on its seafood. A century ago, this seaside idyll was awash with inns both quaint and ornate. As the dominance of the automobile redrew the geography of leisure over the 20th century, business in faltered, and only a few inns still operate, including the Brynmere. Failing to evolve with midcentury economic conditions, these inns seemed an unlikely site for a design workshop on evolutionary adaptations as technological "innovations inspired by nature."

Figure 1: The Brynmere[2]

My driver dropped me off in front of a grass lawn and a three-story Victorian building. A covered veranda wrapped around the Brynmere's street and ocean sides, where chipped wicker chairs lent one a panorama of the Ipswich Bay. As I walked inside the foyer, my footsteps caused

[2] Unless otherwise noted, all photographs in this dissertation are the author's.

the aged hardwood floors to creak under foot. On wood-paneled walls, sepia photographs from the 1920s depicted an exterior unmarked by the passage of time, as well as an all-women crew of hotel workers. I dropped off my bags at reception and followed the sound of a voice into a salon. In one corner of the room, a square table served as an exhibition on the material culture of biomimicry: a library of naturalist guides, biology reference books, and primers on biomimicry, as well as scattered seashells, seaweed, seeds, cones, and crab skeletons, curated like found art.

Figure 2: *Objet Trouvé*

Sitting in a tufted antique chair next to a disused fireplace, an older white man in a button-down and khakis stood up from his conversation with another participant to greet me. Firmly gripping my hand in his, he introduced himself as Peter, one of the three co-founders of Biomimicry New England. Peter was genial and outgoing, describing his background to me as waited for the workshop to begin. With bachelor's degrees in economics and architecture from

Lafayette College and Rhode Island School of Design, respectively, Peter's life mission has been spent convincing business leaders of design's value, first as a director of the Design Management Institute, and then as a chair of the Corporate Design Foundation, a position he held for 29 years. Peter knew from first-hand experience what management professionals want—a client-oriented awareness that, I would discover, suffused how he and his co-organizers thought about mimesis.

When I asked, he also described himself as a homeowner in Annisquam, a member of the Annisquam Yacht Club, and a friend of the Brynmere's proprietors, a couple who only rent the inn to personal acquaintances. While he considered the neighborhood his year-long residence, he and his wife had newly purchased a luxury apartment—a "departure" from his usual "taste" in old, refurbished houses—in a high-rise in the "Combat Zone" of Boston, a dated name for a strip in Chinatown once infamous for, as Peter said, "prostitution and gang violence." Before long, he looked down at his watch and said we should start soon. A bell rang, summoning us to the porch.

Over a cacophony of cicadas and songbirds, Peter and two other workshop leaders, Tim and Taryn, spoke to us, welcoming our multi-disciplinary cohort of eight participants, which included: an architect, an ecologist, an industrial designer, an urban planner, a microbiologist, a nonprofit director, a teacher, and myself. We would learn about biomimicry through lectures, a kayaking trip, and a two-day design challenge. To "kick-start" the five-day course, Tim, a white, middle-aged biologist, designer, and co-founder of Biomimicry New England, led us down to a private beach to practice "quick biomimicry." Under cloudy skies and the watchful eye of two families that tracked our steps from afar, Tim explained that ancient glaciers slid down the shore, depositing a residue of granite boulders that still studded the sand. In the cracks and crevices of these rocky heads, the high tides of the ocean become trapped, forming pools teeming with life—biological organisms that our guides would help us see anew as embodied technical innovations.

"Observation," Tim prefaced, is a "key technique" of biomimicry, like "science," but with what he called a "different lens." We could proceed without knowing the names of what we were observing—a kind of "amateur naturalism," as he put it. For thirty minutes, he wanted us to walk the intertidal zone and "keep an eye out for an organism or living artifact of interest," sketching it and documenting "as many observations of form, process, or system that you can," using series and steps to depict processes, and diagrams or maps to depict the system's relations. With these observations, we were to select one and explain "why" it exists—"what value does it have for the organism," he asked, paraphrasing, "what function is being performed?" From its function, he asked to imagine "where you could use this function in your work, life, technology."

"This is an extreme environment," Tim said to us after we scuttled back to him at the conclusion of the assignment. "You have to be resilient here." He asked: "What did you notice?" Scattered observations of several organisms on the beach—flies, snails, barnacles, crabs, and seaweed—received "good, what else?" from Tim. As we shared our reflections, Peter pointed out a razor clam squirting out a jet of water and burrowing into the sand. "That does not seem like it would be a good thing to do," he said. "It could alert predators." The clam also intrigued Tim. "Why does it exist?" he asked the group. "What's the function?" Taryn, a white consultant with a bachelor's in environmental science and a PhD in management, rattled off some functions: "Protect the clam, dig, move water, filtering, breathing, anchors…" she trailed off. Tim replied, "It is doing a lot of functions," which are "difficult to determine." "What do you want to learn from it?" he offered as a resolution. "Everything [visible] has a function," Taryn summated.
In the epistemology of life that animates biomimicry, there is an imagined symmetry or parallel, as Tim and Taryn indicated, between functions that organisms possess in order to "exist," their "value" for the organism, and the valued functions that designers can build into mimetic artifacts.

Back at the Brynmere, Tim situated our intertidal activity in a skill-based curriculum centered on the concept of function(s). While "design" programs run by the Biomimicry Institute are often taught through its signature method, Tim wanted us to refocus on acquiring a "skill set" that, based on his career working as a consultant, was better suited to the reality of contract work. The first skill, which we had recently practiced, was "creative observation." This encompassed "sketching," "empathy," and "immersion." Sketching, Tim theorized, "changes the observation process because the image itself gives you more information," but those "patterns are not really there," he stipulated. "Sketching is already translational." To understand empathy, Peter then presented the analogy of the "Good Grips" product line from the manufacturing company OXO. Through "empathy for a range of ages" and "uses," their industrial designers increased the value of their kitchen tools and expanded their market. Thinking with Good Grips, he asked: How can we move empathy beyond humans to nature? How can we be empathetic to the biological world? Tim agreed: Empathy "increases our ability to see the world in new ways, enables people to select interests, and fosters curiosity" through immersion, which we would undergo by kayaking.

Functional knowledge, the second skill, is the "skill most unique to biomimicry," Taryn emphasized. This is, she said, our "translational ability"—our ability to "build functional language and organize what you see in the world." The language of function enables what she termed "field jumping," which "allows the transition of biological terms, strategies, and insights to other fields of application or study." The third and final skill, connected application, pertains to the individual and collaborative design techniques that one employs to make mimetic artifacts. It is, as Tim said, about "combining functional insights with existing innovation techniques […] to bring nature into innovation." Our learning objectives defined, we signed up for communal tasks in the kitchen and broke for dinner, where Tim shared his thoughts on the "biophilia" thesis

proposed by biologist E.O. Wilson and elaborated upon by ecologist Stephen Kellert.[3] Where the thesis has postulated "seven different ways of valuing nature," Tim said (in fact, Kellert offered a typology of nine values), biomimicry is "another value," not just "using nature," but imitating it.[4] Ilya, a white nonprofit professional in his mid-20s, remarked that he "gets in trouble with the bio, with the big 'B'," referring to the idea of Nature as an unspecified abstraction. "It's broader than that," he contended, joking that we wash our "greasy hair" with soap, killing microbes in nature. Tim laughed and said, "It's a broader definition of mimicking. There are many kinds of nature."

In this chapter, the first of three, I attend to the "kinds of nature" that biomimics like Tim, Taryn, and Peter imagine when they make design principles based on biological functions. Behind the discourse, or metalanguage, of biomimicry is a particular set of cultural assumptions about what "nature" is—a set bracketed by a "romantic"[5] view of evolution and an "Arcadian"[6] view of ecology. According to the just-so story narrated by Janine Benyus, biological organisms, over 3.8 billion years of evolution, have perfectly adapted to their environments. The "secrets" to their harmonious co-existence lie in the characteristics or traits they have acquired during natural

[3] On biophilia, see E.O. Wilson, *Biophilia* (Cambridge: Harvard University Press, 1984) and Stephen Kellert and E.O. Wilson, eds., *The Biophilia Hypothesis* (Washington, D.C.: Island Press, 1995). Wilson, and later Kellert, hypothesized that humans have an innate (evolutionarily acquired) affinity toward nature. Through Kellert's work, the concept of "biophila" has become a design philosophy that is premised on an imagined link between green space and human wellbeing. See Stephen Kellert, *Nature by Design: The Practice of Biophilic Design* (New Haven: Yale University Press, 2018) and Timothy Beatley, *Biophilic Cities: Integrating Nature into Urban Design and Planning* (Washington, D.C.: Island Press, 2010). On the history of the biophilic design, see Jana Söderlund, *The Emergence of Biophilic Design* (New York: Springer, 2019). In my fieldwork, the biophilia hypothesis was often used to justify biomimicry. The logic went: Because we have an innate connection to nature, we *should* imitate nature in artifice.
[4] Kellert's theory of the values of nature to humans: aesthetic, dominionistic, ecologistic-scientific, humanistic, moralistic, naturalistic, negativistic, spiritual, symbolic, utilitarian. As a tenth value, biomimicry would fuse elements of the aesthetic, ecologistic-scientific, humanistic, moralistic, naturalistic, spiritual, and symbolic. See Stephen Kellert, *The Value of Life: Biological Diversity and Human Society* (Washington, D.C.: Island Press, 1996) & Stephen Kellert, *Birthright: People and Nature in the Modern World* (New Haven: Yale University Press, 2012).
[5] Robert Richards, *The Romantic Conception of Life: Science and Philosophy in the Age of Goethe* (Chicago: University of Chicago Press, 2002).
[6] Donald Worster, *Nature's Economy: A History of Ecological Thought* (Cambridge: Cambridge University Press, 1994[1977]).

selection[7]—"forms, processes, systems," Tim said, that rest at varying levels of organic "scale."[8] These features, or "functions," enable living beings to survive with minimal ecological burden.

Equating this alleged *survivability* with socioeconomic ideas of *sustainability*, Benyus posits organisms as exemplary models of sustainable *innovation*. From this late modern angle, biological "life" appears as a collection of desired functions—"technologies" to Benyus, "living artifacts" to Tim—that designers can, and should, imitate to reform what anthropologist Michael Fisch names the "technological culture" of the West.[9] Within this "biocultural" construction,[10] nature, or life, is, quite literally, "enterprised up," as Marilyn Strathern called "nature" after reproductive technology.[11] To biomimics, nature seems like Enterprise itself: a reified process of business innovation that reflects and refracts scientific histories of organisms and machines.[12] To biomimics, nature is not just mechanical; it is innovative—a technology at once sustainable and economical. In conversation with histories, anthropologies, and other humanistic (and post-

[7] Evelyn Fox Keller, *Secrets of Life, Secrets of Death: Essays on Language, Gender and Science* (New York: Routledge, 1993).
[8] On the analysis of "scale" in anthropology, see E. Summerson Carr and Michael Lempert, eds., *Scale: Discourse and Dimensions of Social Life* (Berkeley: University of California Press, 2016). In the history of biology, discussion of scale has been implicit in the way that scholars talk about the epistemology or "view" of life at varying scale from the organism to the gene. For instance, see Lily Kay in *The Molecular Vision of Life: Caltech, the Rockefeller Foundation, and the Rise of the New Biology* (Chicago: University of Chicago Press, 1993).
[9] Michael Fisch, "The Nature of Biomimicry: Toward a Novel Technological Culture," *Science, Technology, & Human Values* 42.5 (2017): 795-821.
[10] On the "biocultural," see Sarah Franklin, *Dolly Mixtures: The Remaking of Genealogy* (Durham: Duke University Press, 2007) and Samantha Frost, *Biocultural Creatures: Toward a New Theory of the Human* (Durham: Duke University Press, 2016). Compare with "biosocial" in Timothy Ingold and Gisli Palsson, eds., *Biosocial Becomings: Integrating Social and Biological Anthropology* (Cambridge: Cambridge University Press, 2014).
[11] Marilyn Strathern, *After Nature: English Kinship in the Late Twentieth Century* (Cambridge: Cambridge University Press, 1992).
[12] The classic reference on organisms and machine is Georges Canguilhem, "Machine and Organism," in *Knowledge of Life* (New York: Fordham University Press, 2008), 75-97. See Evelyn Fox Keller, "Organisms, Machines, and Thunderstorms: A History of Self-Organization, Part One," *Historical Studies in the Natural Sciences* 38.1 (2008): 45-75; Evelyn Fox Keller, "Organisms, Machines, and Thunderstorms: A History of Self-Organization, Part Two. Complexity, Emergence, and Stable Attractors," *Historical Studies in the Natural Sciences* 39.1 (2009): 1-31; and Jessica Riskin, "The Defecating Duck, or, the Ambiguous Origins of Artificial Life," *Critical Inquiry* 29.4 (2003): 599-633.

humanistic) studies of the life sciences, I reveal how *biology as innovation* informs biomimicry, producing not only new epistemologies of "nature" but also new ideologies of "sustainability."[13]

More specifically, this chapter asks how "knowledge of life"[14] shapes the mimetic practice of biomimicry. Through an analytical focus on how biomimics abstract design principles from nature with the "biomimicry thinking" method, I elaborate on the concept of meta-design as a technique of analogy used in "routinized business innovation."[15] Drawing on the anthropologist Graham Jones's distinction between "analogy" and "disanalogy," I locate their "design" practice in dis/analogies—work that I call *mimetic labor*.[16] "Mimesis," Michael Lempert writes, "is notoriously unstable and requires labor to stabilize."[17] By this concept, I mean to I show how biomimics produce mimeticism as a relation of function—e.g. *this* biological function is like *that* design function—through social interactions among biomimics and living things (or remains or representations of living things).[18] In the interplay of positive and negative analogies (*this* is *not* like that), or disanalogies, biomimics assemble design principles, what I termed proto-forms, that designers resolve into fleshed out forms. In contrast to biomimics' interpretation of "functional knowledge" as a "translational ability," I reason that the epistemic production of "life's likeness" is best grasped as an instance of "transduction"—a "transubstantiation of matter and meaning."[19]

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[13] See footnote 112 in the Introduction.
[14] Canguilhem, *Knowledge of Life*.
[15] Eitan Wilf, *Creativity on Demand: The Dilemmas of Innovation in an Accelerated Age* (Chicago: University of Chicago Press, 2019).
[16] Graham Jones, *Magic's Reason: An Anthropology of Analogy* (Chicago: University of Chicago Press, 2017). The notion that biomimicry is analogy is supported by biomimics' own accounts of their practice. See Swaroop Vattam, Michael Helms, and Ashok Goel, "A Content Analysis of Creative Analogies in Biologically Inspired Design," *Artificial Intelligence for Engineering Design Analysis and Manufacturing* 24.4 (2010): 467-481.
[17] Michael Lempert, "Imitation," *Annual Review of Anthropology* 43 (2014): 379-395, 383.
[18] For actor-network theory accounts of human and nonhuman agencies in design interaction, see Dominique Vinck, ed., *Everyday Engineering: An Ethnography of Design and Innovation* (Cambridge: MIT Press, 2003) and Yaneva Albena, *Made by the Office for Metropolitan Architecture* (New York: 010, 2009).
[19] Stefan Helmreich, "Transduction," in *Keywords in Sound*, eds., David Novak and Matt Sakakeeny (Durham: Duke University Press, 2015), 222-231, 222.

Biomimics do not find design principles "out there," lying in wait within biological bodies; they make them in asymmetric interactions between human interpreters and nonhuman arti(facts).

As scholars of design have shown, social interaction between designers is rife with disagreements around meaning, and biomimicry's meta-design method is likewise contentious.[20] Not only do biomimics disagree over what constitutes "function" in the organism and a "design principle" based on analogy, but there is also little consensus over how to evaluate function's fit, ecologically—i.e., the place-based logics that set biomimicry apart from other mimetic practices. In line with their cybernetic origins, some biomimics think technological functions should mirror nature's "efficiency" whereas others affirm that it is nature's "resilience" that should be imitated. As Tim, Taryn, Peter, and their colleague, Josh, share in anecdotes in this chapter, such questions and disputes are often determined, in the context of consulting, by the nature of contractual labor. Clients cared less for perfect imitations of nature's functions and fit than for marketable designs.

Instead of the mimetic ethic, biomimics often adopted the stance I call *pragmatic*, in which the capacity for imitation to generate working designs is more significant than its fidelity to nature. Whereas the meaning of "functions" in biology refers to the organism's capabilities to self-organize, biomimics often conflated the meaning of "function" in design as "use" or "utility" that they wanted to see with the functions they allegedly observed in nature, reading their desires onto the bodies of organisms. For biomimics in the pragmatic stance, function's disjunction was of little consequence as long as the analogy to nature produced a novel idea that was worthwhile to the client—a client who might say they did "nature-based design" without any "nature" at all.

This chapter advances the thesis that nature "enterprised up" does not encapsulate the *lack* of nature that haunts "nature-based design." Building on Strathern's analysis, Sarah Franklin

[20] See Louis Bucciarelli, *Designing Engineers* (Cambridge: MIT Press, 1994); Keith Murphy, *Swedish Design: An Ethnography* (Ithaca: Cornell University Press, 2015); and Vinck, *Everyday Engineering*.

calls life artificially transformed "de-natured biology."[21] Witnessed in this chapter is something altogether unique: de-natured design, biology "enterprised up" but kept in name only—an alibi. In biomimicry, particularly in workshops and consulting where the pragmatic stance reigns, "amateur naturalism" prevails over any adherence to biological truth. It is, therefore, not simply that biomimics "enterprise up" nature, poetically glossing life as innovation. Sometimes, nature appears behind design as an empty signifier—a simulacrum of life, or "copy without original."[22]

To give a feeling for the nature of the workshop, my argument moves through this fieldsite as I did, starting with introductory lectures and activities, embarking on a kayaking trip, and ending with a mini design challenge. Tim opens the first chapter with two vignettes about his biographical journey towards biomimicry consulting, in which I analyze his double figuration of nature as innovative and of (meta-)design as imitative. In the following two sections, I recollect how the ecological judgment of function fell into paradigms of efficiency or resilience in talks by Tim and Josh. Briefly, I inspect a failed biomimicry "village" to understand how implementation of design proposals is left to consultants' clients. In the penultimate section, I compare biological and "designerly"[23] notions of function in exercises that honed our skills in seeing function. Last, I review how design principles are made by analogy and disanalogy within biomimicry thinking.

After Nature: Biological Function and Nature as Sustainable Innovation

Even in the summer, dawn is a frigid time at the Brynmere Inn. Westward winds from the Atlantic surge and swell across Annisquam, chilling land and life. Early on the first morning of the workshop, we met in the kitchen to share a catered meal of frittata, fruit, pastries, and coffee.

[21] Franklin, *Dolly Mixtures*.
[22] Jean Baudrillard, *Simulacra and Simulation* (Ann Arbor: University of Michigan Press, 1994[1980])
[23] Nigel Cross, "Designerly Ways of Knowing," *Design Studies* 3.4 (1982): 221-227.

Nearly everyone wore a jacket or a sweater. Some were bundled in blankets. Even the building seemed to shudder with a cold-induced frailty. Feeling personally responsible for the location, Peter apologized for the "bad weather." Taryn corrected Peter, preferring "clothing weather."

Our collective reluctance to get out of bed, let alone talk, was surely chilling to our workshop guides. Gathered in the solarium for our first lecture, we broke the metaphoric ice by each naming our favorite organism. Most answers cited familiar "charismatic" species or genera with relatable anthropomorphic expressions, culturally resonant symbolism, or aesthetic traits of traditional beauty: for instance, bears, prairie dogs, butterflies, and swordfish.[24] Jane, a biologist of East Asian descent and a professor at Olin College in Needham, Massachusetts, said that her favorite organism (or "domain") was the bacterium. Later, Jane told me she taught a class "Six Microbes that Changed the World," in which she figured bacteria as icons of historical agency.

Beginning his presentation, Tim clicked to a slide of *his* favorite organism: the Venus flower basket, a tubular and bioluminescent marine sponge found several kilometers below the surface of the Pacific Ocean. Within its lacy corpus, a commensal form of life unfolds: Shrimp at a young age swim inside for protection, eating and growing to a large body size that prevents them from leaving the basket's web-like enclosure. Trapped, the shrimp search for mates inside. In Japan, the sponge, a common gift at weddings, signifies not imprisonment but life-long love.

What appealed to Tim were the "functions" of the basket. Intricate, flexible, and stiff, the silica-based fibers of this organism are made of biological glass, but at ambient temperatures, without the energy requirements of a "big furnace." The sponge evinced "master craftsmanship," he said, continuing that "Nature is master craftsman." In her history of biomimetics in chemistry, Bernadette Bensaude-Vincent describes this as the image of "nature as an artist, an incomparable

[24] Jamie Lorimer, "Nonhuman Charisma," *Environment and Planning D: Society and Space* 25.5 (2007): 911-932.

engineer from whom we can learn many lessons."[25] In contrast to the organisms most beloved by other workshop attendees, Tim was fascinated with the technological "functionalities" of life.[26]

Function, historians of biology claim, has long been central to the science of life. In the "epistemology of biology," function, for George Canguilhem, is *the* quintessential "biological object" through which biologists distinguish the living from non-living.[27] Canguilhem's pupil, Michel Foucault, argues similarly, positing function as the historical a priori that displaced the study of living beings from natural history to biology.[28] According to Foucault, natural history was an episteme that placed animals and plants in a matrix of superficial differences based on their visible "structure," i.e. organs. For instance, botanists studied the number, form, proportion, and location of roots, stems, leaves, flowers, and fruits to mathematize their similarities and dis-similarities. Over the 19th century, however, physiologists probed deeper inward, under the skin, to discern the invisible functions that structures perform for organisms—functions that pertain to the existence of life in its particular embodiments (functions critical to existence, such as growth, nutrition, reproduction, etc.) and universal organization (function as what enables life itself). In the words of Evelyn Fox Keller, function "turn[s] a structure or pattern into a self," an organism in perpetuity.[29] Function, to biologists, thus means "self-organization." Ontologically, it is first in the science of life, after which structure follows. As Foucault has remarked, the epistemology of biology is that which "subjects the arrangement of the organ to the sovereignty of function."[30]

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[25] Bernadette Bensaude-Vincent, Yves Bouligand, Hervé Arribart, Clément Sanchez, "Chemists and the School of Nature," *Central European Journal of Chemistry* 26 (2002): 1-5, 2.
[26] On "pure functionality," see Roger Stahl, "Life Is War: The Rhetoric of Biomimesis and the Future Military," *Democratic Communiqué* 26.2 (2014).
[27] Georges Canguilhem, *A Vital Rationalist: Selected Writings from Georges Canguilhem* (New York: Zone Books, 2003), 67, 203.
[28] Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York, NY: Vintage, 1994).
[29] Evelyn Fox Keller, "The Disappearance of Function from 'Self-Organizing Systems,'" in *Systems Biology*, eds. F.C. Boogerd, F.J. Bruggeman, J.-H.S. Hofmeyr, and H.V. Westerhoff (New York: Springer, 2007), 303-317, 310.
[30] Foucault, *The Order of Things*, 264.

For a biomimic such as Tim to remark on the Venus flower basket's developmental function was, thus, nothing remarkable from a historical standpoint. Nor was his characterization of nature as a "craftsman." What Canguilhem recognized as the "technological model" of nature, in which organisms are likened to machines, is a perennial theme within the history of biology.[31] In the analogy between organisms and machines, life appears as an assemblage of parts geared toward a functional purpose—i.e. a mechanism. For natural theologians in the late 18th and early 19th centuries (e.g. William Paley, Charles Bell, and John George Wood), the intricacy of biological artifacts like the eye and the hand was incontrovertible evidence of divine design.[32] With the advent of evolutionism, life's design was secularized, and the origin of organic form was attributed to natural selection.[33] Nevertheless, the metaphorics of technology have persisted as a heuristic for understanding life "as if designed"—Fox Keller's reading of Immanuel Kant, who noted that mechanist reductionism guides science even if living beings are self-organizing.[34]

When Tim portrayed nature as a "craftsman," he participated in this tropic history of organisms *as* machines. Within biomimicry, organisms are perceived as machines, and evolution as a process of designing *new* machines. In Jamie Lorimer's taxonomy of "nonhuman charisma," he proposes three types: aesthetic, ecological, and corporeal.[35] To Tim, the flower basket exudes

[31] Canguilhem, *A Vital Rationalist*, 291. The technological model predates the emergence of biology as a discipline of knowledge. See, for instance, the literature on automata: Minsoo Kang, *Sublime Dreams of Living Machines: The Automaton in the European Imagination* (Cambridge: Harvard University Press, 2011); Riskin, "The Defecating Duck," Jessica Riskin, *Genesis Redux: Essays in the History and Philosophy of Artificial Life* (Chicago: University of Chicago Press, 2007); and Adelheid Voskuhl, *Androids in the Enlightenment: Mechanics, Artisans, and Cultures of the Self* (Chicago: University of Chicago Press, 2013).
[32] See William Paley, *Natural Theology or Evidences of the Existence and Attributes of the Deity* (London: Faulder, 1802); Charles Bell, *The Hand: Its Mechanisms and Vital Endowments as Evincing Design* (Cambridge: Cambridge University Press 2010[1833]); and John George Wood, *Nature's Teachings: Human Invention Anticipated by Nature* (London: Daldy & Isbister, 1877).
[33] See Peter Bowler, *Evolution: The History of an Idea* (Berkeley: University of California Press, 2009[1989]).
[34] Fox Keller, "Organisms, Machines, and Thunderstorms: Part One," 50.
[35] To Lorimer, nonhuman charisma is a kind of relational affect that pertains to a visual attractiveness, a sensory detectability, and a face-to-face magnetism. See Lorimer, "Nonhuman Charisma."

a fourth type—a *technical* charisma, perhaps, that oozes from the technological feats or functions that living beings are envisioned performing. Nature is, from Tim's eye, a charismatic craftsman.

Where Tim and other biomimics deviate from epistemic commitments shared by biologists is their romantic and Arcadian interpretation of evolution as a process of designing *perfect* machines harmoniously adapted to their environments—a teleological epistemology of biological progress that ignores phenomena such as waste, accident, extinction, and the fact that much of life's "3.8 billion years" was constituted by single-celled organism.[36] "Since the turn of the nineteenth century," Canguilhem writes, "definitions of biology's specific object have been purged of value-laden concepts such as perfection or imperfection."[37] Benyus, on the other hand, reinserted value into biological nature, reading life's survivability as a sign of sustainability—a desecularized view of life that redoubles natural theology from standpoint of "green" innovation. The anthropologist Felix Ringel calls this sustainability's "endurance" or "persistence" model.[38]

Where the evolution concept has afforded economists and organizational scholars a metaphor for recasting the historical nature of business, Benyus and her biomimics reverse this ana-logic, recasting evolution as the business of natural history.[39] Consider Adiel Gavish, the founder of Biomimicry New York. In a *Medium* article titled "Nature: the coolest #startup in the world," Gavish calls nature the "consummate innovator," a model Silicon Valley entrepreneur:

> In Silicon Valley, where startups are born just as quickly as they perish, the predominant saying is, "Innovate or Die." In the natural world, that saying holds true in an even more literal sense, and applies to not only entire species, but the ecosystems of which they are an integral part. Unlike Silicon Valley, the "enterprises" that comprise nature's business of "creating conditions conducive to life" are billions of years old, with standard operating procedures and innovation strategies connected to the very beginning of life on

[36] For one critique from a biologist, see Stephen Jay Gould, "The Spandrels of San Marco and the Panglossian Paradigm: A Critique of the Panglossian Paradigm," *Proceedings of the Royal Society B: Biological Scienes* 205.1161 (1979): 581-598.
[37] Canguilhem, *A Vital Rationalist,* 205.
[38] Felix Ringel, "Post-Industrial Times and the Unexpected: Endurance and Sustainability in Germany's Fastest-Shrinking City," *Journal of the Royal Anthropological Institute* 20.S1 (2014): 52-70.
[39] See Benoît Godin, *Models of Innovation: The History of an Idea* (Cambridge: MIT Press, 2017).

> the planet… Nature is an entrepreneurial system that has been conducting research and development not for tens, hundreds or even thousands, but billions of years. From a systems perspective, mother nature is a design expert and stellar model of ubiquitous innovation. Our natural world is not only the guru of green design, but a startup whiz kid who's had billions of years to perfect her craft.[40]

This rhetoric of nature as innovation is not restricted to self-promotional literature either. Emile Snell-Rood, an evolutionary ecologist at the University of Minnesota, researches developmental plasticity in butterflies to learn how organisms adapt to anthropogenic environmental change. In conversation with "biomimicry," Snell-Rood and her colleagues borrow from the "innovation literature" to theorize evolution, specifically "resource use and diversification" among insects.[41] While Snell-Rood lacks the teleological language of "perfection" drawn on Benyus and Gavish, she, like the biomimics, reads nature through contemporary economic vernaculars of innovation.

"Nature is," the anthropologist Michael Fischer notes, "an ambivalent term, meaning both what is other to us and what is essentially ourselves."[42] To biomimics, nature is a mirror for capitalist enterprise that reflects American ideas of innovation—"essentially ourselves." But in its polished surfaces, it also clarifies these precepts, presenting a more attractive version of who we want to be—"other to us." What Michael Fisch calls the "nature of biomimicry" is, to borrow a phrase from Marilyn Strathern, "after nature," at least in its connotations as an inviolable and constant "state," as Raymond Williams might say, one that offers a "grounding function" for the idea of culture.[43] Instead, nature manifests as a domain of selection, of choice, and of innovation

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[40] Adiel Gavish, "Nature: The Coolest #Startup in the World," *Medium* online, June 23, 2015, https://medium.com/invironment/nature-the-coolest-startup-in-the-world-e7a2ce577f67.
[41] Emilie Snell-Rood, Eli Swanson, Sarah Jaumann, "Insects as a Model System to Understand the Evolutionary Implications of Innovation," in *Animal Creativity and Innovation*, ed. Allison Kaufman and James Kaufman (Cambridge: Academic Press, 2015), 459-482.
[42] Michael Fischer, *Anthropological Futures* (Durham: Duke University Press, 2009), 114.
[43] Fisch, "The Nature of Biomimicry"; Strathern, *After Nature*; Raymond Williams, "Ideas of Nature," in *Problems in Materialism and Culture* (London: Verso, 1980), 67-85.

in its "inherent momentum toward novelty."[44] Nature is explicitly, to Gavish, "enterprised up," a projection of consumer culture's ideals—a nature to which consumer culture should yet return.[45]

After Culture: "Design Thinking" from Human- to Life-Centered Design

The flower basket "blew my mind," Tim said. "It set me on my path to learn how nature does it." Born outside Seattle, Tim attended Colby College in Maine for undergraduate studies in biology. His interest in nature's "craftsmanship" did not come until after college, back in 2007, when he accepted a position with the Biomimicry Guild in Montana as a "Biologist at the Design Table." For five years, he worked as an innovation consultant, developing and delivering the company's methodological services to clients national and international. During this time, he enrolled at the University of California in Santa Barbara for a master's program in biochemistry and molecular biology, where his research focused on how the proteins in the Venus flower basket contribute to the construction of its glass fibers and their optical properties. After graduating, he moved to Boston in 2013 for a job at the IDEO, a global design firm headquartered in Silicon Valley, where he was hired as "one of the first biologists to spearhead bio-inspired design research." While integrating principles from biomimicry into IDEO's "design thinking" methodology, he co-founded Biomimicry New England with Peter and Anamarija Frankić, a research professor of ecosystem management at the University of Massachusetts in Boston (who could not attend).

After eighteen months at IDEO, Tim returned to Washington to be closer to his parents, specifically to Bainbridge Island, where he currently lives with his wife, a veterinarian, and kids, "close enough to enjoy the amenities" of Seattle but with forests where he can mushroom forage.

[44] Strathern, *After Nature*, 10.
[45] *Ibid.*

Venturing out independently, he established his own biology and design consulting firm that he named LikoLabs, taken from the Hawaiian word *Liko,* for budding and the shade of new growth. As its director, Tim has consulted with Natura, BrightHouse, Canada Goose, TrendDesk, Holos, lululemon, and Fiat Chrysler Automobiles. In addition to his work as an innovation consultant, Tim taught as an adjunct professor of sustainable design at the Minneapolis College of Art and Design and served as manager of the biophilic design transition lab at the Living Future Institute.

"How can our technology be more like nature's technology?" With this question, Tim transitioned into his interpretation of biomimicry—one colored by his previous tenure at IDEO, where he was mentored by Jane Fulton Suri, now an emeritus partner. When Suri co-founded IDEO in 1991, she brought skills in psychology and architecture to bear on the design process.[46] In her role as the chief creative officer, she initiated an emphasis on the "human," expanding the dominant focus of design on ergonomics to "culture" and meanings of status, gender, and age.[47] In "design," Tim said, specifying "human-centered design," "designers go out and observe how people use the technology" to generate "insights from observation that you carry into design," in order to synchronize the function of an artifact (e.g. a chair or ATM) with the contexts of its use. "This," he said, "is how designers think," indirectly referencing the concept of "design thinking."

Peter Rowe, former dean of the Harvard Graduate School of Design, once theorized "design thinking" as an explanatory account of the heuristic style of thought that he believed was specific to architecture and urban planning, following decades of "design research" on, to phrase it in Nigel Cross's vocabulary, "designerly ways of knowing."[48] When Tim mentioned the idea

[46] On Suri, see Christina Wasson, "Ethnography in the Field of Design," *Human Organization* 59.4 (2000): 377-388.
[47] *Ibid*.
[48] Peter Rowe, *Design Thinking* (Cambridge: MIT Press, 1987). See Cross, "Designerly Ways of Knowing." On the history of "design thinking," refer to Kees Dorst, "The Core of 'Design Thinking' and Its Application," *Design Studies* 32 (2011): 521-532. In the conventional historiography of design research, there are three "generations."

of "design thinking," he invoked this genealogy but more likely had in mind the "expansion of the meaning of design" that the anthropologist Lilly Irani attributes to IDEO's "design thinking" commodified method.[49] Once a site of design-based manufacturing, IDEO pivoted in the 2000s to an "innovation company" or consultancy that created and sold workshops focused on "design thinking." With a five-step process (empathize, define, ideate, prototype, test), IDEO abstracted a method from the craft practices of designers (e.g. industrial designers).[50] By enrolling in "design thinking" workshops, IDEO guaranteed that professionals throughout the business world could think like a designer: in production, certainly, but usually management, where "design thinking" drew on "design anthropology" (see Interlude 4) and other group techniques (i.e. brainstorming) to identify new product markets, strategies, and types. This resignification of the word "design" in "design thinking" shifts from a description of design as craft to a promise of design as a means of innovation. To distinguish this from design, I refer to it as meta-design or, in quotes, "design."

Part of the uniqueness of this "expertise"[51] stems from the ethnographic research techniques employed in the first "empathy" step. Tim moved the slideshow forward to an image of various women carrying water jugs on their heads. "You can design a better bottle," he said, "but if it doesn't fix a drought, or why culturally women carry water," then it is not good design. In what IDEO popularized as "human-centered design," designers mine the cultural unconscious of technology "users" *in vivo* to redefine the scope of their design "problems" and extract design principles for future products.[52] In design anthropological studies of exoticized Others, human-

[49] Lilly Irani, "View of 'Design Thinking': Defending Silicon Valley at the Apex of Global Labor Hierarchies," *Catalyst* 4.1 (2018): 1-19.
[50] For official accounts from IDEO's leads, see Tom Kelley with Jonathan Littman, *The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm* (New York: Currency, 2001) and Tim Brown, *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation* (New York: Harper, 2019[2009]).
[51] Irani, "View of 'Design Thinking.'"
[52] For an ethnographic study of this practice, see Lilly Irani, *Chasing Innovation: Making Entrepreneurial Citizens in Modern India* (Princeton: Princeton University Press, 2019).

centered design places more stress on cultural meaning—"why culturally women carry water"—than questions of political economy: to further Tim's example, the social production of drought and water access.[53] "Increasingly," Tim proceeded, "we are looking to design bigger scales: towns, cities, et cetera. How can we solve for complex, big dynamic problems?" In his narrative, the nature of contemporary design problems—"nature" as character but also nature *as* the design problem—poses a limit of complexity to design's rationality, even a rationality supplemented by the ethnographic archive, and an epistemic crisis that biomimics can resolve by life's likeness.[54]

"What if," Tim conjectured, "we look to life as an example of a large, complex system?" Conceived as a system of innovations, "nature" looks to biomimics like a "treasure trove" of the design solutions they need, according to the biomimic Jared Yarnell-Schane.[55] Through mimesis, designers can capitalize on life's examples. Biomimicry was, in Tim's own words, a "technology transfer platform" for translating imitable biological functions into new sustainable technologies. Thus biomimicry: "learning *from*," Tim stressed, "and then emulating natural forms, processes, and systems to create more sustainable, resilient, and adaptable designs." Transitioning from life as design to design as life, biomimicry doubles analogy: from machine to organism to machine.[56]

"Biomimicry changes the design process," Tim said. In IDEO's "adherence model," he explained, "responsive" and "adaptive" design—good design—should address user needs to maximize "adherence" to (or consumption of) the product—that is, to maximize its desirability.

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[53] For a parallel critique in anthropological theory, see Eric Wolf, *Europe and the People without History* (Berkeley: University of California Press, 1982).

[54] On the problem of complexity, see Horst Rittel and Melvin Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4.2 (1973): 155-169.

[55] See Sam Nattress, "The Three 'Seeds of Biomimicry' Every Entrepreneur Should Know About," Biomimicry Institute, November 11, 2020, https://biomimicry.org/the-three-seeds-of-biomimicry-every-entrepreneur-should-know-about/.

[56] The philosopher Gilbert Simondon made a similar move from the organic to the mechanical albeit to different political and intellectual ends. See Gilbert Simondon, *On the Mode of Existence of Technical Objects* (Minneapolis: University of Minnesota Press, 2017[1958]).

"Adherence," which Tim phrased as "taking prescribed actions to gain the maximum benefit," was a "simple but broad-reaching definition [that he] used to describe most design challenges." In the dialectic of user research and marketing, designers arouse a desire for, and adherence to, their design products within consumers.[57] With his practice at LikoLabs, Tim switched from an "adherence model" to a "coherence framework." "If adherence is about sticking," he expatiated, "coherence is about making it a part of a larger system. Technology should not just be human- but life-centered too." In adherence, "well-adapted designs…involve engaging people in the solution." In coherence, design fits "a changing world; it must be responsive to this dynamism." Life-centered design, in other words, was not just about imitating function, but imitating fit, too.

In conventional "design" (read: IDEO), designers "receive feedback frequently throughout the design process," Tim explained. This occurs at four steps: "prototype sharing," "capturing honest feedback and metrics," "getting diverse perspectives," and "tracking the data." "Looking to nature" though, he speculated, "could be a kind of prototyping that you can use as feedback—nature-as-prototype." The central question of biomimicry—"How might nature…?—was, in Tim's estimation, not just a machine for generating novel ideas, but a means to test those ideas by comparing them to natural artifacts whose performance had already been demonstrated. Biological entities were, from this lens, past prototypes of future artifacts waiting to be designed.

Where human-centered design fashions "culture" as a source of value for designers, a "limited" one to Tim, he casts life as a "limitless" reservoir.[58] This is the quality anthropologists

[57] On the imagination of consumer desire as a part of the design process, see Regina Lee Blaszczyk, *Imagining Consumers: Design and Innovation from Wedgwood to Corning* (Baltimore: Johns Hopkins University Press, 2002).
[58] Pronouncements to this effect are commonplace among ideologues of biomimicry. Consider Tamsin Woolley-Barker, evolutionary biologist, biomimic and author of *Teeming*. She has breathlessly written of nature as a source of "infinite abundance." See Lucy Wang, "Interview: Dr. Tamsin Woolley on How Biomimicry Can Improve Happiness and Creativity in the Workplace," *Inhabitat* online, July 24, 2017, https://inhabitat.com/interview-dr-tamsin-woolley-barker-on-how-biomimicry-can-improve-happiness-and-creativity-in-the-workplace/. "Nature's 4-billion-year-old R&D lab," she elsewhere pens, "offers a bottomless treasure-trove of energy efficient, low-toxic and

Karen-Sue Taussig, Klaus Hoeyer, and Stefan Helmreich term "potentiality," an "imaginative gap" between the present and future of design's possibilities.[59] Veronica Davidov calls this the rhetoric of "superabundance" in biomimicry, which runs contrary to economies of "scarcity" that tend to worry environmentalists.[60] Jesse Goldstein and Elizabeth Johnson invite us to ponder the potential biomimicry creates as the "more-than-human intellect," following Karl Marx's notion of the "general intellect."[61] This more-than-human intellect, or industriousness, refers to all the "productive" functions imagined to reside in life—functions that will reform human industry
In parallel to the cultural unconscious analyzed and mobilized within human-centered design, we might think of life's potentiality, not as intellect, but as a *biological unconscious*. If the word "intellect" suggests the articulability of reason, "unconscious" highlights that the latent "design principles" embodied in biological organisms require interpretive work or, herein, *mimetic labor*. Where "more-than-human intellect" suggests that design principles reside within living beings, the concept of biological unconscious locates them in the "situated knowledge" of biomimics.[62]

The Biomimicry Conglomeration™ teaches the labor of life's interpretation as a "spiral" method, Tim explained. In its current iteration, the method consists of eight iterative steps: define (context), identify (function), integrate (life's principles), discover (natural models), abstract (biological strategies), brainstorm (bio-inspired ideas), emulate (design principles), and measure (using life's principles). Designed in imitation of IDEO's "design thinking" schemata

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time-tested Innovations." Tamsin Woolley-Barker, "10 Amazing Uses for Biomimicry in Business," *GreenBiz* online, December 28, 2016, https://www.greenbiz.com/article/10-amazing-uses-biomimicry-business?fbclid=IwAR2tx0AHFyCMiKaMPC9DKfiQeH_etYtMscTonlo92z_Yr53sQKg6ESonPfg

[59] Karen-Sue Taussig, Klaus Hoeyer, and Stefan Helmreich, "The Anthropology of Potentiality in Biomedicine," *Current Anthropology* 54.S7 (2013): S3-S14, S5.

[60] Veronica Davidov, "Biomimicry as a Meta-Resource and Megaproject: A Literature Review," *Environment and Society: Advances in Research* 10 (2019): 29-47.

[61] Elizabeth Johnson and Jesse Goldstein, "Biomimetic Futures: Life, Death, and the Enclosure of a More-than-Human Intellect," *Annals of the Association of American Geographers* 105.2 (2015): 387-396.

[62] Donna Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective," *Feminist Studies* 14.3 (1988): 575-599.

(and the workshop genre in which it is conveyed),[63] most steps in the filial meta-design method of "biomimicry thinking" resemble its parent method (Figure 3). What differentiates biomimicry is, for one, the substitution of a quarter of steps—identify, integrate, discover, and abstract—for the "empathize" stage of design thinking. This replaces applied ethnography with what Tim had earlier described as "amateur naturalism." In this part of the process, biomimics first articulate a legible design principle in biology by analogy. Through "comparisons in terms of similarity," as the anthropologist Graham Jones, following Cameron Shelley, characterizes analogy, biomimics demonstrate that a particular biological organism exhibits a function—in Tim's flower basket: an ambient manufacturing process—that is *like* a valuable function in the domain of design—i.e. the "function" of analogy.[64] As I stated in the Introduction, these analogies are not forms per se but, rather, proto-forms that act as lures, provocations, or suggestions toward technological form. They hint *how* a technology should function mimetically without yet specifying its embodiment. Made in interaction, these analogical design principles are often contested—a point I revisit later.

After these four steps, the method returns to the conventional steps of design thinking, albeit with different names. The second unique step of biomimicry thinking appears at the end of the process: measure. While biomimicry thinking first generates formal ideas based on functional design principles from nature, at which point a designer must incorporate these ideas in concrete artifacts, it also insists that technology made through biomimicry should be measured in accord with place-based metrics of ecological performance. The artifact's function should behave as the biological function did in its original context. In other words, it should "fit" into its environments

[63] Recall from the Introduction that "Biomimicry Thinking" and the workshop genre were themselves modeled on IDEO's "Design Thinking" workshops. The movement back toward IDEO through Tim exhibits a recursivity both methodological and organizational. Recently, Suri has described using "life-centered design," but without crediting Tim. See Mixed Methods, "The Future Is Life-Centered: Jane Fulton Suri, IDEO," podcast, July 24, 2019, https://www.mixed-methods.org/episodes/2019/7/24/the-future-is-symbiotic-jane-fulton-suri-ideo

[64] Jones, *Magic's Reason*, 25.

as organisms do: innocuously. This is the quintessence of the mimetic ethic. Whereas "modern" or "Western" design tests artifacts with human metrics, biomimicry weighs artifice against life.

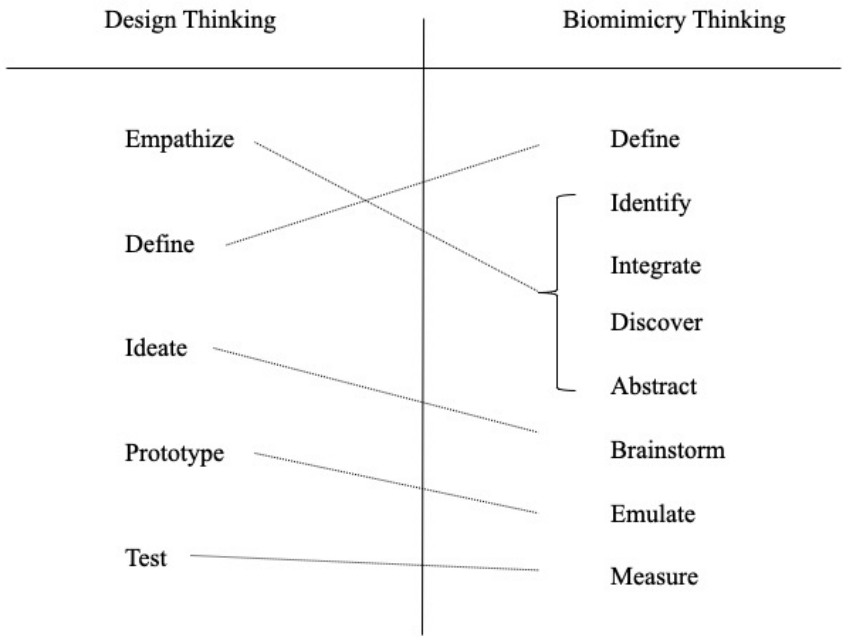
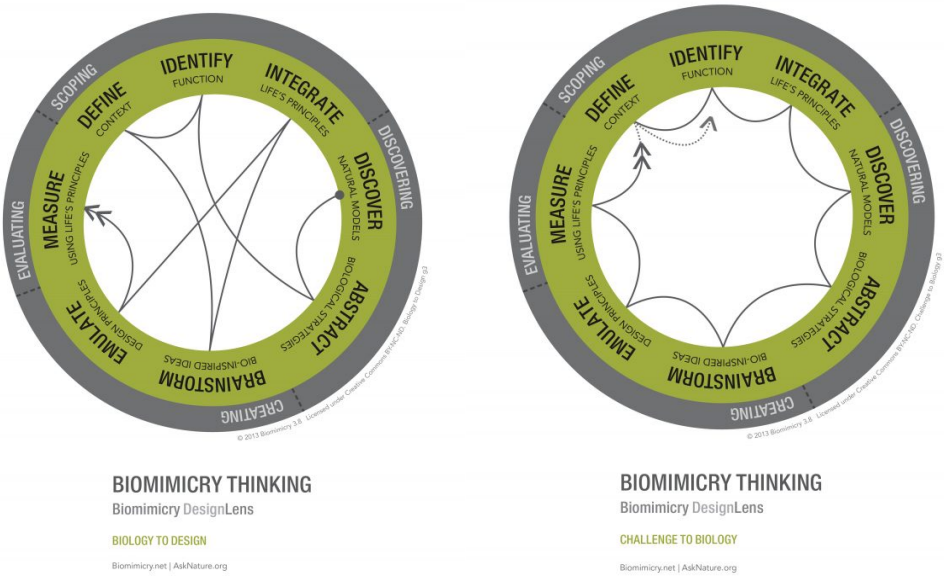


Figure 3: Methodological Comparison

Tim further explained that there are two standard progressions in the methodology: "Biology to Design" and "Challenge to Biology" (compare Figures 4 and 5). They diverge mainly in their respective starting points, "discover" for the former, and "define" for the latter. Tim likened "Biology to Design" to that "a ha moment" that begins with the discovery of a design principle and ends with its emulation in a new technology—for example, the plant burrs that adhered to the engineer George de Mestral's dogs, (al)luring him to invent Velcro, a French portmanteau of *velours croché*, or hooked velvet, named for the burr's hook-and-loop structure. Like de Mestral, a biomimic in this progression would extrapolate from known design principles to technical applications unknown through a mode of abductive reasoning Eitan Wilf observed in

"routinized business innovation."[65] As Wilf argued, innovation consultants instruct attendees in their workshops to "evolve" products using hypothetical "accidents," thought experiments that deform known products in order to abductively generate new ideas (and importantly, markets for those ides).[66] "Biology to Design" operates likewise: Biomimics abduce applications from life.[67] In "Challenge to Biology," however, de Mestral's serendipity is rendered by routine: a technical problem prompts the biomimic to search for and locate a biological solution. In this latter path, it is not necessary to "evolve" technology because, as biomimics see it, nature has already done so.



Figures 4 and 5: Biology to Design and Challenge to Biology Methods[68]

For consultants like Tim, the second pathway predominates—a consequence of the economic realities of contracted work, which demand resolutions to pre-defined technical issues.

[65] Wilf, *Creativity on Demand*, esp. Chapter 2.
[66] *Ibid*.
[67] On abduction, see Charles Peirce, *The Essential Peirce: Selected Philosophical Writings, Vol. 2 (1893-1913)* (Bloomington: Indian University Press, 1998); Stefan Helmreich and Sophia Roosth, "Life Forms: A Keyword Entry," *Representations* 112 (2010): 27-53; Dorst, "The Core of 'Design Thinking' and Its Application"; and Claire Webb, "Technologies of Perception: Searches for Life and Intelligence Beyond Earth," PhD diss. (MIT, 2020).
[68] Biomimicry 3.8, "Biomimicry DesignLens," accessed September 27, 2021, https://biomimicry.net/the-buzz/resources/biomimicry-designlens/

One of Tim's first projects working for the Biomimicry Institute came from a food manufacturer in pursuit of waterproof packaging for their cereal. Tim asked: How does nature create moisture barriers? His team researched dragon flies, Venus fly traps, frogs, whales, and plants before they decided that they would mimic the snail with a "mucus principle" with layers of water resistance. After patenting the design, the company's scientists developed a manufacturing coating that was both more efficient and less energy and material intensive. Through this project and others, Tim gradually realized that the "skillsets people build are more important" than a steadfast adherence to the method itself. Practice, for Tim, demanded procedural flexibility—hence the focus of our skill-based workshop. In his firm, LikoLabs, he uses "life-centered design," *not* biomimicry, to reflect this meta-methodological disagreement over the practicality of "biomimicry thinking."

At the end of his lecture, Tim offered a historical reflection on the novelty of "life-centered design," or biomimicry. "Looking to nature is nothing new," he said. "We've been doing this forever, as long as we've been human, whether you're Native American in Alaska," where the Inuit people learned from polar bears to design igloos, "or in Colorado," where adobes mimicked the animal architecture of ground squirrels. As I examined in the first interlude of this dissertation, narrations of the past in biomimicry frequently reference imitation as the rationality intrinsic to "Native American" culture writ large—a figure that I ideal typified as *Homo mimesis*. Historicities such as these portray biomimicry as an anthropological universal. At the same time, however, Tim claimed a discontinuity between biomimicry now and biomimicries "past." "As we have gotten better at learning from nature, we are emulating new things," he said, continuing, "Biology has exploded. Now we know so much more—it's astounding," a claim that Taryn corroborated by remarking, without reference, that "since the late 1990s, our knowledge of

biology has been doubling every year." Continuous and discontinuous with imagined Indigenous technicity, Tim ambiguated the "expertise" that is culturally specific to "biomimicry thinking."

In her history of IDEO's transition from craft production to "design thinking", Irani observes that the ideological enactment of "design thinking" as a distinctively American form of creativity coincides with mounting fears of Asian, specifically Chinese, manufacturing and the anxieties around its massive labor pool. In conversation with scholars like Rayvon Fouché, Ruth Oldenziel, and Kavita Philip, Irani argues that firms like IDEO performed the "conceptual" value of "design thinking" against the "mechanical" work of manufacture.[69] In this global hierarchy of ethnoracialized technology, white American design was asserted as superior to Asian production. Like the performative expertise of human-centered design, Tim presented life-centered design as a distinctively mimetic capacity exhibited only in contemporary (and mostly white) biomimicry. Enlightened by facts of life epistemologically inaccessible, biomimicry, in Tim's account, shows a technical mode of mimesis stratified by race, time, and (non-)Indigeneity—hence, its new-ness.

"If early anthropology saw human nature as rife with potential, and a midcentury thinker such as [Victor] Turner leaned more toward 'culture' as the site of potential," Taussig, Hoeyer, and Helmreich suppose, "today those of us engaging biomedicine witness a strange return to 'nature,' but a nature conceived as having potentials […] realized through culture."[70]

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[69] Irani, "'Design Thinking.'" See also Rayvon Fouché, "Say It Loud, I'm Black and I'm Proud: African Americans, American Artifactual Culture, and Black Vernacular Techological Creativity," *American Quarterly* 58.3 (2006): 639-661; Ruth Oldenziel, *Making Technology Masculine: Men, Women, and Modern Machines in America*, *1870-1945* (Amsterdam: Amsterdam University Press, 1999); and Kavita Philip, "What Is a Technological Author? The Pirate Function and Intellectual Property," *Postcolonial Studies* 8.2 (2005): 199-218. For similar analyses, reference Michael Adas, *Machines as the Measure of Men* (Ithaca: Cornell University Press, 1990) and Daniel Bender, *American Abyss*: *Savagery and Civilization in the Age of Industry* (Ithaca: Cornell University Press, 2013).
[70] Taussig, Hoeyer, and Helmreich, "The Anthropology of Potentiality in Biomedicine," S7.

As in biomedicine, and biotechnology more generally, biomimicry thinking, as Tim portrayed it, revisits the potentiality of nature *after* the potentiality of culture that preoccupies human-centered design—a nature realizable through the cultural artifice of mimesis that only some cultures have.

The Function Paradigm: Efficiency and the Pragmatic Stance

In a second lecture, Tim presented a cavalcade of slides in rapid succession. First on the screen was a close-up image of *Deilephila elpenor*, the elephant hawk-moth. Appearing to stare into the camera with its large black eyes, these eyes, Tim explained, had led to an anti-reflective coating for scanning electron microscopes and mobile device screens—an example of "biomimicry," he said. Their ocular morphology was more "efficient" than human-made lenses, which resulted not just in glare protection but improved light gathering too. A second slide depicted the humpback whale, whose tuberculated fins had inspired the construction of bumpy and more "efficient" fans, turbines, and windmills. In a third example of "biomimicry, a water bottle from Vitalist copied the twisting form of Scots pine trees—a "sustainable innovation" that saved material and energy.

As Thomas Kuhn taught us, examples, especially exemplary examples, are culturally indicative: They point to shared "paradigms" of questions and answers, methods and skills, and theories and assumptions that model normal practice.[71] Paradigms can form around "exemplars," "standard example[s]."[72] Around such examples, what Ludwik Fleck called "thought collectives" gather.[73] Examples are therefore socially indicative: Pointing to them, persons index themselves as members of a community bound by a paradigm.[74] Paradigms, as Michael Fischer writes, are

[71] Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 2012[1962]).
[72] *Ibid*, 186.
[73] Ludwik Fleck, *Genesis and Development of a Scientific Fact* (Chicago: University of Chicago Press, 1981[1935]).
[74] As Ian Hacking notes in the introduction to the 50th anniversary edition of Kuhn's book, Kuhn himself understood shared examples or exemplars to be the primary meaning of "paradigm" at the time of writing—a meaning that has a basis in Aristotle's theory of rhetoric (*paradeigma* as analogy). After the linguistic Margaret Masterman discovered twenty-one meanings of "paradigm" in Kuhn's text, he penned "Second Thoughts on Paradigms," distinguishing the

"models for living and a mnemonic for thinking about how to live."[75] During this workshop and other fora of biomimicry, the enumeration of examples was a rhetorical strategy that I repeatedly heard. To understand, as Kuhn did, how paradigms animate collective action, I attend to their examples below. How do biomimics educe exemplars of biomimicry, and what do these say about the overarching grammar, or epistemology, of life that governs the field of biomimicry?

Most of Tim's examples escaped dispute, or much comment at all—evidence of the uncontested belief Kuhn considered "normal."[76] After the moth, the whale, and the pine, Tim projected an image of a human skeletal system, which he said digital modelers had imitated in a manufacturing algorithm that optimized for the strength and weight of any physical structure. If the first three organisms had inspired specific artifacts, the osseous architecture of the human had been copied in a program for making artifacts (note, as Fischer did, nature here being human and not, part of ourselves and yet external).[77] What united his examples as paradigms of biomimicry was their "efficiency." In contrast to the efficiency of biological "functions," Tim presented their human counterparts as "not mechanically ideal." A fifth example illumined efficiency from a non-mechanical angle. With a photo of a lotus flower behind him, Tim explained that its form, an outer layer of hydrophobic nanostructures, wicks off liquids—a "structural solution" to a "chemical problem." Researchers studying the lotus flower invented a coating made without fluorinated toxins, proving to Tim that life's efficient functions exceeded human imagination.

"local" use of "paradigm" as exemplar and the "global" use of paradigm as a kind of shared grammar, which derived from medieval language pedagogy (and survived through the Vienna Circle and Ludwig Wittgenstein). See Kuhn, *The Structure of Scientific Revolutions.*

[75] Michael Fischer, *Iran: From Religious Dispute to Revolution* (Madison: University of Wisconsin Press, 2003[1980]), 21.

[76] Kuhn, *The Structure of Scientific Revolutions*.

[77] Thanks to Stefan Helmreich for pointing out that this is a perplexing example of biological idealization, considering that the human skeletal system is prone to chronic injury, often necessitating surgical replacement.

In addition to its "forms," "processes" and "systems" in nature could likewise inspire sustainable innovations in energy production (photovoltaics based in photosynthesis) and computation (chips based in neurotransmission). Whereas the cybernetic sciences of biomimetics and bionics value life's efficiencies, biomimics like Tim interpret efficiency through the language of sustainability. Nature's functions are valued because they embody what Aidan Davison calls "eco-efficiency."[78]

Not all examples were accepted as paradigms of biomimicry. Tim showed a photograph of a seashell. Based on the seashell, Tim alleged, Jay Harman, author of *The Shark's Paintbrush: Biomimicry and How Nature Is Inspiring Innovation*, invented a spiral impeller that mixes large vats of liquid at a fifth of the energy relative to its competitors. Used first in manufacturing, a second purpose for the impeller was discovered in computer fans, where its shape reduces power costs and noise. "Spirals," à la the seashell, are a "packing strategy" that minimizes total volume, Tim explained; they are also strategies of "flow," in air and water. Ben, a white product designer and a professor at Olin College, objected to the exemplary status of Harman's device. "I thought it was based on a frozen whirlpool," he mused, trailing off with a show of deferent uncertainty.

Tim retracted: "The company is evasive if you ask. The whirlpool was tried at first, but then they experimented with other natural forms," settling on a notion of spiral patterns in nature: in phenomena of fluid dynamics, such as whirlpools and tornadoes, but also in biological entities from lilies to the shell of the nautilus. What Ben had contested was the "bio" of "biomimicry." If design principles are based on analogies to biological function, then the origin story of Harman's invention mattered because it would determine whether the impeller was biomimicry or mimesis of physical principles held across biotic *and* abiotic nature. Michael Lempert argues that mimesis is reflexively grasped *qua* imitation through the "creeping sense of incongruity" that he terms the

[78] Aidan Davison, *Technology and the Contested Meanings of Sustainability* (Albany: SUNY Press, 2001).

"differential"—a sign of dissimilarity and interrupted iconicity between an original and a copy.[79] For Ben, this "incongruity" was a feeling of dissimilarity between the seashell (the original) and the impeller (the copy). Science and technology studies scholars have shown that these moments of "crisis"[80]—Kuhn's term—or "controversy"[81] can unsettle a paradigm's normalcy. In this case, what was at stake was the paradigmatic nature of Harman's design as an example of biomimicry.

