

Bioart and *Bildung*—Wetware: Art, Agency, Animation, an Exhibition as Case Study

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Recent events in the field of biology have further unfixed the definition of life. The negotiability of “life” is at the center of the exhibition “Wetware: Art, Agency, Animation” at the Beall Center for Art + Technology at the University of California, Irvine. The exhibition includes art by nine international artists working in the avant-garde area of contemporary art called “bioart.” This article is devoted to the unique educational space opened through the practice of bioart, focusing on how the exhibition brings the scientific question “What is life?” to a public audience. *Bildung*, a term that translates as education but encompasses exploration and growth, is based on the holistic unity of science and art and is used here to show that neither science nor art sacrifices legitimacy or distinction within bioart. Art can suggest design and be useful; science can point to abstraction and be poetic. Bioart inspires a chain of curiosity about the form, materials, media that artists use to probe, shape, direct, and display scientific processes and concepts.

INTRODUCTION: THE *BILDUNG* OF BIOART

Recent events in the field of biology have further unfixed the definition of life. These include the advent of the gene editing tool known as CRISPR (clustered regularly interspaced short palindromic repeats), the human-made 531,000-base, 473-gene cell billed as the essence of life called JCVI-syn3.0, and the development of the greater arenas of synthetic and post-genomic biology (10, 12, 4, 18). The negotiability of “life” is at the center of the exhibition “Wetware: Art, Agency, Animation” at the Beall Center for Art + Technology at the University of California, Irvine. Co-curated by Jens Hauser and David Familian, the exhibition includes art by nine international artists, including Adam Brown, Gilberto Esparza, Thomas Feuerstein, Klaus Spiess and Lucie Strecker, Orkan Telhan, Evelina Domnitch and Dmitry Gelfand, and Anna Dumitriu, working in the avant-garde area of contemporary art called “bioart.”

Bioart is an enigmatic practice within contemporary art because of the use of living materials—enzymes, yeast, DNA, bacteria, flesh, etc.—and scientific tools and methodologies, all of which make it a challenging commodity. Bioart is not only intellectually demanding, but it is difficult to buy, sell, and trade in the contemporary art market. Within

the nomenclature of contemporary art, bioart is situated within the rubric of “new media art.” This is an area of art problematic for similar market-based reasons, which emerge from new media art’s transformation of the classical art object into a mechanical effect or computational performance and the related destabilization of traditions of beauty, the masterpiece, and artistic genius (1). It is a field characterized by technological hybridity forged by the artist Marcel Duchamp’s kinetic “Rotoreliefs” (1935) and mathematician Ben Laposky’s photographic and oscilloscope installations of geometric abstractions called “Oscillons” (1952) (22). Bioart is also part of conceptualism in art, a tendency and attitude within art that gives primacy to the idea over the object of art. Conceptualism was similarly triggered by Duchamp’s early twentieth-century anti-aesthetics, which fully effloresced in the late 1950s with the “dematerialization” of the art object, its displacement by live performances called “happenings” and a new prioritization of philosophy within art shortly thereafter referred to as “theory” (13). Bioart occupies a unique position within these overlapping fields in that bioartists do not simply deploy technology or prioritize philosophical contents over matter in art, but infuse conventional forms, such as painting, sculpture, and theater, with living materials and often transform the gallery into a makeshift biology lab.

This article is devoted to the unique educational space opened through the practice of bioart. Education here is a matter of *Bildung*, a term that is translated in English simply as “education” but within German means “shaping,” “training,” “growth,” “culture,” “maturation,” and “humane education” (17, 2). *Bildung* distills the complexity of learning

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as a never-ending process of life and “serves as a code-name to bridge the gap between the scientific approach to and the social function of education” (17). Based on the ideas of the German philologist Wilhelm von Humboldt (1767–1835), *Bildung* emerges from science as a holistic and unifying enterprise ensconced in the fundamental interlocking of education and research. The last component, teaching and exploration, marked in Humboldt’s time a turn toward the “acquisition of new knowledge by means of scientific research” away from Renaissance humanism circumscribed by canonical texts worthy of imitation (2). Science in this context is an ongoing seeking and building outward based on new knowledge. “Since the totality of human knowledge was anything but fully explored,” for Humboldt, “science must be understood as a *‘noch nicht ganz Gefundenes und nie ganz Aufzufindendes’* (something not yet completely discovered, and never to be completely discovered)” (2).

This article looks at the *Bildung* at work in the exhibition of bioart “Wetware: Art, Agency, Animation,” focusing on how the exhibition brings the scientific question “What is life?” to a public audience. The bioart of “Wetware” clears an intellectual ground that is exceptional in that the utility between fields, art and science, is neither linear nor causal but circulates in a feedback loop. Art is not simply in service to science, and similarly, science is not simply in service to art. Rather, the two areas work in conjunction to open a space of praxis in which art has an educational utility spreading knowledge and critical consciousness of science, while science expands beyond reductionist outcomes into the area of disinterested artistic exploration. Art can suggest design and be useful; science can point to abstraction and be poetic. Bioart inspires a chain of curiosity about the form, materials, and media that artists use to probe, shape, direct, and display scientific processes and concepts. A variety of artistic cues—lighting, color, installation, sound, touch, interactivity, and general aesthetic experimentation—sheds light on the political and social repercussions of science within everyday life. Aesthetics brings science to the public in order to spread scientific literacy, making science accessible, while also raising critical consciousness about the power of scientific language and discovery to mold identity, open opportunity, and affect reality. This collaboration between fields updates the German concept of *Bildung* for the twenty-first century, merging the latest cultural commentary at work in art with cutting-edge biotechnologies.

WETWARE AND THE QUESTION OF LIFE: WHAT IS LIFE? WHAT WAS LIFE? WHAT ARE LIVES?

The art of “Wetware: Art, Agency, Animation” plays with the ambiguity of life that is at the core of the field of biology: its definition in scientific language, its material formation in laboratories, and its processes in nature. The field of biology was founded in the early nineteenth century on this very question: What is life? It proved to be explosive and energetic, reappearing with rhythmic regularity ever

since. The German naturalist Gottfried Reinhold Treviranus first posited the question in 1802 with his discipline-opening book, *Biologie* (24). Then, physicist Erwin Schrödinger did so again in 1944 in *What is Life?* (20). In 1995, biologists Lynn Margulis and Dorion Sagan pluralized life in their book of the same title—*What is life?*—by examining the living in its manifold incarnations across bacteria, protists (or protoctists according to Margulis and Sagan), fungi, plants, and animals (16). In 2002, biophysicist Evelyn Fox Keller pointed to the question of life again in *Making Sense of Life* in order to foreground “morphogenesis, embryogenesis, and developmental biology” against the primacy of gene reductionism and gene-centric definitions of life (9).

The term “wetware” similarly contends with the grey areas within scientific definitions of life. For the curators of the exhibition, the term wetware supersedes computer-based metaphors of life, such as hardware and software, in how it “encompasses the biological and systems theoretical understanding of life [while] disrupt[ing] the border between organisms and machines” (5). Computer scientists and engineers have used the word “wetware” to identify the human brain and nervous system (18). Dennis Bray employs wetware to pinpoint the inherent computational function of a cell, arguing that there is “a computer in every cell” (3). He cites as an example the “short-term memory” of bacteria “that tells them whether conditions are better at this instant of time than a few seconds ago” (3). Jessica Riskin situates the term within the history of robots, androids, and artificial life, focusing on examples of “eighteenth-century wetware,” such as Pierre Jacquet-Droz and Jacques de Vaucanson’s automata. Riskin also cites the ambivalence of the word, highlighting how it wavers between expressing belief “that the processes and consciousness [of life] are essentially mechanistic and can therefore be simulated” and the persuasion “that the essences of life and consciousness will ultimately be beyond the reach of mechanical reproduction” (19). In the exhibition, the two work in tandem. The term wetware is a linguistic apparatus by which the question “What is life?” is disseminated.

Yet, it is a more recent variation on this question—“What was life?”—that really piques the curators of “Wetware” (5, 6). Recast by anthropologist of science Stefan Helmreich, whose influences loom large in the exhibition, the query of life in the past tense places life at its outer limits. Life here is a matter of what Helmreich calls “limit biologies” (6). Limit biologies set in relief life in the extreme. They embody “a worry about ends” and an “argument from the future,” which above all else “point to larger instabilities in concepts of nature—organic, earthly, cosmic” (5, 6). The mystery of life cannot be answered with one question. Life is not monolithic, metaphysical, or in abeyance but rather situated, contextual, and changing. Life in the past tense is testament to its always already being impinged upon, affected, and even constructed by artificial and unnatural forces on one end and the extreme conditions of nature on the other. Helmreich’s three examples of “limit biologies”—Artificial

Life (AL), oceanic extremophiles, and astrobiology—inscribe the thresholds of biological life shaping the exhibition “Wetware.” The exhibition thus also begs for life in the plural: “What are lives?”

Gilberto Esparza’s work is a direct instantiation of the limit biology that is Artificial Life. Artificial Life, in this instance, is both dry and wet, as it consists of robots, sound, and microbial life. In Esparza’s installation, small robots climb atop a heap of throwaway broken devices on the floor, the garbage resulting from rapid obsolescence that is essential to disruptive technology. Esparza’s “Pepenadores” (Gleaners), made from recycled motors of toys, crawl amid mechanical detritus (Figs. 1a and 1b). They are programmed to remove and screen technological scraps for possible new uses. Meanwhile, “Moscas” (Flies), mechanical insects made from discarded cell phone vibrators attached to invisible metal lines, zigzag above and around viewers’ heads (Fig. 1c). Esparza’s “BioSoNot” offers a more direct example of wetware in that it combines machines and living matter. It is a sonic device and musical synthesizer that makes noise out of the electrical oscillations of bacteria as they clean contaminated water (Fig. 2). For this work, Esparza made microbial fuel cells, which are connected to oscillators and piezoelectric sensors. The dirty water filtered through “BioSoNot” was found locally in Southern California and captured for the installation of “BioSoNot” at the Beall Center.