Unperturbed by Ben's challenge, Tim averred that the copy's referent was largely irrelevant. "Jay was inspired by it [the seashell] but didn't necessarily stay true to nature," at least the biological nature of the seashell. In an interview I later conducted with Jay Harman at the 2017 Bioneers Conference in San Rafael, California, Harman confirmed as much. "If you're really precise, I'm not a biomimic," he said. "I focused on what nature copies," meaning general biophysical patterns, not a particular organism and its functions. None of this stopped Tim from deploying it as an example of biomimicry, however. "Even if the science doesn't match up," he said, as long as "you're being effective," then biomimicry was warranted. Taryn agreed, nodding and admitting "it's a messy process." Tim asked, "What's the value proposition of biomimicry?" before answering himself: "It's not always taking away that you know how it's going to work but being inspired by it and trying. Sometimes the innovations are unexpected, and the benefits much more beneficial." Within their roles as designers and consultants, Tim and Taryn concurred that a demonstration of effectiveness trumps, for their clients, any fidelity to biology, to the "original." More significant was that mimesis led to a functioning artifact, whether or not its "functioning"

[79] Lempert, "Imitation," 381.
[80] Kuhn, *The Structure of Scientific Revolutions*.
[81] On the history of the concept of "controversy" in STS, see Sophia Roosth and Susan Silbey, "Science and Technology Studies: From Controversies to Post-Humanist Social Theory," in *The Blackwell Companion to Social Theory*, ed. Bryan S. Turner (Hoboken: Blackwell, 2008), 451-473.

was copied truthfully with regard to life. This crisis exposed the mimetic stance I call pragmatic, which conflicts with the ideological commitment to fidelity that defines Benyus's mimetic ethic.

Tim clarified this stance with another example: the gecko. Based on sticky feet that allow the gecko to scale vertical surfaces, engineers developed an attachment mechanism which affixes without glue or other chemical compounds.[82] This specific design was formulated on the supposition that the gecko achieves this function through a feathered shape that goes from stiff to flexible. After the design was shown to work, later investigations revealed that, in nature, geckos attach to walls at an atomic level, due to Van der Waals forces. None of this was of any concern to Tim, who maintained that the technology was an example of biomimicry. He said that because the artifact worked—and worked better than existing products—its fidelity to life was a triviality.

Taryn, who had consulted with Tim at the Biomimicry Guild, validated his stance. "That's normal," she said. "Most consumers don't care. At the end of the day, it simply has to *perform* better." She also said, "It still has to be cost-competitive, which matters to clients. It still has to compete in a traditional market. Being biomimetic is not enough." Peter was in agreement: "Most people won't believe it will work." For consultants like Tim, Taryn, and Peter, their end is to produce working artifacts, regardless of whether the effectiveness of those technologies is due to the mimesis of life's efficiency—hence their adoption to a pragmatic stance toward imitation.

One more example betrayed the artificiality of this paradigm about artifice. Displayed behind Tim was a diagram of cellulose biosynthesis, the metabolic process through which plants produce the structural polysaccharide found in cell walls. Taryn claimed that waste does not exist in nature, and one company, inspired by this premise, had created a technology that converts CO_2 in the atmosphere into plastic, re-incorporating human waste into material economies of design.

[82] Cf. Elizabeth Johnson, "Reanimating *Bios*: Biomimetic Science and Empire," PhD diss., (University of Minnesota, 2011).

Franziska, a white Swiss-born architect with a studio in Boston, questioned the likeness of design to life. "What happens to the CO_2 at the end of the plastic's life?" she asked, implying that while it might fix carbon, the technology does not eliminate waste. Tim admitted that it "faces the same challenge as any plastic," then countering that "not all plastics are bad," by which he meant bio-degradable plastics. "Some are edible," Tim stated, "depending on their structure"—a reply that deferred the question of its paradigmatic status into the future, when plastics might be waste-less.

Ben was skeptical for a different reason. "The story implies their success is due to biomimicry," he spoke slowly, pondering the problem aloud, "but is their success not due to the fact that pulling CO2 out of the air is a good thing—valued right now? Biomimicry might help people get somewhere, but it's not the key to their perceived success." Ben suspected neither the resemblance of the technology to nature nor its exemplary status as an instance of "biomimicry." Tim responded: "I'm not giving examples as *why* they are [perceived as] successful"—a topic of the appearance of mimeticism that Chapter Three probes—"just that they *are* a biomimetic idea." What Tim said next was surprising: "My guess," he stated, "is that no one [there] knows they are doing biomimicry. I'm simply pointing out a biomimetic idea." To validate his point, Peter gave an additional example of another carbon-fixing company that was doing "biomimicry" unawares.

Through the indication of exemplars, or local paradigms, biomimics like Tim, Taryn, and Peter construct the impression of the field of biomimicry—a global paradigm united by the perceived value of life's efficient functions. If, as I have argued, design principles are analogies drawn between organisms and machines, then Tim's rehearsal of examples of "biomimicry," in which analogies are made between biomimicry and case studies of technology, could be labeled meta-analogical: analogies about analogies. In his analysis of anthropology as "meta-analogy," Graham Jones defines the term thus: "a comparison of analogy-making practices in two different,

but interrelated, domains."[83] Through meta-analogy (another kind of mimetic labor), biomimics plot the dimensions of the field of analogy-making practices. This ideational work is remarkably durable. Even in the face of contestations to the examples that Tim presented, he maintained the illusion of biomimicry's ubiquitous presence, what I called the mimetic field in the Introduction, by reframing biomimicry, not as the achievement of the mimetic ethic, but a process for making new technological forms that often worked effectively, irrespective of their fidelities to function.

Tim concluded with one last example. As he explained, bees regulate the temperature of their hives with distributed intelligence. Heat from the sun does not trigger the colony to respond *en masse* but according to a bodily gradient of heat tolerance—a "slow curve of minimal energy use," he said. One company copied apian decision-making to make a smart energy management system that, in contrast to the energy "extremes" of conventional air conditioning, reduced usage by a quarter through responsive temperature regulation. In the midst of the research, a conflict arose between the company's scientists and engineers: The former wanted to study the bees for longer, to refine the theory, whereas the latter sought to start the design process. The latter won. Tim, sharing this story with us, sided with the engineers. "It's a good thing they didn't stay true to nature," he reflected. What mattered was that they had "an insight that can transform in a large way what's going on" in the industry. What mattered to Tim, that is, was that the design *worked*, not merely in an abstract technical sense but that it worked convincingly enough to profit from it.

From Efficiency to Resilience: Ecological Fit and the (a)Politics of Nature

"How do you apply biomimicry to cities, urban planning, and architecture on a bigger scale?" What if our cities performed according to the ecosystem standards of its local environment?"

[83] Johnson, *Magic's Reason,* 144.

These were the questions that occupied one of our guest speakers, Josh, a white attorney in environmental law and a "counselor at law, resilience, and biomimicry." Josh sought to expand biomimicry past product functions and into metrics for ecological performance: function's "fit."

Josh received his bachelor's in biology from Cornell University in 1997, his law degree in 2002 from the State University of New York at Buffalo in 2002, and his master's in law from New York University in 2003. His education was also, Josh said, "in the Peruvian rainforest" where he traveled for his BPro certification in 2007. Josh's law practice centers on the legality of land use. With his father, he also runs a construction and design consulting firm in upstate New York that specializes in "resilient" buildings, from upscale single-resident homes to multi-family residential properties, alongside mixed-use community- as well as district-based urban projects. As the founder of Biomimicry Northern Forest, a chapter of the Global Biomimicry Network, Josh has developed his biomimicry curriculum around the socio-ecological science of resilience.

In 1973, the ecologist Crawford Holling posited the concept of resilience to unsettle the notion of inexhaustible equilibrium that motivated the resource management practices of his time in agriculture and forestry.[84] While ecosystems did exhibit homeostatic tendencies, Holling said, "complex adaptive systems" like forests have limits that contradicted the conservationist belief in endless cycles of ecological growth and resource extraction. Originally, then, "resilience" named the quantities and relations needed for ecosystems to endure in the face of external disturbance.[85]

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[84] See C.S. Holling, "Resilience and Stability of Ecological Systems," *Annual Review of Ecology and Systematics* 4 (1973): 1-23. For further discussion of Holling's work, see Tom Özden-Schilling, "Salvage Cartographies: Mapping, Futures, and Landscapes in Northwest British Columbia," PhD diss. (Massachusetts Institute of Technology, 2016)

[85] As Jeremy Walker and Melinda Cooper chronicle in their genealogy of the term, "resilience" grew from an ecological concept to a vast discourse of economic and environmental (in)security that Bruce Braun labeled the "new urban dispositif." See Jeremy Walker and Melinda Cooper, "Genealogies of Resilience: From Systems Ecology to the Political Economy of Crisis Adaptation," *Security Dialogue* 42.2 (2011): 143-160 and Bruce Braun, "A New Urban Dispositif? Governing Life in an Age of Climate Change," *Environment and Planning D: Society and Space* 32.1 (2014): 49-64.

At the outset of his talk, "Socio-Ecological Systems: Reconnecting to the Biosphere (Irrevocably Immersed in Life)," Josh quoted the Resilience Alliance to define resilience as the "capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedback."[86] Tim rephrased this as a question: "How do you keep being a system despite damage?" Airplanes, Tim said, are equipped with three means to lower their wheels—securing performance through diversity of function and location—"diversity, distribution, redundancy." Josh offered an example from his first workshop on biomimicry. Two Boeing employees informed him that their testing protocols for airplanes engines involved the simulation of seabird collision. One employee was content to throw a single frozen turkey into the engine; the other demanded twenty Butterballs be thrown, "for resilience."

Bringing his legal practice to bear on his consulting practice, Josh became interested in the design of land use, that is, how buildings, neighborhoods, and cities could imitate their local ecologies, not just in functionality, but in "fit," too. Across his portfolio, Josh has built in accord with Leadership in Energy and Environmental Design (LEED) standards, a certification program codified by the United States Green Building Council, where Josh also partly works a consultant. The LEED program, however, lacks any notion of place, he recognized. What he envisioned was a "place-based" system of resilient design standards through the mimesis of resilient ecosystems.

For Josh, biomimicry at the ecosystem scale (i.e. beyond the organism) translates the "genius of place" into ecological metrics.[87] "Architects," he said, "understand how the laws of

[86] Holling created the Resilience Alliance. On this definition, see Brian Walker, C.S. Holling, Stephen Carpenter, and Ann Kinzig, "Resilience, Adaptability and Transformability in Social-Ecological Systems," *Ecology and Society* 9.2 (2004): 5.

[87] In architectural discourse, the notion of the *genius loci* is an ambiguous term, referring doubly to natural landscapes and vernacular typologies, Josh's use of the phrase "genius of place" drew on a more recent tradition of systems theory-inflected place-making that is indebted to the work of the landscape architect Ian McHarg. In his magnum opus, *Design with Nature* (1969) McHarg created a geographic information systems (GIS)-based method for regional planning that predicated land use on ecological metrics of soil type, climate pattern, and hydrology. See Ian McHarg, *Design with Nature* (New York: Wiley, 1995[1969]).

physics and the laws of human health influence buildings, but not yet ecology of biology." Josh was not alone in tying biomimicry to resilience. Taryn said it was "part of biomimicry for her," a key question to be addressed during the "measure" step of biomimicry thinking. In an oft-cited essay, the graphic designer Carlos Fiorentino characterizes biomimicry a "paradigm shift toward design for resilience."[88] Resilience, Josh said, is one way to "reconnect" development to nature.

Josh portrayed resilience as an alternative paradigm, or grammar, of life to efficiency. Differentiating "resilient" from "efficient" systems, he attributed a host of qualities to the former: diverse strategies, redundant components, distributed capabilities, dynamic relations, & emergent behaviors. On the contrary, he implicated efficient systems—homogeneous, lean, centralized, tightly coupled, induced—in the etiology of the Anthropocene.[89] "All our ways of civilization," Josh pontificated, "evolved within the bubble of the Holocene," but, he continued, "as we have grown as a geological force, we have shattered the serenity of the Holocene. We have emerged as geological force, globally and locally." Citing Anthropocene scientists (Paul Crutzen, Erle Ellis, and Will Steffen, Josh claimed that efficient systems, exemplified by technologies of energy extraction (e.g. the infrastructure of coal mining and burning), are causally responsible both for the sedimentation of traces of human technicity in the rock layers and more importantly, he believed, for the loss of biodiversity that Elizabeth Kolbert, he told us, names the "sixth great extinction," and E.O. Wilson, the "death of birth." Reading this scholarship on resilience and biodiversity with urban theorist Jane Jacobs's *The Death and Life of Great American Cities*, Josh postulated: "We have homogenized our designs to achieve efficiency at the cost of resilience."

[88] Carlos Fiorentino and Carlos Montana-Hoyos, "The Emerging Discipline of Biomimicry as a Paradigm Shift towards Design for Resilience," *The International Journal of Designed Objects* 8.1 (2014): 1-15.
[89] Here, I follow the anthropologist Amelia Moore in tracing how the Anthropocene concept animates social practice. See Amelia Moore, "Anthropocene Anthropology: Reconceptualizing Contemporary Global Change," *Journal of the Royal Anthropological Institute* 22 (2015): 27-46.

"Biomimicry," however, "gets to a different goal beyond efficiency," Josh reflected. "Resilience, maybe." While "there was little variability" in Holocene ecologies, he remarked, "the future will look more like the distant past than it does today because it will change rapidly." This, to him, posed a crucial problem: "How do we adapt to, or manage, that change while we maintain our identity? How do you design within that uncertainty? We have to learn to manage unknowable or unprecedented change"—for instance, he said, the devastation inflicted upon the residents of New York by Hurricane Sandy back in 2012. "Is resilience always desirable?" Josh asked, indicating that we would not want resilient dictatorships. "It's how it's applied," he said, adding, "How confident are we with the persistence of our cities? Do we need them to persist?" Designers, in Josh's mind, were thus confronted with a political decision between efficiency and resilience. "You can't be both," Josh said. "You have to choose. One is not better than the other, but sometimes one makes more sense in a certain situation. An environment that is stable [read: resilient] requires efficient systems too. It's useful to look to nature to know when to do which."

"One of the dangers of thinking about the Anthropocene is that it puts us in a position of power," Josh warned. "But we need to think about how to do it in a responsible way. We have a responsibility to decide what those systems will look like." For Josh, this responsibility entailed a fundamental and irresolvable indeterminacy—an open moment of what Jacques Derrida terms an "aporia," and what the anthropologist Michael Fischer thinks of as "ethical plateaus"—that could not be resolved through the indiscriminate mimicry of Nature.[90] "*Nature is not out there*," Josh said. "That's an antiquated idea." Deliberating over whether a mimetic artifact should be resilient or efficient was an open question that demanded that biomimics reflect on the politics of design. Where the discourse of biomimicry "smuggled in a view of nature as pure, perfect," as Elizabeth

[90] On aporias, see Jacques Derrida, *Aporias* (Stanford: Stanford University Press, 2003). On ethical plateaus, see Michael Fischer, *Emergent Forms of Life and the Anthropological Voice* (Durham: Duke University Press, 2003).

Johnson notes, here Josh expressed a more nuanced mode of reasoning. "When pigeons eat out of trash cans," he asked, "is that nature?" Likewise, Taryn had earlier asked over breakfast if we should copy all biological parenting models—elephants, maybe, she surmised, but probably not a species that engages in filial cannibalism. As opposed to a nature "out there"—a nature that has incontrovertible "moral authority"[91]—Josh described nature as a set of ecological standards that required the judgment of biomimics to pragmatically interpret whether to copy its efficiency or resilience. The "diversity" of such nature(s) was what he noted as a contextual "tool of design."

On a practical level, this decision-making processes manifests in the selection of ecological performance standards. "Designing for resilience," Josh said, citing Eric Sanderson, entails the use of "cultural memory" to compare the present with the historical ecology of a site. Offering an example from his own practice, Josh narrated a "city-scale deconstruction pilot program" that he and his father recently initiated as an exercise in "systems biomimicry." Josh told us that a nearby town, in advance of an impending enrollment at its community college, wanted to demolish eighteen "tax-delinquent "homes near campus to clear space for a dormitory. "Think of all of the carbon released into the environment," he said, from that case, but also from all the "materials flows" of construction, which comprise, he said, 60% of the US economy—a problem that will only intensify as "new materials" become ever-more resistant to degradation.

Working with the town as a consultant and construction manager, Josh and his father analyzed the site to determine the best course of action. A commitment to resilience as the preservation of identity would imply refurbishing and renovating the homes in a manner that would enable them to persist against future perturbation. But archives at a local historical society suggested to him that this area had been "trapped in poverty despite money being poured into

[91] Lorraine Daston and Fernando Vidal, "Introduction: Doing What Comes Naturally," in *The Moral Authority of Nature*, eds. Lorraine Daston and Fernando Vidal (Chicago: University of Chicago Press, 2004).

it"—a "resilience trap," he said, that prevented other architectural possibilities, such as the "luxury hotel" that he had discovered once stood on the very same land in the early 20th century.

In this case, Josh looked to nature—not for resilience metrics, but models of waste. Rather than demolish the homes, sending them to the landfill without further gain, Josh decided to "deconstruct" them and salvage their components back into the "market." Up front, the project cost $25,000, but the team was able to "recover the costs" by reselling the cabinets and other wood to a recycled flooring manufacturer. While the structural conditions of the houses are also deciding factors (asbestos and black mold, for example, would prohibit recycling), Josh said that this pilot program demonstrated "the law of reciprocity" in nature and enacted to him a "shift from cost to value," where value, as Jason Moore has observed, can arise from the cultural trans-valuation of waste into future cycles of capital.[92] But, by emphasizing that they "recovered the costs," he not only reinforced the significance of cost but also indexed the economic contexts in which the object of mimesis is selected—an economy of mimesis. In his reasoning, Josh copied the waste cycle of ecosystems rather than their resilience because refurbishing a poverty-stricken neighborhood would have been too costly—the determination of ecological fit, subjected to cost.

After his talk, I sat with Josh at lunch to chat. "I try to apply resilience thinking to my own life," he said to me. "Worried about environmental crises," he purchased land in Cazenovia, a town twenty miles southeast of Syracuse where 98% of the population self-identifies as white. "I assessed the functionality of the land before I bought it," he recalled, verifying that he would have multiple sources of water in the event of something cataclysmic—"resilient" water access.

[92] Jason Moore, *Capitalism in the Web of Life* (London: Verso, 2015).

His ownership of a "resilient" land plot betrayed a hierarchy of resiliency and vulnerability that mimetically retraces extant architectural differences and stratifications through race and class.[93]

While Josh publically acknowledged the politicization of nature, the specific political form that nature's politics took echoed the "insecurity by design" logic that the political theorists Brad Evans and Julian Reed discern in the liberal ideology of resilience.[94] Evans and Reed argue that a fixation on the "positivity of danger"—imminent environmental disasters—leads to a conservative idea of "authenticated vulnerability." "Liberalism is aimed today," they write, "not at solving or preventing the manifestation of dangers and threads to security but making us forget the very idea and possibility of security."[95] Resilience, then, de-politicizes environmental politics at the same time that its use in biomimicry re-politicizes nature—a "politics of nature"[96] that remains subordinate to capitalist metrics of value, cost, and profit. To point to this hierarchy is not to designate Josh as a founding author. Indeed, in his consultation with the city his firm was restricted by the structure of his contract and history of the site as the future of a dormitory. It does, however, index the determination of ecological fit in mimesis by larger economic forces.

On the Social Life of Design Proposals: In the Shadow of the Shelf

To further Josh's discussion of ecological performance metrics, Tim recalled an anecdote from his experience as a consultant. In his abridged telling, biomimicry roots the function and fit of architecture and city planning in nature. An expanded version discloses the extent to which the "problem space" of mimesis is constrained and determined by the economics of contract labor.

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[93] For a broad overview of perspectives on the intersection of architecture and race (as well as class), see Irene Cheng, Charles Davis, and Mabel Wilson, eds., *Race and Modern Architecture: A Criticial History from the Enlightenment to the Present* (Pittsburgh: University of Pittsburgh Press, 2020).
[94] Brad Eans and Julian Reid, *Resilient Life: The Art of Living Dangerously* (New York: Wiley, 2014).
[95] *Ibid*, 2.
[96] Bruno Latour, *Politics of Nature: How to Bring the Sciences into Democracy* (Cambridge: Harvard University Press, 2004).

In 2008, HOK, the world's largest architecture and engineering firm, announced a historic partnership with the Biomimicry Guild during Tim's tenure there. HOK had recently opened an office in Mumbai to support a multi-million-dollar contract with the billionaire Ajit Gulabchand and his company, Hindustan Construction Company Limited (HCC). The contract stipulated the design of a master plan for the smart city of Lavasa. In the late 1990s, the Indian state of Maharastra passed "hill station" legislation to incentivize tourism development. In reply, HCC purchased 12,500 acres of land in the Western Ghats mountain range—a UNESCO "world heritage" site prized for biodiversity—to build a "holistic destination" for residents and tourists of this rapidly urbanizing nation. About one hour by car from the information technology hub of Pune and three hours from HOK's office in Mumbai, Lavasa was imagined as a cluster of five "villages" that, by 2020, were expected to house between 30,000 and 50,000 denizens. Billed as India's "largest urban infrastructure project," Lavasa was anticipated to embody New Urbanism, a design philosophy for walkable city centers and proximity to green spaces and other natures.[97] In 2005, construction on this $30 billion mega-project began the first village of Davase, where a typology was modeled off the design vernacular of the colorful Italian seaside town of Portofino.

In 2008, HOK's director of sustainability contracted the Biomimicry Guild to consult them on the second village, Mugaon. In a press release on the rationale for hiring Janine Benyus, Tim, Taryn, and other "biologists at the design table," HOK explained that they wanted Mugaon to exist in harmony with "local biologies" and climatologies.[98] As the Guild members arrived in Lavasa, which is located off the Mutha River, they found, in their own words, an "arid" and "deforested" landscape. "The genius [of place] has left," remarked one member of the team, a

[97] On New Urbanism, see Congress for the New Urbanism (2000), "Charter of the New Urbanism," *Bulletin of Science, Technology & Society* 20(4): 339-341.
[98] On local biologies, see Margaret Lock and Patricia Kaufert, "Menopause, Local Biologies, and Cultures of Aging," *American Journal of Human Biology* 13.4 (2001): 494-504.

representative for HOK later recalled.[99] In Tim's account, they identified the native ecosystem as a "moist deciduous forest" where "monsoons come every year, dumping water every fifteen minutes," as if, he said, "an engineer [were] feeding the clouds." To avoid the threat of erosion in this hillside city, the biomimics examined how animals and plants in the forest had adapted to the 27 feet of rainfall that recurs seasonally, with the intent to imitate their strategies within Mugaon.

They discovered that the canopy of the forest aids in the evaporation of the water—a finding that led them to the creation of a design principle based in hydrological "percentages" or performance metrics: 60-65% of the rain should filter into the soil, 20-30% should evaporate, and 10-15% should flow out as run-off. To achieve these goals, they studied the functions of two organisms in particular—the Banyan fig tree, which breaks apart water droplets, aiding in their evaporation, and the ant nest, which diverts run-off through multiple, moat-like channels—both of which ultimately inspired their design of the buildings' rooftops and their adjacent walkways. Through a "story of place," the Biomimicry Guild sought to, as Tim said, "preserve its function."

Unaware of Lavasa's history, I asked Taryn if the Lavasa project was ongoing. She responded that she had meant to contact the lead environmental engineer on the project who was in charge of the city's sustainability plan. She confessed to me that, as a design consult, their expertise is often commissioned to "demonstrate to higher officials that they are doing something good." Once they leave, however, "these proposals are often shelved, maybe incorporating a few ideas but not all of it. The rest is left to industry and city developers and the private funders who drive development of master cities" (Chapter Three explores this *performative* mimetic stance).

[99] Daniel Grushkin, "A New Industrial City Based on Biomimicry," *Environment and Ecology* online, accessed September 27, 2021, http://environment-ecology.com/biomimicry-bioneers/376-a-new-industrial-city-based-on-biomimicry.html.

After my fieldwork, I read news articles about Lavasa. In November 2010, the Biomimicry Guild ended their contract. The same year, the Union Ministry of Environment and Forests issued a construction moratorium on Lavasa, claiming that the HCC had skirted legally required environmental clearance; had engaged in rock cutting that threatened the stability of the unstable hills; and had settled on and diverted a water supply crucial to the downstream Pure. While the moratorium was lifted the following year, worse violations surfaced. In a concerted effort to acquire the land, over three thousand villagers of the Bhil, Thakar, and Dhanger peoples had been displaced away from the river and up the hills, where water was scarce, even by truck. What appeared as an "arid landscape" to the biomimics was farming land that had been parceled into eighteen villages for Indigenous Adivasi people as part of the land reforms movement in the 1972—"ceiling land" that should not have been transferred or sold but was expropriated from the villagers through the intermediary efforts of local agents who doctored their land records, signed fraudulent checks, and even threatened and harassed the villagers into transferring their titles. In biomimicry's notions of nature, Indigenous peoples and their habits of land use are often effaced in their imaginaries of native ecologies—a point I revisit in Interlude Two and in Chapter Two.

At the time of writing, Lavasa sits "unfinished."[100] With $610 million accrued in debt, construction has halted, as has maintenance, leaving in disarray a ghostly waterfront of vacant apartments that, even at the height of development, were unaffordable to all but the upper class. This history of Lavasa, which is often upheld as an example of the paradigm of biomimicry,[101] dramatizes questions about the relation of the human in "nature" as well as the politics of life's

[100] João Biehl and Peter Locke, eds., *Unfinished: The Anthropology of Becoming* (Durham: Duke University Press, 2017).
[101] See Biomimicry 3.8, "A Biomimetic Monsoon-Proof Landscape Master Plan," accessed September 27, 2021, https://biomimicry.net/b38files/Biomimicry+38+Project+Example+HOK.pdf.

likeness more broadly: Who determines what to imitate in nature, and to what technological end? How do these ends, and their economic determination, shape the meaning of "nature" in design?

Function Disjunction: Nature Lost in Translation

After an extensive background in the "theory" of biomimicry, we were ready to learn its "method": how to identify function. On the second day, Tim opened a session on "functional knowledge" with a metaphor of biomimicry as "natural language translation." In 2016, Google engineers "trained," he said, an artificially intelligent (AI) agent to translate between English and Korean and English and Japanese. To their surprise, the machine learning algorithm could also translate between Korean and Japanese without English as an intermediary computational step—proof, the engineers deduced, of an "interlingua." Tim called this interlingua an "internal logic." Tim opined that the concept of "function" in biomimicry is like this internal logic, save between organism and machine, and the skill of "functional knowledge," a linguistic practice: translation.

When we do this biology piece," Tim said, "We translate biology into abstract ideas. We are building the ability, access, so that we can bring the biological knowledge into our own experience. We are learning how to observe, build functional knowledge." To Tim, the word "biology" meant organisms, and "function," the object of technological imitation. But, as Tim went on, "biology" acquired linguistic connotations, as the name of a discipline with a lexicon: "We're often not working alone but in teams. Having a conversation is a big part of this as well. We need a common language with which we can speak and share." In this metaphor, "function" functions two-fold: as a "bridge" between capital "B" Biology—life—and Design, as well as a lingua franca between biological science and the design disciplines.[102] What Tim had presented

[102] In this sense, "function" might be like what Peter Galison describes as a "trading zone." Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997).

was a metaphor of a metaphor—biomimicry as language translation and language as statistical and stochastic information[103]—that depicted biomimicry as a "seamless transition," he said, from the functions of living organisms into technical copies via the "translation" of design principles. Here, I read the mimetic labor needed to make design principles against his translation metaphor.

To assist with the identification of function at varied biological scales, the Biomimicry Conglomeration™ released a design tool—the "biomimicry taxonomy" (see Figure 6)—that, as Tim explained, "can help us further develop the question: 'What do I want my design to do?'" Visually diagrammed as a nested series of concentric half-circles, the taxonomy classifies life by "verbs" that differentiate in ascending specificity, from broad "groups" to narrow "functions." On first impression, the taxonomy's radial arrangement resembles biologists' knowledge that organisms perform seven functions that are essential to "life," i.e. "function" in its biological meaning: reproduction, growth, movement, sensitivity, respiration, nutrition, and excretion.

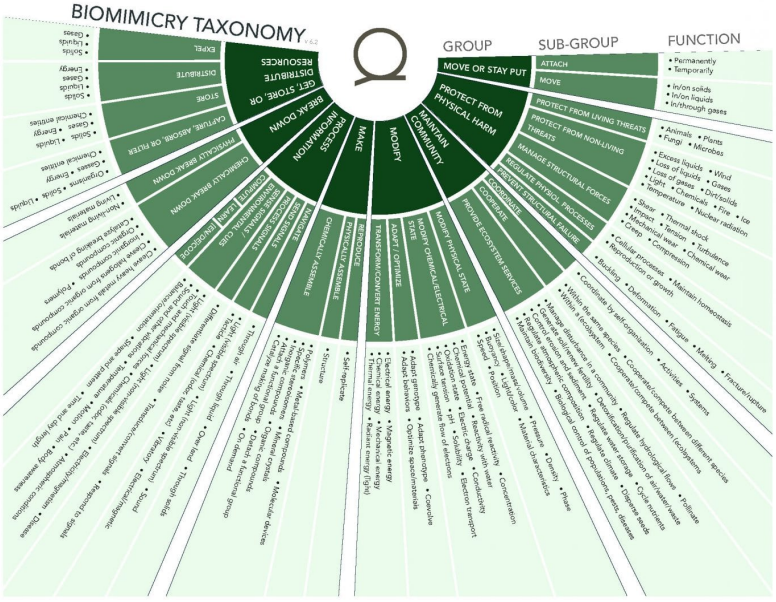

Figure 6: Biomimicry Taxonomy[104]

[103] Lily Kay, *Who Wrote the Book of Life?* (Stanford: Stanford University Press, 2000).
[104] Biomimicry Institute, "Biomimicry Taxonomy," accessed September 27, 2021, http://toolbox.biomimicry.org/

An in-depth examination, however, refutes any sense of direct correspondence. Organismal movement has an obvious counterpart in "move or stay put," but other functions in the taxonomy lack a traditional referent (for instance, "maintain community" and "modify"), recur multiply ("get, store, or distribute resources" could signify both nutrition and respiration), or appear redundantly ("break down" and "get, store, and distribute resources" each vaguely suggest nutrition). From a quick glance at the taxonomy, then, one begins to detect already that the meaning of "function" in the biomimicry community exceeds its denotative use in biology. "The taxonomy is helpful," Taryn said, skimming the page, "but not always intuitive. One of the challenges is that function isn't always clear when reading a journal [or] observing an organism."

This taxonomy of function is at the core of the epistemology of life in biomimicry. The Biomimicry Taxonomy is, to take one example, the epistemic infrastructure on which the Biomimicry Institute built AskNature: a web archive and catalog of biological design principles that first went live in 2007. Based on scientific reports of biological research, AskNature lets the community of biomimics to search for the "strategies" organisms use to achieve their functions. Organized into collections sorted by organism, ecological context, and industry of application, AskNature is, in Tim's own words, "a resource for a community to look at nature functionally." "Biology literature is not organized by function," he stated, explaining that organism, discipline, and technique were more common sorting devices. "Accessibility becomes a challenge," he said.

"It's a social community as well," Taryn elaborated. "But it's a work in progress," she said, explaining that "it's a tough challenge to boil nature down. Putting things in the database is slow. It takes time." To accelerate data entry, the Biomimicry Institute enlisted the help of Ashok Goel, a computer scientist associated with the Center for Biologically Inspired Design at Georgia

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wp-content/uploads/2015/01/AN_Biomimicry_Taxonomy.pdf

Institute of Technology, and a member of the chair of directors for the Biomimicry Institute from 2012 to 2017. An expert in "human-centered computing," Goel investigates human cognition *in situ*, specifically analogical reasoning in biomimicry, to model and develop assistive algorithms.

Before Goel, AskNature was an onerous undertaking that required experts to read scientific articles and glean biological design principles from them. Goel's idea was, according to Tim, to "crowdsource it [the design principles] by using machine learning to identify internal logics." On the projector behind him, Tim guided us through the site, which solicited help from anonymous reviewers willing to read and review a randomly generated abstract—abstracts taken from a list of journals available on the Web of Science online database. After adjudicating whether an abstract is relevant to the database—a seemingly innocent question that itself already imports questions of utility and value into nature—a reviewer identifies the living system in question and identifies its "function" and "mechanism" (here, used as a synonym of "strategy").

Machine learning protocols traditionally employ the "trained judgment" of experts to label unclassified data, thereby "training" an algorithm in rules for later unaided classification.[105] This was the premise behind a prior database for nature's design principles that Goel had created, in which the "training" phase was conducted by members of his team who were familiar with the "structure-behavior-function" ontology common within contemporary design science research. In this approach, "function" refers to the intended "use" of an artifact—its practical "purpose."

But, as Tim recalled, problems of labor and language retarded the project. The ontology was not only pedagogically demanding—"too much training," he opined on Goel's project—but it was also indecipherable and opaque to database users who did not come from an engineering

[105] On "trained judgement," see Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone, 2007).

or technological background. "No one could use it," Tim recalled, chuckling. Due to such issues, Goel's progress on the database faltered, ultimately forcing him to abandon this project till 2007.

With AskNature, Goel was afforded a second chance to realize his vision of a database of biological design principles—a database that, in this iteration, would eschew the ontology of structure-behavior-function and adopt the Institute's de facto parlance of functions and strategies. A distinction still greater was also made operational with AskNature: Whereas Goel had before relied upon the interpretive judgment of trained experts to feed his algorithm, AskNature made no demands of expertise—not trained judgment but untrained judgment. This alteration in the social production of design principles made it possible for common sense meanings of function as human "use" or "purpose" to appear in the trappings of self-organizing biological functions.

This much was certain when Tim announced that we would practice our "functional knowledge" skill by processing several abstracts for AskNature as a group—human expertise and machine learning co-produced in one act of classification. Tim displayed the abstract below:

> The escape paths prey animals take following a predatory attack appear to be highly unpredictable – a property that has been described as 'protean behavior'. Here, we present a method of quantifying the escape paths of individual animals using a path complexity approach. When individual fish (*Pseudomugil signifer*) were attacked, we found that a fish's movement path rapidly increased in complexity following the attack. This path complexity remained elevated (indicating a more unpredictable path) for a sustained period (at least 10 s) after the attack. The complexity of the path was context dependent: paths were more complex when attacks were made closer to the fish, suggesting that these responses are tailored to the perceived level of threat. We separated out the components of speed and turning rate changes to determine which of these components contributed to the overall increase in path complexity following an attack. We found that both speed and turning rate measures contributed similarly to an individual's path complexity in absolute terms. Overall, our work highlights the context-dependent escape responses that animals use to avoid predators, and also provides a method for quantifying the escape paths of animals.[106]

After reading the abstract aloud, Tim suggested that we move through the questions it prompted.

[106] J.E. Herbert-Read, A.J. Ward, D.J.T. Sumpter, and R.P. Mann. "Escape Path Complexity and Its Context Dependency in Pacific Blue-Eyes (*Pseudomugil Signifer*)." *Journal of Experimental Biology* 2017, 220: 2076-2081.

Our collective efforts began in consensus: All agreed that the abstract was relevant to AskNature.

By the second question, dissensus mounted. Everyone agreed that the "system" in question was living, but not if the system was *the* blue-eyed fish, *a* fish, or any prey animal. Ilya, Ben, and Dorna had diverging opinions and rationales, with varied implications for the generality of the design principle at hand. Tim entered the first answer, blue-eyed fish, commenting that we could return later. Complexities and indecisions multiplied when we reached the heart of the exercise: what function the organism performed and what mechanism (or strategy) facilitated it. Encouraging us to voice our ideas through the taxonomy's lexicon, Tim asked for the function. Ben suggested "protect from physical harm"; Taryn, "get, store, or distribute resources" or "maintain community"; and myself, "move or stay put." Tim hesitated. "Hmm, it's not obvious," he muttered. His doubt was temporarily allayed when he discovered an option for entering multiple functions. For several minutes, we moved back and forth recursively across what finally culminated in three complete function-mechanism relationships. During this process, it became progressively unclear how to best fit the intricacies of the abstract and its reference to time and variation into the infrastructural constraints AskNature provided. As Geoffrey Bowker and Susan Leigh Star argued, technologies of classification like AskNature twist nature, producing "torque" between our realities and the force of an inflexible epistemic grid.[107] What did, however, become progressively *clearer* was that design principles were far from obvious. They require the kind of constructive and disputational social interaction that I have been referring to as mimetic labor.

"They aren't all this hard," Tim attempted to assure us, "but this one," he emphasized, "is a *hard* one…" Nevertheless, with three relationships identified, we concluded, with dubiety. Tim asked for our level of confidence. "Somewhat…?" Jane offered with a shrug and a grimace.

[107] Geoffrey Bowker and Susan Leigh Star, *Sorting Things Out: Classification and Its Consequences* (Cambridge: MIT Press, 1999).

Ilya joked: "Who ever clicks very confident?" Tim laughed, selecting that one. "I do all the time. You have to be egotistical." Later, when I asked Tim about the review process, he suspected that any answer "less than very confident will be reviewed by people at the Biomimicry Institute or perhaps the experts who wrote the abstracts." But if Tim marked "very confident" despite the discord and friction that vexed our deliberations, what would stop others from doing the same?[108]

Tim swore that other abstracts were easier. Buoyed by his reassurances, we ventured a second attempt on the following abstract:

> The goal of this study was to gain insight into how ankle exoskeletons affect the behavior of the plantarflexor muscles during walking. Using data from previous experiments, we performed electromyography-driven simulations of musculoskeletal dynamics to explore how changes in exoskeleton assistance affected plantarflexor muscle-tendon mechanics, particularly for the soleus. We used a model of muscle energy consumption to estimate individual muscle metabolic rate. As average exoskeleton torque was increased, while no net exoskeleton work was provided, a reduction in tendon recoil led to an increase in positive mechanical work performed by the soleus muscle fibers. As net exoskeleton work was increased, both soleus muscle fiber force and positive mechanical work decreased. Trends in the sum of the metabolic rates of the simulated muscles correlated well with trends in experimentally observed whole-body metabolic rate (R^2=0.9), providing confidence in our model estimates. Our simulation results suggest that different exoskeleton behaviors can alter the functioning of the muscles and tendons acting at the assisted joint. Furthermore, our results support the idea that the series tendon helps reduce positive work done by the muscle fibers by storing and returning energy elastically. We expect the results from this study to promote the use of electromyography-driven simulations to gain insight into the operation of muscle-tendon units and to guide the design and control of assistive devices.[109]

Tim looked around at us, his face a humorous expression of trepidation, exasperation and regret. Jenine, a white resilience officer in Boston, tentatively guessed an interpretation of the function

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[108] Digital theorists Hamid Ekbia and Bonnie Nardi refer to technologies of automation like AskNature as "heteromation" to illuminate their obscured dependence on human labor. Claims of automation cover up not just signatures of human labor but, as other scholars have shown, conflicts between coders, presenting the end result as the execution of an algorithm. AskNature potentially exacerbates these trends by allowing untrained raters to train an algorithm in the logic of function that they themselves do not fully understand, masquerading their uncertain ignorance as certain knowledge. Hamid Ekbia and Bonnie Nardi, *Heteromation, and Other Stories of Computing and Capitalism* (Cambridge: MIT Press, 2017).

[109] Rachel Jackson, Christopher Dembia, Scott Delp, and Steven Collins, "Muscle tendon mechanisms explain unexpected effects of exoskeleton assistance on metabolic rate during walking," *Journal of Experimental Biology* 220.11 (2017): 2081-2095.

and mechanism relation. Dissatisfied with his pedagogical approach to teaching function through AskNature, Tim transitioned to another set of design exercises. "Function," it turned out, was remarkably difficult to recognize from a bioscientific perspective, even for trained biomimics.

We began with "Verb-o-City" and "Function Tactic Trees." "Designed to help you reframe your questions based on function," the first exercise was a mock design challenge: the "purse problem." Tim and Ben concurred that this thought exercise and others (e.g. the "toaster" and "pill bottle" problems) were common in design. First, we had to articulate the "functions" of an imagined future solution—"what you want the solution to *do*." For instance, the solution has to "keep the purse from sliding around," "allow access to the purse," and "stay out of the way for passengers." We reduced these solutions to two-word phrases ("hold purse," "stabilize purse," and "control purse") and their synonyms. In turn, these generated a rich vocabulary with which to ask "how might nature" accomplish it. "If you are stuck on steps three or four," Taryn advised of the verbalization steps, "pull functions," she said, from the biomimicry taxonomy and "imagine your answer to the question *How might nature…?*" in order to narrow down the translatable verbs between biology and design. In a dizzying display of multimodality, what we imagined design *could* do in the subjunctive was conditioned by what nature might tell us design *should* do in the prescriptive—an enterprised nature already colored by what we *wish* for design. This, Taryn reflected, was how she often approached a design problem in the path of consulting, where a desire for particular technological functions motivates an analysis of biological function.

As the second exercise showed, such anthropocentric functions can be read onto life, regardless of any grounding in biological truth. Tim held up a pinecone and instructed us to sketch it in the center of a page in our workbooks. On lines that "branched" from the central illustration, he told us to write down four "primary functions" that the pine tree performs through

the pinecone with verbs describing "what it does." From these main branches, other descending lines asked for the "tactic," or "how it does it." Soliciting our replies, Tim agreed with the group that it "stores," "packs," and "protects" by the structural arrangement of its bracts. When asked why the bracts tapered off at the end, Tim remarked that "it may not have a reason" but that should not stop us from drawing inspiration from its function. Ascriptions of function did not necessarily have to match biology if they generated insights for biomimics: the pragmatic stance.

In these two final exercises, functional knowledge emerged from abductive reasoning in forward and reverse. After abducing a desirable resolution to our fictive challenge, we rewound toward life's functions backwards, superimposing functionalities of the future onto organisms in the present. This inverts the logic of function that Foucault described in biologists. "To classify, therefore…will mean…to relate the visible to the invisible, to its deeper cause, as it were, then to rise upwards once more from that hidden architecture towards the more obvious signs displayed on the surface of bodies."[110] As I said earlier, function is ontologically first in biology. But, and this is a crucial distinction, function comes second epistemologically. Only through the semiosis of reading "visible" structure as a "sign of what was most essential in it" does a biologist go from the "most visible point upon its surface" to "a function that governs the individual."[111] In the two exercises Tim led us through, however, we toppled the semiotic order of things, beginning with a function-not-yet-real that the designer values and scanning the living for valuable structures that bespeak these functions, sometimes finding them while other times reading them onto organisms. Function as "use" thus blurred into function as "self-organization," confounding desire and truth.

Ben was sensitive to function's polysemy. "Within the artifact space, you talk about function," he reflected at the end. "This is a hierarchy derived from the biological domain, but it

[110] Foucault, *The Order of Things*, 229.
[111] *Ibid,* 228.

gets weird when you apply this functional mapping [back] to a living thing. At some level, it is beautiful. At another, it is odd. It is not really what it is." As Ben recognized, function as "use" derives, historically, from function as "self-organization." In his keyword entry on the concept of "function," the design historian Adrian Forty remarks that the word has upward of nine meanings in architectural discourse alone.[112] First conceived in mathematics as "the result of the action of one quantity upon another," function, as Foucault recognized, was applied by Georges Cuvier to describe, in organisms, the "purposes of the parts of the construction relative to each other and to the whole"—a meaning that architects used as a metaphor for buildings.[113] Through architectural theory, function gradually expanded into the broader design disciplines as a synonym of use. Biomimicry goes one step further, looping the meaning of function as "activities designated"[114] for artifacts—human intents—back onto biology. Life becomes whatever designers want to find.

In light of the interdisciplinary history of the concept of function, it was perhaps not surprising that the word "function" would denote multiply in biomimicry, a community that has biologists, designers, and other professionals among its ranks. That said, it did contradict Tim's metaphor of biomimicry as translation. In contrast to glosses of translation in postcolonial theory as an uneven and saltatory motion between linguistic forms of life, Tim described biomimicry as a "seamless transition" between organism and machine and between biologists and designers that was enabled by the idea of function.[115] Over the course of our pedagogical exercises, it was clear that what Tim saw as "seamless" was, in fact, the complete opposite. Design principles, that is, analogies between life and technology based on function (where one *seems* like the other), were seamed together through contest and controversy—mimetic labor. In addition, the concept itself,

[112] Adrian Forty, *Words and Buildings: A Vocabulary of Modern Architecture* (London: Thames & Hudson, 2000).
[113] *Ibid,* 174, 175.
[114] *Ibid*, 179.
[115] See, for instance, Homi Bhabha, *The Location of Culture* (New York: Routledge, 1994).

function, was polysemic, meaning both "self-organization" and "use." If function was seen to be an interlingua, it was less a shared pidgin than it was the forceful imposition of a designerly idea of function onto the domain of life.[116] Perhaps, then, biomimicry ought to be rethought from the metaphor of "transduction," or "transubstantiations of matter and meaning"[117]—a metaphor that highlights the mimetic labors of making design principles and the lability of the term "function."

In the practice of biomimicry as a meta-design method, "nature," I observed, was an extraneous category. It is not (just) the case, as Elizabeth Johnson observes in the discourse of biomimicry, that life is a "double mirror" for the "language and ideology of production"[118]—what I earlier characterized as nature "enterprised up," or *nature as innovation*. If, to Johnson, biomimicry "aligns our efforts of production with the productive powers of 'life itself,'" to Tim and the other biomimics present at the workshop I attended, biomimicry aligned their efforts of production with an empty signifier of Life—a capacious term that accommodated whatever they sought to find, neither "life-as-it-could-be" nor "life-as-we-know-it," [119] but life-as-they-will-it.

Since the 1990s, anthropologists of the life sciences have called attention to the denaturalization of the object of biology: life.[120] In his prognostication on the future of genetics, Paul Rabinow famously asserted that "nature will be known and remade through technique and will finally become artificial, just as culture becomes natural."[121] Likewise, Stefan Helmreich has detected—in the "limit biologies" of Artificial Life, marine biology, astrobiology—"instabilities

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[116] See footnote 102.
[117] Helmreich, "Transduction."
[118] Elizabeth Johnson, "Reconsidering Mimesis: Freedom and Acquiescence in the Anthropocene," *South Atlantic Quarterly* 115.2 (2016): 267-289, 270.
[119] Stefan Helmreich, *Silicon Second Nature: Culturing Artificial Life in a Digital World* (Berkeley: University of California Press, 2000), 13.
[120] For a review, Stefan Helmreich, "What Was Life? Answers from Three Limit Biologies," *Critical Inquiry* 37.4 (2011): 671-696, especially footnote 1.
[121] Paul Rabinow, "Artificiality and Enlightenment: From Sociobiology to Biosociality," in *Essays on the Anthropology of Reason* (Princeton: Princeton University Press, 1996), 91-111, 99.

in the nature supposed to ground life" indicate a feeling of indeterminacy about life at a "moment of epistemological dizziness."[122] Sophia Roosth, in her account of synthetic biology, writes that "the new living things biologists make function as 'persuasive objects' that materialize theories of what synthetic biologists seek to understand about life."[123] "Life," it seemed, had met its end.

In biomimicry, it is not quite true that life has lost its coherence. Indeed, I heard no shortage of syncretic explanations about what life is. Biomimics do not doubt that life exists, in some definitive sense, as a stable mode of existence. It *was* true that, in the pragmatic stance of so-called "nature-based design," design became unmoored from biological nature, or life itself. What is striking about Tim's "amateur naturalism" is, therefore, not merely that nature reflected the facts and artifacts of sustainable innovation, but that biomimics abandoned or discarded life as a grounding function when nature failed to realize a desired function—as long as it "worked." In the workshop genre that mediates biomimicry's reproduction, representations of nature are not grounded in experimental research but open to techniques of ideational manipulation that project the desires of designers onto the bodies of organisms—designers who may well continue to state that their designs are "bioinspired." What is at stake, then, is the meaning of nature as biomimics attach its name to technologies that bear little to no resemblance to biological functions. One gets the impression, as Lempert described it, of a "creeping sense" of the *absence* or *void* of life—i.e. of purported "copies" that, in truth, have no originals, what Jean Baudrillard called simulacra.[124] If biology after biotechnology became, in Sarah Franklin's estimation, "denatured biology," then design after biomimicry becomes *denatured design*—naturalesque designs without bio-referents.

[122] Helmreich, "What Was Life?", 695.
[123] Sophia Roosth, *Synthetic: How Life Got Made* (Chicago: University of Chicago Press, 2017), 5.
[124] Baudrillard, *Simulacra and Simulation.* See also Richard Doyle on the "post-vital" body of biology in *Wetwares: Experiments in Postvital Living* (Minneapolis: University of Minnesota Press, 2003).

Routinized Business Inspiration? The Volley of Analogy and Disanalogy

Midway through the workshop, we received prompts for the design challenges that would occupy the rest of our time at the Brynmere. We picked from five options: a single-use fragrance package for a cosmetics company, a master plan for an industrial city in India's Deccan Plateau, a resilient disaster readiness infrastructure for the city of Dallas, a "circular" plastic container for the Ellen MacArthur Foundation, and an open call from the engineering firm Arup's Cities Alive Initiative to submit any idea around design and the built environment.[125] All of these challenges, Tim and Taryn revealed, were ones they had encountered during their experiences as consultants. Over two days, we would reenact a process of innovation that could last up to a year in duration.

My team—Ben, Jane, Dorna, and myself—picked the fifth option. To find "functions," we would "AskNature" and take a kayaking trip on the Ipswich Salt Marsh. "Nature walks," Tim shared, had grown into a personal ritual for him before consulting begins—"to prime myself for design thinking," he said. While Tim had presented "life-centered design" as an alternative to the methodological rigidity of Biomimicry Thinking, the application of skills in creative observation, functional knowledge, and connected application largely retraced in sequence this conventional stepwise routine. Tim announced a major caveat: we *had* to engage in the "verb-o-city" exercise.

In addition to the meta-method of biomimicry, Tim wanted us to practice common exercises in business innovation. At some point, we had to use four interactional techniques that he picked up during his ten-year tenure at the Institute, IDEO, and LikoLabs: "Socratic Inquiry," the elicitation and elucidation of assumptions embedded in a design problem; "Yes, and…," the validation and elaboration of ideas; "Brainstorming," the rapid and uncritical proposal and accumulation of responses to a prompt; and "Affinity Diagrams," the visual sorting of scattered

[125] On the circular economy, see Walter Stahel, *The Circular Economy: A User's Guide* (London: Routledge, 2019).

responses (not unlike thematic coding in qualitative social scientific methodology). Such techniques complement biomimicry, Tim expressed. If biomimicry, as a mode of routinized business innovation, involves the provocation and evaluation of proto-forms, these techniques, he explained, centered on communication, structuring social interaction to facilitate a consensus.

As an expert on design, Ben undemocratically assumed a managerial role in this collaborative challenge. Seated in the kitchen, he pulled a personal pad of Post-It notes from his vest pocket and began to scrawl one technique on each yellow sheet. He then aligned them in a vertical column, peeling the sticky squares off the table to shuffle them around until he arrived at an order that satisfied him. We needed "design representations," he said, a process to help identify the problem that we wanted to address with the still unspecified Arup design challenge. Tim stopped by and asked what designers did before Post-Its. "Toil in obscurity," Ben quipped.

Upon Ben's recommendation, we first gathered our thoughts, individually, about problems in the built environment that we wanted to address. Next, we reconvened at the kitchen table and each presented our ideas, which varied from traffic regulation to garbage collection. Ben inscribed each idea onto a separate sticky note until they covered the table, at which point he sorted them into "clusters" and suggested that we "blind vote" to select our preferential problem. Dorna's proposal to confront food availability won. Using the Socratic and yes/and methods to suss out what this meant, we arrived at our challenge: how to raise food animals (e.g. chickens, fish, or pigs) in the city—humanely, with limited space, and in a manner that builds community. Not everyone was as enthusiastic as Ben about his sequence: Dorna twice remarked, first to the group, and then later at dinner to me, that she felt we spent too much time clarifying the problem.

At this point, one last step remained before we could query *How might nature…?* with the verb-o-city exercise, which would determine the desired functionalities of our hypothetical

solution, and thus the analogical zone of our search. After brainstorming, and with the aid of the biomimicry taxonomy, we distilled all of the functions of our solution down to a series of verbs that Ben wrote down, one per page, on sticky notes: "optimize space," "protect," and "isolate." Throughout the remainder of the design process, these sticky notes winked in and out of the solution space by virtue of their adhesion to the kitchen table. As the anthropologist Eitan Wilf explains, these "semiotic technologies" work precisely because of their liminal status between mobility and immobility.[126] Affixed to the table, each note contributed, weakly, to the analogical relationship between organism and machine. When analogies failed to "stick," the note, an icon of the analogy, was removed from the table—the causality of what I theorized as "disanalogy." Disanalogy is Cameron Shelley's term for a counter-argument *against* analogy, in particular one that not only rejects likenesses (here: between organism and machine) but pragmatically couples new constructive effects to rejection.[127] Disanalogies are discursively productive. As biomimics attempted to demonstrate analogies (through sticky notes), so too did they put forth justifications when they failed to stick. These justifications often possessed a more transformative effect on the resultant biological design principle and the ensuing proposal than the first analogical utterance.

When all the teams had resolved their design problems, we prepared to depart the Brynmere for an afternoon in Ipswich at the Great Marsh, a vast and labyrinthine network of marshes, beaches, dunes, and winding waterways that spans from Cape Ann to New Hampshire, nearing some 30,000 acres in landmass. Due to the flooding action of the tides, which redraws its topography hourly, kayaks are the most versatile means of transportation across its shifting land. In an electric caravan of Prii, we traveled to a kayak rental shop to get the teams outfitted. On the

[126] Eitan Wilf, "The Post-It Note Economy: Understanding Post-Fordist Business Innovation through One of Its Key Semiotic Technologies," *Current Anthropology* 57.6 (2016): 732-760.
[127] Cameron Shelley, "Analogy Counterarguments: A Taxonomy for Critical Thinking," *Argumentation* 18.2 (2004): 223-238.

drive, we passed by a cemetery. Peter pointed it out to me through the window and regretted that cemeteries and arboreta had not been more systematically scoured for design strategies. “They’re an untapped resource,” he said, sighing. At the outdoor recreation outlet, we were joined by three white, college-aged guides—all in backwards hats, yellow tank tops, shorts, and flip flops—who had been hired to lead us across the marshes. Officially designated an “Important Bird Area” by the National Audubon Society, the marshes promised a profusion of life, avian or otherwise, that Tim and Taryn expected our guides to discuss, hoping we would discover new design principles.

As we paddled down narrowing currents that, at several points, swept us onto encroaching dunes, their ambitions were similarly run aground. None of our guides, it came to light, were naturalists, to Taryn’s consternation. Home from school for the summer, all three were students at the University of Massachusetts at Amherst—two mechanical engineers, and the other, an environmental economist. To her even greater frustration, an odor of sulfuric decay viscerally signaled the presence of life in decomposition. Bioinspiration was less visible than Tim and Taryn had wished. A few seagulls flew overhead, and the occasional razor clam in hasty retreat was spied by its fugitive spray as it burrowed under sand. Walking up one dune, Tim said to me that he was worried there were not enough organisms, with the exception of one cormorant that he spotted from afar, its wings outstretched. He informed us the cormorant coats its wings in a glandular secretion that provides some degree of hydrophobicity to the water-diving organism. But, like the water, none of the functions that Ben, Jane, Dorna, and I imagined in our solution would stick to the cormorant. Dorna tried to suggest an analogy on the grounds of optimization, but Ben rejected this, distinguishing the optimization of space, which we had desired, and the optimization of speed underwater that the cormorant attains by means of its lipidic feather layer. Analogical reasoning, it became clear, had limits dependent on the ecologies of our encounters.

Back at the Brynmere and empty-handed, the four of us redirected our attention to organisms of a digital nature by trying to query AskNature using the three functions we picked. To our relief, the first term, "optimize space," was productive—a successful analogy. Upon entry in the search bar, we received a design brief that detailed how soil microbes optimize the relation between available minerals and their particular nutritional requirements by differentiating spaces, or niches, by species. A second result from the search, about the ecological succession of species communities from pioneer to climax, hinted temporal differentiation as another kind of partition. In turn, Ben and Dorna reasoned by analogy that our solution could feature a biological principle of "adaptive differentiation," wherein animals with different spatial needs (e.g. chickens vs. pigs) would be allocated room according to their physical demands at different stages of the life cycle. This principle, it was said, would address a previously identified problem of humane treatment, stemming from the cruelty of cramped living quarters; space was optimized with best practice. (An alternative interpretation of ecological succession stipulated that zoning rules would emerge gradually over time, allowing for an initial experimental phase, then a refining of relationships). This round of analogical thought clarified that the solution would be less a physical artifact than it would be a town plan and zoning strategy, although still exclusively in the residential domain.

Whereas the analogy enabled by the function "optimize space" succeeded, the other two functions that we tried—"isolate" and "protect"—failed to realize any biological analogues. Despite this, however, they were no less productive in the crystallization of the design problem and its solution. In each case of disanalogy, a new facet of biological similarity became known. Due to the potential for noise and smell, we had decided that it would be advantageous to isolate the spaces of animal rearing, to avoid complaint. None of the strategies that AskNature generated in response to our query, however, offered analogical relief from these issues, Jane and Ben both

argued, dismissing the analogy. During this discussion, we recruited Taryn, who was wandering the kitchen offering assistance. She suggested that we ask the inverse question—not how does nature isolate, but how does nature coordinate and cooperate. She often found this useful for her.

Ben agreed with her suggestion and related an "apocryphal story" from a course he had taught on biomimicry. One of his students had repeatedly asked how "nature keeps things on the ground," seeking an attachment mechanism, just to later realize that "nature does this through gravity." Ben unspooled the lesson: "The whole question restricted what they could envision. The question can only answer what it is designed to solve. There are multiple framings." On the basis of this revision, we removed the "isolate" Post-It note from the table, replacing it with one that said "cooperate or coordinate." A theme that recurred among results from this search gave us principles of symbiosis, and one strategy in particular produced, simultaneously, a new problem and a new solution: waste. Raising animals would invariably produce fecal matter that could lead to disease, but Dorna proposed that a mixed residential and commercial plan could lead to a symbiotic trade relationship between producers and businesses that reuse and recycle their waste.

In a second example of disanalogy, the term "protect," also proposed as a means to insulate the sites of food production from outside complaints of noise and odor, was found to be analogically unproductive. Ben removed "protect" from the table and replaced it with "conceal" after Dorna suggested a better function might be to mask the sound and scent. A strategy based on the glass frog on AskNature presented camouflage as a means of concealment. Ben remarked that, perhaps, we "flip the script." He asked: "What if, instead of finding concealed animals, we protect the vulnerable thing, the neighbor? In design, sometimes you have to kill your darling." He returned the "protect" Post-It to the table's center, together with "cooperate" and "optimize." As a result of this series of disanalogies, we at last arrived at our final proposal: a city plan that

would place animal production within rings of symbiotic businesses that would function as a sort of olfactory buffer between urban farms and the other residential zones that smells might offend.

During the design challenge, life's likeness was not given but achieved through social interaction that involved human biomimics and nonhuman organisms (or discourses about them). Likeness is not found in nature but constructed. Walter Benjamin called this the "production of similarities," a shift in meaning from likeness as a passive object waiting to be recognized to the outcome of an active process.[128] Likenesses, *viz* design principles, were manufactured by people. Specifically, life's likeness was socially assembled with analogical propositions between present organisms and future machines—a strenuous process of mimetic labor. Sometimes analogies had success; other times, they did not. What is presented in hindsight—"rational reconstruction"—as the routinization of analogy production can be seen, from the perspective of real-time practice, to involve a precarious volley of analogies and their obverse: disanalogies.[129] In contradistinction to what Wilf termed "routinized business innovation," business "inspiration" in the meta-method of biomimicry is not governed per se by a "rule-based imagination" than it is an absence of rules, in which negative analogies, or disanalogies, constrain design principles as much as analogies do.

Conclusion: Deferral and/as Deference

At the end of the workshop, Taryn presented a lecture on her doctoral research. From 2007 to 2012, Taryn worked as a "Biologist at the Design Table" for the Biomimicry Conglomeration™, leveraging her undergraduate training in environmental biology from Western Stage College. In 2013, a year after founding her own biomimicry consultancy Symbiosis, Taryn experienced what

[128] See Walter Benjamin, "Doctrine of the Similar," in *Selected Writings, Volume 2, Part 2, 1931-1934* (Cambridge: Belknap Press, 1999).
[129] Imre Lakatos, "History of Science and Its Rational Reconstructions," *Proceedings of the Biennial Meeting of the Philosophy of Science Association* 7 (1970): 91-136.

she described as an "existential crisis," wondering "what it means to do biomimicry." To resolve this feeling, she pursued a PhD in Business and Management at the University of Exeter, where a focus in organizational studies prompted her to question "what types of bio-inspired innovation is attempted by multinational corporations" and "what factors influence its adoption." In most of the companies that Taryn studied, technical performance and financial profitability were how the design proposals of biomimics were principally evaluated—a finding that corroborated what she, Tim, and Peter already knew, hence their adoption of the mimetic stance that I labeled pragmatic.