Adam Brown’s piece brings laboratory equipment into the gallery in order to replicate early modern chemistry. His work catalyzes marine bacteria to create a natural element and thus exemplifies the limit biology of marine extremophiles. Brown’s “The Great Work of the Metal Lover” is an alchemical machine hosting the metallotolerant extremophilic bacterium *Cupriavidus metallidurans* that, under the engineered atmosphere created in the gallery, produces gold. The installation has three components: 1) the machinery, which is a glass alchemical bioreactor, a gas manifold, and a gas tank filled with carbon dioxide and hydrogen; 2) a series of images with gold made using a scanning electron microscope; and 3) a small specimen of gold from the bioreactor in a small display case mounted on the wall (Fig. 3). The extreme minimal ecosystem within the bioreactor forces the bacteria to metabolize high concentrations of gold chloride, turning soluble gold into usable 24K gold.

Evelina Domnitch and Dmitry Gelfand’s “Luminiferous Drift” delves into the limit biology that is astrobiology in order to ponder the signature of life as extraterrestrial. The viewer walks into a dark room and looks over a small whirling, circular bath of water in which primordial cellular conditions have been recreated. The installation transcribes primitive life by way of an enzyme-activated metabolism, which releases energy as light. The artists have used phytoplankton, unicellular autotrophs that metabolize and trans-

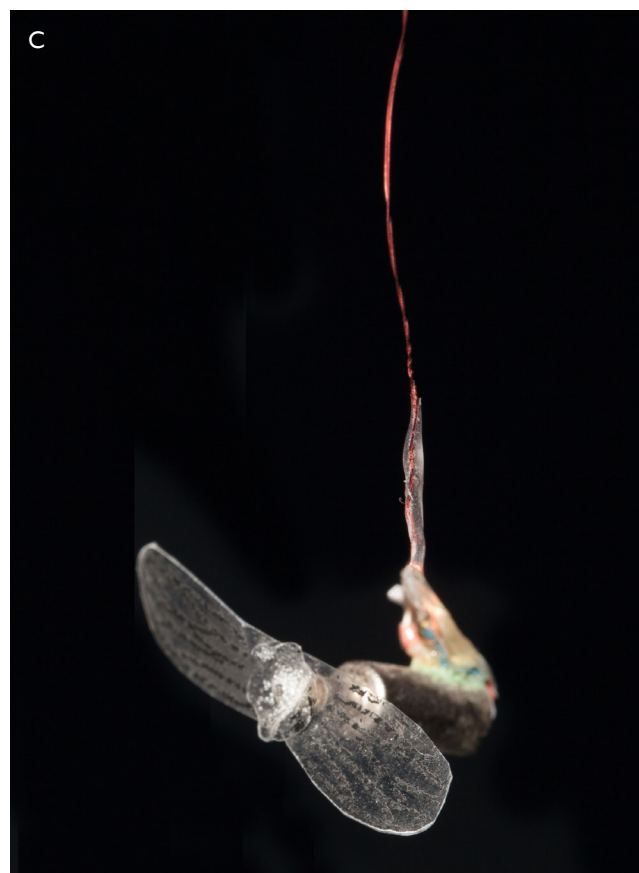
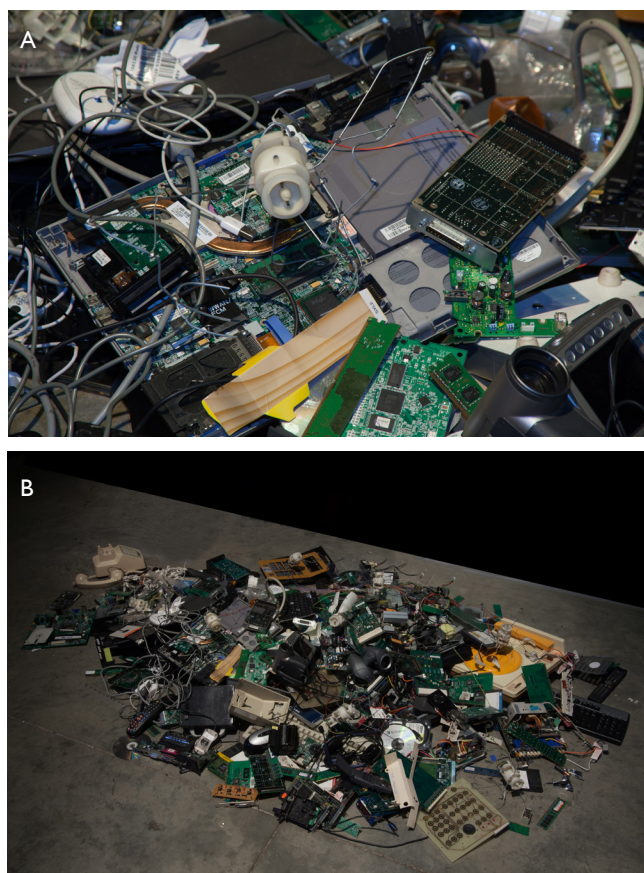


FIGURE 1. Gilberto Esparza, 2010–2014. a) and b) Pepenadores (Gleaners); c) Moscas (Flies).]