To these workshop guides and to most, if not all, of the biomimics I met, the value of mimesis emanates from its power to harness the alleged sustainability of life's design principles. To the corporate representatives who pay for biomimicry counsel, however, what Tim called the "value proposition" of biomimicry was not its ecological commitments but its promise to convert 3.8 billion years of evolution into infinite commodities, unending novelties—just another font for business innovation as usual. Maneuvering within a design space already predetermined by what these companies want to find, biomimics revert from the mimetic ethic to economic pragmatism, eschewing fidelity to life—biomimicry's ethos of "revolution"—in favor of whatever may work.

In an interview with Leigh Stringer, the former vice president of HOK and author of *The Green Workplace*, Tim acknowledged that most companies do not care for the future claims of biomimicry. "While working with leading designers," Tim expressed, "I was at first frustrated to see how people typically frame biomimicry innovations as 'push' technologies…solutions that are in need of a market, rather than 'pull' technologies that have a clear market that is ready and waiting."[130] On the contrary, Sharklet's technology—an anti-bacterial surface—demonstrated to

[130] Leigh Stringer, "Interview with Timothy McGee, Entrepreneur, Biologist, and Designer at LikoLab," *Leigh Stringer,* October 28, 2015, https://www.leighstringer.com/interview-with-timothy-mcgee-entrepreneur-biologist-and-designer-at-likolab/.

Tim that what now seems like a "push" technology would, in the future, transform into its "pull" variation (here: a "post-Pasteurian" future where antibiotics are seen as undesirable).[131] What he believed, then, was that biomimics should keep championing the imitation of life for innovation, for the future value of ecologically "coherent" products would ultimately, gradually reveal itself.

Anticipation toward the future is an ambivalent *pharmakon*, and what to Tim was reminiscent of deferral looked more like deference to me as I watched how the pragmatic stance encouraged biomimics to circumvent the ideals of truth in favor of conveniences of expediency, explicating biological function in whatever manner was advantageous. The vow of biomimicry is to re-vitalize innovation, in the dual sense that it, first, transforms innovation by, second, copying the vital functions of the living. As I have shown in this chapter, however, the "nature" that is oft evoked is, in Donna Haraway's words, a "nature of no nature"[132]—a husk of a category without a relation of referentiality to how organisms function. By subordinating biomimicry to a consulting practice where "amateur naturalism" outweighs the back-and-forth of scientific investigation, the meta-design method of biomimicry thinking allows corporations to enact the outward appearance of mimeticism to nature. This act of deference engenders a double mystification. Not only does a focus on "nature" divert attention from political economic structures—as "culture" did in human-centered design—but it also obscures that there never was any nature within nature-based design. "Likenesses" to life proliferate while life further and further recedes into the background. Instead of aligning with nonhuman, ecological metrics of fit, or value, biomimics in the pragmatic stance

[131] Heather Paxson, "Post-Pasteurian Cultures: The Microbiopolitics of Raw-Milk Cheese in the United States," *Cultural Anthropology* 23.1 (2008): 15-47.
[132] Donna Haraway, "Mice into Wormholes: A Comment on the Nature of No Nature," in *Cyborgs and Citadels: Anthropological Interventions in Emerging Sciences and Technologies*, eds. Gary Lee Downey and Joseph DUmit (Santa Fe: School of American Research Press, 1997), 209-243.

merely capitulate to traditional, financial regimes of value, the mirror image of the mimetic ethic. In Chapter Two, I attune to their ethical demands to understand why its implementation is utopic.

2

Design from the "Native's" Point of View: On the Anthropology of Nature Understanding

On a warm spring afternoon in New York City, I met Julia at the Brooklyn Botanical Gardens.[1] Julia was an "biomimicry consultant" who had founded her own firm. When I contacted Julia, she requested that we convene outside because she was "partial to meetings in parks or gardens."

Biomimics often suggested that we conduct our interviews within botanical gardens. Since their origins as biological collections of far-flung flora, botanical gardens have spatially realized the economic and political value of botany. Globally sourced, systematically arranged, and meticulously tended, botanical gardens are cultivated landscapes that root empire in plants.[2] Grand exemplars of the imperial tradition, the Kew Gardens in London and the *Jardin du Roi* in Paris were more than aesthetic spectacle for the aristocratic elite who walked their paths.[3] In their material organization, they re-presented scientific knowledge about the colonies and consolidated national power by breeding crops to be used for agriculture at home and abroad. Historians and anthropologies have argued that these spaces exhibit and stage idealized moral relations between people and plants—an architectural model for valid forms of social action.[4]

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[1] "Julia" is a pseudonym. I have intentionally kept any identifying information to a minimum.
[2] David Philip Miller and Peter Hanns Reill, *Visions of Empire: Voyages, Botany, and Representations of Nature* (Cambridge: Cambridge University Press, 2011); Londa Schiebinger and Claudia Swan, *Colonial Botany: Science, Commerce, and Politics in the Early Modern World* (Philadelphia: University of Pennsylvania Press, 2007).
[3] Lucile Brockway, *Science and Colonial Expansion: The Role of the British Royal Botanic Gardens* (New Haven: Yale University Press, 2002); E.C. Sparry, *Utopia's Garden: French Natural History from Old Regime to Revolution* (Chicago: University of Chicago Press, 2000).
[4] Natasha Myers, "From Edenic Apocalypse to Gardens against Eden: Plants and People in and after the Anthropocene," in Kregg Hetherington, ed., *Infrastructure, Environment, and Life in the Anthropocene* (Durham: Duke University Press, 2019).

More than once, I heard botanical gardens, as well as zoos and aquaria, described literally, as "sourcebooks" or "encyclopedias" of biological design principles—a re-spatialization of the "book of life" metaphor that 20th century biologists drew upon to comprehend the gene. If, as Richard Doyle writes, the literary metaphors of genetic science "transfers the reading practice out of the double helix and into the lab," then in biomimicry, it relocates from the lab to the field, to the ordered space of the botanical garden.[5] And, if, as Clifford Geertz once stated, culture is an "acted document" and ethnography "like trying to read […] a manuscript," then the ethnographic account I provide here is a reading of a reading (practice).[6] What pages did Julia highlight? What passages did she skim over? And how was her reading in-formed, intertextually, by *Biomimicry*? By asking how biomimics like Julia "read" nature, I aim to get a sense for the phenomenology of "amateur naturalism." With Timothy Ingold's maxim that "knowledge is movement" as my walking stick, I probe how understandings of nature in biomimicry are made on foot.[7] As I heed the duration of Julia's attention, the cadence of our transit, and the direction of her gaze, I offer a "rhythmanalysis" of environmental perception to attune to the tempos of biological inspiration.[8]

To biomimics, gardens cross-pollinate the economic and political with the physical and ethical—a condensed topography of "life's genius" that biomimics explore for inspiration into sustainable innovations. In Chapter One, Tim confessed that "nature walks" prime him for "design thinking." As I learned by walking the Brooklyn Botanical Gardens with Julia, "nature walks" are more than epistemological. They are avenues by which biomimics, often travelling in the company of other biomimics, learn and reinforce a set of sensory and affective dispositions to

[5] Richard Doyle, *Wetwares: Experiments in Postvital Living* (Minneapolis: University of Minnesota Press, 2003), 62.
[6] Clifford Geertz, "Thick Description: Toward an Interpretive Theory of Culture," in *The Interpretation of Cultures* (New York: Basic Books, 2000[1973]), 10.
[7] Tim Ingold, *Being Alive: Essays on Movement, Knowledge, and Description* (New York: Taylor & Francis, 2011).
[8] Henri Lefebvre, *Rhythmanalysis: Space, Time, and Everyday Life* (London: Bloomsbury, 2013[1992]).

nature, specifically a sense of "wonder." The anthropologist Tulasi Srinivas theorizes wonder as a mode of resistance to modernity.[9] So too for biomimics, for whom wonder, as Heidi and Dayna Baumeister told me, serves to "reconnect" alienated "Westerners" to a state of natural harmony. In this interlude, I "go along" with Julia, strolling the garden to ask about wonder in biomimicry, specifically how notions of "premodern" i/Indigeneity structure the nature(s) that elicit wonder.[10] As I discovered, romantic tropes of Indigenous phenomenologies informed how Julia understood biomimicry's modes of sensation. While my narrative centers on Julia, I would hear similar ideas from other biomimics throughout my fieldwork—a regularity I attribute to the anthropology of design that Janine Benyus put to paper in *Biomimicry* and reinforced with immersive workshops.

In step with Julia, my guide, I proceeded down the path along to the first section of the garden, the Osborne Garden: a large grassy lawn framed by a florid halo of blooming wisterias, crabapples, and cherry blossoms—a panorama of pink and purple. Stunned by the beauty that I found in this Italianate landscape, I paused to take a photograph. Julia, however, pressed onward in ambulant indifference to the manicured grounds. A near-distant sign signaled her destination: the Native Flora Garden, a portion of the park artificially contrived to resemble the indigenous "wilderness" of New York City's botanical history—horti-culture masquerading as horti-nature. Living recreations of a forest, a meadow, a bog, and a pine barren—nature ordered—fascinated Julia with their intimations of Nature's Order. The Osborne Garden, which made no pretenses about its artificiality, had not impressed, even though, strictly speaking, both had been designed.

After a jog, I caught up to Julia. "Do you see that over there?" she asked, pointing to

[9] Tulasi Srinivas, *The Cow in the Elevator: An Anthropology of Wonder* (Durham: Duke University Press, 2018).
[10] Margarethe Kusenbach, "Street Phenomenology: The Go-Along as Ethnographic Research Tool," *Ethnography* 4.3 (2003): 455-485.

the ground. Out of a blanket of decomposing leaves and branches, a thick chartreuse stalk with a base of flat green leaves had grown skyward. I confirmed our shared view, but I confessed that I knew nothing about it. "That's a skunk cabbage," she said, halting, then turning to face the plant. Halfway up the stalk, the outer layer split to form a protective hood around the three sides of the central flower (like the slightly cupped Windsor wave if frozen mid-gesture). Julia explained that the skunk cabbage was endothermic, which meant that it generated its own heat. At winter's end, the heat melts the surrounding ice and allowed the flower to rise up—a sign of "nature's design" and a sure sign of spring, if one had not already been alerted (assaulted) by its eponymous odor.

We resumed our walk, only to pause again not a few paces down the path, next to a white fungal protrusion growing out of the duff. With its distinct brown cap, the likeness to a phallus was unavoidable, and stimulated a perfunctory joke. Where the naturalist Linnaeus had called the plant *Phallus impudicus* ("shameful phallus"), I learned that this mushroom now took the name of the "stinkhorn," so-called for its stench of rotten carrion. Julia told me she found great inspiration in this noisome organism, and not just for the geometricity of its fruiting body, which cages the cap within a netting in some stinkhorn species, or for its awfully repugnant odor.

What inspired Julia about the stinkhorn was its ecologies. "I began with the badger," she told me, explaining the history of a project that she had worked on previously. As she dug into the scientific literature, she discovered that stinkhorns appear with great frequency around badger setts, their networked dens. Coincidentally, this is where badgers tend to die, leaving an accumulation of organic material for flies to feast upon in their wake. Stinkhorns grow next to the netts to seduce the necrophagic insects feeding nearby with their own deathly perfume. The flies transport the mushroom's spores upon consuming the flesh of the stinkhorn, allowing it to propagate elsewhere. In turn, the mushroom redoubles the aromatic gravity of the space: drawing

more flies, ensuring the rapid decomposition of pestilent bodies, and slowing the transmission of disease. I tried to badger Julia about the biological design principles that she had derived from stinkhorns, but before I could ask, she had already embarked toward our next stop along the trail.

Skunk cabbage and stinkhorns were not the only forms of plant life that would attract and distract Julia along our garden walk, enticing her away from our conversation like bees to flowers—an irony, considering their widely-regarded repulsiveness. Much as I tried to complete my mini-checklist of semi-structured questions, Julia would invariably pivot backward (or forward) to our multispecies milieux—to the pitch pines, which required heat to blossom; to the hemlocks, which once dotted the Eastern Seaboard; and to conelets on the ground beneath us, which, Julia told me, were younger cones. To Julia, I was a student, and a bad one at that, an urbanite unlearned in the lessons of life's genius. My distanced anthropological interest in her training as a biomimic, her career, and her ambitions were distractions to the life that surrounded us, a nonhuman world brimming with untold technical insights. The garden was not merely the location of our interview, a backdrop for the exchange of information, but was more importantly the content and the form of the biological knowledge that she wanted to communicate to me.

Julia suggested we cross over the road and continue our conversation in Prospect Park. We found our entrance into the park through a grove of trees that Julia identified as chestnuts. "Have you read the book *Mannahatta*?" she asked me. She reported that the thicket under which we stood used to be much more common. This was before a fungal blight ravaged the indigenous population of American chestnuts in the early 20th century. In recent years, park officials had initiated an experiment to repopulate the state with these prized fruiting trees, in what Julia called "untouched," "wild" areas of the park where they could be left to regrow in strength and number.

Julia celebrated this "return" to "indigenous" natures. At the time, this struck me as odd. Notwithstanding that "wilderness," by definition, cannot be re-grown, her characterization of the landscape as "untouched" effaced the Lenape people who, according *Mannahatta*'s author, Eric Sanderson, grew corn, beans, and squash. In her perception of the land, the cultivated indigeneity of the chestnut tree masked Indigenous cultivation. Later, her statement seemed even more odd. These very same chestnut trees at Prospect Park harbored among their ranks a variant that a team of geneticists at the State University of New York had genetically modified to withstand blight. What Julia had praised as "indigenous" was, in fact, the technological product of a laboratory.

Had Julia known, I am sure she would have protested this hybrid of nature and artifice. When I mentioned that I was interested in how biomimicry related to biotechnology, she stated that she found the latter "creepy." Nature was already "well adapted," unlike biotechnology, its "maladapted" inverse. Perhaps, she mused, this adaptive imbalance might have something to do with the higher percentage of men working within the field of biotechnology—a reflection that drew from long-standing Western affinities and dichotomies of male/culture and female/nature.[11]

After a pause to glance around, Julia split from the forelain path and took a few steps across the dirt to the wide trunk of a nearby chestnut. "You can't tell from sight alone," Julia said, with one hand stroking the plant, palpating the secrets of its hidden interior, "but this tree is different from all the others." She traced her fingers along the bark's ridges. For Julia, sight alone could not sufficiently differentiate it from the adjacent trees. "You have to engage all of your senses. Listen to the tree. Smell it. Touch it." She turned back to me, with a smile, "But avoid tasting it unless you're certain about it." Julia craned her neck upward to scan the tree canopy. "Can you hear that?" she asked me. I became aware of birds chirping above us. Julia

[11] On the gender of nature in biomimicry and Western culture in general, see footnote 114 in the Introduction.

told me that the birds we were listening to had become louder with the intensification of the urban soundscape, an adaptation to their entanglement with humans and the noise of the city. This co-evolution concerned Julia. She would have preferred that the birds remain "natural."

Out of the wooden glade of "untouched" chestnuts, we traversed a grass lawn and proceeded toward a chain-link fence. At its impasse, Julia again broke path through a tear in the woven metal. Her errancy, I realized, was not just spatial, but discursive too. Julia strayed from our interview to an expression of alarm about the empty can of beer she spotted on the ground. Julia carries a reusable canvas bag to pick up any trash she finds on her walks. Even though the park employs a janitorial crew, she feels a sense of responsibility to collect whatever garbage she may find in the park. Without a bag, Julia held the can for the duration of our walk, as well as a discarded plastic six-pack ring she discovered next—Mary Douglas's "matter out of place."[12]

On the other side of the fence, we rejoined a trail—whether *the* trail or *a* trail, I cannot say with certainty—and our interview. Twice, I tried to solicit biographical background from Julia. Twice, she diverted my questions to attend to more proximal concerns: first, to a turtle in the lily-pad laden pond nearby, or, rather to bubbles at its surface, from which Julia inferred the presence of the water-dwelling lizard. These turtles, she noted, had unparalleled respiratory capacities, and could remain buried in the mud for up to six months—expiration as inspiration.

I leveraged the charisma of the turtle to ask Julia whether she had any pets as a child. She replied that she had kept "pets that weren't pets," meaning that she spent her childhood, "in the wild," where she would regularly visit her own private menagerie of undomesticated animals. Her youthful sentiment for animals motivated an early interest in primatology but was displaced during her undergraduate training in sociology. "From ethology to ethnology," I joked. While

[12] Mary Douglas, *Purity and Danger* (New York: Routledge, 2003[1966]).

working in marketing research, Julia became disillusioned by the lack of appreciation for the "histories" of technologies. Ecosystems, she countered, have nothing but histories, functions, and interconnectedness. At that moment, Julia realized the need for a language and perspective within which to articulate this immense source of "value." After reading *Biomimicry*, she chose to pursue a master's. "You could say I'm something of a primatologist once again," Julia said. She shared her dream with me of visiting the Congo to study bonobos. "I want to become a child again," she added dreamily, "to grow backwards, to grow back, to grow behind"—to "wonder."

No sooner had Julia made her wistful remark about anti-development than another organism distracted her from our dialogue. A witness to a flurry of cherry blossoms that twirled and danced around a couple nearby, Julia stopped our walk. Moved to remark on their "beauty," she said their outward appearance reflected the self-sacrificial use of energy the plant had made. Julia told me that cherry blossoms, along with magnolias and pussy willows, devote themselves to a short period, a few weeks in length, of flower production. This could be a potential model for our infrastructures of water, she added: syncopated bursts of water and energy that would align our technological habits with the natural cycles of the earth and avoid over-consumption.

We resumed our walk, along a foot path where urban denizens, similarly eager to embrace the warmth of the day, were out in numbers: pushing strollers, jogging, and cycling. Enframing the busy thoroughfare were an even row of arboreal columns, colossal oaks that had just begun to regrow their leaves. Julia asked if I had seen Disney's animated film *Pocahantas*, specifically the scene during which the "oak tree" speaks with and "hugs" the titular heroine. I replied that I had, ages ago, and queried what made her ask this question. She responded that, whenever on this path, she fantasized that she was like Pocahantas, fluent in all the "Colors of the Wind"—a reference to the film's famous song, performed by the singer Vanessa Williams.

Julia began to sing the lyrics, "But I know every rock and tree and creature / has a life, has a spirit, has a name." This song, she said, clarified "what it is like" to do biomimicry, where knowledge of nature—names, features, functions—accords the knower quasi-mystical power.

The "oak tree" Julia referenced was a willow named "Grandmother Willow," a four-hundred-year-old talking tree and matriarchal figure, represented by a wizened and smiling face on cracked teal bark that physiognomically and anthropomorphically embodies dominant Western tropes of Mother Nature. Drawing on long-standing cultural tropes about age and sagacity, gender and nature, and Indigeneity and spirituality, Grandmother Willow serves as an elder guide to Pocahantas as she mediates between the Virginia Company, an emblem of English colonialism, and her own Powhatan people of Tsenacommacah (eastern Virginia, in settler nomenclature). In Disney's narrative re-telling, the conflict ends with peaceful resolution, but *Pocahantas* is an amnesic fable of a deadly confrontation that, in reality, never ended. Instead, it endured in countless forms of structural and symbolic violence against Native or Indigenous peoples in North America. As a tree of life, Grandmother Willow instructs Pocahantas to tap into the generational wisdom of her cultural heritage: a phenomenology of epistemic and ethical intimacy with the natural world. By listening to life, the "spirits of the earth," Pocahantas enacts Indigenous personhood, at least as imagined in American fantasies of the "Ecological Indian."

Informed by the romanticized discourses of Indigeneity that Benyus articulated in *Biomimicry* (Interlude One), Julia invoked *Pocahantas* and its fictional cast as a dramatic *meta*-discourse about the phenomenology of wonder and the praxis of "reconnection" in biomimicry. In other words, she redeployed Benyus's tropes to depict the nature of her nature understanding by relying on an anthropological distinction between "Western" and "indigenous" subjectivities.

In this factitious sensorium, the biomimic, like the Indigene, is fully attuned to the "wonders" of nature, in contrast to, and excess of, the attenuated sensory regimes of the modern "Westerner," i.e. the figure of *Homo industrialis*. Julia posed biomimicry as an indigenized phenomenology, one based within settler colonial imaginaries of ecologically harmonious Indigenous lifeworlds. Related to what Sachi Sekimoto terms the "sensory apparatus of race," biomimicry depends upon rhetorics of Indigenous senses that might be rephrased as the *sensory apparatus of Indigeneity.*[13]

In anthropology, perspectival speculation about how the Other feels dates back to the discipline's 19th century origins. E.B. Tylor's psychological interpretation of animistic religion, which he defined as the "belief in Spiritual Beings," equated theology and belief.[14] As Stanley Tambiah recounts, "Tylor 'imagined' himself into the savage's mental condition and deduced that the first animistic projections were the doctrines of the soul and spirit."[15] When Julia equated imagined Indigenous phenomenologies with biomimicry, she presumed to know "how natives think, feel, and perceive."[16] Not just "playing Indian," she felt that she perceives "Indian," too.

In his essay "From the Native's Point of View': On the Nature of Anthropological Understanding," Clifford Geertz dispelled this assumption that *verstehen* requires "extraordinary sensibility," "psychological closeness," 'transcultural identification," or "communion," instead framing "anthropological understanding" as a "continuous dialectical tacking between the most local of local detail and the most global of global structure in such a way as to bring them into

[13] Sachi Sekimoto, "Race and the Senses: Toward Articulating the Sensory Apparatus of Race," *Critical Philosophy of Race* 6.1 (2018): 82-100. See also Erica Fretwell, *Sensory Experiments: Psychophysics, Race, and the Aesthetics of Feeling* (Durham: Duke University Press, 2020).
[14] Tylor, *Primitive Culture*, 424. On Tylor's psychology of religion, see Webb Keane, *Christian Moderns: Freedom and Fetish in the Mission Encounter* (Berkeley: University of California, 2007).
[15] Stanley Tambiah, *Magic, Science, Religion and the Scope of Rationality* (Cambridge: Cambridge University Press, 1990), 48. Compare with E.E. Evans-Pritchard's "What if I were a horse?" critique of Tylor in *Theories of Primitive Religion* (Oxford: Oxford University Press, 1968).
[16] Geertz, "On the 'Native Point of View'," in Clifford Geertz, *Local Knowledge: Further Essays in Interpretive Anthropology* (New York: Basic Books, 2000[1983]).

simultaneous view."[17] Biomimics like Julia, however, have revived this pernicious assumption by imagining that they have intersubjective access to design from the "Native's" point of view, one which reflexively constrains how they grasp their sensory, affective, and ethical dispositions. In the next chapter, I revisit these dispositions. The figure of *Homo mimesis* is never far behind.

[17] *Ibid*, 56, 56, 56, 70, 69.

II

A Mimetic Ethic: Designing Third Nature from Barragán down the Río Bobos

In Mexico City, nothing but a white gate partitions the streets of Ampliación Daniel Garza, a middle-class *colonia*, or neighborhood, from the private gardens of Casa Estudio Barragán—a white sheet of metal bespotted by dust, rust, and other dregs of time. From the sidewalk, the Mexican modernist Luis Barragán's hand was restrained, even demure, next to the worn concrete walls that flanked it. This was unlike the monumental style of his idol, Le Corbusier, the French architect, who, in Frederic Jameson's estimation, "radically separate[d] the new Utopian space of the modern from the degraded and fall city fabric which it thereby explicitly repudiates."[1] The banal gate was not a statement of repudiation nor separation. It bordered on stating nothing at all.

On a balmy June morning, this pedestrian portal had been opened, inviting all us participants in the Biomimicry and Design Workshop to cross the threshold from a tranquil residential area that used to hum with the buzz of sawmills and into the lush foliage leading to the Pritzker Prize-winning architect's studio—located just opposite the street from his home. As we wandered in, wading into a dense umbra that trickled down from a thicket of trees, a meandering gravel walkway to our left cut a narrow path through the brush occluding the studio. After a few paces, the trail disappeared, reforming into gray concrete steps that descended under a gray concrete arch, beyond which, to our right, was a burst of color. There, a brilliant cobalt

[1] Frederic Jameson, *Postmodernism, or, The Cultural Logic of Late Capitalism* (Durham: Duke University Press, 1992[1989]), 40.

blue wall, the auteur's signature, intersected with a rectangular reflecting pool at a right angle. Nestled in green ivy, its waters were still, except for the play of our mirror images on its surface.

Figure 1: Chromatics

Whereas Le Corbusier's architectural modernism rejected décor and ornament for its association with cultural particularity—a Spartan style the historian Peter Galison, describing the Bauhäusler, called an "unaesthetic aesthetics"—Barragán's interpretation of the modern was less the triumph of the new over the old than it was the reformatting of the past.[2] In Barragan's mind, Mexican modernism would fuse the cosmopolitical ambitions of modernism's rectilinearity with the affective symbolism of *mexicanidad*, especially the color wheel of the hacienda vernacular—a palette that paints in *rosa mexicano*, rust red, tangerine orange, and, as I saw there, cobalt blue.

[2] Peter Galison, "Aufbau/Bauhaus: Logical Positivism and Architectural Modernism," *Critical Inquiry* 16.4 (1990): 709-752.

"Emotional architecture," Barragán believed, should induce feeling by way of "qualisigns" of heritage, evoking traditional meanings through sensual qualia—the hacienda through blueness.[3] In this way, Barragán grounded the technics of the international within the lifeworld of Mexico.[4]

Spatiality, too, afforded a second register through which Barragán recuperated history. Across his oeuvre, Barragán juxtaposed the public appearance of gates, walls, and doors with the private realities of domestic interiors choreographed through the dance of light, color, and form. Eschewing the impudence of the utopian, he favored instead the Christian art of confession: veiled spaces that, at first, mask and deflect, only gradually disclosing their inner, naked truths. "Where do you find more eroticism than in the cloister of the convent?" the Catholic mused.[5] Widely believed to be homosexual, Barragán never identified as such. Perhaps one can read in his eroticization of the cloister a kind of solipsistic solace in the concealing enclosure of the closet: a nested series of demarcations of the inside from the outside—the garden from the street, the studio from the garden—that doubled and enabled the defense of his selfhood from the intrusive, hetero-sexualizing gaze of the public eye. Barragán's was an architecture of fugitivity.

After the pool, the garden's unruly edge expanded again, consuming everything in its path but the path itself and a duo of headless male statues, immodest and without legs. When it contracted at last to a clearing, we had arrived at the studio: a weathered gray concrete rectangle, with a case of stone stairs to the left, a middling white picture window, and a recess to the right.

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[3] On "qualisigns," see Charles Peirce, *Peirce on Signs: Writings on Semiotic* (Chapel Hill: University of North Carolina Press, 1991); Nancy Munn, *The Fame of Gawa: A Symbolic Study of Value Transformation in a Massim Society* (Durham: Duke University Press, 1986); Richard Parmentier, *Signs in Society: Studies in Semiotic Anthropology* (Bloomington: Indiana University Press, 1994); and Nicholas Harkness, "The Pragmatics of Qualia in Practice," *Annual Review in Anthropology* 44 (2015): 573-589.

[4] It should be noted that, as an upper-class, white, and educated man, Barragán's lifeworld was not universal.

[5] On the fraught relations of truth and sexuality, see Michel Foucault, *The History of Sexuality, Vol. 1: An Introduction* (Vintage: New York, 1994[1976]); Eve Kosofsky Sedgwick, *Epistemology of the Closet* (Berkeley: University of California Press, 2008[1990]); and Judith Butler, *Gender Trouble: Feminism and the Subversion of Identity* (London: Routledge, 1990).

In front of the building, a group of international attendees had gathered for this orientation day: Grecia, a graphic designer from Puebla, greeted Simon, a permaculturist from Johannesburg, who, in turn, shook hands with Adam, an American middle school teacher working in Dubai. Behind the window, Raúl, Delfín, and Ana Gabriela, the workshop leaders, were lining black chairs up in rows and preparing snacks: coffee, bananas, and *alegría* (amaranth-chocolate bars).

Figure 2: Erotics

When they finished, they called us in, inviting us to take our refreshments and listen while they reviewed the purpose and itinerary of our ensuing trip. Raúl walked behind the desk that anchored the front of the room. He thanked us, revealing a slight lateral lisp in his voice and smiling briefly, with a quiet and humble warmth. Wearing a starched blue shirt and grey pants, Raúl was a serious and eloquent middle-aged man who appeared to me to be dressed the part of a buttoned-down architect. Despite his traditional look, Raúl held wide fame as a forward-thinking practitioner whose use of bamboo—his material, medium, and muse—had altered the practice of sustainable architecture, both as a principal of his own design studio in the upscale neighborhood of San Angel, and as a professor of architecture at Universidad Iberoamericana. After I had told

Peter (Chapter One) of my intent to attend this workshop, he insisted that I convey his regards to Raúl, noting how "impressive" he found his work ("well, except for that Leonardo DiCaprio project," he added, chuckling). When I first met Raúl during my fieldwork in Mexico City over the summer of 2017, he had been organizing biomimicry workshops for over 10 years through Biomimicry Mexico, which he founded after inaugurating the first one in 2006 and for which he still served as president. Raúl clicked a remote control in his hand, starting a slideshow as Delfín and Ana Gabriela passed around white, spiral-bound training manuals for this training workshop.

Figure 3: Estudio Barragán

"Like a drop of water," Raúl said, we (the workshop attendees) would rain down from the summit of Cofre de Perote, a dormant volcano in the state of Veracruz, to the Atlantic Ocean, traversing a watershed transecting ten ecosystems, from desert xeric shrub to coastal mangroves. As Raúl spoke, his undulating hand sketched a sloping curve—downward, or, rather, seaward. "Nature is about flows and the exchange of things," he said of our coastbound peregrination. By retracing the circulation of water, he suggested, we would arrive at an understanding of life's conditions as they manifest across the biological corridor formed by the outflowing Bobos River.

Talloguaya, a bamboo camp Raúl built in the rainforest, would be our home for the trek—a remote haven "with no noise, no electricity" and "no cellphones." Faced with "just the forest," we could commune in "close relation with nature." After warning us of all the dangers awaiting us, a not small list of mosquitos, spiders, snakes, and poisonous plants, Raúl cautioned: "We are the beings invited to this place. We don't own it. We are guests." Thrown into the wild, we could "open [our] minds, souls, eyes, ears, [and] senses to the experience." If we "sit together and admire" nature, "not saying something, but listening," we could become better "designers."

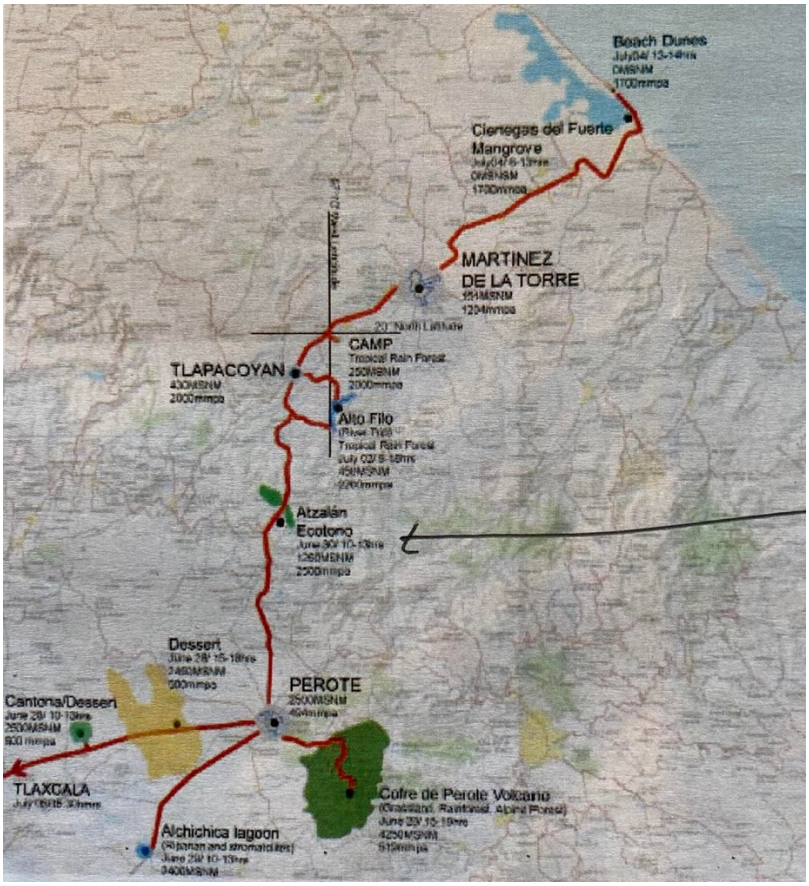

Figure 4: Our Flow[6]

To feel out, in a visceral, immediate way, what it meant to "listen to nature," Raúl beckoned us outside, where we retreated, re-arranging on our walk from four rows into a circle.

[6] Map courtesy of Biomimicry México.

As the sound of footsteps subsided, and the dust clouds of dragged soles settled, we all looked to Raúl. He entreated us to shut our eyes and direct our attention to our other senses—to the influx of stimuli that continuously impress upon us from without, from the ecologies of life around us. Any whispered chatter quickly dissipated from our ambient soundscape, replaced only by the crunching gravel of nervous shuffles, the stirring of plants from the wind, and a distant car horn.

Raúl asked us to heed the warmth of the sun on our bare skin, which intensified the longer we stood still. "Listening to nature" exceeded aurality to Raul; it was a synecdoche for sensation itself. After ten minutes of meditative reverie, interrupted by the surreptitious meeting of peeking eyes, our workshop leader spoke to say that biomimicry was about more than design. It was about "growing our state of being." To reach this "state of being," we would "need to develop these capabilities of listening" to help us realize that "the locus of control is inside us." Standing outside a cultural landmark of modernism, Raúl averred that the "genius" of the natural landscape would only reveal itself to our minds if we worked to retune our "modern" sensorium.

Figure 5: (R)eorientation Day[7]

[7] Photograph courtesy of Simon Inglis.

We withdrew back to Barragán's studio. I questioned Raúl about his reasoning for commencing the workshop at Casa Estudio Barragán, a modernist shrine. He paused, pensively. He told me that Barragán's construction of the space was "exceptional," so "precise" in its composition of light and shadow, shape and affect. He found that fact inspiring for his projects. But what Barragán ignored, in his opinion, was the "nature" of space—not "space"[8] in the abstract but built space as ecological. For Raúl, the sensuousness of space that Barragán framed as a forgotten dimension of design meant more than mere cultural heritage; through sense, we admit an embodied bond to life's genius, one we should heed, he held, in sustainable innovation. From Raúl's perspective as an architect, "modern" design—Le Corbusier's International Style *and* Barragán's Mexican modernism—was sensuously insensitive to its biological milieu. To the contrary, the mimetic ethic of biomimicry, he felt, instilled bodily "capabilities," or dispositions, toward other living organisms—a corporeal kinship that the anthropologist Kath Weston labelled "intimacy."[9] Through intimacy with nonhumans, Raúl hoped to "reconnect" humanity to nature.

Not unlike Barragán's interiorization, our subsequent journey to Talloguaya (some 200 miles away from our origin in Mexico City) was also seen by Raùl as fugitive—an escape, not from identification, but from "modern" distractions of city noise, electricity, and cellphones. Through this immersive workshop, we would enter what Raúl called a "close relation to nature." As I trekked with these biomimics down the watershed for seven days, "listening to nature," I came to see our forest pilgrimage as a retreat into the self, not unlike Barragán's—a motion toward solitude that the ancient Greeks knew as *anachoresis* and a notion of inwardness that the

[8] Adrian Forty, *Words and Buildings: A Vocabulary of Modern Architecture* (London: Thames & Hudson, 2000), esp. "Space."
[9] Kath Weston, *Animate Planet: Making Visceral Sense of Living in a High-Tech Ecologically Damaged Planet* (Durham: Duke University Press, 2017).

Stoics later spiritualized, and the Jesuits ritualized.[10] Yet, if, for Barragán, the territorialization of the self resulted in its inaccessibility, its impenetrability at its moment of monastic individuality, Raúl anticipated the opposite of our remote excursion: as he said, an "open[ing]" of our "minds" and "souls"—our selves—to life. Contra Barragán's contracted self, Raúl sought its expansion.

Whereas Chapter One examined biomimicry's immersive workshop genre as an epistemological space for the (de)coupling of "nature" and "artifice" through design principles, the present chapter pivots from the formation of knowledge to the transformation of subjectivity. As I traveled the Bobos with Raúl, Delfín, and Ana Gabriela, I came to understand the workshop as a "mobile"[11] site of moral "self-fashioning"[12]—i.e. of "growing our state of being." As I show in this chapter, the mimetic practice of biomimicry entails more than a meta-design method. It is, also, a demand for a mode of subjectivity that Ana Gabriela would soon term the *ecological self*: an art of existence wherein self-negation mediates a sensuous orientation to nonhuman lifeforms.

Fleeing from the city and the distractions of "modernity," these biomimics strived to cultivate an ecological self via introspective exercises aimed at reforming their sensorial relation to nature. To design mimetic artifacts with fidelity to "life," Raúl, Delfín, and Ana Gabriela believed that biomimics had to first identify interior traces of anthropocentric intents, which were variously parsed as "cleverness" or "thought-ing." These intrusions of the self were considered to be impediments to "listening to nature"—to truly sensing life's functions, not just, as Tim said in Chapter One, taking "what works." In what I will characterize as the *idealistic stance*, biomimics

[10] Michel Foucault, *Technologies of the Self: A Seminar with Michel Foucault* (Burlington: University of Vermont, 1988).
[11] Cf. Clapperton Chakanetsa Mavhunga, *The Mobile Workshop: The Tsetse Fly and African Knowledge Production* (Cambridge: MIT Press, 2018).
[12] On the production of subjectivity, see Foucault, *Technologies of the Self*. On "self-fashioning" specifically, please refer to Stephen Greenblatt, *Renaissance Self-Fashioning: From More to Shakespeare* (Chicago: University of Chicago Press, 1980); Mario Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago: University of Chicago, 1994); and Joseph Dumit, *Picturing Personhood: Brain Scans and Biomedical Identity* (Princeton: Princeton University Press, 2004).

aspire to inhabit a bodily state of intentional un-intentionality, grounding the epistemology of life in a relationship to the self. Following Michel Foucault, I understand this "relation to oneself" as an ethic, as *the* mimetic ethic.[13] For Foucault, the subject constitutes the self through a relation to "desire as an ethical problem."[14] Here, I offer an anthropology of "design" as an ethical problem.

"A designer is a cunning plotter laying his traps," wrote Vilém Flusser, negatively explicating the word "design" as "intention, plan, intent, aim, scheme, plot, motif."[15] Indeed, for Raùl, Delfín, and Ana Gabriela, it is the intentional subject of "modern" design, its willfulness, that they vilify as the author of all manner of ecological crisis—a subject who substitutes artifice, human "cleverness," for nature's design logic. If, as Raúl would later say, "design is our relation to nature," then a "respectful" relation to nature—a "considerative" ethos—required biomimics to problematize design, their intentions, through inward self-examination. With theories of sense, soma, and self, I detail the ideational dimensions of the moral phenomenology of biomimicry—a meta-design practice in which sensory experience becomes a vehicle for ethical subjectivization. Whereas anthropologists and other scholars of design have theorized intention as the quiddity of design as social action, biomimics moralize intentionality, trussing its absence to the "good life."

By virtue of the mimetic ethic, biomimics hope to forge a new "relation" with nature, predicating the epistemic and technical on the somatic and affective. In this chapter, I attend to this "nature" in its material and imaginative dimensions, querying how human (moral selves) and nonhuman (natural ecologies) are coproduced in *third nature*—nature remade through artifice

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[13] Michel Foucault, "On the Genealogy of Ethics: An Overview of Work in Progress," in *The Foucault Reader*, ed. Paul Rabinow (New York: Vintage Books: 1984), 340-372, 355.
[14] Foucault, "On the Genealogy of Ethics," 351. Foucault's interest, of course, was in a particular kind of subject, one that he traces from Greco-Roman paganism through Western Christianity. Recognizing that a relation to the self as the basis of ethics is a culturally specific understanding of morality, I nonetheless draw on his theorization of ethics because biomimics themselves understand ethics through the self, *as* a relation to the self, specifically by reference to intentionality, which I describe below.
[15] Vilem Flusser, "About the Word *Design*," in *The Shape of Things* (London: Reaktion Books, 1999[1993]), 17.

made in life's likeness. Where first nature refers to "untouched" environment, and second nature, to those environments transformed by industry, third nature points to second natures designed in first nature's image. As a function of social laws about natural laws, third nature depends on how human agents, biomimics among them, culturally imagine first nature, or, in their terms: "place."

As I trailed Raúl, Delfín, and Ana Gabriela into the rainforest, I began to sense that nature—the first nature biomimics imitated—was not a human space, "modern" or Indigenous, for these urban, non-Indigenous, and educated professionals (an architect, an urban designer, and a sustainability consultant). During our expedition, essentialisms about the aesthetics, ontologies, and phenomenologies of two Pre-Columbian civilizations native to Mexico, the Olmecs and the Totanacs, were romanticized as an inspiration for biomimicry and a reference for "what it is like" to be a biomimic (see interludes one and two). Contemporary Indigenous persons were, however, conspicuously absent from their accounting of nature, fully erased from the landscapes, or worse, implicated in its ruination as agents of extractive capitalism. Contrary to logics of conservation, Raúl stressed that "regeneration," his philosophy of design, acknowledged the historical agencies of nature, admitting an evolutionism to the environment; temporality was not, however, extended to the Indigenous persons who lived within, and worked upon, the land we crossed in our travels.

A cultural ideology of design—who can design and who cannot—thus pervaded the construction of third nature. While non-Indigenous biomimics with a "considerative" attitude could study the land and imitate it in third nature, Indigenous persons were frozen in the past as inspiration to their anti-"modern" design aesthetic, denounced as rapacious consumers of natural resources, or relegated to positions of service in this vision of third nature: cooking, running eco-tourism ventures around Talloguaya, etc. Within the production of human and nonhuman in third nature, Indigenous persons were "supplementary," included in neither the moral communities of

ecological selves nor in the ecologies transformed, but stationed someplace external, maintaining the material-semiotic integrity of the structure as rhetorical foils or laboring supports.[16] While the anthropology of the environment has brought attention to the erasure of Indigenous persons from conservationist projects, this chapter points to their continued absence in regenerative design.[17]

The order of the argument in this chapter recapitulates the itinerary of our expedition, starting with lectures and activities at Casa Estudio Barragán and "flowing" down the Río Bobos as we observed how biological functions spatially varied across ecosystems—just as our mimetic artifacts ought to change in sync with their ecological contexts. In Chapter One, I suggested that, in biomimicry, the failure to realize the mimetic ethic and the appearance of the pragmatic stance were effects of contract work. In the second chapter of the dissertation, I stake another claim for the non-space of biomimicry. Notwithstanding the im/possibility of a mental state without intent, the unmediated relationship to life that biomimics desire is anything but; there is, to the contrary, an infrastructure of intimacy required to materialize this mimetic ethic. To reside in the idealistic stance, biomimics must escape to "ecological" retreats cleansed of people and politics—sanitized natures that do not reflect the quotidian realities of "design" practice. There is, to rephrase it once more, a circumscribed space for their more-than-human sensuality—their moral phenomenology. "Going deep," as Raúl would express it, was more than mere obstacle. It was a utopian demand. To outline the contours of this demand, I begin with the epistemic grounds of the mimetic ethic.

[16] On the "supplement," see Jacques Derrida, *Of Grammatology* (Baltimore: Johns Hopkins University Press, 2016[1967]).
[17] The literature on the anthropology of conservation is vast. For a comprehensive, if dated review, see Benjamin Orlove and Stephen Brush, "Anthropology and the Conservation of Biodiversity," *Annual Review of Anthropology* 25 (1996): 329-352.

"Design is Our Relation to Nature": Moral Self-Fashioning with Self-Organization Theory

"We are part of a process of self-organization," Delfín stated, continuing the half-day introductory lesson on biomimicry that Raúl initiated. Introducing himself as an urban designer, Delfín was a spirited and spry man in his mid-30s, darting across the front of Barragan's studio as he explained this concept, his lively figure casting frenetic shadows on the screen behind him. His shirt wrinkled and untucked, Delfín appeared an unlikely pair with Raúl. Even his speech patterns, ebullient and prosaic, contrasted with Raúl's simmering cadence and poetic locution. Despite their outward differences, however, Delfín had been a chief collaborator of Raúl's since 2008, when he attended Raúl's second biomimicry workshop (there was no 2007 workshop).

Over the course of our weeklong journey, Delfín told us more about his biography. Trained in biology at Mexico City's prestigious Universidad Nacional Autónoma de México, from which he graduated in 2007, Delfín was a *chilango* (slang for a resident of Mexico City) whose father was a bureaucrat with the Instituto Mexicano del Seguro Social. Lacking career direction, Delfín spent a wayward year adrift across Europe, where he sheepishly confessed that he lived on the streets, stealing food. According to Delfín, the workshop with Raúl was a turning point in his sense of self. With biomimicry, he could re-apply his background in biology toward improving the environment and bettering humanity. Since that fateful year, Delfín has consulted with Biomimicry 3.8 as a "Biologist at the Design Table." In 2009, he enrolled in a master's in urbanism at Universidad Iberoamericana, from which he graduated in 2011. Afterwards, he was hired to lecture on sustainability at the Universidad del Medio Ambiente, a postgraduate school in Valle del Bravo. In addition to teaching, Delfín operated Bio Logica Urbana, a design studio

for public parks and gardens, and worked part-time as an educational coordinator at Isla Urbana, a non-profit dedicated to building rainwater harvesting systems for residents of Mexico City.[18]

By "self-organization," Delfín did not mean the organization of his own self, per se. What he sought to index what was the emergence of humanity from nonhumanity—of complex living systems arising from matter and energy. Delfín cited Fritjof Capra as a major influence on his thinking. Capra is a deep ecologist in the biocentric tradition of Arne Naess who reads in the systems theorists of the 20th century—among them Ludwig von Bertalanffy, James Grier Miller, Ilya Prigogine, and Humberto Maturana and Francisco Varela—a metaphysical resonance with Buddhist principles of spatial interdependence and temporal dynamism. To stress that "we are part of a process of self-organization" was for Delfín to mark physical kinship with other species.

To reinforce the point, Delfín gestured to a timeline displayed on-screen, inviting us to plot our humanist accounting of history at the scale of the universal—literally, of the universe. In the cosmogenic "calendar" to which he pointed, the Big Bang occurred on the first of January at midnight, approximately 13.8 billion years ago. Biological life, specifically the emergence of prokaryotic lifeforms, did not register till September 21st, about 3.8 billion years ago (now: 4.2). Progressing from the dawn of life to the evolution of photosynthesis, eukaryotic life, and then through the kingdoms, phyla, and classes of the most common animals and plants, Delfín finally reached the emergence of *Homo sapiens,* an event occurring "just eight seconds from midnight."

Delfín did not invent this calendar of the universe, he told us. He borrowed it from the astronomer Carl Sagan, who popularized it as a pedagogical tool to plot the universe in human timescales that he thought would be more tractable for comprehending events of cosmic nature.

[18] At the time of writing, Delfín is working at Isla Urbana full-time.

While Delfín did not invent it, he did invert it. The "Cosmic Calendar," as Sagan had named it, functioned, in Delfín's hands, to situate human life universally, minimizing human significance, and submerging the human into the vastness of the universe, in both biological and cosmic time.

How does this make you feel, he asked us. Jeremy, a Dominican-American man in his early 20s with a jet-black ponytail, gauges, and a camouflage overcoat, stood up and introduced himself as a "Dream Director" at The Future Project, a non-profit based out of New York City. There, Jeremy "coaches" high school students on "purpose-driven" community projects. Jeremy felt that the calendar reinforced how "fragile" humanity is—how "unimportant" we really are. Adam stood up next. Adam was an American schoolteacher from Michigan living and working in Dubai. He came to this workshop to learn how biomimicry could add an applied dimension to his biology lessons. He affirmed Jeremy's sentiment, "It's like we're the new kids on the block!"

Cedric, a high school student from Beirut and a biomedical engineer to-be, said that we are "at the end of the system" but "destroying the whole process." Delfín cheered, "Yes! We are not working *with* living systems. We don't think about this when we are on top, so we ignore this fact." For Delfín, self-organization implies a relation of imbrication between the human and the nonhuman that is, at the same time, an ideal of interconnection—the object of biomimicry. "We are a part of a complex process that starts with molecules. We are an entity that can create complexity." A contradiction arose: We are temporally insignificant, but ecologically significant, accelerating toward our extinction. "[Just] one second in, and we are judging the whole story," Delfín opined. "We are capable of such a large impact," he stressed. "What [are we] to do in this last second?" he implored. "This is our question. This workshop is related to this question."

In his meditation on narrative, Paul Ricoeur grounds the horizon of human action in time's coordinates.[19] Anthropologists of narrative have likewise pointed to the relation between cultural axes of time and the imagined possibilities and imperatives of moral behavior.[20] Such a perspective illuminates Delfín's reading of self-organization as not just a diagram of relatedness but a field of ethical parameters that constrains the future space of the moral duty of biomimics. For Delfín, the ontology and temporality of the human as the culmination of an extended process of becoming through self-organization points to the ethical demand of stewarding the nonhuman.

Jeremy ruminated and returned with an idea, pointing to the nonhuman timeline of life. "What works survives," he shared. "It's a test of its organization. There's such vast knowledge." Delfín lit up at his answer. "What if," he began, we did not "kill each other" but instead worked and "survived" together? What if we learned to design our technology based on this knowledge? "It's a proven fact," Delfín pronounced in his gloss on evolution, "that life has been sustainable." This posed a crucial question for Delfín: "How can we move to grasp higher levels of systems?"

The manner in which Delfín embraced scientific theories of self-organization to re-organize his own sense of moral selfhood resembled what Joseph Dumit has named "objective self-fashioning": the way that "the person…is developed through references to expert knowledge and invoked through fact."[21] Through Capra's systems theory and deep ecology, Delfín understood his "self" as having a particular nature: a biophysical affinity to nonhuman lifeforms. Likewise, his romanticization of interconnection as the basis of a designerly self resonated with what anthropologists of design have documented as aesthetic self-fashioning. In her ethnography

[19] Paul Ricoeur, *Time and Narrative* (Chicago: University of Chicago Press, 1990[1983]).
[20] See, for instance, Cheryl Mattingly, *Moral Laboratories: Family Peril and the Struggle for a Good Life* (Berkeley: University of California Press, 2014). See also her chapter "Moral Willing as Narrative Re-Envisioning" in *Toward an Anthropology of the Will*, eds. Keith Mpurphy and C. Jason Throop (Stanford: Stanford University Press, 2010), 50-68.
[21] Dumit, *Picturing Personhood*, 164.

of art students in Beijing, Lily Chumley describes the linguistic techniques of "self-styling" through which artists enact themselves within an "aesthetic community," and in his research in a design studio in England, Thomas Yarrow found that architects play up "creative individuality" in order to perform their selves as artists.[22] In Delfín's words, I read a sort of self-fashioning that was not just objective and aesthetic but moral, too—a statement about nature and design that was as descriptive as it was normative, articulating the ethical obligations built into self-organization.

Raúl joined our conversation with an unorthodox idea, "Design is our relation to nature." For many design theorists, design is opposed to nature. Consider Vilem Flusser, who figured design as nature's antithesis. To make this point, he ponders a rudimentary mechanism, the lever:

> The lever is a simple machine. Its design copies the human arm; it is an artificial arm. Its technology is probably as old as the species *homo sapiens*, perhaps even older. And this machine, this design, this art, this technology is intended to cheat gravity, to fool the laws of nature and, by means of deception, to escape our natural circumstances through the strategic exploitation of a law of nature. By means of the lever - despite our body weight - we ought to be able to raise ourselves up to touch the stars if we have to, and - thanks to the lever - if we are given the leverage, we might be able to lever the world out of its orbit. This is the design that is the basis of all culture: to deceive nature by means of technology, to replace what is natural with what is artificial and build a machine out of which there comes a god who is ourselves. The design behind all culture has to be deceptive (artful?) enough to turn mere mammals conditioned by nature into free artists.[23]

The deceptiveness of design is a consequence of substituting artifice for nature, a nomothetic *coup d'etat* that bends the letter of nature's law against itself, defying nature, deifying humanity. Like Flusser, Herbert Simon opposed the "sciences of the artificial" to the natural sciences.[24] For Raúl, another mode of design—another relation to nature—could obtain, beyond "abusing" or "defying nature," the *modus operandi* of a tradition of design that he had been calling "modern."

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[22] Lily Chumley, *Creativity Class: Art School and Culture Work in Postsocialist China* (Princeton: Princeton University Press, 2016) and Thomas Yarrow, *Architects: Portraits of a Practice* (Ithaca: Cornell University Press, 2019).
[23] Vilem Flusser, "The Lever Strikes Back," in *The Shape of Things* (London: Reaktion Books, 1999[1993]), 19.
[24] Herbert Simon, *The Sciences of the Artificial* (Cambridge: MIT Press, 1996[1968]).

He called this alternative "becoming nature." Finding this option in Sim Van der Ryn's definition of "ecological design" as the merging of the "technosphere" and the "ecosphere," Raúl interpreted biomimicry as a means to "become nature," "connect with everything," and "become one single species," in "education, the arts, industry, and politics."[25] "We need to reconcile."

Biomimicry, as the word itself implies, is predicated on the mimesis of biological life. "Emulation," however, is only one of three "pillars" that together comprise "design," as Delfín informed us, continuing Raúl's overview—the final pillar, not just one among three equivalents. Before emulation can proceed, the other pillars—"reconnection" and "ethos"—must first occur. To Delfín, reconnection (Raul's reconciliation) concerns the relation of nature and humanity. Reconnection is the recognition that the two are intertwined, not separate: "becoming nature." The purpose of our immersive trip was, therefore, to facilitate a reconnection with our environs.

In tandem with reconnection, ethos instills "respect for" and "responsibility to" other lifeforms through the intention to "do what's accurate to the world," by which he meant fidelity. Doing what is "accurate to the world" is the aim of the mimetic stance that I consider idealistic. Unlike other mimetic practices in nature-based design, biomimicry insists upon bio-centrism.[26] A functional "view of biology" (see Chapter One), informs "bio-inspired design," but only in biomimicry do the "functions" of nature become the "model, measure, and mentor" of designers. Biological function is not merely a heuristic for building, but a metric of what is right and wrong. Together, these three pillars ensure biomimicry will reproduce the "conditions conducive to life" rather than, as Francis Bacon so gruesomely phrased it, "torturing nature to reveal her secrets."[27]

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[25] Sim Van der Ryn and Stuart Cowan, *Ecological Design* (Washington, D.C.: Island Press, 1995).
[26] On "biocentrism," see Oliver BOtar and Isabel Wünsche, eds., *Biocentrism and Modernism* (London: Routledge, 2011).
[27] This particular phrase originated with Francis Bacon, *The New Organon* (Cambridge: Cambridge University Press, 2000[1620]) and was cited by Janine Benyus in *Biomimicry: Innovation Inspired by Nature* (New York: Harper Perennial, 1997). For contrasting historical interpretations, compare Evelyn Fox Keller, *Secrets of Life,*

Biomimicry is *not*, Delfín emphasized, about extracting from nature, but "learning from her."[28] But to learn from a nature that we are enmeshed in through the fact of self-organization required a re-attunement of our "modern" sensibilities—the task that occupied the rest of our orientation.

"Quieting Your Cleverness": Active Listening as a Technology of the Self

"Clear your senses," Delfín ordered from the cubic recess carved into Estudio Barragan, prefacing an activity in "active listening" that was intended to exercise what Raul had termed, moments prior, our "capacities" for "listening to nature"—capacities presently underdeveloped. "You need to open your Being to what is real as we journey from place to place," he implored. First developed by the American psychologists Carl Rogers and Richard Farson in 1957, "active" listening earns its name from the work of attuning an ear to the will of an(other)—self-(ef)facing work focused on the negation of one's will. In therapy, "our usual response," Rogers and Farson wrote, "is to try to change [the other's] way of looking at things—to get him to see his situation the way we see it or would like him to see it"—an ego-centrism.[29] "Under these circumstances," they continued, "we are usually responding to *our own* needs to see the world in certain ways."[30] Rogers and Farson therefore, invented the strategy of active listening as a tactic for silencing the listener's self in order to gain access to knowledge created *through*, and *about*, the will of an other—a self-negating "epistemic virtue" that, to Delfín, "open[s] your Being to what is real."[31]

Originally conceived as a tactic of elicitation for therapists to promote the self-expression of their clients, active listening resounded across the late 20th and early 21st centuries as an aural

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Secrets of Death: Essays on Language, Gender and Science (New York: Routledge, 1993) with Peter Pesic, "Wrestlign with Prometheus: Francis Bacon and the 'Torture' of Nature," *Isis* 90.1 (1999): 81-94.

[28] On nature as a "her," see footnote 114 in the Introduction.

[29] Carl Rogers and Richard Farson, *Active Listening* (Chicago: University of Chicago Industrial Relations Center, 1957), 5.

[30] *Ibid*.

[31] Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2010).

technique variously employed by industrial managers, group therapists, and social researchers.[32] When Delín invoked active listening as a self-facing exercise that morning, he drew upon its overlapping circulation, in "human-centered design" as well as in ecological counseling circles, but repurposed it.[33] Actively listening to one another, we would practice how to listen to nature.

Dividing into pairs, our group dispersed throughout the garden, resting on fallen logs and stone benches to undertake our dyadic task: a ten-minute "conversation" that consisted of two five-minute narratives about our respective morning. Before we split off, Delfín had commanded that we "stop [our] expressions," by which he meant the cessation of any meta-communicative cues, verbal and nonverbal, that signal to a speaker the reception of speech, including head nods, facial gestures, hand signs, hummed affirmations, and any follow-up questions and commentary. This was a curious restriction, considering that Rogers and Farson had intended for the listener to communicate their role as an "active" listener "in a way that makes it clear that he appreciates both the meaning and feeling behind what [a speaker] is saying." The anthropologist Beth Semel would categorize such public displays of interactional felicity as instances of "linguistic labor."[34] Delfín clarified that such "expressions" were outer extensions of "what your mind is doing," the nullification of which, he elaborated, was the ultimate object of our exercise in "active listening." Regardless of the problematic conventions of sincerity assumed by this language ideology, what this exercise aimed at, it became clear, was the identification and extirpation of any index of will.

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[32] For a sampling of humanistic research on Carl Rogers, see Svend Brinkman, "Changing Psychologies in the Transition from Industrial Society to Consumer Society," *History of the Human Sciences* 21.2 (2008): 85-110; Roy deCarvalho, "Otto Rank, the Rankian Circle in Philadelphia, and the Origins of Carl Rogers' Person-Centered Psychotherapy," *History of Psychology* 2.2 (1999): 132-148; Raymond Lee, "The Most Important Technique…': Carl Rogers, Hawthorne, and the Rise and Fall of Nondirective Interviewing in Sociology," *Journal of the History of the Behavioral Sciences* 47.2 (2011): 123-146.; and Benjamin Smith, "Ideologies of the Speaking Subject in the Psychotherapeutic Theory and Practice of Carl Rogers," *Journal of Linguistic Anthropology* 15.2 (2005): 258-272.
[33] See, for instance, Joanna Macy and Molly Young Brown, *Coming Back to Life: The Updated Guide to the Work that Reconnects* (Gabriola Island: New Society Publishers, 2014[1998]).
[34] Beth Semel, "Speech, Signal, Symptom: Machine Learning and the Remaking of Psychiatric Assessment," PhD diss. (Cambridge: Massachusetts Institute of Technology, 2019).

For this activity, I partnered with Jesús, a Mexico City resident who also went by the nickname Chuy, or "Chewie," as he saved it in my phone. Chuy was a sustainability educator and master's student at Universidad del Medio Ambiente, "UMA," where Delfín was a lecturer. UMA is a postgraduate institute with sustainable architecture, law, development, and agriculture programs run from its bucolic eco-campus in the affluent, mountainside town of Valle del Bravo. Chuy volunteered to go first. While he recollected how he prepared his breakfast shake, led his four dogs on a leashed walk, and traveled by public transit from Cuauhtémoc, the city's center, my attention wandered, from his day to mine, from his actions to my analysis, from the sounds of his speech to the movements of his mouth, to the tension in my body as I struggled not to reply. What became difficult, as Delfín intended to highlight, was any sustained focus on his "will." During my turn, I retraced my steps to Casa Barragán from my then-apartment in Tlatelolco, a neighborhood still remembered as the site of the 1968 massacre of university student protesters. As I spoke in short declarative sentences, I scanned Chuy's face for any sign of understanding, finding nothing in his countenance but impassivity and the demoralizing display of indifference.