FIGURE 2. Gilberto Esparza, “BioSoNot,” 2015.

form light into oxygen, to stage the primordial conditions of life. At night, their leftover energy is emitted as bioluminescence. Domnitch and Gelfand’s installation in a darkroom mimics this effect of bioluminescent phytoplankton and the creation of a life-supporting climate on Earth (Fig. 5).

The politics of wetware: Sex, gender, and bacteria

Questions of sex and gender further emanate from the theme of life unfolding at “Wetware.” Anna Dumitriu’s three projects in the exhibition offer the most obvious invocation of gender in the show. “Engineered Antibody,” “Necklace,” and “Faster Mutation” play with the leitmotifs of femininity and traditional women’s work. “Engineered Antibody” (Fig. 5a) looks like a colorful wearable necklace; “Necklace” (Fig. 5b), while named for jewelry, is a set of seven petri dishes organized on a podium in the shape of a chain; and “Faster Mutation” (Fig. 5c) is a set of embroidered squares of velvet framed and mounted on the wall.

The shapes and forms of Dumitriu’s work elicit meaning within and beyond gender. The artist-scientist collaboration at work in all three pieces embodies an equally if not more powerful meaning-maker than sexual categories, even while

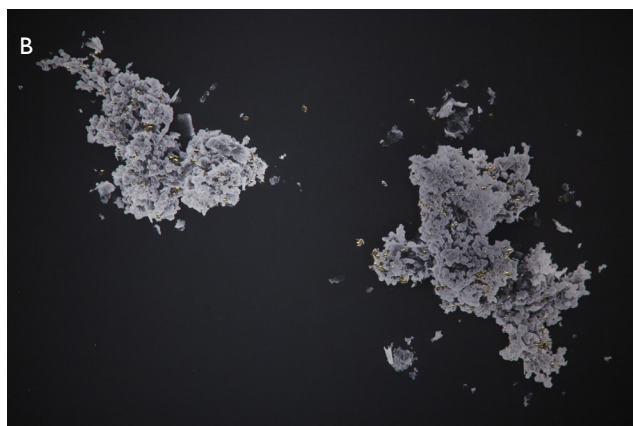
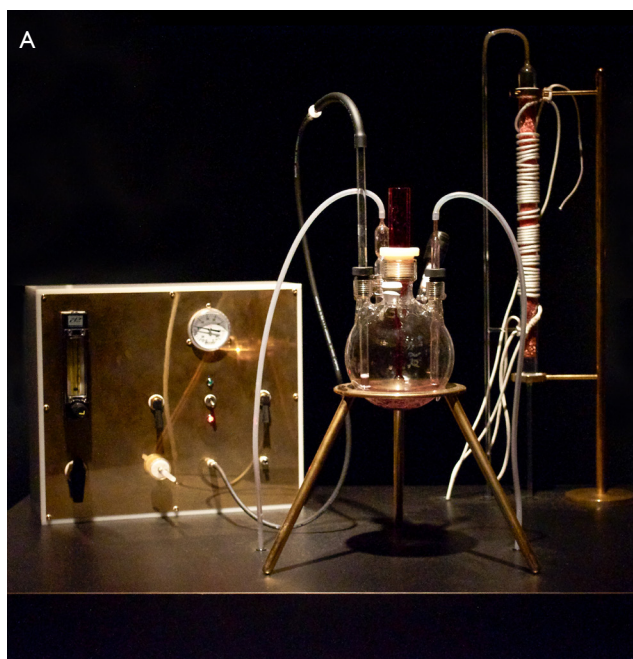


FIGURE 3. Adam Brown, “The Great Work of the Metal Lover,” 2012. a) View of alchemical installation. b) View of images with gold made using a scanning electron microscope.]