When Chuy and I finished our assignment, we spent the time leftover discussing his master's curriculum in sustainability education and his gardening work with students. Delfín's voice found us through the trees, beckoning us back to the studio to reflect on the activity. Grecía commented first on the "awkward"-ness of listening rather than forming a reply, adding that she was accustomed, as an industrial designer, to probe for answers to specific problems—not listen. If, as Pierre Bourdieu has argued, we carry in our carriage unconscious, habitual dispositions, the "awkward" exceeds such embodied customs, a liminal state betwixt one "habitus" and the next.[35] Learning to inhabit this "next" state was the intended outcome of our "education of the senses,"

[35] Pierre Bourdieu, *The Logic of Practice* (Stanford: Stanford University Press, 1990).

but Grecía was not yet there, still accustomed to an "attitude of the body" that Delfín rejected: a modern attitude inclined toward the ideational and linguistic creation of answers and solutions.[36] Altering Marcel Mauss's definition of "techniques of the body," we might think of awkwardness, following Grecía's lead, as the ways in which people do *not* know how to use their bodies.[37]

Corroborating her experience, Chuy remarked that he found it difficult to listen to me because he was concerned with his own "self," and the "suppression" of the "urge" to respond. In the "somatic mode of attention" assumed by this exercise, Chuy found his self a distraction.[38] Delfín then addressed what I recognized in Chuy's comment as a critique of active listening to nature—an inability to see the forest for the me's—by reframing the challenges he and Grecía faced as the first stage of "quieting [your] cleverness." "Shutting it down," Ana Gabriela added.

Delfín's use of the word "cleverness" referred to a passage from *Biomimcry,* where Janine Benyus told of her encounter with animal architecture as an "object lesson" in the hubris of "human-centered" design: "In seeing how seamlessly animals fit into their homes, I began to see how separate we managers had become from ours. Despite the fact that we face the same physical challenges that all living beings face—the struggle for food, water, space, and shelter in a finite habitat—we were trying to meet those challenges through human cleverness alone."[39] With its connotations of skill and intelligence but also, in her phraseology, the improprieties of their excess, "cleverness" epitomized the danger of unbridled reason: a sense of being *too* clever for one's own good. Returning to the term, she concluded *Biomimicry*, "Learning from them [animals] will take only stillness on our part, a quieting of the voices of our own cleverness."[40]

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[36] Marcel Mauss, "Techniques of the Body," *Economy and Society* 2 (1973[1935]): 70-88, 71.
[37] *Ibid*, 70.
[38] Thomas Csordas, "Somatic Modes of Attention," *Cultural Anthropology* 8.2 (1993): 135-156.
[39] Benyus, *Biomimicry*, 4.
[40] *Ibid*, 297.

Benyus described the "Western" culture of cleverness in Spenglerian terms, as the collective "habits of thought" and "aesthetics" that pervade a society, which Ruth Benedict would later term a "cultural configuration."[41] Delfín and Ana Gabriela moved cleverness inward, to the individual, as a psychological phenomenon and a discernable mental event—an object of thought and, therefore, of reform. As Delfín wrapped up the conversation, he explicitly posed the suppression of the self and its cleverness as the target of habit. If we "dedicate ten minutes every day" to exercising our active listening capacities, he said we would learn to listen without the interruption of cleverness. The habitual self-scrutiny to which Delfín propelled us recalls the "hermeneutics of the self" that Michel Foucault found in Roman and Christian sexual ethics, in which the presence of desire was self-subjected to an internal system of accounting and control.[42]

Elsewhere naming this relation of the thinking subject to the self "problematization," that which "allows one to step back from this way of acting or reacting, to present it to oneself as an object of thought and to question its meaning, its conditions, and its goals," Foucault helps me to see in active listening—a simulation of listening to nature—the target of the mimetic ethic.[43] Like the sexual mores around desire in the ethics of sex Foucault describes, active listening here initiates a "relation to oneself," the fundamental ground of ethics to Foucault: a reflexivity made through practices of listening, both to the "urges" of the self and to the "will" of another subject, whether human or nonhuman. When Delfín encouraged us to devote our time to exercising this habit or capacity, he aligned active listening with Foucault's understanding of ethical action as an engaged form of self-work and "cleverness" with the language of conduct behind moral acts. It is in this sense that I grasp active listening as a "technology of the self," the spiritual exercises

[41] On "habits of thought," see Oswald Spengler, *The Decline of the West* (Oxford: Oxford University Press, 1991[1926]). On "cultural configuration," see Ruth Benedict, *Patterns of Culture* (Boston: Mariner, 2006[1934]).
[42] Foucault, "On the Genealogy of Ethics," 348.
[43] Michel Foucault, "Polemics, Politics, and Problematizations," in Rabinow, *The Foucault Reader,* 381-390, 388.

that permit "individuals to effect by their own means or with the help of others a certain number of operations on their own bodies and souls, thoughts, conduct, and way of being, so as to transform themselves in order to attain a certain state of happiness, purity, wisdom, perfection, or immortality."[44] Through the practice of active listening, Delfín foresaw a future "state of being."

"We don't need to forget what we already know," Delfín concluded, but we *do* need to pause and listen—to hold the self in abeyance in order to "change our problems and solutions." Raúl, who had been silently listening throughout the conversation, legs crossed and arms folded, at last spoke, "Sustainability is not about hugging trees. It is moving our considerative attitude." Raúl would later verbalize this deferential relationship as one of "awe," "wonder," and "respect." Sustainability, a la Raúl, concerns the cultivation of an attitude through the exercise of listening, an attitude that Rogers and Farson predicted as "the change that takes place within the listener."[45] That morning, I heard in "listening" two distinct meanings: a literal one pertaining to the ability of the ear, but also a figurative one, a relation of obeisance, as a pupil might "listen" to a teacher.

The "capabilities" we nurtured were thus sensual and epistemic, but also affective and moral, directed as much to living organisms as they were to internal feelings and states of mind. The "attitude of the body" I recall here brings to mind the union of corporeality and conduct that the anthropologist Charles Hirschkind has termed "ethical listening."[46] In his ethnographic study of Muslim believers in post-Islamic Revival Egypt, Hirschkind records how the ear has become the consecrated organ of moral self-fashioning; listeners tune in to taped sermons of preachers, synchronizing their posture and sentimentality to the divine word as they strive for a pious life.

[44] Foucault, *Technologies of the Self*, 18.
[45] Rogers and Farson, *Active Listening*, 4.
[46] Charles Hirschkind, *The Ethical Soundscape: Cassette Sermons and Islamic Counterpublics* (New York: Columbia University Press, 2006), 10.

The "moral physiology" that Hirschkind finds in the body's duality doubles the "morphology of moral actions" that Saba Mahmood outlines in her research of a women's mosque movement.[47] According to Mahmood, the repeated performance of sanctioned emotions by the devout—in prayer, persuasion, and other speech acts—culminates in the ethical transformation of the self. Drawing on Foucault's notion of technologies of the self, Mahmood deftly reveals how Maussian techniques of the body do more than discipline the flesh; they fold inside, involving—from the Latin *in* and *volvere*, a turning inward—the exterior in the constitution of the interior.

For Delfín and Raúl, the repetition of active listening cements a restrained self, habituating ways of feeling, thinking, and doing that ultimately open oneself up to life's genius. "Listening to nature" is, as biomimics saw it, never just *listening*; it is always *just* listening, in the sense that listening opens one up to possibility of enacting an attitude of respect for nature.[48] Our conversation ended, we parted for lunch and a night of rest before we applied our new skills.

"Sense of Place": "Modern" and "Pre-Columbian" Dis/orientations

The next morning, we met at the Coyoacán metro station, departing from Barrágan and the deafening "volume" of Mexico City, Raúl said, covering his ears with his hands in mock distress. For our rainforest journey, Raúl had ditched his business attire for jeans and a leather *gaucho* hat. Piling into a caravan of white Volkswagen vans, we stuttered through standstill traffic for over four hours, half of which was spent just exiting the far-reaching orbit of the metropolitan sprawl. To pass the time, Melissa, a sustainability consultant from Chiapas, waxed poetic about the food I "absolutely must try" when I returned to the capital, soulful *posoles* and bracing *aguachiles,*

[47] *Ibid,* 75. Saba Mahmood, *Politics of Piety: The Islamic Revival and the Feminist Subject* (Princeton: Princeton University Press, 2004), 25.
[48] My play on "just" is indebted to a similar move Keith Murphy makes in *Swedish Design* with respect to "just design" (Ithaca: Cornell University Press, 2015), 1.

while I stared with growling disappointment at the limpid sandwich I bought from a street cart. Outside the window, unevenly dispersed species of cacti and agave replaced the graveled streets and graffitied cinderblock homes that define the urban ecology of Mexico City's outer rim—an ecotone Raúl delineated as our transition into the xeric shrub desert, our first ecosystem of study.

We passed a sign for Puebla City. Grecía, soft-spoken, reserved, and always dressed in black, mentioned to me that she currently lives there. Originally from Veracruz herself, Grecía moved to Puebla City to study graphic design at Universidad Popular Autónoma del Estado del Puebla. Then a freelance designer, Grecía developed an interest in the environment after her father, an engineer, invited her to a conference on sustainable technologies in the chemical field. A vegetarian of nine years, Grecía was often seen hand-rolling cigarettes with "natural tobacco." She told me that, at the time of my fieldwork, she was attending meetings at a co-working space, hoping to learn about industrial design; the facilitator encouraged her to attend this workshop. (After my fieldwork, I learned that she founded a design practice for "healthy living" products). An hour north of Puebla City, we arrived at Cantona, the ruins of a 3,000-year-old Olmec city.

Raúl parked the van. Exiting the vehicle, he waved his left arm expansively, describing Cantona, reverently, as "the most spectacular archaeological site." What Cantona exhibits, he shared, is a distinct "sense of place." While only a fraction of the city that housed nearly 80,000 endures visibly, what inspires Raúl, he informed us, is the symbolic relation of architecture and cosmology, each vertical division of its pyramidal shape representing the hierarchy of earth to sky, human to divine, profane to sacred, and rural farmer to the ruling class of priest and elite. We ascended skyward along diagonal avenues that abutted mud domiciles abandoned, leveled, and overrun with opportunistic species of grass, at least reaching the zenith, where, in proximity to the star above, Raúl told us the Nahautl word for this place: *caltonal*, or "House of the Sun."

Where Barragán found in the colonial *hacienda* architecture an abiding source of inspiration, the "heritage" that Raúl references in his work, he told me, is "Pre-Columbian art and architecture." This was a "unique trait" of the group of designers that he leads in Mexico City and the Yucatan.

Figure 6: "Heritage"

Amidst the acropolitical remains of temples, palaces, and ball courts, Raúl welcomed us to sit on igneous soil forged by the neighboring and by-then dormant volcano, Perote, the summit of the effluent Bobos watershed. Visible in the near distance, Perote's figure was unmistakably august, even against a sinusoidal ground of mountainous peaks and desert valleys. On top of this "sacred space," we participated in what Raúl called a "Being Here" activity, which we would repeat with every new ecosystem, "orienting [us] to place" through attention to our senses. "Quiet your cleverness," Raúl directed, repeating a refrain he had introduced before at Casa Barragán, then continuing: "You must slow down before you can focus on your surroundings." "Modern" subjectivity, he admonished, is an experience defined, distracted, and disoriented by speed—an analysis that echoes social theoretical assessments of the modern and postmodern.[49] Listening to nature would allow us, he said, to "reconnect" with other decelerated temporalities.

[49] See, for instance, Walter Benjamin, *The Work of Art in the Age of Mechanical Reproduction* (New York: Penguin, 2008[1935]); Michel de Certeau, *The Practice of Everyday Life* (Berkeley: University of California Press,

We sat still, addressing our newfound skill in active listening toward a speaker sans voice, at least a human one. Raúl asked us to stop thinking about our wishes, our wills, our wants, and to listen to what nature was telling us. As the turbulent air swept Raúl to talk louder, he prompted us to attend, in turn, to the humidity of the air, the warmth of the sun as it beamed onto our skin, the texture of the dirt, the squalls of wind that overwhelmed his words, and the grass's rustling.

No one spoke until Raúl interrupted our quietude with a "story of place" that was biogeological in character, one he hoped would help us to orient us to the "sense of this place." In his ethnography of architects in Engand, Thomas Yarrow identifies this as a "feel for place."[50] While mineral lava from Cofre de Perote had, over time, enriched the ground upon which we sat, nourishing life in an otherwise inhospitably arid desert landscape, a fire two years prior had ravaged the vegetation beneath us, in contrast to the ecologies that persevered outside Cantona. What Raúl impelled us to notice, then, was the biological succession of species, made manifest in the juxtaposition between the climax communities outside the ruined city, and the pioneering types of grass that some participants had been idly plucking. Through a natural history centered on the mutable identity of the flora nearby, a temporal concept ecologists call a "sere," Raúl narrated a historical phenomenology of Cantona that grounded our sensory experience of place in a mess of interdigitating, inter-dissolving agencies that Donna Haraway calls a "compost."[51] What was missing from Raúl's compost was any humanity past or present—a de-peopled nature.

With a motionless nod to Buckminster Fuller, Raúl termed the atmospheric and geological context of Cantona its "operating conditions": the cybernetic theater in which the

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2011[1980]); Paul Virilio, *Speed and Politics* (Cambridge: MIT Press, 2006[1977]); and Michael Taussig, "Tactility and Distraction," *Cultural Anthropology* 6.2 (1991): 147-153.

[50] Yarrow, *Architects*, 75.

[51] Donna Haraway, *Staying with the Trouble: Making Kin in the Chthulucene* (Durham: Duke University Press, 2016), 97.

drama of life unfolds in slow burns and decimating conflagrations.[52] Such conditions—water, sunlight, gravity, among others—are the underlying forces that constrain how biological organisms adapt, endure, survive, and diversify. Acquainting us to these conditions would allow us to "see underneath" the merely phenomenal and to identify life's dynamically stable function.

Cultural anthropologists recognize how symbolic narrations of place are dialectically constituted with phenomenological orientations to place.[53] Place-making is no different for Raúl. Making sense of sense demands the "story of place" that eludes the insensitive "modern" subject: a poetics of place derived from biogeological modes of storytelling.[54] Through a "story of place," Raúl aimed to acquire a "sense of place" similar to the imagined phenomenologies of the Olmec: an "invented tradition" of *Homo mimesis* (see interlude one) that Raúl, a white-presenting, non-Indigenous man, claimed as part of his cultural and aesthetic "heritage." To Raúl, Olmec design was a source of "inspiration" that inflected how he understood his own re-orientation to nature.

"Thought-ing": Sense and the Moral Phenomenology of Intent

"We have a narrow-sighted experience of the senses," Raúl bemoaned. To strengthen the embodied bond between our sense of place and the place of our senses, Raúl introduced a new sensory exercise atop Cantona: "sensing function." He read out loud from our training manuals:

> Because of the strong link between our eyes and our minds, when we see something and are asked to think about it we tend to refer back to what we already know, rather than focusing on what is right in front of us. This exercise helps to break that pattern by using senses other than vision to explore natural artifacts. DIRECTIONS: Working with a partner, take turns wearing a blindfold and exploring an unknown natural artifact using senses other than sight (touch, smell, hearing…maybe taste). Describe what you notice

[52] On the cybernetic understanding of the planet's ecologies, see Peder Anker, *From Bauhaus to Ecohouse: A History of Ecological Design* (Baton Rouge: Louisiana State University Press, 2010).
[53] The classic text is Steven Feld and Keith Basso, eds., *Senses of Place* (Santa Fe: School for Advanced Research Press, 1996).
[54] For a similar account, see Sophia Roosth, "Turning to Stone: Fossil Hunting and Coeval Estrangement in Montana," *Res: Anthropology and Aesthetics* 67-70 (2018): 62-75.

> about the object to your partner, who will log your observations.... What characteristics does the artifact have? What possible function(s) might each characteristic serve?

The example function "protect from predators" followed from the characteristic "has spines." If, in listening, an overactive self interferes with an empiricism true to the reality of the world, in sight, as Raúl read, this intrusive self doubly interferes, twisting reality into readymade concepts. Our task in this exercise was to apply the technology of the self that we learned through active listening—the suppression of our "expressions"—toward nonvisual experience more generally.

I fastened a blindfold to Chuy and recorded his impressions of a clump of grass he plucked after sweeping his hand over the earth. He fingered its extensive root system. "It's half roots," he conjectured, then suggested that its ratio of body to roots could function to stabilize the plant in the dry, loose soil. "It's straight. Upright." He drew the grass under his nose, sniffing. "Smells warm. Fresh. Earthy." He rubbed its blades between his thumb and index. "I don't think it's segmented." He ripped it asunder. "Wet inside." Sliding his fingers down one end, he found a string of seeds. "It's bumpy. Are these its seeds? There are so many." He hypothesized that, in its hard, short life, the low-lying might focus on seed dispersal to guarantee its genetic reproduction. As in Tim's "amateur naturalism" (Chapter One), biomimics in this workshop were initially told to educe biological functions from their impressions of the sensible structure of living organisms.

Figure 7: "Considerative"

Sensory studies scholars have compared, in Kathryn Geurts' words, "the generic shape of the meaning system that defines an experience as sensory," examining how the "senses" are culturally divided into modalities which ramify within perception, emotion, reason, and ethics.[55] For instance, among Anlo-Ewe speakers in Ghana, Geurts has observed how the concept used for bodily experience, *seselelame* (a word meaning, literally, "feel-feel-at-flesh-inside"), is agnostic toward the somatic origins of a feeling, con-fusing external sensations with internal emotions.[56] In Western systems of the sensible, sensory experience often appear in five or six modalities: sight, sound, touch, taste, smell, and, sometimes, proprioception, kinesthesia, body awareness.[57] While Raúl did not present any novel decomposition of the senses, leaving intact a five-fold taxonomy, he did challenge the sensory hierarchies of "modern design, "especially its latent oculocentrism, urging us to shut our eyes and engage the other senses that we neglect to use.[58] Sight to him enacted epistemological violence, carving life into anthropocentric concepts; on the contrary, other senses withheld analytic judgment, allowing nature to express its "being."

At the conclusion of our sensing activity, everyone stood up, slowly, suspended in an atmosphere of newfound awe that lingered long after Raúl finished speaking. Some curiously fingered spiny plants that grew from infinitesimally small crevices in nearby stone paths and

[55] Kathryn Linn Geurts, "On Rocks, Walks, and Talks in West Africa: Cultural Categories and an Anthropology of the Senses," *Ethos* 30.3 (2008): 178-198, 181.
[56] By "confusing," I do not mean misguided, but of "fusing" and "con," or "with," i.e. not distinguishing
[57] On the anthropology of the senses, see (or hear, taste, touch, smell) Kathryn Linn Geurts, *Culture and the Senses: Bodily Ways of Knowing in an African Community* (Berkeley: University of California Press, 2002); Constance Classen, "Foundations for an Anthropology of the Senses," *International Social Science* 49.153 (1997): 401-412; Jack Goody, "The Anthropology of the Senses and Sensations," *La Ricerca Folklorica* 45 (2002): 17-28; and Paul Stoller, *The Taste of Ethnographic Things* (Philadelphia: University of Pennsylvania Press, 1989).
[58] For a discussion of the extensive literature on oculocentrism, including Marshall McLuhan and Walter Ong, consider Johannes Fabian, *Time and the Other: How Anthropology Makes Its Object* (New York: Columbia University Press, 1983). A (relatively) more recent reference would be Jonathan Crary's *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge: MIT Press, 1990).

walls—"epiphytes," Delfín said quietly, observing their observations—while others crept cautiously to the precipice of our lookout, gazing over grounds below and sights yonder. Simon, rarely in the center of action but often watching from afar, snapped a photo on his DSLR camera.

We made our hike down the once-fortified urban center. Raúl encouraged us to continue our "considerative" attunement to the environment as we returned back to the vans to disembark. Duos and trios of conversational partners on the climb up reassembled into a single-file march of shoegazers, doe eyed and hands out-stretched—feeling, sensing, touching any plant within reach. One surprising duet of deviants, shy Simon and serious Alejandra, began audibly giggling, only to be hastily and sternly shushed by Delfín. As his acute reprimand ricocheted along the path, its reverberations loudly reinforced the grave air of reverent silence that weighed our descent down.

Our ride was short-lived, a few minutes back on the highway before we turned off another dirt road, this one leading to an unexpectedly verdant grass lawn, fenced in with wood. Behind it sat an eclectic building, a pastiche of stucco, lumber, stone, and painted mission tiles. Onto the yard we walked, past a rusted, disused wagon, adorned with flower pots and a rainbow roof, and past an oak, its limbs puppeteering a neighborhood of hanging birdhouses that swayed in the wind. Under a covered patio, we sat at red checker-clothed tables for a lunch of tortas. Between bites, Raúl, Delfín, and Ana Gabriela moderated a conversation on "sensing function."

How was your experience of sensing? Raúl asked. Cedric answered that his senses revealed new structures he would not have noticed with sight alone—an "art of noticing," as Anna Tsing might describe it.[59] Raúl nodded and hummed. A jewelry designer from Denver, Jenn, added that did not consciously sense with her skin, which was a new experience for her.

[59] Anna Lowenhaupt Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (Princeton: Princeton University Press, 2015), 17.

Chuy reflected that, despite closing his eyes, he continued to make pictures in his mind, fitting information from his other senses into this loose visual mold—the persistence of oculocentrism. This was normal, the moderators concurred; with time and practice, we would uproot the visual.

Alejandra joined in, "It was difficult to not bring past…" she started to say in English, switching to Spanish mid-sentence, "…*pensamiento*." ("Thought-ing," Ana Gabriela translated.) "Right," she continued, "past assumptions and associations." "Cleverness!" Delfín interjected. During our prior conversation on active listening, I had thought of cleverness as a synonym for the "intent" of a willing subject—intent, in its common sense, as "a consciously formulated plan, a 'mental event' conceptually separable from the act that may or may not follow from it," which Robert Paul defines for us.[60] But Alejandra seemed to be pointing to cleverness in the restricted, technical sense that phenomenologists use to name the experience of being directed to an object, of experiencing an object *as* that particular object, as opposed to a flux of indeterminate qualia.[61] From *a* plan to *the* hallmark of conscious awareness, cleverness was a capacious term that named any instance of anthropocentric orientation toward nature. Cleverness was a vernacular of intent.

In Western conceptions of the person, intent rests in the mind. Thus writes Marilyn Strathern: "Intention and cause are alike located within the agent, who is a carrier, so to speak… of the self, and intention and cause are 'thereby' expressed in the fulfillment of…wishes."[62] In a reflection of this notion of personhood, theorists of design conceptualize artifice as an expression of these "wishes." Herbert Simon for example read design's archive as an archaeology of desire, a landscape of materialized intent: "These things we call artifacts…are what they are in order to

[60] Robert Paul, "Act and Intention in Sherpa Culture and Society," in *Other Intentions: Cultural Contexts and the Attribution of Inner States*, ed. Lawrence Rosen (Santa Fe: School for Advanced Research, 1995), 15-46, 15.
[61] See, for instance, John Searle, *Intentionality: An Essay in the Philosophy of Mind* (Cambridge: Cambridge University Press, 1983).
[62] Marilyn Strathern, "Disembodied Choice," in Lawrence Rosen, ed., *Other Intentions*, 69-90, 73.

satisfy our desire…As our aims change, so too do our artifacts."[63] In the anthropology of design, Keith Murphy theorizes design as "an active, almost teleological ordering of raw materials into some resultant thing."[64] "Indeed," Murphy continues this line of thought, "design is primarily an intentional structuring of some portion of the lived world in such a way as to transform how it is used, perceived, or understood."[65] With the moral vernacular of "cleverness," biomimics render a desiring subject problematic, seeking instead to cultivate an intentional form of un-intentionality. Cleverness names and challenges an *im*moral phenomenology of "modern" design—what Byron Good, in his study of the "will" in Emil Kraepelin's psychiatry, calls "pathologies of the will."[66]

Another concern surfaced: the logic of deducing function from structure. Miguel, a student of biology at "UNAM" (Delfín's alma mater), worried that not all form has a function. "Function doesn't always exist," he reminded the group. "You can't find function *after* form." This was because, as he elaborated, evolution is blind. It produces waste: forms without function. Alejandra, another lecturer at UMA and a doctor of philosophy in biology, had a similar issue. She found herself wanting "to describe functions that aren't always there in order to escape past assumptions…*to feel from a different perspective*." Alejandra found this direction alluring, but misleading, a straying from the facts of evolution. Blindfolded, she missed evolution's blindness.

To my surprise, Raúl smiled and agreed. "After you identify some parts of function," he said, "you must go to tests and experiments." Exactly what Raúl meant by this would have to wait until later in our trip. But, notwithstanding its present obscurity, Raúl conceived function, not as a definitive truth but an invitation to thought to be verified with "tests and experiments."

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[63] Simon, *The Sciences of the Artificial*, 3.
[64] Murphy, *Swedish Design*, 32.
[65] *Ibid*.
[66] Byron Good, "Emil Kraepelin on Pathologies of the Will," in Murphy and Throop, *Towards an Anthropology of the Will*, 158-176.

In contrast to the pragmatic stance I identified in the previous chapter, his stance was different. Discontent with mere inspiration, Raúl, in the idealistic stance, insisted upon repeated research. "We fragment experience," he said, citing the reductionism of Western visuality and continuing, "We must be conscious of relations." Sensing nature in its sensuous totality returns to relations. In Raúl's art of noticing, function functions as a generative machine of possibility-making. Function legislates an epistemology of openness that resists the conceptual closure of the visual. Sensing past sight is an ethics of relation. Raúl's sense of virtue comes from the virtue of sense.

How did it make you feel? Ana Gabriela asked. "Excited," Cedric ventured. "Captivated." Jeremy doubled this sentiment, stating that the exercise led him to a deeper appreciation of place. "You are falling in love with nature," Raúl declared. Orientations, as Sara Ahmed has illumined, are saturated with affect.[67] To orient toward one thing versus another is to have a feeling about it. Through this exercise in sensing nature, Raúl sought to foster in us that feeling of "connection through contact" which Kath Weston calls intimacy, an embodied tie to another living body.[68] And, sometimes, that connection can lead to an entirely out-of-body experience. Reflecting on his experience of the intense aroma of a flower, Adam commented that he could understand the attraction it would have for a bee—that, for a second, he could understand its appeal outside his own olfactory sensibilities. Orienting to the flower was, to him, a disorientation from the human. Re-orienting to nature involved affective dispositions of "wonder" or "awe" toward nonhumans.

"Universal Design": Ancient Patterns and Nonhuman Times

"How has life been sustainable for the last 3.8 billion years?" Delfín shouted at us through the raucous, tireless winds that screamed and crashed across the perimeter of Laguna de Alchíchica.

[67] Sara Ahmed, *Queer Phenomenology* (Durham: Duke University Press, 2006).
[68] Weston, *Animate Planet*, 23.

A two-hour drive from Puebla City brought us to this *axalapasco*, also known as a crater lake or a "maar," which had formed in the hollow, cavernous volume left by Perote's past extinction. Yet, within the afterlife of the volcano, life had resurged, after—a very "ancient" kind of life. Due to the continuous influx of mineral-rich groundwater from the volcanic aquifer, which grew ever concentrated by the evaporative force of a dry climate, this aqueous ecosystem was saline—so saline, in fact, that a natural zone of exclusion had slowly settled along the lake's outer ridge.

While a few brave grasses dared to venture close to the cold, teal depths of Alchíchica, the cacti that lined the edge—prickly pears and the even more untoward jumping chollas—halted several meters away from the water's perimeter, at what Delfín identified as the "salt gradient." Even the goat farmers who grazed their mottled herds on the surrounding flora kept safely away. Besides the grasses, the only other species intrepid, or perhaps foolish, enough to approach the mortal body of water were, well, us, in addition to a family of black widow spiders nestled in the white rocks, their billowing webs a sticky pantry of flying grub net by co-conspiratorial winds. Delfín had a brazen fascination with the spiders, which he pointed to, calling us over to see them. I zipped up my windbreaker and smiled through gritted teeth; growing up in the Sonoran Desert of Arizona, I had come to internalize a rather Puritanical fear of their scarlet hourglass lettering.

Figure 8: Cyclical Time

"This right here is a proven fact that life has been sustainable," Delfín said, gesturing to his side—not to the arachnids, but to the halo of white, calcareous rocks that bordered the crater. Geological residue from the aerobic and anaerobic cyanobacteria that can withstand the extreme conditions of this salty ecosystem, these chalky, coralline structures ("stromatolites," as Delfín named them) were salt "fossils," or more accurately "deposits"—"proof" of life's sustainability. Despite the harsh, hostile, and inhospitable conditions, cyanobacteria had adapted to the salinity, evolving metabolic techniques that enabled them to process and excrete out the salt as sediment. In Delfín's terms, salinity presented a "challenge" that cyanobacteria had overcome; by imitating them, we might also learn to design technologies capable of surviving in uncertain environments. Like the axolotls that also lived in these waters, cyanobacteria were icons of renewal to Delfín.[69] Stretching his arms out and skyward, Delfín commented that "time" and "age" abounded nearby; "bacteria from the beginning of life" persisted in the living descendants of "indigenous" bacteria, where bacterial heritage signifies, as Delfín then listed, "endurance," "resilience," and "history."

After we conducted a Be Here exercise, standing in a circle next to the lagoon, we heard about what he called *the* axiom of biomimicry: "Life creates conditions conducive to life." Reinforcing this principle, Delfín tasked us to "look [around] for patterns," which could include shape, color, number, distribution, and size. "Patterns evince success," he said. "Their repetition is key," that is, a sensible order "proven for years." When we regrouped in a circle to discuss our observations about surrounding organisms, which I collected with Cedric, we listened as Delfín differentiated between human and nonhuman time. "Humanity," he told us, "does linear time to

[69] Emily Wanderer, "The Axolotl in Global Circuits of Knowledge Production: Producing Multispecies Potentiality," *Cultural Anthropology* 33.4 (2018): 650-679. On cyanobacteria and other extremophiles, consider Stefan Helmreich, "Extraterrestrial Relativism," *Anthropological Quarterly* 85.4 (2012): 1125-1140 and Juan Franciso Salazar, "Microbial Geographies at the Extremes of Life," *Environmental Humanities* 9.2 (2017): 398-417.

make it easier," referring to humanity in its culturally specific "modern" form or type.[70] On the contrary, life traffics in "universal designs," the non-linear times of "cycles" and "loops." "Pre-modern societies" recognized this too, doubling life's circular timelines in mimetic temporalities. Against the linearity of "modern design," Delfín saw a return to the looping effects of nonhuman kinds of artifacts—their repetitiveness and sustainability—through their technological emulation.

Settler Mimicry: Hacienda *Visions of More-than-Human Perspectives*

Built on top of the spectral effluent of eruptions past, Perote is a small city of approximately seventy thousand residents nestled on the lower, western basin of Cofre de Perote. Its volcanic peaks, uncannily present from every street view, rise four thousand meters above sea and cast a "rain shadow" that deprives the city of moisture that may be windswept from the Atlantic Ocean.

Once the Nahuatl village of Pinahuizapan, Perote is named after Pedro "Perote" de Anzures, a colonist from mainland Spain who settled and established a small inn there in 1527 as a waystation and rest stop between Mexico City and the port of Veracruz (Villa Rica de la Cruz). In Spanish, the word "cofre" means "vault" or "safe," and like the veil of grey clouds that hung over our arrival, its connotations of protection and defense haunt the city with a history of battle. Located on the northern outskirts of the city, Fortaleza, or Castillo, de San Carlos (fort or castle) has long served as a scene and vehicle of violence, from its commission in the late 18th century as a defense against an anticipated (but never actualized) British invasion, through its occupation by Spanish, American, and Mexican forces across the 19th century, and up to its 20th century use as a prison for political dissidents, Axis civilians and captured soldiers, and, at its end, criminals. The fort now doubles as a museum, its moat dry, overrun by throngs of camera-toting tourists.

[70] For a review, see Laura Bear, "Time as Technique," *Annual Review of Anthropology* 45 (2016): 1-16.

We approached the city in the early evening after a half-hour upward drive from Alchichica, during which time, as Raúl pointed out, agaves had ceded the territory to pine trees, marking our emigration from Cantona's xeric shrub and into Perote's "cone" forest ecosystem. After a quick stop at a roadside stand for an *antojito*, or snack, of cotija-dusted maize (*elote*) that brought Raúl unexpected joy, we pulled into the historic center and parked near a Chedraui to buy, Raúl suggested, "beer and any other necessities" before we left the conveniences of the city. Unlike the needle-covered conifer landscape surrounding Perote, alive with pine, cedar, cypress, and other trees of the high steppe, the historic center did not have, to my counting eye, one tree, a flat, concrete expanse of crumbling automotive lots, *lavanderias*, electricians, and gas stations. Ana Gabriela mentioned that Perote is famous for its cured meats—*jamón serrano* and *chorizo*—and butchery that refugees of the Spanish Civil War brought with them to Mexico in the 1930s. So, to my disappointment, when we made a second stop at a restaurant which Raúl entered alone, leaving us in the van for the better part of thirty minutes, he returned, not with porcine delicacies, but with a well-coifed, middle-aged man. Raùl did not introduce him, preferring to converse with the new occupant of the passenger seat privately. Errands finished, we departed from downtown.

During our eastward ascent up the base of the volcano, I witnessed the boundaries of an ecotone that was human in kind. As we wound our way along a snaking road, green life returned, in between and within walled estates more spaciously separated than their central counterparts. As with Cantona, verticality traced a hierarchy of capital and, here, race: Behind signs claiming private roads and gated entrances sat the large stately *haciendas* that had once inspired Barragán, still inhabited and tended to by the landed descendants, I would come to learn, of white colonists. Among them was our mysterious rider, who, as the van tumbled down a long, cobbled driveway, through a wrought-iron gate, and onto a plush lawn, revealed himself to be an owner of the grand

house that stood before us. He and his wife, who had been waiting to greet us as we unloaded our luggage, managed the property, which they were busy converting to a boutique hotel, in addition to two restaurants in the city, including the one where we had spent our now-explicable sojourn. While the hotel was not open yet at the time of our visit, Raúl informed us that we were welcome to stay for the evening. Throughout his thirty-five years charting Veracruz and rafting the Bobos, Raúl had become a close friend of the couple, who had graciously offered their hospitality to us.

With our hosts at the lead, we toured the grounds: an assemblage of stone and stucco buildings, white and sand colored, that orbited a manicured courtyard. One building housed a trio of guest suites with sumptuous canopy beds and travertine bathrooms. Another terracotta-roofed building with wooden doors closed to curious glances had been decorated with heritage *objets*: a horseless wagon, an oven, a grain mill, and what appeared to be an old-fashioned butter churn. Every architectural detail of the *hacienda* had been meticulously preserved or artfully remodeled, and yet I had the impression that I was the only member of our group taking photographs, despite its explicit presentation as an archive of colonial design. (At the trip's end, my suspicion was confirmed: In no photo album shared but my own were there pictures of the hacienda that night. If the Spanish *hacienda* as an architectural type was an "evocative object" to Barragán, it was significantly insignificant to my companions, whose lenses fixed on animals, plants, and vistas.)

Figure 9: *Hacienda*

As the sun set and the monotone sky surrendered to a psychedelic band of colors, we recessed to the dining hall for a wine reception, a cavernous space in which two paintings of the archangel Michael slaying Satan had been hung; in one, he held a sword, and in the other, a rifle. Over a dinner of chicken taquitos, prepared by an unseen chef or chefs, we heard stories from the owners about the *hacienda* and its patterns of ownership while *tequileros* were filled and refilled. Built by the couple's Spanish ancestors over two hundred years prior, the property traded hands to a German family that, the couple suspected, were involved in the Nazi party, or sympathizers. After dinner, they led us back to a room that had earlier eluded our tour. Opening the door, they revealed what they called a "museum": a collection of artifacts—Nazi propaganda, regalia, and even small incendiary devices—that they had discovered after reacquiring their family's home.

Unsettled, we split and returned to our shared rooms. Adam cracked a can of beer and played electronic R&B music on his phone. Jeremy rolled a joint and sighed, "That was heavy." Adam voiced that he was enjoying this "leisure" time away from work, although he missed his wife and his two kids. Together we crept outside the room to steal a moment on the rooftop under the light of the moon. Contacted by text, Grecía, Cedric, and Rebecca joined us. While the scholar of religion Bron Taylor has commented on the neo-animism that animates the New Age current of American environmental thought, biomimicry included, a more-than-human ontology that lingered at the edges of our trip shaded into an explicit discussion of the more-than-natural: the domain of ghosts and other supernatural beings.[71] In a hushed tone, Jeremy confessed that he had ghostly experiences in his past that he could not reconcile with the "scientific" perspective. He added that he was also open to the possibility of aliens. Grecía agreed and commented that she was fascinated with *brujería* and spirits. For both Jeremy and Grecía the expansion of agency

[71] Bron Taylor, *Dark Green Religion: Nature Spirituality and the Planetary Future* (Berkeley: University of California Press, 2009).

to living organisms went hand-in-hand with a challenge to secular conceptions of what nature is, a challenge that was routed through New Age revivals of "pre-modern" ontological traditions. A more-than-human design theory resonated with a mystical belief in ghosts, spirits, and other "unseen things" in the more-than-natural realm Mayanthi Fernando calls "supernatureculture."[72]

"Your Vision Will Change": Active Objects and Passive Subjects

In the dim light of the next dawn we crossed the dewy courtyard for breakfast to prepare for a strenuous hike up Cofre de Perote. Elevated nearly 2,800 meters at the *hacienda*, the volcano caps at another 4,200 meters. While we would not ascend its entirety, we would nevertheless be exposed to an unpredictable combination of elements: stinging wind, freezing rain, burning sun, and temperature fluctuations. Ana Gabriela recommended we protect our skin with sunscreen. When I went to apply the SPF90 product I had purchased, she gasped when she saw the bottle. Skimming the ingredient list, she said had harmful "toxins" like oxybenzone and other endocrine disruptors. Ana Gabriela offered her nontoxic, biodegradable sunscreen for me to use instead.

I crawled into the back row of one van and, after me: Adam, Rebecca, Cedric, Jenn, and Jeremy. Leaving behind Perote the city, and the rain shadow that looms over it, we traveled northeast to loop around to a wetter trailhead on the volcano's northern face. Under optimal road conditions, one can reach the peak by car, but we were to climb up by foot in order to observe our day's theme: how "function" varies between ecosystem, based on their operating conditions.

In this cone forest, winds wick moisture from the Atlantic Ocean, watering prairies of marigold asters and amethyst lupines that blossomed beside firs and pines. A billowing fog blanketed the ground, through which, as we drove past, we detected a farmer pushing a horse-

[72] Mayanthi Fernando, "Supernatureculture," *The Immanent Frame* (blog), December 11, 2017, https://tif.ssrc.org/2017/12/11/supernatureculture/.

drawn plow through tidy plots of potato plants. Not far, a woman was bent over in harvest while a lone dog circled, nipped, and herded a flock of sheep. While we tumbled up the bumpy road, Rebecca told me that she would like to return to school to train as a wildlife biologist, conducting survey studies. As an undergraduate student at Champlain College in Vermont, Rebecca studied environmental policy, with ambitions to be an environmental lawyer. Her advisor, however, had advised her to "take some time off" after graduating. In the interim, she realized that she did not want a lifestyle defined by 80-hour work weeks, despite the allure of "material things." After a few jobs working in outdoors recreation, she joined the Biomimicry Institute, first as volunteer coordinator and then as design challenge manager. She came to Veracruz as their representative.

Figure 10: The Ascent

Past the prairies, we stopped the vans in a dirt lot covered by a dense shade of trees. Standing outside, we received our instructions for a new activity: "discovering function." After Raúl led us through a group reading of the Biomimicry Taxonomy (described in Chapter One), he assigned our task: With a partner, we should find organisms along the damp slopes of the cone forest that surrounded us and, using the language of the taxonomy, analyze the functions these organisms must be able accomplish under the prevailing conditions of the cold, wet forest.

He suggested “regulate temperature,” “protect,” and “regulate moisture” as possible functions to address, considering the climatic demands of the volcano’s northern side. With Cedric, for a second time, I clamored up the steep incline, occasionally slipping, then sliding on the loose rock and damp soil. We began with a small carpet of moss that was affixed to a boulder. The moss, Cedric speculated, had to “attach, permanently” to rocks; “cooperate between different species,” such as lichen and trees; “protect from non-living threats,” including light that waxed and waned and excessive hydration; and “provide ecosystem services,” i.e. making soil and slowing the rain. We continued to scan the forest, learning to read “functions” in lupines, aloes, pines, grasses, and an unidentifiable species of blue-purple fungus through the lexicon inscribed in the taxonomy.

Delfín approached to remind us that our hour-long task was nearly over. We returned to the vans for another group discussion. Adam volunteered to go first and shared that he observed how multiple organisms sought protection from the elements through rocks. Cedric agreed, citing how the conifers conferred shelter as well. Alejandra scaled from singular creatures to “clusters” of “grass, succulents, and lichen” that coincided, leading her to wonder if the cluster as a relation heightens as one looks higher up the volcano, where harsher conditions might promote a greater degree of cooperation—and less competition. Their relationships, she insinuated, were not fixed. Delfín stated that she was learning to “look for *patterns*.” By training, “*your vision will change*.” “Visión de búsqueda,” he described in Spanish, suggesting “search vision” for English-speakers. When you “think you found a model,” he said, “an observation of a specific plant or plants, then you must find it elsewhere to be sure it is in nature,” that is, to be sure “it is not our thought-ing.”

Delfín’s comment on the transformation of vision, and the senses generally, through habitual training in function detection calls to mind the “enskilment of vision” Christina Grasseni

saw in cattle breeders, for whom the appreciation of an ideal cow is an effect of apprenticeship.[73] Learning to see function obeys a similar logic: Through practice, discussion, and correction, we came to perceive nature through the discursive, disciplinary lens that Charles Goodwin has called "professional vision," the "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group."[74] Grasseni and Goodwin describe vision as the standardized application of what Foucault termed a "grid of intelligibility" to a constant, unchanging, and immutable object.[75] Alejandra's observation of an ecologically variable "pattern," on the other hand, a focus on the vagaries of life, transposes the "dialectic of resistance and accommodation" that Andrew Pickering overlaid onto the relationship between a knower and a stable unknown to a relationship between a knower and an object that is presently unknown, and potentially, and fundamentally, unknowable.[76] In order to react to this variability, Delfin proposed a praxis of repetition—a repeated return to the suggestive "model" or "pattern." This form of vision is not a one-sided imposition but a relation of interrogation and interaction.

Inspired by philosopher of technology Gilbert Simondon, the anthropologist Michael Fisch doubts if biomimicry could admit a "progressive technics."[77] Contrasting Janine Benyus with the "neomaterialist" Neri Oxman (see the Epilogue), he contends the "science of nature" in biomimicry arrests the flux of life in an "authoritative diagram of relations," the interpretation of

[73] Christina Grasseni, "Skilled Visions: An Apprenticeship in Breeding Aesthetics," *Social Anthropology* 12.1 (2004): 41-55.
[74] Charles Goodwin, "Professional Vision," *American Anthropologist* 96.3 (1994): 606-663, 606.
[75] Michel Foucault, *The History of Sexuality, Vol. 1: An Introduction* (Vintage: New York, 1994[1976]), 93. See also Bruno Latour, "Visualisation and Cognition: Drawing Things Together," in *Knowledge and Society: Studies in the Sociology of Culture Past and Present*, ed. H. Kuklick (Greenwich: JAI Press, 1986), 1-40.
[76] Andrew Pickering, *The Mangle of Practice: Time, Agency, and Science* (Chicago: University of Chicago Press, 1995). See also Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham: Duke University Press, 2007). This relationship is not unlike what Popper described as *the* logic of science: conjecture (the generation of design principles) and falsification (their evaluation). See Karl Popper, *The Logic of Scientific Discovery* (New York: Routledge, 2002[1934]).
[77] Michael Fisch, "The Nature of Biomimicry: Toward a Novel Technological Culture," *Science, Technology, & Human Values* 42.5 (2017): 795-821.

which biomimicry, "operating in a mimetic mode," reserves for itself: "Mimicry…rehearses a representational idiom of knowledge that parallels the project in Western modernity of mapping the natural world with all its constituent curiosities, wonders, and (savage) cultural others."[78] "In claiming to make available nature's design secrets for emulation," Fisch elaborates, "biomimicry claims an exclusive ability to know and represent the natural world," and "claims the right to constitute oneself as an active subject vis-à-vis a passive object."[79] Was Delfín this self-assured?

Where Fisch sees certainty, I hear in Delfín's words a hermeneutic of doubt and a mimetic ethic of deference and deferral that Raúl earlier called "considerative"—contemplation of the illusoriness of intent. Biomimics were supposed to interrogate their sensory qualia as signs of intent versus function. Delfín's epistemology of the "elsewhere" revisited Raúl's "tests" and "experiments," posing vision as a relation of *active* objects and *passive* self-restraining subjects. As it would become clear throughout the rest of our expedition, however, only *some* subjects had been authorized to exercise this kind of "considerative" ethos toward nature. Paraphrasing Fisch, biomimicry claims the right to constitute oneself as a passive subject vis-à-vis an active object.

We finished our exercise, ready to hike to hike up to the "páramo," a high mountain prairie with a dramatically wide range of "operating conditions." Sometimes the area experiences "four seasons a day," Raúl said, due to the wind's vicissitudes. At other times, 3600 meters high, even the clouds sometimes "get stuck," shrouding its lonely heights in a dark, wet dreariness that persists for weeks. We crossed the "timber line," a thinning of the air that limits the evaporative transpiration trees need to grow. A function of latitude and altitude, the timber line marks a zone of exclusion past which few species can survive. Grasses predominate there, specifically *zacatón* (sacaton), a mountain grass that uses three strategies to "protect" itself from the violence of frost:

[78] *Ibid*, 11.
[79] *Ibid*, 11.

high intracellular glucose; spiny, cylindrical leaves that resist snow burial; and a root hierarchy, the most essential located near its warm interior. If sacaton has a set of "resilient" strategies for defending against the cold, the thistle, for Delfín, modelled protection against the cold *and* heat. With its burrowing roots, the thistle was an exemplar of homeostatic "plant architecture." A third plant, the bromeliad, was indexed by Delfín as an example of evolutionary convergence: Like the agave, the bromeliad had developed a "base architecture" that channeled the rain toward its core.

Figure 11: Adaptation

After an hour of hiking, our group, once an orderly rank-and-file march, had dispersed into an out-of-step race of athletic onwards and stragglers struggling to breathe in the rarified air. We stopped to conduct a Be Here exercise while the frigid air chilled our bones. Not long passed before we had to embark on the descent; one attendee was physically unable to proceed farther. Unlike the plants that survived by evolving, not all of us were as well-adapted to these heights.

A "Respectful" Relation: Designing Talloguaya as Third Nature

From the timber line to sea level we descended, first by foot, then by vans, which perilously careened down slick, winding roads. With each wobbling turn, I grabbed my armrest with a white-knuckle grip while Delfín cheerfully lectured about the epiphytes and species of climbing vegetation well-adapted to the humidity of the cloud forest through which we were swerving. There, an endless fog bathes these rootless plants in a mist that they drink through their leaves. Meanwhile, Jenn told me about past jobs working for a snowboard company that repurposes post-harvest corn products—husks, leaves, and stalks—and, more recently, designing jewelry in her own studio, both in Telluride, Colorado. While we talked, the clouds dissipated, an occasion that Delfín seized upon to talk about the tropical evergreen forest we had entered: its biodiversity and its issue of limited space, which some plants had addressed with superficial, spreading roots.

Soon, the roads levelled, and Delfín announced our imminent arrival at Talloguaya, located about 9 km northeast of Tlapacoyan, a small city known for its eco-tourism. A little over halfway down the Bobos watershed, the Talloguaya camp sits at the end of a long, unpaved dirt road with deep potholes full of water from rainfall that occurs daily for seven months of the year. As we slowed to navigate the bumps and dips, I rolled down the window, and a tidal wave of the thick, sticky air flowed into and filled the van. In this region of Veracruz, water precipitates and evaporates fast, but it poses no intractable climatic challenge to the indigenous flora and fauna. To the banana, coffee, and orange plantations that replaced these native ecologies in the 1900s, however, the constant rain created a problem of run-off and soil erosion, due to their sparse plots.

In the story that I gathered from Delfín and later Raúl, these plantations covered the landscape when Raúl first visited in the late 1980s. With his mentor, Eduardo Bernstein, a man whom Raúl credited as Mexico's importer of whitewater rafting, Raúl explored Veracruz to raft

the Bobos river, discovering a region deforested by years of voracious agricultural "extraction." "Mexico doesn't care," he lamented. Working with "local stakeholders," Raúl tried to protect the forest, manipulating the campsite, and the attraction of ecotourism more broadly, as a "lever" to "transform peoples' interactions with the river." In 1992, he successfully persuaded the federal government to establish the Filobobos Natural Protected Area, which spans over 10,800 hectares. The name of the river (and other nearby towns and points of interest designated "Bobos"), Raúl told me, derives from a species of mullet, native to its waters and known to locals as the *bobos*.

His decision to call the region Filobobos thus recognizes this familiar species and its eponymous riparian home alongside the specific location of the camp, which abuts the river in a segment that is defined by its rocky crags—hence "filo," the Spanish word for "cliff" or "edge." Protecting the Filobobos did *not* mean constructing another "isolated park," Raúl stressed. "People live here." As we avoided holes that could slow our movement, we passed a house and chicken coop, where a family of four were seen tending to animals. After designating the region a protected area, Raúl worked with its residents to train them as guides in rafting and kayaking, many of whom still operate ecotourism companies out of Tlapacoyan. "It was about changing the dynamics of using the land," he told me, away from "extraction," towards a "respectful" relation. More recently, Raúl has staved off government projects to build dams for energy along the river.

As the anthropologist Cori Hayden recounts in her ethnography of bioprospecting, sustainability initiatives like Talloguaya exploded during in Mexico during the 1990s as large farms were turned into small organic plots or conservation sites.[80] In contrast to conservation projects, however, Raúl framed Talloguaya as "regeneration." Whereas conservationism seeks to balance natural cycles with human resource cycle, regeneration, or "regenerative design," is a

[80] Cori Hayden, *When Nature Goes Public: The Making and Unmaking of Bioprospecting in Mexico* (Princeton: Princeton University Press, 2004).

"system of technologies and strategies, based on an understanding of the inner workings of eco-systems that generates designs to regenerate rather than deplete underlying life support systems and resources within socio-ecological wholes," according to Pamela Mang and Bill Reed, the co-founders of Regenesis, a regenerative design group affiliated with Raúl.[81] Biomimicry, Raúl said, was a potent methodology for accomplishing this goal of "self-organizing," "self-evolving" sites, leveraging biological design principles to create new "socio-ecological" natures that mimic life's natural temporalities. Unlike "restoration," which aims to re-materialize nature from a moment in times past, regeneration to Raúl was about giving time back to a nature robbed of temporality by plantation systems of agriculture, enabling its inherent tendency toward growth and generation.[82]

Involving, or "enrolling,"[83] what Raúl called "local stakeholders" is a key element of regenerative design.[84] Before he broke ground on Talloguaya—or, rather, broke ground again, as "people live here," he acknowledged—Raúl said he "consulted" with the Indigenous people who live in the area. While Raúl did name any Indigenous groups by name, referring to them, instead, in the abstract, roughly a fifth of Veracruz identifies as Indigenous, including Nahua and Totanac peoples in the region around Talloguaya. The anthropologist Robert Fletcher notes, "Locals are understood to embrace ecotourism primarily as the result of demonstrating the economic benefits that can be generated from preserving rather than depleting natural resources."[85] Indeed, as Raùl indicated to us in the van, he sought to mobilize "locals" in the region to support his regenerative

[81] Pamela Mang and Bill Reed, "Regenerative Development and Design," in *Encyclopedia of Sustainability Science and Technology,* ed. Robert Meyers (New York: Springer, 2012).
[82] See Eric Higgs, *Nature by Design: People, Natural Process, and Ecological Restoration* (Cambridge: MIT Press, 2003).
[83] Michel Callon, "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay," *The Sociological Review* 32.1S (1984): 196-233.
[84] On the importance of "local stakeholders" to regenerative design, see Pamela Mang and Ben Haggard, *Regenerative Development and Design: A Framework for Evolving Sustainability* (Hoboken: Wiley, 2016).
[85] Robert Fletcher, *Romancing the Wild: Cultural Dimensions of Ecotourism* (Durham: Duke University Press, 2014), 5.

design initiative through recreational water activities. What Fletcher argues about eco-tourism is that it involves more than the economic capitulation to outside influences, but "commonly entails a promotion of the particular cultural perspective"—hence the shift Raúl hoped to effect in locals who previously didn't "care," "extract[ing]" from nature, toward a "considerative" "interaction." Transforming their attitudes toward life, he believed, was pivotal to Talloguaya's future success.

At last we parked at the camp, just outside a short wall of bamboo poles tied together. Talloguaya is a permanent encampment that Raúl built entirely out of locally available materials, and mostly *Guadua*, a genus of bamboo endemic to Mexico that architects call "vegetable steel." Beyond the entry wall snakes a stone path that cuts through the crowded forest and terminates at a central *palap*a, a thatched, open-air gathering space with a semi-circular kitchen and six tables. From the *palapa,* a library and fifteen rooms radiate outward, each comprised of one canvas tent, an outhouse and exposed showers, and a pitched cover that protects the entire "suite" from rain. Raúl named every room after an animal or plant found near, including the coati and *tepexcuincle*, the Nahuatl word Raúl uses to call the lowland paca. During our stay, the water for our showers, collected from the daily showers of rain, was dysfunctional—at worst, non-existent, at best, cold, and, falling somewhere in the middle, brief, soapy, and interrupted. When not in use by Raúl, the camp serves as accommodations for other ecotourism ventures. By the end of our trip, I came to think of Talloguaya's aesthetics as *nature in the middle distance*—neither the intimacy of the hut (see Interlude 3) nor the spectacular distance of the hotel, an architecture somewhere in-between.

Figure 12: Immersion

After we shed our belongings in the suites, we met back at the *palapa*, where Raúl initiated a tour of the camp. Covering a scant ten percent of the federal protected area, the camp was vast, full of trees, vines, and bushes that extended in every direction. All of this was second growth, Raúl informed us. When he built Talloguaya, most of its native flora had been cleared to make room for banana and coffee plants. He researched the landscape's ecological conditions to inform its re-design. In this tropical semi-deciduous forest, growth is dense and diverse, creating a canopy that blocks much of the sky and competition for the sun's light. Amid such exuberance, organic matter cycles between lifeforms, rarely lingering in the ground. With shallow, poor soil that is at every moment depleted of nutrients, trees must employ wide root strategies to survive.

Found across the rainforests of Mexico, the vanilla tree was demonstrably well-adapted to the cycles of the region—hence the first plant in his experimental reforestation of Talloguaya. He led us to the first plot of *vainilla* trees, the limbs of one now home to a poisonous caterpillar. Next came a grove of bamboo—the same grove with which Raúl constructed the camp—and a fruiting *bromelia.* Perhaps most grand was a towering *ceiba*, or "pochota," tree, whose fluffy and

fibrous fruits have been used by Mesoamerican peoples. While Talloguaya might have appeared to be a restoration project, his choice of new species veered from this nostalgic mode of design. Raúl did not seek to return the land to a point in time but to the evolutionary times of adaptation, to cycles of life's emergence within the "boundary conditions" of this humid, forested "place."

As we walked the forest, Raúl displayed soursop, black peppercorn, lychee, and *canela*, or cinnamon, none of which were native to the region. Pointing to the pepper tree, Raúl urged us to notice the bark, which was in a constant state of sloughing to fight against climbing parasites. We paused last at a robust *cacao* tree with hefty pods emblazoned with orange-yellow pigments. Its genetic origins, Raúl remarked, lie in Ecuador, but like maize, it was a "food technology" that "spread fast, spread across Mesoamerica," he said, now with eight variations (twelve for maize). Decentering humanity as the agent of environmental history, Raúl observed that we "perform the function of diversification"—an aside that recalled a favorite line of mine in Bruno Latour's *The Pasteurization of France*: "But if you are mixed up with trees, how do you know they are not using you to achieve their dark designs? Who told you that man was the shepherd of being?"[86]

When I asked Raúl about his criteria of inclusion for Talloguaya's forestation, he responded that he "will use it if it adapts to this place." The "rewilding" of Talloguaya was not a return to the imaginary of a sublime "wilderness" that William Cronon defined as "a pristine sanctuary where the last remnant of an untouched, endangered, but still transcendent nature can for at least a little while longer be encountered without the contaminating taint of civilization."[87] For Raúl, nativity pales as a logic of design compared to the flourishing expressed in adaptation.

[86] Bruno Latour, *The Pasteurization of France* (Cambridge: Harvard University Press, 1993), 194.
[87] William Cronon, "The Trouble with Wilderness: or, Getting Back to the Wrong Nature," *in* William Cronon, ed., *Uncommon Ground: Toward Reinventing Nature* (New York: W.W. Norton & Company, 1995), 69-90, 69.

Instead, Talloguaya would be a "socio-ecological system": natural growth supported by humans. In the "multispecies biopolitics" of adaptation, whatever survived was welcomed into the fold.[88]

What Raúl hoped to see in Talloguaya was not wilderness but what I call *third nature*. Stefan Helmreich parses "first nature" as "the given, pristine Edenic nature of physical and biotic processes, laws, and forms" and then "second nature" as "the rule-driven social world of society and the market, culture, and the city, in which social change is driven by a parallel set of socially imposed laws."[89] Talloguaya would be neither a people-less first nature nor a nature-less second nature but a peopled third nature designed to emulate first nature's idea—nature vis-à-vis culture. In contrast to Cronon's wilderness, Dana Graef terms this "wildness"—spaces of "intermingling" wherein "wild meets domestic, and the native and invasive blend."[90] But what of the Indigenous?

My use of the concept of third nature deviates from the "third nature" described by the anthropologist Anna Tsing in her ethnography of matsutake, which she classifies as that "which manages to live despite capitalism."[91] For Tsing, matsutake mushrooms "pop in and out of" what Helmreich,[92] reading Tsing, phrased as the "ruins of capitalism."[93] They thrive in spite of capital, indebted to its effect on the landscape yet not cultivated by human will—living embodiments of what Tsing identifies as "unintentional design."[94] Like Tsing's third nature, Talloguaya was a product of the "world-making activities of many agents, human or nonhuman."[95] Yet, unlike a

[88] Emily Wanderer, *The Life of a Pest: An Ethnography of Biological Invasion in Mexico* (Berkeley: University of California Press, 2020), 16.
[89] Stefan Helmreich, *Silicon Second Nature: Culturing Artificial Life in a Digital World* (Berkeley: University of California Press, 2000), 11.
[90] Dana Graef, "Wildness," in *Theorizing the Contemporary* series with *Cultural Anthropology*, September 30, 2016, https://culanth.org/fieldsights/wildness.
[91] Tsing, *The Mushroom at the End of the World,* viii.
[92] *Ibid*.
[93] Stefan Helmreich, "Book Review: The Mushroom at the End of the World," *American Ethnologist* 43 (2016): 570-572, 570.
[94] Tsing, *The Mushroom at the End of the World*, 152.
[95] *Ibid*.

"landscape of unintentional design," Talloguaya was fashioned through intentional un-intentions, i.e. through the purposeful, "considerative" mimicry of first nature. If, as Michael Taussig writes, mimesis is "the nature that culture uses to create second nature," then biomimicry can be thought of as the nature that culture uses to create third nature.[96] Through biomimicry, Raúl aspired to regenerate the place of Talloguaya—a place ruined but also revitalized by green capitalist intent.

Through the "design" of third nature, worlds are (re)made: new subjects, new objects. What the design of Talloguaya revealed, I argue, was a third nature where the role of "designer," of passive biomimics vis-à-vis active natures, was restricted to the non-Indigenous sustainability professionals who hold a "considerative" attitude toward nature. For Raúl, Olmec ruins were an "inspiration," but the design practices of contemporary Indigenous persons were ignored, their presence on the land either erased in his "story of place" or else held responsible for the ruination of its ecological integrity. Within the third nature of Talloguaya, local Nahua and Totonac people were neither subjects of design, nor included as its design objects, in the "nature" of this "place." Talloguaya was, according to Raúl, not an "isolated park," but the people who lived there were stationed outside its "design," as supplements, relegated in Raúl's vision to service roles in support of his third nature: coordinating rafting and kayaking trips, or, as I would learn, cooking.