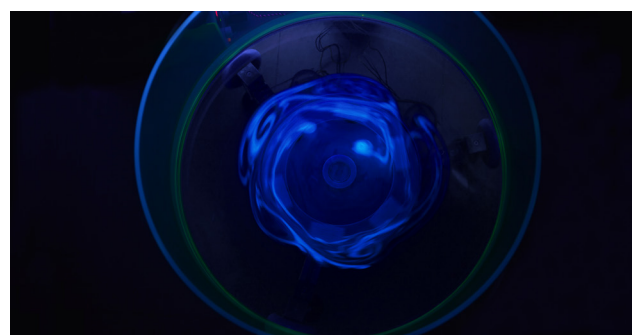


FIGURE 4. Evelina Domnitch and Dmitry Gelfand, “Luminiferous Drift,” 2016.

the presence of Dumitriu—a woman *and* artist—in the lab is a resounding, even revolutionary, symbol of open frontiers and progressive thinking. A result of her residency working with researchers in the Liu Lab for Synthetic Evolution at



FIGURE 5a. Anna Dumitriu, “Engineered Antibody,” 2015–2016. “Engineered Antibody” looks like an actual necklace made up of 452 handmade beads containing the actual 21 amino acids of an antibody purified from the blood of an HIV-positive patient.

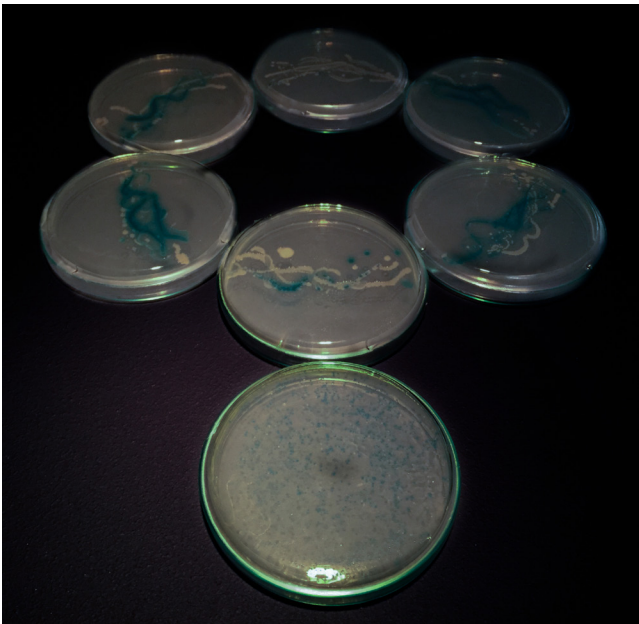


FIGURE 5b. Anna Dumitriu, “Necklace,” 2015–2016. “Necklace,” by contrast, symbolically references a necklace using the circular arrangement of agar plates. Bacterial colonies grew, turning blue or white depending on the compatibility of the fragment insertion into the lacZ selection marker. “Necklace” was made in collaboration with Felix Grun, Center for Complex Biological Systems at UCI.