At the conclusion of our tour, we moved to the *palapa* for a dinner of deep-fried fish caught by local fishermen and prepared by a team of four "local Indigenous women." During our meal, Raúl said he had three kids: two were chemical engineers, and the other was in business. As the sun set, Adam spotted a shadowy figure afar—what appeared to be a tree-hugging animal. Calling attention to our nocturnal dinner guest, he guessed it might be an opossum. "Oh, yes," Raúl said, following Adam's gaze, "*tlacuache*." Like vanilla, he had introduced this marsupial.

[96] Michael Taussig, *Mimesis and Alterity: A Particular History of the Senses* (New York: Routledge, 1994), xiii.

"The Environment Interacts with You Differently": A Design Culture of Natural Vision

During the night, the rain sputtered loudly on the canvas tarp stretched taut across my tent, keeping me awake for the night. So too did the bestiary of spiders that stalked the sealed exterior. Lit up by my flashlight, they performed a menacing shadow theater. In the morning, I emerged weary from my tent and met the others at the *palapa*. After a breakfast of *huevos a la Mexicana*, corn tortillas handmade by the kitchen staff, and cups of local coffee spoon-drawn from a large clay pot (I wondered: from plantations?), Raúl instructed us to conduct the Be Here activity solo. "In modern society, it's easy to forget how interconnected we are with nature." To "reconnect," he told us to disperse throughout the camp to find "personal space and time to reflect on nature."

Figure 13: The Bobos I

While some lost themselves in the forest near, others, like myself, set out for the embankment of the Bobos. Rain began to fall, and the wind carried a cool breeze down the river from the mountains—a relief from the heat. Eschewing a dry patch under a nearby *ceiba* tree for a damp boulder close to the water, I listened to the trickle of the sky, the roar of the river, the call of a distant *oropendola* (*oro*, for its golden tail), and a pulsing insectoid drone Kristina Lyons

portrays as the sound of life's endurance.[97] On a bridge that conjoins the two banks, a fisherman had cast his barbed rod into the depths below. Turning about, I observed the micro-ecology that obtained next to the murky, flowing river. There, where the forest opened to a clearing, bamboo lost ground to tallgrass, ferns, and other short plants that offered meager protection from the rain. In my head, I could hear the voice of Delfín asking how the bees, ants, fireflies, and birds in this space had evolved numerous biological "strategies" to confer the "function" of water repellence. A plant nearby caught my eye with a leaf that had been folded upward, unto itself. Repositioned, I bent over to inspect this unexpected origami, only to find, to my surprise, a spider inside, dry. With a thread of its web, it had stitched together the sides of the leaf to build a roof over its head.

Following the cue of Adam and Grecía, who stood up from their respective seats, I returned to the *palapa*. Regrouped, we held a discussion about our experiences with Being Here. Jeremy started, saying that he "noticed more," including how two dragonflies had a flight pattern that varied with the rainfall, and Grecía documented how plant stems grew thicker in the river. Meanwhile, Cedric had studied a nest of vines that had wound up- and out-ward to the canopy and, also, to the shape of the leaves around him, which sloped down to deposit the water below. When I discussed the spider-in-the-leaf, Delfín responded that, while environments can shape an organism, so too can it "change the environment" at a "different functional level" than adaptation in form, which had thus far preoccupied our attention. Reflecting on the duration of perception, Alejandra expressed that "things were loud" but then "things slow down, relax, and move again." She "saw more—shapes, colors, structures." "*The environment interacts with you differently.*"

Delfín validated her: "Humans," he said, can see "two hundred different tones of the color green," a "special ability" related to a "history" of "running and walking through woods."

[97] Kristina Lyons, *Vital Decomposition: Soil Practitioners and Life Politics* (Durham: Duke University Press, 2020).

We are "landscape readers," he continued, with "specialized sight." Delfín's words naturalized a phenomenology of the landscape that anthropologists have shown is as much (if not more) about cultural narrations of the land as it is about innate biological capabilities. At first, this seemed to contradict the message of the workshop itself, which promised to "transform" our sight. But this cultural transformation was romanticized by Delfín as a return to a more natural phenomenology.

Simon found his time in the forest "peaceful." "We can't connect if we are overthinking," he shared, continuing, "if we are caught up in mental processes." As a former investment banker in London, Simon, a white man from South Africa in his mid-30s, later reflected that he was all too familiar with being "caught up." He has described himself as a "nine-to-fiver who stared at Bloomberg screens, settling trades and climbing London's corporate ladder." Depressed, he left London to travel around the world: Aconcagua, Lima, Florianopolis, Salar de Uyuni, and La Paz. Eventually, upon returning to Johannesburg, he discovered permaculture, which, he described as "more than a farming philosophy," but "principles" for "the way we live our lives as individuals, the choices we make, and the future we choose to build." Today, he runs an educational platform for sharing his knowledge about permaculture with others. Delfín replied that this is "why we are in a camp without electricity." This was a partial truth: a car-powered generator had been kept in reserve for emergencies. Still, during my time at Talloguaya, I was unable to acquire a cell signal on my phone, save for on top of one slippery rock several feet into the river, where several of us were sometimes seen contorting our limbs for reception, often at the cost of balance and dryness.

For Delfín, our forest retreat provided an intimate space to retrain our arts of noticing. He elaborated: "We have to manage ourselves and our state of being." He likened our exercises to the technologies of the self practiced in Buddhist-inspired mindfulness training, in Japanese "forest bathing," and in *waldeinsamkeit*, the German word for the feeling of the sylvan sublime.

By cultivating a different "state of being," we would attain a "deeper appreciation" of nature and, in so doing, "transform our way of doing things," the "same design paradigm" we have had for the past "two hundred years." "We *must* change our way of thinking, but we have to *be* different to do so, to change as a species on a planetary level." To design better, we had to change the self, a process initiated through the workshop, which aimed to give both the language to describe life but also the opportunity to experience it. "We need the knowledge, language," he said, to make sense of what we sense. In other words, Being Here was not an exercise in "amateur naturalism." Our goal, he said, was to "describe first, only later explain," for to explain was to invite what we had been referring to as "thought-ing." To Delfín, "explaining" evinced the "rootless caring" that Carol Sanford has described, he cited—rootless being a play on ruthless. Only in an embodied, face-to-face interaction with nature could we develop the "capacities" for seeing nature properly.

"Conscious Emulation of Life's Genius": The Mimetic Ethic in Relief

For half an hour, I watched an army of ants moving in perfect unison. From a perch across the Bobos, I observed their synchronized movements. With words from biomimicry taxonomy, I identified their sociological functions: moving, coordinating, cooperating, navigating, as well as sending and sensing signals. Adam was gently stroking the leaves of a fern, fascinated as they curled away from his touch. For half an hour, we sought organisms whose functions we could imitate, communicating our findings in a one-minute "commercial" that marketed our designs.

Energetically, we presented our inventions: cicadic speakers, cocoon-shaped sleeping pods, inchworm-inspired polymers, mossy bathmats, and my own ant-based navigation system. Without the scope of an ecosystem or design problem, our "tech" was predictably unpredictable, pointless, fanciful, and speculative. I had anticipated Raúl or Delfín to counter that our design

had more to do with "cleverness" than any connection to nature, but it appeared that our task was a simple exercise in tying nature to artifice through the logic of function—mere "brainstorming."

Still, one commercial, Simon's, received explicitly negative feedback from Delfín: a straw made from bamboo that Simon had presented as an alternative to the single use plastics that litter seas. "This is *not* biomimicry," Delfín stressed in his critique. "This is bio-utilization," which he defined as "using nature itself to create something." In contrast, biomimicry is when you "use function to emulate nature in design." After his aside, we resumed our commercials, only to return afterwards to the definition of biomimicry, which Delfín stressed as "important." Unlike bio-utilization, which involves the "manipulation" of nature, biomimicry is emulation. Not all bio-utilization is inherently "mal-adapted," he cautioned, citing medicinal plants and the straw that Simon had proposed, but this style of design has a tendency to "extract" without considering its embeddedness in an ecology of place, thus leading to unsustainable consumption.

Delfín offered a definition of biomimicry that he borrowed from Janine Benyus. Biomimicry, he said, "is the *conscious emulation of life's genius*." Emulation, the second term, distinguishes biomimicry, he said, from "biomorphism, designs that visually resemble elements from life." Emulation is "learning from" or "modeling the essence of" life, "not just copying it." In his parsing, copying is the reproduction of form where emulation aims to translate function. Biomimicry does not "look like" but "works like" life. "It's not a copy and paste," Raúl added.

According to Delfín, "biomimetics," a third term, "has no ethical code." This "code" referred to the evaluative logics that, in his mind, sets biomimicry apart as a mimetic practice. "Living things have evolved countless well-adapted solutions to have stood the test of time within the natural constraints of our planet," Delfín said. "Through biomimicry, we see an important opportunity to apply lessons from nature to begin creating human technologies that are

as sustainable (well adapted to Earth) as the living systems that surround us." Without this code, one could build a "nature-inspired bomb" or "beetle-inspired armor" vis-à-vis biomimetics. Raúl suggested that biomimetics was also a kind of "copying," yet its target was only the reproduction of function, not the reproduction of an "ethical" regime of value based on a "story of place."

To reinforce his point, Delfín quoted at length a passage from Benyus's *Biomimicry* that had been reprinted in our training manual:

> What will make the Biomimicry Revolution any different from the Industrial Revolution? Who's to say we won't simply steal nature's thunder and use it in the ongoing campaign against life? This is not an idle worry. The last really famous biomimetic invention was the airplane (the Wright brothers watched vultures to learn the nuances of drag and lift). We flew like a bird for the first time in 1903, and by 1914, we were dropping bombs from the sky. Perhaps in the end, it will not be a change in technology that will bring us to the biomimetic future, but a change of heart, a humbling that allows us to be attentive to nature's lessons. As author Bill McKibben has pointed out, our tools are always deployed in the service of some philosophy or ideology. If we are to use our tools in the service of fitting in on Earth, our basic relationship to nature—even the story we tell ourselves about who we are in the universe—has to change.[98]

This ethical aspect, which hinges on "quieting our cleverness," is "transformational," he stated. Defining the first term, "conscious," as "an intentional practice," Delfín had constructed what at first seemed paradoxical. If cleverness is intentionality, then biomimicry, as a polemic against the cleverness that has bedeviled modern design, is thus an intentional form of un-intentionality.

Cleverness, therefore, did not mean the phenomenology of intent—the experience of being directed toward something, as if one could have an experience-less experience—but the lack of moral intentions derived from life's 'will"—a disorientation to nature that brings design principles, or functions, "to hand" without care for the ecological limits of place.[99] If design, as Jeffrey Meikle defines it, is a kind of "intentional ordering" of worlds, then biomimicry, as Raúl

[98] Benyus, *Biomimicry*, 8.
[99] On the world as "ready to hand," see Martin Heidegger, *The Question Concerning Technology, and Other Essays* (New York: Harper Perennial, 2013[1954]).

and Delfín saw it, questions these world made. The habits of mind that biomimics aim to repress were thus seen as pivotal to becoming "good" designers, in the idealistic sense of copying nature with fidelity. Not everyone, however, could become a good designer. Excluded from this moral community of converts were not just the unethical practitioners of bio-utilization, biomorphism, and biomimetics practitioners, but the Indigenous people in Talloguaya's surrounding area, too.

"We Don't Need Human Systems": Diagramming Linearity

That afternoon, Delfín gathered everyone under the *palapa* to talk about "systems." While the heavy rain percussed on the roof and training manuals fanned panting faces slick with sweat, Delfín asked, "What is a system?" Alejandra replied: "A set of direct and indirect relationships," then "parts and relations with varying value." Delfín nodded, agreed and then proceeded to introduce systems by way of Ludwig von Bertalanffy's general systems theory, cybernetics, Fritjof Capra, and the ecological design theory of the American environmentalist David Orr. After defining what he called "systemic thinking" as an analysis of "process" along "six basic concepts"—network, recursion (subsystems), cycles, flows, evolution, and balance (later adding a seventh, emergence, to the fray)—Delfín stated, "Humanity has been oriented to components." But looking to components, he said, does "not help to understand the dynamic." For us to grasp how "human design systems" overlook dynamism, we conducted two diagramming activities.

Beginning, first, with "systems in nature" and, then, the "designed system" of a "human-made product or service," Delfín instructed us to "make a list of components, organize them by strength, define the types of relationships, and then add emergent properties and their dynamics," using an idiom of symbols, arrows, names, and notes to visually represent all relations and flows. We broke to think, and when we resumed, Jeremy compared two systems of energy production:

solar panels, which are not only costly in terms of rare minerals but also break and create waste, and the "oxygen cycle" in nature: a sun-driven cycling between photosynthesis and respiration. Raúl commented that human systems produce waste, garbage, and pollution but not natural ones. He used this distinction to return to Delfín's comment at Alchichica that humanity is linear while nature is non-linear, and clarified that this was a matter of intent. Human systems clearly behave non-linearly, with "unintended consequences," but they are all "designed" with linearity in mind. "*We do not need human systems*," he claimed. "Natural systems existed before us, and they will exist afterwards," agreed Delfín. We will not survive with only a "one-directional relationship." Simon joined the discussion and suggested the food forest around us as an alternate configuration of the agencies of humanity and nature, each shaping and reshaping the other with equal balance. "Exactly!" Deflín replied, "We need to move from a human-centered to a bio-centered universe." Returning to design, he concluded, "Humanity's state of being should be reconnected to nature."

In our second activity, we practiced diagramming nested systems using the "Systems Explorer Tool." Representing systems as boxes-within-boxes, we identified "super-systems," "systems of interest," "parallel systems," and "sub-systems." Raúl provided an example for us: a conifer tree contains a pine cone, the system of interest, which, in turn, contains bracts and seeds. Alternatively, he said, one could consider the conifer as the system of interest, nested in a forest; in this second system, birds and squirrels each contain within them, as the conifer, simpler parts. "This" tool, for Raúl, "implies that everything is connected, in one way or another way." Delfín added, "It gives dimension to the world." As we each tried our hand at applying the tool (for me, to a skate mosquito I had earlier followed along the shoreline), Alejandra noted that "there are lots of options…billions," she said, exasperated. "It's very complex," Delfín responded, offering that "it gives order to the universe." Raúl jumped into the conversation Alejandra had initiated,

"The choice of super-system varies…Change it until it makes more sense." "*It's just a model*." But, according to Delfín, not all models were the same. He observed, based on the prior activity, that very few of us had placed humans in natural systems, or natural elements in design systems. Echoing contemporary posthumanist critiques of social scientific theories of human history, sociality, and agency, he stated, "How we think determines how we give meaning to the world." The irony was that these biomimics were also guilty of imagining nature without people, without the people who had worked the land around Talloguaya before them but were erased from place.

"Church in the Wild": From an Instrumental Ethic to the Ecological Self

"Dissonance" was the word that Raúl selected to convey the "modern" relationship between design and nature—an apt metaphor, I thought, for the sonic disjunction he had earlier described. After a meal of tortillas and stewed corn, bean, and *chayote* (three vegetables planted together in in the polycultural farming method known by the Nahuatl word *milpa*, or "cultivated field"), we sat under the *palapa* in a circle and discussed the ethics of design. Quoting Aldo Leopold's "land ethic" from memory, Raúl postulated: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." Design in the "modern" paradigm has led to a sense of "dissonance" or, switching metaphors, a "fault" between nature and culture that has instrumentalized the biotic along a "spectrum of usefulness" with little concern for questions of its integrity, stability, and beauty. Janine Benyus, he said, has given us her own land ethic—"life creates conditions conducive to life"—and axiomatized how to enable its reproduction through "Life's Principles" (Figure 14). These principles allow us to see all the natural "design principles" lying "underneath" life—a design heuristic for biomimics.

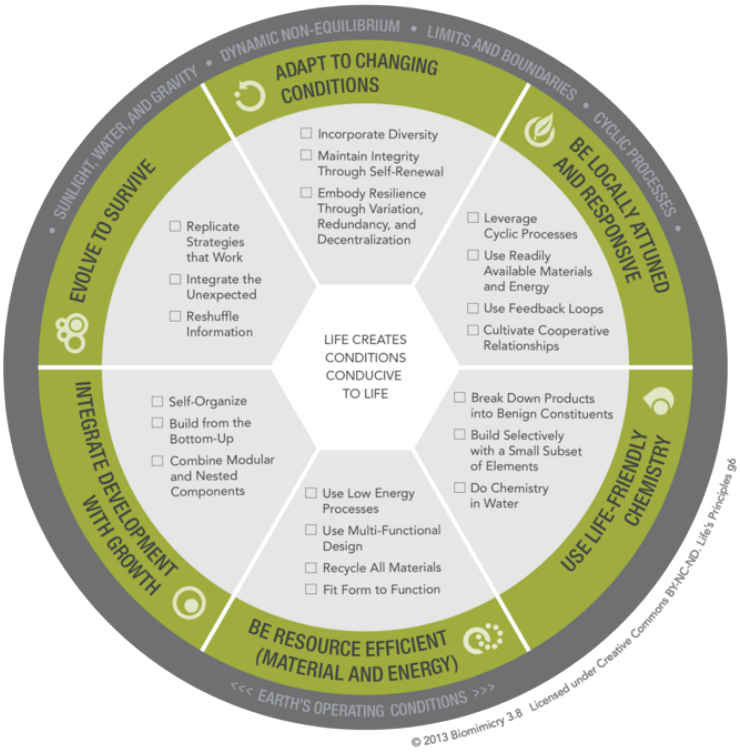

Figure 14: Life's Principles (courtesy of Biomimicry 3.8)

Despite our biotic nature, "we are more than biotic," Delfín said. "Nature does not have right or wrong," which fashions another kind of "fault" between logic, or science, and our ethics. Reconnecting with nature, ethically, would require another type of work beyond the epistemic: Knowing *what* nature *is* does not necessarily justify *how* design ought to make new things. Where place can reveal guides for a mimetic ethic, it was for biomimics to make sense of them, an indeterminacy that demanded a new kind of ethical self sensitive to the "will" of the living.

Ana Gabriela, an eco-psychologist and consultant whom I had earlier seen paging through a copy of the deep ecologist Arne Naess's *Thinking like a Mountain*, contended that ethics begins with an embodied and affective grasp of our relationality with life. From the material fact of face-to-face "engagement" grows an emotional "connection" to nature. With this felt notion, we can direct our "will" toward developing a "biospheric egalitarianism," one which safeguards the inherent value of all life—"a species consciousness beyond divisions." There are

"layers of being," she said, from an "egotistic self" to an "ecological" or "species" self, and reaching the highest layer leads to the realization that tending the self tends to nature too.[100] For Ana Gabriela, "care of the self" was seen as prior to John Hartigan's "care of the species."[101] Through affects of wonder and awe toward nature, biomimics believe they can recognize, as the anthropologist Gregory Bateson did, that our selves are always already ecological, enmeshed.[102]

"What habits are we cultivating?" Ana Gabriela asked. "And how?" Biomimicry, she believed, offers both a language and a space for experiencing the sublime interrelatedness of life as well as a set of "habits" for effecting, not just an "individual shift," but a "systems level shift" toward a "higher consciousness." Reaching this plane of consciousness would demand educational forms that transcend the "silo-ing" she believed to be a key feature of the university.

Winding back, Ana Gabriela asked if anyone had experiences connecting to nature. Nearly everyone had a story from their past. Adam remembered playing with turtles in his yard while Alejandra recollected a fascination with books about dinosaurs. Simon used to escape to the sea while Delfín would ditch high school to float down the river. Ana Gabriela stared at the stars on travels with her father, who administered and distributed vaccines to rural communities. Rebecca and Grecía both had memories of social introversion and nature as their preferred place, the one in the mountains, the other under avocado trees that her family had planted in the garden. Where most invoked a childhood past, Jeremy closed the conversation with a recent encounter: While hiking with friends amongst redwood trees in the San Francisco bay area, he recalled that they were overwhelmed with a feeling of relation. Stricken with this sense, they genuflected and

[100] See Arne Naess, *Thinking like a Mountain: Towards a Council of All Beings* (Gabriola Island: New Society Press, 2007).
[101] John Hartigan, *Care of the Species: Races of Corn and the Science of Plant Biodiversity* (Minneapolis: University of Minnesota Press, 2017).
[102] For a different read on the "ecological self," see Gregory Bateson, *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology* (Chicago: University of Chicago Press, 1999[1972]).

began to pray. "It was like church," he said, before elaborating, "It was like church in the wild." Through the recitation of these memories, Ana Gabriela framed an affect of wonder, or awe, as the mediator between human and nonhuman and the developmental origin of the mimetic ethic. In turn, she recast our workshop as the furtherance of this ethic—a mode of "ritual semiosis."[103]

"How Can I Live My Life?": Moral Renewal in Trees and Totomac Ruins

The following morning, we gathered by the vans for the day's outdoor excursion: a drive upstream to a segment of the Bobos River known as *El Alto Filo*. There, according to Raúl, the Mexican whitewater rafting industry exploded in the mid-nineties. Along the banks of the river, a "gallery" forest had grown, so named for the trees that, at a height of forty meters, extend up and over the river; as their canopies touch, they give the impression of a tunnel, passage, or corridor. In addition to resembling a corridor in form, this forest also functions as a biological corridor: a space, rich in biodiversity, where birds, fish, and insects moving upstream and downstream meet. As such, *El Alto Filo* would offer an ample inspiration for the week's capstone design challenge. We swapped our rain jackets for a different mix of waterproof gear and all gathered by the vans. During a prolonged wait for dilatory participants, Ana Gabriela calmly told us that a scorpion had wandered into her tent the evening before, and onto her leg. She gingerly ushered it back out. Rebecca, who had forgotten to pack shorts, said she had just been stung—less attuned, perhaps.

We were not on the road long before we pulled over beside a small banana farm and pressed onward through the trees, over fallen brush and overripe fruit, crunching and squishing. We reached a clearing of bananas, a vista of the zigzagging river, and a sudden, precipitous drop. To reach our destination, a trio of rafts at the foot of the ravine, we had to hike a path down the

[103] Eitan Wilf, *Creativity on Demand: The Dilemmas of Innovation in an Accelerated Age* (Chicago: University of Chicago Press, 2019).

face of the cliff—a hard trail made ever more treacherous by thick roots. On our descent, I spoke with Ana Gabriela about her background. While her bachelor's was in information sciences and journalism from the Monterrey Institute of Technology, her training in environmental studies did not begin until 1997, when she enrolled in a master's program at the University of Guadalajara in environmental education, with a specialized concentration in psychology and behavior change.

After, she joined Pronatura Noreste, a branch of Pronatura México, the largest environmental nonprofit in the country. Based in Monterrey, she developed a communication plan for the conservation of the Chihuahuan desert and the Tamuilpecas wetlands. In 2003, she left to found and run Punto Verde: her own consulting firm that counsels NGOs, governmental agencies, and private companies on sustainability management and public relations, including a ten-year contract with HSBC México. In 2019, after my fieldwork, she relinquished her position as the chief executive officer to become the chief creative officer. This has allowed her to focus more on other creative projects, which, beyond Biomimicry Mexico, include a "hands on" reiki practice and Mamá Changuito ("Little Monkey Mom"), a nonprofit that coordinates a series of menstruation classes and therapies based on a syncretic, mystical theology of sacred motherhood.

Figure 15: The Bobos II

At last we arrived at the base, where a team of local eco-guides were awaiting us, having already carried down our rafting equipment—guides whom, as he told us, Raúl trained. While we boarded our dirigible crafts, Raúl veered toward a kayak that he would operate alone, taking off before we had finished receiving instructions. Much of the initial section of the river was too strenuous and demanding for us to "listen" to nature, its waters rough and tumultuous, but as the stream slowed and our rafts steadied, Raúl paddled close by and began to tell us about riverine ecologies. Sometimes sitting up, others times lying down, arms crossed contemplatively, he informed us that rivers are "flows of matter and energy" that "connect in biological objects." In this vital place, water and the moisture that it provides defines the main operating condition. The plants on each side of the river—the large trees that touched above but also shrubs, orchids, moss, and climbing plants—had to contend with moving water, flooding, fast evaporation, high humidity, and the problem of runoff, all of which contributed to an exceedingly moist soil level. Because of the challenge hydration posed, there were "layers to the ecosystem"—distributions of species and the stratification of their biological strategies over "frontiers, borders, and barriers."

Relaxed and supine, Raúl was in his watery element, absorbed in a state of flow, psychological and physical. The farther down the river that we floated, the closer the walls of the ravine became until they adjoined the water—sheer, with almost hand-carved rectilinearity. These rock walls, Raúl told us, were extensions of the Sierra Madre mountain range that spans a wide swath of eastern Mexico. We stopped at a small beach, where a waterfall filled the reusable water bottles of most of our group. At another beach, we recessed to "Be Here" and enjoy lunch. Raúl highlighted distant cranes and an oropendola, a growth of wild tomatoes near where we sat, and then a colossal ficus tree, approximately one hundred feet in height, also native to the region. After explaining how its fruits, figs, feed a plethora of animals, and how its limbs shelter others,

Raúl urged us to "mimic how it gives life," asking ourselves "how can I live my life" like a ficus. He asked us to "stop and pray," to "give thanks" to this tree, a "provider of ecosystem services." Raúl contrasted the ficus with the pruned bonsai—a "cruel" practice, he felt, that "limits life."

If the flower basket exuded what I called *technical charisma* to Tim (Chapter One), another species of "nonhuman charisma" attracted Raúl to the ficus.[104] To him, the ficus was less technological model than it was moral exemplar—a role model, he thought, for how to live life. while the fig exuded *moral charisma* in its positive form, the bonsai was a negative case, a point of moral revulsion. The ficus and the bonsai, in Raúl's scheme, were ethical antipodes that define the limits of "good" and "bad" behavior. These plants were, to Raúl, living embodiments of what Claude Levi-Strauss might have said were "good to think with," but also act like, and against.[105] In their dialectic of good and evil, Raúl found a reply to the question of how to live a good life: one which would further and support life's vital processes, not limit them (i.e. regeneration).

Still farther down the river we flowed until we disembarked the rafts at our final stop: El Cuajilote, an archaeological site that, as Raúl said to us, he stumbled upon while rafting in the early nineties. In his telling, there are six ruins littered along the Bobos, all of which were built by the Totonac people. While one, Vega de la Pena, was previously known to archaeologists, the other five, El Cuajilote included, were familiar only to local residents—"their property," he said. As Raúl encountered and explored these places, he recognized their anthropological value, and he contacted a federal scientist affiliated with the Instituto Nacional de Anthropología e Historia with the hope of mapping the sites and opening them up to public visits. To his dismay, however, this particular official tried to "steal" the discovery, writing Raúl out of numerous press releases.

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[104] Cf. Jamie Lorimer, "Nonhuman Charisma," *Environment and Planning D: Society and Space* 25.5 (2007): 911-932.
[105] Claude Levi-Strauss, *Totemism* (Boston: Beacon Press, 1963[1962]), 89.

At the time of our visit, only two of the sites, El Cuajilote and Vega de la Pena, had been cleared for tourism. When we arrived, we were the only visitors. Closed to the public due to recent loots, we had only been granted access after Raúl had sought explicit permission to lead us through it.

Named for the chote tree, a scarce plant once prevalent across the Totonac region, El Cuajilote was the ceremonial site of a "fertility cult" associated with the bounty of the Bobos. Located four kilometers away from Vega de la Pena, a zone of tribute and commerce trafficking in obsidian, fruit, and fish, El Cuajilote, as Raúl put it, "separates the commercial from sacred." Obscured by many centuries of encroaching foliage when Raúl first wandered into the space in search of a private place to urinate, he told me impishly, El Cuajilote had since been cleaned up. What we saw was an immense plaza of cut grass, an avenue lined by two rows of buildings that led to a second plaza and culminated in a massive stone pyramid. Inhabited from 200 to 900 CE, El Cuajilote is, in its spatial design, orographic. As we walked toward the central pyramid, Raúl encouraged us to note how, with the distribution of hills in the background, this temple appeared like a mountain itself. So too did the distant mountains recall pyramids, and every evening the sun sets in between their triangular shapes. Like the ficus and the bonsai, El Cuajilote, as well as Cantona, exhibited to him a design aesthetic. El Cuajilote's design was also hydrographic. As we noticed on our visit, the location of some buildings corresponded with waterfalls and views of the river. This, Raúl explained, was no accident as water symbolized fertility. The main pyramid, he added, sat atop a spring, and in front of it guarded the headless statue of a frog—a river deity who, when the site was abandoned, was sacrificially beheaded. Before its end, however, the frog watched over fertility rituals conducted here by Totonac people traveling in religious pilgrimage.

"There is no ritual in modern society," Raúl regretted as we rested near the pyramid.[106] But, as he saw it, biomimicry offered a way "back"; "biomimicry renews" the action of ritual. Introducing our next exercise as an undertaking in ritual, we sought to enact systems theory with our movements by playing two rule-based games. Distributing ourselves out across the plaza, we first learned about how "interconnected" we are by selecting two other individuals in secret and attempting to maintain an equal distance between them at all time to form an equilateral triangle. When Raúl removed one player, the experience of ensuing chaos was meant to prove, with our bodies, that we are all affected by the actions of others. In the second game, "prey and predator," we were each given two types of behavior—straight lines or cross-wise movements—that aimed to show the most efficient patterns that obtained between players. When we were called back to sit in front of the temple, Raúl introduced the concept of "leverage points" by Donella Meadows. Through embodied pedagogy, not unlike the "body work" that Natasha Myers uses to describe the knowledge protein crystallographers attain with somatic enactments of folding, our actions were meant to affectively reinforce a relation with nature—the corporeal sense of an ethical bond to other living beings that Ana Gabriela had before portrayed as the genesis of an ecological self.

"Leaving a Trace": The Cultural Politics of Third Nature

In further preparation for the design challenge, we departed for the terminus of the Bobos, an 800-hectare forest of mangrove trees under federal protection as a natural reserve. Less than a kilometer from the ocean, an inland lagoon had formed where the Bobos meets the Atlantic. In its shallow depths, a mess of mangroves littered the land and water, the labyrinthine roots of one inextricably interwoven with the roots of their kin. Some of these mangroves dated over three

[106] Compare with Max Weber on ritual in *The Sociology of Religion* (Boston: Beacon, 1993[1920]).

hundred years old—a testament to their "sustainability" in the salty, brackish conditions of the Cienegas del Fuerte Mangrove Protected Area. While rich in nutrients from the river and ocean tributes, the lagoon would be uninhabitable were the mangroves not "filtering devices," as Raúl explained on our drive—"natural living machines" that have evolved to desalinate the water and expel the excess salt from varying places across their bodies: leaves, roots, trunk, and branches. Where the mangrove excretes salt depends on the species—black, white, red, and yellow—and, with eyes panning the lagoon, one can note, he said, a gradient of species and of salt tolerances. In addition to filtering the water, the mangrove has evolved a distinctive root system. Most were used for stability and support; a couple rise above the water to perform vital gas exchange.

Our immediate destination was Martinez de la Torre, a cheery and colorful town dotted with palm trees that lies a few kilometers shy of the mangroves. Raúl had hired an Indigenous guide, to take us by boat to and through the forest. The guides, he said, were trained in ecology, "guardians of the ecosystem." (Note the contrast between people who "don't care" the river vs. "guardians," after training.) Aboard the Sofia Valfria, we suited up in lifejackets and departed from the shore; as we cruised toward the mangroves, its gas motor orchestrated a flabby score. The waters of Cienegas del Fuerte are calm, with a current that pulses in gentle waves. They are also shallow, no more than three meters deep, and they glisten with a ruddy sheen from tannins released by the mangroves. On the way, we passed shrimp and crab fishermen with conical nets (*attaraya*). Pelicans circled them, waiting for a release; one fearless bird perched on their boat. Soon, we neared, and our driver cut the motor, idling to enter a narrow strait between the trees.

Turning to face us, Raúl called the mangroves, the main organisms there, "ecosystem engineers." The muddy soil that lay beneath our boat was a product of their activity. So too were the seeds that fed and nourished multiple species of fish below—seeds that had captivated Raúl.

“Bullet-like” in form, they grow roots before falling at a certain weight into the water, piercing its surface and diving fast to the soil below. Dense in nutrients, they grow as fast as they fall in order to escape the mud and reach the sun. One mangrove can generate a thousand seeds a year, and with such a plentiful supply of food, many fish leave their young here for food and shelter in and among the nest of roots. Barnacles affix to their roots too—roots that also affix ecosystems, shielding against hurricanes. Because of their many attachments and points of anchor, mangroves can distribute the forceful winds. Likewise, they grow in clusters, which, Raúl told us, makes for a resilient system. “They don’t face a hurricane alone.” This, he recollected, was why a hurricane that once hit the Sumatran shores leveled numerous five-star hotels but left its mangroves intact. Pointing to a spider on one mangrove, a skull tattooed on its thorax, Raúl praised the strength of its web, which was also resilient “like the mangrove.” Both possessed a sort of charisma to him.

“Listen to the voice of the mangrove. Become the mangrove. Be welcome to the mangrove,” Raúl instructed as we stalled to “Be Here.” With the motor off, the atmosphere was quiet, except for the binaural chorus of cicadas and the occasional plunge of crabs into the water. When he spoke again, he led through an activity based on “extracting” biological strategies from the mangroves (the extraction step of the biomimicry design method is detailed in Chapter One). As we worked through the exercise, Raúl shared that he had once designed a building based on a different kind of tree. After researching how this tree supported the weight of its canopy through a “pattern” of six structures, he designed a ceiling enclosure that consumed less roofing material.

At the end of his story, Raúl ate a banana and discarded the peel off the boat’s side. Copying his lead, other members of our party followed suit, throwing their bananas overboard.

In a stern tone, Ana Gabiela reprimanded him for "leaving a trace" in the mangrove ecosystem. Little more was made of their conversation, and we returned to the docks for a relaxing afternoon at the beach, where some lounged in hammocks while others followed Ana Gabriela in tai chi.

Figure 16: Traces

The next day, the question of traces lingered. After learning about the methods of biomimicry in the evening, we received our design challenge following the night's rest. On an easel propped upright in the *palapa*, a prompt to design a "container system" had been written:

> A study group needs to travel for 8 days through 10 different ecosystems [author's note: ecosystems, i.e. *not* inhabited socio-political territories]. They need a container that is able to carry light enough and has access for every different kind of clothing, gadgets, gear, and food needed to take every day of the journey in a way that leaves no trace and optimizes carbon emissions in the making, use, reuse, and disposal of the system.

After a round of question clarified the prompt, two additional constraints were revealed: the study group in question numbered fifteen to thirty persons, and there were no budgetary limits.[107]

[107] An unrestrained budget was meant to simply our design process given the brief amount of time we had for our challenge, but Raúl later reflected that the container system should, ideally, be widely affordable.

Furthermore, the ten ecosystems were, we were told, the same ten that we had recently traversed, which thus required a system impervious to fluctuations in temperature, hydration, and sunlight. As retrospective as it was prospective, the challenge mirrored our past as it built to the future. Over two days, Grecía, Jenn, and I ("Team 3") reviewed our notes and wandered the camp for bio-inspiration, seeking organisms whose ecologically adapted strategies might befit our system.

In a way that leaves no trace. My thoughts kept returning to this line in the prompt. Should our systems contain space for waste, or did this mean we could pack food without waste? More importantly, why was this highlighted, and what did the disagreement between Raúl and Ana Gabriela say about their notions of a mimetic ethic and ontologies of nature and the human? Several hours into our open design time, Ana Gabriela and Raúl sat beside us, inviting question. At this point, I asked about the meaning of the "trace." Ana Gabriela opened by stating that the container system should be well-adapted—"specific to these ecosystems"—to which Raúl added that we should consider the "resources for each ecosystem: animals, plants, social communities."

I asked about waste. Ana Gabriela wondered if the food waste would be "bioavailable." She stated, "You cannot leave anything that would not *naturally* be there": toilet paper or food. Raúl had a dissenting opinion: "As super-organisms, our traces should be regenerative." He said that the notion of leaving "no trace" was misguided; it assumed an unchanging Nature out there. In contrast, a regenerative trace would "follow the purpose of the system," adding to the system but not altering its underlying patterns, not unlike the mangrove—an ideal ecosystem engineer.

In principle, Ana Gabriela agreed, but, when I queried if the banana constituted a trace, she was adamant that discarding spent bananas "can only put in energy that's not sustainable." "They do not eat bananas in México?" Raul quipped. "No," she responded. "Not in the water." Raúl pressed onward. "Should we kill non-native species? Contain them? Should we let them be

a part of evolutionary history? *We are a part of it.*" Immediately, Ana Gabriela answered in turn, "*Everything we do is questionable*," by which she expressed discomfort with our "cleverness." Raúl paused and reflected. "Perhaps," he admitted, "I should not have done it [tossed the peel]." Without conceding that traces could be regenerative—that "garbage [can] be good"—he posed, as a thought experiment, the possibility that water lilies might grow with the excess of nutrients created by the banana peel, which, in turn, can be harmful to the fine balance of local ecologies. "But," he concluded, "lilies cannot tolerate brackish water," even if they can originate upstream. While he could not determine if the peel was beneficial, he was satisfied with the knowledge that it did not actively cause harm—at least for the time being, until further inspection said otherwise.

For Arjun Appadurai, to be human is to design.[108] "Design is only partly a specialist activity, confined to an artisanal or digital class," he writes, "and is better seen as a fundamental human capacity and a primary source of social order."[109] To Ana Gabriela, this existential condition—the condition of being human in nature—was a source of abiding consternation and uncertainty about our "cleverness" and of perennial doubt about the "intentional ordering" that underlies the nature of being human, that is, design, our "relation to nature." On the other hand, Raúl embraced this indeterminacy. His words: a "continuous process of becoming fully human." Yet, in his reduction of the ambivalence of the "trace" to ecological cycles of energy and matter, Raúl made the politics of third nature—of leaving a trace—a technoscientific question, one that was the purview of biomimics alone. Excepted from this "matter of concern"[110] were the people who inhabited the land, farming banana plantations. Raúl, however, could toss a banana peel.

[108] Arjun Appadurai, *The Future as Cultural Fact: Essays on the Global Condition* (London: Verso, 2013).
[109] *Ibid*, 254.
[110] On "matters of concern," see Bruno Latour, "Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern," *Critical Inquiry* 30.2 (2004): 225-248.

When I was later asked to recapitulate to the group what I had labelled "bananagate," Raúl extolled biomimicry as a species of design that did not aim to "preserve" nature, but to "regenerate" life. In his estimation, the emulation of life's genius allows us to reconnect with a nature that "modern" design had abandoned. To imitate morally, however, emulation had to proceed with "biophilia," an affective sense of interconnection, and "bioethics," a "questioning, always questioning" of our "cleverness," our intents toward nature. To regenerate nature, Raúl continued, we have to "regenerate the self," to "go outside our own needs." Only then will we develop "empathy, compassion, and care" for nature. Focusing on the self, Delfín added, would "grow our species or planetary being," into an ecological self—"a holobeing," he concluded.

Before we left, Raúl summarized four principles of design he derived from Fritjof Capra. He started, "Nature is the best teacher…Sustainability through community…Know the 'place.'" Pausing, he struggled to remember the fourth. Finally, he gave up, and invented one: "Tequila!"

Going "Deep": On Mimicry and Monsters

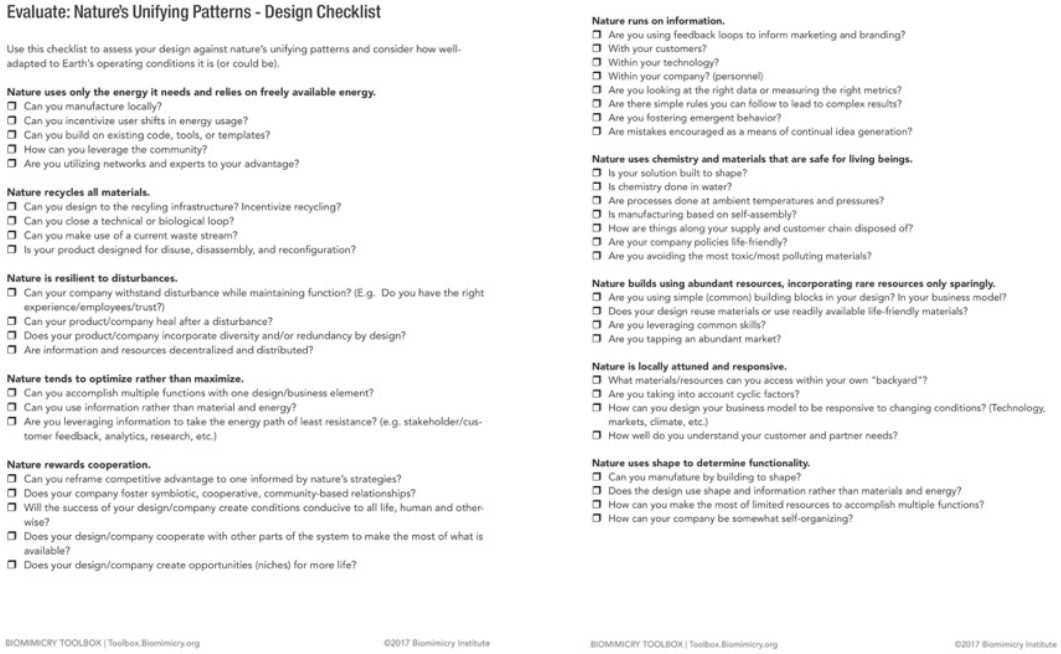
The considerative attitude that Raúl urged us to adopt recurred throughout the challenge that occupied our final two days. At the outset of the challenge, we reviewed the biomimicry design "spiral" (see Chapter One). Because we had been prompted to design with a set "problem" in mind (i.e. a "container system"), the path we selected was "challenge to biology", where one "defines" and "biologizes" the question to "ask nature" before later "discovering," "extracting," "emulating," and "evaluating" a biological model. Raúl summarized the first step, "Identify a *real* challenge," where "'real' is the key word," he stressed. Questions, he continued, are oft the "cause" of our problems—cognitive "symptoms" of an unexamined moral conscience. "Good" design involves questioning the question itself. Delfín spoke to add that self-evaluation ensures

that we "go deep into the functions we want to perform"—our capacity to interpret and imitate life's genius. "With better questions," Raúl said, resuming, "we will find better answers."

Their comments induced a stirring of reflective design thinking. Whereas preliminary conversations between groups over cups of coffee and fruit from the forest had indicated to me that a "backpack" was the consensual interpretation of the container system, Grecía queried if the "apparatus" had to work for the entire group or just one person. Similarly, Rebecca wondered if everyone had to carry the same amount and if members of the study group could rotate the packs. Jeremy, building on their questions, started to emphasize the "system" word in the design prompt by asking what would happen if someone left; the pack, for him, needed durability *and* duration. Raúl seized Jeremy's interrogation of the prompt as a system or "process" to caution everyone, "Don't focus on the artifact yet!" Generally pleased with the questioning he had witnessed, Raúl again spoke, "Remember that the design spiral is a simplified version of what is in reality a non-linear and iterative process." He continued: "You should expect to revisit earlier steps and revise your work along the way as new discoveries lead you to rethink previous conclusions. That's the reason it's a spiral, not a straight line." Iteration and interrogation were integral items of design.

While the hermeneutic attitude that Raúl promoted was informal and internal, the moral principles to which it adhered had been formalized and objectified as a "checklist" of "Nature's Unifying Patterns" (Figure 17). "All organisms perform these in nature," Raúl told us. These "patterns" were natural ideals against which we ought to evaluate the "rightness" of our designs. Reading from our manual, he said: "The intent behind applying nature's unifying patterns for biomimetic designs is to create more sustainable solutions. only by considering nature's lessons in a systems context can we ensure that our designs fit in well with life on Earth." Returning to a comment earlier about the recursiveness of design, he mentioned that the patterns should inform

the entire process of the biomimicry method: "Once you begin to understand these patterns, you should start applying them at the very beginning of your design process, in the scoping phase, and continue pondering and using them throughout all your design phases." As we evaluated our designs in turn, he asked, "Which [of the patterns] would be easy to do? Which would be right?"



Evaluate: Nature's Unifying Patterns - Design Checklist

Use this checklist to assess your design against nature's unifying patterns and consider how well-adapted to Earth's operating conditions it is (or could be).

Nature uses only the energy it needs and relies on freely available energy.
- ❒ Can you manufacture locally?
- ❒ Can you incentivize user shifts in energy usage?
- ❒ Can you build on existing code, tools, or templates?
- ❒ How can you leverage the community?
- ❒ Are you utilizing networks and experts to your advantage?

Nature recycles all materials.
- ❒ Can you design to the recyling infrastructure? Incentivize recycling?
- ❒ Can you close a technical or biological loop?
- ❒ Can you make use of a current waste stream?
- ❒ Is your product designed for disuse, disassembly, and reconfiguration?

Nature is resilient to disturbances.
- ❒ Can your company withstand disturbance while maintaining function? (E.g. Do you have the right experience/employees/trust?)
- ❒ Can your product/company heal after a disturbance?
- ❒ Does your product/company incorporate diversity and/or redundancy by design?
- ❒ Are information and resources decentralized and distributed?

Nature tends to optimize rather than maximize.
- ❒ Can you accomplish multiple functions with one design/business element?
- ❒ Can you use information rather than material and energy?
- ❒ Are you leveraging information to take the energy path of least resistance? (e.g. stakeholder/customer feedback, analytics, research, etc.)

Nature rewards cooperation.
- ❒ Can you reframe competitive advantage to one informed by nature's strategies?
- ❒ Does your company foster symbiotic, cooperative, community-based relationships?
- ❒ Will the success of your design/company create conditions conducive to all life, human and otherwise?
- ❒ Does your design/company cooperate with other parts of the system to make the most of what is available?
- ❒ Does your design/company create opportunities (niches) for more life?

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Nature runs on information.
- ❒ Are you using feedback loops to inform marketing and branding?
- ❒ With your customers?
- ❒ Within your technology?
- ❒ Within your company? (personnel)
- ❒ Are you looking at the right data or measuring the right metrics?
- ❒ Are there simple rules you can follow to lead to complex results?
- ❒ Are you fostering emergent behavior?
- ❒ Are mistakes encouraged as a means of continual idea generation?

Nature uses chemistry and materials that are safe for living beings.
- ❒ Is your solution built to shape?
- ❒ Is chemistry done in water?
- ❒ Are processes done at ambient temperatures and pressures?
- ❒ Is manufacturing based on self-assembly?
- ❒ How are things along your supply and customer chain disposed of?
- ❒ Are your company policies life-friendly?
- ❒ Are you avoiding the most toxic/most polluting materials?

Nature builds using abundant resources, incorporating rare resources only sparingly.
- ❒ Are you using simple (common) building blocks in your design? In your business model?
- ❒ Does your design reuse materials or use readily available life-friendly materials?
- ❒ Are you leveraging common skills?
- ❒ Are you tapping an abundant market?

Nature is locally attuned and responsive.
- ❒ What materials/resources can you access within your own "backyard"?
- ❒ Are you taking into account cyclic factors?
- ❒ How can you design your business model to be responsive to changing conditions? (Technology, markets, climate, etc.)
- ❒ How well do you understand your customer and partner needs?

Nature uses shape to determine functionality.
- ❒ Can you manufature by building to shape?
- ❒ Does the design use shape and information rather than materials and energy?
- ❒ How can you make the most of limited resources to accomplish multiple functions?
- ❒ How can your company be somewhat self-organizing?

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Figure 17: Design Checklist / Ethical Code[111]

In *The Uses of Pleasure*, Michel Foucault marks the "ethical work" that individuals perform in the process of moral becoming—"technologies of the self"—as distinct from three other aspects of ethical "subjectivation": the ethical substance, mode of subjection, and telos.[112] Where the foremost refers to the exercises and operations a person conducts upon themselves, he defines the others, in turn, as the "object" of inward-facing introspection (desires, feelings, etc),

[111] Biomimicry Institute, "Evaluate: Nature's Unifying Principles – Design Checklist," accessed September 27, 2021, https://toolbox.biomimicry.org/wp-content/uploads/2017/10/NUPs.Checklist-10.17.pdf.
[112] Michel Foucault, *The History of Sexuality, Vol. 2: The Uses of Pleasure* (New York: Vintage, 1990[1983]), esp. "Morality and the Practice of the Self," 25-32.

as the style of inhabiting a particular moral code, and as the final aim of moral self-fashioning.[113] Earlier, I identified the sensory activities we engaged in as instances of technologies of the self, directed as they were to the negation of the self vis-à-vis intent—the "substance" of biomimicry. The suppression of the self, i.e. "cleverness," would lead to us "becoming nature," design's telos.

As Raúl circled around the *palapa*, peering over our shoulders as we discussed our checklists, it became clear that Nature's Unifying Patterns occupied the role of the ethical "code" through which we should all, from his perspective, craft our notions of selfhood. Even as Raúl recognized the pragmatic constraint on attaining all of these patterns in one design, he reinforced their status as our moral objective. "Although," he mused, "it may be impossible to fully apply all ten patterns within a design, given current limits in human-made materials and systems," it remained true that "replicating all of these patterns is an excellent aspirational goal." *Going deep*, as Delfín called it, meant evaluating our designs against a standard that one may, in most contexts of practice, only near asymptotically—a utopian demand but also a moral imperative.

If "deep" emulation represented a material state one may never reach, then the inverse situation of *shallow* design was an all-too-common result that one must always strive to avoid. At the culmination of our two-day design challenge, each of the three teams prepared ten-minute presentations that showcased their products alongside a meticulous description of their methods. While no team drew inspiration from the same organism as another, exhibiting a range of source material from cacao beans to *Talavera* spiders, every team, in spite of pretension to do otherwise, reverted back, in their designs, to the geometry of the bag or backpack—a failure to question the "artifact space," as Alejandra phrased it later in retrospect (compare Figures 18, 19, and 20).

[113] For an expanded theorization of Foucault's four-part anatomization of ethics, reference James Faubion, *An Anthropology of Ethics* (Cambridge: Cambridge University Press, 2011), in which he identifies six components.

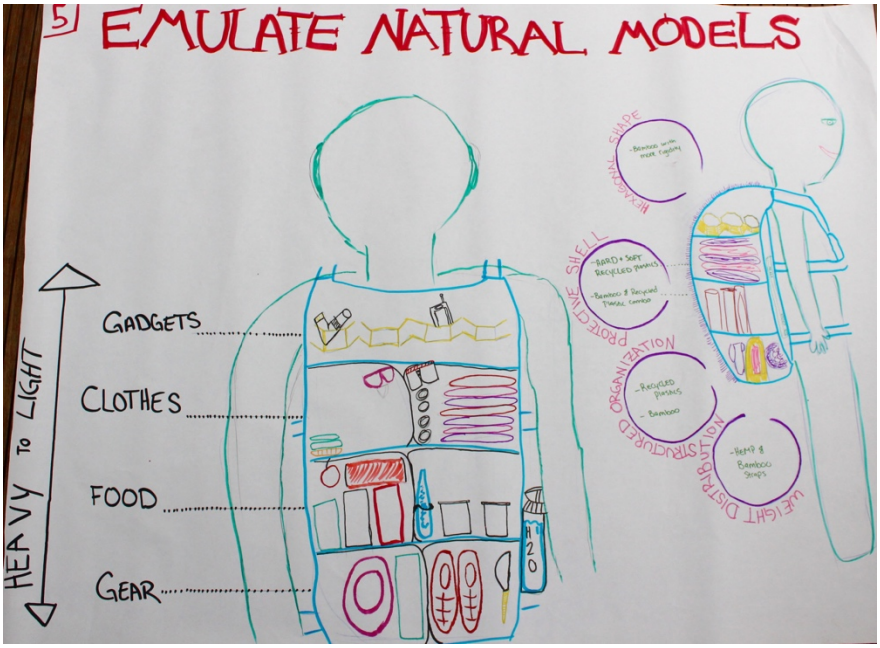

Figure 18: Team 1 (Rebecca, Jeremy, Cedric)

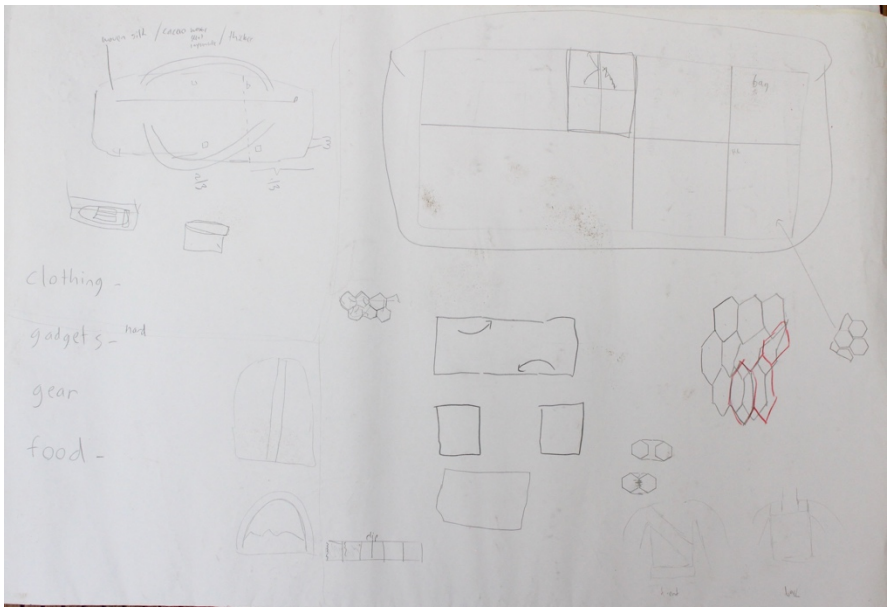

Figure 19: Team 2 (Alejandra, Adam, Simon)

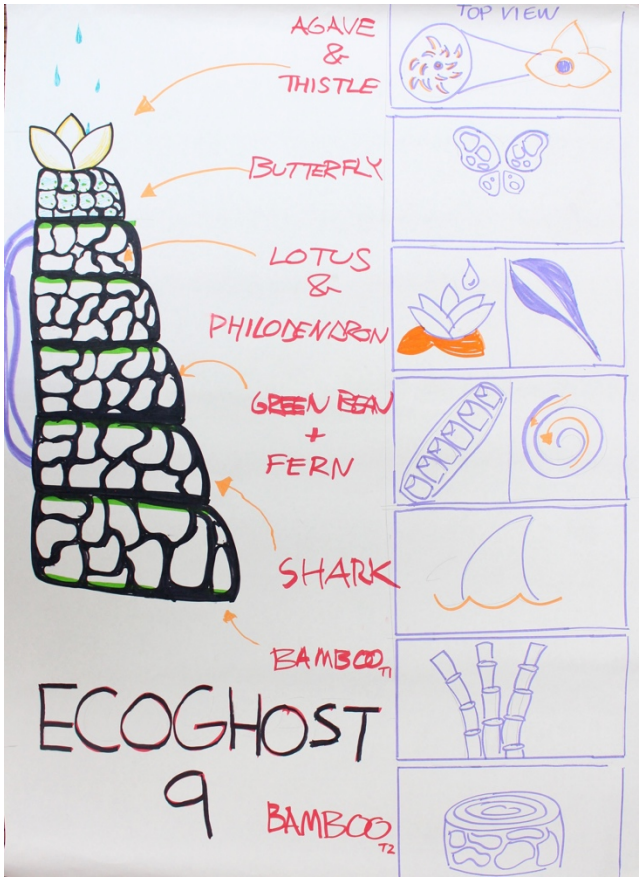

Figure 20: Team 3 (Grecía, Jenn, author)

More disconcerting to our guides than this conceptual inertia, however, was the *in*fidelity of our imitations to the "will" of nature. Each team presented a design that fused a minimum of four "design principles" (for a definition, refer to Chapter One) in one single artifact; our team presented, in homage to "Bananagate," the Ecoghost 9—a design with a whopping 17 principles. Initiating what turned into a critique of the monster in design, Delfín admitted that biomimicry is a "dynamic process" that can, when unrestrained, birth "*chimeras of design*," unsettling hybrids of animals ecologically unrelated, unbound.[114] "A whale, a clam, a kidney," he gave an example. Raúl accepted that, for our first attempt, in the time we had, with a multi-locale challenge, what

[114] On monsters, see Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York, NY: Vintage, 1994). On other crossings of natural kinds, see Sophia Roosth, *Synthetic: How Life Got Made* (Chicago: University of Chicago Press, 2017), esp. Chapter 2.

we had made was normal for the "first conceptual stage," but he warned us that emulation in this manner can "become more rhetorical than it was in nature." "It doesn't serve a purpose," he said, but "if you *go deep,* you will find patterns." We "don't always need to go deep," he then mentioned, "but then it's just *inspiration*," not biomimicry, which pledges allegiance to pattern. In this idealistic stance, "going deep" demanded an impossible fidelity to life's design principles.

Ana Gabriela labeled our work "Franken design"—human-made, artificial, "clever." But deviation from nature's purpose can come in many forms, she said, not just in the chimeric. She cited the Shinkansen bullet train in Japan. Broadly revered as an exemplar of biomimicry, Ana Gabriela offered a diverging opinion: While the train might have "borrowed the form of the kingfisher [bird]" for its technical innovations in speed, it "ignored" nature's unifying patterns. "Speed was attained but its tracks do not work well"—a failure to consider its ecological context. For her, its performance inefficiencies were read as both a design flaw and a moral transgression. With advice that was conclusive and prospective, Delfín returned to the motions of the spiral: "Select what organisms you really wanted to use," he told us, "then follow the spiral and iterate several times to identify for deeper levels of abstraction and consistency." Otherwise, we would create "designs not carried all the way through," stuck between the virtuous and the monstrous.

Design as an Ethical Problem?

On the last day, Raúl requested that we walk with him through the forest to a clearing of trees. Recently tilled soil surrounded a hole in the ground. Every year, workshop attendees had seeded a new species of tree, experimenting to see if it would "adapt" to this "place." As the rain lightly fell atop our heads, we buried a *chico* seedling, also known as the sapodilla fruit. Raúl asked us to "give thanks" to Talloguaya and contribute to the land by tossing a handful of soil on its roots.

As a rite of passage, this communal planting commemorated the end of the workshop, but it also symbolized the beginning of our moral roles as biomimics—builders, designers, of third natures. Leaving behind what we hoped would be a positive trace on the land, we enacted regeneration in a gesture that was believed to reflect the "purpose" of this place. It was fitting that none of us would return to Talloguaya. In our absence, it was up to Raúl to decide if we had adapted to life.

Figure 21: Ritual, Renewed

In biomimicry, immersive workshops like the one documented in this chapter sell an escape from the sensory distractions of "modern" existence, presenting nature, as Shiho Satsuka notes of wilderness retreats in Canada, as a "utopian space" of freedom.[115] Within these spaces

[115] Shiho Satsuka, *Nature in Translation: Japanese Tourism Encounters the Canadian Rockies* (Durham: Duke University Press, 2017), 1. See also Fletcher in *Romancing the Wild*, in which he describes ecotourism as "an attempt to escape the anxiety, alienation, and dissatisfaction commonly experienced in everyday work routines; to immerse oneself in a timeless wilderness where one can achieve a sense of peace and freedom ostensibly unattainable within the confines of (post)industrial civilization," 4.

of intimacy to life, workshop guides like Raúl, Delfín, and Ana Gabriela instruct participants in the art of cultivating an ecological self through exercises that instill a set of sensory, affective, and moral dispositions toward nature—an intentional un-intentionality. Through a new "relation to oneself," we were told we could constitute a new "relation to nature" through design that was "accurate" to "place"—the idealistic stance. Beyond teaching an epistemology of life, workshops also teach an ethic of life—a mimetic ethic—that animates the moral subjectivities of biomimics. Realizing this ethical ambition in the everyday practice of design—"going deep"—was a utopian demand that even Raúl acknowledged. In his architectural work, he mentioned to me on the drive back to Mexico City that biomimicry was more often a "tool" or a "technique" than the basis of a studio's entire design philosophy. Like Tim, Taryn, and Peter recognized in Chapter One, what is demanded by biomimicry was deemed unattainable in the context of contract work with clients.

Implicit within Raúl's musings on the possibility or impossibility of fidelity was a cultural politics of imitation. Who controlled the perception of "nature" and adjudicated whether its mimesis in third nature was successful or not? By predicating an epistemology of life on their mimetic ethic, the biomimics I trailed down the Río Bobos authorized themselves as "life's" true whisperers—"ethical" actors in contrast not just to bio-utilization or biomimetics but also all the local Indigenous people who were interested, in Raúl's own words, in "extraction" from the land. This ethical language promised what Elizabeth Johnson has called "human subjectivity without oppositional consciousness"—a fantasy of first nature accessible to a select few who cultivated a "considerative" attitude. Formulating "design" or "intent" as an ethical problem masked what is, in reality, a problem of the political economy of nature—of multiple, conflicting designs on life.

3

The Elementary Forms of Design: The Epistemic Space of *Homo mimesis*

In *Biomimicry*, Janine Benyus etched a romantic anthropology of *Homo mimesis*—an original modality of mimetic technopoeisis—in which she positioned the present Indigenous peoples of North America. Rudiments of this anthropological figure, however, can be discerned across the Western canon of design theory, especially architectural. From the Roman architect Vitruvius in the 1st century B.C.E. to Benyus in the present day, design theorists have looked to the technical practices of foreign societies—to the Other's technicity—and found them to be innately mimetic. Throughout this millennia-spanning lineage, cultural "difference" has been grasped as "distance" in time, as Johannes Fabian once said.[1] To put it in other terms, imaginaries of mimetic peoples abroad (or, in settler states: at home), have located imitation in the past: design's first principle or what Émile Durkheim might have called its "elementary form."[2] Through a return to "origins," a long tradition of design theory has drawn on mimesis to reflexively ponder the nature of design.

I said "rudiments" because the significance of *Homo mimesis* to Benyus is not the same as it would have been to Vitruvius. In this interlude, I intend to chart the evolving meanings of an "epistemic space" from which *Homo mimesis,* i.e. its contemporary incarnation, has developed.[3] In their history of the concept of heredity, Staffan Müller-While and Hans-Jörg Rheinberger state

[1] Johannes Fabian, *Time and the Other: How Anthropology Makes Its Object* (New York: Columbia University Press, 1983), 9.
[2] Émile Durkheim, *The Elementary Forms of the Religious Life* (Oxford: Oxford University Press, 2008[1912]).
[3] Staffan Müller-Wille and Hans-Jörg Rheinberger, *A Cultural History of Heredity* (Chicago: University of Chicago Press, 2012).

that, while "heredity" did not exist until the 19th century, prior notions of "generation" occupied a congruent space of thought. For them, the historiographic method of "epistemic space" maps a domain of continuity and discontinuity between the two "epistemes."[4] Likewise, by tracing what mimesis has evoked to design theorists from Vitruvius to Benyus, I aim to distinguish three types of understanding mimetic design—*speculative*, *romantic*, & *anthropological*—that are united in their referral to current practices of the Other as evidence of design's past. For Müller-While and Rheinberger, the use of the word "space"—as opposed to, say, "genealogy"[5]—reflected not only the spatial dimensions of epistemology ("a vast, spatial configuration of distributed technologies and institutions connected by a system of exchange"[6]) but also mutations in the epistemology of space in biology (i.e. the relocation of heredity into the cell). In a related fashion, the three mini-histories of *Homo mimesis* that I chronicle here allude to a dilation in the geography of design theory's object of contemplation (the expansion of the "globe" and increase in "contact" through colonialism and globalization) and shifts in the meaning of design, or: the construction of space.

Speculative: Vitruvius

According to the architectural historian Joseph Rykwert, Marcus Vitruvius Pollio's *Ten Books of Architecture* is the oldest written record of design theory.[7] Commissioned by and dedicated to the Roman emperor Augustus in the first century B.C.E., *De Architectura* ("On Architecture") aimed to provide the Imperator Caesar with theoretical principles for fortifying the authority of public space—an early union of statecraft, power, and design. Vitruvius postulated that each and every architectural work should accord with one, or a hybrid, of three "Orders" which he derived

[4] Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York, NY: Vintage, 1994).
[5] Michel Foucault, *The Archaeology of Knowledge* (New York: Vintage, 1982[1969]).
[6] Müller-Wille and Rheinberger, *A Cultural History of Heredity*, 23.
[7] Joseph Rykwert, *On Adam's House in Paradise: The Idea of the Primitive Hut* (Cambridge: MIT Press, 1981).

from classical Greek architecture: the Doric, the Ionic, and the Corinthian. Vitruvius created a logic for sorting a building into the Orders by its ratios of arrangement, eurythmy, and symmetry.

De Architectura is also the oldest written record of *Homo mimesis*, or a variation upon it. To logically justify how architecture had differentiated into the Orders, Vitruvius envisioned the first artificial habitat—design's primal scene, a mythical fireside shelter that he described as the "origin of the dwelling house."[8] The genesis of architecture, Vitruvius believed, lay in mimesis:

> The men of old were born like the wild beasts, in woods, caves, and groves, and lived on savage fare. As time went on, the thickly crowded trees in certain places, tossed by storms and winds, and rubbing their branches against one another, caught fire, and so the inhabitants of the place were put to flight, being terrified by the furious flame. After it subsided, they drew near, and observing that they were very comfortable standing before the warm fire, they put on logs and, while thus keeping it alive, brought up other people to it, showing them by signs how much comfort they got from it. In that gathering of men, at a time when utterance of sound was purely individual, from daily habits they came upon articulate words just as these had happened to come; then, from indicating by name things in common use, the result was that in this chance way they began to talk, and thus originated conversation with one another.
>
> Therefore it was the discovery of fire that originally gave rise to the coming together of men, to the deliberative assembly, and to social intercourse. And so, as they kept coming together in greater numbers into one place, finding themselves naturally gifted beyond the other animals in not being obliged to walk with faces to the ground, but upright and gazing upon the splendor of the starry firmament, and also in being able to do with ease whatever they chose with their hands and fingers, they began in that first assembly to construct shelters. Some made them of green boughs, others dug caves on mountain sides, and some, in imitation of the nests of swallows and the way they built, made places of refuge out of mud and twigs. Next, by observing the shelters of others and adding new details to their own inceptions, they constructed better and better kinds of huts as time went on.
>
> And since they were of an imitative and teachable nature, they would daily point out to each other the results of their building, boasting of the novelties in it; and thus, with their natural gifts sharpened by emulation, their standards improved daily. At first they set up forked stakes connected by twigs and covered these walls with mud. Others made walls of lumps of dried mud, covering them with reeds and leaves to keep out of the rain and the heat. Finding that such roofs could not stand the rain during the storms of winter, they built them with peaks daubed with mud, the roofs sloping and projecting so as to carry off the rain water.[9]

[8] Vitruvius, *The Ten Books of Architecture* (New York: Dover Publications, 1960[1914]), 38.
[9] *Ibid*, 38-39.

The transition from a state of nature, "like the wild beasts," to a culture of nature turned on a capacity for mimesis, i.e. of "others" and of "the nests of swallows and the way they built."[10] Imitation and intercourse are the causal principles of his morphogenetic theory, in two ways: both ontogenetically (i.e. the building) as well as phylogenetically (the history of architecture).

Testimony to this ur-architecture came to Vitruvius in the design practices of near and distant tribes. "That houses originated as I have written above, we can see for ourselves from the buildings that are to this day constructed of like materials by foreign tribes: for instance, in Gaul, Spain, Portugal, and Aquitaine, roofed with oak shingles or thatched."[11] He continued surveying, in turn, the Colchians in Pontus, the Phrygians, Marseilles, and Athens. "From such specimens," Vitruvius reasoned, "we can draw our inferences with regard to the devices used in the buildings of antiquity, and conclude that they were similar."[12] Drawing parallels between the past state of civilization and the present art of the ethnic Other, Vitruvius anticipated the reading of space as time that Fabian later termed "allochronism."[13] Over time, Vitruvius then concluded, the Greeks eschewed the animalistic references of "rude and barbarous modes of life" for the mimesis of the ideal human body—a revolution in tectonic symbolism that he viewed as the era of civilization.[14]

Romantic: Laugier

In 1753, the French critic and ex-Jesuit Marc-Antoine Laugier returned again to architecture's mimetic origins. After *De Architectura* was lifted from obscurity during the Italian Renaissance, classicism—a revival of Vitruvius's Orders—became the regnant style of architectural design.[15]

[10] Rykwert, *On Adam's House in Paradise*, 110.
[11] *Ibid*, 39-40.
[12] Vitruvius, *The Ten books of Architecture*, 40.
[13] Fabian, *Time and the Other,* 32.
[14] *Ibid*, 42.
[15] Vitruvius's Orders appeared sparsely and sporadically across the Middle Ages, and his concept of the "dwelling house" was even more uncommon in medieval theory. While Poggio Bracciolini is often applauded for rescuing *De*

Laugier viewed the dominant interpreters of Vitruvius (but not Vitruvius himself) with disdain. To him, architects like Andrea Palladio and Leon Battista Alberti were "servile imitators" who "copied the faults as scrupulously as the beauty."[16] While they had upended the "barbarism of the succeeding centuries," such as the stones "in fretwork, shapeless masses, and […] grotesque extravagance" of the "Gothic and Arabesque styles," they replaced them with a "low and faulty taste" and a "complete decadence."[17] Laugier mused derisively: "Lacking principles which could make them see a difference, they were bound the confuse the two."[18] Written from his apartment in Paris, Laugier's *Essai sur L'architecture* thus turns to "man in his primitive state without any aid or guidance other than his natural instincts."[19] Origins, he thought, would purify architecture.

"It is the same in architecture as in all other arts," Laugier began. "Its principles are founded on simple nature, and nature's processes clearly indicates its rules."[20] We catch our first glimpse of what Laugier called the "savage" at rest—poised, peacefully, "on the banks of a quietly flowing brook," then wandering elsewhere, driven by the elements.[21] To the forest he goes, for shelter from the sun; then, to a cave, for relief from the rain; and, last, to architecture, where, "by his ingenuity" and "some fallen branches," the "savage" builds a house made of twelve sticks, marking his transition from a nomadic life of itineration to an architecture of endurance: four sticks planted skyward, the vertical edges of a three-dimensional cube, four laid horizontally to connect the uppermost vertices, and four that stretch from these corners to a

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Architectura, Rywkert attributes its lasting appeal to the Renaissance humanists who elevated the classical Orders to the level of canon: Cesare Cesariano, Daniele Barbaro, Andrea Palladio, Leon Battista Alberti, Francesco di Giorgio and Sebastiano Serlio. In his analysis of the Temple of Jerusalem, Juan Bautista Villalpanda secured classicism by unifying notions of nature, reason, and the Orders with Christian grace. During the Renaissance, the dwelling house did not anchor any theory of architectural principles. See Rykwert, *On Adam's House in Paradise*, esp. Chapter 5.

[16] Marc-Antoine Laugier, *An Essay on Architecture* (Los Angeles: Hennessey & Ingalls, 1977), 2.

[17] *Ibid*, 8, 8, 9, 9, 9.

[18] *Ibid, 2.*

[19] *Ibid,* 11.

[20] *Ibid.*

[21] *Ibid,* 12.

central elevated line—a slanted frame for a roof of leaves.[22] In this manner, "man is housed."[23] Out of this "little rustic hut" (*petite cabane rustique*), he partitions, through space, his culture.[24]

In what became known in architecture as the "primitive hut," the vertical sticks evoked the columns of antique ruins; the hut's frame, the entablatures; and its roofing, the pediments.[25] From the primitive hut, Laugier traced a history of architectural progress and the evolutionary conservation of three generic categories of form across the many species of Western architecture. At the origin of of architecture is mimesis. His "savage" mimics nature to find elemental relief. "By imitating the natural process, art was born. All the splendors of architecture ever conceived have been modeled on the little rustic hut."[26] In "the simplicity of the first model," Laugier found "true perfection"—a renewed paradigm for following the Doric, Ionic, and Corinthian Orders.[27] "From now on it is easy to distinguish the parts which are essential to the composition of an architectural Order and those which have been introduced by necessity or have been added by caprice," he wrote. "The parts that are essential are the cause of beauty, the parts introduced by necessity cause every license, the parts added by caprice cause every fault," a "fertile" model.[28]

The primitive hut grounded a theory of architectural positivity as well as negativity. "Everything that goes against nature may be peculiar but will never be beautiful," he decreed.[29] Only through the elaboration of rational criteria of taste can the discerning public exclude what he called "*bizzarreries*" in form, from "replacing round columns with oval ones" to pillars with

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[22] *Ibid*.
[23] *Ibid*.
[24] *Ibid*, 12.
[25] The numerological symbolism of the sticks might reflect physical necessity for the "savage" architect, but, more likely, stems from Laugier's polemical desire to retrospectively justify the Orders and police their classical revival.
[26] *Ibid*, 12.
[27] *Ibid,* 12.
[28] *Ibid,* 12.
[29] *Ibid,* 32.

faces greater than four.[30] Yet while Laugier admitted the entrance of new variations upon these three generic categories, such ornamental novelties had to meet strict requirements: an adherence to the "moral authority" of nature.[31] In other terms, it was not exactly diversity that Laugier decried but rather perversity—queer aberrations of nature. "My reasoning," Laugier concluded, "is that nature has not two different ways of bringing about an effect," adding that "the effect is more or less satisfying according to how strictly one adheres to the unique way that leads to it."[32]

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[30] *Ibid,* 17.

[31] Lorraine Daston and Fernando Vidal, "Introduction: Doing What Comes Naturally," in *The Moral Authority of Nature*, eds. Lorraine Daston and Fernando Vidal (Chicago: University of Chicago Press, 2004).

[32] *Ibid,* 63. In effect, Laugier's critique amounts to a theory of the necessary and the unnecessary. Exactly what constituted the necessary for the "savage' builder was an open question that vexed thinkers who came after Laugier. For Quatremere de Quincy, Jean-Louis de Cordemoy, Carlo Lodoli, and Claude Perrault, the controversy of his "primitive hut" emanated from the hut itself—not the fact of mimesis. What troubled them was the paleontological tenet that wood (and thus the hut) and *not* stone (and the mound) was elevated to a first principle—a proposition that rested uneasily within nationalist efforts to construct myths of architectural origins. That mimesis drove the multiple *origins* of architecture stood unchallenged. See Rykwert, *On Adam's House in Paradise*.

Influenced by disputes over national "styles" of architecture, which, outside France, included John Ruskin and Augustus Welby Pugin, Gottfried Semper's *Der Stil* (1861) mounted a different attack on the notional validity of Laugier's "primitive hut" theory. In his philosophy of aesthetics, Semper reconsiders architecture through the act of weaving, drawn from nature itself, which, for him, begat all other modes of technical production: "As the first partition wall made with hands, the first vertical division of space invented by man, we would like to recognize the screen, the fence made of plaited and tied sticks and branches, whose making requires a technique which nature hands to man, as it were." More than a substitution of a "primitive" tent for the primitive hut, Semper's technical preference led him to conclude that mimesis did not copy natural appearances but cosmic structures. One theorist to break from the mimetic theory of technopoeisis was the Austrian art historian Alois Riegl. In *Stilfragen* ("Problems of Style"), Riegl contended that the psychological question of why "primitive" builders would seize upon natural appearances or any other principle remains unaddressed. In lieu of mimesis, Riegl proposed *Kunstwollen* (loosely translated as "artistic intention") as an alternative. The artist, for Riegel, took elements from nature, not by instinct or reason, but in accordance with contingent ideas of style. Quoted in Rykwert, *On Adam's House in Paradise,* 30.

The advent of modernism largely reproduced the "primitive hut." In Le Corbusier's *Vers une Architecture* ("Towards a [New] Architecture"), he writes: 'Primitive man has halted his chariot: He has decided that here shall be his home ground. He chooses a clearing and cuts down the trees that crowd it in; he levels the ground about it; he makes a path to the stream or to the settlement of his fellow tribesmen which he has just left […] This path is as straight as his tools, his hands, and his time will let him make it. The pegs of his tent describe a square, hexagon, or octagon: the palisade forms a rectangle whose four angles are equal […] the door of the hut opens on the axis of the enclosure, and the gate of the enclosure faces the doorway of the hut." Similar configurations of the "primitive" and the "modern" appear in writings by André Lurçat, Frank Lloyd Wright, Adolf Loos, and Ludwig Mies van der Rohe, who exhorted his fellow architects to return to origins: "Let us guide students over the road of disciplines from materials, through function, to creative work. Let us lead them into the healthy world primitive building methods, where there was meaning in every stroke of an axe, expression in every bite of the chisel." Le Corbusier phrased it similarly: "They had forgotten that great architecture is at the very origins of humanity and that it is the immediate product of human instinct," lending "protection against the arbitrary." Quoted in Rykwert, *On Adam's House in Paradise*, 18, 18, 15. See also Marcel Vellinga, "The Noble Vernacular," *The Journal of Architecture* 18.4 (2013): 570-590; Jo Odgers, Flora Samuel, and Adam Sharr, eds., *Primitive: Original Matters in Architecture* (London: Routledge, 2006); Felicity Scott, "'Primitive Wisdom' and Modern Architecture," *The Journal of Architecture* 3.3 (2010): 241-261.

The architectural historian Anthony Vidler hypothesizes that Laugier's "primitive hut" was, in part, based on the Iroquois architecture that the French missionary-ethnographer Joseph-François Lafitau observed in Quebec, Canada (Kahnawake Mohawk Territory).[33] For Vitruvius, the "dwelling house" was a logical fiction that, while corroborated by the design practices of his "foreign tribes," primarily functioned as an explanation by way of history. To the contrary, what Laugier located in Iroquois design were what the anthropologist Michel-Rolph Trouillot detailed as "descriptions of an alleged state of nature in the realist mode."[34] Returning to design's origins, for Laugier, was a "realist" means to construct a "nature" that would justify architectural praxis. In the transition from the "dwelling house" as descriptive to the "primitive hut" as normative, the Vitruvius's "men of old" came to inhabit what Trouillot thought of as the "savage slot"—a space of discourse wherein the "savage" embodied the inverse of Western "order" and, simultaneously, its "utopic" climax. In the wake of the Renaissance, the birth of "Europe" as an idea, and the rise of colonialism, Laugier's romantic theory of first mimesis sought aesthetic renewal in the Other.

Anthropological: Alexander

In *Notes on the Synthesis of Form* (1964), Christopher Alexander, a prominent figure in the 1960s Design Methods movement and one of the most widely read theorists of the 20th century, returned to mimesis to escape from "modern" reason. With an eclectic synthesis of postwar information theory and experimental psychology, Alexander argued that the "modern" designer, unbound by aesthetic tradition, resorts, vainly, to "intuition" in order to process the "complexity"

[33] Anthony Vidler, "Rebuilding the Primitive Hut: The Return to Origins from Lafitau to Laugier," in *The Writing of the Walls: Architectural Theory in the Late Enlightenment* (Princeton: Princeton Architectural Press, 1987).
[34] Michel-Rolph Trouillot, "Anthropology and the Savage Slot: The Poetics and Politics of Otherness," in Richard Fox, ed., *Recapturing Anthropology: Working in the Present* (Santa Fe: School of American Research Press, 1991), 23.

of current design problems. "Bewildered," Alexander averred, "the form-maker stands alone." Eschewing nostalgic defenses of "individual genius" and "period style," which would seek to rescue design from modernization, Alexander turned to the anthropological archive to unearth the "origins" of design's demise and a "rational" method for creating form—nostalgia, revisited.

Architectural studies by Robert Redfield, Margaret Mead, Raymond Firth, and other anthropologists formed the evidentiary basis for Alexander's contention that "cultures" can be divided into one of two types by their "method of making things and buildings": "selfconscious" and "unselfconscious" cultures.[35] Alexander's two-culture model associated what he described as "primitive" unselfconsciousness with technical reproduction unmediated by formal reflections on design. Selfconscious cultures, conversely, objectify their know-how in principles that are debated, modified, and overturned. Without the inertia of tradition, designers languish in the soil of arbitrariness. According to Alexander, design went awry when mimesis ceded to reasoning.

Alexander's distinction between cultures on the basis of imitation and rationality borrowed from an anthropological tradition of theorizing "primitive" mentalities as mimetic.[36]

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[35] *Ibid,* 33.

[36] In *Primitive Culture* (1871), Edward Burnett Tylor tentatively arranged the languages, beliefs, and rites of societies contemporaneous with one another to draw an evolutionary axis of "savagery" to "civilization"—a thought experiment designed to challenge the received-ness of the social order. At the zero point of this imaginary line, Tylor situated the "imitative faculty," a psychological function that early humans used in their attempts at speech, technology, and even reason itself. Like J.G. Herder, Tylor stated that language was, in the beginning, mimetic, which could be verified, indirectly, through the "survival" of "sounds of interjectional or imitative character, which have their meaning…by being taken up directly from the world of sound into the world of sense." "Directly natural" sounds, "like pantomimic gestures, … are capable of conveying their meaning of themselves, without reference to the particular language they are used in connexion with." Tylor's original mimetic language was representational but not symbolic: Vocal sounds referred, immediately, that is, without the mediation of an arbitrary sign system, to a nature out there. "Savages," Tylor believed, "possess in a high degree the faculty…of going straight to nature." Mimicking the "primitive war" theory of Augustus Pitt Rivers, Tylor also based the origin of technology in mimesis: "The lower stages begin with the mere direct imitation of nature, copying the shelters which nature provides, and the propagation of plants which nature performs." So fundamental was mimesis to Tylor's anthropological history that he attributed the genesis of modern scientific reason, which derives from, in its prototypical form, the "association of ideas" or mimetic analogies known as magic—the "pseudo-science" that birthed Western rationality. "Such resemblances," he asserted, "…thrust themselves directly onto the mind, without any necessary intervention of words. Deep as language lies in our mental life, the direct comparison of object with object, and action with action, lies deeper"—an unmediated relation to nature. See Edward Burnett Tylor, *Primitive Culture, Volume 1* (Mineola: Dover, 2016[1871]), 65, 160, 160-1, 163, 68, 116, 119, 26. On Herder, refer to Anson Rabinbach, "Introduction to

Where Laugier and Vitruvius returned to the primal scene of mimesis to understand architecture's first principles, Alexander was interested in mimesis as an alternative rationality that would permit an escape from the corruption of "modern" reason. For him, anthropologies of mimetic design promised a return to the natural, the instinctive, and the given—another human mode of thought. It is within this most recent iteration of the epistemic space of *Homo mimesis* that Janine Benyus wrote *Biomimicry*, representing mimesis as another sort of anti-modern logic.

Walter Benjamin's 'Doctrine of the Similar,'" *New German Critique* 17 (1979): 60-64. On Tylor's fight with the Church of England, see Michael Fischer, "Culture and Cultural Analysis as Experimental Systems," in *Anthropological Futures* (Durham: Duke University Press, 2009), 1-49.

In his discussion of "sympathetic magic," James Frazer (1890) continued Tylor's inquiry into the associative psychology behind magic, which, he argued, could be further divided into imitative and contagious species of magic. Where the former kind of magic governed by the logical principle that "like produces like," the latter operates under the assumption that "things which have once been in contact with each other continue to act on each other at a distance." Denigrating magic as a "spurious system of natural law" and a "false science," and imitative magic specifically as a fallacy of "assuming that things which resemble each other are the same," Frazer corroborated the Tylorian identity between imitation and irrationality, which positions the mimetic faculty as the ancestral and inferior mode of rationality that scientific reason amends. See James Frazer, *The Golden Bough* (Oxford: Oxford University Press, 2009[1890]), 26.

In a short essay published in 1933, Walter Benjamin re-interpreted the "mimetic faculty," the "capacity for the generation of similarities," as a cipher for decoding humanity's deep history, in particular the cultural evolution of language and thought. For Benjamin, mimesis saturated the primal scene: Speech, he argued, originated with mimetic onomatopoeia, later developing into words and other signs of "nonsensuous similarity." Benjamin observed a decline in mimesis: "Our gift for seeing similarity is nothing but a weak rudiment of the once powerful compulsion to become similar and also to behave mimetically." Benjamin also attributed its psychological twilight to the emergence of modernity, albeit with no causal argument: "For clearly the perceptual world of modern human beings seems to contain far fewer of those magical correspondences than did that of the ancients or even that of primitive peoples." See Walter Benjamin, "Doctrine of the Similar," in *Selected Writings, Volume 2, Part 2, 1931-1934* (Cambridge: Belknap Press, 1999), 696, 697, 695. See also "On the Mimetic Faculty" in the same volume.

Citing Tylor and Frazer, mimicry was also a focal point for Roger Caillois, who, two years after Benjamin, portrayed the faculty in anti-Darwinian terms. In mantises and other animals, Caillois contended that mimicry functioned, not as a "defensive reaction," but rather as a "luxury"—a "dangerous luxury"—and a "pathology" that reflected an unconscious desire to "become assimilated into the environment," to sacrifice the "distinction[s]" of organismal difference to the "lure of space," or abnegation. This expression of an "*instinct d'abandon*"—one present in animals but visible too, he argued, in "primitive magic," in psychasthenia, and in mathematics—was Bergsonian vitalism perverted, a manifestation of the "inertia of the *elan vital,*" wherein "life withdraws to a lesser state." Unlike Benjamin, Caillois viewed mimesis as an enduring feature of human psychology and a constitutive supplement to the reproduction of life, not merely a relic of bygone rationalities. See Roger Caillois, "Mimicry and Legendary Psychasthenia," in *The Edge of Surrealism: A Roger Caillois Reader* (Durham: Duke University Press, 2003), 97, 91, 98, 91, 99, 102, 102, 101.

Much of this discussion would be continued and debated by Lucien Lévy-Bruhl, Paul Radin, and Claude Levi-Strauss. See Lucien Lévy-Bruhl, *How Natives Think* (Mansfield Centre: Martino Publishing, 2015[1925]); Lucien-Lévy Bruhl, *Primitive Mentality* (Boston: Beacon Press, 1966[1923]); Paul Radin, *Primitive Man as Philosopher* (New York: NYRB Classics, 2017[1927]); Claude-Levi Strauss, *The Savage Mind* (Chicago: University of Chicago Press, 1996[1962). See also Stanley Diamond, "Introduction: The Uses of the Primitive," in Stanley Diamond, ed., *Primitive Views of the World* (New York: Columbia University Press, 1964), v-xxix.

Homo mimesis *as Renewal*

In the epistemic space of *Homo mimesis*, design theorists glance at once to the past and to the future—a kind of exotropic temporality. "Speculation on the essentials of building," Rykwert notes, "intensif[ies] when the need is felt for a renewal of architecture," and a new "paradigm."[37] Such speculations, seen from a historical perspective, authorize reform through first principles. "If architecture was to be renewed, if its true function was again to be understood after years of neglect, a return to the 'preconscious' state of building…would reveal those primary ideas from which a true understanding of architectural forms would spring," Rykwert wrote of the "hut."[38] The power of the original, he deduced, "seemed to be a staple of the human social condition."[39]

In her 2016 Frazer Lecture, Jane Guyer reads returns or "recuperations" as dialectical responses to indeterminacies—expressions of "general uncertainty about framing the future."[40] "People," she noted, "attempt to bridge a damaged past (judged as deserving or undeserving of such destruction) and an indeterminate, emergent future within a present that requires effort and imagination, by drawing on retrievable elements or fragments rather than (or in addition to) systemic replacement."[41] Like Guyer, I understand the nostalgic longing for *Homo mimesis* within biomimicry as a kind of yearning for a livable future that depends on an (imagined) past.

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[37] Rykwert, *On Adam's House in Paradise*, 183, 190.
[38] *Ibid*, 28.
[39] *Ibid,* 191. On the power of the original, see also Taussig, *Mimesis and Alterity*.
[40] Jane Guyer, "Aftermaths and Recuperations in Anthropology," *Hau* 7.1 (2017): 81-103, 82. See also Fischer, *Emergent Forms of Life and the Anthropological Voice*. On death/rebirth, see Frazer, *The Golden Bough*.
[41] Guyer, "Aftermaths and Recuperations in Anthropology," 90.

III

Can the Biological Innovate? Imitative Prestige and Strategic Animacy

The David Brower Center in Berkeley, California, is a long, grey building, almost cylindrical, and segmented by cement pillars that lend the exterior the resemblance of a millipede doubled back on itself, were millipedes four stories tall. (Thankfully, they are not.) On an October day in 2018, an A-frame sign had been propped up on the sidewalk near the entry, directing pedestrians through doors of reclaimed wood into the Biomimicry Launchpad Showcase, where finalists in the 2017 Biomimicry Global Design Challenge were building their own biological resemblances.

Since 2008, the Biomimicry Institute has run an annual design challenge that prompts teams of 2-8 individuals to confront environmental problems through their meta-design method.[1] These problems have varied in scale and scope, from a "sustainable" tent or quilt, the first two challenges sponsored by Pacific Outdoor Equipment, to climate change, the theme that designers at the 2018 Showcase had been tasked to address.[2] Since 2013, the Institute has invited finalists to participate in the Biomimicry Launchpad, an "innovation accelerator" that introduces them to "lean startup methodology."[3] Over six weeks, innovation consultants shepherd these "early-stage

[1] The challenge is now named the Biomimicry Global Design Challenge. In 2008, it was known as the Affiliate Student Challenge because only students from four universities affiliated with the Biomimicry Institute were invited to participate (see the Introduction). In 2011, the third year of the program (there was no challenge in 2010), the Institute allowed any university student to submit an entry. In 2015, any design practitioner over the age of 18 was included in what was retitled as the Biomimicry Global Design Challenge, regardless of enrollment status. In 2018, the Biomimicry Institute began a second program, the Biomimicry Youth Design Challenge (grades 6-12). See "History and Impact," Biomimicry Institute, accessed December 1, 2020, https://challenge.biomimicry.org/en/page/history-and-impact-en.

[2] Other challenge years confronted issues of energy efficiency, water access and management, and transportation.

[3] See Eric Ries, *The Lean Startup: How Constant Innovation Creates Radically Succesful Businesses* (New York: Viking Press, 2011).

entrepreneurs" from concept toward commodity.[4] Finalists then showcase their wares-*in-potentia* to investors who receive priority on their business ideas in exchange for their patronage of the challenge.[5] The winning team receives $100,000, named the Ray of Hope Prize for the glinting promise personified in these biomimics—guarantors that saving the planet can turn a profit, too.

Inside the David Brower Center, I stepped into an atrium spanning two floors. On its sparse concrete walls, toothy mackerel, whitetip, and blue sharks grinned at ambling spectators from color-saturated photographs that the journalist Brian Skerry had captured and paraded for a traveling National Geographic series. "There are sharks everywhere!" Rebecca joked to me as I found her unfolding a collapsible table. A program manager at the Biomimicry Institute, Rebecca was in charge of every aspect of the competition and its related events—financial, operational, and pedagogical. While her hand ostensibly pointed to the predators depicted in the artwork, it gestured forward to the venture capitalists and other high-profile invitees who would later attend. Interspersed with the sharks, six teams of formally dressed finalists, totaling thirty persons,[6] were standing poster boards illustrated with dragonfly wings, cactus spines, and fish gills next to prototypes inspired by them—a menagerie of mimicries displayed as "sustainable innovations."[7]

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[4] For a description of what finalists learn during the Launchpad, see Biomimicry Institute, "Launchpad," accessed September 27, 2021, https://biomimicry.org/launchpad/.

[5] Where Pacific Outdoor Equipment (now Hyalite Equipment) sponsored the first two challenges, hence the focus of the prompts those years on camping gear, the Biomimicry Institute shifted away from an explicitly product-centered emphasis in later iterations. In 2013, with the advent of the Launchpad program, the Institute engaged with corporate sponsorship again with the Showcase, which traded an exclusive glimpse at new design concepts for their donations.

[6] From a total of 96 submissions to the 2016-2017 Biomimicry Global Design Challenge, only 8 finalist teams were selected by judges to advance through the Launchpad program, and out of the 8 finalists, only 6 were invited to present to investors and the general public at the Showcase: two from the United States, and one each from Taiwan, Colombia, Brazil, and Mexico. See Biomimicry Institute, "Challenge," accessed September 27, 2021, https://challenge.biomimicry.org/en/custom/gallery/directory.

[7] Earlier in the year, Rebecca had invited me to judge submissions to the challenge. This turned out to be a lonesome affair spent in the confines of my home, on my computer, through which I uploaded my scores to the six entries that I had been asked to evaluate. As an anthropologist trained to idealize participant observation, this was disappointing from a methodological standpoint—all participation and no observation, *un*observant participation. When I came across an advertisement online for the showcase, I contacted Rebecca. At last, I thought, an opportunity to talk to the team members and fellow judges. I was mistaken. Rebecca corrected me: The showcase would feature the finalists from 2017, *not* the 2018 cohort. Nevertheless, I requested to attend and offered to volunteer in exchange for a ticket.

For this ticketed event, I worked as a bouncer, admitting 200 guests who had pre-registered and (mostly) pre-paid their way onto my list. Because we were already at capacity for the theater that would host the keynote lecture of the evening by Janine Benyus, I was required to turn away all walk-ins. I also had the duty of refusing entry to anyone in possession of single-use plastics, a policy mandated by building regulations.[8] Still more essential than the distinction of inside/outside and single-/multi-use was the hierarchy between upstairs/downstairs. Names on my guest list marked with an asterisk were elite donors whose ingress, I was told, should be communicated to Gretchen, another program manager, or to Beth, the executive director of the Biomimicry Institute. Both monitored me from afar. With a wink, the same expression that the anthropologist Clifford Geertz examined as a cipher of culture, I discreetly signaled the arrival of donors, who were swiftly escorted to a private gala on the mezzanine overlooking the showcase.[9]

Trays of hors d'oeuvres that circulated slowly and incompletely on the ground were copious and unending upstairs, and drinks from a cash bar downstairs were instead poured freely. Bronislaw Malinowski, in his ethnographic account of the Kula ring in the Trobriand Islands, taught me to look for flows of prestige in the direction of objects.[10] Indeed, food, drink, and eyes were all directed toward pampered guests who were as much the night's focus as the participants

[8] Named for the first executive director of the Sierra Club, the David Brower Center memorializes its namesake as a co-working space that furnishes office infrastructure for thirty environmental organizations, nonprofit and for-profit. These include the Earth Island Institute and Friends of the Earth, both founded by David Brower, as well as the Center for Ecoliteracy, co-established by Fritjof Capra in 1995. Designed by Daniel Solomon, one of five founding charters of the *Congress for New Urbanism*, the David Brower Center is, according to its website, "green from the ground up," equipped with solar panels that rotate to face the sun, natural ventilation, and other energy-saving systems. The building has earned a platinum LEED (Leadership in Energy and Environmental Design) certification from the US Green Building Council—the highest available, reserved for a select roster of 3,800 buildings globally. Plaques above the toilets encouraged users to conserve water collected and recycled from rainfall by selecting a half or a full flush while venue policies stipulated that bottles, caps, and other single-use plastics were contraband. See "Our Building," David Brower Center, accessed December 1, 2020, https://browercenter.org/about/our-building/.
[9] Clifford Geertz, "Thick Description: Toward an Interpretive Theory of Culture," in Geertz, *The Interpretation of Cultures*: *Selected Essays by Clifford Geertz* (New York: Basic, 1973), 3-32.
[10] Bronislaw Malinowski, *Argonauts of the Western Pacific: An Account of Native Entreprise and Adventure in the Archipelagoes of Melanesian New Guinea* (New York: Routledge, 2014[1922]).

of the design challenge, if not more. As the evening yawned and the gallery swelled with the sound of teams presenting their designs, members of the upper echelon would periodically descend the elevator, wine-in-hand, to swim along the floor, circling the designers to sniff out investment opportunities. Bottles and bites were not alone in motion within this feeding ground.

Prior to the start time, Gretchen convened the finalists in a small conference room. Jacques, a Launchpad "coach," spoke to the teams: "There are lots of people here who are going to fall in love with you and want to hear all about what you're doing. These are all potentially people who are interested in helping you." Gretchen announced a second prize: the People's Choice Award. Every guest had been allocated five bills of fake currency to "invest" in their favorite team(s), and the "richest" team would receive $2000. "You want to try to convince them to invest as much of their money as possible in your venture," Gretchen said. While the Ray of Hope Prize was selected by a jury of experts (e.g. Jay Harman, see Chapter One), the People's Choice Award encouraged what Geertz called "deep play": a high-stakes contest in which the logistics of the game symbolize the logic of a more general sociality.[11] At stake in this game-in-a-game was the suasive nature of the challenge and the showcase. Primed to treat any interaction as a sales pitch, designers recognized the night as an exercise in economic persuasion. (That said, not all games enchant. On many table corners and windowsills, forgotten stacks of bills next to bottles of flat beer and soggy cocktail napkins hinted that some guests found this game shallow.)

Long before the showcase, I talked with Dayna Baumeister about my ethnographic interests in how biomimics communicate "value". Dayna, a staid, pragmatic woman with a PhD in organismal biology and ecology, responded, matter-of-fact, that "there wasn't anything there," that this topic was "not deeply rich." What was "exciting" were the stories of "life's genius" that

[11] Clifford Geertz, "Deep Play: Notes on the Balinese Cockfight," in Geertz, *The Interpretation of Cultures*, 412.

biomimics told. Moments later, she said that biomimics are "like ants": Their "antennae" are "tuned to listen to different kinds of information," not to "share it in the way we want to share," but "to tune our signal to match our antennae to what they [their publics] are already looking for: new ideas, being innovative." With this second-order Aesopian analogy (biomimicry discourse is like formic language, which is like radio engineering), Baumeister separated what biomimics hold true (the idealistic stance)—"the way we want to share"—from how they market a mimetic practice to investors, consumers, and other audiences, i.e. what I call the *performative stance*.

Whereas Baumeister sought to direct my attention away from the communication, or "performance," of biomimicry's value, this chapter asks: How do biomimics sell biomimicry?[12] In spite of her re-direction (itself an ideological function of the performative stance), or, perhaps, *because* of her analogy, I examine here how biomimics talk, and stage products, to their publics, thus "tuning" my antennae of analysis to how they portray mimesis as "new…being innovative." As I wiggled and excused my way through the crowd after being relieved of my post at the door, peering over the shoulders of finalists and the small crowds that formed around them, I saw the Biomimicry Launchpad Showcase as a spectacle of value. From Janine Benyus's headlining act to the supporting cast of competitors who delighted with their monologues and interactive shows, the David Brower Center was turned that evening into a theater for biomimicry's ideology that "innovation inspired by nature" could be economically generative *and* ecologically regenerative.

To "convince" the audience of biomimicry's value, the Showcase actors performed the esteem of mimesis as a mode of making "sustainable innovations." I name this *imitative prestige*. This shimmering quality that designers ascribe to mimesis is the conceptual negative of an old locution that the ethnologist Marcel Mauss recorded in the anthropological lexicon a century ago.

[12] For a sampling of literature on the analytic of performance in anthropology, see Frank Korom, ed., *The Anthropology of Performance*: *A Reader* (Hoboken: Wiley, 2013).

In the "education of movements" that stretches across generations, "what takes place," Mauss observed, "is a prestigious imitation. The child, the adult, imitates actions which have succeeded and which he has seen successfully performed by people in whom he has confidence and who have authority over him."[13] Just as Mauss recapitulated Gabriel Tarde's mimetic theory of social reproduction in his coinage of "prestigious imitation," so too have anthropologists after Mauss's time extended his ethnographic insights in imitative succession, studying the duplication of signs of identity across ranked hierarchies of race, ethnicity, class, gender, sexuality, and dis/ability. This behavioral emulation was an unmistakable part of the action at the Showcase: Finalists had to literally and figuratively look up to their would-be investors on the upper floor, adopting their dress styles and speech patterns to play the role of successful innovators deserving of investment.

With *imitative prestige*, I flip the order of "prestigious imitation" to shift the limelight from the imitation of prestigious actors onto the acted prestige of imitation. Following theoretical insights from the anthropology of design, I demonstrate in this chapter how biomimics "enact"[14] imitation as "innovative" and, moreover, how they designate mimeticism as a material-semiotic quality of their mimetic artifacts.[15] In so doing, I reveal imitative prestige as the principal value form within the speculative bioeconomy of biomimicry, resolving cultural dichotomies between capitalism/environment and imitation/innovation by framing "biology" as sustainable innovation.

Informed by dramaturgical theory, I examine the phenomenon of imitative prestige through analyses of the "front-stage" performance and "back-stage" preparations.[16] In the first section, I read Janine Benyus's keynote, "A New Species of Entrepreneur," as an instance of the

[13] Marcel Mauss, "Techniques of the Body," *Economy and Society* 2 (1973[1935]): 70-88, 85, 73.
[14] See footnote 51 in the Introduction.
[15] My approach here is indebted to Keith Murphy, *Swedish Design: An Ethnography* (Ithaca, Cornell University Press, 2015).
[16] On dramaturgical analysis, the primary reference is Erving Goffman, *The Presentation of the Self in Everyday Life* (New York: Anchor Press, 1959). For a more recent analysis in this vein, see Stephen Hilgartner, *Science on Stage: Expert Advice as Public Drama* (Stanford: Stanford University Press, 2000).

"ritual semiosis" of biomimicry.[17] Publicly narrating an ecological "drama" between capitalism and the environment, Benyus plotted biomimicry as its "green" resolution. Using anthropological theories of agency, I chart how Benyus cast biomimics as "intermediaries" of nature, minimizing their authorship in order to attribute the biological with the agency of "sustainable innovation."[18]

Next, I move from the auditorium back to the atrium to observe how the finalists interactionally ascribed biological mimeticism as a quality of their designs. If, in Chapter One, I proposed mimetic labor as the work of making analogies and meta-analogies, this chapter educes a third function: the signification of artifacts *as* mimetic. In the third section, I pivot to a behind-the-scenes look at the judging process for the design challenge, illuminating how the curators of the competition deliberated over which finalists should advance to the showcase. In a logic that was characteristic of the performative stance, judges acknowledged that "good teams" had better likelihoods of commercial success than "good biomimicry" but, nevertheless, privileged designs that would tell a "good story" about life's agency. In conversation with posthumanist theorists, I name this *strategic animacy*. This chapter ends with a glance "off-stage" at the winning finalists as they peel off the mimeticism of their artifacts, putting biomimicry's performativity into relief.

"A New Species of Entrepreneur": The Ritual Semiosis of Nonhuman Agency

To the muttered consternation of several event organizers, Benyus arrived late to the showcase, minutes before her lecture was scheduled to start. Whizzing past the welcome desk where I had earlier sat, she wheeled a suitcase in hand up the elevator to mingle at the gala for donors while a camera-clad entourage trailed behind. At Beth's cue, all of the employees and volunteers, myself

[17] Eitan Wilf, *Creativity on Demand: The Dilemmas of Innovation in an Accelerated Age* (Chicago: University of Chicago Press, 2019), especially Chapter 2.
[18] Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network Theory* (Oxford: Oxford University Press, 2007).

included, corralled all the showcase attendees into a large auditorium at the rear of the gallery. A tall, white woman with long, dark, curling hair and knee-high leather boots, Beth, the executive director stepped onto the stage to greet the audience: "I do not even have to tell you all the bad news about the climate because you guys already know. What you are here to do is to celebrate the hope that is biomimicry. We believe that there is a path, and that we have stumbled on it. It is what nature has been providing for us for literally billions of years."[19] In a future tense familiar to linguists of capitalist grammar, she commenced with a tale of peril and promise, ruination and salvation. In the face of imminent climatic apocalypse, biomimicry promised "nature" as "hope." Whereas hawkers of the bioeconomy of life's substance forecast profits on discoveries-yet-to-be, Beth depicted nature as a "path" toward technologies already-made—a new spin on the romantic forms of value I termed *nostalgic innovation*.[20] Here, the nonhuman past held limitless potential.

Before leaving the lectern, Beth introduced the second speaker, John Lanier, the executive director of the Ray C. Anderson Foundation. She thanked John and his organization for their sponsorship of the $100,000 "Ray of Hope Prize." An early proponent and client of the Biomimicry Guild (see the Introduction), Ray C. Anderson was, according to John, his grandson, a "radical industrialist" who "understood that sustainability was a moral imperative." Standing in a room tiled with carpet panels his grandfather invented, he reflected: "He also understood that it was an opportunity." He ended: "When done right, business can be a force of good in the world."

The "radical" industrialism that John admired was an idiosyncratic expression of the "verdant optimism" that the anthropologists Cymene Howe and Dominic Boyer find overrun in

[19] For a review of the anthropology of hope, see Nauja Kleist and Stef Jansen, "Introduction: Hope Over Time—Crisis, Immobility, and Future-Making," *History and Anthropology* 27.4 (2016): 373-392.
[20] On the grammar of biocapitalism, see footnote 19 in the introduction.

discourses of "green" capitalism.[21] "A weird optimism rings out," the two note, "promising a sustainable way of doing more of the same—the same consuming, the same ways of moving, the same models of living in the world—the same impulse to growth and ballooning wealth." For John, the Biomimicry Global Design Challenge was a means for inculcating this mindset among students and other biomimics—for making environment subjects, that is, "environmentalities,"[22] devoted to planet's spirit, the mimetic ethic, and the spirit of capitalism, the "Protestant ethic."[23] "That's what this prize is about," John explained, "creating the Ray C. Andersons of tomorrow, people—entrepreneurs—who are committed to finding a better way, and we have found no better way than with what biomimicry offers. When entrepreneurs humble themselves, enough to learn from nature, they become stewards in the work they do—of the future we all collectively need."

In recent years, cultural anthropologists have examined how corporations produce cultural models of action conducive to their business through displays of meaning.[24] With anthropological theories of "ritual,"[25] scholars have ethnographically shown how organizations like the Biomimicry Conglomeration™ utilize slogans, retreats, talks, and other activities that expose and reinforce significant categories of thought. Through "ritual semiosis," participants in

[21] Cymene Howe and Dominic Boyer, "Verdant Optimism: On How Capitalism Will Never Save the World," *Theorizing the Contemporary* series in *Cultural Anthropology* March 24, 2020, https://culanth.org/fieldsights/verdant-optimism-on-how-capitalism-will-never-save-the-world. Contrast with Lauren Berlant, *Cruel Optimism* (Durham: Duke University Press, 2011).
[22] Arun Agrawal, *Environmentality: Technologies of Government and the Making of Subjects* (Durham: Duke University Press, 2005).
[23] On the Protestant ethic of capitalism, see Max Weber, *The Protestant Ethic and the Spirit of Capitalism* (London: Routledge, 1992[1905]). For another take on the subjectivity of capitalism, see Aihwa Ong, *Spirits of Resistance and Capitalist Discipline: Factory Women in Malaysia* (Albany: SUNY Press, 1987). Contrast with the ethic of "green capitalism" described by Jesse Goldstein in *Planetary Improvement: Cleantech Entrepreneurship and the Contradictions of Green Capitalism* (Cambridge: MIT Press, 2018).
[24] See Greg Urban and Kyung-Nan Koh, "Ethnographic Research on Modern Business Corporations," *Annual Review of Anthropology* 42 (2013): 139-158; Lucy Suchman, "Anthropological Relocations and the Limits of Design," *Annual Reviews in Anthropology* 40 (2011): 1-18; Jakob Krause-Jensen, *Flexible Firm: The Design of Culture at Bang & Olufsen* (New York: Berghahn, 2010); and Wilf, *Creativity on Demand*.
[25] On ritual, consider, for instance, Victor Turner, *The Ritual Process: Structure and Anti-Structure* (Chicago: Aldine, 1969) and Sherry Ortner, *Sherpas through their Rituals* (Cambridge: Cambridge University Press, 1978).

these group rituals—employees but also consumers, investors, and clients—depart the "bounded microcosm of ritual social-spacetime," i.e. the showcase, with new maps, diagrams, of culture.[26] In the three talks delivered that evening, Beth, John, and Janine Benyus presented biomimicry as a green resolution to the cultural "drama" between climate change, and ecological crises in the general sense, and capitalism.[27] While environmentalist scholars and activists have often vilified the capitalist mode of production and consumption for degrading nature,[28] these talks affirmed that "green" capitalism, specifically biomimicry, could resolve this tension or conflict vis-à-vis a "radical" mode of subjectivity attuned to, "humble enough," to heed life's genius (Chapter Two). Through biomimicry, this logic went, entrepreneurs can attain benign, even regenerative, growth

Building on Beth's history, John contrasted 100,000 years of human existence with the sum total of 3.8 billion years that life, in some form or another, has existed upon the earth. In spite of this epistemic tradition, "we"—that is, the anthropological we, a first-person plural that flattens cultural differences in environmental relations[29]—have relied upon self-knowledge:

> There was a species that came to earth that had the capability to choose, at a really profound level. We've been making choices, all of us, but collectively choices about how we will be a part of the web of life. We have made choices about how we will interact with others. We've made choices about how we will organize ourselves. We've made choices about how we will manufacture things. Unfortunately, humanity has chosen to do its own thing—to say that 3.8 billion years…of learning we know better. It turns out we don't. There's a certain choice in the context of this room that humanity is also capable of. We don't have to accept that our species has chosen, particularly in the last few hundred years, to do it the wrong way. You can still choose to learn from nature. It's a choice that so many of us don't realize we have."

[26] Michael Silverstein, "Private Ritual Encounters, Public Ritual Indexes," in *Ritual Communication*, eds. Gunter Senft and Ellen Basso (New York: Berg, 2009), 271-292, 273, quoted in Wilf, *Creativity on Demand*, 61.
[27] On drama, see Victor Turner, *The Forest of Symbols: Aspects of Ndembu Ritual* (Ithaca: Cornell University Press, 1967).
[28] For instance, Jason Moore, *Capitalism in the Web of Life* (London: Verso, 2015).
[29] On positionality within the Anthropocene, Gabrielle Hecht offers a critical review in "Interscalar Vehicles for an African Anthropocene: On Waste, Temporality, and Violence," *Cultural Anthropology* 33.1 (2018): 109-141.

In John's accounting, the real problem was not capital *per se* or the capitalist mode of production but, rather, the "choices" that "we" have made. In this enunciation of "responsibilization,"[30] John implicated the impersonal "you," the individual designer, as the culprit for climate change—not an entrenched system of social organization. The real problem, by his logic, was design's intents, the technological agency of humankind. Biomimicry, therefore, resolves the drama of capitalism/ environment by renouncing human agency, instead intentionally choosing to "learn from nature."

Beseeching the audience to choose biomimicry, as the competition finalists had done, John ceded the floor to Benyus, whose fingers had been typing at her keyboard while he spoke. Looking up and smiling, she broke her concentration to stand and walk up onto the stage. "What a beautiful young man!" Benyus said of John while she connected her computer to the podium. Whispers of excitement and adulation murmured throughout the packed space: "She's my guru," a "revolutionary," and "simply the best" were just a few idolatries I was quick to scribble down. All around, the audience was "coming under [the] conviction" of biomimicry (Interlude One).[31]

[30] On responsibilization, see Michel Foucault, *The Birth of Biopolitics: Lectures at the Collège de France, 1978-1979* (London: Palgrave Macmillan, 2008) and Nikolas Rose, *Inventing Our Selves: Psychology, Power, and Personhood* (Cambridge: Cambridge University Press, 1996).
[31] Susan Harding, "Convicted by the Holy Spirit: The Rhetoric of Fundamental Baptist Conversion," *American Ethologist* 14(1): 167-181, 180.

Figure One: *The Creation of Artifice*

On the screen behind her, Benyus projected a lime green gecko perched atop a downturned leaf, its tiny front left paw outstretched to touch the white skin of a human finger. An imitation of the iconography of Michelangelo's fresco painting *The Creation of Adam*, this image of interspecies contact exemplified the relation of humanity to nature that Beth and John had each endorsed in their comments. If Michelangelo's *magnum opus* symbolizes the Christian doctrine of humanity's likeness to the divine[32]—a relation of similarity that doubled as a relation of deference, or humility, to the Creator—then Benyus's first slide likewise pictured the likeness

[32] On the iconography of *The Creation of Adam* in science and technology, see Donna Haraway, *Modest_Witness@ Second_Millenium.FemaleMan?_Meets_OncoMouseTM* (New York: Routledge, 1997) and Stefan Helmreich, *Silicon Second Nature: Culturing Artificial Life in a Digital World* (Berkeley: University of California Press, 2000).

between the human and the nonhuman, an ideal relation. What this photograph diagrammed was the network of agencies within biomimicry's ideology: nonhuman "genius," human deference.[33]

Speaking slowly, carefully, handling each word with caution and concern, as if her passion for biomimicry might tear her speech asunder, Benyus commenced her keynote address, titled: "Biomimicry: Nurturing A New Species of Entrepreneur." "It's not every day that you see a new species come into form," she said. Addressing the packed theater with all the deliberate informality of an accomplished speaker, Benyus exuded the charm I had been primed to notice but still surprised to witness firsthand. "We are nurturing a new species of entrepreneur. It is what happens to people when they do this work," she remarked. Pointing to the gecko on-screen, she reminisced about her encounter with the animal and the researchers who studied it. In a storytelling mode that defined her manner of speech, Benyus shared that the doctoral students she met in the biomimicry PhD program at the University of Akron had named the small lizard Catherine the Great—a ritual of personalization often shunned in most biological laboratories, as the anthropologist Lesley Sharp has observed.[34] Benyus interpreted this as proof of the humility that the "new species of entrepreneur" held toward the wonders and marvels of nature's design.[35]

"You may feel like we are hanging on by a thread. I just want to acknowledge that," Benyus continued. "Everybody, and especially young people, needs to take a breath. We are in the presence of an incredibly competent planet, and we're just getting to know her." Assuaging fears of ecological calamity, Benyus reified nature as a "competent" innovator that the "new species of entrepreneur" was uniquely equipped to imitate, by virtue of their ethical dispositions.

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[33] Another look of the photograph suggests a different reading. In Michelangelo's version, humanity and divinity were *not* mirror images. The human (Adam, on the left) was made in the image of the divine (on the right), not vice versa. Benyus inverted this binary. Perhaps, as I argued in Chapter One, biomimics only find themselves in "nature."
[34] See Lesley Sharp, *Animal Ethos: The Morality of Human-Animal Encounters in Experimental Lab Science* (Berkeley: University of California Press, 2018).
[35] On wonder, refer to Lorraine Daston and Katherine Park, *Wonders and the Order of Nature, 1150-1750* (Princeotn: Princeton University Press, 2001).

In a series of prophetic aphorisms that Benyus accented with a pregnant pause between stanzas, she represented nature through the idea of "innovation," eliciting a chorus of hums, claps, and finger-snaps from a crowd held captive by her rousing sermon on the productivity of nature:

> The sustainable world already exists. All these teams know that. This is the circular economy perfected. We don't have to invent that. Materials reincarnate. And indigenous technologies evolve in context. That's what really… So many of the technologies we come up with evolve in our heads. These evolved in the context of the earth. So this life… Life is the oldest, largest R&D program on the planet, I guarantee. The reason it gives rise to such magnificence is its single-mindedness and the fact that it keeps on having kids. *Innovation*! And those kids are the most important criteria for whether it's successful. It's not whether the market adopts it or it has a certain ROI. It is whether or not that generation... That's how you judge the rightness of the nest, whether or not the chicks do well. That is a good measure of success. And that's…we teach the teams that.[36]

According to Benyus, life *is* innovation, and an esteemed mode of it—an epistemology of life that I described in Chapter One as *nature as innovation*. Equating sexual reproduction with the generation of newness, natural selection with consumer adoption, and energy flows with circular recycling, she reconceived biology as a domain of green business—as sustainable innovation.[37] Strictly speaking then, the "new species of entrepreneur" to which Benyus had earlier referred was not just a kind of humble subjectivity. Life had, itself, become a zone of entrepreneurialism.

"Why biomimicry?" Benyus asked rhetorically. Kneeling down to interact with a wayward child who had teetered and tumbled upon the stage, she seamlessly resumed her train of thought: "Two reasons that I tell most audiences. It's because the inventions are *novel to us*, and they're sustainable." To evince her claim that nature's "inventions" are "novel," Benyus cited a

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[36] Through the synchrony of hummed affirmations, the audience of benevolent environmentalists failed to object that the slides from which Benyus read did not spell "Indigenous," but rather "ingenious." Benyus had confused Indigeneity for nature's genius. One might dismiss her verbal gaffe as nothing more than an innocent slip of the tongue, but, as Sigmund Freud keenly discerned over a century ago, judgments of innocent often cloak and negate the existence of truths operating at levels beneath and beside the words themselves. Here, the substitution of the two terms betrays the synonym between nature and Indigeneity that I criticize in the interludes. On slips of the tongue, see Sigmund Freud, *The Psychopathology of Everyday Life* (New York: W.W. Norton & Company, 1990[1901]).

[37] There is also, one can sense, a gendered association between productivity and reproductivity, that is, fertility, in Benyus's reading here. See footnote 114 in the Introduction on the gendering of nature in biomimicry.

research paper from Julian Vincent, a zoologist at Heriot-Watt University in Edinburgh. Vincent, who was influenced by the innovation method TRIZ,[38] compared "human" design principles in a database of patents with their "natural" analogues—a project that Vincent labelled "BioTRIZ."[39] "There was only twelve percent overlap," Benyus reported, meaning: "eighty-eight percent of the time we're going to be surprised, and it's going to be new to us." In her explication of Vincent's scholarship, Benyus exploited the non-identity of human and nonhuman "inventions" to perform the value of imitation—the imitative prestige of biomimicry. Where imitation is often opposed to innovation in the United States, Benyus overcame the perception of their antimony by recasting biomimicry—the mimesis of nature—as a privileged mode of access to life's untold innovations.

What the ritual semiosis of the Biomimicry Launchpad Showcase achieved was a reshuffling of the agency of human and nonhuman in traditional ideas of design. In contrast to liberal conceptions of personhood that reify agency as the capacity of the sovereign individual to act, anthropologists contend that agency is instead, to Webb Keane, a meta-pragmatic category that guides actions.[40] Agency, in this scheme, is not a property of humans (or even nonhumans), but a cultural "model" for understanding the actions of others—one tied to notions of power and embodiment, language and thought.[41] In models of design specifically, agency is presumed to lie

[38] Conceptualized by the Soviet engineer and science fiction writer Genrich Altshuller (penname: Genrikh Altov), TRIZ is an innovation methodology developed on patent literature that allows inventors to "innovate" new artifacts by resolving contradictions in existing technical objects. For a history of the method and an analysis of its role in the (self-)fashioning of Soviet subjectivities, see Alexey Golubnev, *The Things of Life: Materiality in Late Soviet Russia* (Ithaca: Cornell University Press, 2020).
[39] Julian Vincent, Olga Bogatyreva, Nikolaj Bogatyrev, Adrian Bowyer, and Anja-Karina Pahl, "Biomimetics: Its Practice and Theory," *Journal of the Royal Society Publishing – Interface* 3.9 (2006): 471-482.
[40] Webb Keane, *Christian Moderns: Freedom and Fetish in the Mission Encounter* (Berkeley: University of California, 2007), 53. Cf. Michael Fischer, "Epilogue: To Live with What Would Otherwise Be Unendurable: Return(s) to Subjectivities," in *Subjectivity: Ethnographic Investigations,* ed. João Biehl, Byron Good, and Arthur Kleinman (Berkeley: University of California Press, 2007), 423-446.
[41] On Western theories of the agent, see Charles Taylor, *The Sources of the Self: The Making of the Modern Identity* (Cambridge: Harvard University Press, 1992). On anthropological theories of agency, see Michelle Rosaldo, "The Things We Do with Words: Ilongot Speech Acts and Speech Act Theory in Philosophy," *Language in Society* 11.2 (1982): 203-237; Marilyn Strathern, *The Gender of the Gift: Problems with Women and Problems with Society in Melanesia* (Berkeley: University of California Press, 1988); Lila Abu-Lughod, "The Romance of Resistance:

within human designers, in their capacities to plan and build. The metalanguage of biomimicry is an indictment of this agency, which biomimics like Beth, John, and Benyus inculpate as a cause, *the* cause, of ecological crisis. In the model of design agency that they offer as a resolution to the conflict of capital and the environment, biomimics (a "new species of entrepreneur") function as "intermediaries"—that which "transports meaning or force without transformation"—between a natural world of design "mediators" and technology.[42] Through the cultivation of a considerative ethos, as Raúl called it, biomimics, the logic goes, renounce their agency to let nature "speak."[43] Unlike "technologies we come up with…in our heads," design by mimesis is not human design.

Through this mythological mode of imaginative world-building, biomimics "enact" the imitation of biological design principles as "sustainable innovation." In her auto-ethnographic research on Silicon Valley, Lucy Suchman has proposed to "interrogat[e] the category of the new according to a more performative metaphysics," in which "the new…is an outcome rather than a starting point."[44] Following Suchman, the ethnographer Lilly Irani has analyzed how enactments

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Tracing Transformations of Power through Bedouin Women," *American Ethnologist* 17.1 (1990): 41-55; Talal Asad, *Formations of the Secular: Christianity, Islam, Modernity* (Stanford: Stanford University Press, 2003); Sherry Ortner, "Thick Resistance: Death and the Cultural Construction of Agency in Himalayan Mountaineering," *Culture* 59 (2010: 135-162; Deborah Battaglia, "Ambiguating Agency: The Case of Malinowski's Ghost," *American Anthropologist* 99.3 (1997): 505-510; Keane, *Christian Moderns*; Webb Keane, "Self-Interpretation, Agency, and the Objects of Anthropology: Reflections on a Genealogy," *Comparative Studies in Society and History* 45.2 (2003): 222-248; Saba Mahmood, *Politics of Piety: The Islamic Revival and the Feminist Subject* (Princeton: Princeton University Press, 2004); Soumhya Venkatesan, "Rethinking Agency: Persons and Things in the Heterotopia of 'Traditional Indian Craft,'" *Journal of the Royal Anthropological Institute* 15 (2009): 78-95; Hirokazu Miyazaki, "Faith and Its Fulfillment: Agency, Exchange, and the Fijian Aesthetics of Completion," *American Ethnologist* 27.1 (2005): 31-51; and Laura Ahearn, "Language and Agency," *Annual Review of Anthropology* 30 (2001): 109-137. On agency as a cultural "model," see Claudia Strauss, "Blaming for Columbine," *Current Anthropology* 48.6 (2007): 807-832 and, for more recent analyses in this vein: Eitan Wilf, "Sincerity versus Self-Expression: Modern Creative Agency and the Materiality of Semiotic Forms," *Cultural Anthropology* 26.3 (2011): 462-484 and Ilana Gershon, "Neoliberal Agency," *Current Anthropology* 52.4 (2011): 537-555. For a critique of the "cultural model" approach to theories of agency, see E. Summerson Carr, "Occupation Bedbugs: Or, the Urgency and Agency of Professional Pragmatism," *Cultural Anthropology* 30.2 (2014): 257-285.