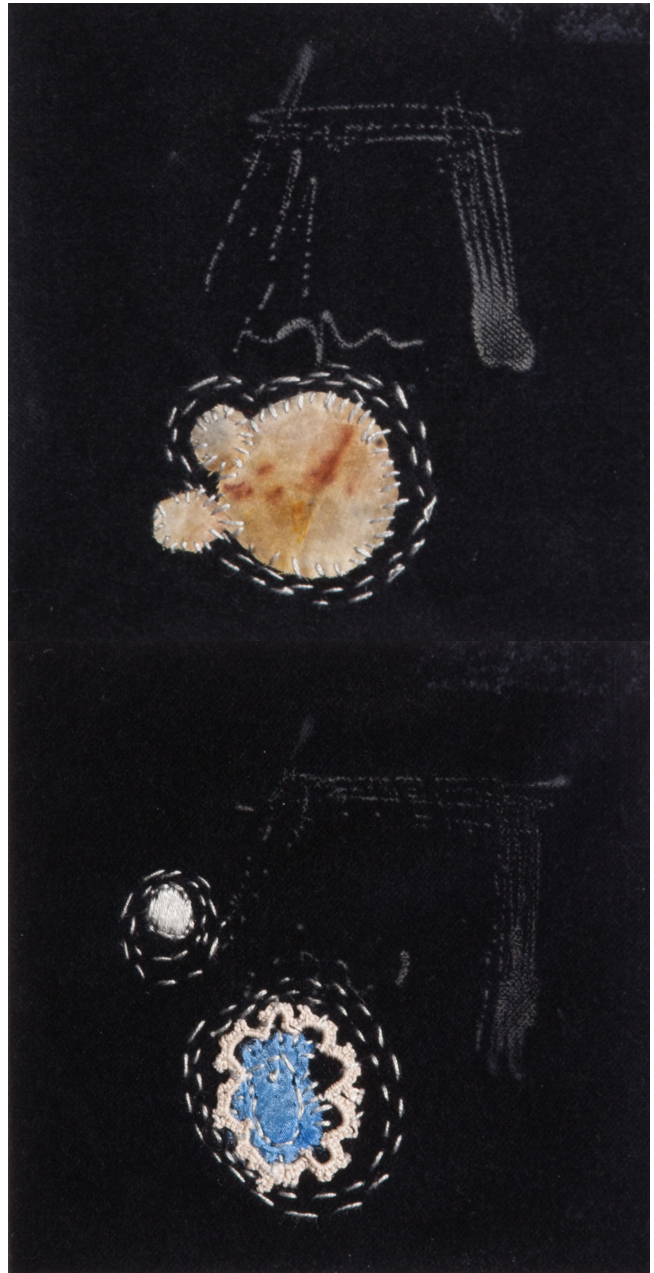


FIGURE 5c. Anna Dumitriu, “Faster Mutation,” 2015–2016. Here, Dumitriu made embroidered works on velvet impregnated with yeasts that contain an enzyme derived from a bacteriophage that is undergoing increased mutation. Such velvet is used in scientific labs and traditional sewing. In the lab, scientists use velvet squares as part of ‘replica plating,’ a process which allows them to produce an exact copy from one agar plate to another. The bacteria-created embroideries recall ecclesiastic embroideries and metaphorically hint at public suspicion that scientists are “playing God.”

the University of California Irvine, Dumitriu’s “Engineered Antibody” plays on the metaphor that amino acids are the “beads of life:” the idea that scientists enlist to describe the structures of proteins constructed from chains of amino acids. The work is a necklace made up of 452 handmade beads containing the actual 21 amino acids of an antibody purified from the blood of an HIV-positive patient. In “Necklace,”

Dumitriu dissects further the “string of beads” metaphor, situating this literary-cum-scientific figure materially within the genomic level. Bacterial colonies have been grown in the form of a necklace on chromogenic XGAL plates containing a plasmid vector. “Faster Mutation” is a series of framed square patches of black velvet bearing small, abstract shapes rendered by hand stitching. The velvet was impregnated with yeasts that contain an enzyme derived from a bacteriophage undergoing increased mutation.

The gendering of form in Dumitriu’s pieces resonates with the writings of Evelyn Fox Keller, a pioneering voice in the discourse on gender and science. In addition to probing the linguistic moorings of life and the gene, Keller has written extensively about the social construction of gender and science, “the historic conjunction of science and masculinity, and the equally historic disjunction between science and femininity” (7, 8). Yet “Wetware” reveals other ways of getting at the politics of sex and gender within science, in particular through bacteria and the microbiome. Margulis has argued for a reframing of evolution in terms of symbiogenesis and the diversity of sex across organisms within the five kingdoms of species, rooting life in anaerobic prokaryotes of the Archean Eon 3,900 million years ago, long before mammals appeared in the Cambrian explosion (15). Lateral gene transfer in bacteria, the fact that “through symbiogenesis, organisms acquire not traits but entire other organisms,” further opens evolution to a rejiggering based on sex, reproduction, species continuation, and diversification (23). In addition to gradual, deep geological time, there is the more rapid speciation of bacteria through lateral gene transfer, or symbiogenesis, begging scientists to take serious account of the “inheritance of acquired gene sets,” or neo-Lamarckianism (14). Evolution through gene transfer “interrupts what Darwin called the ‘natural classification’ that would follow from tracking lines of descent,” and begs for thinking reproduction in terms of ‘sex’ over ‘gender.’ From this point-of-view, “‘gender’ does not and should not always reduce to ‘sex’ and be about reproduction” (6). By connection, Margulis argues, “gender is not intrinsic to life. Gender evolved” (15). Based on the wide range of organismal reproduction, Helmreich cautions against the primacy of “binary ontologies of sex-gender” articulated in the male-female dyad (6). Here “sex... the joining together [of] individuals and populations” is supplanted by “transfer...an asexual, many-directioned connection, which undoes the stability of the very categories it brings into juxtaposition” (6).

The use of bacteria in contemporary bioart is not just a matter of trendy materials eliciting shock value but is part of an ecological politics in which “life” moves beyond a mammal-centric paradigm of evolution to one rooted in the limit biologies of extremophile bacteria, the microbiome, and an understanding that bacteria are not just germs but essential to the proper function of our bodies, environments, and imbricated ecologies (23), all of which impinge upon gender norms in culture and society. So the bacteria in Thomas

Feuerstein’s “PANCREAS” (Fig. 6) and Orkan Telhan’s “Biorealize: Microbial Design Studio” (Fig. 7) have layered purpose. While, in Feuerstein’s brain in a vat, it works to simulate digestive processes in breaking down cellulose to glucose and, in Telhan’s prototype, microorganisms are transformed, incubated, and purified to simulate the smell of bananas, the presence of bacteria in both pieces communicates a collective message about evolution and life itself. Bacteria in this art draw attention to evolution from the perspective of microbes, not just plants and mammals, and the attendant world of diversified reproduction manifesting in asexuality, hermaphroditism, parthenogenesis, and lateral gene transfer.