[42] Latour, *Reassembling the Social,* 39.

[43] On the voice of nature, see Bruno Latour, *Politics of Nature: How to Bring the Sciences into Democracy* (Cambridge: Harvard University Press, 2004) and Timothy Mitchell, *Rule of Experts: Egypt, Techno-Politics, and Modernity* (Berkeley: University of California Press, 2002).

[44] Lucy Suchman, "Anthropological Relocations and the Limits of Design," 14, 15.

of the new in India reflect a post-colonial geography of caste, race, region, and ethnicity. As Irani clarifies, innovation is not a "process of making new things," but rather a "designation of agency, discerned in sites of social interaction."[45] While urban entrepreneurial designers of forward castes portray their design approach as "innovative," nearly identical work in design and development by less privileged individuals is cast as "imitative," an inequality of the new that led Irani to rephrase Gayatri Spivak's question of the subaltern's voice, asking instead, "Can the subaltern innovate?"[46] In other words, how is the subaltern discursively, or materially, barred from innovation?[47] At the Biomimicry Launchpad Showcase, the query was posed anew—not "can the subaltern innovate?" but "can the biological innovate?" The answers I heard from Beth, John, and Benyus was emphatic: "Yes!" Life has the agency to innovate—and sustainably, too.

Beyond Cultural Geometry: Mimetic Labor and the Dressing of Resemblance

From the dead center of a white aperture, a lone sapling rose two-feet-tall. Two concentric rings of oscillating ridges and valleys carved in bioplastic encircled the solitary lifeform and isolated it from the mottled, decaying plant matter that had been strewn about nearby in a dissimulation of decay, a sylvan simulacrum, detritus by design. To the immediate left on the table-in-tree-drag, a vertical cross-section of the artifact's toroid architecture exposed a hollow, pneumatic chamber that encompassed the core. To the right, two neatly stacked piles of glossy pamphlets advertised the word "Nucleário": the name for this "nucleation" technology, which protects young plants.

[45] Lilly Irani, *Chasing Innovation: Making Entrepreneurial Citizens in Modern India* (Princeton: Princeton University Press, 2019), 173.
[46] *Ibid*, 22. On the subaltern, see Gayatri Chakravorty Spivak, "Can the Subaltern Speak?" in *Marxism and the Interpretation of Culture*, eds. Cary Nelson and Lawrence Grossberg (Basingstoke: Macmillan, 1988), 271-313.
[47] See, for instance, Ajantha Subramanian, *The Caste of Merit: Engineering Education in India* (Cambridge: Harvard University Press, 2019).

Figure Two: Nucleário

In front of a crush of attendees clustered around the table, a young man with a topknot of curling, copper hair introduced himself as Bruno, one of this object's designers and the co-founder and chief executive officer of the company that owns it. Bruno began his pitch with an origin story for Nucleário based in a biographical narrative of ecological tragedy and redemption. Born in a small, mountainside town in the Atlantic rainforest outside the city of Rio de Janeiro, Brazil, Bruno talked of a quaint childhood deeply interconnected with the lifeworld of the forest. Leaving home to study industrial design at the Pontifical Catholic University of Rio de Janeiro, Bruno later returned for a kayaking and paragliding trip. While soaring over vast, flat grasslands that once towered with trees, he realized first-hand the extent of Brazil's rampant deforestation. Back in the city, he resumed work as an industrial designer by day, making products as varied as chairs and GPS units, but, by night, he devoted himself to innovating a solution to this problem.

With his younger brother, Pedro, a graphic designer, and a forest engineer named Bruno as well, the future CEO led his team toward Nucleário, which they billed as a "geoengineering concept."

If Benyus, in her keynote address, performed the imitative prestige of biomimicry as a methodology, it was up to the finalists to perform the imitative prestige of their mimetic artifacts, enacting their novelty as sustainable innovations. Restoration ecology, Bruno explained, is often laborious and expensive. Without supervision, only 10% of all seedlings planted will grow to full maturation due to pests, drought, and competition for land with more aggressive species of grass. Even with supervision, much of the 17 million hectares in Brazil that are viable for reforestation rests on remote acreage where maintenance is prohibitively arduous. With Nucleário, Bruno and his collaborators promised to automate this costly form of care. Pivoting to face to the prototype, Bruno indexed its structural features, enumerating their functions: 1) a barrier that encloses the seed, defending it against the maw leaf-cutter ants and the encroach of grass; 2) a bioplastic core that disintegrates after the plant has matured, nourishing the soil around it; and 3) a cistern that is not only lightweight when empty, allowing airborne delivery by helicopter, but also collects rain water, hydrating the tree. This "innovative" artifact, as Bruno depicted it, eliminates the need for supervision and pesticides—thus saving costs and boosting the "efficiency" of forest restoration.

In his analysis of Swedish design, the anthropologist Keith Murphy contends that museums, trade shows, expos, and department stores are nodes in an "exhibitionary complex": spaces where the meaning of design—its significance and value—is conveyed to its public(s).[48] In this chapter, I postulate that design "challenges" (or competitions) and their "showcases" are

[48] See Murphy, *Swedish Design*, esp. Chapter 5. Murphy's use of the concept of an "exhibitionary network" is a theroetical encore of the sociologist Tony Bennett's analysis of the "dramaturgy of power" in 19th century museums. In conversation with Michel Foucault's genealogies of carceral institutions (i.e. the asylum, clinic, and prison), Bennett argued that museums (plus galleries, arcades, and panoramas) were institutions, not of *enclosure*, but *exposure*. Through their demonstrative theatricality, exhibitions at museums visually transmitted a moral vocabulary for modern forms of life: a spectacle of signification. See Tony Bennett, "The Exhibitionary Complex," *New Formations* 4 (1988): 73-102.

also cultural stages on which design's ideologies are displayed. As Murphy and anthropologists of material culture have theorized, meaning does not inhere in objects; people must make design signify, draping artifacts in value and meaning with material-semiotic practices of signification.[49] Across the atrium where this suasive event was held, finalists such as Bruno were therefore seen interacting with their audiences, demonstrating the economic value of their entries (their novelty as "innovative" designs). This was accomplished through a choreographed display of material devices (e.g. posters, handouts, models) and speech acts: recited texts, prepared soundbites, and impromptu answers to questions posed by curious listeners. In interaction, novelty was enacted.

The communication of imitative prestige required finalists to not only evince the economic novelty of their "innovations" but also their character as "sustainable innovations," a distinction that hinged on their signification as *mimetic*. The Biomimicry Launchpad Showcase was not simply an exhibition of design writ large but of biomimicry's metalanguage. It is in this sense that the showcase conformed with what Murphy calls an "indexicalizing heterotopia"—a curated experience of the ideological particularity of a design aesthetic. "Such heterotopias," he defines, "are filtering spaces, mapping this to that without clutter or noise, presenting a preferred understanding of how things are ordered and what they mean."[50] Through mimetic labor, Bruno and other finalists indexicalized their artifacts as *mimetic* artifacts. Mimeticism was, in this light, a quality of objects—not a practice of persons—that biomimics dressed over their naked designs.

Bruno's pitch was thus mostly an explication of the biological analogues that had inspired Nucleário. The double winged seeds of Bignonia, a climbing vine native to Brazil, had suggested a dispersal method for the seedlings: interior air chambers and structural ribs that

[49] For a contemporary volume of essays on material culture studies in anthropology, see Daniel Miller, ed., *Materiality* (Durham: Duke University Press, 2005).
[50] Murphy, *Swedish Design*, 186.

enabled a gentle fall. Likewise, the tank bromeliad, which diverts water to its core through the form of its leaves, was the reason the team incorporated cyclical ridges around the object's core. Finally, Bruno cited the Atlantic rainforest leaf litter as the source for Nucleário's open center, a permeable eye that traps moisture in the soil layer beneath the forest floor. The poster that Bruno and his co-designers made schematized the mimetic labor that he performed through interaction. Branching out from multi-perspectival illustrations of Nucleário were lines and text articulating the functions of its structure: a visual convention in design communication.[51] Less conventional were supplementary lines that traced these structures to the organisms that had inspired them. With word, print, and gesture, the Nucleário team semiotically enacted the design's mimeticism. Through mimetic labor, Bruno fixed how the audience interpreted Nucleário as more than a mere object. Through Bruno's linguistic efforts, Nucleário was fashioned into an index of biomimicry

When I paused to listen to Bruno, a wicker basket half-full of bills on their table intimated that these biomimics were exceptional salespeople. The "semiotic" form that was so distinctive in their presentation—lines articulating organism to artifact—was, however, wholly unexceptional next to the five other designs on the floor (among them: carbon-capturing façade panels and a passive cooling system).[52] As I wandered from table to table, it was clear that this convention was universal. While their speech patterns and graphic aesthetics varied, each team did not simply connect the morphology of their static images and models with the function of their designs-in-use. They also, always, tied these nonliving artifacts to their living counterparts.

Murphy argues that the "exhibitionary network" permits the public to witness for themselves the resonance between what he calls the modernist "cultural geometry," a visual

[51] Darin Phare, Ning Gu, and Michael Ostwald, "Representation in Design Communication: Meaning-Making in a Collective Context," *Frontiers in the Built Environment* 4.36 (2018): 1-9.
[52] On "semiotic form," see Webb Keane, "Semiotics and the Social Analysis of Material Things," *Language and Communication* 23 (2003): 409-425 & Webb Keane, "On Semiotic Ideology," *Signs and Society* 6.1 (2018): 64-87.

aesthetic dominated by rectilinearity, and the "final vocabulary" of the welfare state, a lexicon comprised of ideological terms like "democratic, social, equality, good, satisfaction, pleasure, quality, better, beautiful."[53] Through exhibition, the public comes to "see" beyond the form of design toward its moral-political implications. The former stands as a sign of the latter's relation.

As I mingled with the biomimics that evening, it was difficult to distill the presence of any visual grammar that united the objects on display. There were straight lines and right angles, surely, but there were also curves, waves, spirals, tubes, straws, nets, and countless other shapes. Whereas the aesthetics of the biological has long been associated with curvature (for instance, in Art Nouveau or organic architecture), the biomimics I met during my fieldwork insisted upon the "ethical" distinction between the emulation of function and the "biomorphism" that obtains when design is made to "look like" an organism—for instance, in robotic animals (see Chapter Two). In the absence of any shared vocabulary of visuality, biomimicry thus appeared to lack a cultural geometry that Murphy would recognize. Without this geometry, how did biomimics make their artifacts speak to the environmental sustainability that they promised biomimicry would deliver?

Instead of designing with a set palette of form, one which indexed an ideology, the finalists at the showcase relied on mimetic labor to stage their artifacts as icons of biological function that resembled "how nature works." This was less a cultural geometry than it was, to borrow a different scientific metaphor, a natural physiology: the discipline of organic function. Not icons in the traditional sense of signs made to resemble another in perception, the icons at the show were perhaps more in line with what the linguistic anthropologist Michael Silverstein terms an "indexical icon"—a resemblance fashioned through a connection forged in activity.[54]

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[53] Murphy, *Swedish Design*, 41.
[54] Michael Silverstein, "'Cultural' Concepts and the Language-Culture Nexus," *Current Anthropology* 45.5 (2004): 621-652.

Within the frame of this natural physiology, the objects at the showcase were interpreted by the publics there as signs of nature. In this manner, nature's agency authorized their sustainability.

Strategic Animacy: The Performance of Posthumanism

On the day after the Biomimicry Launchpad Showcase, Janine Benyus and Jay Harman announced the winners of the Ray of Hope Prize: Nucleário. In front of a packed auditorium at the Marin County Civic Center, a Frank Lloyd Wright-designed building in the North Bay city of San Rafael, Bruno and his fellow team members cheered and accepted their reward. John Lanier, in a press release with the Biomimicry Institute, offered his commentary on their decision. "The six judges were impressed with all of the teams, but the Nucleário stood out because they have a clear understanding of path to commercialization." When I spoke with Jay Harman outside to get his perspective on the judging process, he corroborated John's opinion: "These teams put a lot of work into it, but at the end of the day, the real criteria is: "Is it biomimetic?' […] and 'What is its chance for actually succeeding?' We are going to pump funds into it. We want to know that it is going to have a multiplier effect." On their choice to pick Nucleário, he recalled, "It was well-advanced. The others were all… These guys had basically done it all. They had the data, had the passion, had the support and instrumentalities they needed." He concluded: "The others are more speculative. All worthy of support, of course! But we really backed a winner with these guys."

As John and Jay both confirmed, the commercial viability, or potential, of finalists' submissions to the design challenge was the primary metric of evaluation. As a nonprofit with a limited set of resources, the Biomimicry Institute must choose the winners carefully, not (just) because they want them to do well, but because the material-semiotic integrity of the imitative prestige of biomimicry depends on their survival along the "path to commercialization." In the

months after the Biomimicry Global Design Challenge, news articles circulated with descriptions of the winning team's design, renderings of their concept, and photographs of the people—media objects that stand as tokens of biomimicry.[55] In 2020, the Biomimicry Institute altered its policies to reflect the public impact of the Ray of Hope Prize, decoupling the award from the challenge to encourage applications from startups with "minimum viable products" and a record of sales.[56]

In June 2020, nearly two years after the Biomimicry Launchpad Showcase, Rebecca invited me to judge the Biomimicry Global Design Challenge again. As a judge in 2018, I was familiar with the job requirements: apply their scoring criteria to the application dossier of 6-8 teams and submit my annotated judgments online—about 8 hours of work.[57] Judging occurs in three phases: preliminary review (in 2020: 107 teams), secondary review of the top 40, and then tertiary review of the top 20.[58] As a repeat judge, I was asked to partake in the second and third stages of the judging process, which included a two-hour long meeting over Zoom with the other judges and with three representatives of the Biomimicry Institute: Rebecca, Michelle, and Lex.[59] To learn how mimesis was evaluated by judges, I helped to select 10 finalists out of the top 20.[60]

[55] See, for instance, Peter Kotecki, "As Brazil's New President Threatens the Amazon, Brazilian Entrepreneurs Create a Device for Large-Scale Forest Restoration," *Business Insider* online, October 29, 2018, https://www.businessinsider.com/brazilian-reforestation-device-bolsonaro-endangers-amazon-2018-10.
[56] Whereas finalists from previous iterations of the Biomimicry Global Design Challenge were automatically registered to compete in the Ray of Hope Prize selection process, their recent decision separated the competition, as a space for early-stage entrepreneurs, from more advanced businesses. Finalists from the design challenge *could* still apply, but it was no longer an automatic transition between the two programs. This decision was made at the advice of Jared Yarnall-Schane, the Biomimicry Institute's newly hired Director of Entrepreneurship—a startup consultant.
[57] Scoring (0-5) was weighted according to the following categories: Biomimicry Process (25%), Context and Relevance (20%), Social and Environmental Benefits (20%), Creativity (10%), Presentation and Communication (10%), and Team (15%).
[58] The final decision was reserved for executives at the Biomimicry Institute, presumably Janine Benyus or Beth Rattner. In the second year that I judged, our recommendations were mostly but not entirely accepted, suggesting the final decision might reflect institutional priorities.
[59] In 2018, I participated in the preliminary review only. Both the preliminary and secondary stages are solitary.
[60] Because of the SARS-CoV2 pandemic, there was no in-person showcase for the finalists after they completed the Biomimicry Launchpad program, which was also conducted virtually. (Before, it involved immersive workshops.)

The design "brief" for the 2020 Biomimicry Global Design Challenge opened with an eschatological forecast of a looming apocalypse. "Earth has always been a changing planet, but the rapid climate and ecological changes humans have set in motion in the last century are nothing any species has experienced before. Hungry for energy, food, and other resources, our growing populations are pushing Earth's systems toward a frightening and well-documented tipping point." Then, from ecological destruction to technological salvation, the brief expressed a call to arms: "To reverse course, we need a new generation of innovators who know how to create human materials, products, and systems that are regenerate, circular, and generous to all species. Our challenge is this: Create a nature-inspired innovation (a product, service, or system) that aligns with…the…Sustainable Development Goals, outlined by the United Nations."[61]

The brief elaborated what would constitute a good proposal: "Successful teams will define a concrete, well researched, area of focus for their design efforts and apply the core concepts and methods of biomimicry in developing a solution. We are especially interested in projects that go beyond familiar approaches by identifying unique leverage points for change, removing barriers to the adoption and spread of existing solutions, and/or clearly demonstrating how biomimicry can lead to new, novel, or more effective solutions." The attributes of a winning design most prized by the judging committee were the legibility of biomimicry in their concepts and the novelty of their innovations relative to market competition: "The entry must show a clear connection between a biological mechanism, process, pattern, or system, and the technological

[61] Of the 17 UN Sustainable Development Goals, the Biomimicry Institute selected 7 that they believed were problems of design. These were Zero Hunger; Clean Water and Sanitation; Affordable and Clean Energy; Industry, Innovation, and Infrastructure; Sustainable Cities and Communities; Life Below Water; and Life on Land. For a full list, including the *excluded* goals, see United Nations, "Sustainable Development Goals," accessed September 27, 2021, https://www.un.org/sustainabledevelopment/sustainable-development-goals/. Somewhat curiously, these goals never explicitly figured into any of deliberations over the top 10 finalists.

solution submitted; i.e., the solution must emulate a natural model(s). Entries must describe an entirely new solution and represent a given team's unique work and intellectual property."[62]

A full submission consisted of biographical information, a project title, concept images (i.e. drawings, renderings, or photographs), a team picture, an overview, a video, and a proposal. In the overview, applicants identified their design problem, its relevance to the UN Sustainable Development Goals, their biological analogues, and a design solution. In the video, biomimics presented this same information in multi-modal form. Lastly, the proposal included a review of the scope, their biomimicry method, the concept, and a discussion of limitations and future steps.

In mid-July, Rebecca hosted a video conference with all of the eleven judges who had scored the top forty, a global panel of jurists from Berlin, Granada, Cape Town, Buenos Aires, and Taipei City (in addition to cities in the United States). After brief introductions, Leon, a "connecting catalyzer" and "exploration facilitator" from Riverside with a biomimicry master's, asked Rebecca whether the Biomimicry Institute preferred ideas with demonstrated, or actual, "risk management" or ideas with virtual "potential" from teams less far down "the path."[63] Curt, a systems engineer from Minneapolis, rephrased Leon's inquiry potential. "With my engineering mindset," Curt said, "I always ask, 'Is this practical? Would it have a chance to work?' Maybe that's not so important because, as we know, any good team is going to pivot." His stance toward evaluation, which stressed practicality ("work"), at first seemed pragmatic (Chapter One), but

[62] These attributes were also identified negatively, in taboos. "What are we not looking for?" the brief asked, prohibiting "biomimicry after the fact" and "common characters." "If you already have a design solution, please do not retroactively argue that it is biomimetic or 'like nature' just to apply." Likewise, it warned against using popular examples, "As new stories and information about biomimicry has spread, many case studies and biological strategies have become common (e.g. the water capturing abilities of the Namib Desert beetle). While this is great for public awareness, creativity and innovation are limited when designers don't look beyond the common cast of characters. For this reason, designs that rely on biological strategies, design concepts, or biomimetic technologies that have already been well documented should offer significant comparative advantages or greater depth of emulation."

[63] On the virtual and the actual, see Gilles Deleuze, "The Actual and the Virtual," in *Dialogues II* (New York: Columbia University Press, 2002), 148-152. For an exposition, see Brian Massumi, *Parables for the Virtual: Movement, Affect, Sensation* (Durham: Duke University Press, 2002).

then he asked Michelle, the competition's new manager: "What do you want in terms of how we do this thing? Like, this is a brilliant idea that has potential regardless of how they are proposing it is going to work, or, oh yeah, these guys have actually done a prototype?" What was potential?

Before Michelle could reply, Colin, a "bioinspired brand builder" from Los Angeles, interjected: "I think a lot of times we focus on what we refer to as feasibility." Colin, the chief market officer of the Biomimicry Institute from 2011 to 2012, opined: "I believe this is a huge part of what we are trying to do here. The mission and vision from the institute's standpoint, as I understand it, is…to make sure that these things make it out onto the market and have the possibility to be biomimetic solutions to prove that this is a viable and powerful pathway." Michelle responded: "We are still very much looking for solutions that have potential to become real things out there in the world…but we are recognizing that these are early designs, so we are looking for something that does have some business potential but that is also just a solid design." Between actual and virtual, Michelle sought to strike a balance in our judging deliberations, agreeing that commercially viable products "allow us to tell those successful biomimicry stories" but countering that the design challenge was as much a story about the potential of this ideology.

Michelle then added a new variable: "I do think an element of it is the team… Do they have a multidisciplinary team? Even if their design isn't perfect as is, do they have the ability to think creatively, to pivot, and to take in the learning that they'll get in the Launchpad program? ...so, yeah, Feasibility, solid team, and, yeah, creativity!" Leon, Colin, and Jacques agreed that teams could be a proxy for the commercial potential of their design. "This is less," Leon began, "about the projects and the innovations and the ideas and more about the individuals, those that will carry this forward." Michelle concluded the discussion of judging criteria with a summary: "A solid team can pivot, but if the fundamental design isn't good, that's a piece to consider."

In the calculus of mimetic appraisal negotiated over the course of this conversation between judges, the "potential" of a design concept for commercialization emerged as a central category of evaluation. Whereas actual "practicality," "feasibility," and "practicality" were all necessary ingredients in the recipe for public storytelling, in addition to the "creativity" (a.k.a. the novelty of their design), the judges all recognized that a "good team" could "pivot"—that a good team had the "potential" to re-think their design, altering its design principles or otherwise applying their concept in another context. By this logic, a "good team" was more important, in a sense, than the design. Whereas the "front stage" performance of the showcase that I observed as a spectator was based around the agency of design, in these "back stage" deliberations, it was, on the contrary, the people—the teams—that possessed the agencies of innovating with biomimicry.

The most successful entries told a compelling story about biomimicry in their design. Elightra, a solar-powered light with a retractable outer shell modeled off a ladybug's elytra was a clear shoe-in. Demonstrably feasible and compellingly "biomimetic," with an argument for analogy that enacted imitation as novel *and* functionally superior to its competitors, its design was an obvious finalist to the judges. Conversely, WeFlant, a self-water pot, was praised by an engineer named Gama from Cape Town for its practicality, but Jacques, an innovation consultant from San Diego, countered that teams in the past had arrived at the same concept. Julia, a public relations manager from Taipei City, agreed with Jacques, nothing that there are "so many similar designs and solutions in Taiwan." Sound in principle, WeFlant was construed as imitative but not innovative. In her study of "proper" and "improper" copies, Cori Hayden remarks that not all

copies (in her case: pharmaceutical generics) are seen as equally valid.[64] So too in biomimicry where imitations of already existing technologies were less valuable than innovative imitations.[65]

When a submission did *not* tell a good biomimicry story, this was most often attributed to the team's misuse of the meta-design methodology of biomimicry thinking. For instance, the app named CHALO77, which listed nearby food options for train passengers, was inspired, the team argued, by the social intelligence of bees. This analogy was deemed "uncreative"—"biomimicry after the fact" instead of strict adherence to the method. This was another kind of improper copy. Yet, in a reversal of the precedent, Colin defended Swaderoo—a kangaroo-based swaddle—even though it was "shallow biomimicry." Despite its dubious methods, Colin proposed that its patent "biomorphism…makes for a good story even if it's not functionally a perfect abstraction." In the workshops I attended, "biomimicry" was opposed to "biomorphism," but in a surprising instance of the performative stance, Colin judged this as a worthy finalist because of its public legibility.

Still, a "good team" could weather criticisms of its "biomimicry." In one example, MyOAK, an app made to connect food producers with consumers, was universally praised for the clarity of their idea, the depth of their research, and the sophistication of their presentation. Curt, however, expressed doubts about their mimeticism. "It's a solid team with good expertise. They consulted with a lot of experts. I live in an area with producers who would like this," he began, then turned, "But it's similar to things outside the challenge—that are on the market. But it's a good team." Colin agreed that it was a great team with "well-produced" materials, but he "want[ed] them to go deeper, to explain what was more of a metaphor," especially one that he

[64] Cori Hayden, "The Proper Copy: The Insides and Outsides of Domains Made Public," *Cultural Economy* 3.1 (2010): 85-102

[65] WeFlant was not a finalist. Nor was SmartDegrader, a tabletop biogas producer, which Therea, a sustainability manager at Kohler International, criticized. "It won't work," she said, but worse, "it's derivative." She explained that other—and better—versions existed on the market.

had already seen before: a "network" based on the mycorrhizal connections of trees and fungi. Jacques reiterated that it was a "strong team" with "high level biomimicry that has been done before." Curt ended the conversation, "Even though the biomimicry isn't that good, it has value, and they could actually get it done." In this case, the judges conceded that the team's ability to "get it done"—to realize the product—was more important than its indexicality as biomimicry.[66]

Between the "front stage" and the "back stage" there was a disjunction or duality in biomimicry's diagrams of agency. To their audiences gathered at the Biomimicry Launchpad Showcase, Benyus and other biomimics imbued nonhuman life with the agencies of innovation, yet, behind-the-scenes as a judge for the Biomimicry Global Design Challenge, I heard instead a cultural model of action that designated people as the primary actors of design—people who can "pivot" from their current plans and remake their technologies anew. While, publically, nature is the author of biomimicry, in private, a different notion of authorship predominated, reflecting the performative, or strategic, quality of their ideological discourses of human/nonhuman agencies.

In recent years, post-human theorists have attributed nonhumans, both organic and inorganic, with agency in a philosophy often portrayed as a political act against human-centered ontologies.[67] These "new animisms," as the anthropologist Kath Weston calls them, "reconceive

[66] Other examples were similarly evaluated. TheSINC, an arctic water collect system, was criticized for its method. "Is this an existing solution they are making biomimetic," Colin asked, "or did it begin with biomimicry thinking? It would be OK if they improved it with biomimicry, but if they said it came out of biomimicry thinking, it loses integrity maybe." Fabian, the founder of a Berlin-based network of sustainability consultants, concurred that the "biomimicry process is an afterthought" but insisted that the science was "brilliant" and that the team could "pivot" later. "There's room for them to rethink were the solution could apply," he said. "Maybe it's not in the market or the area they are looking for. There are broader applications." After he spoke, Curt agreed that they had "potential." Pranavayou, an electrostatically charged air filter, was praised by Leon for its "biological discovery process," but they doubted its feasibility without a "proof of concept to demonstrate whether it's actually effective." Nevertheless, Leon stressed that the "team, its dynamics, the process, the scoping" were all "effective." Curt, who formerly drove cabs, was skeptical if the device would function efficiently in cabs, its proposed application site. "Was it a creative idea?" he asked. "Yes. Biology? Yes. Team good? Yes. I can imagine the team doing something interesting." When Rebecca asked if he thought there was "potential" for it to be used elsewhere, he agreed: "The filter at the end of a washing machine? They have a great potential to pivot."

[67] See, for instance, Bruno Latour, *We Have Never Been Modern* (Cambridge: Harvard University Press, 1993) and Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham: Duke University Press, 2009).

humans as the products of an 'environment' that has itself taken shape through embodied human action."[68] What I saw in biomimicry was not dissimilar: the re-configuration of human designers as conduits, or intermediaries, of nonhuman "genius"—at least, in public. To make sense of these "new animisms" as they emerge in practice, through embodied relations with more-than-humans, Weston mobilizes the concept of "animacy," less an "ontology" than it is a "symptom" of all the entanglements of human and nonhuman knotted through capital.[69] Yet, where Weston situates an analysis of animacy at the level of individuals who choose, or refuse, to involve their selves with the nonhuman, biomimics and the businesses for whom they speak enact animisms, or animacies, not within their bodies, but in their words, discourses. This type of *strategic animacy*, as I started to think of it, was a performance of posthumanism designed to portray biomimicry as a paradigm of design *after* the human, one which, in reality, did not match how biomimics judged designers.

Commodity Animism

The Biomimicry Global Design Challenge was not the only competition that Bruno entered his undergraduate thesis project in industrial design: Nucleário. In addition to the Ray of Hope Prize, Nucleário also won the Green Dot Awards the Red Dot Design Award, the International Design Excellence Award, the Braun Prize, as well as IDEA/Brasil and Desafio Ambiental WWF-Brasil. When I read through his submission to the Braun Prize (the same Braun that manufactures razors and blenders), I was struck by the absence of any discussion of Nucleário's mimeticism. While a semiotic form that structured how spectators perceived artifacts as *mimetic* of specific organisms was ubiquitous at the Biomimicry Launchpad Showcase, it was conspicuously missing from their

[68] Kath Weston, *Animate Planet: Making Visceral Sense of Living in a High-Tech Ecologically Damaged Planet* (Durham: Duke University Press, 2017), 4.
[69] *Ibid*, 7, 4.

entry to other awards. For instance, his proposal for the Braun Prize mentions all the same functions that were in the iteration that I observed—"protection from ants, accumulation of water, shade for seedlings, crowning invasive species, as well as storable and able to glide"—but indices to biomimicry (and, thereby, to the design agencies of nature) were nowhere to be found.

Nor were they in the application for a "modular plant protection device" that brothers Bruno and Pedro sent to the United States Patent and Trademark Office.[70] As a rhetorical genre, patent proposals require "inventors" to demonstrate the novelty, non-obviousness, and utility of the technology in question[71]—hence their extensive review of the "state of the art" in their text.[72] Because the "product of nature" doctrine in American patent law forbids inventors from claiming

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[70] I quote the abstract in complete:

> The present invention provides a modular apparatus for protecting a plant from invasive species and adapting a protective area as a plant grows with little to no post-planting maintenance. For example, a modular apparatus comprises a base comprising a first rim, a water storage, and a plug-in-joint, a lid comprising a second rim and an opening, wherein the first rim is configured to correspondingly fit the second rim, wherein the opening is configured to correspondingly fit the plug-in-joint; and a recess disposed on an edge of the base and on an edge of the lid. An infinite number of modular apparatuses can be coupled to expand protection for plant growth. The modular plant protecting apparatus can be installed manually or deployed by an aerial vehicle into degraded areas with limited-access."

See Bruno Rutman Pagnoncelli and Pedro Rutman Pagnoncelli. 2019. Modular Plant Protection. US Patent 62688953, filed June 24, 2019.

[71] For social scientific literature on patents and other forms of intellectual property, see Peter Galison and Mario Biagioli, eds., *Scientific Authorship: Credit and Intellectual Property in Science* (New York: Routledge, 2003); Mario Biagioli, Peter Jaszi, and Martha Woodmansee, eds., *Making and Unmaking Intellectual Property: Creative Production in Legal and Cultural Protection* (Chicago: University of Chicago Press, 2011); and Rosemary Coombe, *The Cultural Life of Intellectual Properties: Authorship, Appropriation, and the Law* (Durham: Duke University Press, 1999).

[72] Citing three other patents accepted by the United States Patent and Trade Office, they argue for the novelty of their device by virtue of its superior utilities to existing inventions:

> The prior devices fail to address issues of resource competition from invasive species such as leafcutter ants, mosquitos, insects, undesired vegetation, weeds, and grass. Further limitations include costly post-planting maintenance, use of toxic measures to manage invasive species, and the plant protection unsuitable for sloped terrains and adapting to varying planting area. Also, current devices can provide insufficient ventilation and insufficient water to a plant and be cumbersome to transport, in particular, to hard to reach areas. Therefore, there is a need for a modular plant protection apparatus that requires minimal or no post-planting maintenance, uses non-toxic, passive measures against invasive species, and provides adaptable protection as a plant grows over time.

See Pagnoncelli and Pagnoncelli, Modular Plant Protection.

ownership over nature without significant evidence of transformation (i.e. non-obviousness), the ideology of nature's design agency is discursively barred from this literary form.[73] The "source" of the invention is thus implicitly assumed to be the authors of the application, and *not* life itself.

That the mimeticism of Nucleário and other artifacts of biomimicry could be so easily shorn from their objectivity reflects the performative nature of their context of enunciation at the Biomimicry Launchpad Showcase. Within the metalanguage of biomimicry, technologies crafted through their method accrue value by virtue of their mimeticism: Because the "human" is made a suspect figure, biomimics must labor to dress their designs in a mimetic coat of meaning that will bespeak their "origin" in biological agency. Yet as I showed in this chapter, this model of agency does not reflect how judges attribute teams with authorship, nor does it capture the artificiality of organism-to-machine analogies made in Biomimicry Thinking that concerned us in Chapter One. In the field of biomimicry then, the agency of design is doubled, rendered ambivalent, strategic.[74] Mimetic artifacts are, in this sense, like what Murphy calls "heteroglossic artifacts"—capacious objects that can accommodate many systems of significance.[75] They are palimpsests of meaning.

As the public value form of biomimicry (recall Tim's "value proposition), imitative prestige depends on a scaffolding of stories and signs of life's sustainability. Just as "blue-green" capital acquires value in the bioeconomy through fantasies about the generativity of life, mimetic artifacts in the speculative economy of biomimicry become culturally significant through tales of life's agency as a sustainable innovator. At first glance, mimetic artifacts seem to depart from the

[73] On patents in the life sciences, see Daniel Kevles, "Patents, Protections, and Privileges," *Isis* 98.2 (2007): 323-331; Sophia Roosth, *Synthetic: How Life Got Made* (Chicago: University of Chicago Press, 2017), esp. Chapter 3; and Shobita Parthasarathy, *Patent Politics: Life Forms, Markets & the Public Interest in the United States & Europe* (Chicago: University of Chicago Press, 2017).
[74] Unlike the "ambiguation" of agency that Battaglia describes in "Ambiguating Agency," here it is not quite that agency is ambiguous, i.e. the co-existence of multiple cultural models of agency at once. Instead, it is that biomimics switch between them within different contexts. They are, in this sense, ambivalent.
[75] Murphy, *Swedish Design*, 92.

"commodity fetishism" that Karl Marx attributed to the objects of capitalist exchange, in which a feeling of value is misattributed to the commodity itself, not to the organized labor that made it.[76] Because mimetic artifacts bear/bare "traces" of nature's authorship, they might recall instead the "gift" that Marcel Mauss examined—objects that were "inalienable" from histories of production and circulation.[77] In biomimicry, these traces—their appearance of inalienability—are, however, profoundly ideological, obscuring the authorial role of designers. Building on Marx and on Arjun Appadurai,[78] the design historian Hazel Clarke fittingly terms this "design fetishism."[79] They are strategic (alienable inalienabilities: *strategic animacy*[80]) in a way that confounds any distinction of commodities and gifts—not commodity fetishism but something unique: commodity animism.

[76] Karl Marx, *Capital: A Critique of Political Economy, Vol. 1* (New York: Penguin, 1992[1867]).
[77] Marcel Mauss, *The Gift: The Form and Reason for Exchange in Archaic Societies* (New York: Routledge, 2001[1925).
[78] Arjun Appadurai, "Disjunction and Difference in the Global Cultural Economy," *Theory, Culture & Society* 7.2-3 (1990): 295-310.
[79] Hazel Clarke, "New Approaches to Textile Design," in *The Handbook of Textile Culture*, eds. Janis Jefferies, Diana Wood Conroy, and Hazel Clarke (London: Bloomsbury Publishing, 2015), 17-24.
[80] For other scholarship on the hybridity of alienability and inalienability, see, for example, Annette Weiner, *Inalienable Possessions: The Paradox of Keeping-While Giving* (Berkeley: University of California Press, 1992) and Cori Hayden, *When Nature Goes Public: The Making and Unmaking of Bioprospecting in Mexico* (Princeton: Princeton University Press, 2004).

4

Design's Anthropologies: Or, Design Has Always Been Anthropological

Anthropology has a design problem.

For some anthropologists, design is its solution. In a book-length transcript of a conversation between George Marcus and Paul Rabinow, these doyens of the discipline concurred that the Malinowskian ideal of the lone, virtuosic fieldworker was no longer a desirable figure.[1] In reply, Marcus proposed "design," specifically the collective nature of architectural studios, as a model for re-socializing the ethnographic methodology: "This idea of a design process de-centers the significance and the weight of the fieldwork process conventionally viewed and makes it more organic and balanced with what occurs before and after it as part of research."[2] As a template of best practices for anthropologists, design could lend the "studio" as both a real and imagined place where collaborative and recursive inquiry would drive how researchers define their field.[3]

Marcus later expanded the metaphor of design into a full conceit. Ethnography, he supposed, should strive to become more akin to the "prototype": provisional and experimental.[4]

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[1] Paul Rabinow, George Marcus, James D. Faubion, and Tobias Rees, *Designs for an Anthropology of the Contemporary* (Durham: Duke University Press, 2008), 73-92.
[2] *Ibid*, 84.
[3] *Ibid*, 73-92, 113-114. This conversation builds on several decades of methodological reflection on the social construction of the field. For instance, see Akhil Gupta and James Ferguson, *Anthropological Locations: Boundaries and Grounds of a Field Science* (Berkeley: University of California Press, 1997). For a report on an institutional attempt to conceive and operate an ethnographic "studio," refer to Keith Murphy and George Marcus, "Epilogue: Ethnography and Design, Ethnography in Design…Ethnography by Design," in Wendy Gunn, Ton Otto, and Rachel Charlotte Smith, eds., *Design Anthropology: Theory and Practice* (London: Bloomsbury, 2013), esp. 262-265.
[4] George Marcus, "Prototyping and Contemporary Anthropological Experiments with Ethnographic Method," *Journal of Cultural Economy* 7.4 (2014): 399-410.

Going further, Marcus, along with Keith Murphy, has proposed "design" as anthropology's master narrative, fundamentally rewriting "its conceptual infrastructure and its operationalization, the politics of encounter, the tools used for handling knowledge and knowledge production, the kinds and contours of the partnerships that anthropologists form, and the effects and affects anthropological work can bring to the world."[5] The consecration of "design" as the spirit of anthropology recurred in another methodological critique from Caroline Gatt and Tim Ingold, who envisioned "an anthropology *by means of* design"—that is, a way of "moving forward with people in tandem with their desires and aspirations rather than looking back over times past."[6] "Design," in this strand of anthropological theory, provides both the diagnosis and the remedy.

Lucy Suchman offered a divergent assessment. The "problem" that design poses to anthropology, she argued, is less a "design problem" in the sense that heirs to the cognitivist tradition of Herbert Simon might use the phrase, *viz,* to reduce complex issues to sets of goals.[7] On the contrary, the problem inheres in the notion of "design" and anthropology's relation to it. "I believe," Suchman rebutted, citing the conversation between Marcus and Rabinow, "that we need less a reinvented anthropology as (or for) design than a critical anthropology of design."[8] Based on two decades as a design ethnographer at the Xerox Palo Alto Research Center (PARC), Suchman has contended that "design and innovation are best positioned as problematic objects for an anthropology of the contemporary."[9] Precisely because design—as a discourse, a practice, and

[5] Marcus and Murphy, "Epilogue," 253.
[6] Caroline Gatt and Tim Ingold, "From Description to Correspondence: Anthropology in Real Time," in Gunn, Otto, and Smith, eds., *Design Anthropology*, 141.
[7] See Herbert Simon, *The Sciences of the Artificial* (Cambridge: MIT Press, 1996[1969]). On Simon's cognitivism, please refer to DJ Huppatz, "Revisiting Herbert Simon's 'Science of Design,'" *Design Issues* 31.4 (2015): 29-40. For a practice analysis of the problem-oriented *dispositif* (a *dispositif* toward problematization) in design, see Nigel Cross, "Designerly Ways of Knowing," *Design Studies* 3.4 (1982): 221-227. Cf. Ton Otto and Rachel Charlotte Smith, "Design Anthropology: A Distinct Style of Knowing," *in* Gunn, Otto, and Smith, *Design Anthropology*.
[8] Lucy Suchman, "Anthropological Relocations and the Limits of Design," *Annual Reviews in Anthropology* 40 (2011): 1-18, 3.
[9] *Ibid*, 3.

a discipline—participates in the re/production of colonial relations by designating who exists at the center and the periphery of "innovation," Suchman warned that anthropologists should approach design with cautious reservation and critical distance before heedlessly embracing it as "the form fieldwork/inquiry takes and the form of textual presentation to which it might lead."[10]

The impetus for this debate over the problem(s) of design comes from the institutional migration of anthropological *émigrés* from academic departments to design firms in the 1990s. As William Reese has documented, the first collaboration between anthropologists and designers took place in W. Lloyd Warner's study of workplace productivity in the 1930s—research that he conducted at the Hawthorne Works complex with the organizational psychologist Elton Mayo.[11] Within the niche of "business anthropology" that Warner and Mayo created, labor management was the predominant issue for anthropologists until the marriage of "engineering psychology" and "human factors analysis" began to expose the design object itself to the anthropological gaze.[12] According to Christina Wasson, business and marketing research oscillated between the cognitive myopia of individual psychology with the statistical hyperopia of consumer behavior before two prominent designers, Jane Fulton Suri (of IDEO) and Liz Sanders (of SonicRim), recommended that culture might offer a valuable middle level of analysis between the person and population.[13] In software design (i.e. computer-supported cooperative work and human-computer interaction),

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[10] Rabinow et al., *Designs for an Anthropology of the Contemporary*, 116.
[11] William Reese, "Behavioral Scientists Enter Design: Seven Critical Histories," in Susan Squires and Bryan Byrne, eds., *Creating Breakthrough Ideas: The Collaboration of Anthropologists and Designers in the Product Development Industry* (Westport: Bergin and Garvey, 2002), 17-44.
[12] *Ibid*.
[13] Christina Wasson, "Ethnography in the Field of Design," *Human Organization* 59.4 (2000): 377-388. According to Wasson, Suri's interest in "culture" started with a study of motorcycle accidents. Moving past "human factors" of lights and clothing, she framed social status, gender (e.g. masculinities), and "meaning" as important questions for designs. See also Jean Fulton Suri, "Poetic Observation: What Designers Make of What They See," in Alison Clarke, ed., *Design Anthropology: Object Culture in the 21st Century* (New York: Springer Verlag, 2010), 16-32.

first, and subsequently in industrial design consultancies, anthropologists were hired in increasing numbers to discern the cultural values that inform how "users" engage with new technologies.[14]

Ton Otto and Rachel Charlotte Smith observed that scattered, isolated pockets of anthropologists coalesced, over the course of the 1990s and early 2000s, into the hybrid subfield known as "design anthropology," formalized by the publication of important edited collections.[15] So central was the ethnographic method to this inter-disciplinary exchange that Otto and Smith have declared it the principal currency between the two fields: "The major relationship between design and anthropology has been through ethnography."[16] This significant relocation of theories and methods did not go without comment from anthropologists, whose engagement with design came from one of two sites: internal to design, as a warning against the reduction of ethnography to its "implications for design,"[17] or externally, in wistful remarks from commentators like Marcus and Murphy, who wrote, "We cannot help but notice that this relationship has historically been, by and large, one-sided, with a predominant emphasis on the benefits of anthropology for design without much regard for any potential contributions of design for anthropology."[18]

To map how ideas and techniques move in this budding inter-discipline, Murphy has proposed a cartography of three "arrangements" or "configurations" between anthropology and design, a vector space that accounts not just for the fact of their exchange but also the direction.[19] The first, "design for anthropology," includes proposals, *a la* Rabinow and Marcus, that would remodel anthropology after design, in its conceptual and methodological likeness.[20] The second,

[14] *Ibid*. Cf. Otto and Smith, "A Distinct Style of Knowing."
[15] *Ibid*.
[16] *Ibid*, 2.
[17] Paul Dourish, "Implications for Design," *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (April 2006): 541-550.
[18] Murphy and Marcus, "Epilogue," 252.
[19] Keith Murphy, "Design and Anthropology," *Annual Reviews in Anthropology* 45 (2016): 433-449, 434.
[20] E.g., Rabinow et al., *Designs for an Anthropology of the Contemporary*.

"anthropology for design," refers to the adoption of ethnographic method within design practice.[21] The third, "anthropology of design," encompasses research that addresses design as its object, whether "present," in recent scholarship, or "absent," in the persistence of form in anthropological theory.[22] After all, as Murphy has commented "design lurks in the shadows of anthropology."[23]

In a rejoinder, Suchman impugned Murphy's endeavor to map design and anthropology as timeless singularities: "Debate over relations between any two things presupposes the prior question of how the entities being considered are (separately) constituted in the first place."[24] In the case of PARC, Suchman witnessed how the meanings of "design" were multiple even in the span of her own tenure there: As neoliberalism became the dominant economic logic within the United States, PARC regressed from what was, formerly, a "space of generative difference," receptive to critical anthropology, to a factory that prized "frictionless solidarity."[25] Suchman's prepositional worries about design and anthropology—as/for/of—were nervous symptoms of the subsumption of design by neoliberal regimes of value, i.e. not generic concerns about cross-over.

In a series of essays, Alison Clarke has corroborated the multiplicity of "design," uncovering the historical antecedents of the present valorization of ethnography in design, which predate its methodological institutionalization in the 1990s and over the following two decades.[26]

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[21] E.g. Gunn, Otto, and Smith, *Design Anthropology*.
[22] E.g., Natasha Schüll, *Addiction by Design: Machine Gambling in Las Vegas* (Princeton: Princeton University Press); Keith Murphy, *Swedish Design* (Ithaca: Cornell University Press, 2015); Lily Chumley, *Creativity Class: Art School and Culture Work in Postsocialist China* (Princeton: Princeton University Press, 2016); Lilly Irani, *Chasing Innovation: Making Entrepreneurial Citizens in Modern India* (Princeton: Princeton University Press, 2019).
[23] Murphy, "Design and Anthropology," 434.
[24] Lucy Suchman, "Border Thinking about Anthropologies/Designs." Unpublished manuscript, February 2018.
[25] *Ibid*, 5, 4.
[26] Alison Clarke, "The Anthropological Object: From Victor Papanek to Superstudio," in Alison Clarke, ed., *Design Anthropology: Object Culture in the 21st Century* (New York: Springer Verlag, 2010), 74-87; Alison Clarke, "Design Ethnologist: Ettore Sottsass Jr.," *in* A. Cole and C. Rossi, eds., *The 1970s Italian Design Avant-Garde* (Berlin: Sternberg Press, 2013); Alison Clarke, "The Indigenous and the Autochton," *in* V. Borgonuovo and S. Franceschini, eds., *Global Tools: When Education Coincides with Life 1973-1975* (Istanbul: Salt, 2019); Alison Clarke, "Design for Development, ICSID and UNIDO: The Anthropological Turn in 1970s Design," *Journal of Design History* 29.1 (2016): 43-57; Alison Clarke, "The New Design Ethnographers 1968-1974: Towards a Critical Historiography of Design Anthropology," *in* Rachel Charlotte Smith, Kasper Tang Vangkilde, Mette Gislev

The "anthropological turn" occurred, she argued, in the 1960s and 1970s when avant-garde collectives like Archizoom, SUPERSTUDIO, and *Global Tools* rejected the "rationalism" of the Ulm School and its object-oriented practitioners, looking to the "primordial" and the "primitive" instead to rediscover "authentic" practices of form outside the capitalist subsumption of design.[27] Just as Marcel Mauss sought economic alternatives in the gift-giving customs of Polynesia and the Pacific Northwest, so too did these designers contrast "the otherness of the vernacular" with the bourgeois aesthetics that they had inherited—a cross-cultural dialectic between self and other that anthropologists George Marcus and Michael Fischer have referred to as "cultural critique."[28] Part of the Italian post-Fordist movement against mass unemployment and immiseration, these collectives found, in anthropology, a genetic definition of labor in design, an "ur-design," which acted as a counter-paradigm of design against its narrow codification by elite criteria of taste. The same democratic sentiment, Clarke argued, repeats in the discourse of participatory design that became popular in Denmark and Sweden through and alongside the work of Victor Papanek.

By revisiting the potential invested in anthropological studies of "primitive" design, Clarke's historicization of ethnography in design reveals how the "acculturation"[29] of the object

Kjaersgaard, Ton Otto, Joachim Halse, and Thomas Binder, eds., *Design Anthropological Futures* (London: Bloomsbury, 2019), 71-88.

[27] Alison Clarke, "The Anthropological Turn"; Alison Clarke, "The New Design Ethnographers."

[28] *Ibid,* 76; George Marcus and Michael Fischer, *Anthropology as Cultural Critique: An Experimental Moment in the Human Sciences* (Chicago: University of Chicago Press, 1996[1986]).

[29] I use the term "acculturation" more playfully, and abstractly, than its original reference to "those phenomena which result when groups of individuals having different cultures come into continuous first-hand contact," referring instead to the process by which an object of discourse becomes amenable to the anthropological concept of culture. On acculturation, see Robert Redfield, Ralph Linton, and Melville Herskovits, "Memorandum for the Study of Acculturation," *American Anthropologist* 38.1 (1936): 149-152. For a history of the culture concept, see Michael Fischer, "Culture and Cultural Analysis as Experimental Systems," *Cultural Anthropology* 22.1 (2007): 1-65.

was, initially, an act of anti-capital, as well as an index of a "design ideology"[30] that could not be further from the commodification of the "social"[31] that defines "design thinking" in the present.[32] A compelling proof of the multiplicity of "design," her account nevertheless re-animates the same historiographic fetish it aims to demystify, leaving intact the assumption that ethnography was, in fact, the primary commodity and medium of exchange between design and anthropology.

In its presentist fixation on ethnography, the historiography of design obscures the "anthropological" knowledge that has long animated design theory. As I noted in interlude three, imaginaries of the Other's cultural design practices have been central to theories of technology's first principles from antiquity to the present, Vitruvius to Benyus. Through the Other, scholars of design have reflexively theorized design itself in a dialectic of self and non-self. "No prophet or philosopher of any consequence," the anthropologist Stanley Diamond avers, "has spelled out the imperatives of his version of a superior civilization without assuming constants in human nature and elements of a primitive condition, without […] engaging in the anthropological enterprise."[33] Despite the perenniality of (proto-)anthropological knowledge in design, ethnography dominates the conversation around design and anthropology, belying their many epistemological relations. Perhaps it is not anthropology that has the design problem but, to flip the predicate, design that has the anthropology problem. More than a "turn," perhaps it is anthropology that, *pace* Murphy, lurks in the shadows of design. Perhaps, in other words, design has always been anthropological.

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[30] Adrian Forty, *Objects of Desire: Design and Society Since 1750* (London: Thames & Hudson, 1992[1986]).
[31] Clarke, "The New Design Ethnographers." See also Lucy Suchman, "Consuming Anthropology," in Andrew Barry and Georgina Born, eds., *Interdisciplinarity: Reconfigurations of the Social and Natural Sciences* (London: Taylor & Francis, 2013). On the commodification of culture in social context, cf. Jean Comaroff and John Comaroff, "Millenial Capitalism: First Thoughts on a Second Coming," *Public Culture* 12.2 (2000): 291-343.
[32] Peter G. Rowe, *Design Thinking* (Cambridge: MIT Press, 1998[1987]).
[33] Stanley Diamond, "Introduction: The Uses of the Primitive," in Stanley Diamond, ed., *Primitive Views of the World* (New York: Columbia University Press, 1964), v-xxix, x. See also Daniel E. Bender, *American Abyss: Savagery and Civilization in the Age of Industry* (Ithaca: Cornell University Press, 2009).

As an anthropologist of design, it was an uncanny experience to find in biomimicry anthropologies of design that imitated but did not match my own, like tropes of the timeless, ecologically harmonious Indigene or fantasies of sensorily inhabiting the "native point of view." To account for the "anthropological" knowledge that shapes design from the "shadows," I offer the concept of *design's anthropologies*—an "arrangement" or "configuration" between the two domains of thought that is irreducible to ethnography. This concept, as I intend it, seeks to make visible the points, lines, and planes of contact between design theorists and practitioners and the knowledge of cultural differences that they marshal to understand, talk about, and materialize the concepts and objects of design, whether through personal interaction with anthropologists, direct citation of anthropological texts, or participation in a shared (but not identical) field of discourse.

This concept, which scans the past as much as it assays the present, opposes the universalization of anthropology, asking instead why and which anthropological categories of the human and their variations become useful to designers at specific "intra-disciplinary" junctures.[34] Answering Suchman's plea to pluralize "design" *and* "anthropology," I am interested in tracking not just the shifting political economies of design, as Suchman and Clarke have mapped so well, but also the multiplicity of anthropologies, from the romantic to the pragmatic (see Introduction).

More than a record of the incidence of connection, critical ethnographies of *design's anthropologies* attend to the "social life" of anthropological knowledge(s) within design praxis, analyzing how the anthropological activates other categories of thought in design—for instance, in biomimicry, categories of time, value, and sense.[35] Insofar as such ethnographies interrogate

[34] I use the prefix "intra," alluding to Karen Barad's notion of "intra-action," to refer to how the disciplines of design and anthropology are mutually co-constituted, rather than pre-formed. See Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham: Duke University Press, 2007).
[35] Arjun Appadurai, "Introduction: Commodities and the Politics of Value," in Arjun Appadurai, ed., *The Social Life of Things: Commodities in Cultural Perspective* (Cambridge: Cambridge University Press, 1986), 3-63.

the distortion of anthropological thought into—to take one example—"green primitivism" or capitalizations on Indigeneity, there is a politics to the anthropology of design's anthropologies. Through the scrutiny of these colonial representations, this program partakes in what Suchman has described as the "anthropology of design's decolonization"[36]—a project that furthers similar critiques by contemporary scholars of design.[37] While anthropology is not free from its colonial pasts either, as Talal Asad and other scholars noted,[38] there has been, for well over a century, an effort to practice an anthropology sensitive to the pitfalls of romanticism, ethnocentrism, etc.[39]

[36] Suchman, "Border Thinking about Anthropologies/Designs," 16.

[37] Design history has long universalized white history, an elision of colonial proportions that, to Tony Fry, framed Western development as *the* story of "the 'manmade' designed world." "The contemporary mainstream concept of design in the West," Rajewshwari Ghose has elaborated, "is in some vague manner connected with new sources of energy, technological breakthroughs, mass production, minute specializations, and global quest for markets." The corollary was that designers elsewhere were robbed of agency, grossly caricatured as apes of Western ingenuity. On the contrary, Fry has questioned how histories *from* and *about* geographies of "marginality" might resist the default narrative of the copy for non-Western design while also capturing how colonial economies operated *through* design and the coerced sale of consumerist social forms. Pivoting from the past to the present, other theorists have asked how the colonial persists, after the event of "decolonization," in the "colonialist codes" that organize space, people, and things. With the lens of "postcolonial computing,' Kavita Philip et al. have analyzed the way that codes of "power, authority, legitimacy, participation, and intelligibility" continue to influence how "intercultural encounters in design practice" form atop a landscape sedimented by colonialism. To decolonize design, Dori Tunstall has recommended design anthropology; ethnography, she said, is best attuned to the differences in meaning that constrain the human use of technology. Here, I suggest a complementary approach to hers. See Tony Fry, "A Geography of Power: Design History and Marginality," *Design Issues* 6.1 (1989): 15-30, 17; Rajewshwari Ghose, "Design, Development, Culture, and Cultural Legacies," *Design Issues* 6.1 (1989): 31-48, 31; Jeanne van Eeden, "Imperialism, Myths, and South African Popular Culture," *Design Issues* 20.2 (2004): 18-33; Kavita Philip, Lilly Irani, and Paul Dourish, "Postcolonial Computing: A Tactical Survey," *Science, Technology, and Human Values* 37.1 (2010): 3-29, 3, 8; Elizabeth (Dori) Tunstall, "Decolonizing Design Innovation: Design Anthropology, Critical Anthropology, and Indigenous Knowledge," in Gunn, Otto, and Smith, eds., *Design Anthropology*, 232-250. See also Arturo Escobar on "decolonial design" in *Designs on the Pluriverse* (Durham: Duke University Press, 2019).

[38] Since the 1970s, anthropologists have documented how the genesis of their discipline coincided with the consolidation, intensification, and extension of colonial domination the world around. For instance, Talal Asad directed the anthropological gaze back upon itself, onto its own historical *a priori*, namely, the asymmetry of access that was born from the pre-configuration of "an unequal power encounter between the west and third world." For Asad, the ramifications of this constitutional inequality were manifold, seeping outward into "the practical preconditions of social anthropology; the uses to which its knowledge was put; the theoretical treatment of particular topics; the mode of perceiving and objectifying alien societies; and the anthropologist's claim of political neutrality." Talal Asad, "Introduction," in Asad, *Anthropology and the Colonial Encounter* (Amherst, NY: Humanity Books, 1973), 9-20, 16, 17. See also Dell Hymes, ed., *Reinventing Anthropology* (New York: Vintage, 1974) and Diane Lewis, "Anthropology and Colonialism," *Current Anthropology* 14.5 (1973): 581-602.

[39] For a review, see George Marcus and Michael Fischer, *Anthropology as Cultural Critique* (Chicago: University of Chicago Press, 1986). Consider also Faye Harrison, "Anthropology as an Agent of Transformation: Introductory Comments and Queries," in Faye Harrison, ed., *Decolonizing Anthropology: Moving Further toward an Anthropology for Liberation* (Arlington: American Anthropological Association, 1990), 3-4.

Informed by this latter anti-/de-colonial tradition of anthropological theorization, ethnographies of design's anthropologies aim to query the translation of anthropological knowledge within the panoply of "cultural," "human," and "social" paradigms of design that have proliferated over the past two decades and their ideas of *anthropos* in the nexus of knowledge, technology, and power.

CONCLUSION

Ruins of a Future Perfect Bioeconomy: Revisiting the Magic of Mimesis

> Who's copying whom? Is copying ever not a form of self-replication? When it's all done with mirrors, it's difficult, if not impossible, to find out who's really spinning the sticky web.
> —KAREN BARAD, *Meeting the Universe Halfway* (2007)[1]

> At best Utopia can serve the negative purpose of making us more aware of our mental and ideological imprisonment…and that therefore the best Utopias are those that fail the most comprehensively.
> —FREDERIC JAMESON, *Archaeologies of the Future* (2007)[2]

> A direct obvious imitation often produces a sterile imitation because none of the original sensibilities are actually emulated, only a product-orientated spin-off, like Barbie's many clones.
> —MARY RUEFLE, *Madness, Rack, and Honey* (2012)[3]

On my final night in Gloucester, members of the Biomimicry and Resilience Workshop were gathered around a picnic table on a rocky outcropping that jutted into the Atlantic Ocean. As the sun receded, brushing faces ruddy with alcohol in a golden hue, Taryn pulled out a deck of cards, a reinterpretation of the popular children's game GoFISH produced by the Biomimicry Institute.[4] The rules were simple. Each player received seven cards: either "biology" cards that depicted organisms and their notable design principles (e.g. the boxfish and its "hydrodynamic shape") or "challenge" cards that articulated design problems (e.g. the need for a vehicle that "meets human

[1] Karen Barad, "Quantum Entanglements: Experimental Metaphysics and the Nature of Nature," in *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007), 366.
[2] Frederic Jameson, *Archaeologies of the Future: The Desire Called Utopia and Other Science Fictions* (London: Verso Books, 2005), xiii.
[3] Mary Ruefle, *Madness, Rack, and Honey: Collected Lectures* (Seattle: Wave Books, 2012), 65. Thanks to Sophia Roosth for pointing me to this essay.
[4] Biomimicry 3.8, "Biomimicry GoFish," accessed September 30, 2011, https://biomimicry.net/product/gofish/.

comfort and safety needs" with "aerodynamic perfection"). During a turn, a player drew one card from their hand that another player paired with a card of the opposite kind and a justification for why that was sound biomimicry. Group assent validated a pair, and the game ended at 25 pairs.