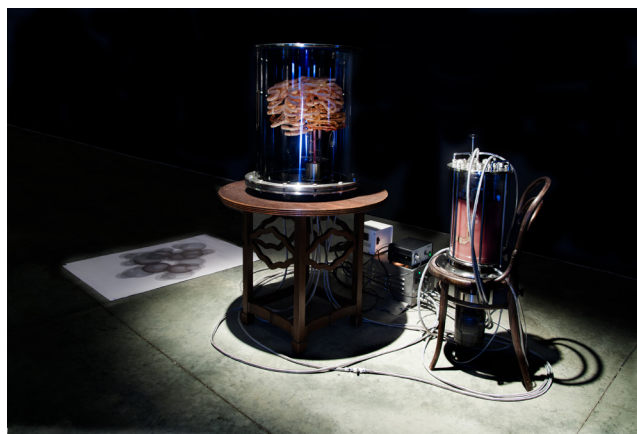


FIGURE 6. Thomas Feuerstein, “PANCREAS,” 2012. Thomas Feuerstein’s work supersedes mind-body dualism with organismic holism. Feuerstein’s “PANCREAS” rethinks putative mind and the classical humanist text in terms of the biological processes extending across the body. While organismic integration is its theme, the work of art looks foremost like a disembodied brain. The entire text of Georg Wilhelm Friedrich Hegel’s *Phenomenology of Spirit* is ground up, soaked in water, and pressed into an artificial intestine, in which modified bacteria break down the cellulose into glucose. The glucose is filtered, purified, and fed to the cells growing in the brain in the vat. Here, thinking and consciousness are rooted in the pancreas as much as the brain.

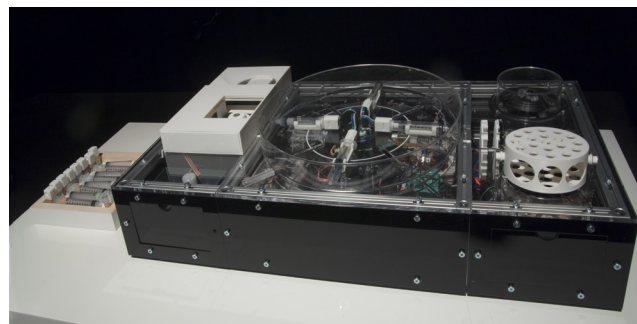


FIGURE 7. Orkan Telhan, “Biorealize: Microbial Design Studio,” 2015. Orkan Telhan’s “Biorealize” is a prototype: a piece of custom liquid handling and incubation hardware that serves as an automated biolab that designs, cultures, and tests genetically modified organisms. While it looks remarkably like a DJ’s turntable, it functions in real time at “Wetware” to manufacture the smell of bananas.

CONCLUSION: *BILDUNG* IN CONTEMPORARY BIOART EXHIBITIONS AND CLASSROOMS

In this essay, I have introduced an idea of education, *Bildung*, based on the holistic unity of science and art, to show that neither science nor art sacrifices legitimacy or distinction within bioart. There is a surrendering of disciplinary autonomy in the name of transdisciplinarity in order to create new modes of learning, problem solving, and aesthetic formulation and to make scientific ideas accessible to the public. In this instance, “Wetware” has introduced the conundrum of “life” within contemporary biology, while foregrounding Artificial Life, marine extremophiles, astrobiology, evolution, the history of evolution, sexuality, gendering, bacteria, and the microbiome. “Wetware” is one of several contemporary bioart exhibitions pivoting on bacteria as a game-changer in the definition of life. Curated by Eben Kirksey and a “swarm” of other curators, “Emergent Ecologies” was an exhibition in spring 2016 with almost 100 artists¹ taking place in a large makeshift space on Green Avenue in Brooklyn called Kilroy (11). The exhibition focused on a theme of emergent forms of life that are deleterious and beneficial, and how diseases as well as new forms of post-volcanic life subvert “dominant political strategies, economic systems, or agricultural practices” (11). Two exhibitions, “Mind the Gut,” forthcoming at the Medical Museion in Copenhagen, Denmark, and “Gut Instinct: Art, Design, and the Microbiome,” an online exhibition sponsored by the SciArt Center of New York², focus on gut bacteria, the microbiome, the gut-brain axis, and how putative mind is organismal and extends beyond the brain across the body (15, 21). Like “Wetware,” these exhibitions exercise *Bildung* in that they introduce and explain biology to the public without reducing art to the utilitarian illustration of scientific ideas or bastardizing scientific processes for the sake of entertainment.