Figure 1: Biomimicry Go Fish

Dissent was immediate. When the "boxfish" was matched with "automobile design," Tim objected that, in reality, this pairing was fishy. In the 1990s, Dieter Gürtler, the lead concept engineer at the Mercedes Technology Center in Sindelfinger, Germany, contacted ichthyologists at the Naturkundermuseum Stuggart for inspiration on a bionic car. They settled on the boxfish: a bony and, as one might guess, boxy organism with a distinctive morphology that was believed to confer the fish a hydrodynamic profile and self-correcting movements—an obvious parallel, it

seemed, to the design problem at hand, i.e. a car with spacious carriage, minimal drag, and high levels of stability. In 2005, Mercedes-Benz released the "Bionic" concept car to great fanfare at the DaimlerChrylser Innovation Symposium in Washington, D.C. While the car exhibited lower gas emissions, this was not due to the inherent sustainability of biological function.[5] In fact, it was later revealed to be based on dubious scientific knowledge about the fish. In 2015, a team of biologists from the University of Antwerp, the University of Groningen, and UCLA disputed the alleged hydrodynamism of the boxfish, confirming that its shape promoted drag *and* instability.[6] The car foundered, and because of that, Tim thought, the match floundered. Notwithstanding that the game designers at the Biomimicry Institute had identified a bionic car as "biomimicry," Tim dismissed this pair as biomimicry because it was not premised on good science—fidelity to life.[7]

As the second decade of the third millennium came to a close, much of the unfettered optimism (or pessimism) in technologies made through "biomimicry," like the boxfish-inspired car, had subsided. News articles about biomimicry that flooded my inbox with regularity in the early days of my fieldwork—gifts from benevolent friends and colleagues—had slowed to a trickle. Blogs and other webpages about "nature-inspired innovation" had been abandoned by the time I went to read them, cast down to the netherworld of the Ethernet. Everywhere it seemed as if the promise of a new bioeconomy had been broken as artifacts made in life's likeness failed to deliver on expectations of unparalleled efficiency and ecological harmony. Indeed, enthusiasm in chambers of commerce had waned. According to the Fermian Business and Economic Institute (FBEI), the think-tank which had predicted the financial potential of biomimicry, interest in this

[5] Instead, it was a consequence of a new catalytic technology the engineers had employed.
[6] S. van Wassenbergh, K. van Manen, T.A. Marcroft, M.E. Alfaro, and E.J. Stamhuis, "Boxfish Swimming Paradox Resolved: Forces by the Flow of Water around the Body Promote Manouevrability," *The Journal of the Royal Society – Interface* 12.103 (2015): 1-11.
[7] Note that it was through Tim that I discerned the pragmatic stance and yet here he espouses the idealistic—hence my assertion that mimetic stances are situational and interactional, irreducible to person, context, practice, or time.

field peaked in 2014, the year I began this project. Based on their "Da Vinci Index," a metric of articles, patents, and grants about biomimicry, the institute observed that a five-fold increase in the index from 2000 to 2013 (after *Biomimicry* was published in 1997), followed by a sharp decline in 2014 that persisted in 2016, the last datum entered (itself a sign of some significance).[8] "Although the fall in the DaVinci Index could be short-lived," their website read, "those working in the field should be concerned about the possible loss of momentum due to the recent decline."

Nowhere was the disappointment of deceleration more acutely seen than in San Diego, where the FBEI had anticipated a future "biomimicry hub."[9] Seen as a mirror image of Silicon Valley, where "intellect" and "capital" met "entrepreneurs" and "collaborations," San Diego was the darling object of economic speculation—a capitalist idyll where a booming regional network of 600 cleantech and 550 biomedical firms would foster the commercialization of biomimicry.[10] In a 2010 report, the FBEI guessed that the concerted effort of 1,000 "biologists, naturalists, and other scientists" would generate 2,100 jobs and $325 million for the city of San Diego by 2025.[11] For some commentators, glimpses of the bioeconomy of tomorrow could be stolen in the current success of the telecommunications company Qualcomm, which is headquartered in San Diego.[12] In 2004, Qualcomm acquired the San Francisco-based business Iridigm, and with the acquisition, the rights to license its patented reflective display technology. In 2007, Qualcomm rebranded this technology as Mirasol™: an energy-saving screen "inspired" by the iridescent Morpho butterfly.

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[8] The Fermian Business & Economic Institute, "The Da Vinci Index & Biomimicry," accessed September 30, 2021, https://www.pointloma.edu/centers-institutes/fermanian-business-economic-institute/da-vinci-index-biomimicry.
[9] Randy Ataide, *Global Biomimicry Efforts: An Economic Game Changer* (San Diego: Fermian Business and Economic Institute, 2010), 4.
[10] *Ibid*, 36-40.
[11] *Ibid*, 36.
[12] See, for instance, Rebecca Boyle, "San Diego Zoo Wants Inventors to Design New Robots and Devices Inspired by Its Animals," *Popular Science* online, August 31, 2012, https://www.popsci.com/technology/article/2012-08/san-diego-zoo-wants-inventors-design-new-robots-and-devices-inspired-its-animals/.

At heart of this enterprise was the San Diego Zoo, the sponsor of the report and the "fulcrum" of this "new economy."[13] As historians of natural history have described in detail, botanical gardens, zoo(logical gardens), aquaria, and other spaces of biological collection have long stood at the intersection of power, knowledge, and capital, ordering and concentrating life for various intents: scientific production, economic gain, ritual symbolism, entertainment and diversion, and, increasingly, environmental conservation.[14] In 2008, Paula Brock, chief financial officer of San Diego Zoo Global, sought to reactivate this history in the service of biomimicry. After reading Paul Hawken's *Natural Capitalism*, which cites Janine Benyus's *Biomimicry*,[15] she re-envisioned the zoo as a space of product innovation. Each of the 840 species of animals and 40,000 species of plants could be a model for a new sustainable technology, and the zoo, a model for "technology transfer and commercial development" to parks internationally. Between 2009 and 2011, the zoo hosted three annual conferences on biomimicry, inviting dignitaries like Janine Benyus, Jay Harman, representatives of Qualcomm, and San Diego's mayor, Jerry Sanders, who, along with the National Science Foundation, funded the event, stating, "for entrepreneurs, there's money to be made in this."[16] In 2012, the San Diego Zoo founded the Center for Bioinspiration, a biomimicry "incubator" that would not only create value for the San Diego economy but also persuade business professionals to value nature as an "untapped" wellspring of design wisdom.[17]

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[13] Randy Ataide, *Global Biomimicry Efforts*, 37.
[14] See footnote 2 in Interlude 2.
[15] Recall that Benyus herself cited Paul Hawken's *The Ecology of Commerce*. In a sense, this dissertation is an ethnography of the book *Biomimicry* and its lives and afterlives.
[16] Interviewed in Glenn Croston, "Biomimicry, the Zoo, and San Diego Too," *Fast Company* online, October 7, 2009, https://www.fastcompany.com/1393091/biomimicry-zoo-and-san-diego-too.
[17] See Kristine Wong, "How the Business of Biomimicry Is Happening at the Zoo," *GreenBiz* online, February 25, 2013, https://www.greenbiz.com/article/how-business-biomimicry-happening-zoo. See also Tom McKeag, "Nature's Inventions: San Diego Conference Showcases Biomimicry Products," *GreenBiz* online, October 7, 2009, https://www.greenbiz.com/article/natures-inventions-san-diego-conference-showcases-biomimicry-products and Mary Hoff, "Z Is for Inspiration: How Zoo Life Teaches Us to Solve Problems," *GreenBiz* online, June 5, 2014, https://www.greenbiz.com/article/z-inspiration-how-zoo-life-teaches-us-solve-problems. For a startling about-face, compare with Tom McKeag, "Innovation Doesn't Guarantee Success: Mirasol's Market Journey," *GreenBiz* online, April 2, 2013, https://www.greenbiz.com/article/innovation-doesnt-guarantee-success-mirasols-market-journey.

When I went to investigate the Centre for Bioinspiration as a fieldsite in 2018, it had vanished. A rash of media features about the zoo in 2012 and 2013—in *Popular Science, BBC, The San Diego Union-Tribune, GreenBiz,* and *Popular Science*—led me to nothing but a website for a facility named Tech to Reconnect (at the time of writing, this, too, has since up and gone). The last conference they organized, from what I could find, took place in 2013, five years prior. Taken aback by its ephemerality, I emailed its former managing director, Larry Stambaugh, and Gabriel Miller, the zoo's director of research and development. Both agreed to speak with me, so I drove out to San Diego to meet the two. What they told me about evanescence of the Centre for Bioinspiration, I ponder in conclusion, is a touchstone for thinking about biomimicry's utopia.

The Death and Life of a Great American Centre

"We're not helping anyone unless we apply this knowledge," Larry Stambaugh told me at a dimly lit restaurant near San Diego's Seaport Village, blocks away from the convention center. When he read *Biomimicry* in the early 2000s, he was impressed by Benyus's vision but wanted to see it realized in products. Born in Kansas, Larry is an "entrepreneur at heart," a "serial CEO" with a business administration degree who left a seven-year stint at the accounting firm KPMG to run companies in retail, banking, environmental services, and biomedical research. Through a position with Connect, a network of entrepreneurs in Southern California, he learned that the San Diego Zoo was looking to establish a new center for biomimicry. "This could be really important for the planet, for people," he said to me. In 2012, he reached out to Brock, helping her to broker a relationship with Biomimicry 3.8. When he met with Benyus, he praised her work, telling her it was "fabulous" but that he "like[d] to see things applied," not just "hugging trees." He recalled to me that Benyus said, "I don't like business people, but I like you." At the backing of Benyus, the

San Diego Zoo opened the Centre for Bioinspiration in August of 2012. As managing director, Larry's responsibility was to leverage his experience raising over $500 million in capital to drum up seed money for the center. His first target was philanthropy, and, later, venture capital, a plan for operations that would become self-sufficient with the licensing of intellectual property created and patented during the workshops that became the Centre for Bioinspiration's mainstay.

To facilitate the transfer of knowledge from the bodies of organisms and the "minds" of their handlers and keepers, Larry hired Gabriel ("Gabe") Miller, an Oxford- and Harvard-trained zoologist with expertise in locust ecology, who joined in March of 2013. As director of research and development, Gabe oversaw the corporate workshops that introduced companies with design problems to latent solutions in nature—how the California condor protects its bald spot from UV radiation or how the honey badger survives a cobra's poison, Larry offered as examples. "Nature solves just about everything we face," he professed. "We just don't know how to match and look for it." Based on the "design thinking" workshop form popularized by IDEO and later adapted by the Biomimicry Conglomeration™ (Tim McGee consulted Gabe before he started), the Centre for Bioinspiration primarily existed as a coordinator of three-day-long workshops with high-level executives from, in total, twelve companies: P&G, Chrysler, New Balance, Nike, and NASA.[18]

In one workshop with Sprint, which was video-recorded and documented as a Harvard Business School case study,[19] the mobile network operator needed packaging for its phones that was, according to its environmental initiative director, "flexible, durable, recyclable, lightweight, aesthetically pleasing, and environmentally friendly."[20] After clarifying their criteria, Gabe led a

[18] Although I did not interview her, Claire Wathen was involved in the Centre for Bioinspiration as its coordinator of corporate programs and communication, i.e. corporate "outreach," recruiting new companies to buy said workshops.
[19] Karim R> Lakhani, Vish V. Krishnan, and Ruth Page, *Bioinspiration at the San Diego Zoo* (Cambridge: Harvard Business Publishing, 2014).
[20] Mary Hoff, "What Can an Engineer Learn from a Tortoise?" *Ensia* online, May 19, 2014, https://ensia.com/features/zoo-biomimicry/.

group from Sprint (see Figure 2) "behind the scenes," as Larry said, to animals that embodied the "protect" function: the tortoise, three-banded armadillo, and hedgehog (and one plant: the bird of paradise). In subsequent indoor sessions—"essentially lots of Post-It Notes interspersed with animal presentations and facilitated discussions and brainstorming games"—Gabe, an invited materials scientist, and the Sprint team collaboratively produced a product "look" that would, according to a spokesperson from Sprint, leave "no question [that] this is something that draws from nature's inspiration."[21] In August of 2013, Larry quit his position, and the Centre closed.

Figure 2: Screens "Behind the Scenes"[22]

When I asked Larry why he thought the Centre for Bioinspiration had failed as an institutional experiment in commercialized biomimicry, he pinned its dissolution on his sense

[21] Jennifer Walter, "Why Sprint Turned to Biomimicry for Packaging Design," *GreenBiz* online, October 2, 2013, https://www.greenbiz.com/article/why-sprint-turned-biomimicry-packaging-design.
[22] *Ibid*.

of the San Diego Zoo's moral qualms with business. "I filed a patent," he disclosed to me, "and I thought they were going to faint." He elaborated, "Nonprofits don't generally feel like business is a good thing." Nor did Larry think that universities were fertile ground for future endeavors:

> I don't think it's an academic thing. It's got to be an undertaking that's for-profit. Because companies are going to be more comfortable working with a for-profit. It can be done in a fashion where the for-profits not there just to make money but understands how to work with for-profit companies: filing patents, bringing in development programs, getting venture money behind things, helping entrepreneurs take technology out to the companies where they can develop it, make discoveries. Big companies can come in and fund some project, take it back out and apply it, more like an institute or development organization. I'm really talking about applying, not just research. I could care less about writing a hundred papers. Papers can be for getting something applied. But if you don't apply it, to mankind or the planet, it's just a good idea. That's where I was frustrated.

A self-described "visionary thinker," Larry doesn't "like precise"—hence his grievances toward the zoo, which slowed his efforts at commercialization. For Larry, what mattered more than talk about biomimicry, or text (i.e. scientific papers), was advancement to market. Any sort of fidelity to nature was subordinate to its exchange value. This was why he chose "bioinspiration" over "biomimicry" when naming the Centre. "I don't think we actually mimic," he reflected. "We are inspired by biology, and we learn from them and adapt it." Total mimesis would slow the motion of value that, as Karl Marx noted, is crucial to the functioning of capital—what he termed the "*perpetuum mobile* of circulation."[23] "I could have done that the rest of my life," Larry pined at the interview's end, "if they had been willing to be a little more commercial and business-like."

For Gabe, it was precisely Larry's "business-like" disposition and the "commercial" nature of biomimicry that led to the Centre's demise. A San Diego native who attended Caltech as an undergraduate student before pursuing doctoral and post-doctoral study at Oxford and then Harvard, respectively, Gabe was searching for work related to "nature plus design," he said. But,

[23] Karl Marx, *Capital: A Critique of Political Economy, Vol. 1* (New York: Penguin, 1992[1867]), 227.

when he arrived, he quickly grew "critical of biomimicry as a nonacademic practice." Over lunch at an island plantation-themed restaurant at the San Diego Zoo, he reflected on this turning point:

> I came in with naïve optimism that we could leverage academic findings in new ways with corporations, but then I started to be disillusioned by the fact that academic findings or evidence-based things were trumped by marketing things and sloppy thinking and… The method for starting with a turtle shell and then trying to create a new packaging for a cell phone, which was the premise of the Sprint workshop, starting with cardboard that uses corrugation (it has durability and a light-weight element, and sustainable because it's from trees), and you're pretending that looking at a turtle shell is going to make something better than that.

To Gabe—an "ex-biomimic," perhaps—workshops were little more than "high-priced corporate retreats" that merely "pretended this environment was more special than a retreat at Disneyland." In workshops, teams were "trying to force cases together that don't belong," not doing "science."

The source of his animus toward what transpired at the Centre stemmed from what he called "romantic" biomimicry. Parsing its stress on "marketing and aesthetics and story-telling" from "academic" research on robotics and materials science—i.e. biomimetics and bionics—that is not about "conservation," he contended that, with the romantic version, there is no "legitimate derivation of function that isn't already known from the biological world." "Nature," he claimed, "does not inform our understanding. Math and science do." In contrast to biomimicry's "amateur naturalism," as Tim called it, or empiricism, Gabe felt it was "naïve to think that natural systems could teach you something you don't already know unless you are a primary researcher." What is "already known" is simply read into nature, and for this reason he believed that biomimicry was mostly debunked. In the case of Mirasol™, he disputed their "convenient story" of the butterfly:

> What could be a more eco-friendly and sexy symbol of their product than a butterfly? But the engineers that worked on it are angry that the true story of the origin of the product, their labor, is taken away by the butterfly as a symbol of what could have been equally embodied by an oil slick (rainbow colors on an oil spill, thin film interference known for hundreds of years) because we understand that. That's how we talk about it. The butterfly doesn't teach us anything we don't already know.

Biomimicry was, therefore, little more than a "cute story"—a "good way to get donor money," i.e. a "marketing effect," and a "fashionable shorthand for people doing what they've always done." What the Sprint workshop on phone packaging attained was simply "repacking old stuff."

In Gabe's view, the epistemology of "biomimicry thinking" stood on a "circularity." Through "forced analogy," biomimics project "authorship onto nature for human stuff," which he labeled as the "fetish view"—a paradox that "both says nothing and tries to say everything":

> You can tell any story you want about nature… There are so many systems that do so many things… It's almost like the Bible. You can selectively quote it to tell any story you want, and the notion of quoting becomes meaningless, or at least equal to any other system with a diversity of forms and shapes… Nature is silent. We make it speak for us. Any kind of interpretation can ensue.

Mimesis was less one of Whitehead's "lures" to Gabe than it was, as he called it, "a trap," an especially pernicious one. The problem with its "romantic and untrained projection of value" was that it diminished nature's worth to its technological use, or "productivity," as Elizabeth Johnson has phrased it.[24] Whereas Larry had found value in the circulation of stories about nature, Gabe found these stories to be disingenuous and "sad," lacking any empirical basis in biological fact.

As a result of his growing disillusionment, Gabe was, he recollected, "responsible for steering the zoo away from this initiative" and toward the Tech to Reconnect project. Underlying this transition was a shift in the imagined relationship between nature and the human. While life is, to biomimics, perfect, optimal—"Nature doesn't make any junk," Larry told me—Gabe had a less sanguine view of biology. Describing the human brain as a "ramshackle house," he liked to think of nature as a "patchwork, haphazard, barely surviving accumulation of accidents." Nature, to Gabe, was not "cooperative" but a Hobbesian zone of "competition." Substituting one cultural imaginary of nature for another, Gabe remarked that we need to be "less like nature" to survive:

[24] Elizabeth Johnson, "Reconsidering Mimesis: Freedom and Acquiescence in the Anthropocene," *South Atlantic Quarterly* 115.2 (2016): 267-289.

> One can argue that we're destroying the planet because we're doing what all other organisms do when they start to dominate an ecosystem: start using up resources; start aggregating territory, driven by instincts, selfishness; compete for mates and wealth; try to become powerful; use all things we can. Bacteria replicate until there's no food, until they die. What's more natural than one species slowly dominating? … There's a romantic view that wolves don't eat all the deer, leave some for next year, [that] nature is always in balance, but there's no evidence for that… Things use up everything they can, reproduce as quickly as possible.

Biomimicry "forgets that we *are* nature." His second venture at the San Diego Zoo started from a different premise: that we "need to be *less* like nature," or "unnatural, in the sense," he said, "of planning ahead, which we do to a unique extent."[25] Handing me a pair of googles that simulated "what it would be like" to hear and see like a bat,[26] he proposed we should be developing design, not based *on* nature, but *for* nature—a change in perspective from biology as origin to outcome.

Traps of a Capitalist Utopia: Difference and Repetition

Since the implosion of the Centre for Bioinspiration in 2013, no other institution dedicated to biomimicry aside from the Biomimicry Conglomeration™ has withstood the test of time[27]—a test of "survivability" that, to this community of *mimetic practice*, is a proxy for "sustainability." Not unlike the "ghost" of the "high-modern" Volta resettlement plan that ethnographer Thomas Yarrow beheld in New Senchi, Ghana, the "ruins" of the San Diego Zoo's plan for biomimicry (really: a three-room office building that was repurposed for Gabe's Tech to Reconnect) linger as architectural mementos of the "myriad juxtapositions of actual circumstances with the unrealized plans of modernization," or, rather, in biomimicry's case, of post-humanization[28]—of an anti-

[25] Compare with Marx on the architecture of bees and spiders in *Capital*, 284.
[26] Thomas Nagel, "What Is It like to Be a Bat?" *The Philosophical Review* 83.4 (1974): 435-450.
[27] Given Larry's preference for "bioinspiration," it is perhaps more accurate to say that no institution dedicated to biomimicry has *ever* existed.
[28] Thomas Yarrow, "Remains of the Future: Rethinking the Space and Time of Ruination through the Volta Resettlement Project, Ghana," *Cultural Anthropology* 32.4 (2017): 566-591, 567.

modern, mimetic retreat, escape, or "way out" from the ongoing ruination of the contemporary through recourse to the design agency of a nonhuman hand.[29] The failure to grow, or *non-space*, of such centers—infrastructures that never were, or *were* but temporarily[30]—is a reminder, not of the unfulfilled promises or unrealized "expectations of modernity"[31] that have preoccupied the anthropological literature on ruins.[32] It is a reminder of unrealized expectations of post- or anti-modernity and the effort of biomimicry believers to deliver us from the sins of "modern" design.

Among biomimics, it is a common pastime to speculate about the reasons for biomimicry's popularity over the course of the 21st century, among them:[33] the sophistication of new visualization technologies, the stature of the biological sciences (especially, the dwindling hegemony of genetic determinism), and what the anthropologist Gisli Palsson and his colleagues term a "gradual, growing awareness of the extent to which human beings have been altering the global environment."[34] It is seldom, if not never, discussed why biomimicry has diminished, or, more specifically, why its evolution has been split in two: its spectacular presence as a consulting or educational practice and the lifeless absence of design or "design" practices centered on life's likeness. This dissertation advances one such theory: the incoherence of the field of biomimicry, that is, the fractionation of Janine Benyus's metalanguage of imitation into multiple value forms.

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[29] Johnson, "Reconsidering Mimesis."
[30] Yarrow, "Remains of the Future,"
[31] James Ferguson, *Expectations of Modernity: Myths and Meanings of Urban Life on the Zambian Copperbelt* (Berkeley: University of California Press, 1999).
[32] On ruins, see, for instance, Ann Laura Stoler, ed., *Imperial Debris: On Ruins and Ruination* (Durham: Duke University Press, 2008); Gaston Gordillo, *Rubble: The Afterlife of Destruction* (Durham: Duke University Press, 2014); or Shannon Lee Dawdy, "Clockpunk Anthropology and the Ruins of Modernity," *Current Anthropology* 51.6 (2010): 761-793.
[33] Consider Veronika Kapsali, *Biomimicry for Designers: Applying Nature's Processes and Materials in the Real World* (London: Thames & Hudson, 2016).
[34] Gisli Palsson, Bronislaw Szerszynski, Sverker Sörlin, John Marks, Bernard Avril, Carole Crumley, Heide Hackmann, Poul Holm, John Ingram, Alan Kriman, Mercedes Pardo Buendía, and Rifka Weehuizen, "Reconceptualizing the 'Anthropos' in the Anthropocene: Integrating the Social Sciences and Humanities in Global Environmental Change Research," *Environmental Science and Policy* 28 (2013): 3-13, 4.

This incoherence, I contend, exposes the imaginative limits of biomimicry: the restriction of its eco-utopic vision to an apolitical design space dictated by the capitalist logics of financial return.

As this brief history of the Centre for Bioinspiration shows in an exemplary fashion, the disagreement between Larry and Gabe entailed, as I have argued, a social conflict between disparate *mimetic stances*. Whereas Larry wanted to accelerate mimetic artifacts toward a market for them regardless of their fidelity to nature (the *pragmatic* stance), Gabe refused, insisting that real mimesis, the kind of mimetic practice seen in biomimetics and bionics, demanded prolonged and deep scientific research into nature. While Gabe dismissed biomimicry as, yes, romantic, but mostly *performative*—recall the *mimetic labor* that Sprint invested in the "look" of packaging to evoke its *imitative prestige*—his *idealistic* stance toward what a proper copy should embody, i.e. a sense of genuine surprise from nature, resonated with how Raúl (Chapter Two) explicated the *mimetic ethic* in design as a ceaseless dialectic between human design and nonhuman genius. Far from unified, the field(s) of biomimicry reflect the contradictions between utopia and reality.

Part of this incoherence stems, I believe, from the reliance of biomimics upon the workshop—a medium of communication in which the very form of the genre excludes the kind of ethical relationship to nature envisioned by Benyus. Not only is access mediated through the transfer of money: a curious barrier to an "ethical" community that, notwithstanding my scruples (after all, everyone needs to make a living), serves only to restrict the "meme" or "movement" to an elite audience, as the Biomimicry Institute rightly circumvented by freely sharing biomimicry "thinking" materials online. But, more importantly, the temporal duration of the event, or its lack thereof, delimits and defangs the *meta-design* method of biomimicry, exposing attendees to rapid and highly mediatized corporate "experiences" of nature, promoting circular reasoning that could be deployed toward the extrapolation of any biological function from life. Most of the "products"

are thus poorly conceived, never achieving commercial success, like the Bionic car. As a result, I was hard pressed to find any consistent example of a viable artifact made through biomimicry—a void of referentiality that biomimics compensated for by ambiguously claiming examples in the fields of bionics and biomimetic as biomimicry. As I stated in the dissertation's introduction, this is the only magic of mimesis in business innovation: the illusion of a field—or, a *mimetic field*.[35]

I previously said that the workshop "defangs" biomimicry due to the fact that its abbreviated temporality precludes the mimesis of both functionality *and* ecological "fit" that real biomimicry requires. The art historian Jennifer Johung has witnessed that practitioners in bio-art and bio-architecture move the category of "life" away from biologists, deforming and reforming its meaning[36] (this is as biologists themselves have moved away from life,[37] and as the West has moved away from "nature").[38] In biomimicry, proponents likewise move life away from biology, not to question its pre- and post-suppositions, but to give the "power" of mimesis,[39] as Michael Taussig described it, to corporate executives who mask the traces of their own authorship under the pretense of nature's will. Reading biomimicry the *ethic* against biomimicry the *practice*, my fieldwork revealed that biomimicry led only to "sterile" copies, as Mary Ruefle describes them, "product-oriented spin-off[s]" wherein "none of the original sensibilities are actually imitated."[40]

Of this imitation of an imitation, Karen Barad employs the provocative phrase "the topology of Sameness," elaborating this as the "deadening and sinister symmetry of Sameness

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[35] At this point, the reader will have surely noticed the repetition of the adjective "mimetic" in the conceptual armamentarium I have pulled from in this dissertation. This is intentional, reflecting both the name of the topic but also its underlying ideas of repetition with (or without) a difference.
[36] Jennifer Johung, *Vital Forms: Biological Art, Architecture, and the Dependencies of Life* (Minneapolis: University of Minnesota Press, 2019).
[37] Stefan Helmreich, "What Was Life? Answers from Three Limit Biologies," *Critical Inquiry* 37.4 (2011): 671-696.
[38] E.g., Marilyn Strathern, *After Nature: English Kinship in the Late Twentieth Century* (Cambridge: Cambridge University Press, 1992).
[39] Michael Taussig, *Mimesis and Alterity: A Particular History of the Senses* (New York: Routledge, 1994)
[40] Ruefle, *Madness, Rack, and Honey*, 65.

that uses the hall of mirrors to suck time, history, and mater into the black hole of stasis (leaving in its stead a culture of no culture and a nature of no nature)."[41] After Gabe (and Bruno Latour), one might think of this as making nature "speak"—a vocalization that only parrots human truths in an echo chamber of the similar.[42] This "defanged" or, to borrow a metaphor from our viral era, attenuated form of mimesis might grant immunity from difference, but it is a far cry from the less enfeebled interpretation of mimesis that Taussig recognized in *Mimesis and Alterity*, which had a tendency against "self-replication" that Raúl noticed too.[43] This tendency resides in the sensuous, a nature which biomimics *could* return to mimetically find their selves and their artifacts anew.[44]

This is not Barad's "nature of no nature,"[45] Gabe's "pure nature"[46] of competition, or the apolitical nature that Johnson finds in the discourse of biomimicry.[47] This nature is akin more to the provoking nature evoked in Hans-Jörg Rheinberger's notion of "difference machines," or in Andrew Pickering's "dialectic of resistance and accommodation," in which nature and culture (or artifice), human and nonhuman, and life and technology are remade together, "intra-actively" as Barad might say.[48] In this style of mimesis, the human is not repeated within nature's image but re-produced a second time through, in Barad's words, "responsibility and accountability for the entanglements 'we' help enact," along with "what kinds of commitments 'we' are willing to take on, including commitments to 'ourselves' and who 'we' may become."[49] While I take issue with Barad's assessment that "the emerging field of biomimetics is not about copies of originals

[41] Barad, *Meeting the Universe Halfway*, 382.
[42] Bruno Latour, *Politics of Nature: How to Bring the Sciences into Democracy* (Cambridge: Harvard University Press, 2004).
[43] Taussig, *Mimesis and Alterity*.
[44] *Ibid*.
[45] Barad, *Meeting the Universe Halfway*, 382.
[46] Johnson, "Reconsidering Mimesis."
[47] See Hans-Jörg Rheinberger, *An Epistemology of the Concrete: Twentieth-Century Histories of Life* (Durham: Duke University Press, 2006).
[48] See Barad, *Meeting the Universe Halfway*, esp. the Introduction.
[49] *Ibid*, 382.

or even copies of copies without beginning or end,"[50] not the least of which because it conflates, as I have argued, the field of biomimicry with related areas of biomimetics and bionics, I find her reading of "biomimesis" as a "particularly poignant call for the incorporation of difference at every level," i.e., her excavation of the political and ethical in biomimicry, to be an apt descriptor of the revolutionary "magic" of mimesis that I heard in Raúl's longings for a successor paradigm to "modern" design. Revisiting Taussig's formulation of the "mimetic faculty" as "the nature that culture uses to create second nature,"[51] Raúl envisioned a *third nature*—a revitalized first nature. Implicit in the "we" transformed through mimesis was an exclusion of Indigenous persons. What these biomimics might consider better in their mimetic equation is not just nature but culture too. Who can imitate? Who is visible in imitations? And whom do these imitations of nature benefit?

What inhibits this other mode of mimesis from flourishing is the subsumption of biomimicry "design" within the capitalist logic of the commodity. In recent times, "design" has been revered as a nostrum for ecological crisis. William McDonough, champion of the "circular economy" and author of *Cradle to Cradle* (another book I was often told to read), calls "fugitive carbon" a "design failure" and climate change a "design project needing lots of attention,"[52] one that the recycling of products and their parts would rectify. Like McDonough, Benyus framed the relationship of human and environment as a design problem: "the design of sustainable products through biomimicry," she said in *Biomimicry*, "may actually precede the sustainability revolution and help bring it into being."[53] As scholars of design have noted, climate change and problems of

[50] Barad, *Meeting the Universe Halfway*, 382.
[51] Taussig, *Mimesis and Alterity*, xiii.
[52] Marcus Fairs, "Climate Change Is a 'Design Project Needing Lots of Attention' Says William McDonough," *Dezeen* online, June 21, 2021, https://www.dezeen.com/2021/06/21/carbon-climate-change-design-project-william-mcdonough-interview/.
[53] Janine Benyus, *Biomimicry: Innovation Inspired by Nature* (New York: Harper Perennial, 2002[1997]), 283.

an ecological nature are what Horst Rittel called "wicked problems"[54]—problems which Richard Buchanan describes as fundamentally "indeterminate," torn between clients with "multiple value systems."[55] What I have characterized as the proliferation and multiplication of mimetic stances indexes this indeterminacy: Biomimics in practice are caught between conflicting forms of value.

While, in theory, the design problem these biomimics face might be wicked, in the context of everyday life, it is not entirely in-determinate. Rather, it is often determined, if not "overdetermined,"[56] by the profit motive that consultants, designers, and other biomimics must confront when making products, or commodities, under contract, wherein exchange value almost always trumps the mimetic ethic. Because the *utopic* demand of biomimicry is impossible under the labor conditions of most product designers, biomimics end up making the same things with a veneer of nature's difference, or, more often, their proposals are shelved, dismissed, or exhibited by "green" businesses as evidence of noble intent without any resolution to implement them. The practice of mimesis is, as Karl Marx might say, "subsumed" by capitalism's commodity logics.[57] While many of the biomimics I spoke with voiced apprehensions about the product emphasis of biomimicry in private, or even publically, the "green" capitalist mode of production was viewed as a necessary or strategic alternative to doing nothing. What my fieldwork suggests is that mimetic product design is also tantamount to doing nothing—new iterations upon old products, if anything is really made at all. Despite the rhetoric of "ecological" or "sustainable" design, it is true that, as Victor Papanek once criticized, little of this has destabilized design's economies:

> Since the 1970s, the critiques and visions…have continued to ripple through design schools and conferences but have never strongly threatened the underlying premise of

[54] Horst Rittel and Melvin Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4.2 (1973): 155-169.
[55] Richard Buchanan, "Wicked Problems in Design Thinking," in *The Idea of Design: A* Design Issues *Reader*, eds. Victor Margolin and Richard Buchanan (Cambridge: MIT Press, 1995), 3-20, 14.
[56] Louis Althusser, "Contradiction and Overdetermination," in *For Marx* (London: Verso, 2006[1965]), 97-128.
[57] Marx, *Capital*, 1019-1038.

> design practice that the role of the designer is to provide services to his or her clients within the system of consumer culture… Designers settle for small victories that are ultimately dependent on the willingness of manufacturers to undertake some form of good work with such a green product.[58]

In the lack of any material revolution, biomimics sell more workshops, hoping to effect change, a societal transformation in values. But they don't produce things. They only produce biomimics. Waiting in anticipation of a promise that will never be kept, they squander the magic of mimesis.

The failure of the San Diego Zoo's Centre for Bioinspiration and the non-existence of biomimicry in institutions of design are not without their lessons. As Frederic Jameson perceived in *Archaeologies of the Future*, "the best Utopias are those that fail the most comprehensively" for the reason that they make us "more aware of our mental and ideological imprisonment."[59] In Gabe's language, this is the "trap" of biomimicry: the prison of possibility in which mimesis has been confined. Bereft of its revolutionary potential, mimesis only serves to further the ambitions of a corporate few. If, as Jameson argues, "utopia serves as the mere lure and bait for ideology," then the dissolution of the dream of biomimicry exposes that "our imaginations are hostage to our own mode of production"—that biomimicry has only been imagined as a *capitalist utopia*, a non-space where profitability meets sustainability.[60] In her ethnographic study of green design in Masdar City, Gökçe Günel names this future perfect vision of "technological complexity without interrogating existing social, political, and economic relations" as a "technical adjustment" that "open[s] up certain interventions while foreclosing others."[61] Delimited by the commodity form,

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[58] Victor Margolin, *The Politics of the Artificial: Essays on Design and Design Studies* (Chicago: University of Chicago Press), 95.
[59] Jameson, *Archaeologies of the Future*, xiii.
[60] *Ibid*, 3, xiii.
[61] Gökçe Günel, *Spaceship in the Desert: Energy, Climate Change, and Urban Design in Abu Dhabi* (Durham: Duke University Press, 2019), 11.

biomimics never think to consider what Clive Dilnot has termed a "post-product society," one in which capital itself is re-examined alongside their ecological critique of nature and technology.[62] Thinking beyond the producer-consumer sociality of the product form, designers like biomimics could take more equitable steps toward rebuilding the plural ecologies of life that lie in ruination.

[62] Clive Dilnot, "Design as a Socially Significant Activity: An Introduction," *Design Studies* 3.2 (1982): 139-146, 144.

Epilogue

Totems and Taboo

Just as my fieldwork on biomimicry was coming to a close in 2019, another romantic anthropology arose in a new paradigm of design that has been called biomimicry's successor. In a bustling room at the heart of the XXII Triennale di Milano, the architect Neri Oxman, a celebrity once exalted in the design journal *Domus* as the "demiurge of the third millennium," had installed two black columns, slender and roughly ten-foot-tall.[1] The display would have eluded notice altogether were it not for the translucent cubes they held, illuminated, at their core. There, Oxman had grown an undifferentiated and inchoate substance of unknown provenance and identity—a mottled mass spanning the full spectrum of brown, from off-white to near-black.

From six holes at the top of the encasement, the foreign matter appeared to ooze down the middle, there dividing and recombining, folding, unfolding, and refolding in serial, before ultimately seeping, at the bottom, out of eyesight. In actuality, it was entirely motionless, bound in a plasticized prison. Its illusory optics were a result of its general morphological similarity to the curving materials typically classed as living—less still life than it was anima(tion) suspended.

The journalist Mark Wilson found the spectacle to be alluring: "The pieces manage to look enchantingly organic—somehow capturing the natural beauty of our skin and eyes without resembling a mutant creature grown in a lab."[2] Felix Amiss, an architectural photographer, was

[1] "Neri Oxman: Design, Biography, and Works of Neri Oxman," *Domus*, February 11, 2020, https://www.domusweb.it/en/biographies/neri-oxman.html.
[2] Mark Wilson, "MIT's Radical Plan to Make Buildings out of Melanin," *Fast Company*, April 8, 2019, https://www.fastcompany.com/90330635/mits-radical-plan-to-make-buildings-out-of-melanin.

less sanguine: "Lovely – reminds me of something I caught growing in my carton of milk."[3] Whatever the aesthetic response it elicited, Oxman's artisanship invariably intimated an organic origin, possibly even the organic's origin, like the *Urschleim*, or "primordial slime," that the 19th-century German evolutionary biologist Ernst Haeckel once hypothesized as the intermediary link between the organic and the inorganic, the protoplasm from which all life was begotten.

Figure 1: Romantic Biology[4]

That the form of this object, named *Totems*, would allude to the primordial was an apropos move, intentional or not, for a white designer whose exposition of the project referred to another imagined firsthood—not biological, but "anthropological," that is, "indigenous peoples." "If we are to continue to survive on this planet," Oxman prognosticated thus, "we must return to this state of 'being' and universal wisdom previously recognized by indigenous [sic] peoples."[5] Echoing the "green primitivism" of Benyus, Oxman forecast white futurity through romantic ideas of Indigenous yesteryear—a fictitious time when nature and design were unbroken, whole.

[3] Felix Amiss, April 5, 2019 (9:18 a.m.). Comment on Rima Sabina Aouf, "Neri Oxman Builds with Melanin for Totems Project," *Dezeen*, April 5, 2019, https://www.dezeen.com/2019/04/04/neri-oxman-totems-technology/
[4] The Mediated Matter Group, "Totems," *Mediated Matter Group*, February 2018, https://mediatedmattergroup.com/totems.
[5] Aouf, "Neri Oxman Builds with Melanin for Totems Project."

In this iteration of what I am calling design's anthropologies, the spacetime Elizabeth Povinelli calls "settler modernity" was contrasted against an invented tradition of ecological Indigeneity.[6]

Her nostalgia dovetailed neatly with the rest of the artifacts that the triennial's curator, Paola Antonelli, had assembled for the theme *Broken Nature: Design Takes on Human Survival*. Antonelli, who works as the director of R&D at the Museum of Modern Art in New York City, commissioned Oxman's contribution specifically as a centerpiece for the exhibition, which, according to her, "highlights the concept of *restorative design* and studies the state of the threads that connect humans to their natural environments—some frayed, others altogether severed."[7] Into the cabinet of "less speculative" curiosities that Antonelli showcased, which also featured a biodegradable pregnancy test, washable period underwear, and anti-radioactive stilettos, Oxman added *Totems*: a sculpture "dedicated to all sentient beings across the six kingdoms of life—past, present, and future," and carved out of a peculiar material: melanin, the "ink" of organisms.[8]

Totems was the artist's address to a perceived dualism between nature and design, a constitutional problem which has recurred across Oxman's decade-long oeuvre. Born in Haifa, Israel, to a family of famed architects, Oxman pursued medicine before pivoting to a fated career in architecture. She earned her PhD in Design and Computation from MIT under the tutelage of William J. Mitchell, a leading theorist of formal and digital approaches to architectural design. Her dissertation, "Material-Based Design Computation," analyzed the "crisis of form" that has plagued modernist design theory and practice: "Over the long trajectory of architectural design history the design and production of artifacts has been characterized by the growing separation of

[6] Elizabeth Povinelli, "Settler Modernity and the Quest for an Indigenous Tradition," *Public Culture* 11.1 (1999): 19-48.
[7] Paola Antonelli and Ala Tannir, "Reparations by Design," *Broken Nature*, March 1, 2018, https:www.broken nature.org/reparations-by-design/.
[8] The Mediated Matter Group, "Totems."

form-making from its natural foundations in material conditions."[9] To redress this bifurcation between form and material (she alternatively parses material as matter), Oxman called for a shift toward what she labeled, initially, a "New Materiality," a "post formal paradigm in architecture" that would achieve "formation without formalism."[10] What might design look like, she queried, if "material [were] not considered a subordinate attribute of form, but rather its progenitor?"[11]

In 2010, immediately upon graduating, Oxman founded the Mediated Matter Group, an "anti-disciplinary" team of designers, biologists, computer scientists, and materials engineers, based at the MIT Media Lab, that collaboratively researches what she calls "material ecology": "the realization that the environment and the design object interact through multiple dimensions and a spectrum of environmental variables."[12] Oxman's resolution to the tension between form and material inhered, first, in an algorithm for computing the form of a design object as an effect of its ecologies—a morphogenetic dialectic of materiality and environment that, rewound, finds its *primum movens* in biological substance, "as in Nature, when creation *begins* with matter."[13]

For the insight that, in life, "form generation is driven by maximal performance with minimal resources through local material property variation," Oxman has credited an eclectic set of influences, from Frank Lloyd Wright's idea of organic architecture to D'Arcy Thompson's biomechanical studies of development in biology.[14] Her conceptual affinity to Benyus was

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[9] Neri Oxman, "Material-Based Design Computation," PhD thesis completed for the Department of Architecture, Massachusetts Institute of Technology, 2010, 27.
[10] Neri Oxman, "Per Formative: Towards a Post Materialist Paradigm in Architecture," *Perspecta* 43 (2010), 1-17, 14, 1, 9.
[11] Neri Oxman, "Material Ecology," in *Theories of the Digital in Architecture*, eds. Rivka Oxman and Robert Oxman (New York: Routledge, 2014), 1.
[12] Neri Oxman, Christine Ortiz, Fabio Gramazio, and Matthias Kohler, "Editorial: Material Ecology," *Computer-Aided Design* 60 (2015: 1-2, 1.
[13] Oxman, "Material Ecology," 1.
[14] Neri Oxman, "Material-Based Design Computation," esp. "Abstract" and "Nature's Way: Sources and Development of a Design Cultural Phenomenon."

prominent in her early writing: "Nature is demonstrably sustainable. Her challenges have been resolved over eons to enduring solutions with maximal performance using minimal resources."[15]

Unlike biomimicry, Oxman's aspirations for material ecology extend beyond what the design critic William Myers has called "mere mimicry" toward something else: "biogenesis."[16] Of biomimicry, Oxman wrote, "Such organic fallacies resulted in an appropriation of nature and the organic as prescribed metaphors."[17] Rather than copy natural form, Oxman looks to copy the form of organic growth itself—"from biologically inspired to biologically engineered design."[18] Pairing her signature style of digital computation with new techniques in additive manufacturing (more widely known as 3-D printing), Oxman has fabricated an array of "natural artifacts" that reflect her philosophy of "forming form," including exhibits at the Boston Museum of Science, the SFMOMA, and a midcareer "monograph" at the MoMA, which closed due to COVID-19. A theoretical curiosity toward designing "as if" biology has pushed Oxman to experiment with design techniques that directly utilize and modify biological materials and organisms, beginning with her foray in vermitecture, the silkworm architecture of *Silk Pavillion,* completed in 2013.[19]

Justifying her use of melanin in *Totems*, Oxman waxed, "Melanin is the color of life."[20] In biological organisms, "melanin" refers to a family of related molecules, synthesized from the amino acid tyrosine, that contributes epidermal pigment (skin color) as well as pigmentation in eyes, hair, feathers, and exoskeletons. There, melanin functions to confers protection to cells

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[15] *Ibid,* 41. On the gendering of nature, reference footnote 114 in the Introduction.
[16] William Myers, *Bio Design: Nature Science Creativity* (New York: The Museum of Modern Art, 2013), 14; Oxman, "Materials-Based Design Computation," 46.
[17] Oxman, "Per Formative," 10.
[18] Neri Oxman, "Templating Design for Biology and Biology for Design," *Architectural Design* 85.5 (2015): 100-107, 107
[19] Here, I invert the historian Evelyn Fox Keller's description of how mechanistic biologists understood living organisms "as if" designed. See Evelyn Fox Keller, "Organisms, Machines, and Thunderstorms: A History of Self-Organization, Part One," *Historical Studies in the Natural Sciences* 38.1 (2008): 45-75, 50.
[20] The Mediated Matter Group, "Totems."

from the deleterious effects of ultraviolet radiation. Melanin's evolutionary conservation across taxonomic phyla from humans to birds inspired Oxman to design with a molecule she glossed as the "universal pigment" and "a biomarker of evolution"—a biological symbol which "represents unity in the diversity of life."[21] Seizing upon an "ancient" biological medium that, in her mind, was "clearly linked to biological survival throughout the ages"—she has cited fossil records of melanin in the Mesozoic era—and "in the age of climate change […] key to human survival on earth," Oxman initiated a research program into the production of melanin within architecture.[22]

At *Broken Nature,* Oxman choreographed and staged a public demonstration of her newfound mastery over the making of melanin—over melanopoesis. The architect introduced the enzyme tyrosinase into the tyrosine substrate that filled the column's core, catalyzing a reaction that, over the duration of a day, generated a polychromatic sculpture of melanin Oxman called a "biological" or "chemical totem." The finished product, she said, was a "structural embodiment" of that "spirit being, sacred object, or symbol that serves as an emblem of the Tree of Life."[23] "Our use of the word [Totem] is rooted in admiration and respect of and for all things alive materially and immaterially," Oxman explained in an interview with *Fast Company*, "and for the wisdom of the Ojibwe people, who coined the word, as well as other First Nation peoples, who,

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[21] *Ibid*.

[22] *Ibid*. To transform melanin into a design tool, the Mediated Matter Group abstracted the molecule from the biological milieu that bound it to, and in, living organisms. One line of investigation consisted of bioprospecting melanin from living sources, like birds and cuttlefish; another, replicating the *in vivo* chemical synthesis of melanin with the application of fungal enzymes to tyrosine; and a third and final, the genetic engineering of an *E. coli* colony to produce melanin. After proving that the extraction and manufacture of melanin was feasible, the team ascertained its "tunability," or their ability to reliably induce one of five hues across liquid or solid phases. Last, they developed, a "generative design" program to "grow" and "print" hollow "channels" into a clear vessel containing the melanin. For a critical analysis of the discourse of "generative design" and its claims to sustainability through complexity, see Christina Cogdell, *Towards a Living Architecture? Complexism and Biology in Generative Design* (Minneapolis: University of Minnesota Press, 2018).

[23] The Mediated Matter Group, "Totems." On arboreal symbolism in biology, see David Archibald, *Aristotle's Ladder, Darwin's Tree: The Evolution of Visual Metaphors for Biological Order* (New York: Columbia University Press, 2014).

unlike us, saw and felt and connected with this synergy."[24] She concluded her justification for *Totems'* use of melanin: "In our project, we are revisiting the Totem as we acknowledge and commemorate diversity through biological (and chemical) diversity so essential to life on earth."

Oxman's polysemic reference to the totem—first as a particular linguistic term used by the Ojibwe people, then as an ontology universal across all Indigenous and First Nation peoples, and, lastly, as a metaphor for metaphorical thought in general—mirrors its epistemic history as a concept studied and utilized by anthropologists since the second half of the nineteenth century.[25] To Oxman, in other words, *Totems* "commemorate[s] diversity" with a "totem" of "totemism," a biological metaphor that symbolizes the metaphorics of cross-species ontological identification. The journalist Mark Wilson of *Fast Company* seconded her assessment of *Totems*, which "teases a future of resilience and diversity—both in buildings and in the people who occupy them."[26]

Yet, like the "fetish" in social theory, the "totem" of *Totems* flattens and distorts the original. In his history of the voyage of the concept of the fetish across the black Atlantic, the anthropologist J. Lorand Matory argues that the Western appropriation of the fetish, from the rites of the Guinea Coast and into the theories of Hegel, Marx, and Freud, misrepresents the

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[24] Mark Wilson, "MIT's Radical Plan to Make Buildings out of Melanin."

[25] Entering the Western lexicon in 1791 via John Long, an English fur trader who wrote about the "Chippewa" *totam*, a zoomorphic spirit and symbol of an animal class barred from consumption, the "totem," and totemism, became, to the historian Robert Alun Jones, "an evocative object" for anthropologists who hypothesized totemism as a stage of social evolution. This theoretical lineage begins with George Grey's *Journals of Two Expeditions in North-West and Western Australia* (1841), which generalized and abstracted the totem beyond the Ojibwa, imbuing it with an anthropological "secret," Jones says, the key to the evolution of mankind. Part of its mystique was the seeming ubiquity of a "totemic" stage of culture, not just among the Ojibwa, or even First Nation peoples, but worldwide, in "primitive" societies that organized their clans and pasts by totems, and that proscribed totem-related prohibitions in hunting and kinship. Comment on this "universal" phenomenon came from J.F. McLennan, William Robertson Smith, A.R. Radcliffe-Brown, and James Frazer, as well as Emile Durkheim and, lastly, Sigmund Freud. Following critiques of totemism from Franz Boas and A.A. Goldenweiser, which cast doubt on the coherence and integrity of totemism, the "totemic illusion," as Claude Levi-Strauss came to phrase it, mutated as an epistemic thing: less objective social fact, or psychological law, than it was a style of thought, of classification for Levi-Strauss and Edmund Leach, and identification, most recently, for Philippe Descola, who, like Irving Hallowell, treats the totem as ontology. Robert Alun Jones, *The Secret of the Totem: Religion and Society from McLennan to Freud* (New York: Columbia University Press, 2005), 3, 9. See also Irving Hallowell, "Ojibwa Ontology, Behavior, and World View," in Diamond, *Primitive Views of the World.*

[26] Mark Wilson, "MIT's Radical Plan to Make Buildings out of Melanin."

nature and reality of fetishism, reflecting a disagreement between Europeans and Africans over "the value and agency of people and things," slotting Africans as "Europe's regressive Other."[27] Just as the fetish figures Africa as the inverse of the West, so too does *Totems'* "totem" mold Ojibwa belief into a token of an essentialized Indigenous ontology that contrasts with Oxman's. Where Levi-Strauss denounced how the anthropological use of the totem "allowed the savage, within culture itself, to be isolated from civilized man," Oxman's artwork relies on this contrast while simultaneously subordinating Ojibwa thought into Western symbolism, the tree of life.[28] Rather than respecting epistemic diversity, her romanticized appropriation of the totem was little more than what Zoe Todd called "disembodied representatives of an amorphous Indigeneity that serves European intellectual or political purposes."[29] Perhaps totems are not good to think with.

The contradictions of a white designer of Eastern European descent appropriating an Indigenous term to construct a future of racial unification were nowhere more pronounced than in the melanotic architectures that Oxman envisioned alongside the installation. Hung behind the work, three digital renderings depicted one practical application of melanin: "an environmentally responsive melanin-infused glass structure."[30] In these simulations, a rectangular prism rested atop a gently rounding knoll, rocky and sparsely vegetated. The central third was opaque, dyed in cream and ochre. Oxman framed it as a "first-of-its-kind biologically-augmented façade," made from local melanin.[31] In a label next to the images, Oxman wrote: "The structure is designed to mirror and protect endangered species […] and to celebrate the diversity of life on our planet."[32]

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[27] J. Lorand Mattory, *The Fetish Revisited: Marx, Freud, and the Gods Black People Make* (Durham: Duke University Press, 2018), xii.
[28] Levi-Strauss, *Totemism,* 2.
[29] Zoe Todd, "An Indigenous Feminist's Take on the Ontological Turn: 'Ontology' Is Just Another Word for Colonialism," *Journal of Historical Sociology* 29.1 (2016): 4-22. 17; see also Sarah Hunt, "Ontologies of Indigeneity: The Politics of Embodying a Concept," *Cultural Geographies in Practice* 21.1 (2014): 27-32.
[30] The Mediated Matter Group, "Totems."
[31] *Ibid*.
[32] *Ibid.*

Figure 2: *Terra Nullius*[33]

Theorists have historically drawn on corporeal metaphors to anatomize architecture, especially using "skin" as a metaphor for a building's façade.[34] In *Totems*, Oxman interpreted this figure of thought literally, envisioning an edifice of skin, or melanin, as a "molecularized" synecdoche for racial "diversity."[35] Oxman turned a proxy of (bio)diversity into its mechanism, instrumentalizing a substance that can "sustain and enhance diversity across living systems, and which ha[s] thus far endured the perils of climate change": an architectural technology that tans with sun, shields its animal occupants from radiation, absorbs toxic metals, and even generates energy.[36] Where Gilles Deleuze and Felix Guattari described a "body without organs," Oxman inverted their locution.[37] *Totems* was an organ without bodies—a monument to, and of, skin.

[33] The Mediated Matter Group, "Totems."
[34] The classical writer Vitruvius was the first, likening the ratios of architecture to the proportions found in the human body. In the 15th century, the neo-classicist Leon Battista Alberti discovered Vitruvius a second time, during the Italian Renaissance, and fleshed out his skeletal comparison, dissecting the "roof," as an example, into "the bones, muscles, infill paneling, skin, and crust." See Leon Battista Alberti, *On the Art of Building in Ten Books* (Cambridge: MIT Press, 1991[1556]), 421. Subsequent theorists have considered the skin, in particular, as an appropriate description for the walls of a building, which function, physiologically, as membranes between inside and out. See George Dodds and Robert Tavernor, eds., *Body and Building: Essays on the Changing Relation of Body and Architecture* (Cambridge: MIT Press, 2006[2002]).
[35] Nikolas Rose, *The Politics of Life Itself* (Princeton: Princeton University Press, 2008); Duana Fullwiley, "The Molecularization of Race: Institutionalizing Human Difference in Pharmacogenetics Practice," *Science as Culture* 16.1 (2007): 1-30.
[36] The Mediated Matter Group, "Totems."
[37] Deleuze and Guattari, *A Thousand Plateaus*.

On closer inspection of her proposal, a small crowd appeared at the monument's base. Almost imperceptible compared to the Kubrickian monolith, they stood at the edge of visibility. Standing around the perimeter, they gazed up, in reverence, at an architecture so sublime that it emptied the surrounding landscape of inhabitants: a desolate, unpopulated space, *terra nullius.*[38] Not unlike the British colonists' dream for Boston, Oxman had designed a building upon a hill. Oxman was surely not the first to picture building on uninhabited ground. As historians and anthropologists have demonstrated, the notion of *terra nullius* (Latin words for "no one's land") has featured prominently in the strategies and tactics of settler colonialism.[39] It is, at the same time, an aesthetic norm as well as a geo-juridical category. In its capacity as the former, works of art that mobilize the fantasy of *terra nullius* erase humanity from the landscape, eliminating any trace, or claim, of Indigenous occupation, just as Oxman imagined a vast nothingness for *Totems*. As a legal apparatus, *terra nullius* facilitates the territorial dispossession of Indigenous peoples from their native lands by stipulating that only sovereign bodies can rightfully possess a territory.

The architecture of material ecology on display operated in tandem with a related but more insidious form of dispossession: an unawareness of, silence toward, or, even worse, denial of the ongoing violence that has been enacted through the colonial sciences of race, which have elaborated skin color, melanin, as a political "technology" of difference, domination, and death.[40] As Chanda Prescod-Weistein writes of *Totems*, "Melanin is being treated like a useful tool, or maybe even an art piece, yet again divorced from the people who have made it most visible […]

[38] On the technological sublime, see David Nye, *American Technological Sublime* (Cambridge: MIT Press, 1994).
[39] See, for instance, Andrew Fitzmaurice, "The Genealogy of *Terra Nullius*," *Australian Historical Studies* 129 (2007): 1-15.
[40] See Wendy Chun, "Introduction: Race and/as Technology; or, How to Do Things to Race," *Camera Obscura* 70 (2009): 1-38; Ruha Benjamin, *Race after Technology: Abolitionist Tools for the New Jim Code* (Princeton: Princeton University Press, 2019); and Achille Mbembe, *Necropolitics* (Durham: Duke University Press, 2019).

who have suffered for being partly made of it."[41] What *Totems* ignores: how early scientific discourses measured and ranked races through the morphometry of the body (e.g. the skull);[42] how the visual aesthetics of scientific racism evolved alongside and in connection with optics of racial discrimination that categorized people on the basis of the visible color of the skin;[43] how, when the discovery of melanocytes in the 19th century failed to reinforce a scientific theory of racial difference, melanin persisted as a means of racial discrimination and of identification.[44]

Oxman re-signified melanin in *Totems*, from a symbol of difference, of a local, provincial, and racialized humanism, to a "universal pigment": a molecule that makes kin of human *and* nonhuman. From this light, it can be seen that *Totems* exceeded what Paul Gilroy envisioned, utopically, as a "nonracial humanism."[45] *Totems* was a *universal biologism*. The problem of this colorblind ecumenism, which Gilroy helps us to understand, was its refusal to remember the racial atrocities committed through melanin. Another dispossession has thus transpired with *Totems*: the dispossession of memory. While *Totems* provocatively interrogated "who owns biological color," it whitewashed the past in which skin color determined (in)human

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[41] Chanda Prescod-Weinstein, *The Disordered Cosmos: A Journey into Dark Matter, Spacetime, and Dreams Deferred* (New York: Bold Type Books, 2021), 109.
[42] Stephen Jay Gould, *The Mismeasure of Man* (New York City: W.W. Norton & Company, 1996[1981]).
[43] Over skin a racial schema was thus imposed—a process Frantz Fanon called "epidermalization," the superimposition of an "inferiority complex" onto the "visible appearance" of black people. Frantz Fanon, *Black Skin, White Masks* (New York: Grove Press, 2008[1952]), xv, xiv, 18. Fanon also wrote of an "epidermal racial schema" (91). "The white gaze, the only valid one, is already dissecting me," Fanon wrote. "I am *fixed*. Once their microtomes are sharpened, the Whites objectively cut sections of my reality" (95). Elsewhere: "The Other fixes me with his gaze, his gestures and attitude, the same way you fix a preparation with a dye" (89). Fanon concluded, "At the first white gaze, he feels the weight of his melanin" (128). Examining under the skin as well, Fanon engaged in subdermal psychoanalysis, revealing how this complex between black and white bore internally into the consciousness of colonial subjects. The "reification" of the black person as one "object among other objects," "overdetermined from the outside," was reflected in neurotic pathologies, among black *and* white men and women (89, 89, 95). The failure to "recognize" colonial subjects, the "disalienation of the black man," as Fanon said, dispossessed white and black persons alike of mutual humanity—melanin's imprint on history (xiv).
[44] Taking up Fanon's idea of epidermalization, Paul Gilroy describes how "epidermal thinking" persisted across the 20th century, notably in Afrocentric ideologies based on melanin's virtues. Paul Gilroy, *Against Race: Imagining Political Culture beyond the Color Line* (Cambridge: Belknap, 2000).
[45] *Ibid*, 15. Similar claims have been made of the gene. See, for instance, Sandra S. Lee, Barbara Koenig, and Sarah Richardson, eds., *Revisiting Race in a Genomic Age* (New Brunswick, Rutgers University Press, 2008); Catherine Bliss, *Race Decoded: The Genomic Fight for Social Justice* (Stanford: Stanford University Press, 2012).

ownership[46]—a void of memory only worsened by her greenwashing of Indigenous peoples, whose skin once circulated as a grotesque form of currency. "Otherworldly—defined by neither time nor place," Andrew Bolton has said of Oxman, but the architecture of skin she envisioned, however, is inextricably of *this* world—a world where skin bore the architecture of the colonial. In this light, *Totems* was amnesic design, skin-deep—essentializing culture, forgetting history.

According to Oxman, material ecology transcends biomimicry. In *Totems*, however, a romantic anthropology that suffuses the discourse of biomimicry—one between "Western" and "native" or "indigenous" design—persisted as an epistemological foundation upon which Oxman has reflexively built her understanding of architecture. This anthropological discourse has real, material consequences, not just in the sense of physical buildings and talk about them, but also for the Black, Indigenous, and other People of Color whom Oxman did not consult with over her use of melanin, and whom *Totems* certainly did not benefit. *Totem* stood only as a monument of immemoriality, forgetting the past and present atrocities conducted in the name of skin and race.

In 2017, I spoke with Oxman in person to see if I could spend time in the Mediated Matter Group. After expressing hesitation that it might interfere with their "design process," she said she would get back to me later. Not long after, I received an email stating that she could not facilitate an anthropologist in her studio. Perhaps, however, anthropologists *should* interfere with the design process, collaborating with architects and other designers—critically, but fairly—so as to challenge the "anthropological" representations of human difference that circulate, at times, so insidiously within the design disciplines. As moments of cultural encounter, contact, and friction multiply in the 3rd millennium, what anthropologies will shape design's world-building activities, and how will cultural anthropologists push designers toward a more cosmopolitan anthropology?

[46] The Mediated Matter Group, "Totems."