In addition to art exhibitions, university settings are ideal for the promotion and enactment of collaborative and cross-disciplinary *Bildung*. The most well known art-and-science program is SymbioticA, a research laboratory in which artists and scientists engage in wet biology practices at the University of Western Australia. There, Director Oran Catts is hewing a path for citizens from around the world who are in pursuit of training in biology and art, architecture, and design. Other guiding programs in art-and-science expertise include: Alternate Anatomies Lab started by Stelarc in 2013 at Curtin University in Perth, Australia, V2_Institute for Unstable Media in Rotterdam, Waag Society’s Open Wet Lab in Amsterdam, Bio Art Lab at the School of Visual Arts in New York, founded in 2011, Metaphorest in Tokyo, The Art and Genomics Center at the Faculty of Science in Leiden, Germany, (Art)ScienceBLR based in Bangalore, India, Media x Design Laboratory (LDM), a bio-architecture/design research lab at the École Polytechnique Fédérale Lausanne in Switzerland, The Finnish Bioart Society started in 2008, Ectopia in Lisbon, TASML, the Tsinghua University Art and Science Research Center Media Lab in China, BIOS ex MechanicA at the University of Mexico, Biofilia: Center for Biological Arts at the Aalto University in Helsinki, Fluxmedia, a research-creation network at Concordia University in Montreal, Canada, and Genspace’s Biosafety Level One in Brooklyn, New York. While this ever broadening field signals the full-fledged establishment of a new discipline and profession globally speaking, many professors in both art and science may nonetheless find it difficult to germinate such collaboration at the grassroots level.

Yet, that is exactly where the *Bildung* of bioart begins: with artists and scientists simply discussing ideas both privately and publicly. I have seen, for example, the great momentum created by a contemporary art space simply hosting a forum in which a biologist and an art theorist parse the world of bioart and bioarchitecture. Such impetus translates

1. The exhibition was curated by Eben Kirksey, Lissette Olivares, Ellie Irons, Grace Glover, Cody Kohn, Kayli Marshall, Greg Umali, Alexandra Palocz, Jeffrey Bussolini, and Cheto Castellano, took place April 30–May 21, 2016, and showed the work of Maria Aiolova, Patricia Alvarez, Marcela Anabalón, Krisanne Baker, Steve Barrett, Tarsh Bates, Peter Bauer, Vaughn Bell, Karin Bolender, Rogan Brown, Chloe Byrne, Natalia Cabezas + Montserrat Negrete, Corinne Cappelletti, Cheto Castellano, Alonso Cedillo, Sophia Chao, Atom Cianfarani, Tatiana Czekalska + Leszek Golec, J. D. Doria, Krista Dragomer, Ellen Driscoll, Anna Dumitriu, Grayson Earle, Melanie Fessel, Ivan Fuentealba, Regina José Galindo, Mikhail Gervits, Grace Glover, Yucel Guven, Andrea Haeggi, Christian Hamrick, Shandor Hassan, Elena Tejada Herrera, Kathy High, Jeff Hoelle, Susan Hoenig, Henry Horn, Ellie Irons, Antonia Isaacson, Maca Jimenez, Mitchell Joachim, Sharon Kallis, Anja Kanngieser, Christopher Kennedy, David Khang, Katie King, Eben Kirksey, Kitch, Michael Klingler, Cody Kohn, Miguel Lantigua-Inoa, Lian Lian, Lenore Malen, Matsya, Jane Marsching, Mary Martin, Alex May, Laura McLauchlan, Felipe Molina, Lucia Monge, Sung Moon, Leila Nadir, Eli Neira, NEOZOOON, Juan Olivares, Lissette Olivares, Terreform ONE, Alexandra Palocz, Cary Peppermint, Anne Percoco, Eva Perrotta, Angela Petsis, Praba Pilar, Deanna Pindell, Prima and other suspects from the Center for Feline Studies, Danny Reveco Appelger, Peter Richards, Coco Rico, Shark Roth, Christy Rupp, Robyn Shapiro, Sin Kabeza Production, Karolina Sobocka, Anna-Sophie Springer + Etienne Turpin, Annie Sprinkle + Beth Stephens, Polly Stanton, Andi Sutton, Matthew Tarpley, The Natural History Museum (Not an Alternative), Vandra Thorburn, Anaïs Tondeur + Marine Legrand, Marlene Tseng Yu, Greg Umali, Anuj Vaidya, Kamila Varela, Vesper, *Artemisia vulgaris*, Ruth Wallen, Maria Whiteman, JiaChen Xu, Amanda Yates, and Adam Zaretsky.
2. This exhibition marked the culmination of a virtual residency, September 2015–February 2016, conducted through the SciArt Center New York between the author and David Wessner, Professor of Biology at Davidson College. The exhibition includes artwork by artists Anna Dumitriu, Kathy High, Rachel Mayeri, Ken Rindaldo, Meredith Tromble, and Adam Zaretsky and by scientists Mehmet Candas and François-Joseph Lapointe.

into greater comfort within the audience and across fields, with science in everyday life and art as a practical necessity for grasping new and otherwise mysterious ideas. Course development is another area where educators might seed the grounds of this type of *Bildung*. Art professors might borrow from science and its history in their courses by integrating the history, philosophy, and practice of science in syllabi, and, reciprocally, science professors might integrate the history, theory, and criticism of art and aesthetics. *Bildung* begins by admixture, interaction, and, most basic of all, talking.

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